88139.

A MONOGRAPH
OF THE
ECHINOIDEA

I.
CIDAROIDEA

BY

TH. MORTENSEN

WITH 88 PLATES AND 173 FIGURES IN THE TEXT

TEXT

COPENHAGEN
C. A. REITZEL
PUBLISHER

LONDON
HUMPHREY MILFORD
OXFORD UNIVERSITY PRESS

1928

A MONOGRAPH

OF THE

ECHINOIDEA

I.
CIDAROIDEA

BY

DR. TH. MORTENSEN

WITH 88 PLATES AND 173 FIGURES IN THE TEXT

PUBLISHED AT THE EXPENSES OF THE CARLSBERG-FUND

D 228.23

TEXT

COPENHAGEN
C. A. REITZEL
PUBLISHER

LONDON
HUMPHREY MILFORD
OXFORD UNIVERSITY PRESS

1928

READY FROM THE PRESS DECEMBER 7TH 1928

PRINTED IN DENMARK
BY BIANCO LUNO
COPENHAGEN
1928

CONTENTS

	Page
Preface	1
Introduction	3
Order Cidaroidea	9
Morphology of the Cidaroidea	9
Classification of the Cidaroidea	43
Key to the families of Cidaroidea	56
Fam. Archæocidaridæ	57
Genus Archæocidaris	59
— Nortonechinus	60
Fam. Cidaridæ	61
Key to the subfamilies of Cidaridæ	61
Subfam. Streptocidarinæ	61
Key to the genera of Streptocidarinæ	62
Genus Miocidaris	62
— Triadocidaris	63
— Mikrocidaris	64
— Aplocidaris	65
— Anaulocidaris	66
Subfam. Stereocidarinæ	68
Key to the groups of Stereocidarinæ	68
Group Histocidarina	69
Key to the genera of Histocidarina	70
Genus Histocidaris	70
Key to the species of Histocidaris	71
Histocidaris elegans	72
— crassispina	77
— misakiensis	79
— variabilis	82
— Cobosi	84
— Sharreri	86
— carinata	89
— australiæ	91
— magnifica	94
— formosa	94
— recurvata	97
— Nuttingi	98
— sp.	99
— acutispina	100
— denticulata	100
Genus Poriocidaris	102
Poriocidaris purpurata	104
Group Ctenocidarina	108
Key to the genera of Ctenocidarina	108
Genus Aporocidaris	109
Key to the species of Aporocidaris	110
Aporocidaris Milleri	110
— fragilis	114
— antarctica	116
— incerta	118
Genus Ctenocidaris	120
Subgen. Eurocidaris	120
Key to the species of Ctenocidaris	122
Ctenocidaris speciosa	122
— Perrieri	123
— spinosa	124
— Geliberti	126
— rugosa	126
— nutrix	128
— — longispina	129
Genus Notocidaris	130
Key to the species of Notocidaris	131
Notocidaris Mortenseni	131
— gaussensis	134
— hastata	135
— platyacantha	135
— — contracta	136
Genus Homalocidaris	137
Homalocidaris gigantea	137
Genus Rhynchocidaris	139
Rhynchocidaris triplopora	140
Genus Austrocidaris	140
Key to the species of Austrocidaris	141
Austrocidaris canaliculata	141
— spinulosa	143
Genus Ogmocidaris	143
Ogmocidaris Benhami	144
Group Goniocidarina	144
Key to the genera of Goniocidarina	149

Page

Genus Goniocidaris 149
Subgen. Discocidaris 149
— Petalocidaris 149
— Aspidocidaris 150
— Cyrtocidaris 150
Key to the species of Goniocidaris 154
Goniocidaris tubaria 156
— — impressa 163
— umbraculum 164
— florigera 167
— spinosa 171
— biserialis 173
— mikado 178
— mikado × clypeata 181
— mikado × Rhopalocidaris rosea 183
— peltata 183
— clypeata 186
— fimbriata 190
— alba 193
— crassa 195
— sibogæ 198
— australiæ 201
— tenuispina 204
— — tuberculata 204
— — major 204
Genus Schizocidaris 204
Key to the species of Schizocidaris 205
Schizocidaris assimilis 206
— serrata 211
— fasciata 211
Genus Psilocidaris 211
Psilocidaris echinulata 212
Genus Rhopalocidaris 213
Key to the species of Rhopalocidaris 213
Rhopalocidaris hirsutispina 214
— — viridis 216
— gracilis 216
— rosea 220
— — tenuis 223
Group Stereocidarina 225
Genus Stereocidaris 225
Key to the species of Stereocidaris 231
Stereocidaris grandis 233
— — hyatorina 235
— hawaiiensis 239
— granularis 242
— — rubra 245
— squamosa 245

Page

Stereocidaris stylifera 248
— purpurascens 251
— sulcatispinis 254
— microtuberculata 257
— tubifera 260
— — impressa 263
— indica 263
— — philippinensis 265
— Alcocki 266
— ingolfiana 267
— capensis 269
— leucacantha 271
— sceptriferoides 274
— — lanceolata 277
— — lamellata 278
— japonica 280
Genus Sinæcidaris 284
Genus Temnocidaris 284
Group Cidarina 286
Key to the genera of Cidarina 286
Genus Cidaris 286
Key to the species of Cidaris 288
Cidaris cidaris 289
— — meridionalis 298
— abyssicola 301
— rugosa 305
— Blakei 307
— nuda 311
Genus Calocidaris 312
Calocidaris micans 312
Genus Tretocidaris 314
Key to the species of Tretocidaris 315
Tretocidaris Bartletti 315
— spinosa 317
Group Stylocidarina 320
Key to the genera of Stylocidarina 320
Genus Acanthocidaris 321
Key to the species of Acanthocidaris 322
Acanthocidaris curvatispinis 323
— hastigera 325
— maculicollis 329
— sp. 333
Genus Stylocidaris 334
Key to the species of Stylocidaris 335
Stylocidaris affinis 336
— lineata 342
— Reini 342
— — cladothrix 346
— — rubida 346

Page

Stylocidaris amboinæ 348
— annulosa 350
— conferta 351
— rufa 354
— calacantha 356
— bracteata 359
— maculosa 364
— effluens 368
— tiara 368
— Lorioli 372
— albidens 373
— badia 376
— brevicollis 379
— fusispina 382
Genus Eucidaris 384
Key to the species of Eucidaris 385
Eucidaris metularia 386
— Thouarsii 393
— — galapagensis 399
— tribuloides 400
— clavata 408
Genus Actinocidaris 411
Actinocidaris Thomasi 412
Genus Hesperocidaris 415
Key to the species of Hesperocidaris 415
Hesperocidaris panamensis 416
— dubia 419
— perplexa 421
Genus Centrocidaris 423
Centrocidaris Döderleini 424
Genus Plococidaris 428
Plococidaris verticillata 428
Genus Prionocidaris 434
Key to the species of Prionocidaris 436
Prionocidaris baculosa 437
— — annulifera 443
— — longicollis 449
— pistillaris 452
— australis 456

Page

Prionocidaris glandulosa 461
— hawaiiensis 465
— bispinosa 468
Genus Plegiocidaris 475
Subgen. Paracidaris 477
Genus Alpicidaris 479
Genus Polycidaris 480
Genus Procidaris 482
Genus Balanocidaris 483
Genus Cyathocidaris 484
Genus Tylocidaris 485
Subgen. Sardocidaris 486
Genus Porocidaris 487
Group Rhabdocidarina 489
Key to the genera of Rhabdocidarina 490
Genus Rhabdocidaris 490
Genus Chondrocidaris 491
Key to the species of Chondrocidaris 492
Chondrocidaris gigantea 492
— brevispina 497
Genus Phyllacanthus 500
Key to the species of Phyllacanthus 503
Phyllacanthus imperialis 504
— dubius 510
— parvispinus 513
— longispinus 517
— magnificus 518
— irregularis 520
Subfam. Diplocidarinæ 524
Key to the genera of Diplocidarinæ 524
Genus Diplocidaris 525
Genus Tetracidaris 526
Geographical Distribution 529
List of Abbreviations 542
Echinoderm names composed of -cidaris, which do not mean Cidarids 544
Appendix 545
Index 547

The explanation of the plates is found in the volume with the plates.

In presenting herewith the first part of a planned Monograph of the Echinoidea I have the agreable duty to express my gratitude to the Institutions and Colleagues who have rendered me assistance.

First my thanks are due to the R. Danish Government for a subsidy enabling me to carry on steadily my work on the Monograph. But above all I am under obligation to the Carlsberg Fund for the liberal grant enabling me to have the work published in so satisfactory a way, particularly as regards the illustrations. In a work like the present the illustrations are of the most eminent importance, both drawings of details and photographs of the various species. No description, be it ever so careful, can make it out for the photographic figures. One never can tell what will be found by future researches to be of importance for the morphology or classification of any class of animals. The future student should therefore be able by means of the figures to trace such features, even where nothing is found about it in the descriptions. The necessary condition is, of course, that the photographic figures are reproduced in such a way that they allow an examination in details, even by means of a lens. The ideal would be to have direct photographic copies of the figures. This is done in some of the plates of the "Revision of the Echini"; these plates therefore are an invaluable help to the student of Echinoids, and remain the insuperable model for echinological illustrations. It has been under consideration to have the photographic plates of the present work reproduced in this way. There have, however, been various difficulties for having it done in this way, as also there is hardly guarantee that such photographic reproductions will keep unaltered for the future. It has therefore been thought advisable to have the figures reproduced by means of the heliotype process, which makes possible to a fair degree to examine the figures by means of a lens, and at the same time gives guarantee that no gradual deterioration of the figures takes place. It is thus the author's hope that no future reproach should be raised against the work for insufficiency in regard to the illustrations; also I hope it will be found gratifying that reproduction by means of the half tone process has been avoided — that detestable mode of reproduction, which destroys all details in the figures, unfortunately used in a great many publications, to the despair of the student, who, whenever he wants to see some detail, mentioned or not in the accompanying descriptions, sees nothing but a net, more or less coarse, but always only a net. (For pencil drawings reproduction by half tone is much more satisfactory, if the net employed is only of the finest sort).

Through another liberal grant from the Carlsberg Fund I was enabled to under-

take, in 1926, a journey to the various Museums of Europe and the United States in which larger collections of Echinoderms, and more especially of Cidarids, are found. I have thus had the opportunity of examining practically all the material of Recent Cidarids available up to the present day, my studies of this group thus resting on the broadest possible basis. By far the main part of the material on which the work rests is in the collection of the Zoological Museum of Copenhagen. This material was for the overwhelming part collected by myself on my various expeditions, especially the Pacific Expedition 1914—16 and the Expedition to the Kei Islands in 1922, the first of which was paid by the Danish Government and the Carlsberg Fund, the latter by the Rask-Ørsted Fund. This is another reason for my profound obligation to the said Foundations, as without the rich material collected during these Expeditions I should not have ventured to undertake a work of such comprehensive character as the present Monograph.

Material has been sent me on loan for examination from various Zoological Museums: Amsterdam, Berlin, the Museum of Comparative Zoology, Cambridge Mass., the South African Museum, Cape Town, the R. Scottish Museum, Edinburgh, the Museums of Genève, Hamburg, Leiden, Leningrad, Liège, the British Museum, London, the Museum d'hist. nat., Paris, the Museums of Stockholm, Strasbourg, Tokio, the U. S. National Museum, Washington D. C. I beg to express my sincere thanks to the authorities of these Museums for the very important help thus rendered me. Special thanks are due to the authorities of the Australian Museums, Melbourne, Perth and Sydney, for sending their whole material of *Phyllacanthus*, thus enabling me to throw light on the interesting problems of the distribution of the various species of this genus along the Australian Coasts. Dr. Edgar R. Waite, the late director of the Museum of Adelaide, who was kind enough to recommend to the authorities of the said Museums to send me this material has made me greatly obliged to him for this help. Likewise I am deeply obliged to my friend J. P. J. Ravn, Copenhagen, to Mr. J. Lambert, Paris, Dr. F. A. Bather, London, and Prof. H. L. Hawkins, Reading, for much important help.

Several of the photographic illustrations I owe to the courtesy of the authorities of the British Museum, the Museum of Comparative Zoology, the U. S. National Museum, the Leiden and the Strasbourg Museum, for which my sincere thanks are due. The main part of the photos were made, under my supervision, by Mr. v. Huth, of the firm Pacht & Crone, Succ., Copenhagen. I am under great obligation to him for his eminent skill and eagerness to procure good results from the often very difficult objects.

Last, but not least, I beg to tender my most cordial thanks to my friends and special colleagues in the study of Echinoids: Professors H. Lyman Clark, Cambridge, Mass., L. Döderlein, Munich, and R. Koehler, Lyon, for their very kind and untiring efforts to assist me in every way.

Introduction.

When thirty years ago I began studying Echinoids, it was a comparatively simple matter to keep account of the literature dealing with the recent forms. A. Agassiz had, in his "Revision of the Echini", given a fairly satisfactory representation of the old literature, and the literature after 1872 consisted in the main of Agassiz' own great works on the Echinoids of the "Challenger" and the "Blake" Expeditions, and Döderlein's Monograph of the Japanese Cidaridæ and Salenidæ.

While it was thus rather easy to find the way in the literature, it was exceedingly difficult to identify the Echinoids by means of this literature, the descriptions being for the main part very defective and disorderly, with the sole exception of Döderlein's work and of Wyv. Thomson's Report on the "Porcupine" Echinoidea. Having felt this a very severe difficulty at the beginning of my studies, I advocated very emphatically, in the first part of my Report on the Echinoidea of the "Ingolf" Expedition, 1903, the necessity of giving much more full and detailed descriptions and of taking also the microscopical structure of pedicellariæ and spicules into account in classification. This opened up a new period in echinological literature. The following years brought an exceedingly rich literature on Echinoids, filled with very vivid — partly rather too vivid — discussions of the new principle of classification and its results. Only those who have taken actively part in these discussions and the great progress of echinological science connected therewith can keep account of it all, whereas it must, evidently, be a very hard task for a newcomer in echinology to master this whole literature and keep clear to himself the intricate ways along which modern classification of Echinoids has evolved step by step. From this consideration it has seemed to me not only a good idea through a monographic representation of the whole class to help future students of Echinoids over these difficulties, but I rather have thought it my duty, as one of the main partakers in the said discussions to undertake this work. It is, of course, also very satisfactory to myself thereby to get the opportunity of giving a complete representation of my views on Echinoid classification, views that are to be found scattered in my various publications. There are also some groups of Echinoids which till now I have not had the opportunity of studying

more closely — especially the fossil forms; the present monographic representation will provide ample opportunity for taking up the study of such groups also, and of forming a definite view of their systematic relations.

The present would seem to be just the proper time for giving a monographic representation of the Echinoids. By the time of the "Revision of the Echini" Deep-Sea investigations had just begun; a few of the new discoveries, like *Pourtalesia miranda*, *Neolampas rostellata*, *Cænopedina cubensis* and *Podocidaris sculpta* could just be included in the work. Immediately after the "Revision" the great reports on the Echinoids of the Deep-Sea Expeditions began to appear, first the modest, but excellent report on the "Porcupine" Echinoids, next the large, but unfortunately far from excellent, report by Agassiz himself on the overwhelming rich collections of the "Challenger". Then successively the reports on the Echinoids of the "Blake", the "Ingolf", the "Siboga", the "Valdivia", the "Albatross", the "Investigator", and the various Antarctic Expeditions; further the reports on the investigations in the Australian Seas (the "Thetis" and the "Endeavour") and in the South African Seas. After the publication of all these reports, by which our knowledge of the recent Echinoid fauna has grown immensely beyond that embodied in the "Revision", the number of forms known being many-doubled since the time of the "Revision", it has now come to a relative standstill; we have now time to digest the enormous amount of information thus brought together, and may try to survey it all and present it in a perspicuous and easily accessible way. This is the object of the present Monograph.

As already said the old literature was dealt with in a rather satisfactory way in the "Revision of the Echini".[1]) It has, therefore, seemed to me unnecessary to waste time in again working through the whole of the ancient literature, especially the pre-Linnean, the descriptions and figures of which are, on the whole, quite insufficient for a sure recognition of the species. We have recently seen a deterring example in Lambert & Thiéry's digging up such old, in reality quite unrecognisable, species and substituting the names of such for names hitherto in unanimous use (e. g. *Cidaris Mauri* of Rumphius for *Eucidaris metularia*). This serves no reasonable aim, but brings endless confusion and trouble. Only archæological interest connects with these old works, and I, for one, am not going to waste my time on archæological work, in which I take no special interest.

Otherwise I have made all efforts to bring together under each species a complete list of literary references, from Linnæus up to date; only to simple lists which are bringing no new information at all, as to localities or otherwise, no references are given. In regard to the manner of quotation I have thought it practical always to give the title of the work referred to, the more important and continuously quoted works much abbreviated (e. g. "Rev. of Ech." for "Revision of the Echini"; "Hawaiian Ech"., for "Hawaiian and other Pacific Echini" and so on. A list of the more important of these abbreviations is given at the end of the work). The much used man-

[1] An excellent historical account of the old literature is given in the Introduction to Lambert & Thiéry's "Essai de nomenclature raisonnée des Échinides". 1910.

ner of quotation, by only the year of publication of the work added to the author's name, or simply a number referring to a list of literature found at the end (or at the beginning) of the work, I find unpractical and troublesome, and I could not adopt this manner of quotation either, for the simple reason that I am not going to begin the work with a list of literature. A very complete list of Echinoid literature has recently been given by Lambert & Thiéry in their "Essai de Nomenclature Raisonnée des Échinides" (1910—25). I do not see the necessity or even the desirability of publishing a similar list here again, the more so as it could not fail to be incomplete before the work has been brought to an end. It may rather be desirable to give such a list of literature at the end of the whole work — but that is for the future.

It is evident that a Monograph of the Echinoids confined to the recent forms alone would be an absurdity. The Echinoids are, together with the Crinoids (and the Pelmatozoa on the whole), specially fit for being preserved in a fossil state, and the number of known fossil types is exceedingly large. As, moreover, the characters of the greatest morphological value are found in the test, and the structure of the test generally allows us with certainty to draw conclusions as to the inner anatomy, we have here the means of tracing the genetic relations of recent Echinoids back to the oldest times, as far back, indeed, as fossils are known to occur.

But while all the recent species are to be dealt with as completely as possible, this is out of question for the fossil species — for several reasons. Partly the number of known fossil species is so great that a work dealing with all these species would be insuperable for one man, especially for one who has never actually worked on fossil forms. Partly the fossils are to a great deal incompletely known; all the finer microscopical structures which have proved to be of such eminent importance for the classification of the recent Echinoids, are, for the greater part, unknown in the fossils, and great uncertainty therefore reigns in regard to the interrelations of many fossil forms. To a student of recent Echinoids the study of fossils, therefore, must be somewhat unsatisfactory. This fact has recently been emphasized in a very peculiar way through Lambert & Thiéry's "Essai de nomenclature raisonnée des Échinides". In this work the authors deal with the recent Echinoids on the same lines as those on which fossil forms are generally dealt with, founding on the principle that only those characters that can be found in fossil forms should be taken into consideration in the classification also of the recent forms. The result is such that it may almost be designated an outrage to science, and certainly cannot be taken seriously.[1]) Otherwise, this work is exceedingly useful in giving references to all known fossil (and recent) species, and workers on both recent and fossil Echinoids must be under deep obligation to the authors for the very laborious task they have undertaken of bringing all this, for a great part not easily accessible, information together.

In the present work, therefore, the fossil forms are not dealt with in greater details. All

[1] I feel it a duty to the memory of my late friend, Dr. P. Thiéry, to state that, when I called on him in the fall of 1926, a few months before his death, he agreed that he had gradually come to modify, to some degree, his views about the classification of Echinoids as given in the "Essai de nomenclature raisonnée".

the genera are discussed and diagnosed but only part of the species are mentioned, especially the better known ones, the numerous species known only from isolated fragments of plates or spines being generally of very small morphological interest.

As students of the recent Echinoids are as a rule equally unfamiliar with the fossil forms as are generally the specialists on fossil forms with the recent Echinoids, it has been thought practical and desirable to include textfigures of the more important fossil forms, at least of all the generic types, in some cases also of some of the more interesting specific types. This will, I think, serve to facilitate the comparison of the recent and the fossil forms, and, on the whole, make the fossil Echinoids more easily accessible to the students of recent Echinoids, for whose benefit this work is, of course, in the first line intended.

It might be desirable to begin this Monograph of the Echinoidea with a general survey of the morphology and the general classification of the whole class. It is, however, hardly possible to do so in a satisfactory way at present. There is every reason to expect that facts of interest to the general morphology of the class will result from the planned monographic study of all Echinoids, and it would, therefore, be premature to give a general view of the morphology of the Echinoids as an introduction to the work. And as for the classification, it is still in the making.

For a long time the division into the two subclasses *Palechinoidea* and *Euechinoidea*, introduced by Zittel (Handbuch d. Palæontologie. I. 1876—80) was rather generally adopted. The more recent works treating the classification of the whole class, Bather's article "Echinoderma" in the Encyclop. Britannica, XI. Ed. VIII. 1910 (p. 881), Jackson's "Phylogeny of the Echini" (1912) and Lambert & Thiéry's "Essai de nomenclature raisonnée des Échinides" (1910—25) have each a different classification — and I, for my part, cannot adopt either the old or any of the new classifications, at least, not in their totality. However, I have not yet been able to satisfy myself with regard to some of the problems connected with Echinoid classification, and do not expect to form a final opinion on these problems until in the course of the completion of this monograph.

I therefore propose to set forth the results of my studies as regards both the general morphology and the classification under each order separately, leaving an eventual representation of the morphology and classification of the whole class till the end of the work. A few remarks on the classification must, however, be given here, bearing on the relation between the Palæozoic forms and those of later geological periods up till recent times.

First as regards *Bothriocidaris* I can no longer regard it as a true Echinoid. As set forth in my paper "Bothriocidaris and the origin of Echinoids" (Vid. Medd. Dansk Naturh. Foren. Bd. 86., 1928) the radial position of the "teeth" and of the madreporite in *Bothriocidaris* are facts so strongly opposed to Echinoid morphology on the whole that it must be out of question to see any natural affinity between *Bothriocidaris* and Echinoids, and still less to regard *Bothriocidaris* as the ancestor of all other Echinoidea, as especially maintained by Jackson. *Bothriocidaris* represents a special branch

from the diploporite Cystids of the family *Protocrinidæ* (or the *Estonocystidæ* of Jaekel) and has, apparently, not left any descendants. It represents a parallel to the Echinoids, an analogous development, a convergency, but it is no true Echinoid. The ancestor of the Echinoids must be sought for among the oldest Edrioasteroids, like *Stromatocystis*, forms with a great number of interambulacral plates, not definitely arranged. From such forms the development proceeds through gradual arrangement of the interambulacral plates into fewer and fewer regular series, until towards the end of the palæozoic time the arrangement in only two series in each interambulacrum has been arrived at, the condition which, with a few exceptions, *Tetracidaris*, *Sperosoma* and the small Arbaciids *Tiarechinus* and *Pygmæocidaris*, has been retained by all post-palæozoic forms up to recent times. The many series of interambulacral plates in palæozoic forms therefore is by no means to be regarded as a specialized, but on the contrary as a primitive condition, representing the transitional stage between the Cambrian ancestor and the post-palæozoic forms, in accordance with what was to be expected from general morphological and phylogenetical considerations. (The many series of ambulacral plates in some of the palæozoic Echinoids, of course, represent a special development, such forms being side branches on the main Echinoid stem).

Accordingly the old division of the Echinoids into two subclasses, the *Palechinoidea*, comprising all the palæozoic pluriseriate forms, and the *Euechinoidea*, comprising all the later forms, with only two series of plates in the interambulacra, must be given up as unnatural. There is, in my opinion, no reason to doubt that the Archæocidarids are the direct ancestors of the Cidarids, and that the Lepidocentrids are the ancestors of the Echinothurids and the Diadematoids on the whole.

For the present I must confine myself to these remarks, which will suffice to make clear my general views on Echinoid classification. The details have, as stated above, not yet all been worked out; I shall therefore not try here to give any key to the greater divisions, but only state that I do not see any reason for a division into subclasses, only for dividing the class into a number of equivalent orders. How many, and which, I am not prepared to say definitely at present. We may then pass directly to the first order, the Cidaroids.

In the descriptive part of this Monograph it has been made a rule to describe the various characters always in the same order so as to make the descriptions easily comparable, contrary to what is the case in the older literature, where, on account of the disorderly descriptions, it is usually very troublesome to find the characters one wants to compare — if they are mentioned at all.

It is often a matter of doubt which characters should be mentioned in the descriptions or diagnoses. As a general rule such features as represent the characters of the preceding, higher grades of the system are not to be mentioned, viz. in the descriptions of species the characters of the genus to which it belongs should not be mentioned, in the diagnosis of a genus not the characters of the family to which it belongs, and so on. But this principle cannot be carried through rigidly. — Further, it is often important to state that one or other character is not found in the

form in question, especially for the comparison with related forms; but to state in every case which characters are not found in a species or genus would be intolerable. Thus, some inconsistency must prevail in this regard, which may perhaps be felt as a difficulty by the beginner — but, I hope, not to those more acquainted with the subject.

A series of measurements of specimens of various sizes is given as an introduction to the description of each species, all given in the same order so as to be directly comparable.

I. Order. Cidaroidea.

Regular, endocyclic Echinoids of usually spherical form, and with well developed dental apparatus (lantern). Interambulacral plates each with a single, large, primary spine (tubercle), usually surrounded by a circle of smaller, secondary spines; the primary spines provided with a specially differentiated outer or cortex layer, except on the basal part, the collar. Tubercles, with very few exceptions, perforate, often crenulate, surrounded by a large areole. Ambulacra simple, pore-pairs usually in single, regular series, more rarely in alternating double series. Apical system regular, the anal opening placed in the centre of the periproct; none of the periproctal plates specially developed. Peristome wholly covered with series of imbricating ambulacral and interradial plates. No external gills, and no gill slits at the edge of the peristome. No spheridia. Pedicellariæ of two main sorts only, tridentate and globiferous; the latter, which occur in a large and a small form, have an internal poison gland, situated in the interior of the valves. In the dental apparatus the upper surface of the pyramids is smooth, not grooved; epiphyses small, not joining above the foramen magnum. Teeth grooved. Edge of test with interradial apophyses for the attachment of the muscles of the dental apparatus. From the upper side of the dental apparatus proceed five bush-shaped organs, the Stewart's organs.

Morphology of the Cidaroidea.

In giving here a general survey of the morphology of Cidaroids special attention will be paid to the question of the classificatory value of the various structural characters. These will be dealt with in the same order as used under the description of the species.

1. Shape of the test; size.

The test of the Cidarids is generally of a very regular and beautiful, almost spherical shape. It is often more or less flattened above and below; the sides are generally beautifully arched, rarely subvertical; the peristomial edge is often slightly incurved. The circumference is circular, only rarely subpentagonal, and when so, apparently, only as an individual character. The relation between the vertical and horizontal diameter appears to be so varying that no generic or even specific value can be attached hereto (see e. g. *Goniocidaris tubaria*).

In the Archæocidarids the test was more or less flattened, and evidently movable, on account of the imbricating of the coronal plates.

H. L. Clark (The Cidaridæ, 1907) introduced the abbreviations h. d. and v. d. for the horizontal and vertical diameter. This is very practical and has been adopted in the subsequent literature and is also used consistently in the present Monograph. — The horizontal diameter is always measured from the midline of an interambulacrum to the midline of the opposite ambulacrum, at the ambitus, giving thus the greatest value of the h. d. The vertical diameter always means the height of the corona, viz. from the oral[1]) end to the aboral end of an ambulacrum or an interambulacrum (— which gives as a rule the same value —); not the greatest height, from the mouth to the centre of the periproct. The reason for not choosing the latter way of measuring the v. d. is this that both the peristome and the periproct may be more or less protruding, partly as a result of the preservation, which causes a rather considerable uncertainty in the measurement. The nonconformity sometimes found between the measure of the v. d. as given here and that given in other works is apparently due to the measurement in the latter being taken from the mouth to the centre of the periproct.

The size of the test of Cidarids rarely exceeds ca. 60—70 mm. in horizontal diameter. In *Chondrocidaris gigantea* it may reach as much as 100 mm. and in *Phyllacanthus irregularis* even as much as 110 mm., the latter case being the record size of recent Cidarids. As a contrast hereto we have some real pygmies among the Goniocidarids, *Rhopalocidaris rosea* and *Goniocidaris fimbriata* scarcely exceeding 15 mm. h. d. Also some of the fossil Cidarids from the Trias are real pygmies, especially the genus *Mikrocidaris*; on the other hand the fossil forms of the genus *Rhabdocidaris* and *Diplocidaris* are among the giants of Cidarids, though scarcely exceeding the above named recent forms in size. It is true, *Diplocidaris Jacquemeti* Lambert is stated (Ess. nom. rais. p. 139) to have been no less than 130 mm h. d.; but since only isolated plates are known of this species, the calculation of its size rests on too uncertain a base.

In order to study the structure of the test it is essential that it be well cleaned. For this purpose I have found it very practical to use strong hypochlorite of sodium applied to small parts of the test, in case of single specimens, or for cleaning a whole test in case there is material enough. Care must be taken not to treat the specimen too long as the test will then fall to pieces; particularly in case of delicate specimens it is necessary to follow the treatment step by step under the binocular microscope. Potash is much less practical, especially the cleaning of the deep areoles is very difficult by using potash, whereas it is easily done with hypochlorite of sodium (applied directly in the areole by means of a pointed match).

[1] In most of the previous literature on Echinoids are used the terms "actinal" and "abactinal" for "oral" and "aboral", "actinostome" for peristome, "abactinal system" for apical system etc. As the mouth of Echinoderms is quite evidently homologous with the mouth of other animals, I do not see any reason for using a special term for it, and, accordingly, neither for having the special terms actinal or abactinal for oral and aboral, or combinations derived therefrom.

2. Ambulacra.

The ambulacra of Cidarids are as a rule much narrower than the interambulacra, generally only about $^1/_4$ the width of the latter, sometimes only 18—20 % of that width. Only in a few instances, like *Centrocidaris Döderleini* (A. Ag.) they are almost half as wide as the interambulacra. The interporiferous zone (see fig. 2) is as a rule twice the width of a pore zone. The relative widths are not very constant, and only little classificatory value is connected therewith. The ambulacra are more or less sinuate; this is, however, a character of very small value in classification[1]), being too varying and only to be described in very indefinite terms.

The ambulacra of the Cidarids consist in the main of simple primary plates. There may be an indication of a beginning compound condition in the adoral part of the ambulacra in some forms, e. g. *Stereocidaris grandis* (Pl. LXX Fig. 2), the marginal tubercle lacking or being displaced inwards on some of the plates, while those of the neighbouring plates increase in size; but they do not appear to cover more than their own plate, and the plates without marginal tubercle in all recent forms reach to the midline of the area. In some fossil forms e. g. *Paracidaris*, *Alpicidaris*, *Diplocidaris*, there is a more regular alternation of plates with a large marginal tubercle and such without a marginal tubercle and more or less reduced in size, so that we may here almost speak of compound ambulacral plates.

Whether this character, the existence of more or less distinctly compound ambulacral plates on the oral side in some forms, is sufficient for generic distinctions, may perhaps be doubted. At least, in the case of *Stereocidaris grandis* it is rather a question whether the specimens with such ambulacra on the oral side are specifically different from the specimens which have simple ambulacra also at the peristome, than whether they are generically different — the latter alternative being, in my opinion, not to be seriously taken into consideration. Some of the fossil genera, e. g. *Paracidaris* and *Alpicidaris*, are mainly founded on this character of the ambulacra. Lambert & Thiéry do not fail, however, to point out the great variation that exists in regard to this structure (Ess. nom. rais. p. 140).

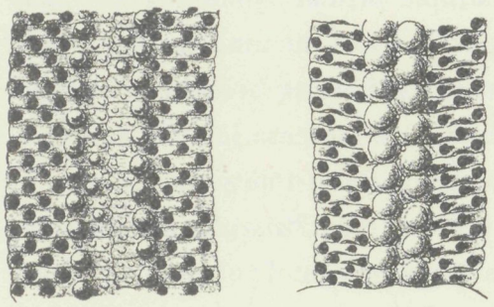
In the genus *Diplocidaris* this condition has become particularly developed, so that also the pores of the plates lacking a marginal tubercle have been displaced inwards, and the usual arrangement of the pore-pairs in a single, regular vertical series has been transformed into an arrangement in double series (Fig. 1).

The number of the ambulacral plates is on the whole considerably larger than that of the interambulacrals, often very much larger, up to more than 20 ambulacral plates corresponding to one interambulacral plate on the ambital and aboral parts of the test. These relative numbers are of some classificatory value and are, therefore, given in the table at the beginning of the description of each species, under the designation: Number of I. A. and of A. pro I. A. The latter number

[1] A striking example affords the genus *Diplocidaris*, in which some species (e. g. D. *miranda* Cotteau have very strongly sinuate ambulacra, others (e. g. *D. Etalloni* de Loriol) have perfectly straight ambulacra, others again being more intermediate.

is always taken from the part of the test just above the ambitus, where the interambulacral plates have their largest height and the number of ambulacral plates corresponding to one interambulacral is the largest.

Every ambulacral plate typically carries a larger tubercle close to the innner pore, the marginal tubercle; these marginal tubercles form two very regular longitudinal series, limiting the interporiferous zone from the pore-zones (Fig. 2). More rarely, as stated above, there is some irregularity in the marginal series, the tubercles being displaced inwards or entirely lacking on some of the plates, a more or less regular alternation of plates with and without marginal tubercle taking place (see e. g. *Histocidaris cobosi*, *Phyllacanthus irregularis*; several fossil forms.) This marginal tubercle has the character of a secondary tubercle and is never crenulate, as are the primary tubercles in many cases. The designation "primary series" and "primary ambulacral tubercles" much used in literature, also by myself previously, is therefore less appropriate, and the term "marginal tubercle" or "marginal series" introduced by H. L. Clark ("The Cidaridæ", 1907) in literature on recent Cidarids (while it has been used more or less consistently in literature on fossils) is much to be preferred. The marginal tubercles usually have a rather distinct mamelon, which is, however, never perforate, as are the primary tubercles, with the sole exception of the fossil genus *Procidaris* Pomel, which, according to the diagnosis of the genus given by Pomel, has the marginal tubercles "bien mamelonnés et nettement perforés", as also the figure of the species "*Cidaris Toucasi*" Cotteau (Pal. Franç. Terr. Jurass. X. 1. Pl. 143. 4) shows this perforation distinctly. Also the *Cidaris Edwardsi* Wright (British Oolitic Echinod. I. Pl. I. 1. b.) is stated, and represented, as having perforate marginal ambulacral tubercles. I am, however, informed by Lambert that the marginal tubercles are not perforate in either *Cidaris Toucasi*, *C. Crossei*, or *C. spinosa*, cited by Pomel as belonging to his genus *Procidaris*. On the other hand, Dr. Bather informs me that *Cidaris Edwardsi* Wright, the fourth of the species mentioned by Pomel under *Procidaris*, really appears to have perforate marginal ambulacral tubercles, being thus in this regard quite unique in the whole order of the Cidaroids.[1]



1 2

Fig. 1. Part of ambulacrum of *Diplocidaris Etalloni* de Loriol (1) and *Diplocidaris miranda* Cotteau (2). After Paléontologie Française. Terr. Jurass. Pl. 234, 4 and 237, 4.

In the genus *Aplocidaris* Lambert & Thiéry, from the Trias, the ambulacra are reduced to the pore-zones alone, lacking marginal tubercles and, indeed, an interporiferous zone (Fig. 35, p. 65).

The part of the interporiferous zone between the two marginal series is to a various extent covered with smaller secondary tubercles, the outer of which are generally arranged in distinct vertical series; these tubercles are usually placed at the lower edge, more rarely in the middle of the plate. Also the other secondary tubercles may form distinct vertical series, but more often

[1] I have recently had the opportunity of examining the type-specimen of *Cidaris Edwardsi* Wright in the British Museum and must agree that the marginal tubercles are really perforate.

they are quite irregularly arranged, the more so the more there are of them. The arrangement of these inner ambulacral tubercles is exceedingly varied and affords a systematic character of eminent importance. Still it is not to be relied on too confidently, as there may be a considerable variation also within the species. It must be kept in mind that the full number of the inner tubercles is only to be found at the ambitus in the larger specimens; in the younger specimens, and at the oral and aboral end of the ambulacra in adult specimens, they are less numerous. The inner tubercles are rarely distinctly mamelonate, never perforate. — Very small miliary tubercles often occur between the inner and marginal tubercles, more generally one at each side of the marginal tubercle, at the lower edge; not rarely, where the marginal tubercles are not contiguous, there is a series of such miliary tubercles along the lower edge of the plates, separating the marginal tubercles. These miliary tubercles usually carry pedicellariæ.

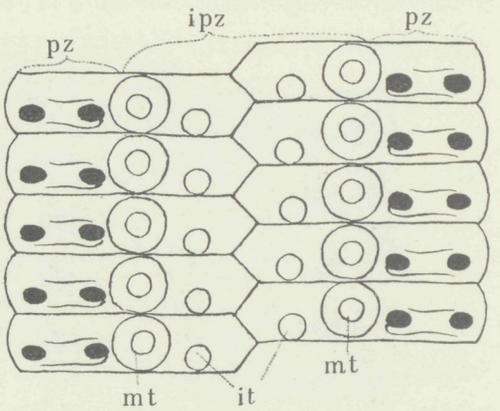


Fig. 2. Part of ambulacrum of a Cidarid. Diagrammatic. ipz. Interporiferous zone; it. inner tubercles; mt. marginal tubercle; pz. pore zone.

The sutures between the ambulacral plates are generally fairly distinct, the vertical median suture often more or less sunk. As a rule the horizontal suture makes a small downward curve under the inner pore. In the Goniocidarids there is a more or less conspicuous groove at the admedian end of the horizontal sutures, these grooves sometimes uniting so as to form a conspicuous depression along the midline of the area. A similar depression also occurs in *Austrocidaris canaliculata* and in *Ogmocidaris Benhami*.

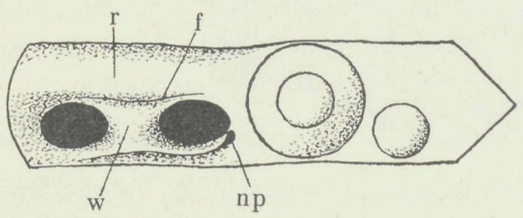


Fig. 3. Ambulacral plate of a Cidarid; diagrammatic. f. Furrow; np. neuropore; r. ridge; w. wall.

The pore-zone, comprising the part between the marginal tubercles and the outer edge of the ambulacrum, may be more or less sunken, the marginal tubercles thus rising to a various degree above the pore-zone. The pores (Fig. 3) are always at the lower edge of the plate, usually of equal size, more rarely the outer or inner somewhat the larger. In adult specimens they are usually horizontally placed, in young specimens (and often also in the aboral part of the adult) they are oblique; also in the group of the Ctenocidarina the pores are oblique. At the inner, lower corner of the inner pore there is a small notch, like a small pore, for the nerve of the tubefoot; it is not quite separated off from the tubefoot pore and is generally inconspicuous, though quite distinct on well cleaned tests (Fig. 3. n. p.). In *Rhynchocidaris triplopora* Mrtsn. it is unusually large, almost as large as the tubefoot pore (Fig. 4. d.). From this neuropore proceeds a fairly deep furrow along the lower edge of the plate, usually till about the middle of the outer pore; also on the upper side of the pores there is a more or less distinct furrow (Fig. 3. f.). — The pores are separated

from each other by a wall (Fig. 3. w.) of various width, and exceedingly varying in shape. In most cases it is moderately broad, forming a low crest, or rising into a more or less prominent tubercle (e. g. *Goniocidaris* Fig. 4. a.); in others it is very broad and even excavate, the two pores thus being united by a furrow (Fig. 4. b.); such pores, which are termed conjugate, are found in the recent genera *Prionocidaris* and *Phyllacanthus*, and among fossils e. g. in the genera *Rhabdocidaris* and *Diplocidaris*. In some forms the wall is exceedingly narrow, so that the pores almost become confluent (*Ctenocidaris*, *Notocidaris*, Fig. 4. c.).

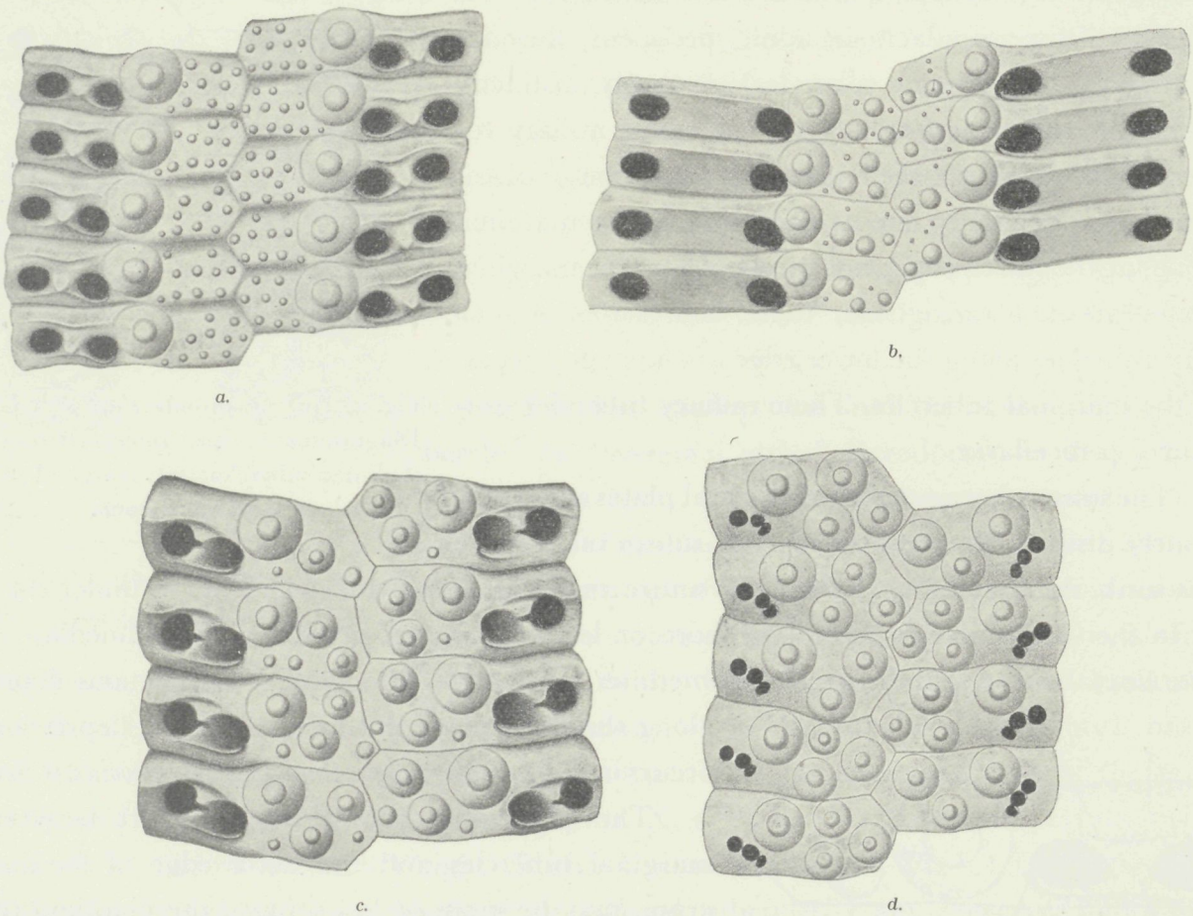


Fig. 4. Part of ambulacrum of various Cidarids. a. *Goniocidaris biserialis* Döderlein; b. *Prionocidaris baculosa*, var. *annulifera* (Lamk.); c. *Ctenocidaris Perrieri* Koehler; d. *Rhynchocidaris triplopora* Mrtsn. (a—c. Original drawings; d. from Th. Mortensen. Ech. d. Deutschen Südpolar Exped. Taf. X. 10). All figures ca. 12 times magnified.

At the upper side of the pores there is another furrow (Fig. 3. f.), more or less distinct, which separates the lower part of the plate, with the pores, from the upper part. This part, which is termed the ridge, is usually low, rounded, but may form a rather sharp keel; rarely small tubercles are found on the ridge, e. g. *Porocidaris Schmidelii* (fig. 155.4, p. 488) or, more occasionally, *Goniocidaris mikado* (Pl. LXIX. 16), *G. umbraculum* (Pl. LXIX. 15), *Stereocidaris ingolfiana* (Pl. LXX. 6).

The character of the "wall" is of very considerable importance for classification; but it must be emphasized that it is by no means always easy to decide whether the pores should be

termed conjugate or not, many forms being rather intermediate — "subconjugate". For making sufficiently clear the character of the pores it is necessary to give special, enlarged drawings; the usual photographs do not show these very small structures in a sufficiently detailed way.[1])

In all recent Cidarids the ambulacral plates are sharply limited against one another and against the adjoining interambulacrals; in the Archæocidarids they are imbricating adorally and bevelled under the adjoining interambulacrals. In the Triassic Cidarids (Streptocidarinæ) the imbrication and bevelling is still retained to a various extent. In the post-triassic forms both the imbrication and the bevelling have disappeared; only in young stages of development a trace of this imbrication and bevelling may still be observed, e. g. *Austrocidaris canaliculata* (Döderlein. Jap. Seeigel. Taf. IX. 6).

3. Interambulacra.

The number of interambulacral plates is always rather small, as a consequence of the large size of the plates, scarcely more than 12—15 in the largest specimens, and in many species never exceeding 6—7 in a series, even in adult specimens. In recent forms there are never more than two series of interambulacral plates, but in the palæozoic forms there are four series (*Archæocidaris*) or even so many as 12—14 series (*Nortonechinus*). Also in the Cretaceous genus *Tetracidaris* there are 4 series of interambulacrals; all other fossil and recent Cidarids have only two series.

In the Archæocidarids the interambulacrals imbricate aborally and over the adjoining ambulacrals. In some of the triassic Cidarids the imbrication is still to some degree preserved, in the post-triassic forms till those of recent times any trace of imbrication has disappeared, except in the very young stages, as stated above, the plates abutting with straight, sharp cut edges against one another.

Each plate carries one single primary tubercle surrounded by a large areole (Fig. 5); only in the genus *Stereocidaris* and in some species of *Diplocidaris* this tubercle and its areole have become rudimentary on the uppermost one or two plates in each interambulacral series. An indication of such condition is also found in *Stylocidaris tiara* and *Stylocid. effluens*.

The tubercle consists of a cone, the boss, terminating in a distinctly set off knob, the mamelon. This latter has in the centre a very conspicuous, rather deep depression, like a pore, in which is attached a ligament, the other end of which is attached in a corresponding groove in the base of the primary spine. The depression is usually somewhat elongate in the direction of the vertical axis of the animal; this is especially distinct on the uppermost tubercles; sometimes e. g. in *Aporocidaris*, *Notocidaris*, it is quite round. Such tubercles are designated perforate. All Cidarids have perforate primary tubercles, with the exception of the cretaceous genera *Tylocidaris* and

[1] In the present work the pores have always been especially studied, and drawn, under the binocular microscope by a magnification of 30 times. Thereafter the details have been drawn in the smaller figures of the ambulacra, which are usually drawn with a magnification of 12 times. Thus it is thought that a sufficient exactitude has been arrived at, and that the larger detail figures could be omitted.

Sardocidaris which have imperforate tubercles. Also the triassic *Aplocidaris* appears to have imperforate tubercles. Sometimes (in the species *Tylocidaris clavigera*) the upper tubercles are perforate, only the lower ones imperforate (cf. Fig. 153, p. 486).

The genus *Anaulocidaris* is unique in having the mamelon transversely elongate.

At the base of the mamelon there is a small platform separating it from the boss; the outer edge of the platform may be raised into a more or less marked wall, the "parapet". This is of no classificatory value in the recent forms, but for the fossils it may have some value, the genus *Eocidaris*, so far as at present known, being distinguished from *Archæocidaris* alone by the absence of a parapet.

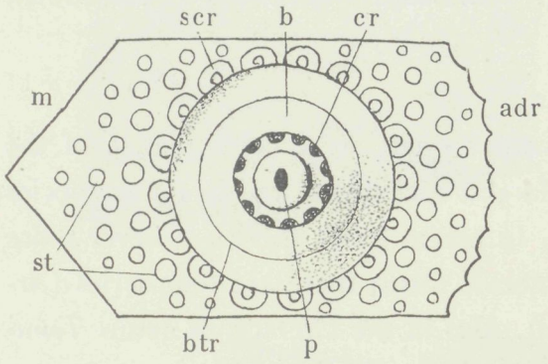


Fig. 5. Diagram of an interambulacral plate of a Cidarid. adr. Adradial margin of the plate; b. boss; btr. basal terrace; cr. crenulation; m. median edge of the plate; p. pore; scr. scrobicular tubercle; st. secondary tubercles.

Very often there are some impressions along the edge of the platform, a crenulation, and in such case the tubercle is said to be crenulate. The crenulation appears to be a rather primitive feature; it is not found though in the Archæocidarids, and among the old, mainly triassic forms of the subfamily *Streptocidarinæ* it is well developed only in the genus *Miocidaris*; but from the Jurassic period the crenulation is general. In later geological periods forms with smooth, non-crenulate tubercles again become more numerous. Among recent Cidarids forms with crenulate tubercles are by no means rare, and the crenulation is the most developed in such forms as *Histocidaris*, which for various reasons must be regarded as one of the more primitive of recent Cidarids. In many forms with smooth tubercles, more or less distinct traces of crenulation are found on the uppermost tubercles, and more generally only on the adapical side of the tubercles, and more distinct in young than in adult specimens. Gradually as the tubercles are displaced downwards the crenulation disappears. There can thus be no doubt that the crenulate tubercles represent the more primitive condition. I cannot, therefore, agree with Lambert in his statement ("Sur trois genres nouveaux d'Échinides fossiles". Ann. Soc. Linn. Lyon. LVII. 1910, p. 29) that there is nothing to support the hypothesis that the forms with smooth tubercles are derived from such as have crenulate tubercles.

No very great classificatory value can be placed on the crenulate or non-crenulate character of the tubercles, at least among such recent forms where it is in a rudimentary condition, and there are cases of nearly related species one of which has crenulate, the other non-crenulate tubercles, e. g. *Stylocidaris tiara* and *Stylocidaris effluens;* in this case there cannot be the slightest doubt of the two species belonging to the same genus. But in general it must be said that species with strongly crenulate tubercles should not be referred to the same genus as species with smooth tubercles.

The boss is usually a conspicuous cone, limited by a generally rather inconspicuous, in

recent forms often quite indistinct, circular impression, the basal terrace, which marks the lower limit of the elastic tissue connecting the spine with the boss. The outermost part of the areole, the scrobicule, in which the large muscle of the spine is attached, may be more or less deep. Often, in recent forms at least, the sloping from the top of the boss to the outer edge of the areole is very gradual, and in such cases the areole (or rather the outer part of it, the scrobicule) is almost flush with the plate outside the areole. Only little systematic value attaches to the height of the boss, the size of the mamelon or the depth of the scrobicule, especially as they are so relative as to be very difficult to describe exactly.

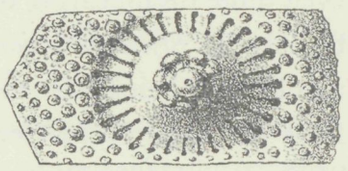


Fig. 6. Interambulacral plate of *Porocidaris Schmidelii* (Münster). (After De Loriol. Monogr. des Ech. nummulitiques de l'Egypte. 1880. Pl. I. fig. 1.e.).

A very peculiar character is that of the pore-like depressions found in the scrobicules of the fossil genus *Porocidaris* (Fig. 6); it would seem that we have here a peculiarity connected with the large muscle of the primary spine, but a quite satisfactory explanation can hardly be given. In recent forms nothing quite similar occurs; perhaps the indistinct radiating impressions not rarely found in the areoles of various recent forms, e. g. *Poriocidaris purpurata* (W. Th.) (which was originally, erroneously, referred to the genus *Porocidaris*, partly on account of these impressions), *Cidaris nuda* (Mrtsn.), and *Acanthocidaris hastigera*, may be homologous to these pores in *Porocidaris*, but this is by no means certain. — Another sort of impressions is seen in the areoles of *Eucidaris metularia* (Fig. 113. a, p. 388), viz. the areoles of the scrobicular tubercles continuing over the scrobicular area of the primary areole.

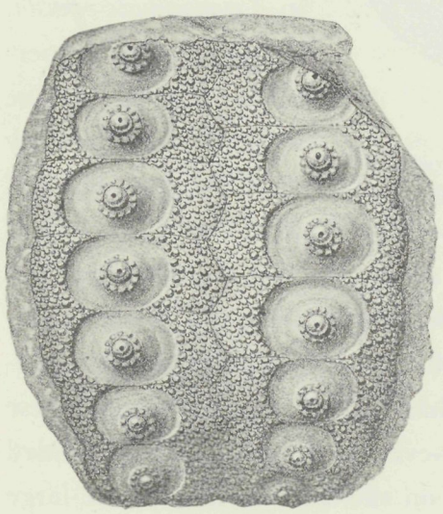


Fig. 7. Interambulacrum of *Rhabdocidaris Rhodani* Cotteau. (After Paléontologie Française, Terr. Jurass. Pl. 210, fig. 8.)

The areoles in each series are generally distinctly separated from each other, excepting the lowermost ones, where the separating wall, consisting of the upper edge of the lower plate and the lower edge of the plate following aborally to it, may disappear more or less completely; the tubercles on this part of the plates are gradually reduced, and finally there is only a mere trace left of the separating wall, the areoles thus merging into one another. Such areoles are designated as confluent. In recent forms it is generally at most 4—5 of the proximal areoles that are thus confluent, but in several fossil forms all of them are confluent, which produces a very characteristic appearance, e. g. in some species of the genus *Rhabdocidaris* (Fig. 7), and especially in the genus *Polycidaris* (Fig. 147, p. 480). In the Triassic *Anaulocidaris* and *Aplocidaris*, especially in the former, the areoles are indistinctly limited.

Another peculiarity is found in the genus *Stereocidaris*, one or two of the uppermost plates in each column of the interambulacra carrying only a rudimentary areole, with no primary spine, this being represented at most by a small knob, like a cap on the top of the tubercle. Among recent

species of *Stereocidaris* this development is the farthest progressed in *St. japonica*, in which the whole upper side is almost entirely devoid of primary spines; among fossil species *Stereocid. Merceyi* (Cotteau) is the farthest progressed, in which species the primary tubercle and areole may be rudimentary, or even quite disappearing on the two-three uppermost plates in each interambulacral column (Fig. 8). Also in *Stylocidaris tiara* and *effluens* there is a tendency in the same direction, the uppermost areole here being also more or less effluent adapically. Several species of *Diplocidaris* likewise have the upper tubercles rudimentary. A very remarkable condition is found in some species of the triassic genera *Triadocidaris* and *Mikrocidaris*, the uppermost plate and its tubercle in one of the series in each interambulacrum developing very strongly, that of the other series being correspondingly rudimentary. This is carried to an extreme in *Triadocidaris venusta*, in which the uppermost plate of the one series has apparently quite disappeared, that of the other series occupying the whole space, its large tubercle being placed in the midline of the area (cf. Fig. 34).

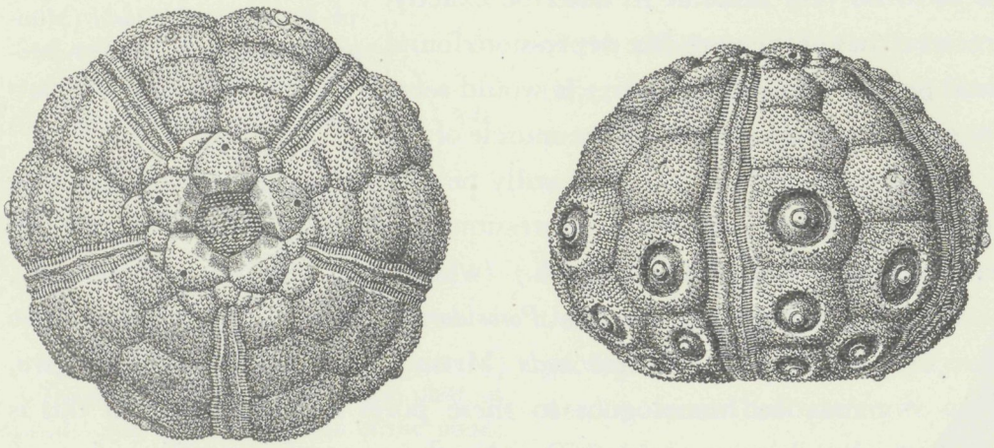
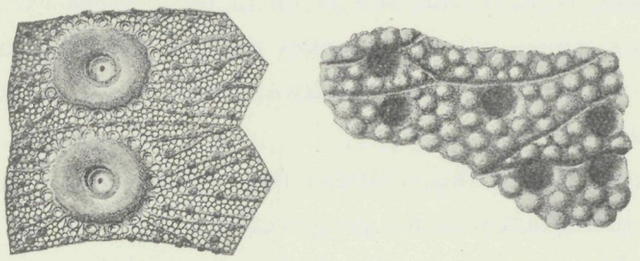


Fig. 8. *Stereocidaris Merceyi* (Cotteau). From above and in side view. The periproct wanting in the specimen. (After Paléontologie Française. Terr. Crétacé. Pl. 1068. 1—2).

The edge of the areoles is set with a ring of secondary tubercles, the scrobicular tubercles, which are usually somewhat larger than the tubercles covering the rest of the plate (in *Rhynchocidaris* and related forms (the Ctenocidarina) they are not larger than the other secondaries). These scrobicular tubercles are generally distinctly mamelonate, but never perforate, and surrounded by a rather distinct areole; as a rule their areole is incomplete on the side turning to the large areole, being thus semicircular. In *Eucidaris metularia* they are outwards widened, elliptical (Fig. 113. a, p. 388). In the genus *Stereocidaris* they are also elliptical, but the long axis of the ellipse parallel to the edge of the large areole; in this genus the scrobicular tubercles also slope rather distinctly towards the areole. In the genus *Phyllacanthus* there is an elevation continuing from the mamelon towards the edge of the areole (Fig. 160, p. 501). — The number of tubercles in the scrobicular ring is usually about 16, more rarely only about 12 or as many as 20, the number being of only very little value for classification. — In the remarkable fossil genus *Anaulocidaris* the areoles are not distinctly limited, and there are no scrobicular tubercles.

Outside the scrobicular ring of tubercles follow a various number of secondary tubercles gradually decreasing in size towards the midline of the area, the number and the arrangement of these smaller tubercles being of a rather considerable value as specific characters. As a rule

the larger of these secondary tubercles are distinctly mamelonate, the smaller not. A very peculiar character have these secondary tubercles in the genus *Chondrocidaris*, where they are glassy knobs, without a mamelon, in correspondance with the remarkable fact that the spines are attached laterally on these tubercles, not to their top as in other Cidarids.



1 2

Fig. 9. *Temnocidaris magnifica* Cotteau; two interambulacral plates (1) and part of an interambulacral plate, more magnified, showing the grooves (2). (After Paléontologie Française, Terr. Crétacé, Pl. 1086, 5—6).

When the secondary tubercles are numerous and closely set they are generally arranged in, mainly horizontal, series, separated by narrow, but distinct furrows. This is found in many different forms, e. g. *Stereocidaris*, *Chondrocidaris*, *Cidaris*, *Calocidaris*, and is quite evidently a parallel development, acquired separately in many different forms. The genus *Pleurocidaris* based by Pomel on this character is therefore untenable. — These furrows, as shown by Prouho (Rech. sur le Dorocidaris papillata, 1888) are the tracks of the superficial nerveplexus.

The median area of the interambulacra, the space between the two series of areoles, is of very different width, from not half as wide as to a good deal wider than an areole. This relative width is of some classificatory value. The measurements thereof, as given in the descriptions, are always taken at or just above the ambitus, the width of the median area always being compared with that of an areole at the corresponding place. The median, vertical suture may be more or less sunk, and is often bordered by a naked space.

The horizontal sutures are often deepened into grooves of various sizes, particularly in the *Goniocidaris*-group, in the genus *Stereocidaris* (the two-three uppermost sutures) and in the fossil genus *Typocidaris* (Fig. 10) (which is scarcely distinguishable from *Stereocidaris*). Another fossil genus, *Temnocidaris* (Fig. 9), is characterized by having numerous small grooves, but they are here scattered all over the plates, not only in the sutures. The grooves are, in the recent forms, usually the seat of large globiferous pedicellariæ.

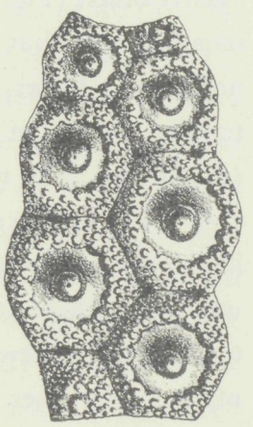


Fig. 10. Interambulacrum of *Typocidaris arduennensis* (Lambert). (After Lambert. Rech. s. l. Éch. de l'Aptien de Grandpré. Bull. Soc. Géol. France. 3. Sér. XX. 1892. Pl. II. 16).

4. Apical system.

The size of the apical system is generally about half the horizontal diameter, more rarely, in the genus *Aporocidaris*, as much as about 70 % of the h. d. — In most of the Cidarids it is somewhat larger than the peristome, more rarely, as in the genus *Phyllacanthus*, and in the fossil *Diplocidaris*, it is distinctly smaller than the peristome. The relative size of the apical system and of the peristome is of some classificatory importance and is therefore given in the measurements of all the species.

The shape of the genital and ocular plates has played a conspicuous part in the descriptions in the previous literature, and there is no doubt that it is a character of systematic value. When such description of the shape of these plates is, as a rule, not given in the present work, it is because of the difficulty of giving a description which can really convey an idea of their form. This is attained much better by means of figures, and therefore such figures are given of all species, by photographs and, in most cases, also by drawings.

A character of considerable systematic importance is this, whether the oculars are exsert, i. e. excluded from the periproct, or insert, i. e. in contact with the periproct and thus separating the genital plates. There is, however, considerable variation in this character, so that it must be used with some caution, and it can hardly ever be regarded as a generic character. In all Cidarids the oculars are exsert in the young specimens, and the insert character always the most pronounced in the old and fully adult specimens. In older literature, and especially in the works on fossil forms, the term "dicyclic apex" is used for cases where the oculars are exsert, "monocyclic apex" for such as have the oculars insert. — Very often only some of the oculars are insert, the others exsert. The development of the insert condition generally follows a constant order of sequence, Ocular V coming in first, then I, IV, III, II, or I, IV, II, III (cf. Jackson. Phylogeny of the Echini, p. 92). The ocular pore is sometimes surrounded by an elevated wall, e. g. in *Cidaris Blakei* (Fig. 90, p. 308), and particularly in the group of the Ctenocidarina. — It may be recalled here that, while there is, as in Echinoids in general, no eyespot on the "ocular" plate, not even a feeler, *Rhynchocidaris triplopora* is exceptional in having a small papilla or feeler protruding from the ocular pore, and even the indication of a pigment-spot (eye) on this feeler (cf. the author's report on the Echinoidea of the German S. Polar Exped. p. 7).

The madreporite is, as a rule, not distinctly larger than the other genital plates. Only in the genus *Phyllacanthus* it is rather conspicuously enlarged so as to encroach upon the periproct which thus loses its regular pentagonal shape. In the *Ctenocidaris*-group the pores are confined to a small, somewhat elevated area, but on the whole the extent of the area of the pores in the madreporite does not appear to be of noteworthy systematic importance.

The genital pores are usually placed near the outer edge, sometimes, e. g. in large specimens of *Histocidaris*, in *Goniocidaris umbraculum* (Fig. 53, p. 165), and in most *Ctenocidaris*-species and related forms, even rupturing the edge of the plate. More rarely, especially in some species of the genus *Stereocidaris*, the genital pore is almost in the middle of the genital plate. The male genital pores are as a rule distinctly smaller than the female pores; in species with direct development, without a pelagic larval stage, as is evidently the case in most deep-sea forms, the female genital pores are very large, corresponding to the large size of the eggs. The same holds good of species which protect their brood, carrying the eggs and young on the peristome or, more rarely, on the apical system. On the whole, one may with a fair degree of certainty draw conclusions from the size of the female genital pores as to the mode of development of the species. — The genital pores do not appear until a rather late stage, when sexual maturity is about to be reached. In several

forms they do not appear until a size of about 20 mm. horizontal diameter, in others at the size of ca. 10—12 mm. h. d., and in species of small size again somewhat earlier, ca. 7—8 mm. h. d. — A small genital papilla is sometimes found developed. According to Prouho (Rech. s. l. Dorocidaris papillata) it is particularly developed at the season of sexual maturity. — A very peculiar feature is found in *Goniocidaris florigera*, the large genital pores being covered with a distinctly plated membrane, leaving only a small pore in the centre (Fig. 54, p. 168); to a less degree this is found also in the related species *Goniocidaris spinosa* (Fig. 55, p. 172), and also in *Austrocidaris canaliculata*.

The genital and ocular plates are covered to a various extent with tubercles, those along the outer and inner edge being usually somewhat larger than those on the middle of the plates, and very often elongate, comma-shaped. Sometimes, e. g. in *Eucidaris metularia*, the tubercles along the outer edge almost alone remain, while the plates otherwise show numerous glassy tubercles, which carry no spines.

The periproct is usually regularly pentagonal, with the corners more or less produced towards the ocular plates. There is almost constantly an outer circle of 10 larger periproctal plates, one in each corner and one off the inner edge of each genital plate. Inside this outer circle there is a various number of plates, gradually decreasing in size towards the anal opening, the innermost being quite small, more or less irregularly styliform. The periproctal plates usually carry a small number of tubercles, increasing in size towards the anal opening, in accordance with the fact that there is usually a tuft of somewhat larger spines covering the anal opening. None of the periproctal plates is specially developed as a central or suranal plate. The number of the periproctal plates is of very little morphological or classificatory value [1]), and never of generic value, as it was maintained for a long time by Agassiz and Clark to be in the case of "*Stephanocidaris*" — one of the most intricate cases of confusion in Cidarid classification. — The size of the periproct in relation to the size of the whole apical system has been carefully noted in most of the previous literature on Cidarids. In the present work this is not done, partly because the author has found it to be rather valueless as a systematic character, partly because of the practical difficulty in giving the exact measure. As a rule the corners of the periproct are produced to a various extent towards the ocular plates; where then to measure to? If to the outer point of the periproctal corner, the measure will in fact get a larger value than the real size of the periproct; but it would be rather difficult to find another fixed point to measure to. While thus omitting measurements of the periproct for the said reasons, I have taken care that in every case the size of the periproct can be seen directly, either on the photographic figures or on the detail drawings of the apical system; thus anybody who wants to get this measurement can get it from the figures.

[1] Some figures showing the gradual increase in number and the change in the relative position of the periproctal plates in "*Porocidaris*" (= *Aporocidaris*) *Milleri* and some other Cidarids are given by Agassiz in the "Panamic Deep-Sea Echini" p. 3—7.

5. Peristome.

The peristome of Cidarids differs from that of all other Echinoids in being covered with regular series of plates in both the ambulacra and interambulacra, the plates imbricating adorally.[1]) In the Lepidocentridæ, Lepidesthidæ, and in the Echinothuridæ alone among recent forms, there are series of ambulacral plates only, none in the interradii. In *Melonechinus* there are besides the ambulacral series also a few interradial plates. In all other regular Echinoids there is only one pair of ambulacral plates, the buccal plates, on the peristome, in each radius; when other plates are found, they are secondarily developed and have not the morphological value of ambulacral plates. As for the plates in the interradial areas of the peristome they have not the morphological value of interambulacral plates (cf. Th. Mortensen. The postembryonal development of some Cidarids, 1927) and should be termed simply interradial plates.

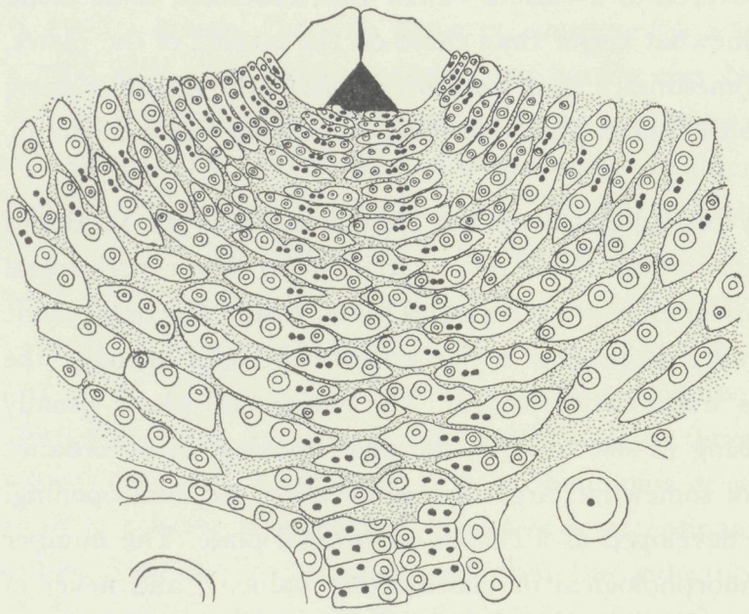


Fig. 11. Part of peristome of *Phyllacanthus imperialis* (Lamk.) showing diploporous condition of pores. × 5.

As stated above, the size of the peristome is generally somewhat smaller than that of the apical system, rarely — especially in the genus *Phyllacanthus* — it is considerably larger than the apical system. Remarkably small it is in the species *Stereocidaris indica* Döderlein. It is sometimes conspicuously protruding, e. g. *Phyllacanthus dubius*, *Goniocidaris mikado*, more generally it is flat. In species which carry their brood on the peristome it is considerably sunken at the peristomial border, mainly in the female.

The main interest, as regards classification, attached to the peristome is that of the number and condition of the ambulacral plates. It is of very considerable interest that in the genus *Phyllacanthus* and, to a less degree, in the genus *Eucidaris* the pores are displaced, the result being, as

[1] In the "Revision of Echini" (p. 257) Agassiz is led from the imbrication of the buccal plates in Cidarids to suggest that "the test of Palaechinidæ must have been made up of plates homologous to the buccal plates of Cidarids . . . . . This similarity is very striking in young Cidaridæ, where the number of coronal plates is small, and when the young Sea-Urchin seems to consist almost entirely of an abactinal and an actinal system, separated by a narrow band of coronal plates. Let this narrow band of coronal plates disappear entirely, and the buccal plates take a correspondingly great development, and we have a Palaechinus made up of small ambulacral and interambulacral plates consisting of several rows, and continuous from the teeth to the abactinal system". — This speculation is quite phantastic and may rather be designated as a morphological absurdity. The peristomial ambulacral plates are derived from the corona, not inversely, and the 15 series of plates on the Cidarid peristome could hardly be expected to give rise to the many rows of coronal plates of Perischoechinids, even if they develop ever so much.

a matter of fact, a diploporous condition (Fig. 11). Also in the fossil genus *Plegiocidaris* the same condition occurs (Fig. 144. 3, p. 476). As a rule each pore series forms a straight line, only at the oral end the two series of each ambulacrum curve against one another.

The pores in the oral ambulacral plates are conspicuously different from those of the ambulacral plates of the corona, being placed not side by side, but one above the other, viz. the outer pore above the inner; while the outer pore gradually decreases in size, the inner pore correspondingly increases in size, and alone remains on the innermost plates (Fig. 12). The pores of the innermost pair are generally somewhat larger than the rest of them.

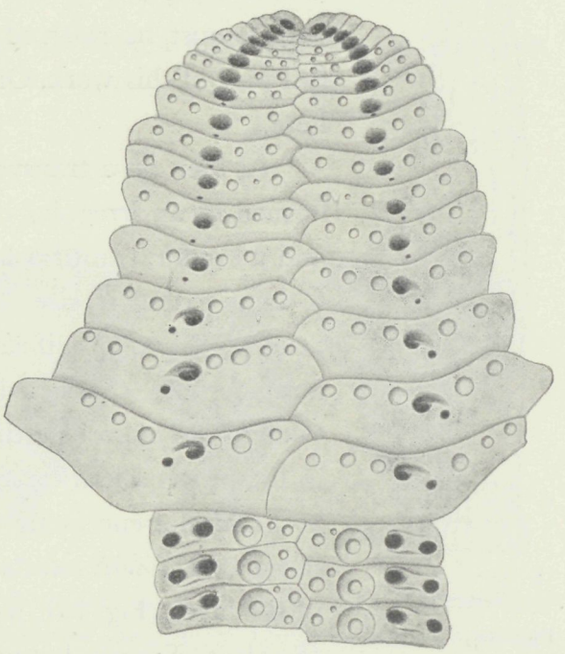


Fig. 12. Peristomial ambulacral plates of *Stylocidaris Reini* (Döderlein) showing gradual transformation of the pores. × 10.

The interradial plates usually form a single, regular series of some 6—8 plates, decreasing in size towards the mouth. There is, however, often some irregularity, some of the plates being double; in the genera *Stereocidaris* and *Austrocidaris* this irregularity is often very pronounced. In these genera also the interradial plates usually reach the very mouth edge, while in most Cidarids the inner parts of the ambulacra are in contact so as to exclude the interradii from the mouth edge. Very little classificatory value attaches to the arrangement of the peristomial interradial plates. This also holds good of the tuberculation of both ambulacral and interradial plates on the peristome. These tubercles are always arranged in a single series along the adoral edge of the plates, and even in the number of these tubercles there is little variation; an unusual case offers *Ctenocidaris rugosa* which has as many as four tubercles adradially to the pore on the oral ambulacrals, the rule otherwise being that there are only two or three such tubercles.

6. Primary spines.

In a primary spine — or radiole, as it is very often designated — we may distinguish the following parts: the shaft, the neck, the collar (or collerette), the milled ring (or annulus), the base, and the acetabulum (Fig. 13).

The shaft affords an extraordinary variation in size, shape and decoration. We may here just recall a few of the more characteristic forms: the almost footlong, slender, flattened and curved spines of *Acanthocidaris curvatispinis*, the equally long, but perfectly cylindric, smooth, shining spines of *Calocidaris micans*, and, as a contrast, the wholly rudimentary upper spines of the genus *Stereocidaris;* the coarsely serrate spines of *Porocidaris*, the shaggy spines of *Goniocidaris mikado;* the

shield-shaped spines of *Goniocidaris clypeata* and of *Anaulocidaris;* the broad, flat spines of *Cidaris blakei*, *Notocidaris platyacantha* and of many *Rhabdocidaris*-species; further the thick, egg-shaped spines of e. g. *Balanocidaris glandifera* or *pleracantha*, the club-shaped spines of *Tylocidaris clavigera* or *T. vexillum*, the sepal-shaped spines of *Cyathocidaris erebus* or the characteristic elongate-club-shaped spines with the well marked handle of a *Plegiocidaris* (cf. Figs. 14—15). There is no end of variation in these spines which are often of exquisite beauty, and, what is still better, they are of the greatest importance for classification. For the details must be referred to the figures and descriptions given in the systematical part of this work. Only the general structure of the shaft needs be described here.

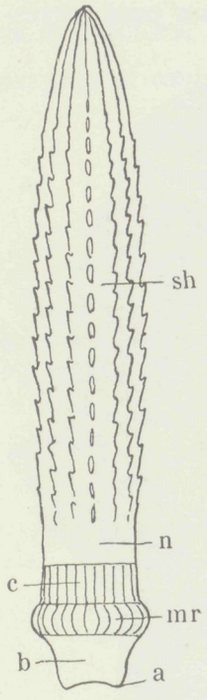


Fig. 13. Primary spine of a Cidarid; diagrammatic. a. Acetabulum; b. base; c. collar; mr. milled ring; n. neck; sh. shaft.

As seen on a transverse section (Fig. 16)[1] the shaft consists of a central core, formed by an irregular calcareous meshwork, a layer of radiating septa or spokes, and an outer, compact layer, the cortex or ostracum. The central core may vary to some extent in size, but is otherwise very uniform and, in the recent forms at least, of no classificatory value. The radiating layer, which consists of perforated septa, connected by small trabeculæ, and appearing in transverse sections in the main as radiating series of round or oval holes, is also very uniform in the recent Cidarids. Only the genus *Phyllacanthus* is characteristic in the septa at their inner end being arranged in small bundles (Fig. 162, p. 502). In the thick spines of *Eucidaris clavata* centres from which new septa arise are found scattered in the layer (Fig. 121, p. 410), as is known also in the fossil "*Cidaris*" *Hausmanni* (Bather. Triassic Echinod. of Bakony, Pl. XVI. fig. 448).

The ostracum or cortex layer is compact, but is perforated by more or less distinct channels, or pores, usually one corresponding to each septum. The spinules or warts decorating the shaft of the spine are for the greater part formed by the cortex layer alone; only the larger thorns may have in their in-

[1] It may not be superfluous to insert here a short notice of the method of making transverse sections of Echinoid spines employed by the author.

Small pieces, some 3 mm. long, so long as to make sure that the hair-coat is intact at least in the middle of the piece, are cut off by means of a knife from the basal or middle part of the spine, where the hair-coat is fully developed; by the cutting the spine must be turned round in order that it may not break. The pieces thus obtained (from a dry spine) are put, end down, not sidewards, in toluol or xylol. Some canada balsam is boiled in a melting pot, so that the xylol disappears and the balsam gets a firm resin-like consistence. Some drops of this molten balsam are poured on an object-slide, and the piece cut off from the spine is placed therein. In order to have the balsam penetrate the piece the slide is again heated over a small flame. Then the piece is made to stand vertically in the balsam. When cooled the piece is thus held by the balsam, and can now be ground on a fine grindstone. When one end of the piece has been ground down into the balsam, and is seen under the microscope to offer a good surface, the balsam is again heated over the flame and the piece now turned, so that the other end of it may be ground. The grinding is then continued until the section has become quite thin and transparent. It is then heated over the flame and removed from the balsam, put into toluol (or xylol) to have all the hard balsam removed from it, and can now be mounted in balsam in the usual way. Care must be taken that the balsam for grinding is hard, but not too hard, as it will then break and

terior a more or less irregular network in continuation of the radiating septa. The thickness of the outer layer is about the same in all recent forms.

The cortex layer, which is found only in some few other Echinoids, especially the Salenids, besides in the Cidarids, has given rise to the name "*Acanthostraca*" for these forms (H. W. Mackintosh. Report on the acanthology of the Desmosticha. Trans. R. Irish Acad. XXVI. 1878, p. 477). Though this is, evidently, a character of great classificatory value, the name *Acanthostraca* can hardly be used as more than a descriptive term.

From the outer surface of the cortex layer usually proceed a great number of fine hairs,

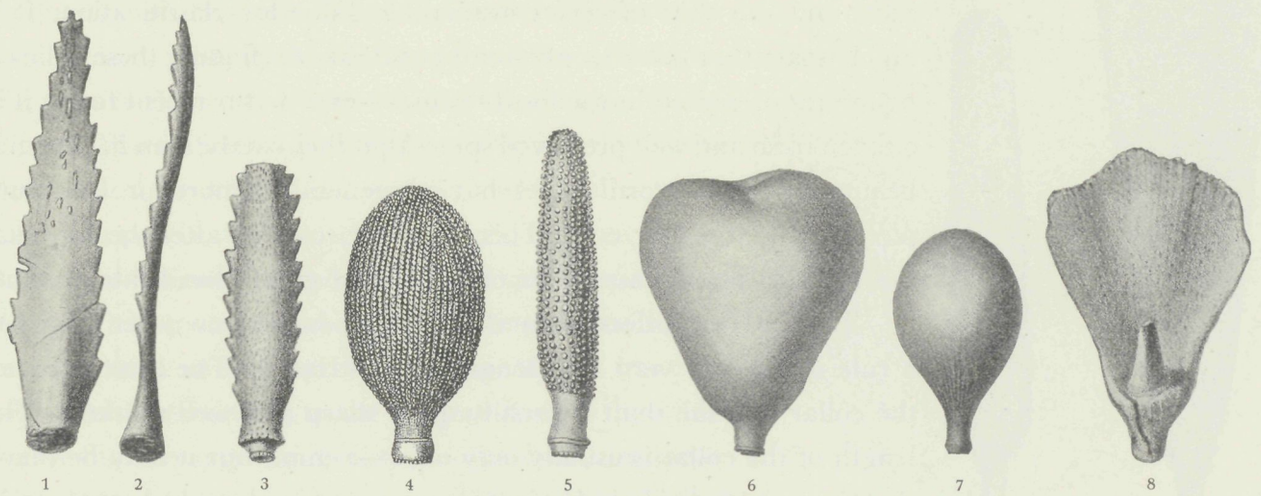


Fig. 14. Primary spines of various Cidarids: *Porocidaris Schmidelii* (Münster) (1—3; 2 in side view); *Balanocidaris glandifera* (Goldf.) (4); *Plegiocidaris cervicalis* (Ag.) (5); *Balanocidaris pleracantha* (Ag.) (6—7); *Cyathocidaris erebus* Lambert (8). (1—7 after Desor. Synopsis des Éch. fossiles, Pl. III, IV, VI and VII; 8. after Lambert. Les Éch. fossiles des îles Snow-Hill et de Seymour. Schwed. Südpolar Exp. III. 1910. Pl. I. 25).

which show an extraordinarily rich and varied development. In their simplest form they are merely short, thin excrescenses, as in most *Stylocidaris*-species, *Stereocidaris indica* var. *philippinensis* and in those species of *Histocidaris* where the surface is not entirely smooth. In other forms they are branching, bush-shaped, and then generally they anastomose with each other, and thus form quite a spongy layer, which may develop to such a degree as to conceal the spinules, the surface of the shaft thus being apparently quite smooth — e. g. *Stereocidaris microtuberculata*, *Actinocidaris Thomasi* and many others. In some Goniocidarids, e. g. *Goniocidaris florigera*, *spinosa*, *mikado* the hairs remain almost or entirely unbranched, but become very long, the spine thus getting quite a fluffy appearance; the tip of the hairs may be hook-shaped (*Goniocidaris sibogæ*) or it may be finely tuberculate, as

injure the spine. If it has become too hard a little toluol is added, and when then heated again the right consistenee may be obtained. With some practice such sections are easily made; in the case of thin spines it generally takes some 20—30 minutes to prepare a section; sections of thick spines require a somewhat longer time.

It is essential to choose quite fresh spines with fully preserved hair coat for sections. As for the hairs it is, however, as a rule not necessary to make sections of the spine for examining them; in most cases it is possible by means of a very fine knife to break off small portions of the surface of the spines with the hair coat intact, and on mounting such pieces in balsam one can study them by any magnification wanted.

in *Goniocidaris spinosa*, or end in a double hook (*Goniocidaris biserialis*) (cf. Fig. 50, p. 151). A most extraordinary development the hairs have undergone in *Schizocidaris* and *Centrocidaris* (Fig. 130, p. 426), their tips widening into a flat, smooth, fenestrated plate, which covers the whole surface of the shaft, like a roof resting upon the basal part of the hairs as upon columns. The spines of these forms are thus apparently quite smooth, in reality they have the most specialized hair coat of all Cidarids. In some species of *Histocidaris* and in the genera *Calocidaris* and *Homalocidaris* the outer layer is perfectly smooth.

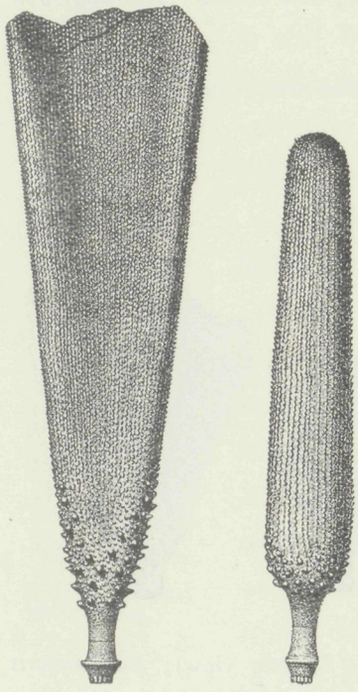


Fig. 15. Primary spines of *Rhabdocidaris copeoides* Desor. (After Paléontol. Française. Terr. Jurass. Pl. 215, 1, 4).

The characters of this hair covering are, on the whole, very constant and are thus of very considerable value for classification. It is unfortunate that there is only small possibility for finding these delicate structures preserved in the fossil forms[1] — even in the recent forms it is only on fresh and well preserved spines that they can be seen in their full beauty, old and worn spines having generally, more or less completely, lost the hair coat. This, however, cannot alter the fact that the hairs in many cases offer characters of great classificatory value.

The collar differs from the shaft in having no outer layer. As a rule it shows a very fine longitudinal striation. The limit between the collar and the shaft is usually quite sharp and well marked. The length of the collar is usually only ca. 1—2 mm., but it may be much shorter, e. g. *Stylocidaris brevicollis*, or very considerably longer, as in *Acanthocidaris* and *Poriocidaris*, and in *Prionocidaris baculosa*, var. *longicollis*. It appears that also the spines of the fossil *Plegiocidaris* (Fig. 14,5) had a rather long collar. Some species of *Diplocidaris* are stated to have no collar on their primary spines; this may, however, well be supposed to be due to unsatisfactory preservation.

The lower part of the shaft, immediately above the collar, may be quite smooth and shining, resembling the collar, but differing from it in having the outer layer developed. This part, which is designated as the neck, is generally well developed, and of about the same length as the collar, as in *Stereocidaris* and *Phyllacanthus*, or somewhat longer, as in *Notocidaris* and related genera, while in many forms it is hardly or not at all distinct. For classification this is only of very slight value. This also in the main holds good of the milled ring and the base with the acetabulum, which are very uniform throughout the order. The milled ring may be more or less prominent, but is always of the same structure, with fine impressions corresponding to the striation of the collar. Often the striæ of the milled ring continue about halfway downwards on the base. In the genus *Homalocidaris* the milled ring is extraordinarily prominent. The base is of compact structure, smooth on the surface. The acetabular margin is crenulated or smooth, corresponding to the crenulation of the tubercles.

In the description of recent Cidarids it is very often mentioned that some of the primary

[1] I have found it very well preserved in a spine from miocene deposits of Java (see under *Cidaris cidaris*, p. 300).

spines on the aboral side are very different in structure from the ambital spines, without spinules and very finely longitudinally striated. These are, however, not a different sort of spines, but only developmental stages of the usual primary spines. The longitudinal striation is due to the fact that the cortex-layer has not yet been formed, the radiating spokes thus reaching the surface; on the living specimens such spines will be found to be covered by a ciliated skin. When the spoke-layer has reached the definitive thickness, the cortex (or ostracum) begins to develop. In the description of this layer it was stated that it is traversed by fine pores. Through these pores the skin remains in connection with the living tissue in the interior of the spine. When the outer layer has been fully formed, with its decoration of spinules and hairs, the pores in this layer obliterate, and the skin gradually dies off. The surface of the fully formed spines thus eventually becomes a dead substrate[1] to which all sorts of foreign organisms — barnacles, sponges, bryozoa etc. — may attach themselves, and old Cidarid spines usually are more or less covered by such foreign organisms, sometimes to such an extraordinary degree that it must be highly incommodating to the animal. But be the spine ever so much overgrown by foreign organisms, the collar of the spine always remains clean. Here, where no cortex layer is formed, the ciliated skin remains intact, preventing the foreign organisms from attaching themselves.

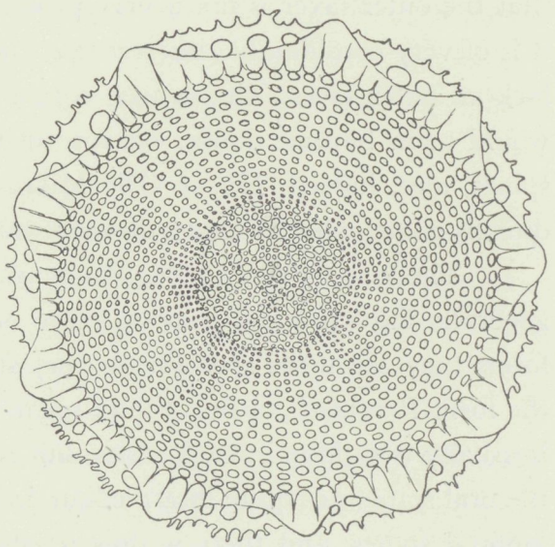


Fig. 16. Transverse section of a primary spine of *Stereocidaris japonica* (Döderlein). × 40.

Such young developing spines (— which are usually of a darker colour than the fully formed ones —) may also occur on any other place in the series of primary spines, at the ambitus or on the oral side. In such cases it is a regeneration that takes place, the old spine having been lost or actively cast off by the animal itself. That the latter case may actually happen is incontestable — cf. e. g. the specimen of *Eucidaris Thouarsii* mentioned on p. 397, which has had most of its primary spines gnawed off, apparently by a Tetrodont fish, and then dropped the stumps and begun to form new spines. Prouho (Op. cit. p. 51) states that, in cases where spines have been broken in the proximal part, a membrane is formed immediately above the milled ring, and the part outside the membrane then dies and falls off[2] — just as a plant sheds it leaves. A new spine is then formed from the surface above the milled ring or, perhaps, above the collar. In *Chondrocidaris brevispina* it is evident that regeneration of the shaft takes place from the end of the enorm-

[1] When Prouho (Recherches sur le Dorocidaris papillata, p. 50) states that the spine, after the outer layer has been formed and the skin died off, plays the role of a wooden leg, this is more amusing than correct, since it is only the surface of the spine that is dead, while the interior contains living substance.

[2] Krizenecky (Ein Beitrag z. Kenntnis d. Regenerationsfähigkeit d. Seeigelstacheln. Arch. f. Entw. Mech. XLII. 1917) has shown that also *Paracentrotus lividus* possesses the power of dropping its spines by autotomy and then regenerating them. It may well be supposed that this phenomenon may occur in Echinoids in general.

ously developed collar (cf. p. 498). Spines which have regenerated only part of the shaft are never met with[1] contrary to other Echinoids, where such half regenerated spines are very commonly seen. — This is a natural consequence of the fact that a fully formed, and particularly a somewhat old spine is a dead body, as far as its outer layer is concerned.

The outer layer is not found on the first formed primary spines in the young Cidarid, as I have shown in my paper "On the postlarval development of some Cidarids" (Mém. Acad. sc. Copenhague, 8. Sér. XI. 1927. p. 378), and it would therefore seem to be the necessary conclusion that the outer layer is not a very primitive feature, but a later acquisition. In the light hereof it is of very considerable interest that the spines of the more primitive Triassic Cidarids seem to lack an outer layer. That a true cortex layer was present in the primary spines of *Archæocidaris* would seem beyond doubt, because of the rich development of spinules on the shaft of these spines, and, indeed, Hesse (Die Mikrostructur der fossilen Echinoideenstacheln. 1900, p. 213) directly states to have found a distinct, though very thin, cortex-layer in spines of *Archæocidaris rossica*.

The oral primaries, which are always considerably shorter than the ambital spines, are generally flattened and smooth, more or less curved, often with slightly serrate edges. In some forms they are more specialized, very strongly serrate as in *Histocidaris* and *Ctenocidaris*, and in the fossil *Porocidaris*, or beautifully spear-shaped, as in *Notocidaris*. The number of the oral spines is usually two-three in each series, but may be as many as five. As a rule, however, the outer of the oral spines are quite intermediate in shape and size, forming a transition from the oral to the ambital spines, and there is thus no sharp limit between the oral and the ambital spines. — Generally the collar is relatively longer on the oral than on the ambital spines and it therefore occurs that the shaft on such oral spines is much shorter than the collar and has the appearance of a small cap. Such "capped" spines are found e. g. in *Acanthocidaris*, *Prionocidaris australis*, *Pr. baculosa* var. *longicollis*.

The oral primaries serve mainly for walking on, are, indeed, the main locomotor apparatus of Cidarids, their tubefeet being of little importance in this regard. As a consequense of this function the oral primaries are very rarely invested by foreign organisms, contrary to what is the case with the spines of the ambitus and the aboral side. Some forms also use the ambital spines for walking on, and the point of these spines is then obliquely worn, as in *Stereocidaris tubifera*. In *Histocidaris magnifica* the ambital spines are even downwards curved so as to reach the ground.

The uppermost primaries, in fullgrown specimens, are usually shorter than the ambital

[1] Koehler (Échinodermes. Deuxième Expéd. Antarctique Française, p. 153.) mentions and figures (Pl. XIII. 5) a primary spine of *Ctenocidaris Perrieri* with a large sidebranch, stating that "cette anomalie s'est produite à la suite d'un processus de régénération". There is, however, no sign of a regeneration on the spine, and it may be said almost with certainty that it is not a case of regeneration, but an anomaly which has occurred in the course of development of the spine. The same holds good of the bifid spine of *Schizocidaris assimilis* represented in pl. XVII, fig. 9. — At least such regeneration could take place only on young spines in which the cortex layer has not yet been formed.

In my memoir "On some West Indian Echini" (p. 4) it is stated that a primary spine in *Calocidaris micans* shows signs of regeneration. I have no doubt that in this case the spine broke before the cortex layer had been formed.

spines. The stage of development of these spines may afford a criterion of whether the specimen has reached full size or not; it may be safely concluded that when these spines are still in an unfinished condition the specimen has not reached its full size, and inversely, when all the apical spines are fully developed, no further growth of the specimen would have taken place. This is especially the case with those Goniocidarids, where the apical spines are transformed into large shields, as in *Goniocidaris clypeata*, or to a delicate, flower-like shape, as in *Goniocidaris florigera*. As a marked contrast to this extreme development of the apical spines stands the genus *Stereocidaris* with its quite rudimentary apical spines, the climax being reached by such forms as *Stereocidaris japonica* and the fossil *St. Merceyi*, in which even any trace of areoles may have disappeared totally on the uppermost plates, a fully formed areole and spine not being found until the fourth plate from above.

7. Secondary spines.

The secondary spines, which are always much shorter than the primaries, rarely exceeding 5—6 mm. in length, differ conspicuously in regard to their structure from the primaries, especially in lacking a central core and the outer layer. More generally they are flattened, in some forms, however, e. g. *Rhopalocidaris*, *Aporocidaris*, *Rhynchocidaris*, and *Ctenocidaris*, they are club-shaped.

The spines surrounding the primaries, the scrobicular spines, are generally the most developed, and they often form a close mail, protecting the base of the primaries with its muscles and nerves. Especially in *Phyllacanthus* and some species of *Stereocidaris* they form a very close mail, the spines being thick, with their lateral edges cut so as to fit very close together. In general they are flat, but often they are more or less concave, sometimes keeled; in *Goniocidaris florigera* and some related forms they are more or less spinulose. On the whole they afford rather important characters for classification.

The marginal ambulacral spines are, as a rule, only 2—3 mm. long, flattened and, on preserved specimens, bend over the pore-zone so as to form a protecting cover over the tubefeet; they are generally flattened, but much narrower than the scrobicular spines and do not form such a close mail over the tubefeet as do the former around the base of the primaries. Generally they increase somewhat in length towards the peristome and are here often somewhat curved adorally and excavate towards the point. In *Chondrocidaris brevispina* they are tuberculate and with hook-shaped point. The secondary or miliary spines covering the rest of the corona and the apical system are not specialised, may be simply setaceous, or have the shape of rounded granules (*Goniocidaris mikado*), or they are more flattened; in the latter case they are often closely appressed, scale-like, as in most *Phyllacanthus*- and some *Stereocidaris*-species. Usually they have a more or less developed bag of glandular skin[1], the so-called "ampulla" (Prouho), at their

[1] According to Prouho (Op. cit. p. 58) it is not really glandular; what appears to be large glandular cells is nothing but intercellular spaces, filled with fluid. According to Hamann (Histologie d. Echinodermen. H. 3. p. 28. Taf. VI. 5, 8) it seems beyond doubt that the skin is really glandular, as would naturally be expected.

base. In most forms the spines on the inner periproctal plates are somewhat longer and more robust and form a raised tuft covering the anal opening. Often also those along the outer margin of the apical system are somewhat larger and outwards bent, forming thus a more or less conspicuous fringe round the apical system; this is especially the case in *Eucidaris metularia*.

The spines on the peristome are usually somewhat adorally curved and widened towards the end, and form a dense coat on the peristome. Their shape is almost identical throughout the whole family, and they do not thus afford characters of value for classification. In *Chondrocidaris*, and to a less degree in some other forms, the interradial spines on the peristome are somewhat shorter than the ambulacral ones. — In such forms as carry their brood on the peristome this is conspicuously sunk in the outer part and rather devoid of spines; this, of course, mainly applies to the females.

8. Pedicellariæ; (Sphæridia).

The pedicellariæ of Cidarids are of three sorts only, viz. two forms of globiferous pedicellariæ and tridentate pedicellariæ; ophicephalous and triphyllous pedicellariæ are entirely lacking. One more form of pedicellariæ has been described from Cidarids, namely what Döderlein designated as "korbförmige" pedicellariæ. This is, however, not a special form, but only a stage of development of the large globiferous form (Fig. 17).

The globiferous pedicellariæ differ essentially in structure from the globiferous pedicellariæ of all other Echinoids; the poison gland lies inside the valves, enclosed in a special chamber of the calcareous skeleton (Fig. 18), while in the globiferous pedicellariæ of other Echinoids the poison gland lies free, generally on the outside of the valve, hanging as a sack on its back. In Cidarids the poison gland has no muscles, while in other Echinoids the wall of the poison sack is provided with muscles. In fact, it may well be doubted, whether the globiferous pedicellariæ of Cidarids are really homologous with those of other Echinoids; the suggestion that it is a type which has developed separately in the Cidarid branch of the great Echinoid stem would seem rather probable — but this must, probably, remain a suggestion, as there is exceedingly little hope of finding proof of the existence of these minute structures in those primitive Echinoids which may be regarded as the common ancestors from which both the Cidaroid branch and the other Echinoid branches developed.

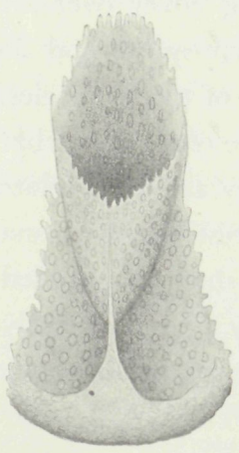


Fig. 17. Valve of a young, developing pedicellaria. × 180.

In those forms where the valves are provided with an endtooth the poison gland opens on the upper side of this tooth (Fig. 18), the larger subterminal opening being closed by strongly ciliated cells, undoubtedly of sensory function. It must be assumed that on a stimulation of these cells the pedicellaria closes, and the poison flows out — in spite of the lacking of muscles in the wall of the gland — into the wound afflicted by the endtooth. In those forms where the valves lack an end tooth the poison gland

probably opens at the upper end of the large opening; this, however, has not yet been investigated.

The two kinds of globiferous pedicellariæ of Cidarids are distinguished as the large and the small globiferous pedicellariæ. They both agree in having a poison gland in the interior of the valve, but differ, in most forms, both in shape and size; in some forms, however, the difference is not sharp, and it is thus not always possible to distinguish the two forms with certainty. The simplest form of the large globiferous pedicellariæ would seem to be that found in *Stereocidaris*, *Austrocidaris* etc.; the valves here have an elongate subterminal opening, surrounded by some irregular teeth, but without an end tooth (Fig. 19, 1). From this form there is an easy passage to the form with a single, unpaired end tooth, e. g. *Cidaris*, *Tretocidaris* (Fig. 19, 2, 4—5); in fact, one may find in *Stereocidaris japonica* a sort of transitional stage, one side of the opening terminating before the end of the valve, the other side continuing to the end and its uppermost tooth thus forming an unpaired end-tooth (cf Pl. LXXXII. 15). Another thing is, that there is sometimes an apparently unpaired end tooth, for instance in *Stereocidaris*; on a closer investigation it is, however, seen that it consists of the two uppermost lateral teeth lying close together so as to give the appearance of a single, unpaired tooth. — A further development of the type found in the genus *Cidaris* is that found in the genus *Tretocidaris* (Fig. 19, 4—5), in which the opening has been reduced to a very small pore.

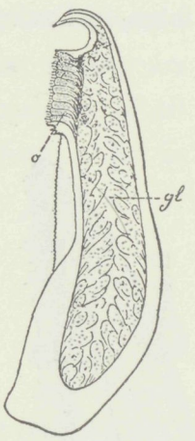


Fig. 18. Longitudinal section of a valve of a large globiferous pedicellaria of *Cidaris cidaris* (L.), partly diagrammatic. gl. Glandular cavity; o. subterminal opening, with sensory cells. (After Prouho. Rech. s. l. Dorocidaris papillata, fig. 11).

Another type of large globiferous pedicellariæ is that found in *Stylocidaris* and *Prionocidaris* (Fig. 19, 3), it has a small terminal opening surrounded by a number of teeth, the lower edge forming a distinct lip. This form may perhaps also have developed from a type like that of *Stereocidaris;* at least, it must be regarded as a more specialised type than that of *Stereocidaris*. A. peculiar type of globiferous pedicellaria is that of the genus *Rhynchocidaris* (Fig. 19,6), the valves ending in a small pore, without any teeth; this type evidently has developed from such a form as the very elongate and slender-valved globiferous pedicellariæ found in *Ctenocidaris spinosa*; here the subterminal opening still exists, but is much reduced; its disappearance would result in a form of valve exactly as in *Rhynchocidaris*.

In general the stalk of the pedicellariæ in Cidarids differs from that of other Echinoids in being of a rather coarse, irregular reticulate structure, and in having a small, more slender upper part immediately under the head of the pedicellaria. There is never a soft neck, the head resting directly on the upper end of the stalk as on an articular surface; it is moved by muscular fibres attached all round at the base of the upper, slender part of the stalk. The stalk of the large globiferous pedicellariæ in some forms, particularly the genera *Stylocidaris* and *Prionocidaris*, has a beautiful limb of freely projecting rods at the upper end, at the base of the slender upper part. In some forms the stalk is very short, much shorter than the head of the pedicellaria. The

stalk of the small globiferous or the tridentate pedicellariæ never has a limb of freely projecting rods.

The small globiferous pedicellariæ are, as the name indicates, generally smaller and also of a more simple type than the large globiferous. In many forms, particularly in the Goniocidarids and *Stylocidaris*, *Prionocidaris* and related forms, they are conspicuously different from the large form, in having a distinct end tooth, which the large form has not. In genera where both the large

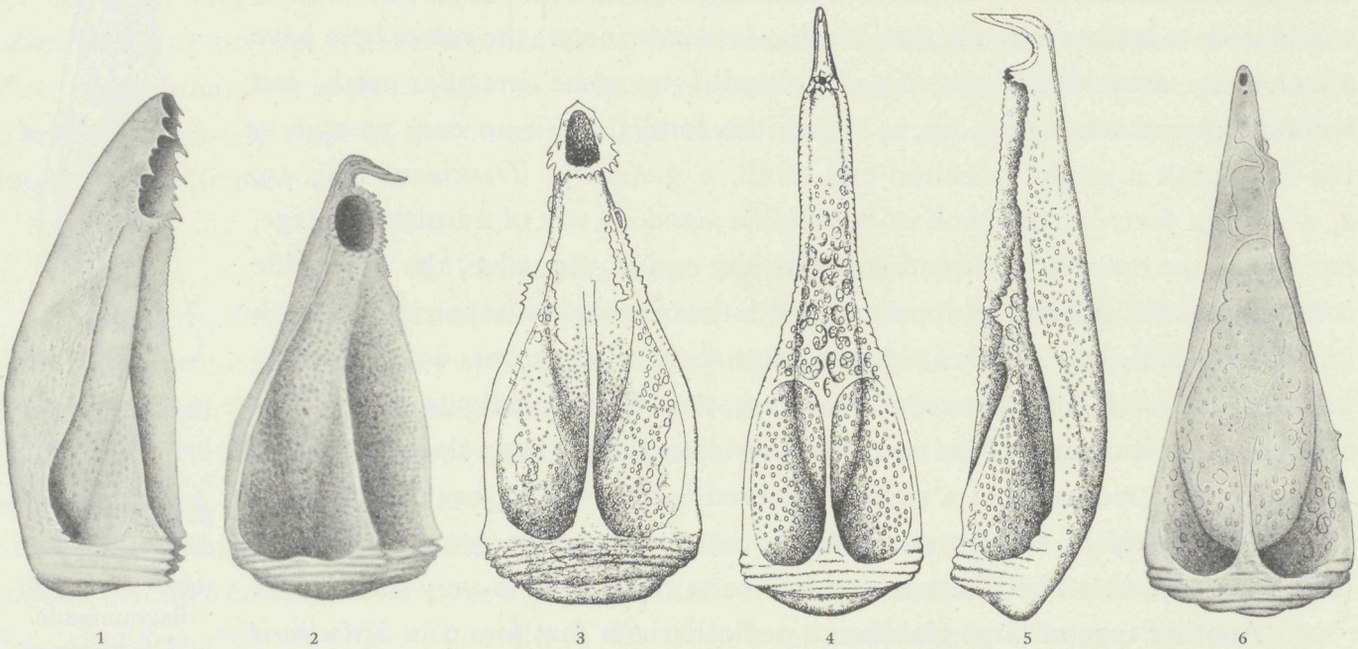


Fig. 19. Valves of large globiferous pedicellariæ of various Cidarids. 1. *Stereocidaris squamosa* Mrtsn.; 2. *Calocidaris micans* (Mrtsn.); 3. *Stylocidaris affinis* (Phil.); 4—5 *Tretocidaris Bartletti* (A. Ag.); 6. *Rhynchocidaris triplopora* Mrtsn. (2. After Th. Mortensen. On some West Indian Echini, Pl. 17. 12; 3—5. after the „Ingolf" Ech. I. Pl. IX. 22; X. 23, 30; 6. after Ech. d. Deutschen Südpolar Exp. Taf. XIV. 20).

and the small globiferous pedicellariæ have (e. g. *Cidaris*) or are lacking an end tooth (e. g. *Stereocidaris*, *Austrocidaris*) it may be difficult enough to distinguish the two forms of pedicellariæ, the more so as the "small" form may sometimes be almost as large as the "large" form. In species where the large globiferous form is only very rare the small form apparently plays its part, being correspondingly richly developed, which fact may cause — and has caused — mistakes in the interpretation of their morphological value, as in the case of *Prionocidaris bispinosa*. As a rule the small globiferous form is the only one to be found on the peristome; the samples occurring here are generally somewhat coarser than those of the corona. — A very peculiar sort of irregular pedicellariæ occurs in some species of *Stylocidaris* among the scrobicular spines on the aboral side of the test (cf. e. g. Pl. LXXXV. 4—5). It appears to be a special development of the small globiferous type, and, in spite of its irregularity, it seems to be a normal form, not an anomaly, since it is found rather constantly in the species where it does occur at all.

Globiferous pedicellariæ, of either form, are entirely lacking in the Histocidarina. A very

curious case of a two-headed small globiferous pedicellaria was observed in *Cidaris abyssicola* (Th. Mortensen. On some West Indian Echinoids. Pl. 17.9).

The tridentate pedicellariæ, which have no poison glands, as a rule have long and slender valves, but in some forms they are very coarse, the blade being filled with a thick, reticulate calcareous meshwork (*Histocidaris*); often there are irregular, serrate crests in the blade. A peculiar case is that of the Goniocidarids; large, coarse pedicellariæ occur here, often very sparingly, which would seem to be tridentate, but are in reality transformed small globiferous pedicellariæ, as appears from the fact that they a ways have a small subterminal opening, and from the existence of all transitional forms between typical small globiferous and the large "tridentate" form. Also in *Phyllacanthus* we find such transitional forms between the small globiferous and the tridentate pedicellariæ.

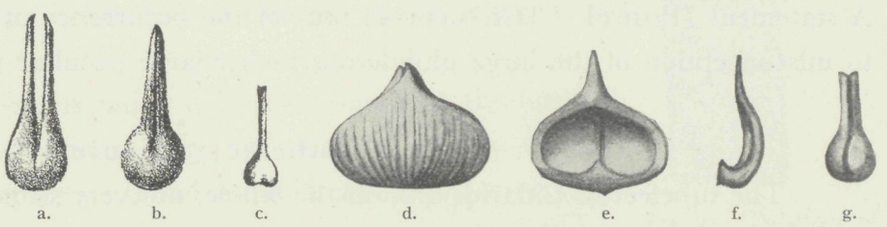


Fig. 20. Pedicellariæ of various fossil Cidarids. (a—b. after Lambert & Thiéry. Ess. nom. rais. Pl. I. 10—11; c. after Lambert. Revis. des Éch. fossiles de la Catalogne. 1927. Pl. I. 4; d—g. after Brünnich Nielsen. Nogle Echiniderester fra Danmarks Senon og Danien. Pl. I. 20—21, 23—24).

The tridentate pedicellariæ of Cidarids may attain a very considerable size, particularly in the Histocidarina, up to a length of head of 5 mm. or even more. — As a rule they have, like the other pedicellariæ, three valves, but in *Histocidaris variabilis* they have not rarely only two valves, and in *Poriocidaris purpurata* they have constantly only two valves.

In all the various forms of pedicellariæ the articular surface at the base of the valves is of the same general structure, and it appears that no characters of any value for classification are to be found therein. This part of the valves has therefore been drawn rather diagrammatically in the various figures of the valves of pedicellariæ, as it would not at all pay the trouble of drawing it in all its microscopical details.

All the three sorts of pedicellariæ afford excellent systematic characters, now of specific, now of generic or even higher classificatory value. It is, of course, unfortunate that only in rare cases we can expect to find pedicellariæ preserved also in the fossil forms, and even if preserved, it cannot be expected that it would be possible to trace on them the finer structures which have proved to be of special classificatory value. That cannot be helped; we have got to agree that the fossils are thus far incompletely preserved and, where the test and the primary spines — without their hair-coat — do not offer such characteristics as to leave no doubt of the genus, we must remain in uncertainty as to the genus to which such species really belong. — Pedicellariæ have been made known of *Miocidaris Lorioli* Lambert & Thiéry (Fig. 20 a—b.).[1] A couple of fossil Cidarid

[1] Also in "*Anaulocidaris*" *Faurai* Lambert has found a peculiar small structure which he regards as a pedicellaria (Rev. Ech. foss. Catalogue. Pl. I. 4); it may well be so — but then he has evidently represented it upside down. (cf. Fig. 20, c.).

pedicellariæ were described by Brünnich Nielsen (Nogle Echiniderester fra Danmarks Senon og Danien. Medd. Dansk Geol. Foren. VI. 1925) (Fig. 20 e—f). There is unfortunately, no certainty to which species these latter pedicellariæ belong. All the fossil pedicellariæ hitherto described appear to belong to the tridentate type. Quite recently H. L. Clark & B. W. Arnold in their work on the Fossil Jamaican Echini (Mem. Mus. Comp. Zool. L. 1927) state that in a specimen of their *Cidaris gymnozona* also pedicellariæ, apparently both small globiferous and tridentate, are preserved; they are not figured or described in detail, but are said to be "not at all distinctive, resembling closely those of the recent species, *Eucidaris tribuloides*".

Sphæridia are entirely lacking in Cidarids, in contradistinction to all other recent Echinoids. A statement (Pomel. Class. méth. p. 110) of the occurrence of sphæridia in *Goniocidaris* is due to misconception of the large globiferous pedicellariæ peculiar to this genus.

9. Tubefeet; spicules.

The tubefeet of Cidarids are, on the whole, not very strongly developed, and do not play any important role as locomotor organs; this part is in the main taken over by the oral primary spines, the main function of the tubefeet being evidently respiratory. The sucking disk is small, and is developed only on the tubefeet of the oral side; those of the aboral side are broad, sac-shaped, as in other Echinoids where tubefeet are transformed into gills.

The innermost of the tubefeet on the peristome, of course, correspond to the buccal tubefeet of the other Regular Echinoids (— contrary to the statement of Prouho (Rech. s. l. Dorocid. papill. p. 100) that "on sait qu'il n'existe chez les Cidaridés rien de comparable aux dix tentacules buccaux des Echinidés" —); they are, however, not specially developed and scarcely larger than the other peristomial tubefeet.

The spicules of the tubefeet are irregular, curved rods, usually rather strongly thorny, especially towards the end of the tubefoot. They are fairly regularly arranged in two series, so as to form a mail round the foot, more or less close, according to the stage of contraction or extension, but leaving a small space naked (Fig. 21.). In this naked streak lies the nerve of the tubefoot. The sucking disk is supported by some larger plates, but these are rather irregular and do not form such an elegant rosette as is found in most other Echinoids. — In some species of the genus *Stereocidaris* and in *Homalocidaris* the spicules are to a various degree transformed into fenestrated plates; in all other Cidarids they are of the typical form of curved, thorny rods. On account of this great uniformity the spicules of the tubefeet are of very small value for classification.

10. Internal Anatomy.

Dental apparatus. The dental apparatus (or "lantern") of Cidarids is characterised by the low, open foramen, the epiphyses being very small, not uniting so as to form an arc above the pyramid. The surface of the pyramid, to which the epiphysis is attached, is smooth, not pitted. The teeth are unkeeled. In *Archæocidaris* the structure of the lantern is the same as in recent Ci-

darids, excepting only that it is more sloping in the former, more erect in the latter (cf. especially Jackson. Phylogeny of the Echini, p. 181—183). The general shape of the dental apparatus is very uniform throughout the whole family and characters of generic or specific value hardly to be found therein.

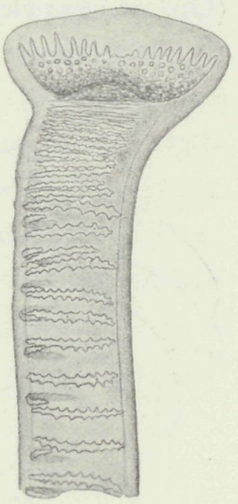


Fig. 21. Tubefoot of *Stylocidaris brevicollis* (de Meijere). × 95.

Perignathic girdle. The apophyses to which the lantern muscles are attached are interradial, while in all other Echinoids they are radial in position. The two types are therefore not strictly homologous and it is consequently preferable not to designate them by the same name. We may then follow Jackson (Op. cit., p. 190—194) in designating them as apophyses in the Cidarids, the old name "auricles" being reserved for the radial processes in other Echinoids.

The shape of the apophyses is rather uniform throughout the family, though subject to individual variations; they are therefore hardly of any value for classification. As a rule they are broad and flat, ear-shaped, diverging with their points. Sometimes an apophysis may join across the ambulacrum with that from the neighbouring interambulacrum. — Apophyses are unknown in *Archæocidaris* and may not have existed there.

Small apophyses also, as a rule, proceed from the inside of the ambulacral plates, all of them or only those at the peristomial edge (Fig. 22); they would appear to be homologous with the auricles of other Echinoids, though none of the lantern muscles are attached to them. In *Histocidaris* inward prolongations from the ambulacral plates are especially developed on the peristome (Fig. 23); as such inner processes are not known in other Cidarids, we have here a noteworthy character distinguishing the Histocidarina from the other Cidarids.

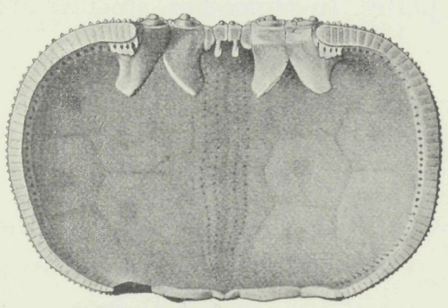


Fig. 22. Inside of test of a Cidarid; showing the apophyses and the small processes from the ambulacral plates. (After Joh. Müller. Bau d. Echinodermen. Taf. II. 9).

Stewart's organs. From the upper side of the lantern five large bush-shaped outgrowths proceed (Fig. 24), placed radially[1]. Stewart (On certain organs of the Cidaridæ, Trans. Linn. Soc. 2. Ser. Zool. p. 570) interpreted these organs as inner branchiæ, thinking that they were in communication with the water through the mouth, the water thus bathing the interior of the supposed gills. There is, however, no such communication with the exterior, and accordingly they can have no function as gills. — True gills are not found in the Cidarids. The statement to the contrary in the "Revision of the Echini" p. 694 is a mistake, due to a misunderstanding of Fig. 7, Taf. II. of Joh. Müller's "Uber den Bau d. Echinodermen" (1854); the five slits in the inner edge of the peristome seen there have

[1] Delle Chiaje (Descrizione e notomia d. animali invertebrati d. Sicilia citeriore, 1841) was the first to see these organs.

nothing with gill slits to do, represent only the limit between the ambulacra at the mouth edge; in life they are covered by skin, and there are no gills or anything else attached thereto, as Stewart (Op. cit.) has clearly shown.

Generally the walls of the organs of Stewart are studded with spicules of a rather characteristic three-radiate shape and fairly large. Sometimes (*Stereocidaris*) spicules are entirely lacking in the Stewart's organs.

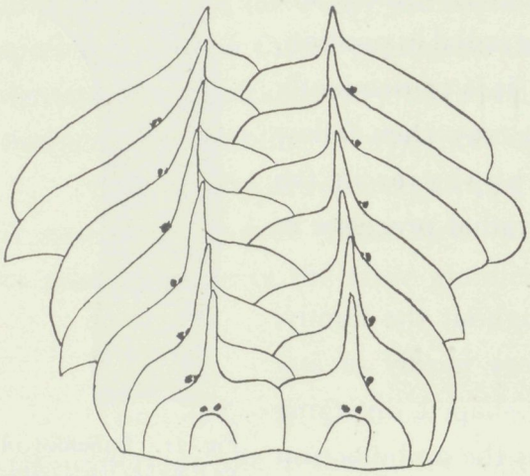
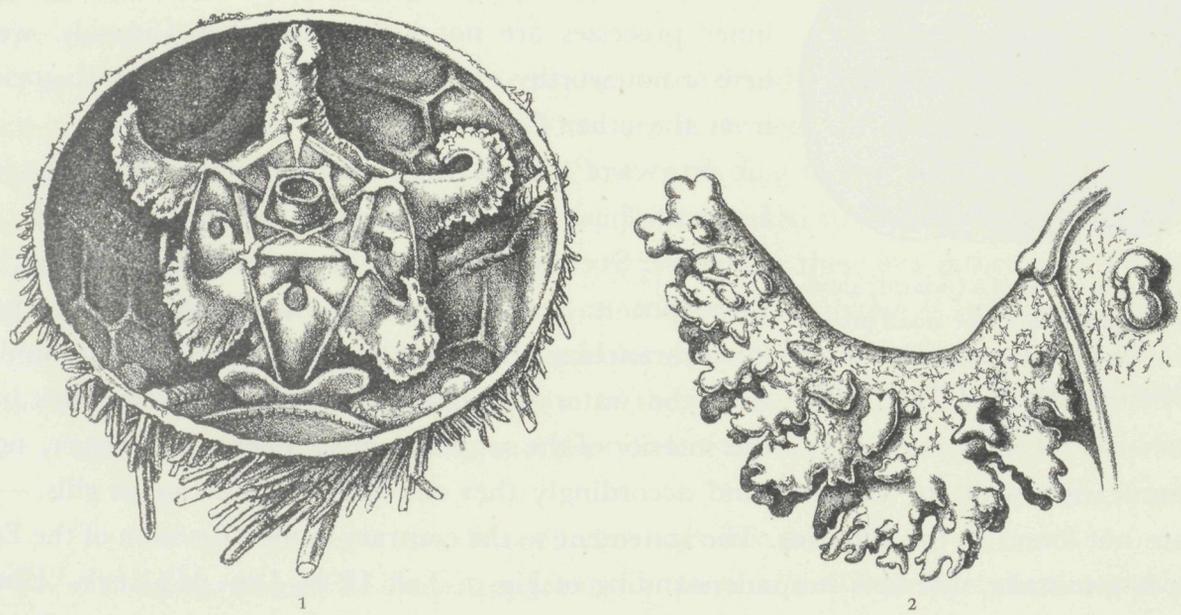


Fig. 23. Peristomial ambulacrum of *Poriocidaris purpurata* (W. Th.), from the inside, showing the prolongations of the plates. × 10.

The alimentary canal in its general shape agrees in the main with the usual type in regular Echinoids, but it is stated (Prouho) to differ from other Echinoids in lacking the sipho (only a ciliated groove is found in the place of the sipho). This may, however, well deserve to be ascertained also on other forms than *Cidaris cidaris* (= *Dorocidaris papillata*), the only form hitherto more closely studied as regards its internal anatomy.

The walls of the intestinal canal usually contain a number of spicules of characteristic shape. In *Goniocidaris* and some species of *Stereocidaris* and the *Ctenocidaris*-group they are small three-radiate bodies or quite simple rods; in *Stylocidaris* and *Prionocidaris* they are, in the upper part of the intestine, small round glassy plates with only a few holes in the middle, the wall being sometimes literally paved with such plates. In *Histocidaris* spicules are



1 2

Fig. 24. Stewart's organs of *Cidaris cidaris*; 1. the lower half of a specimen with the lantern and the Stewart's organs in situ, slightly magnified; 2. a single Stewart's organ, in side view. × 6. (After Stewart. On certain organs of the Cidaridæ. Pl. 70, 2—3).

very rare or entirely wanting in the intestinal wall. It is a very curious fact that the spicules of the intestinal wall thus afford systematic characters of no small value.

The gonads are of rather uniform structure throughout the family, consisting of branching, usually anastomosing tubes; sometimes (*Acanthocidaris maculicollis*, fig. 96, p. 331) they are longer, scarcely branching, simple tubes. Perhaps then some characters of value for classification may be found in the shape of the gonads. As a rule they contain large, irregular spicules in their walls, sometimes (*Stylocidaris conferta*, *St. maculosa*) they are quite paved with large fenestrated plates, sometimes (*Stereocidaris*) they are almost entirely without spicules. A very remarkable form of spicules occurs in the genital organs of *Chondrocidaris gigantea*, viz. large, more or less irregular anchor-shaped plates (Fig. 158, p. 495). It should still be mentioned that from the line of attachment of the mesentery to the intestine large spine-shaped spicules proceed in many Cidarids, projecting free into the body cavity (Figs. 137.4; 168.2, p. 445; 515).

11. Colour.

The colour of Cidarids is partly of considerably value for distinguishing species. This does not apply to the colour of the skin, which is very apt to fading on preservation and therefore not to be relied upon, but to colour bound to the calcareous mass and therefore not fading on preservation — on the contrary, the colour is seen the better the cleaner the specimen, and even cleaning the spines and test with a strong solution of hypochlorite of sodium does not at all make such colour fade. — Very often the interporiferous zone of the ambulacra is intensely coloured, and as a rule the apical system is darker than the test. A rather unique case is offered by *Plococidaris verticillata* the test being mottled with green.

12. Biology; development; growth etc.

Little is known regarding the biology of the Cidarids. It may, however, be said that in general they are very sluggish animals, moving very slowly by means, mainly, of their primary spines. — They may be found in all depths, from the coast down to ca. 4000 metres, and on all sorts of bottom; but as a rule they prefer hard bottom. The species of *Phyllacanthus* appear to prefer rocky coasts, where they conceal themselves over day under stones or in rock crevices, sometimes so narrow that one cannot help wondering how they can get in — and out — with their huge spines. Some species occur among corals, like *Plococidaris verticillata* or *Eucidaris tribuloides*. Such littoral forms may be found lying dry at low tide. — No Cidarid is known to cover itself with foreign objects as do so many other littoral Echinoids. There is a very natural reason for this, viz. the fact that the tubefeet on the aboral side are leaf-shaped gills, without a sucking disk or, at most, with a quite rudimentary one.

The fossil *Anaulocidaris*, which has all its primary spines transformed into shields which must have covered the whole body, might perhaps have led a similar life as *Colobocentrotus*, attached to the rocks washed by the surf; as the necessary condition for this would be that its tubefeet

solved and disappeared.[1] In the apical system it is important to notice that there is no original single anal plate filling up the periproct, as has been assumed.

On the characters of young Cidarids a number of observations are given by Döderlein (Jap. Seeigel. I. Cidaridæ, p. 27—32). Among the most conspicuous features of the young specimens (after the postlarval stage) may be pointed out the scarcity of secondary tubercles (spines), which are at first represented almost alone by the scrobicular and marginal ambulacrals; the areoles are not deepened and are widely confluent. The pores are markedly oblique, and the wall and ridge have not assumed their special characters. The ocular plates are small and widely excluded from the periproct by the large genital plates, which are still without genital pores. The size of both apical system and peristome is relatively larger than in the adult; the number of plates on peristome and periproct is small.[2] Also the number of the ambulacral plates corresponding to an interambulacral plate at the ambitus is considerably smaller than in the adult.

Concerning the rate of growth Grieg (Echinodermata. Scientif. Res. "Michael Sars" Exp. 1910. III. p. 39. (1921)) has shown that *Stylocidaris affinis* must be at least two years in reaching a size of ca. 34—39 mm. h. d. (largest size of this species recorded is 43 mm. h. d.); otherwise nothing is known about this question or about the life duration. — The arival at sexual maturity is marked by the appearance of the genital pores. About the breeding seasons there are observations only on a few littoral forms; whether there is more than one breeding season in the year, such as has been demonstrated for *Diadema* in the Gulf of Suez (cf. Munro Fox. Lunar Periodicity in Reproduction. Proc. R. Soc. B. 95. 1925) is uncertain. Hybrids appear to occur not so very rarely in nature. In the present work presumable hybrids between *Stylocidaris bracteata* and *Stylocidaris Reini*, and between *Goniocidaris clypeata* and *G. mikado* are described. Another probable case of hybrids, viz. *Stylocidaris affinis* and *Tretocidaris Bartletti* was pointed out in the Report on the Echinoidea of the German S. Polar Exp. 1909.

Anomalies of the test are not very rare, sometimes quite evidently caused by the presence of parasitic Gastropods — as in *Stereocidaris indica*. Various instances have been carefully described by Jackson (Phylogeny of Echini) and Koehler (Anomalies, irrégularités et déformations du test chez les Échinidés. 1924. Ann. Inst. Océanogr. I.). Several other cases are mentioned and described in the present work. The present author is not inclined to see in such anomalies anything that can be used for drawing conclusions as to general morphology or phylogeny (atavism!). There is no reason to enter on the various cases of anomalies here. I would only recall the very curious case of a 6-rayed dental apparatus in an otherwise perfectly normal, 5-rayed *Notocidaris gaussensis*, which appears to have evaded the attention of Jackson. (cf. my report on the Echi-

[1] Döderlein's suggestion (Jap. Seeigel. I. Cidaridæ, p. 32) that the interradial plates of the peristome probably derive from the first, unpaired, interambulacral plate, which he supposes to pass directly on to the peristome and then to divide and thus give origin to the following interradial peristomial plates, is disproved by the observations set forth in my paper quoted above.

[2] Döderlein here (p. 28) still accepts the erroneous assumption that the periproctal plates are formed by the splitting up of an original large central (suranal) plate covering the whole periproct.

noidea d. deutschen Südpolar-Exp. Taf. V. 16); further the case of a double ambulacrum in a specimen of *Stylocidaris effluens*, represented on Pl. 59. 3. of the Cidaridæ, "Albatross" Philippine Exped. Also the curious bifid primary spines of *Ctenocidaris Perrieri* (Koehler. Echinod. Deux. Exp. Antarct. Française, Pl. XIII. 5) and of *Schizocidaris assimilis* (the present work, Pl. XVII. 9) may be recalled, as also the double-headed small globiferous pedicellaria of *Cidaris abyssicola* figured in Pl. 17. 9. of my paper "On some West Indian Echini" (Bull. U. S. Nat. Mus. 74. 1910), and the bifurcating tubefoot of *Goniocidaris umbraculum* mentioned in my report on the Echinoids of New Zealand (Vid. Medd. D. Nat. Foren. 73. 1921. p. 148).

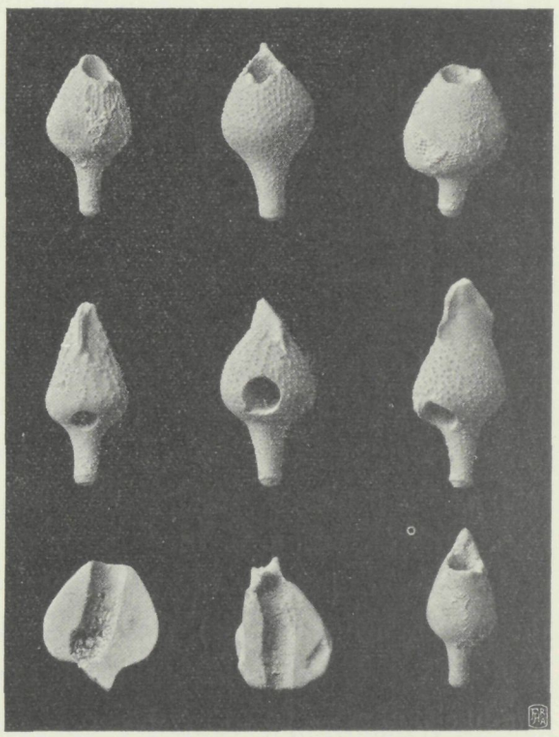


Fig. 26. Spines of *Tylocidaris vexillifera* Schlüter, attacked by a boring organism. (After Grönwall).

Enemies of Cidarids appear to be few. They are not used for food by man, and only few instances are known of fishes eating them. Gourret[1] records having found "Cidaris" in the stomach of *Crenilabrus pavo* in the Mediterranean. The observations by Prouho (Rech. s. l. Dorocidaris papillata) that *Mugil* will in aquaria "arracher par des morsures successives" all the spines of a Cidaris is no proof that this fish will attack Cidarids in the free, under natural conditions. It seems that Tetrodont fishes may attack Cidarids, biting off their spines — see the observation recorded under *Eucidaris Thouarsii* (p. 397). Of great interest is the statement by Schaffer[2] that he has found plates of Cidarids in Coproliths from the Miocene. — That Gastropods will attack Cidarids is beyond doubt, cf. the observations recorded under *Stylocidaris Reini* (p. 346); another similar observation, on *Histocidaris elegans*, was recorded in the "Albatross" Philippine Echinoidea, I. Cidaridæ, p. 253; in this case it was, however, uncertain whether the snails killed the Cidarid or they did only attack it after its death. — Prouho (Op. cit.) has seen *Asterias glacialis* eat Cidaris in an aquarium; that large Asterids will eat Cidarids also in the free seems highly probable.

Parasitic Gastropods (*Mucronalia*) are not rarely found attacking Cidarids. When infesting the test they may cause great anomalies there (e. g. *Stereocidaris indica*); when infesting the primary spines these are generally aborting and transform into galls (e. g. *Stylocidaris tiara*).[3]

[1] "Examen de la pâture de quelques poissons comestibles du Golfe de Marseille". Ann. Mus. Marseille. IV. 1892. (After Zool. Record; paper not seen by the author).

[2] "Der Marine Tegel von Theben-Neudorf in Ungarn" Jahrb. d. Geol. Reichsanstalt Wien. XLVII. 1898, p. 546.

[3] The first case of parasitic Gastropods in the primary spines of Cidarids was recorded by Hupé in 1860 (Observations d'un mode particulier de parasitisme offert par un Mollusque gastéropode du genre Stylifer. Revue & Magasin de Zoologie. 2. Sér. XII. p. 118).

The spines of the fossil *Tylocidaris vexilifera* are often attacked by some boring organisms, the nature of which remains unknown (Fig. 26). It has been suggested that these spines were attacked only after the death of the Cidarid, from the apparent fact that in one case the borer entered from the base of the spine (the middle figure in the lower series of fig. 26) (cf. Grönwall. Borrade Echinidtaggar från Danmarks Krita. Medd. Dansk. Geol. Foren. Nr. 6. 1900). This, however, seems rather improbable. Judging from what is else known of the biological relations of such boring organisms we must assume that they bored in the spines of the living Cidarid, and the single spine with the hole in the base (— among numerous spines with the holes otherwise situated —) may be assumed to have been attacked in its basal part a little laterally, the spine having broken off, when the hole had become so large that the basal part of the spine was eaten away.

A parasitic Nematod was observed in the gonads of *Aporocidaris Milleri* (p. 113). A very peculiar parasitic organism, *Echinophyces mirabilis* Mrtsn., apparently a kind of plant related to the Phycomycetes or the Myxomycetes, was found to infest the spines of *Rhynchocidaris triplopora* where it produces the extraordinary anomaly of the formation of a new genital duct, opening at the edge of the peristome (Ech. deutsche Südpolar Exp. p. 12—17. Taf. XII). Also in *Ctenocidaris speciosa* and *Ct. Perrieri* Koehler the same parasite occurs, producing there a similar anomaly of the genital pores. (Ech. Swedish S. Polar Exp. p. 9—11; Koehler. Échinodermes Deux. Exp. Antarct. Franç. p. 154—159.).

Another instance of what appears to be a sort of parasitic plant-organism is described in the present work (p. 391), viz. in *Eucidaris metularia*, some specimens from the Hawaiian Islands having some of the tubefeet thick and swollen from the presence of great numbers of small *Navicula*-like bodies — so to say a sort of elephantiasis.

Commensals are not common, unless the various organisms that find attachment on the primary spines are regarded as such. Now and then a Polynoid worm may be found on the test, for instance below the scrobicular spines. An interesting commensal is the little Synaptid *Tæniogyrus cidaridis* Ohshima, which winds itself round the primary spines of *Stylocidaris Reini*. Among the hairs of the primary spines of *Rhopalocidaris rosea* specimens of a *Folliculina (Lagotia viridis* Wright) are not rarely found (p. 222).

Classification of the Cidaroidea.

The history of the classification of Cidarids is given by H. L. Clark in his work "The Cidaridæ" (1907), and especially, in great detail, by Lambert & Thiéry in their "Notes Échinologiques. I. Sur le genre Cidaris" (Bull. Soc. Sci. Nat. Haute-Marne. 1909). — While I would protest most emphatically against the two authors, when they declare, without any reservation, various figures of Cidarids in old, pre-Linnean works to represent such and such species — figures which are in reality so poor that it is quite impossible to see with certainty which species they are meant to represent — and then on the base of their interpretation start to upset nomenclature, I find the historical account given in the paper quoted, when disregarding their interpretations and often quite sophistical reasonings, all that could be desired. I shall, therefore, refer to the said paper, as to that of H. L. Clark for the older literature up to the time of the "Revision of the Echini" (1872). In this latter work the recent Cidarids — in all 15 species known by that time, one of which (*Goniocidaris geranioides*) is of doubtful specific rank — are referred to the genera *Cidaris* (= *Eucidaris*), *Dorocidaris* (= *Cidaris*), *Phyllacanthus*, *Stephanocidaris*, *Porocidaris*, and *Goniocidaris*, forming the single family *Cidaridæ*, under which is named, — apparently both as a synonym only and as a subfamily, — *Goniocidaridæ*[1] Haeckel.

The first to attempt a real classification of the Cidarids, recent and fossil, was Pomel. In his "Classification méthodique et genera des Échinides vivants et fossiles" (1883, p. 108—112) he divides all the Cidarid genera — of which he establishes quite a number, unfortunately without naming the genotypes — into three subfamilies, the "Cidariens", with non-conjugate pores and without impressions in the sutures or on the plates, the "Goniocidariens", with non-conjugate pores and with grooves or impressions on the plates, and the "Rhabdocidariens", with conjugate pores.

A very earnest attempt at a natural classification was then given by Döderlein in his excellent work "Die Japanischen Seeigel. I. Cidaridæ u. Saleniidæ" (1887). Through his deep-going studies he reached some very important results, which ought to stand as a firm basis for all future considerations of the mutual affinities of Cidarids. First of all he makes the very important

[1] It does not appear clearly in the later works of Agassiz: "Panamic Deep Sea Echini" and of Agassiz & Clark: "Hawaiian and other Pac. Ech. Cidaridæ" whether the name Goniocidaridæ is meant as a subfamily or as a synonym of the family Cidaridæ; it seems rather as a subfamily, but it is nowhere indicated which other subfamily or subfamilies there are within the family. According to the sense given to the name by its author Haeckel in his "Generelle Morphologie d. Organismen" 1866, II. p. LXX—LXXIII it is simply a synonym of the family Cidaridæ, as it comprises all true Cidarids. (The work is constantly quoted by Agassiz as "Entwickl. Gesch. 1866", which is rather misleading. Haeckel did not publish any "Entwicklungsgeschichte", but the Vol. II of his "Generelle Morphologie" bears the subtitle, "Allgemeine Entwicklungsgeschichte der Organismen").

observation that in the oldest (triassic) true Cidarids the plates show a bevelling of their lateral edges, which means that the test has been to some degree movable, the edge of the interambulacra covering the edge of the ambulacra. — Also in the young *Austrocidaris canaliculata* he finds a trace of imbrication of the coronal plates (Taf. IX. 6). — Further he shows that the conjugate pores represent a more specialized condition than the non-conjugate, and that the crenulation of the primary tubercles is a character "der bei den Cidariden auf verschiedenen von einander unabhängigen Entwicklungslinien allmählig verloren gegangen ist". Whether the crenulate or non-crenulate condition is the more primitive is uncertain, since both types occur together among the oldest, triassic forms, the non-crenulate forms being even the more numerous; but, whereas it is evident that among later forms the non-crenulate condition has developed from the crenulate, a transition from the smooth into the crenulate type "ist nirgends nachzuweisen" (p. 38). — The genera of the Cidaridæ he divides into five groups, — viz. a. with movable test; b. with not movable test, non-conjugate pores and crenulate tubercles; c. with not movable test, non-conjugate pores and non-crenulate tubercles; d. with not movable test, conjugate pores and crenulate tubercles; e. with not movable test, conjugate pores and non-crenulate tubercles. It is thus only a practical subdivision he gives, since he uses here the character which he has himself shown to be of no primary classificatory value, the crenulation or absence of crenulation, as one of the main distinguishing characters; in accordance therewith he does not give these groups special subfamily names.

The next author to deal with the classification of the Cidarids is Duncan in his "Revision of the Genera and great Groups of the Echinoidea" (Journ. Linn. Soc. Zoology. XXIII. 1889). He does not know Döderlein's work, and rejects Pomel's classification, because it does not fit with his main principle, viz. that it is "impossible to admit genera which are not differentiated by characters which have a decided and important physiological value" (p. 3). Evidently he knows all about which characters are of physiological importance and which are not. Perforation or non-perforation and crenulation or non-crenulation is of no value, because "it is a mistake to believe that it is a structure which relates to the strength of the spine-muscles". Conjugated, or the reverse, condition of the pores is of "no physiological importance whatever", and, therefore, "any classification in which these characters are used is artificial". On the other hand, the number of interradial coronal plates is declared to be of physiological importance, "and there is a great temptation to consider typical Cidarids as having but a few, say not more than seven, in a vertical row" (p. 29—30). From these rather extraordinary premisses he reaches the result that most of the previously established genera are not even worthy of a subgeneric position, but that *Rhabdocidaris*, *Leiocidaris*, *Dorocidaris*, *Stephanocidaris*, *Phyllacanthus* and *Porocidaris* are "fairly useful artificial divisions", but in reality only synonyms of *Cidaris*. Only *Goniocidaris* is acknowledged as "a good subgenus". As "not satisfactory" genera are mentioned *Temnocidaris* and *Polycidaris*, whereas he appears to have no objection to acknowledging *Diplocidaris* and *Tetracidaris* as good genera.

This classification represents a great step backwards from the results reached by Pomel and, especially, by Döderlein. Quite apart from the fact that Duncan's statements about which structures are and which are not of physiological importance are as naive as they are apodictic, the principle that only characters of physiological importance can afford reliable foundation for generic divisions is in itself a great mistake. It is a well known fact that structures of apparently little or no physiological importance are the less liable to changes and therefore may continue unaltered, bearing witness of natural relationship between forms otherwise altered, even so much that their affinities may be more or less obscured. Specification would seem unnecessary; let me name only a single, but rather striking example — the parasitic Gastropod *Entoconcha mirabilis*, where the larval shell gives the clue to the natural relationship.

Like Duncan also De Loriol (Catalogue Raisonné des Échinod. de Maurice. Mém. Soc. Phys. & Hist. nat. Genève, XXVIII, 1883, p. 8) states that, in view of the great number of transitional forms "il est douteux pour moi s'il est vraiment nécessaire de diviser ce genre admirable qui apparaît dès la fin de l'ère paléozoïque, et traverse dès lors tous les étages, sans manquer dans aucun, pour se retrouver enfin, dans les mers actuelles, sans avoir modifié aucun de ses caractères". This is much more simply expressed by Bell in his "Catalogue of the British Echinoderms" (1891, p. 139). He names under *Cidaris* all the various genera established, gives a diagnosis of the genus fitting the whole family and then states: "A large number of generic forms have been quite unnecessarily distinguished, as the synonymy of the genus shows". — Quod erat demonstrandum!

In 1900 Lambert gives in his "Étude sur quelques Échinides de l'Infralias et du Lias" (Bull. Soc. Yonne. I. 1899, p. 50, 53) a new arrangement of the Cidarids in the four subfamilies: *Streptocidarinæ*, comprising the forms with movable test, *Tetracidarinæ*, comprising only the genus *Tetracidaris*, *Orthocidarinæ* for the genus *Orthocidaris*, and *Stereocidarinæ*, comprising all the rest of the Cidarids; the latter is subdivided into the tribus *Rhabdocidarinæ*, viz. the forms with crenulate tubercles, and *Leiocidarinæ*, those with smooth tubercles. This classification is also adopted in Lambert & Thiéry's "Essai de Nomenclature Raisonnée des Échinides", with the exception that *Orthocidaris* is removed to the Pedinids (—which seems correct).

In the same year J. W. Gregory gave in the chapter Echinoidea in Ray Lankester's "A Treatise on Zoology", III. Echinoderma, a new arrangement of the order Cidaroida, which is made to comprise the following four families: Lepidocentridæ, Archæocidaridæ, Cidaridæ, and Diplocidaridæ; to the latter family are referred only the two genera *Diplocidaris* and *Tetracidaris*.

In his work on the Japanese Cidaridæ (1887) Döderlein had come to the result that the pedicellariæ, especially his "Form A" (= the large globiferous pedicellariæ) in many cases are of no small value for the classification of the Cidarids; "sie geben jedenfalls sehr brauchbare Charaktere zur Unterscheidung von Arten . . . . . Zur Charakterisirung von grösseren Gruppen innerhalb der Familie finde ich aber Pedicellarien sehr wenig brauchbar" (Op. cit. p. 34).

In my work on the "Ingolf" Echinoidea (I. 1903) I undertook a more profound study of the pedicellariæ of the Regular Echinoids and came to the result that — contrary to the opinion of Döderlein — "the pedicellariæ of the Cidarids (as also of several other families of Echinoids) yield excellent generic characters, while they may only more rarely be used for distinguishing between the species" (p. 15). This result led me to a new grouping of the species of recent Cidarids as far as they had been accessible to me, and even to establishing some new genera, *Tretocidaris*, *Schizocidaris*, *Acanthocidaris*, *Petalocidaris* and *Histocidaris*, diagnosed mainly by the characters of their pedicellariæ. As for the grouping of the genera in larger divisions, subfamilies, it was pointed out that possibly the presence or absence of an end tooth on the valves of the large globiferous pedicellariæ might afford a basis for such grouping. In a concluding remark (p. 31) it was stated that "when in the diagnoses of genera given here other features than pedicellariæ and spicules have only been mentioned exceptionally the opinion of course is not that these structures should be sufficient for definitive diagnoses. It has already been emphasized above, and I shall here emphasize once more that all features must be thoroughly examined in order to get the mutual relations of the forms established. That I have here only treated the pedicellariæ more thoroughly is a consequence of the fact that neither my material nor my time has permitted me to treat the other features more particularly. The system of the Cidarids cannot get its definitive formulation, until all features have been examined in a greater number of species (or best in all species). What is given here is a provisional classification . . . ."

While the classification resulting from the study of the pedicellariæ was in the main acknowledged as correct by de Meijere ("Siboga" Echinoidea, 1904) and especially by Döderlein (Echinoidea d. Deutschen Tief-See Expedition 1906), it was very emphatically rejected by Agassiz in his "Panamic Deep-Sea Echini" (1904) and by Agassiz & H. L. Clark in their "Hawaiian and other Pacific Echini". I. Cidaridæ (1907), as also by H. L. Clark in his monographic paper "The Cidaridæ" (1907), and further by Lambert & Thiéry in their "Notes Échinologiques. I. Sur le genre Cidaris" (1909) and in their "Essai de Nomenclature Raisonnée des Échinides" (1910). There is no reason to enter here again on the objections raised by the two first authors against my classification; they were dicussed in the Introduction to Part II of my "Ingolf" Echinoidea (1907) and, especially, in my "Echinoidea d. Deutschen Südpolar-Expedition" (1909) in the chapter "Einige Bemerkungen über die Klassifikation der Cidariden" (p. 45—53), at the end of which is given a summary of the classification of recent Cidarids, somewhat emended from that given in the "Ingolf" Ech. I., but on the same lines. I would only here again emphasize, that when there is constantly referred to my so objectionable, even "unscientific", principle of classification: that only the pedicellariæ should be taken into account, this is an evident injustice. As emphasized in the paragraph quoted above from the "Ingolf" Ech. I. (as in several other places) my opinion, of course, was, — as it still is and will remain — that **all** characters must be taken into consideration and duly weighed, before we can expect to reach a truly natural classification, be these characters macro- or microscopical. The designation "unscienti-

fic" applies to those, who maintain a priori that microscopic characters must not be taken into consideration in classification. If I have a "principle", it is this that species differing essentially in any character, be it now in the character of the test, the spines, the pedicellariæ, the spicules, or the internal anatomy, ought not to be referred to the same genus; what "essentially" means cannot be said in general. Only a profound comparative study of the group to be treated can give information as to this question.

It is fair to say that the said authors, after having reduced me entirely "in absurdum", add that I have myself protested against the idea that the pedicellariæ should be taken as the sole generic characters; I would suggest that it might perhaps have been more fair to call attention to this fact before starting to turn my classification into ridicule. Also I notice with some satisfaction that the genera which I established in the "Ingolf" Ech. mainly from a study of the pedicellariæ alone have, on a further detailed study of all their characters, proved to hold good (with the only exception of *Petalocidaris*, which I cannot now give more than subgeneric rank), and that H. L. Clark has also, though reluctantly and step by step, felt complied to accept *Tretocidaris* and *Histocidaris* in the meaning I gave them. As to *Schizocidaris* the character upon which it was established has proved to be not of generic value; nevertheless the genus is perfectly well characterized and, evidently, a very natural one, as was shown in my report on the Cidaridæ of the Albatross Philippine Expedition (1927, p. 276), and as will also appear from the present work. Regarding *Petalocidaris* it is rather funny that this was (besides *Acanthocidaris*) the only one of my genera recognized by Lambert & Thiéry, while all the others were slaughtered without mercy; however, the authors were led to this result by the erroneous information from Bell that it had conjugated pores. Had Bell seen the real character of its pores, *Petalocidaris* would have shared the fate of the other genera.

The reason why Lambert & Thiéry object so strongly to the use of the characters of pedicellariæ in classification is this that they cannot be applied to the fossils. This is in general true, of course, and as the number of Echinoids known as fossils is very great, considerably exceeding that of the known recent species, it is certainly very regrettable that we cannot treat them on quite the same line as the recent species. As the said authors are almost exclusively confining their studies to the fossils, it is also intelligible, one may even say fair, that they fight for their pet objects and hate to acknowledge that they are more or less incompletely preserved. But, — as I have set forth in my "Echinological Notes. II. A new principle of classification" (Vid. Medd. Dansk. Naturh. Foren. 1910) — to forbid using some characters in classification, because they are not to be observed in the fossils, is truly unscientific. We have simply got to acknowledge that the fossils are thus far incompletely preserved,[1] and that in certain cases it is im-

[1] This has also repeatedly been emphasized by Agassiz in the Introduction to his " Challenger" Echinoidea. "Such important guides as the nature of the pedicellariæ and the structure of the abactinal system are wholly wanting for comparison, and the difficulty of deciding on the relationship from the test and radioles alone, is too well-known to require further comment" (Op. cit. p. 33). Apparently he has later on forgotten what he said here; at least, his

possible to find out their true affinities. Fortunately a very great number of the fossils are so well characterized by the structures of the test alone that their affinities are beyond question; this applies especially to the irregular Echinoids, in which, on the whole, the pedicellariæ are only of subordinate value for classification. It is mainly in the suborder of the *Camarodonta* and in the Cidarids that the pedicellariæ are of so great importance for classification — but even here many forms have so important structural characters in the test that their classificatory position is beyond doubt. The trouble only comes in, where the structural characters of the test are very uniform, as in the species referred by Lambert & Thiéry to the genera *Cidaris*, *Dorocodaris* and *Plegiocidaris*. Here is no help; we have no clue to deciding what are the true relationships of quite a number of the species referred to these genera. (In several cases the spines may help us to recognize the true affinities; thus for instance the typical *Plegiocidaris*-forms have a very characteristic shape of spines; see fig. 14.5).

It is a fact that many of the recent Cidarids, though perfectly characterized by their spines and pedicellariæ, have the characters of their test very little diversified. If one had to classify them from the characters of the test alone, the result would necessarily be a perfect confusion. It is, therefore, no wonder that Lambert & Thiéry in their "Essai de Nomenclature Raisonnée", when treating the recent Cidarids (and other Echinoids) on their notorious principle that classification must be based on such characters alone as can be found also in the fossils, have come to the most extraordinary results. The recent forms are thrown about among the fossils in the most astounding way, nearly related species, nay even synonyms referred to different genera. To quote one example: *Stereocidaris japonica* is recorded as *Phalacrocidaris japonica* (p. 149) as *Dorocidaris japonica* (p. 560), and as *Cidaris tenuispina* (p. 559). — Impossible to take this seriously! In the present work I have given in the list of literary references under the various species, in order to have it complete, also the names under which they are found in Lambert & Thiéry's work, but as a rule there is no comment — that would be too much to make out of such absurdities.

H. L. Clark in his work "The Cidaridæ" treats also the fossil genera (— of which he recognizes as sufficiently characterized only the following seven: *Diplocidaris*, *Porocidaris*, *Polycidaris*, *Orthocidaris*, *Temnocidaris*, *Tetracidaris*, and *Tylocidaris*, besides, of course, *Stereocidaris* —) including them even in his key to the genera. Finally, in his "Catalogue of the Recent Sea-Urchins of the British Museum" (1925) H. L. Clark reviews the genera of recent Cidarids and arrives at results in the main agreeing with mine. It is especially of importance that he now feels convinced that "essentially different large globiferous pedicellariæ do not occur in species of Cidaridæ of the same natural genus "— which means that the specialists on recent Echinoids of today practically agree on the value of pedicellariæ in classification. I expect that the considerable classi-

later most emphatical protest against the use of the characters derived from the pedicellariæ in classification does not agree well with a sentence like the above. For the rest he never made a practical use of pedicellariæ for classificatory purposes, though he gave, both in the "Revision" and in the "Challenger" Ech., detail figures (more or less satisfactory) of pedicellariæ from quite a number of Echinoids.

ficatory value which is also ascribed to the characters of the cortex-layer of the primary spines in the present work, will likewise meet the approval of my fellow-workers. As we all agree also on the value of the characters of the test, there is good hope of general agreement among Echinologists of today as to the classification of Cidarids — which may again well be taken to mean that we are gradually approaching a classification expressing the natural relationships of the numerous forms into which the great group of the Cidarids has specialized itself.

Before entering on a discussion of the classification of the Cidaridæ it may be practical briefly to resume the main characters on which classification must be based, and the relative value to be ascribed to them.

1. The coronal plates. In the ambulacra the characters of the pores are of eminent importance, whether they are confluent, conjugate or of a more intermediate character, separated by a moderately broad wall, raised in various ways. Only exceptionally (*Rhynchocidaris*) the neuropore offers a character of classificatory value; the oblique position of the pores is characteristic in the *Ctenocidaris*-group. The "ridge" does not offer characters of greater classificatory value. The tuberculation of the interporiferous zone of the ambulacra is of eminent value for distinguishing species, but rarely offers characters of generic value — viz. in the case of *Procidaris*, in which the marginal ambulacral tubercles are perforate, while in all other Cidarids they are imperforate. It is very questionable whether the irregularity sometimes found in the marginal tubercles is of more than specific value; it is certainly not so in e. g. *Histocidaris Cobosi* or *Phyllacanthus irregularis* — and probably it is of even less value in *Stereocidaris grandis;* in a number of fossil forms, e. g. *Paracidaris*, *Diplocidaris*, where it represents a beginning formation of compound ambulacral plates, we may well be justified in seeing herein a character of generic value. — In the arrangement of the pore-pairs the diploporous condition is, of course, of high classificatory value. Among recent Cidarids a diploporous condition is found on the peristome, but not on the test, in *Eucidaris* and *Phyllacanthus*, and the same holds good of the fossil *Plegiocidaris*. A diploporous condition on the corona is known only in the genera *Diplocidaris* and *Tetracidaris*.

In the interambulacra the foremost character is the number of vertical columns of plates — four or more in the Archæocidarids and in *Tetracidaris*, two only in all the other Cidarids. The crenulation of the tubercles is not a very reliable character, as more or less conspicuous traces of crenulation may be found in most species; still it is a character always to be taken into account, and generally it is not doubtful whether a species is to be characterized as having crenulate or smooth tubercles. As a rule it may be said that distinctly crenulate forms are not to be regarded as congeneric with such as have smooth tubercles. A higher value than generic can evidently not be ascribed to this character. — The primary tubercles are perforate, with the exception of *Tylocidaris* and *Sardocidaris*, and, apparently, the triassic *Aplocidaris;* in the former, moreover, the upper tubercles may be more or less distinctly perforate. It seems that also some of the old triassic Cidarids have imperforate (and non-crenulate) tubercles. This character may reasonably be regarded as of generic value. Otherwise there is little in the tuberculation of

the interambulacra of greater classificatory value; the more or less confluent or effluent character of the areoles, the arrangement and size of the secondary tubercles are of great value as specific characters, but scarcely of generic value. (Only the genus *Polycidaris* is mainly characterized by its completely confluent areoles). On the other hand the impressions in the plates (*Temnocidaris*,) or grooves in the sutures (Goniocidarids, *Stereocidaris*, *Typocidaris*), may afford characters of generic value. — The number of the interambulacral plates in a series is of little classificatory value, the more so as it usually increases with age, as a glance at the measurements given under the various species in the systematic part of this work will show.

Finally a character of very high classificatory value is the imbrication of the coronal plates in Archæocidarids, and the bevelling of the plates in the oldest true Cidarids. We have here, evidently, family or subfamily characters.

2. Apical system and peristome do not offer characters of prominent value for classification. It should especially be emphasized that the character of the oculars, whether exsert or insert, (dicyclic or monocyclic apex of writers on fossil Echinoids) is scarcely ever of generic value (except, perhaps, in *Diplocidaris*). Likewise the periproct hardly offers characters of more than specific value, usually not even that. The enlarged madreporite of *Phyllacanthus* appears to be a good generic character. The relative size of apical system and peristome is of some value (*Aporocidaris*, *Phyllacanthus*); also the number of the ambulacral plates on the peristome may be of generic value (very few in *Aporocidaris* and *Ogmocidaris*), whereas hardly any classificatory value can be ascribed to the interradial plates on the peristome.

3. Spines. The primary spines are of very considerable classificatory value, both specific and generic.[1] This applies both to the shape and the structure of the spines, only in a few cases (*Phyllacanthus*, *Actinocidaris*) to the inner structure, but in a very high degree to the cortex-layer and its hair-covering — or the total absence of hairs (*Calocidaris*, *Homalocidaris* and some *Histocidaris*-species). The basal part of the spines — collar, neck, milled ring — is of less importance for classification, only exceptionally (*Homalocidaris*) the milled ring is of a very characteristic shape, which may be a character of generic value. — The oral primaries are in several forms so characteristic that they afford generic characters (*Histocidaris*, *Notocidaris*). — The secondary spines also are of considerable value for classification, e. g. the clubshaped spines of *Rhopalocidaris* and *Ctenocidaris* etc.

4. Pedicellariæ. Here we have characters of very high classificatory value, partly of spec-

[1] I am thus in decided opposition to Agassiz, when he speaks ("Challenger" Ech. p. 49) of the "utter impossibility of distinguishing the species of this family (viz. the Cidaridæ) by any difference in the shape of the primary radioles" — because of the fact that spines of very different shapes may be found in one and the same specimen. No doubt, we have to be cautious in the use of the spines in classification, and, no doubt, Agassiz is right in maintaining that much of what palæontologists make out from isolated spines is of little value. But we have got to be cautious in the use of all sorts of characters; none is absolutely reliable per se. Variation is to be met with everywhere, in every kind of structure. This makes the task of classification a most difficult one, and often the systematist's decision in disputable cases must depend more or less on his personal feelings and tact. But this does not mean that classification is a hopeless case.

ific, partly of generic and of sub-family value; the latter case is a natural consequence of the fact that we have definite groups of genera with almost identical large globiferous pedicellariæ — the *Stylocidaris—Prionocidaris*-group with a well differentiated terminal opening and a limb of projecting rods on the stalk, the *Stereocidaris*- and the *Goniocidaris*-group with a much less specialized type of globiferous, and the *Cidaris—Tretocidaris*-group with a large end tooth on the large globiferous pedicellaria; also the *Histocidaris*-group with only tridentate pedicellariæ; again the absence of tridentate pedicellariæ in the *Ctenocidaris*-group is a conspicuous character.

5. Spicules of the tubefeet are of almost no classificatory value, whereas the spicules of the intestinal wall are of two markedly different types: the simple, three-radiate type in the *Stereocidaris*- and the *Goniocidaris*-group, and the small glassy plates in the *Stylocidaris—Prionocidaris*-group. In the *Histocidaris*-group they are almost wanting.

6. The inner anatomy does not appear to offer characters of value for classification; only the inner processes on the peristomial ambulacral plates in the *Histocidaris*-group may be recalled.

7. The colour is of some value for classification, but, of course, not of any high order.

Thus we have quite a number of characters on which to found the classification. To some degree we can say which characters are the more primitive, which the more specialized; thus we know a conjugate condition of the pores represents a higher degree of specialisation than the non-conjugate, the oblique, narrowly separated or even confluent pores representing the most primitive condition. Of course, also the diploporous arrangement of the pores on the test or the peristome represents a more progressed type. The crenulate tubercles on the whole represent a more primitive type than the non-crenulate, and the non-perforate tubercles found in a few forms can also be said with certainty to represent a very specialized type. The simple, erect, spiniform secondary spines may reasonably be regarded as a more primitive type than the flattened, appressed, more or less scale-like secondaries. The highly specialized hair covering of the primary spines evidently also represents a higher stage than the quite simple hairs, or even the total lacking of the hairs. Finally in the pedicellariæ it is quite evident that the large globiferous pedicellariæ with the well formed terminal opening and those with a powerful end tooth represent two specialized developments from those with a less elaborate structure of the subterminal opening. Thus we may well have some hope of tracing, to some degree, the true affinities and the phylogenetical development of the various recent and extinct types of the great order of the Cidarids. To put it, as does A. Agassiz ("Challenger" Ech. p. 18), in this way that we have a great number, say 20, variable characters, which may be combined in an endless number of ways, "at least 2^{19} combinations", which proves that it is "somewhat hazardous, to say the least, to attempt anything beyond the broadest indications of the outlines of the relationship", is entirely irrelevant. First the various "variables" are of very different value, and we are dealing with living (or formerly living) organisms, not with haphazard objects or quantities, which allow of a simple mathematical treatment.

What is to be tried here is to give the arrangement of the genera in families, subfamilies or other minor divisions; the genera themselves are here taken as given — the discussion of the limitation of the genera themselves will be found in the special, systematic part, under each genus separately.

First it will meet with general approbation to regard the Archæocidarids as a separate family. About this there has been no dispute; all recent echinologists as a matter of fact regard them as forming a separate family. The question is only whether the family should be included in the order of the Cidaroids or, as especially advocated by Jackson, they form part of a separate order, the *Perischoechinoidea*,[1] in contrast with and having no nearer relation to the other Echinoids. In my opinion there cannot be any doubt that the Archæocidarids are most intimately connected with the Cidarids proper and probably represent the ancestral stock from which the latter have been evolved.

The genus *Tetracidaris* was, because of its four columns of interambulacral plates, referred to the Archæocidaridæ in the first edition (1895) of Zittel s "Grundzüge", but in later editions it is referred to the Cidaridæ, as is also done rather unanimously by authors on Echinoids. The question can only be, whether we have got to accept Lambert's view that it should form a separate subfamily, *Tetracidarinæ*, or we should, with Gregory, regard it as belonging together with *Diplocidaris* to a separate family, *Diplocidaridæ*. As both genera agree in the very characteristic arrangement of the pores in double series, differing therein from all other Cidarids, I think Gregory's classification the more natural, as expressing the rather evident affinity of *Tetracidaris* to *Diplocidaris* from which latter it has almost certainly evolved.

Another group rather well marked off from the great bulk of the Cidarids is that of the forms with movable test; Lambert has established a subfamily *Streptocidarinæ* for this group of genera (*Miocidaris*, *Triadocidaris*, etc.) which may be adopted, though I cannot agree with Lambert & Thiéry in excluding from this subfamily (or family) such genera as *Mikrocidaris* and *Aplocidaris*. To this group also belongs the genus *Anaulocidaris*.

In the great number of recent and fossil Cidarids left after the removal of the few above named genera to the subfamilies (or families) Streptocidaridæ and Diplocidaridæ it is not easy to find characters usable for a natural division. The division adopted by Lambert & Thiéry into the *Rhabdocidarinæ*, with crenulate tubercles, and the *Leiocidarinæ*, with non-crenulate tubercles, is, of course, quite practical, in spite of the fact that the crenulation of the tubercles, as seen

[1] It may well be worth while to recall here the classification set forth by Haeckel in his "Systematische Phylogenie" II. 1896. (p. 482), which is otherwise not quoted in the more recent works dealing with Echinoid classification. He divides the class of the Echinoids into the three subclasses, Cystechinida, Palechinida, and Autechinida; the first comprises the orders Promelonaria (Cystocidaris) and Eumelonaria (the families Melonitida and Pholidocidarida); the subclass Palechinida comprises the orders Stenopalmaria (Bothriocidaris) and Eurypalmaria (the families Lepidocentridæ, Archæocidaridæ and Plesiocidaridæ); the subclass Autechinida finally comprises all the rest of the Echinoids. Though I do not in any way find this classification acceptable, I think his attempt not much worse than many another classification, and equally well worth mentioning.

from the study of the recent forms, is not so absolute a character, as it would appear from the fossil forms; as a matter of fact, most recent forms have their upper tubercles more or less distinctly crenulate, and in the genus *Stylocidaris* we have a species with mainly crenulate tubercles (*Stylocidaris tiara*) evidently closely related to and congeneric with the other species of this genus, in which the tubercles are non-crenulate. The division of the Cidarid genera after the character of the crenulation or non-crenulation of the tubercles therefore cannot be a natural one,[1] because, as already pointed out by Döderlein (Jap. Seeigel. p. 38), it is highly probable that forms with non-crenulate tubercles have developed independently along different lines from such with crenulate tubercles. — Among recent Cidarids the *Histocidaris*-group and *Acanthocidaris* are the only genera which may be strictly characterized as having crenulate tubercles, but these two genera cannot, by any means, be said to represent a group of their own in contradistinction to the rest of the recent Cidarids. As a matter of fact, *Acanthocidaris* shows distinct affinities with *Prionocidaris*, whereas *Histocidaris*, together with *Poriocidaris*, forms a group for itself.

The only other character derived from the structure of the test which might be used as base for a grouping of the genera, the conjugate or the non-conjugate condition of the pores, is evidently of less value than the crenulation or non-crenulation of the tubercles, particularly because it is in many cases a matter of doubt, whether the pores should be designated as conjugate or not conjugate. It thus seems impossible from the characters of the test alone to reach a natural grouping of both fossil and recent Cidarids. We may then try, how far it is possible from a survey of the more completely known recent forms to reach a natural division.

As already said, *Histocidaris* and *Poriocidaris* clearly form one separate group, distinguished from the rest of the recent Cidarids by the total absence of globiferous pedicellariæ, and further by the presence of peculiar internal processes from the peristomial ambulacral plates. The other characters — absence of branching hairs on the spines, crenulate tubercles and non-conjugate pores — are less distinctive.

Another group is formed by the genera *Aporocidaris*, *Ctenocidaris*, *Notocidaris*, *Homalocidaris*, and *Austrocidaris*, characterized by the character of the pores: oblique, separated only by a very narrow wall which is very often perforate, so that the pores become confluent. The secondary spines are on the whole erect, cylindrical or club-shaped, only the scrobicular spines more or less distinctly flattened. The globiferous pedicellariæ, both the large and the small form — if the two forms can at all be distinguished — without an end tooth, the subterminal opening being not of an elaborate type; stalk without limb. Tridentate pedicellariæ entirely lacking. To this group also belongs *Rhynchocidaris*, an evident specialisation from *Ctenocidaris*. Further *Ogmocidaris* must be referred to the same group, as resembling in most respects *Austrocidaris*, from which it differs mainly in the character of its pedicellariæ, particularly in the presence of an end tooth on the valves of the small globiferous. But from *Ogmocidaris* we have again a natural passage to *Gonio-*

[1] That the name *Leiocidarinæ* also is unfortunate, since *Leiocidaris* is a simple synonym of *Phyllacanthus*, is a minor matter; were the group designated by that name a natural one, another name could easily be substituted for it.

cidaris, and therewith to the group of genera connected with the latter, viz. *Rhopalocidaris*, *Schizocidaris* and *Psilocidaris*. On the other hand the *Aporocidaris* — *Austrocidaris*-group, or the *Ctenocidaris*-group, as it may rather be designated, seems to be related to *Stereocidaris*, with which it agrees in the character of the pedicellariæ. In the characters of the test there is nothing to disprove such affinity — on the contrary, the presence of grooves in the sutures in *Stereocidaris* (and *Typocidaris*, if this latter is to be accepted as a separate genus) may suggest an affinity with the Goniocidarids.

In the rest of the recent Cidarids we may distinguish two larger groups, characterized very markedly by their large globiferous pedicellariæ. In one group, comprising the genera *Cidaris*, *Calocidaris* and *Tretocidaris*, the valves of the large globiferous pedicellariæ have a well marked end tooth above the subterminal opening; in the other group, comprising the genera *Stylocidaris*, *Eucidaris*, *Prionocidaris*, *Plococidaris*, *Acanthocidaris*, *Actinocidaris*, *Centrocidaris* and *Hesperocidaris* the valves of the large globiferous pedicellariæ have a terminal opening bordered by a fairly regular lip with teeth-like serrations; the stalk of the large globiferous pedicellariæ is usually provided with an elaborate limb of freely projecting rods. In both groups the small globiferous pedicellariæ have a distinct end tooth on their valves, and the tridentate pedicellariæ are well developed.

The two last genera of the recent Cidarids, *Phyllacanthus* and *Chondrocidaris*, cannot be included in any of the above groups, but must form a group of their own, probably both in the same group, though one, *Chondrocidaris*, has small globiferous pedicellariæ with a distinct end tooth, the other, *Phyllacanthus*, such without an end tooth. The large globiferous pedicellariæ have a large, subterminal opening, without an end tooth and without a limb on the stalk. Pores conjugate.

We may now see, whether it is possible to connect any of the fossil forms with one or other of these groups of the recent Cidarids.[1]

1. The *Histocidaris*-group. All of the recent species of this group were by Lambert & Thiéry referred to the genus *Plegiocodaris* Pomel, an exceedingly vaguely defined genus as diagnosed by them, not one of the characters being really distinctive. It is accordingly no wonder that a great number of species could be grouped in that "genus"; no less than 155 are enumerated by Lambert & Thiéry, ranging from the Trias to the recent days. This means that *Plegiocidaris*, as diagnosed by Lambert & Thiéry, is nothing but a lumber room fit to receive all such forms as do not show in the structure of their test any marked characters, but agree in having perforate and crenulate tubercles and non-conjugate pores. It is quite possible, in fact very probable, that some of these so-called *Plegiocidaris*-species are really related to the present day's *Histocidaris*-species, perhaps the direct ancestors of the latter; only we have no means of pointing out exactly

[1] I may recall here the very interesting chapter "Stammesgeschichte der Cidariden" in Döderlein's "Japanische Seeigel I. Cidaridæ", p. 45—47. The views there expressed in general conform with mine, as here set forth. A detailed comparison is difficult, especially because of rather great differences in the conceptions of the genera. But to Döderlein belongs the honour of having as the first seen the main tracks of Cidarid phylogeny.

which they are. This only we can say that the true *Plegiocidaris*, as this genus must be circumscribed after the characters of the genotype, *Plegiocidaris coronata* (Schlotheim), with the peculiar club-shaped spines and with pluriseriate pores on the peristome, has no nearer relation to the recent *Histocidaris*-group.

Whether any of the other fossil genera have a more close affinity to the *Histocidaris*-group it is impossible to say at our present state of knowledge.

2.—3. The *Stereocidaris*- and the *Goniocidaris*-group. We are here in the exceptional position that we can refer a number of recent species to a genus originally established for fossils, and comprising thus a fair number of both fossil and recent forms, ranging from the Cretaceous to the recent days. Closely related to *Stereocidaris* is also the fossil genus *Typocidaris*, it is even doubtful whether the latter can be maintained as separate from *Stereocidaris*. The genus *Temnocidaris* is through the recent species *Stereocidaris stylifera* very closely connected with *Stereocidaris*, forming the most specialized type of that group.

Any fossil genus more nearly related to *Goniocidaris* we cannot point out.

4—5. The *Cidaris*- and the *Stylocidaris—Prionocidaris*-group have no such distinctive characters in their test that we can expect to point out with any reasonable degree of certainty their relations among the fossils. It is highly probable that among the species referred by Lambert & Thiéry to the genera *Cidaris* (= *Eucidaris*) and *Dorocidaris* (= *Cidaris*) we have the relatives and ancestors of the two said groups, but we have no means of proving definitely which of the fossils are related to which of the recent forms, because the test cannot afford sufficient basis for conclusions in this direction. Here again, the "genus" *Cidaris* of Lambert & Thiéry, with 252 species, ranging from the Trias to recent days, and the "genus" *Dorocidaris* with 72 species ranging from the Cretaceous to recent days, are groups of embarrassment into which are put such species as do not show sufficient characteristics for referring them to any better defined genus.

6. The *Phyllacanthus—Chondrocidaris*-group very probably has relatives among the species of *Rhabdocidaris*, "*Leiocidaris*", and *Aulacocidaris*. It would seem that *Chondrocidaris* rather has its relatives among the *Rhabdocidaris*-species; its primary spines recall rather much those of some of the fossil *Rhabdocidaris*-species; that its tubercles are non-crenulate does not speak against its derivation from *Rhabdocidaris*, as we know that smooth tubercles represent a more specialized development from the crenulate type. The pores are conjugate in both.

Among the fossil species referred by Lambert & Thiéry to the genera "*Leiocidaris*" (= *Phyllacanthus*) and *Aulacocidaris* we have undoubtedly relations to both the genera *Phyllacanthus* and *Prionocidaris;* to point out in details which of these belong to one, which to the other of the two recent types is not possible; but there is for instance hardly any doubt that the *Leiocidaris* (*Rhabdocidaris*) *Sismondai* (Mayer) is a *Prionocidaris*.

Of the fossil genera there are still left: *Paracidaris*, *Procidaris*, *Polycidaris*, *Porocidaris*, *Cyathocidaris*, *Balanocidaris*, *Tylocidaris*, and *Sardocidaris*. Of these we may well suggest *Balanocidaris*, with its thick, clavate or glandiform primary spines, to be related to *Eucidaris*, in which there is also a

tendency of forming such thick spines. *Tylocidaris*, and the nearly related *Sardocidaris*, characterized by their imperforate tubercles, represent a separate branch with no nearer relatives among recent forms. Judging from the clavate spines of *Tylocidaris* it may be related with *Balanocidaris* and *Eucidaris*. *Porocidaris*, with the peculiar grooves in the areoles, and with conjugate pores, has certainly nothing to do with the recent *Histocidaris*-species (which were formerly referred to *Porocidaris*). *Procidaris*, with its perforate marginal ambulacral tubercles, is likewise unique; both evidently represent side-branches which have left no descendants. The rest of the genera do not offer any more prominent characters from which any relation with the recent forms may be deduced.

We may still dicuss the question whether the two groups: *Streptocidarinæ* and *Diplocidarinæ* should be designated as families or subfamilies. The matter is rather unimportant, but a decision must be taken. Against the family-rank of the Streptocidarinæ speaks the fact that the bevelling of the coronal plates is a character that disappears very gradually, so that a sharp line of distinction cannot be maintained; the question is much more this, whether the subfamily rank can rightly be maintained for this group. The diploporous condition is also rather gradually developed, and as otherwise in the Echinoids the polyporous character is usually not of sufficiently high rank for characterising families, I shall prefer here also to regard the diploporous condition as a character only of subfamily-value.

We have thus in the order of the *Cidaroidea* only the two families: *Archæocidaridæ* and *Cidaridæ*. The latter family is subdivided into the three subfamilies: *Streptocidarinæ*, *Stereocidarinæ* and *Diplocidarinæ*, the Stereocidarinæ again being divided into the groups or tribus: *Histocidarina*, *Ctenocidarina*, *Stereocidarina*, *Goniocidarina*, *Cidarina*, *Stylocidarina*, and *Rhabdocidarina*.

Keys to the subfamilies and tribus of the family Cidaridæ are given on p. 61 and p. 68.

Key to the families of the order Cidaroidea.

Interambulacral plates in four or more series. Coronal plates imbricating ..... *Archæocidaridæ*.

Interambulacral plates in two series only (exceptionally, *Tetracidaris*, in four series at the ambitus, but not adorally or aborally). Coronal plates usually with rigid sutures, only in the oldest forms more or less distinctly imbricating ..... *Cidaridæ*.

I. Family. **Archæocidaridæ** M'Coy.

Ambulacral plates imbricating adorally and bevelled under the adjoining interambulacrals. Interambulacra with four to many rows of thin plates, which imbricate aborally and laterally, and over the ambulacrals. Lantern sloping.

Other characters those of the order. (Pedicellariæ unknown).

This family differs from the Cidaridæ proper only in having more than two series of interambulacral plates, the coronal plates imbricating also in the older forms of Cidaridæ (the Streptocidarinæ). To separate the two families from each other, even placing them in different orders, as is done by Jackson in his „Phylogeny of the Echini" (1912) and by Lambert & Thiéry in their "Essai de nomenclature raisonnée des Échinides" (1910—1925) — to mention only the two more recent classifications — therefore seems to me quite unacceptable. On the whole, the separation of the Palæozoic Echinoids as a separate order, the *Perischoechinoidea*, seems to me a quite unnatural distinction, due, evidently, to the misconception of the pluriseriate condition of the interambulacra in the palæozoic forms as a highly specialised character, and to the former rather unanimous, but evidently wrong, consideration of *Bothriocidaris* as the most primitive form and the ancestor of all Echinoids. On relegating *Bothriocidaris* from the true Echinoids, and seeking the ancestor of Echinoids among primitive Edrioasteroids, like *Stromatocystis*[1], with a great number of irregularly arranged interambulacral plates, it is seen at once that the pluriseriate condition of the interambulacra in palæozoic Echinoids is by no means a specialised, but a primitive character, the biseriate condition in the younger forms the more specialised type — in accordance with morphological principles in general and with what was to be expected a priori, viz. that the oldest forms should be found to be the more primitive, the later the more specialised.

Accordingly, the only natural course must be to regard the Archæocidarids as the older, more primitive type, from which the Cidaridæ proper developed by the gradual reduction of the rows of interambulacral plates to two, and by the gradual giving up of the imbrication of the coronal plates. When Jackson (Op. cit. p. 257) regards *Miocidaris* as the ancestral form from which the Archæocidarids have developed, this is, accordingly, an obvious putting the matter

[1] Cf. Th. Mortensen. Bothriocidaris and the origin of Echinoids. Vid. Medd. Dansk Nat. Foren. København. 86. 1928.

upside down. The fact that the oldest Cidarids with two series of interambulacrals have still preserved the imbrication and bevelling of the coronal plates is a very important indication of this being really the way along which the Cidaridæ evolved from the Archæocidaridæ.

To the family *Archæocidaridæ* Jackson refers the genera *Eocidaris*, *Archæocidaris*, and *Lepidocidaris*, the genus *Xenocidaris* being placed under „incertæ sedis". Lambert & Thiéry refer the following genera to the Archæocidarids: *Archæocidaris*, *Cidarotropus*, *Lepidocidaris*, *Perischocidaris*, *Xenocidaris*, *Eocidaris*, *Permocidaris*, and *Anaulocidaris*, to which comes later (Op. cit. p. 554) *Nortonechinus*. Leaving aside *Archæocidaris*, about the position of which in the family Archæocidaridæ there can, of course, be no difference of opinion, we may briefly discuss the other genera.

Eocidaris Desor. As definitively shown by Bather („Eocidaris and some species referred to it"; Ann. Mag. Nat. Hist. (8) III. 1909) the only character by which the two species known, *lævispina* (Sandberger) and *scrobiculata* (Sandberger), differ from typical *Archæocidaris* is the lack of a "parapet" on the primary tubercles. This is, however, a rather unimportant character, which may be observed also on the upper tubercles of *Archæocidaris*. As long as we know only some isolated plates of the two said species (— which may very well be in reality one and the same species), the genus remains so insufficiently known that its validity may well be doubted.

Cidarotropus Pomel. This is nothing but a synonym of *Archæocidaris*; the difference between these two genera given by Lambert & Thiéry, viz. that *Cidarotropus* has only 4 rows of interambulacrals, *Archæocidaris* 5—8 rows, rests on a misunderstanding, as definitely shown by Jackson. All *Archæocidaris* species, so far as known, have only four rows of interambulacrals.

Lepidocidaris Meek & Worthen. This genus, with the only known species *L. squamosus* Meek & Worthen, is unique among Archæocidarids, and indeed among Cidarids in general, through its ambulacral structure, every third plate at the midzone being higher and wider than the two intermediate and more or less abutting against the two smaller plates of the opposite half-area (cf. Jackson. Pl. XVII. 7, 12) A quite similar ambulacral structure we find e. g. in *Lepidechinus iowensis* Jackson (cf. Jackson. Pl. LXIII. 3), and as, moreover, the primary spines of *Lepidocidaris* appear to be quite simple, without any outer layer, this genus, in my opinion, does not rightly belong to the Archæocidarids, but should rather be referred to the Lepidesthidæ, or perhaps to the Lepidocentridæ.

Perischocidaris Neumayr is referred by Jackson to the Lepidesthidæ, which may well be correct; at any rate the ambulacral structure of this genus — 6 rows of plates — is so different from all other Cidarids that there is no reason in referring it to the Archæocidaridæ. The primary spines are unknown.

Permocidaris Lambert. This genus is based on *Cidaris forbesiana* Koninck from the Permian of India. As shown by Bather (Op. cit.) this species is so insufficiently known that there is, for the present at least, no reason for maintaining the genus. Also Jackson rejects the genus because of the insufficient evidence as to the characters of *C. forbesiana*.

Anaulocidaris Zittel. There is no proof that this genus had pluriseriate interambulacra; the

isolated plates known rather indicate it to have had biserial interambulacra, and it cannot, therefore, be referred to the Archæocidaridæ.— Also Bather regards it as a Cidarid, related to *Triadocidaris*.

Xenocidaris Schultze (genotype *X. clavigera* Schultze, from the Devonian of Europe) is known only from isolated spines. Judging from its old age and the resemblance of its spines with those of *Nortonechinus*, we have no reason to doubt that it really belongs to the Archæocidarids.

As real and fairly well known Archæocidarids are thus left only the two genera *Archæocidaris* and *Nortonechinus*.

Genus **Archæocidaris** M'Coy. (Fig. 27).

Syn. *Palæocidaris* Desor.

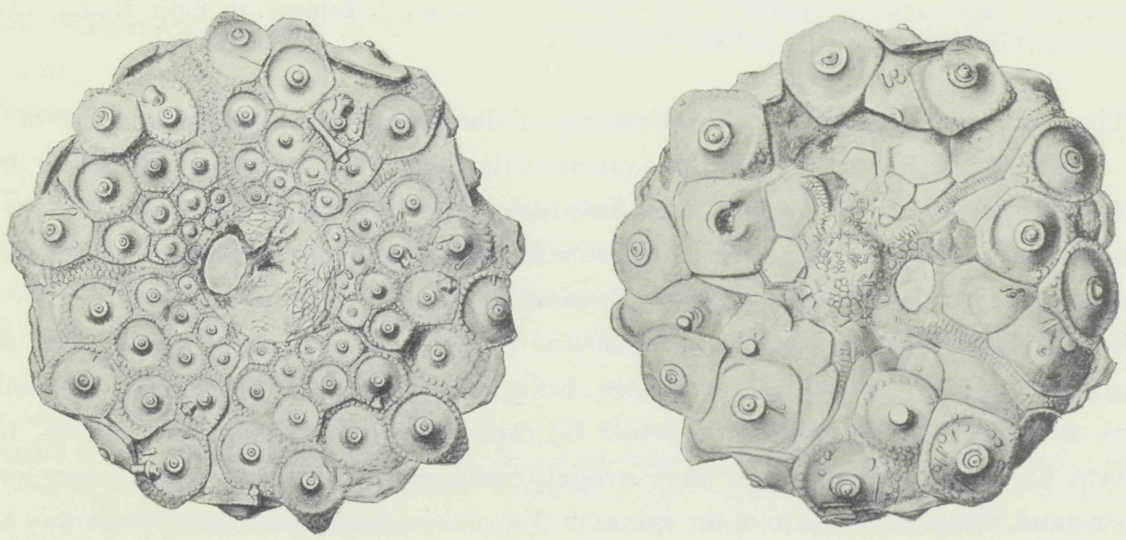
Jackson 1912. Phylogeny of the Echini, p. 256.

Test depressed, spheroidal. Four columns of moderately imbricating interambulacrals. Primary spines simple, not widened at the point.

Genotype: *Cidaris urii* Fleming.

Numerous species from the Carboniferous of Europe and N. America. Complete record and description of all the species given by Jackson (Op. cit.)

As regards the name *Archæocidaris* there is scarcely any possibility for denying the fact that *Echinocrinus* L. Agassiz strictly speaking has the priority[1] — unless it can be maintained, as do Lambert & Thiéry, that *Echinocrinus* is identical with the still older *Echinoencrinus* H. v. Meyer. However, as Jackson in his great Monograph has fortunately taken the wise step of



1 2

Fig. 27. *Archæocidaris rossica* (Buch); from the oral (1) and the aboral side (2). × 1.5. (After Jackson. Phylogeny of Echini, Pl. XI. 1—2).

[1] F. A. Bather. Echinocrinus versus Archæocidaris. Ann. Mag. Nat. Hist. (7). XX. 1907.

retaining the name *Archæocidaris*, no sensible scientist could think now of dropping it for the entirely misleading *Echinocrinus*. The name *Archæocidaris* should of course be made a nomen conservandum.

Genus **Nortonechinus** Thomas (Fig. 28).

A. O. Thomas. 1920. Echinoderms of the Iowa Devonian. Iowa Geol. Survey, XXIX., p. 481. (Bull. Geol. Soc. America. 31. p. 212).

About 12 (or 14) columns of strongly imbricating interambulacrals. Primary spines greatly expanded at the tip; they probably covered the test completely, in the same way as in *Anaulocidaris* and in the recent *Colobocentrotus*.

Genotype: *N. Welleri* Thomas, from the Devonian of Iowa.

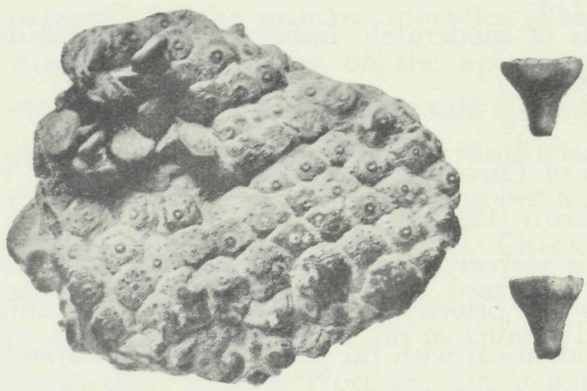


Fig. 28. *Nortonechinus Welleri* Thomas. Type specimen (nat. size) and two spines (× 2). After Thomas. Op. cit. Pl. XLVII., 1 and XLVIII. 5—6.

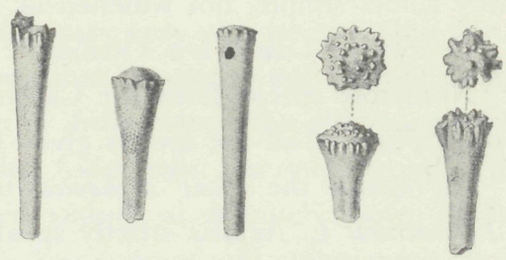


Fig. 29. *Xenocidaris clavigera* Schultze. Primary spines; the two to the right shown also from above. (After L. Schultze. Monogr. d. Echinod. d. Eifler Kalkes, 1866. Taf. XIII. 3.

The fact that the spines of *Xenocidaris* are of the same general shape as those of *Nortonechinus*, only somewhat longer and less expanded at the point (Fig. 29), makes it rather probable that *Nortonechinus* is really identical with *Xenocidaris*, the difference in the shape of the spines being hardly enough for serving as generic distinction. The proof of this suggestion can, however, not be given before the test of *Xenocidaris* becomes known.

The fact that *Nortonechinus* (?= *Xenocidaris*) from the Devonian has many series of interambulacrals, while *Archæocidaris*, not known before the Lower Carboniferous, has only four columns, is in accordance with what should be expected on morphological grounds, that the older form has more numerous and more strongly imbricated plates than the younger form. On the other hand, the peculiar form of the spines in *Nortonechinus* shows it to be in some way a highly specialised type.

II. Family. **Cidaridæ** Gray[1].

Syn. *Goniocidaridæ* Haeckel.

Interambulacra with only two rows of usually solid plates, with rigid sutures or, in some of the oldest forms, more or less distinctly imbricated and bevelled. In one case, *Tetracidaris*, there are four rows of interambulacrals, but only at the ambitus, not in the adoral or aboral part of the test. Lantern erect.

Other characters those of the order.

The arrangement in subfamilies was discussed above, p. 52—56.

Key to the Subfamilies.

1. Coronal plates imbricating and bevelled, or with rigid sutures, but in the latter case very minute forms ..... *Streptocidarinæ.*
   Coronal plates with rigid sutures, larger forms ..... 2.
2. Pore-pairs of test arranged in single series ..... *Stereocidarinæ.*
   Pore-pairs of test arranged in double series ..... *Diplocidarinæ.*

1. Subfamily. **Streptocidarinæ** Lambert.

Coronal plates more or less distinctly bevelled, the ambulacrals being covered by the adjoining interambulacrals; in some, very minute, forms (*Mikrocidaris*) the bevelling has apparently disappeared. The interambulacrals more or less imbricating adorally (excepting the minute forms). Pores non-conjugate, arranged in simple series. Primary tubercles crenulate or non-crenulate. Primary spines may be developed into large shields. (Pedicellariæ known in a single species only).

Forms of moderate or very small size, ranging from the Lower Carboniferous to the Lias. (Europe, N. America).

To this subfamily Lambert & Thiéry (Ess. nom. rais.) refer the genera *Eotiaris* Lambert, *Miocidaris* Döderlein and *Triadocidaris* Döderlein. While there is no disagreement about the generic value of the two latter, *Eotiaris* must, according to Bather (Eocidaris and some species referred to it. Ann. Mag. Nat. Hist. 8. Ser. III. 1909. p. 57—62, and "Triassic Echinoderms

[1] According to Agassiz (Rev. of Ech. p. 384) Joh. Müller is to be regarded as the author of the family Cidaridæ, as he was the first to give, in his famous memoir "Über den Bau der Echinodermen" 1854, an analysis of the Cidarid structure, and to point out the more important characters by which it differs from that of the Echini proper. True, he was; still I cannot agree that he should be named the author of the family. I. E. Gray, in his „Attempt to divide the Echinida, or Sea Eggs, into natural families" 1825, established the family *Cidaridæ*, comprising the genera *Cidaris*, *Diadema*, and *Astropyga*. That the two latter were later on transferred to another family cannot alter the fact that Gray is the author of the family name Cidaridæ. We may ad "emend." to it — as does Agassiz also in the case of "Cidaridæ Joh. Müller"; but Gray remains the first author to use this family name. I here quite agree with Lambert & Thiéry. Moreover, it may be emphasized that Joh. Müller did not properly establish or diagnose a family Cidaridæ.

of Bakony", p. 83—86) be dropped as a simple synonym of *Miocidaris*. The very detailed and accurate discussion of the whole question given by Bather seems to me (— who have not had the opportunity of examining personally any material of these forms —) quite convincing, and I can therefore have no hesitation in accepting his results.

To the same subfamily belongs *Anaulocidaris* Zittel and, I think, also *Mikrocidaris* Döderlein and *Aplocidaris* Lambert & Thiéry. Apparently there is no bevelling of the coronal plates in these forms, but this would seem to be a natural consequence of their very minute size — they are the pygmies of Cidarids. The fact that already in *Triadocidaris* the bevelling has partly disappeared, and the general very pronounced similarity between *Mikrocidaris* and *Triadocidaris* would seem to show that they are really closely related and should, at least, be referred to the same subfamily.

Key to the genera of Streptocidarinæ.

1. Coronal plates bevelled and imbricating; moderately sized forms ..... 2.
   Coronal plates not bevelled nor imbricating; very minute forms ..... 4.
2. Primary tubercles crenulate ..... *Miocidaris*.
   Primary tubercles non-crenulate ..... 3.
3. Areoles distinct; primary spines (probably) simple ..... *Triadocidaris*.
   Areoles indistinct; primary spines shield-shaped ..... *Anaulocidaris*.
4. Ambulacra entirely without tubercles, no interporiferous zone ..... *Aplocidaris*.
   Ambulacra with marginal tubercles; interporiferous zone distinct ..... *Mikrocidaris*.

Genus **Miocidaris** Döderlein.

Syn. *Eotiaris* Lambert.

Döderlein. 1887. Japanische Seeigel, p. 40.
Bather. 1909. Triassic Echinod. of Bakony, p. 83.

Moderately sized Streptocidarids, having the bevelled edge usually (? always) denticulate. Primary tubercles perforate and crenulate. Areoles usually confluent. Primary spines slender, not shield-shaped. Pores non-conjugate.

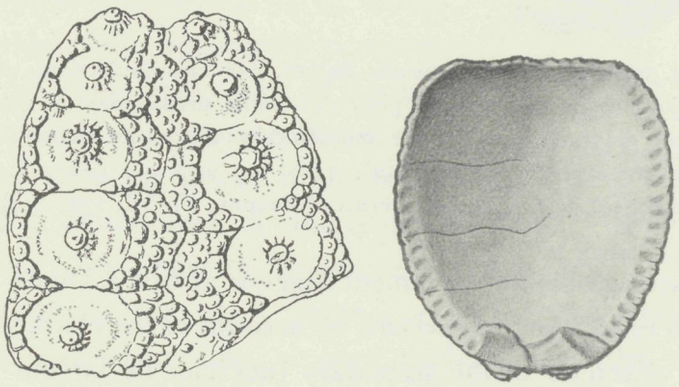
Genotype:	*Miocidaris cassiani* Bather.		Trias.
Other species	—	*Keyserlingi* (Geinitz)	Permian. (Fig. 30).
	—	*subcoronata* (Münster)	Trias.
	—	*verrucosa* Bather	—
	—	*plana* Bather	—
	—	*Lorioli* Lambert & Thiéry	Lias. (Fig. 31)

and some more, incompletely known species from the Lias of Europe.

The type-specimen of *Miocidaris Lorioli* is remarkably well preserved, being not only an almost complete test, but having also both primary and secondary spines and even pedicellariæ attached! (Fig. 20. 3); on the other hand the ambulacral plates are almost entirely lacking. This would seem to indicate that the ambulacral plates were imbricating in this species.

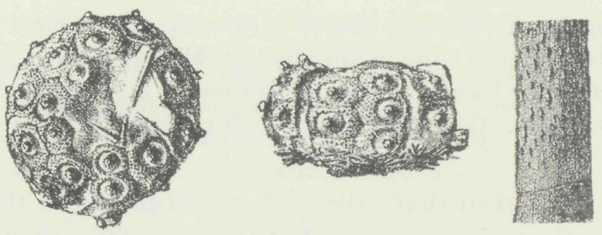
Jackson (Phylogeny of Echini, p. 247) has described a species, *Miocidaris Cannoni* Jackson,

from the Lower Carboniferous of N. America. This species, which is a rather large form, ca. 29 mm. h. d., differs from the other *Miocidaris*-species in having an unusually large number of coronal plates, viz. 14 in each column of interambulacrals; the other species have scarcely more than ca. 7—9 plates in each column. This makes it highly probable that the said species rather represents another generic type, as also hinted at by Jackson. Unfortunately the preservation is so poor — it is a silicious internal mold — that no structural details can be made out beyond those proving that it is a true Streptocidarid — the oldest known of true Cidarids. Until further



1 2

Fig. 30. *Miocidaris Keyserlingi* (Geinitz). Interambulacrum, outer (1) and inner surface (2). × 6. (After F. A. Bather. Eocidaris, and some species referred to it. Ann. mag. Nat. Hist. 8. Ser. III. 1909, p. 58, fig. 7., Pl. I. 9.).



1 2 3

Fig. 31. *Miocidaris Lorioli* Lambert & Thiéry. 1. Test seen from above; 2. side view of test; 3. part of primary spine, showing the limit between collar and shaft. 1—2. Nat. size, 3 magnified. (After Lambert & Thiéry. Ess. nom. rais. des Échinides, Pl. I. 1—2, 7).

knowledge of this highly interesting and important type has been gained, it must then be left in the genus *Miocidaris*.

Genus **Triadocidaris** Döderlein.

Döderlein. 1887. Jap. Seeigel, p. 39.
Bather. 1909. Triassic Echinod. of Bakony, p. 68.

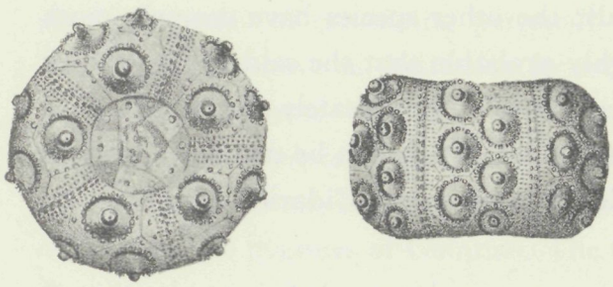
Small to moderately sized Streptocidarids with the bevelled edges of the coronal plates denticulate. Primary tubercles perforate, but non-crenulate; areoles may be confluent or more or less widely separated. Spines unknown. Pores non-conjugate.

Genotype: *Cidaris subsimilis* Münster. Trias. (Fig. 32).

Other species: *Triadocidaris persimilis* Bather. Trias. (Fig. 33).
— *immunita* — —
— *liagora* (Münster) —

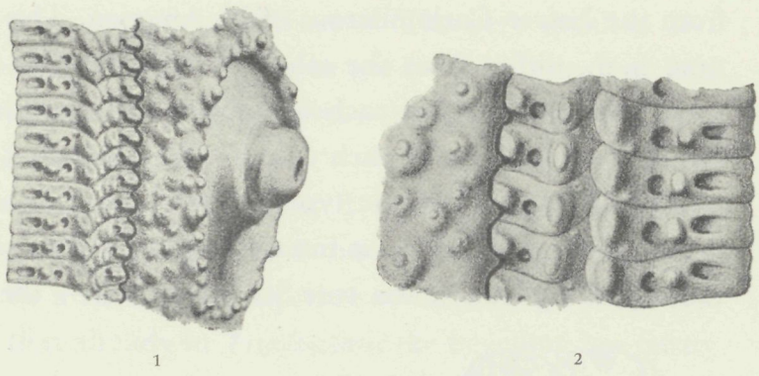
and some other species, more or less doubtfully referable to this genus, all from the Trias.

The species *Triadocidaris præternobilis* Bather (Triassic. Ech. of Bakony, p. 76. Pl. VI. 135—138) differs so markedly from the other species, and, indeed, from all other Cidarids, in having large perforate tubercles in the median interambulacral space that I cannot accept the interpretation of it as a Cidarid. (The ambulacral structure is unknown). Bather has also himself



1 2

Fig. 32. *Triadocidaris subsimilis* (Münster); from the aboral side (1) and in side view (2). Slightly enlarged. (After Laube. Fauna d. Schichten v. St. Cassian Denkschr. Akad. Wien. XXIV. 1865. Taf. VIII. 6.).



1 2

Fig. 33. *Triadocidaris persimilis* Bather. Part of ambulacrum, with adjoining interambulacral plate (1), and a smaller part of same, more enlarged, showing the ambulacral plates partly covered by the interambulacral plate (2). 1. × 10; 2. × 20. (After F. A. Bather. Triassic Echinoderms of Bakony, Pl. VI. 132, 134).

remarked that "the high development of the extrascrobicular ornament suggests at first a Diademoid rather than a Cidarid", but he prefers to refer it to *Triadocidaris* on account of the character of its adradial suture. In my opinion the character of the secondary tubercles by far outweighs that of the sutures, and I must therefore regard it as a Diademoid form.

Genus **Mikrocidaris** Döderlein.

Döderlein. 1887. Jap. Seeigel, p. 39.
Lambert & Thiéry. 1910. Ess. nom. rais., p. 140.

Very small forms with apparently no bevelling of the coronal plates. Primary tubercles perforate, non-crenulate, rather unusually prominent, with small, not confluent areoles. Spines unknown. Pores not conjugate.

Genotype: *Cidaris pentagona* Münster. Trias. (Fig. 34. 1—2).

Other species: *Mikrocidaris subpentagona* (Münster). Trias.

— *gerana* — —

(?) — *venusta* — — (Fig. 34. 3).

All the species from the Triassic deposits of St. Cassian.

The species *venusta* was placed by Döderlein in *Triadocidaris*, whereas Lambert refers it to *Mikrocidaris*. The question is of small importance in view of the fact especially emphasized by Bather (Triassic Echinod. Bakony, p. 69, 74) that the transition from the bevelled condition to the straight, rigid sutures is exceedingly gradual and even observable in one and the same specimen, a distinctly bevelled condition in the adapical part changing gradually into a perfectly rigid condition of the sutures in the adoral part of the test. Therefore, it may be questionable whether there is in reality any sharp distinction between the genera *Triadocidaris* and *Mikrocidaris*,

the forms referred to the two genera being otherwise very alike. To place them even in two separate subfamilies, as is done by Lambert & Thiéry, is evidently quite unnatural.

A remarkable feature in both *Triadocidaris* and *Mikrocidaris* is the strong development of the uppermost plate and its primary tubercle in one of the series in each interambulacrum. This is carried to an extreme in the species *venusta* (Fig. 34.3), where this plate apparently occupies the whole upper part of the interambulacrum, the large tubercle being placed in the midline of the area. A comparison with the figure of *Triadocidaris subsimilis* (Fig. 32.1), where a very small upper plate of the other series in the interambulacrum is still observable, at once explains how the extraordinary condition shown by *venusta* has developed.

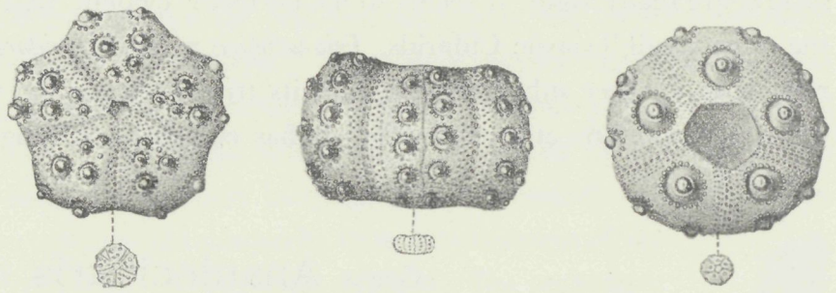


Fig. 34. *Mikrocidaris pentagona* (Münster), from the aboral side (1) and in side view (2); *Mikrocidaris venusta* (Münster), from the aboral side (3). The small figures below represent the specimens in natural size. (After Laube. Fauna d. Schichten v. St. Cassian. Pl. IX, 2—3.)

Genus **Aplocidaris** Lambert & Thiéry.

Lambert & Thiéry. 1909. Notes échinologiques I. Sur le genre Cidaris, p. 31.
Lambert & Thiéry. 1910. Ess. nom. rais., p. 140.

Very small forms with apparently no bevelling of the coronal plates. Primary tubercles imperforate, non-crenulate. Ambulacra without any tubercles at all; pores not conjugate. Primary spines flattened, serrate.

Genotype, and only known species: *Cidaris Helenæ* Vinassa de Regny. Trias. (Fig. 35).

The peculiar character of the ambulacral plates, being reduced to the poriferous part alone, there being thus, in fact, no interporiferous zone, distinguishes this form from all other Cidarids. Judging from the figures it appears that the primary tubercles are imperforate, likewise an exceptional character in a Cidarid; also the areoles are rather indistinct.

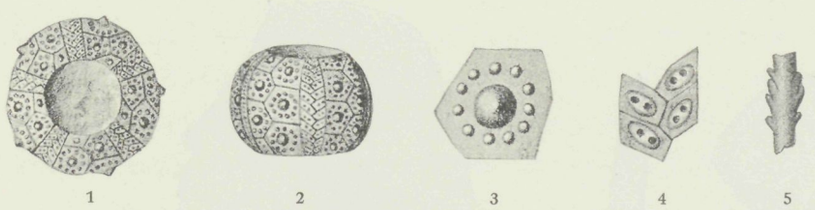


Fig. 35. *Aplocidaris Helenæ* (Vinassa de Regny), from the aboral side (1) and in side view (2); an isolated interambulacral plate (3), part of an ambulacrum (4) and part of a primary spine (5). × 2.5. (After Vinassa de Regny. Fossili del Montenegro. I. Fauna del calcari rossi e grigi del Sutorman. Mem. R. Accad. Ist. Bologna. 5. Ser. X. 1903. p. 463. Pl. II. 1).

Lambert & Thiéry place this genus in the "Leiocidarinæ", because of its non-crenulate tubercles, and — as may be indirectly inferred — because of its coronal plates having rigid sutures. The original description or the figures

given by Vinassy de Regny do not give any definite information about the character of the sutures; perhaps Lambert & Thiéry have had the opportunity of investigating this matter on original material (— I have not found any statement as to this, though —). But even if the sutures are really rigid, it seems to me perfectly evident that this little form is nearly related to the other small Triassic Cidarids, *Triadocidaris* and *Mikrocidaris*, and that it is quite unnatural to refer it to another subfamily far from its triassic congeners, together with forms like *Eucidaris*, *Cidaris*, *Stereocidaris* etc. with which it has evidently nothing to do.

Genus **Anaulocidaris** Zittel.

Zittel. 1879. Handb. d. Palæontologie. Palæozool. I., p. 486.
Bather. 1909. Triassic Echinod. of Bakony, p. 94.

Interambulacrals thin, imbricating, the adradial edge bevelled, but not denticulate. (Ambulacra unknown). Primary tubercles perforate, non-crenulate; no distinct areoles. Primary spines shield-shaped.

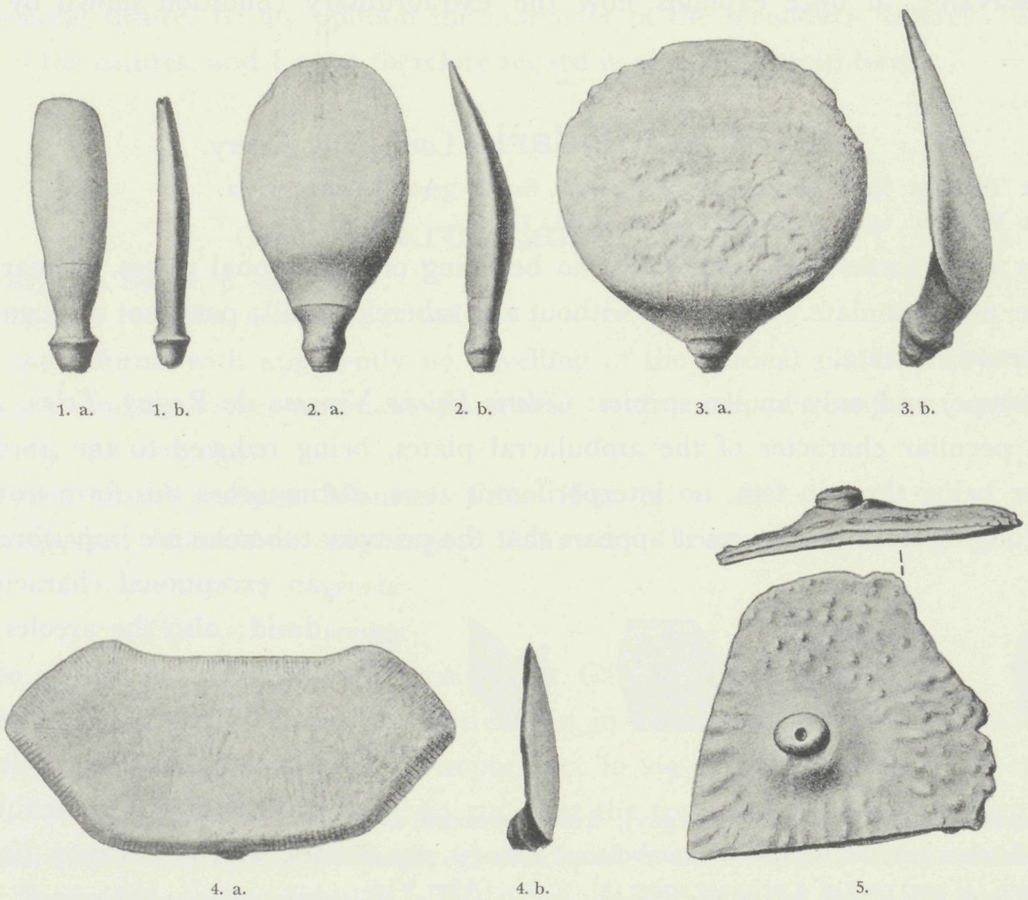


Fig. 36. *Anaulocidaris testudo* Bather. 1—4. Primary spines; a front view, b. side view; 5. interambulacral plate; the figure above shows the same in side view. 1—4. × 3; 5. × 5. (After F. A. Bather. Triassic Echinod. of Bakony. Pl. X and VII).

Genotype: *Cidaris Buchi* Münster. — Trias (St. Cassian).

Other species: *Anaulocidaris testudo* Bather. — Trias (Fig. 36).

In the best known species, *A. testudo* Bather, the shield-shaped primary spines evidently formed a close cover over the whole test, except the oral surface, where the spines were more simple, recalling the oral primaries of recent Cidarids[1]. The shield-shaped spines overlapped each other, imbricating downwards; a slight excentricity of these spines may indicate that they covered also the ambulacra. They were not movable sidewards, only slightly up and down, and in accordance herewith the mamelon of the primary tubercles was transversely elongated. The very slight mobility of the spines also explains the unusually faint development of the areoles, indicating a very reduced condition of the spine-muscles. The secondary spines, which were covered by the primaries, were evidently very much reduced, as is indicated by the imperfect development of the secondary tubercles.

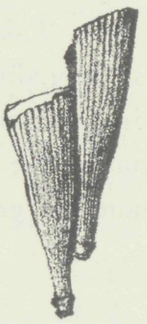


Fig. 37. Primary spines of "*Anaulocidaris*" *Faurai* Lambert. Enlarged. (After Lambert. Op. cit. Pl. I. 2).

That this cover of the test gave the animal a similar protection as is the case with the flattened spines in *Colobocentrotus*, cannot be doubtful; on the other hand, it is scarcely believable that *Anaulocidaris* like *Colobocentrotus* lived attached to rocks exposed to the surf. The faint development of the tubefeet in Cidarids would not fit well with such a life. The same holds good for *Nortonechinus* (? = *Xenocidaris*) among the Archæocidarids, in which the primary spines were also much widened. Bather's suggestion (Op. cit. p. 170) that the widened spines served to protect also the developing young is, of course, very plausible. It should, however, be recalled in this connection that the similarly widened apical primaries found in several *Goniocidaris*-species — especially in *Goniocidaris clypeata* and *fimbriata*, apparently do not serve such purpose; at least it is certain that they do not protect the young in *Goniocidaris umbraculum;* this species, in spite of its shield-shaped apical spines carries the young ones on the peristome. Also all other brood-protecting Cidarids carry the brood on the peristome, with the sole exception of *Austrocidaris canaliculata*, which carries the brood on the apical system.

To the genus *Anaulocidaris* Lambert also refers the species *Faurai* Lambert (Revis. des Ech. foss. de Catalogne. Mem. Mus. Cienc. nat. Barcelona, Ser. Geologica. I. 1927), from Triassic deposits of Spain. I do not think this correct. The spines of this species (Fig. 37) are broad and flat, oar-shaped, entirely unlike the characteristic shield-shaped spines of *Anaulocidaris Buchi* and *testudo*. I suppose, we have here rather the representative of a separate genus of the Streptocidarinæ.

[1] In his Note "Cidaris Buchii Münster, ein Fall der Umbildung von Stacheln zur Schuppenbekleidung" (Carinthia, Mitt. d. Ver. Naturh. Landesmuseum für Kärnten, Klagenfurt, 1914. Jahrg. 104. II., p. 50) H. v. Gallenstein expresses the opinion that the simple spines were attached to the upper side of the test, the broad, shield-shaped to the under side, which further leads him to suggest that the upper part of the test was hard, the lower part thinner, possibly only consisting of soft skin, "an dem zum Schutze sich die plattigen Stacheln anlegen". A comparison with recent Cidarids leaves no doubt that the simpler spines were those of the oral side, as suggested by Bather, and that v. Gallenstein puts it all upside down. Also his suggestion of the character of the test is in contradiction to general morphology of Echinoids.

2. Subfamily. Stereocidarinæ Lambert.

Coronal plates with rigid sutures. Pores non-conjugate or conjugate, arranged in simple series. Primary spines very varied, though in the main cylindrical or clubshaped, sometimes (*Goniocidaris*) the upper ones shield-shaped. Primary tubercles crenulate or non-crenulate. Pedicellariæ typically in three forms, large and small globiferous and tridentate, but sometimes one or the other of these forms may be lacking.

Moderate, more rarely small, to large forms, ranging from the Jurassic period to the recent days.

This subfamily comprises the great bulk of the Cidarids. The recent forms may be arranged, mainly after the structure of their pedicellariæ, in various groups. As these structures are unknown in the fossil forms, it is impossible to assign these latter with certainty to the various groups, unless the characters of test and spines give some fair evidence as to their relation with one or another group of the recent forms (cf. above p. 54—56).

Key to the groups of the Stereocidarinæ.

1. Only tridentate pedicellariæ present, no globiferous pedicellariæ ..... *Histocidarina.*
   Globiferous pedicellariæ present, tridentate present or absent ..... 2.
2. Valves of large globiferous pedicellariæ with a distinct end tooth ..... *Cidarinæ.*
   Valves of large globiferous pedicellariæ without a distinct end tooth ..... 3.
3. Opening of globiferous pedicellariæ rather small, terminal, well formed, with a serrate lower lip; the stalk usually with a limb of projecting rods; small globiferous with a distinct end tooth *Stylocidarina.*
   Opening of globiferous pedicellariæ usually subterminal, usually not with a distinct lower lip; no limb on the stalk. Small globiferous pedicellariæ with or without an end tooth ..... 4.
4. Pores conjugate; no grooves in the sutures of the coronal plates or on the plates ..... *Rhabdocidarina.*
   Pores non-conjugate; often grooves in the sutures of the coronal plates, more rarely on the plates themselves ..... 5.
5. Small globiferous pedicellariæ with a distinct end tooth ..... *Goniocidarina.*
   Small globiferous pedicellariæ usually without an end tooth ..... 6.
6. Pores very close together, usually more or less confluent; secondary spines usually clubshaped *Ctenocidarina.*
   Pores not very close together, not confluent; secondary spines not clubshaped .... *Stereocidarina* s. str.

The groups *Goniocidarina* and *Ctenocidarina* are not very well limited from each other, the genus *Ogmocidaris* occupying an intermediate position. It has the pores close together as in Ctenocidarids, but the small globiferous pedicellariæ have a distinct, though not very large end tooth. It is here referred to Ctenocidarids.

Group *Histocidarina.*

Tubercles perforate and rather strongly crenulate. Pores not conjugate. Areoles not very deep. Primary spines long and slender, cylindrical, smooth or thorny. Oral primaries strongly serrate, curved. Secondary spines rather long, more or less flattened, erect, not scale-like. No globiferous pedicellariæ, tridentate pedicellariæ strongly developed, generally in two forms, the larger form very conspicuous. The ambulacral plates of the peristome each with a conspicuous distally directed prolongation on the inner side, adradially to the pore, these prolongations forming together a high double ridge in each ambulacrum on the peristome and a little beyond. Spicules of intestinal walls very scarce and small, often wanting.

The characters given in the diagnosis mark this group so distinctly from the rest of the Cidarids that it might perhaps rather be justified to regard it as a separate subfamily. As regards the internal prolongations of the peristomial ambulacral plates (Fig. 23, p. 36), this character was first recorded by Wyv. Thomson for *Poriocidaris purpurata* and then by A. Agassiz (Pan. Deep Sea Ech.) for *Histocidaris Cobosi*. I have found them to exist likewise in *H. elegans*, *australiæ*, *variabilis* and *misakiensis*. We may thus well be entitled to see herein a character of the group as a whole. It does not appear to exist in any other Cidarids, at least I have not observed it in any of the rather numerous species of the various groups which I have thus far been able to examine in this regard.

Whether any of the fossil forms belong to this group is hard to say, because we remain as yet ignorant of several of the more important characters of the fossil forms. It is, however, safe to say that the genus *Plegiocidaris* Pomel, with which Lambert & Thiéry associate all the recent *Histocidaris*-species, has no nearer relation with the *Histocidarina*. The diploporous condition of the peristomial ambulacra and the very characteristic clavate primary spines of the typical *Plegiocidaris* (cf. p. 470) show that we have here a type of Cidarids entirely different from *Histocidaris*. Another thing is that very possibly some of the numerous fossil species thrown together in the genus *Plegiocidaris* by Lambert & Thiéry may well have been true Histocidarids; thus, for instance, a form like *Cidaris Chantrei* Cotteau (Paléontol. Franç. Terr. Jurass. Pl. 155. 8—10) with slender, perfectly smooth spines, may not improbably represent an ancestral Histocidarid. — Strongly serrate oral primaries have developed in various forms (e. g. *Aporocidaris* and *Ctenocidaris* among recent forms) and therefore do not afford any decisive character. It should especially be emphasized that the genuine *Porocidaris* Desor, to which genus most of the recent forms were formerly referred on account of the serrate oral primaries, does not belong to this group, as appears from the fact that it has conjugate pores.

The generally well marked crenulation of the tubercles, otherwise found only exceptionally among recent Cidarids, e. g. *Acanthocidaris*, as well as the unspecialized character of the secondary spines would appear to mark this group as the most primitive among recent Cidaris. Also the complete lacking of globiferous pedicellariæ may well be regarded as a more primitive character.

The species of this group are all deep-sea forms, though several of them are found also within the limits of the sublittoral region. Most of them are known to grow to a very considerable size and belong to the most splendid forms of the Cidarids. They must be referred to two different genera, *Histocidaris* Mrtsn. and *Poriocidaris* Mrtsn.

Key to the genera of Histocidarina.

Primaries with a short, simple collar. Pedicellariæ three-valved (only exceptionally, 2- or 4-valved) ..... *Histocidaris.*
Primaries with very long collar, often swollen in the middle. Pedicellariæ constantly with two valves only ..... *Poriocidaris.*

Genus **Histocidaris** Mrtsn.

Th. Mortensen. 1903. "Ingolf" Ech. I., p. 30.
H. L. Clark. 1916. "Endeavour" Echinod., p. 106.
H. L. Clark. 1926. Cat. Rec. Sea-Urch. Brit. Mus., p. 6, 37.

Apical system with rather scarce spines, disposed so as to cover the genital, ocular and anal openings, leaving especially a large part of the genital plates bare. Genital pores usually entirely within the genital plates. Primary spines cylindrical, slightly or not at all tapering, sometimes with the tip more or less widened; collar generally not exceeding ca. 3 mm., not swollen in the middle. Large tridentate pedicellariæ usually with three valves, very conspicuous, the blade generally filled with a dense calcareous meshwork, but often leaving a depression above the apophysis, which latter is short, but broad and of a similar structure as the blade; sometimes the blade is concave, spoonshaped.

Genotype: *Porocidaris elegans* A. Agassiz.

Of the rather numerous (14) species of this genus hitherto made known only two (perhaps three — see under *H. Sharreri* —) occur in the Atlantic (West Indies), the rest of them all in the Pacific. Especially in the Moluccan and Philippine Seas this genus is very richly represented, no less than 5 species being known from there; but also in the Japanese Seas and off East Australia the genus is well represented (respectively two and three species); we may, therefore, be justified in regarding this area as its original home and, especially the Moluccan Sea, as its centre of distribution. We may well expect that even more species will be found there, as it also seems probable that some more species will prove to occur in the Indian Ocean.

It appears that the species of this genus are rather variable as regards most of their characters, and, therefore, the limitation (— and the identification —) of the species offers some difficulties. However, the variation is evidently not nearly so great as hitherto supposed, the "variation" being, in fact, for a great part due to the confusion of various species under the same name. This especially holds good for *H. elegans*. Still it seems beyond doubt that a character which is otherwise generally of great specific value, viz. the shape of the large tridentate pedicellariæ, is not always quite reliable here; in any case it must be regarded as certain that the

presence or absence in the blade of a depression above the apophysis may sometimes be subject to individual variation (see *H. elegans*). — Also the characters of the test would seem to be subject to rather astonishingly great variations, as shown, above all, by *H. australiæ* in which the test may vary to such an extent that one would, on regarding the test alone, rather be inclined to think the specimens to represent separate genera, while the rest of the characters are so decidedly alike that it seems necessary to regard them as one and the same species.

Valuable specific characters are afforded by the primary and secondary spines, the apical system (oculars insert or exsert), the peristome (development of the peristomial interradial plates), and the pedicellariæ; also the colour appears to be of some specific value. The tuberculation and the relative dimensions of the various parts of the test are subject to so considerable variations that they are of less value for the distinguishing of species. The primary spines would appear to offer the most reliable, and at the same time the most conspicuous characters by which to distinguish the various species.

By the great number of species the question naturally arises, whether it is possible to divide them into natural groups, which might perhaps be raised to subgenera, or even genera. Much cannot be said, however, about this matter, especially because of the fact that several of the species are known in only one or a very few samples. This means that we do not know how much reliance we can put on the various specific characters. A larger material may show, perhaps, that what at present seems to represent good, reliable characters may be subject to variations, and thus be of less value than seems reasonable at our present stage of knowledge.

With these restrictions it would seem that *Histocidaris magnifica*, on account of its perfectly smooth and downwards curved primaries stands the most apart, forming a group of its own. Another natural group is, perhaps, formed by the species with uniformly finely serrate primaries: *elegans*, *crassispina*, *variabilis*, *misakiensis*, *Sharreri* and *Cobosi*. Further *carinata* and *australiæ* may perhaps be more nearly related, and *acutispina* with *denticulata* — if, indeed, the two latter can be maintained as separate species. Finally *formosa* and *Nuttingii* may form a separate group, to which *recurvata* might have some nearer relation. — But this can merely be regarded as a suggestion, to be verified or rejected by future investigations.

Key to the species of the genus Histocidaris.[1]

1. Primary spines perfectly smooth, at most with some longitudinal ridges without serrations. Ambital primaries downwards curved ..... *H. magnifica.*
   Primary spines with more or less fine serrations or thorns; ambital spines not downwards curved ..... 2.
2. Primary spines uniformly serrate ..... 3.

[1] On using this key it must be kept in mind that, on account of the scarcity of the material, there is some uncertainty about the constancy of characters. This especially applies to the character of the group 11: the presence of scattered larger thorns, mainly in the basal part of the primary spines. Identifications made after the key should, therefore, always be tested by comparison with the descriptions and figures.

Primary spines of aboral side with scattered larger thorns, mainly in the basal part..... 11.
3. Serrations of primary spines very fine, microscopical..... 4.
Serrations of primary spines coarser, distinctly visible to the naked eye..... 9.
4. Marginal series of ambulacral tubercles very irregular..... *H. Cobosi.*
Marginal series of ambulacral tubercles regular or, at most, slightly irregular in larger specimens..... 5.
5. Interporiferous zone with a well-marked, deeply sunk middle line..... *H. Sharreri.*
Interporiferous zone without a well-marked, deeply sunk middle line..... 6.
6. Valves of large tridentate pedicellariæ spoon-shaped, the whole inside concave..... 7.
Valves of large tridentate pedicellariæ more or less slender, not spoon-shaped, usually with a small concavity above the apophysis..... 8.
7. Primary spines cylindrical..... *H. variabilis.*
Primary spines fusiform..... *H. misakiensis.*
8. Primary spines slender, cylindrical..... *H. elegans.*
Primary spines rather thick, fusiform..... *H. crassispina.*
9. Ambital primaries upwards curved, somewhat flattened towards the end, the serrations mainly arranged so as to form a pair of lateral keels..... *H. formosa.*
Ambital primaries not upwards curved, not flattened in the outer part..... 10.
10. Apical system ca. 50 % h.d.[1]..... *H. acutispina.*
Apical system ca. 36 % h.d.[1]..... *H. denticulata.*
11. Ambital spines somewhat flattened and upwards curved in the outer part..... *H. recurvata.*
Ambital spines not flattened or upwards curved in the outer part..... 12.
12. Valves of large tridentate pedicellariæ very broad..... *H. carinata.*
Valves of large tridentate pedicellariæ narrow, slender..... 13.
13. Primary spines scarcely exceeding h.d..... *H. australiæ.*
Primary spines ca. $2^1/_2$ h.d..... *H. Nuttingi.*

Histocidaris elegans (A. Agassiz).

Pls. I. 1—5; II. 1—3; LXVIII. 6; LXXV. 16; LXXVI. 9—13.

Porocidaris elegans. A. Agassiz. 1879. Prelim. Rep. Chall. Echini. Proc. Amer. Acad. XIV, 1879, p. 198.
Porocidaris elegans. A. Agassiz. 1881. "Challenger" Echinoidea. p. 40. Pl. **III; XXXVIII. 12—16; XLIV. 6—14.**
Porocidaris elegans. Pomel. 1883. Classif. méthodique. p. 112.
Histocidaris elegans. Th. Mortensen. 1903. "Ingolf" Echinoidea I. p. 21. 30. 173.
Cidaris (Histocidaris) elegans. De Meijere. 1904. "Siboga" Echinoidea. p. 24. Taf. XII. 135. a. (partim).
Cidaris (Histocidaris) elegans, juv? De Meijere. 1904. "Siboga" Echin. p. 25. Taf. II. 17; XII. 136—140.
Histocidaris elegans Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 117. Taf. XIII. 1—3, (non 4); XL. 3.
Cidaris elegans. Yoshiwara. 1906. Japanese Echini. Pl. III. 7.
Porocidaris elegans. H. L. Clark. 1907. The Cidaridæ. Bull. Mus. Comp. Zool. LI. p. 227.
Porocidaris elegans. Mc. Culloch. 1907. Res. of Deep-Sea Investig. in the Tasman. Sea. II. The Exped. of the "Woy Woy". Rec. Austral. Mus. VI. p. 345.
Porocidaris elegans. H. L. Clark. 1909. Notes on some Austral. and Indo-Pacif. Echinod. Bull. M. C. Z. LII. p. 133.
Plegiocidaris Challengeri.[1] Lambert & Thiéry. 1910. Ess. nom. rais. p. 134.

[1] It is rather uncertain whether this difference in the size of the apical system will hold good, when specimens of a corresponding size of the two species are available. Possibly the two species *acutispina* and *denticulata* will ultimately prove to be identical.

[2] The species name *Challengeri* the authors introduce (otherwise without a word of explanation) because there is an older species, *Cidaris elegans* Münster (Cotteau. Pal. Franç. Terrains Jurassiques X. 1. p. 120. Pl. 173.

Histocidaris elegans. H. L. Clark. 1916. "Endeavour" Echinod. p. 105. (partim).
Histocidaris elegans. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 37.
Histocidaris elegans. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 250. Pl. **52. 1; 77. 1—3.**
NON. *Porocidaris elegans.* R. Koehler. 1896. Echinodermes du Caudan. p. 89. (= *Poriocidaris purpurata* (W. Th.)).
— *Porocidaris elegans.* Benham. 1909. Echinoderma. Sci. Res. N. Z. G. Trawling Exped. Rec. Canterbury Mus. I., 2. p. 25 (= *Ogmocidaris Benhami* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1.	67 mm	57 mm	32 mm (47.8% h. d.)	19 mm (28.4% h. d.)	13	10	
2.	62 —	52 —	(37 —)	(32 —)	12—13	10—11	115 mm
3.	48 —	35 —	22 — (46 —)	16 — (33.3 —)	11	8—9	
4.	43 —	32 —	19 — (44.2 —)	15 — (35 —)	10	8—10	
5.	39 —	31 —	17 — (41 —)	13 — (33.3 —)	9—10	9—10	ca. 85 —
6.	36 —	29 —	(48.5 —)	(39 —)	8—9	8—10	
7.	24 —	17 —	10.5 — (43.8 —)	9 — (37.5 —)	8	9—11	52 —
8.	14 —	9 —	6 — (42.9 —)	6 — (42.9 —)	6	7—9	

Specimens 1, 3 and 4 from off N. S. Wales; spec. 2 and 5 from the "Siboga" St. 316 and 74, the rest from the Philippines ("Albatross"). I regret having omitted the exact measures of apical system and peristome of specimens 2 and 6, these specimens being no longer accessible to me.[1]

Test rather high, sides nearly vertical, flattened above and below. Circumference rounded, sometimes rather pentagonal, the interambulacra being swollen, the ambulacra sunk.

Ambulacra (Pl. LXVIII. 6) ca. $^1/_4$ the width of the I. A., the number of plates corresponding to an I. A. plate at upper part of ambitus generally 8—10, the specimen of 24 mm. h. d. being unusual in having as many as 9—11 A. plates corresponding to an I. A. Marginal series of tubercles may, in larger specimens, be slightly irregular, the tubercles being sometimes smaller than normally, sometimes wanting on one plate or another; the tubercles, on the whole, rather small, not contiguous, not very distinctly mamelonate. Interporiferous area narrow, rather naked, generally with an irregularly alternating series of small tubercles adradially to the marginal series. In the specimen of 36 mm h. d. there are hardly any tubercles inside the marginal series. Pore-area not distinctly sunk, pores equal-sized, separated by a narrow, elevated wall; ridge very inconspicuous, low.

Interambulacra. Areoles not deepened, confluent, except only the 3—4 upper ones. The upper 3—4 tubercles usually strongly crenulate, the crenulation then gradually disappearing downwards, sometimes, however, remaining distinct — especially on the aboral edge of the tubercle — unto the peristome. The median I. A. area generally very narrow, only half the width

9—11) which they also refer to the fossil genus *Plegiocidaris*, the genus to which they have the boldness of referring the present species. There is no reason to enter on a discussion of this referring of the *Histocidaris*-species to *Plegiocidaris;* the name *Plegiocidaris Challengeri* is simply a perfectly valueless synonym of *Histocidaris elegans.*

[1] When nothing is stated about where the specimens measured are preserved, it means that they are in the collection of the Zoological Museum, Copenhagen.

of an areole. As, moreover, there is a comparatively broad, bare, more or less distinctly sunk midline, the tuberculation is almost confined to the scrobicular circle, only a very few miliary tubercles occurring outside the latter. On the adradial side of the areoles the tuberculation is likewise very sparse, a fairly broad edge remaining bare. In the specimen 48 mm h. d. the tubercles are, however, slightly more numerous here, the bare edge correspondingly narrower, and in the largest specimen there are numerous tubercles and the median space considerably broader, ca. $^3/_4$ the width of an areole.

Apical system (cf. Pl. I. 3 and 5) on the whole rather bare; genital and ocular plates only with a group of tubercles round the genital and ocular pore and, in the largest specimen, a few at the inner edge. Female genital pores large, ca. 2,5 mm, wholly within the plate; male genital pores small, more distant from the edge. The ocular plates widely excluded from the periproct. — Peristome with interradial plates poorly developed, but reaching the mouth edge in a single series.

Primary spines slender, very long, up to 2,5 — 3 h. d., tapering very slightly or hardly at all, but remaining of almost the same width unto the end, which appears to be simply cut, not pointed or widened. The longest spines in the larger specimens are ca. 3 mm thick at base. They are densely set with fine, obliquely upwards directed spinules, which lend the spines a finely rough appearance, just visible to the naked eye, also to the feeling they are distinctly rough. Under the microscope these spinules are seen to be arranged in longitudinal series, the surface of the spines being otherwise finely striated (Pl. LXXVI. 9). In transverse sections these striæ are seen to be elevated ridges (Fig. 38. 1). The collar is short, ca. 3 mm long, gently widening downwards. — The oral primaries with a double series of very strong serrations, the number of serrations increasing from 3—4 nearest the peristome to 12—14 on the 4th, the last of the oral primaries. The three proximal ones are strongly curved at the point, the fourth less so; the serrations stop some mm distance from the end in the outer oral primaries, the terminal part being strongly furrowed. The following one or two primary spines are more or less distinctly transitional between the oral and the ambital primaries.

The secondary spines surrounding the base of the primary spines are rather long, some 8 mm, widened above the base, then tapering gently to a blunt point; they are flattened, at most slightly concave in the wider, basal part. The marginal ambulacral spines, as also those on the apical system are simply setaceous, not flattened or widened; they are somewhat shorter, ca. 5 mm long, but erect. Those of the peristome are slightly widened and flattened towards the point.

The pedicellariæ of the larger form are of a size of ca 4 mm length of head. The valves are characteristically narrowed at the base, so as to leave a small open space between them, when the valves are closed (Pl. LXXVI. 13); the blade is narrow, filled up with a close meshwork, which is seen in side view to be finely spinulose; generally, though not quite constantly, there is

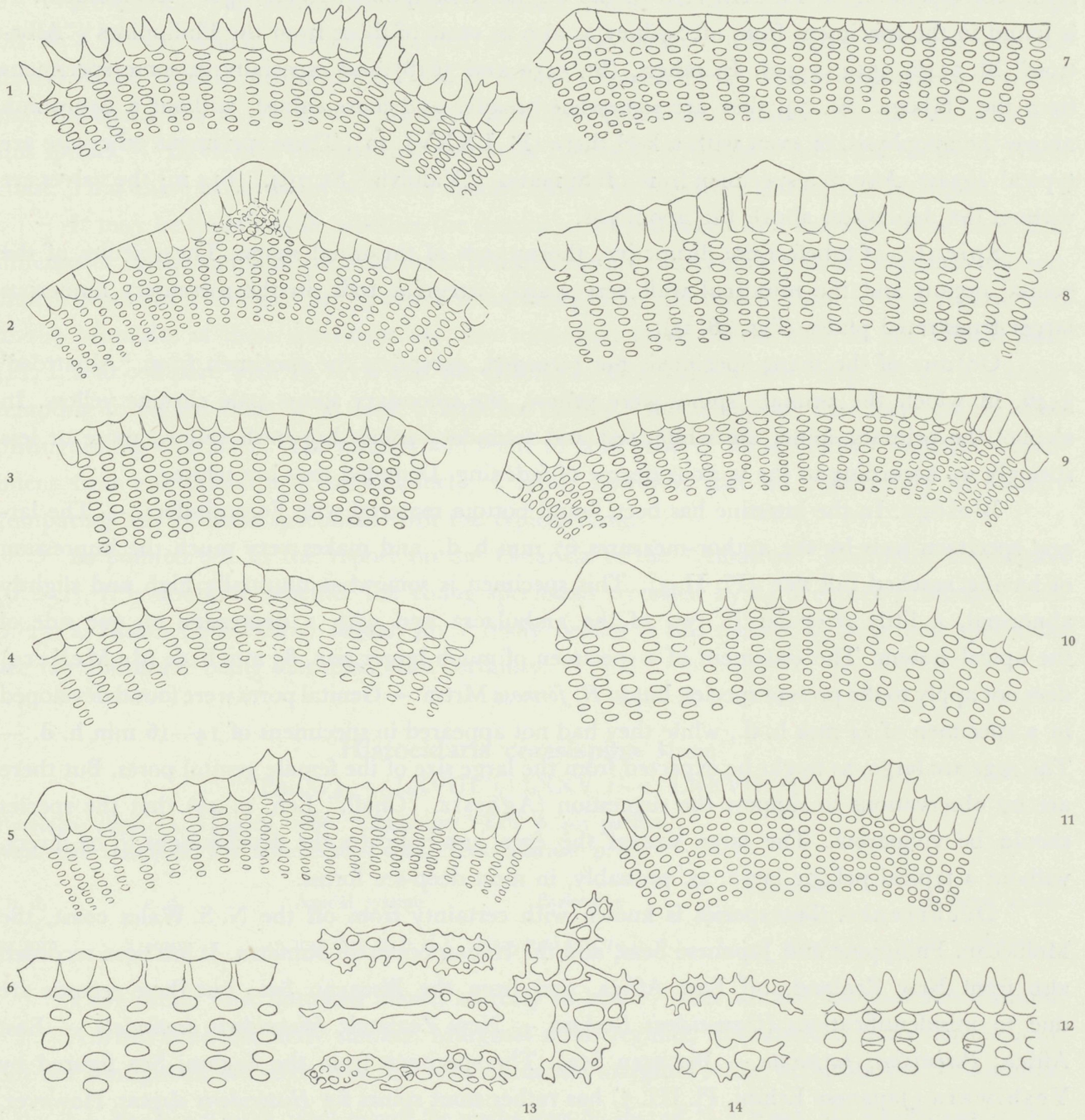


Fig. 38. Parts of transverse sections of primary spines of *Histocidaris*. 1. H. *elegans*; 2. same, from "Siboga" St. 74; 3. *H. misakiensis*; 4. *H. australiæ*; 5. *H. variabilis;* 6. *H. Cobosi;* 7. *H. formosa*; 8. *H. carinata*; 9. *H. magnifica*; 10. *H. Sharreri*; 11. *H. recurvata*; 12. *H. denticulata*. 13. Spicules from mesentery of *H. elegans*; 14. spicules from tubefeet of *H. crassispina*. 1—5 and 7—11 × 80; 6 and 12—14 × 125.

a small, distinct depression in the lower part, just above the apophysis (Pl. LXXVI. 10, 12). The smaller form (Pl. LXXV. 16) is quite simple, with strongly compressed blade.

The form of larger tridentate pedicellariæ described above may be regarded as the typical

form, corresponding to Pl. XLIV. 6 of the orginal description ("Challenger" Echinoidea). It is found in the specimens from off Sydney as also in some of those from the Philippines ("Albatross" St. 5446, 5512, 5510). In others, (St. 5450 and 5618) and especially in some specimens from the "Siboga" St. 74, they are somewhat broader and more robust, without a depression above the apophysis, or even with a keel there (Pl. LXXVI. 11). These specimens otherwise are typical *elegans*. Also in a specimen from off Sumatra ("Valdivia" St. 194.) (614 m) the valves are without the depression above the apophysis.

Spicules of tubefeet not distinctive, thorny rods of the usual shape. The spicules of the genital organs and the intestinal wall very scarce, irregular rods, in the mesentery numerous larger fenestrated plates (Fig. 38. 13).

Colour of the living specimens not recorded, excepting the specimen from "Albatross" 5446, in which the primary spines were yellow, the secondary spines pale chrome yellow. In alcohol the primary spines are white, test and secondary spines brownish yellow, more or less strongly so, according to the various degree of fadening. Denuded tests are white.

Biology. In the intestine has been found bottom material with Foraminifera. — The largest specimen seen by the author measures 67 mm h. d., and makes very much the impression of having reached full size (Pl. II. 3). This specimen is somewhat unusually high and slightly abnormal, a little irregular in two of the ambulacra and with a depression on one side of the apical system. The statement of a specimen of much larger size, 83 mm h. d. (de Meijere) does not apply to the present species, but to *H. formosa* Mrtsn. — Genital pores were found developed in a specimen of 24 mm h. d., while they had not appeared in specimens of 14—16 mm h. d. — The eggs are large, as might be expected from the large size of the female genital pores. But there are no observations to support the suggestion (Agassiz. "Chall." Ech. p. 42) that the species should be viviparous. The large size of the eggs just indicates the development to be direct, without a typical pelagic larva, as, probably, in most deep-sea forms.

Occurrence. The species is known with certainty from off the N. S. Wales coast, the Moluccan, Philippine and Japanese Seas, and the Indian ocean off Sumatra. It has been recorded also from New Zealand, off East Africa, and from the Biscayan Sea, but these records are due to misidentifications (*Ogmocidaris Benhami* — New Zealand; *Histocidaris denticulata* — East Africa; *Poriocidaris purpurata* — Biscayan Sea). The specimen from the Sagami Sea figured by Yoshiwara (Japanese Echini, Pl. III. 7) has rather stout spines for *Histocidaris elegans*. However, it is a true *H. elegans*, as I may state, having had the opportunity of examining this specimen and comparing it with typical specimens of this species. If it be found, when a richer material of specimens from the Japanese seas shall be available, that these have as a rule stouter (and shorter) spines than the specimens from the Australian and Moluccan Seas, there may be reason for distinguishing the Japanese form as a separate variety. For the present we must acknowledge it as a true *Histocidaris elegans*.

Bathymetrical distribution: ca. 200—1440 m.

Remarks. The above description is based mainly on specimens from off Sydney and off N. S. Wales, which may be regarded as the type locality. They agree very well with the figures in the "Chall." Echini, Pl. III and Pl. XLIV. 6 (pedicellaria). It is of importance to notice that the specimens in the British Museum from the "Challenger" station 164. b.[1] all belong to this species, — in view of the fact that two more species of *Histocidaris* occur off the N. S. Wales coast. Thus there is no doubt of which species should be regarded as the true *H. elegans*.

It may be questionable whether the species is not still taken in a too wide sense here. The differences in the shape of the tridentate pedicellariæ are rather conspicuous; especially the specimens from the "Siboga" St. 74 differ remarkably from the typical form in this regard, and as the primaries of these specimens are also somewhat more slender than in the typical form (Pl. I. 2 to compare with Pl. I. 1), and the general surface quite smooth (Fig. 38, 2), it is really tempting to regard them as at least a separate variety.[2] But it appears that there are no other distinguishing characters. The same would seem to hold good of some of the "Valdivia"- specimens from off Sumatra (Nias-Channel); I have, however, had no opportunity of directly comparing any of these specimens with the typical form.

As pointed out in the report on the Cidaridæ of the "Albatross" Philippine Expedition (p. 252), it is doubtful, whether the young specimens recorded by de Meijere ("Siboga" Ech. p. 25) as *Cidaris* (*Histocidaris*) *elegans*, juv.? really belong to this species. In fact, these specimens are too young for being identified with certainty.

Histocidaris crassispina Mrtsn.

Pls. X. 4—5; LXVIII. 5; LXXV. 1—2; LXXVII. 23.

Porocidaris elegans A. Agassiz. 1881. "Challenger" Ech. p. 40; partim.
Histocidaris crassispina. Th. Mortensen. 1928. New Cidaridæ. p. 66.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines.
32 mm	21 mm	15 mm (47 % h. d.)	12.5 mm (39 % h. d.)	7	9—11	58 mm

Test rather low, flattened above, scarcely so below; sides arched, circumference round. Ambulacra distinctly sinuate. Marginal series regular, the tubercles fairly conspicuous, but not contiguous. No secondary tubercles inside the marginal series, except below the ambitus,

[1] A. Agassiz (Op. cit. 1879) records the species from St. 164, off. N. S. Wales, 950 fathoms and 410 fms. In the final Report on the "Challenger" Echini he gives St. 164, a, 410 fms. According to the Summary of Results of the "Challenger" dredging hauls were made only at St. 164, b, 410 fms., and 164, c, 400 fms. St. 164, a was in 1200 fms., but this was merely a sounding. Thus the statement 950 fms. in the preliminary report is a mistake, and the station 164, a, given in the final report is a mistake for 164, b.

[2] The valve of a pedicellaria of "*Porocidaris*" *elegans* figured in the "Challenger" Ech. Pl. XLIV. 11 resembles the form of pedicellariæ found in these "Siboga"-specimens so very much that the suggestion lies at hand it is from (one of) the specimen(s) from the "Challenger" Station 214 (4° 33′ N. 127° 6′ E.) and thus not unlikely identical with the form from the "Siboga" St. 74. (5° 3′ S. 119° E.). I have not seen any of those specimens from the "Challenger" St. 214. They are no more in the British Museum, and not in the Museum of Comp. Zoology either.

where a single, median series is found, continuing to the peristomial edge. At and above the ambitus there is a narrow, naked, scarcely sunk, median area, with distinct vertical sutures. Pore zone narrow, about half as wide as the interporiferous zone. The pores are small, about equal-sized, markedly oblique. The wall separating the pores distinctly elevated; the ridge not very conspicuous (Pl. LXVIII. 5).

Interambulacra. Areoles rather large, slightly sunk, the 3—4 (5) proximal ones confluent; only the 2—3 proximal ones slightly transverse-oval. The tubercles are distinctly crenulate, mamelon fairly large. Scrobicular tubercles not much larger than the marginal ambulacral tubercles, edge of areoles not elevated. Only a single circle of much smaller secondaries outside the scrobicular tubercles, alternating with these latter, and leaving a rather conspicuous bare, somewhat sunk median area. Below the ambitus the median area is wholly covered with tubercles, about as large as the scrobicular ones. Also on the adradial edge there is a single series of small tubercles, alternating with the scrobicular tubercles, which reach close to the edge. The median interambulacral area is about half the width of an areole.

Apical system. All oculars rather widely exsert. Genital pores small (? ♂), near the edge. Very few tubercles on the apical system, which is not raised. Madreporite not distinctly enlarged. — Peristome with 6 ambulacral plates in a series; they are very broad, leaving no room for interradial plates.

Primary spines somewhat thickened (4 mm) in the proximal part, then tapering very gently; they are thus somewhat fusiform. All of the primaries being broken, it is unknown how long they are, and whether the point is simple or widened. The surface of the spine with numerous, slightly irregular, very finely serrate, very low ridges, so as to seem smooth at a first glance; the surface of spine between the ridges quite smooth. They are perfectly white, rather shining. Collar ca. 2 mm long, chocolate-brown; milled ring conspicuous. The subambital primaries are distinctly thinner than those of the upper side. Oral primaries lacking in the specimen.

Secondary spines. The scrobicular spines ca. 5 mm long, tapering to a rounded point; they are flattened, slightly concave in the basal part (Pl. LXXVII. 23). Marginal ambulacral spines much narrower, but also slightly concave in the basal part.

Pedicellariæ short and thick; the valves are remarkably flat on the outer side, the head of the pedicellaria thus getting the shape of a regular three-sided pyramid. On the inside the valves are slightly excavate, the concavity being a little more pronounced just above the apophysis. The smaller form of tridentate pedicellariæ is more narrow, otherwise of the same structure (Pl. LXXV. 1—2). Spicules of tubefeet somewhat coarser than usual, partly assuming the shape of fenestrated plates (Fig. 38, 14).

Colour. Test apparently with a slight brownish tint, especially on the apical system. Secondary spines chocolate-brown, as is also the collar of the primary spines.

Biology unknown. One of the primaries shows an indication of splitting up into four parts in the point; this seems to be due to some sort of (? parasitic) organism.

Occurrence. The type, and only specimen known, was taken by the "Challenger", at station 164, b, off Sydney, 410 fms.

Remarks. I found this specimen in the collection of the Museum of Comparative Zoology, Harvard College, where it was designated as a co-type of *Histocidaris elegans* (A. Ag.). Agassiz evidently did not observe the differences between this specimen and the typical *H. elegans*, the form which he figured in the "Challenger" Ech. Pl. III. In his description, at least, there is nothing to indicate that he did notice this specimen especially.

That it is quite different from *H. elegans* is evident enough. The characters of the primary spines, the pedicellariæ, the ambulacral tuberculation, the remarkably oblique position of the pores, are so conspicuous distinguishing characters that it must be out of question to refer this specimen to *H. elegans*. — In the character of its primary spines it recalls especially *misakiensis*, from which it differs, however, very markedly in the shape of the valves of the large tridentate pedicellariæ. Also *H. Cobosi* has the same characteristic form of the primaries, but also here the large tridentate pedicellariæ are of quite another shape — like those of *elegans* —, and then the marked irregularity of the marginal ambulacral tubercles distinguishes *Cobosi* very sharply from both *crassispina* and *misakiensis*. But if we are entitled to regard the characters of the primary spines as the foremost for recognizing relationship between the *Histocidaris*-species, then *crassispina*, *misakiensis* and *Cobosi* must form a group of nearly related species, to which group should further be added the West Indian species *Sharreri*, and, probably, *elegans* and *variabilis*, the two latter being distinguished by their primaries being simply cylindrical, not fusiform; but they have the same fine, microscopical serrations.

Histocidaris mikasiensis (Yoshiwara).

Pls. X. 3; LXIX. 2; LXXV. 3—4; LXXVII. 24.

Cidaris (Porocidaris) misakiensis. Yoshiwara. 1898. Prelim. Notice New Jap. Echinoids. Annot. Zool. Japon. II. p. 58.
Cidaris (Porocidaris) misakiensis. Yoshiwara. 1906. Japanese Echini. Pl. II. 9—10.
Histocidaris mikasiensis. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 103.
Porocidaris mikasiensis. H. L. Clark. 1907. The Cidaridæ. p. 227.
Plegiocidaris misakiensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 134.
Porocidaris misakiensis. H. L. Clark. 1912. Hawaiian. Ech. The Pedinidæ etc. Mem. Mus. C. Z. XXXIV. 4. p. 383.
Porocidaris mikasiensis. Lambert & Thiéry. 1925. Ess. nom. rais. p. 557.
NON. *Cidaris (Histocidaris) misakiensis.* De Meijere. 1904. "Siboga" Echinoidea. p. 27. Taf. II. 15—16; XII. 141—142. (= *Histocidaris recurvata* Mrtsn.)

Through the kindness of Professor Seitaro Goto I have had the type specimen of this species sent for study and I am thus in a position to supply the necessary details, which are lacking in the description given by Yoshiwara (Op. cit. 1898. The description in Japanese in his work from 1906 of which my friend Professor H. Ohshima has kindly given me a translation, contains a little more information, but this is scarcely accessible to anybody outside Japan). Also the

additional information given by H. L. Clark (Op. cit. 1912) still leaves several points not cleared up. Unfortunately the specimen is now in a very poor condition, having been dried up and broken into several pieces. It is therefore not possible to give a photographic figure of the specimen, so we have got to make the best of the two figures given in Yoshiwara's Japanese work of 1906. But the necessary details can still be made out, so that we may still get a fairly complete knowledge of the species.

The size of the specimen is given by Yoshiwara (1906) as 39 mm h. d. 26 mm. v. d. The shape of the test is stated by Yoshiwara to be "more flattened than in *C. elegans*". The larger of the fragments indicate that the test is very regularly arched, scarcely flattened above and below, and of well rounded circumference.

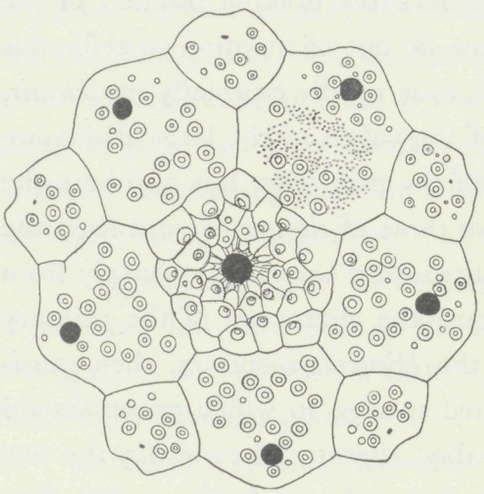


Fig. 39. Apical system of type specimen of *Histocidaris mikasiensis* (Yoshiwara). × 4.

The ambulacra are 21 % of the I. A. (4 mm against 19 mm). Marginal series of tubercles very regular. The interporiferous zone is scarcely wider than a pore zone, so completely filled up by the rather large marginal tubercles that there is hardly room for a single tubercle inside the marginals (Pl. LXIX. 2); only here and there a single tubercle may occur along the midline, never an inner double series. The pores, which are rather oblique, are subequal, the inner one rather unusually semilunar in shape. The wall is elevated, rounded.

Interambulacra. There are 7 plates in a series, each of the upper ones corresponding to 12—13 ambulacral plates. The areoles are fairly deep, the 3—4 proximal ones confluent; the tubercles all very distinctly crenulate. The scrobicular circle of tubercles fairly prominent, somewhat larger than the marginal ambulacral tubercles. A single series of smaller tubercles outside the scrobicular ones, leaving a rather distinct, slightly deepened median line. The median area scarcely half as wide as an areole.

The apical system (Fig. 39) 16 mm, thus 41 % of h. d. The oculars[1] all exsert; both oculars and genitals with fairly numerous tubercles. Genital pores of medium size, rather distant from the edge. — About the peristome no information can be gained.

Primary spines (Pl. X. 3) up to 100 mm long (2.5 h. d.), slightly widening a little beyond the collar, then tapering very gradually, apparently to a blunt point; they are rather robust, 4,5 mm at the thickest part (10—20 mm above the base), distinctly thorny, with ca. 20 slightly elevated, finely serrate ridges, but no longer spinules. Between the ridges the surface is smooth, shining, with very fine longitudinal furrows, scarcely observable in transverse

[1] When Yoshiwara says (Op. cit. 1898) "Basals not extending to peripheral margin of anal system", he evidently means the oculars.

sections (Fig. 38. 3). The collar 3—4 mm long, the milled ring rather prominent. The oral primaries rather slender, slightly curved, fairly strongly serrate, as typical of the genus. It would appear that the third is transitional to the ambital spines, but this cannot be definitely stated.

The secondary spines ca. 6 mm long, slightly widened above the base, then tapering, but with truncate end; they are simply flattened, not excavate or keeled (Pl. LXXVII. 24). The ambulacral spines slightly flattened, pointed. (None found in situ).

Pedicellariæ. Large form very conspicuous, head up to 3 mm length (according to Clark up to 5 mm long). The valves (Pl. LXXV. 4) have the blade excavate in its whole length, spoon-shaped, with a whitish midline. The apophysis very short. The small form quite simple, slender, not at all peculiar (Pl. LXXV. 3). — Spicules of the usual type.

Colour in life (?) dark brown. Primary spines white, the collar brown, secondary spines brownish.

Occurrence. Locality of the type-specimen: Sagami-Sea. No record of the depth.

Remarks. While this species is very clearly distinct from the species *H. recurvata* which was identified by De Meijere as *Histoc. misakiensis*, it is evidently more nearly related to the Hawaiian species *Histoc. variabilis* A. Ag. & H. L. Clark, as already H. L. Clark (The Cidaridæ, p. 228) hinted at the possibility of their being identical. The differences to be noticed on comparison of a couple of specimens of *H. variabilis* of 48 and 60 mm h. d. with the type of *misakiensis* (39 mm h. d.) are: the narrower ambulacra in *misakiensis* (Pl. LXIX. 2, comp. with Pl. LXVIII. 7), the widening of the primaries above the basis in *misakiensis* (quite cylindrical in *variabilis*), the somewhat excavate secondaries of *variabilis*, and, finally, the fact that no bivalve pedicellariæ have been found in *misakiensis*. These differences, however, if constant, would seem important enough for regarding the two forms as distinct species (cf. p. 83). — As pointed out by Clark (1912) the character of the primary spines recalls the West Indian species *Histocid. Sharreri*.

It is a funny fact that Lambert & Thiéry refer this species first (1910) to *Plegiocidaris*, then (1925) — evidently forgetting the position previously assigned to it — to *Porocidaris*, as the only recent representative of this latter genus. Both references are equally arbitrary and without scientific foundation.

Histocidaris variabilis (A. Ag. & H. L. Clark).

Pls. LXVIII. 7; LXXVI. 1—2; LXXVII. 27.

Porocidaris variabilis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ p. 32. Pls. **8; 16—22; 23. 1—4.**
Porocidaris variabilis. A. Agassiz & H. L. Clark. 1908. Hawaiian Ech. Salenidæ. etc. Pl. 43. 1—2. (Inner organs).
Porocidaris variabilis. H. L. Clark. 1907. The Cidaridæ, p. 228.
Plegiocidaris variabilis. Lambert & Thiéry 1910. Ess. nom. rais. p. 134.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines.
82 mm	59 mm	39 mm (47.6 % h. d.)	32 mm (39 % h. d.)	9—10	13—14	85 mm
77 —	60 —	34 — (44.2 —)	25 mm (32.5 —)	9—10	15—16	?
68 —	48 —	29 — (42.7 —)	24 — (35.3 —)	9	12—13	75+
50 —	34 —	20,5 — (41 —)	18 — (36 —)	7—8	12—13	ca. 80
40 —	24 —	17 — (42.5 —)	15 — (37.5 —)	7	12—13	88
36 —	24 —	15,5 — (43.1 —)	15 — (42.8 —)	6—7	12—13	116+
26 —	16 —	11 — (42.3 —)	11 — (42.3 —)	6	9—10	60+.
16 —	10 —	8 — (50 —)	7 — (43.1 —)	6	7—8	45+

The specimen of 82 mm. h. d. is the type specimen (U. S. Nat. Museum).

Test of larger specimens (up to 85 mm h. d.) spherical, in smaller specimens somewhat depressed, flattened above, less so below. — Ambulacra (Pl. LXVIII. 7) ca. 21—23 % of I. A., rather distinctly sinuate. The interporiferous zone slightly broader than a pore zone. The marginal series of tubercles very regular, the tubercles rather small, not contiguous; inside the marginal series a more or less regular double series of smaller tubercles, in the upper part irregularly alternating. No distinct naked or sunk median line. Pores subequal, the inner pore may be slightly larger than the outer one. This is, however, no constant feature, some specimens having them of equal size. In very large specimens the inner pore may be distinctly larger than the outer one. There may also be some irregularities in the marginal series of tubercles in the old specimens; in one case the marginal tubercles have even nearly totally disappeared at the ambitus, only the inner series remaining.

Interambulacra. I. A. plates 9—10 in the large specimens. The 4—5 lower areoles confluent. Primary tubercles distinctly crenulate. The median area about half as wide as an areole (in the specimen "Hawaiian Ech." Pl. 19 apparently somewhat more than half as wide), in younger specimens distinctly narrower than half the width of an areole (A. Agassiz & Clark; Pl. 23, 4). Edge of areoles not elevated. Scrobicular circle of tubercles usually fairly prominent; in larger specimens it is relatively less prominent, may even be very inconspicuous. Rather numerous smaller tubercles outside the scrobicular tubercles, leaving no distinct bare median or adradial space.

Apical system 41—50 % of h. d.; tubercles generally scattered over the whole of the apical plates, rather numerous for a *Histocidaris*. In younger specimens (the long-spined form)

the tubercles are mainly found along the inner edge of the genital plates, forming a more or less conspicuous series. Ocular plates all excluded from the periproct, which is, usually, not elevated. Female genital pores very large, 3 mm, wholly within the plate.

Peristome somewhat pentagonal; there are 7—9 ambulacral plates in a series in the large specimens, 3—4 interradial plates, which may sometimes reach the edge of the mouth.

Primary spines of larger specimens scarcely exceeding (or even not quite reaching) h. d. In younger specimens relatively longer, even exceeding 3 times h. d. They are 3—4 mm thick, quite cylindrical, not widened above the basal part or tapering, except the uppermost ones; the point of the subambital ones usually somewhat widened, fluted. The surface of the spines with numerous fine longitudinal, finely serrate ridges. The serrations do not assume the shape of larger thorns (as in *carinata*). Between the ridges the surface is very finely, but rather distinctly furrowed. (Comp. transverse section, Fig. 38,5). The oral primaries rather coarse, very much resembling those of *carinata;* the 4th— 5th transitional. The secondary spines (Pl. LXXVII. 27) flattened, slightly excavate, not carinate; they are rather slender, somewhat narrowing towards the point. The ambulacral spines very slender, slightly flattened.

The large pedicellariæ up to 4 mm length of head, thick and robust; both 2- and 4-valved samples may occur. The valves are broad, but the blade is lanceolate, not triangular as in *H. carinata;* it is excavate in its whole length, not filled up by meshwork, but otherwise it is built up of a dense, reticulate calcareous network showing an arrangement in radiating lines (Pl. LXXVI. 2). The apophysis short and broad, as usual in this genus. The smaller pedicellariæ with long, narrow, compressed valves; up to 2 mm length of head (Pl. LXXVI. 1). — Spicules of the tubefeet rather scarce and small, but otherwise of the usual type.

Colour of test and secondary spines brown or even dark violet or deep purple; the tip of the secondary spines at ambitus with a greenish tinge. Primary spines whitish, with the tip brownish; the collar brown or salmon coloured. Younger specimens are somewhat lighter coloured.

Occurrence: Known only from the sea round the Hawaiian Islands, ca. 320—555 m.

Remarks. It might seem a little doubtful, whether the longspined form figured in Pls. XX-XXII of the "Hawaiian Ech." could really be identical with the shortspined form, as represented in Pls. XVI—XVII of the same work. To the conspicuous difference in the length and thickness of the primary spines, seen directly on a comparison of the figures quoted, may be added that the apical system is more naked in the longspined form, that the interporiferous zone af the ambulacra is somewhat narrower, the marginal series being so close together as to leave hardly any room for inner tubercles, and that the median interambulacral space is narrower, ca. $^1/_3$ the width of an areole against ca. $^1/_2$ the width of an areole in the shortspined form. Also the marginal ambulacral spines are somewhat broader and flatter in the longspined form. In the other characters they are quite alike. The weight of the differences pointed out here, is however, considerably lessened through the fact that the longspined specimens are all of smaller size, the shortspined of larger size; moreover I found, on an examination of the specimens in the

collections of the U. S. National Museum and the Museum of Comparative Zoology, a couple of specimens of 40—45 mm h. d. to be so intermediate in all their characters that it would be difficult enough to decide, whether they should be reckoned to the longspined or the shortspined form. Therefore, — although it is hard to see, how long, slender primary spines as those of the specimen Pl. XX could be transformed during the growth of the specimen to such short and robust spines as those of the specimen Pl. XVI of "Hawaiian Ech." — I have, though reluctantly, come to the same result as H. L. Clark that all these specimens belong to one and the same species, and that the differences pointed out above are in the main due to age.

H. L. Clark (The Cidaridæ, p. 288) has hinted at the possibility that this species may be identical with *Histoc. misakiensis*. This suggestion is supported by the fact that the large tridentate pedicellariæ are identical in both of them. The main differences which appear to exist between the two species are in the spines. The primaries are quite cylindrical in *variabilis*, rather distinctly fusiform in *misakiensis;* they are also more smooth in *variabilis*, the serrations being less distinct than in *misakiensis*. The secondary spines are more flat in *misakiensis*, further bivalve pedicellariæ are unknown in the latter. The differences in the ambulacra appear to be less reliable: in the longspined (young) *variabilis* the marginal tubercles are so close together as hardly to leave any room for inner tubercles, just as is the case in *misakiensis*. The said differences, especially in the characters of the primary spines would, however, seem to make it unjustifiable, for the present, to unite the Hawaiian and the Japanese form into one species. But it is not unlikely that, when more material of the Japanese form becomes available, and the variations in its characters, — which must be expected to occur in this species as well as in others —, are made known, it will be more difficult to maintain the Hawaiian form as a separate species.

Histocidaris Cobosi (A. Agassiz).

Pls. LXVIII. 11; LXXVI. 3—5.

Porocidaris Cobosi. A. Agassiz. 1898. "Albatross" Echini. Prel. Rep. p. 74. Pl. **III. 2—5.**
Porocidaris Cobosi. A. Agassiz. 1904. Panamic Deep-Sea Echini p. 29. Pl. **9; 10. 4—9; 11; 12; 13. 1—4.**
Porocidaris Cobosi. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ; p. 31, Pl. **7.**
Histocidaris Cobosi. Th. Mortensen. 1907. "Ingolf". Ech. II. p. 16.
Porocidaris Cobosi. H. L. Clark. 1907. The Cidaridæ. p. 227.
Plegiocidaris Cobosi. Lambert & Thiéry. 1910. Ess. nom. rais. p. 134.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
34 mm	24 mm	13 mm (38.2 % h. d.)	ca. 13 mm (38 % h. d.)	8(9)	9—10	ca. 100 mm
22 —	15 —	9,5 — (43.2 —)	10,5 — (47.7 —)	6—7	7—8	63+
20 —	12 —	9 — (45 —)	9 — (45 —)	6—7	7—8	
10 —	6 —	5 — (50 —)	5 — (50 —)	5—6	5—6	
8 —	4 —	4,5 — (56.2 —)	4,5 — (56.2 —)	5—6	4—5	

Test rather low, in the younger conspicuously higher than in the larger specimens, somewhat flattened above and below; the sides are arched, the circumference round.

Ambulacra nearly straight, ca. 25—30 % of width of I. A., in the younger specimens even as much as half the width of I. A. The interporiferous zone unusually narrow, scarcely as broad as a pore area. Marginal series of tubercles very irregular, large and small tubercles alternating quite irregularly. In the upper part of the ambulacrum the marginal tubercles may be thus arranged as to form only one, irregular, median series. On the whole, the two marginal series are so close together as to leave no space for tubercles at their inner side; only in the largest specimens there may be a single small inner tubercle here and there at the ambitus. No naked median space. The pores are equal-sized, separated by a rather narrow, elevated wall; ridge fairly conspicuous (Pl. XLVIII. 11).

Interambulacra. Areoles confluent, only the 2—3 upper ones separated; they are very shallow, the subambital ones somewhat transverse-oval. Tubercles rather large and prominent, distinctly crenulate (also in the specimen of 8 mm h. d.)[1]. The edge of the areoles not elevated; scrobicular tubercles inconspicuous, only about as large as, or even smaller than the larger ambulacral tubercles. A few tubercles outside the scrobicular circle, on both the admedian and the adradial side, alternating with the scrobicular tubercles. No naked median or adradial space; the median area only about $^1/_3$ the width of an areole.

Apical system rather small, ca. 38—45 % of h. d., in young specimens relatively much larger, 50—55 % h. d. The tubercles of the apical system somewhat more numerous than usual in this genus, but arranged in the usual way (Panamic Deep-Sea Ech. Pl. XI, 6). Oculars exsert, only in the largest specimen Oc. I is insert. Genital pores apparently small. Perhaps, however, the largest specimen is not a female, as stated by Agassiz (Op. cit. p. 29), but rather a male, and it may then well be expected that the female pores will prove to be much larger, in accordance with the other species of *Histocidaris*. That the genital pores of the specimens 20—22 mm h. d. are still smaller need not mean that these specimens are males, the larger specimen a female, but only that the genital pores are about to develop in these specimens. In the specimens of 8—10 mm h. d. the genital pores have not yet appeared.

Peristome as large as, sometimes even larger than the apical system. There are 6—7 ambulacral plates in a series in the largest specimens, the plates being so large as to leave no room for interradial plates. In a smaller specimen there is, however, a single interradial plate developed in three of the interradii (Pan. Deep-Sea Ech. Pl. XI. 1—2).

Primary spines up to 3 h. d., slender, slightly tapering, sometimes (in younger specimens only ?) slightly widened at the tip. They are nearly smooth, but with numerous, very fine and low, delicately serrate ridges, the surface otherwise very finely furrowed (Fig. 38,6). The oral primaries apparently somewhat less conspicuously serrate than usual in this genus.

Secondary spines simply flattened, widened in the middle, then tapering to a rounded point. Ambulacral spines simply setaceous, scarcely flattened; they vary conspicuously in size,

[1] The reason why Agassiz could not distinguish the crenulation in this young specimen (Panamic Deep-Sea Echini, p. 29) was probably insufficient cleaning.

corresponding to the size of the tubercles, the largest being as much as 8 mm long, while the scrobicular spines scarcely exceed 5 mm in length.

Pedicellariæ very much like those of *H. elegans*, with a depression above the apophysis;[1] they may reach a length of head of 5.5 mm. Small form of pedicellariæ with the valves not compressed. A noteworthy feature is the narrowness of the basal part, in both forms. (Pl. LXXVI. 3—5) — Spicules of tubefeet of the usual type.

Colour pale pinkish; the naked test white. Primaries white and shining, with brownish collar. Secondary spines of a creamy colour.

Occurrence. Off Chatham Isl. Galapagos, 615 m on rocky bottom. (Only taken once, by the "Albatross").

Remarks. According to H. L. Clark (Op. cit.) this is "the handsomest species of the genus, and . . . . the easiest to recognize". I would say that perhaps *H. formosa* may claim a higher rank as regards the beauty, and that several of the other species e. g. *formosa*, *magnifica*, *acutispina*, *Sharreri*, are no less easily recognizable. The most conspicuous character is the irregularity of the marginal series of tubercles in the ambulacra, and the almost total absence of inner tubercles, due to the narrowness of the interporiferous zone. The character especially pointed out by Agassiz, viz. "its small actinal and abactinal systems" holds good only of the largest specimen, as seen from the measurements given above. In the other specimens of 20—22 mm the apical system and peristome are of the usual size, in the young specimens of 8—10 mm h. d. even unusually large. It would seem that the nearest relations are *H. crassispina* and *mikasiensis*, which have the same characteristic form of the primaries, while on the other hand, the pedicellariæ are quite different, as there are also several other differences.

The description of *H. Cobosi* given here is based on a reexamination of the specimens in the Museum of Comparative Zoology and the U. S. National Museum.

Histocidaris Sharreri (A. Agassiz).

Pls. VIII; IX; LXVIII. 4; LXXVI. 6—7.

Porocidaris Sharreri. A. Agassiz. 1880. Prel. Rep. "Blake" Echini, p. 71 (partim).
Porocidaris Sharreri. A. Agassiz. 1883. "Blake" Echini, p. 12 (partim); Pl. **III.** (non Pl. IV. 1—2 = *Calocidaris micans*).
Porocidaris Sharreri. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 22, 30.
Histocidaris (?) Sharreri. Th. Mortensen. 1907. "Ingolf" Ech. II. p. 16.
Porocidaris Sharreri. H. L. Clark. 1907. The Cidaridæ, p. 226.
Histocidaris Sharreri. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 55.
Dorocidaris Sharreri. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Histocidaris Sharreri. Th. Mortensen. 1926. A new West Indian Cidarid. Univ. Iowa Studies in Nat. Hist. XI. 7, p. 7, figs. **2, 5, 7—8, 10.**
NON: *Porocidaris Sharreri.* R. Rathbun. 1885. Rep. Ech. "Albatross", p. 611. (Descriptive notes refer to *Calocidaris micans*).
— *Histocidaris Sharreri.* H. L. Clark. 1918. Rep. Crin. & Ech. Bahama Exp. 1893, p. 21. Pl. IV, 1 (= *Histocidaris Nuttingii* Mrtsn).

[1] A. Agassiz & H. L. Clark (Op. cit. Pl. 7, fig. 5) erroneously represent them as having no such depression.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
69 mm[1]	48 mm	34 mm (49.3 % h. d.)	ca. 28 mm (ca. 40 % h.d.)	3—9	13—14	110—114 mm

Test rather globular; apical system somewhat raised; (not to be seen whether the test is flattened below). Circumference round.

Ambulacra distinctly sinuate, scarcely 20 % of width of I. A. Marginal series of tubercles very regular, the tubercles fairly large, nearly contiguous. Interporiferous zone about twice the width of a pore zone; it is in the main perfectly naked, only here and there, below the ambitus, a small inner tubercle is found. The midline very distinctly sunk, very sharply marked against the lateral parts of the interporiferous zone, which form like an elevated wall to each side of the sunk midline. The pores about equal-sized, the wall rather narrow, but elevated, distinctly higher than the ridge (Pl. LXVIII. 4).

Interambulacra. The 4—5 upper areoles apparently well separated, the adjoining scrobicular circles being distant enough for giving room for some small spines (tubercles) between them. The shape of the areoles not to be observed. The scrobicular tubercles apparently rather conspicuous, more than twice as large as the marginal ambulacral tubercles. Outside the scrobicular circle, both on the admedian and the adradial edge, a few secondary tubercles, leaving a broad, bare median space, and also a distinct bare adradial edge (Pl. IX). It must be emphasized that the secondary tubercles are not at all arranged in horizontal series, as is erroneously stated in literature, e. g. Panamic Deep-Sea Ech. p. 24, on account of the erroneous figure Pl. IV. 1 of the "Blake" Echini (*Calocidaris micans*; see below p. 314). Median area about $^2/_3$ as broad as an areole.

Apical system. Oculars all exsert. Genital pores rather small, not near the edge. Very probably the specimen is a male; the pores of the female will probably be found to be much larger, as is the rule in *Histocidaris*. As usual in this genus the apical plates are very sparsely tuberculated, the tubercles being on the genital plates in the main confined to the immediate vicinity of the genital pore and to a more or less conspicuous transverse series nearer the inner edge, leaving the rest of the plate bare; on the oculars the tubercles form an arc above the ocular pore. The genital plate 4 is, in the type-specimen, divided into two parts of nearly equal size by a vertical line; only one of the parts, the larger, has a genital pore. Periproct 18.5 mm in diameter; the outer circle of plates rather large. — Peristome with 8 ambulacral plates in a series, they are high and broad, leaving hardly any room for interradial plates.

Primary spines ca. 1.5 the h. d., in the main cylindrical, partly slightly fusiform, the ambital ones fluted and slightly flaring at tip; the apical primaries only ca. 40 mm long, tapering and ending in a distinct crown, as well shown in the Pl. III of the "Blake" Echini. Collar of the

[1] In the "Blake" report the largest specimen of "*Porocidaris*" *Sharreri* is stated to measure 72 mm in diameter. This no doubt refers to *Calocidaris micans*, which was confounded with *H. Sharreri*.

ambital spines ca. 4 mm long, slightly widening towards the conspicuous milled ring. The surface of the shaft has numerous fine, very low ridges, which are finely and densely serrate; no larger thorns; between the ridges the surface is perfectly smooth, shining (Fig. 38,10). The oral primaries are slightly curved, broad and flat, rather spatulate, with distinctly serrate edges and rounded at the point (cf. Th. Mortensen. Op. cit. 1926, Fig. 3). Secondary spines. The scrobicular spines are 8—10 mm long, tapering to a rounded point; they are flattened, slightly concave on outer side, usually thickened at the point (cf. Op. cit. 1926, Fig. 5). The marginal ambulacral spines simply setaceous.

Pedicellariæ (cf. Op. cit. 1926. Figs. 7—8, 10). Large form very conspicuous, ca. 4 mm length of head, which is broad, conical or rather rounded-pyramidal. The valves elongate triangular, with sides somewhat reenteringly curved, and with a conspicuous depression above the apophysis continuing almost halfway up the blade (Pl. LXXVI. 6). The small form with slender, narrow valves, with a more or less distinct median keel (Pl. LXXVI. 7). — Spicules of tubefeet of the usual type.

Colour. Primary spines white, with yellowish-brown collar. Secondaries yellowish-brown, as is also the skin of the test, whereas the naked test appears to be white.

Occurrence. Known with certainty only from off Nevis,[1] 570 m („Blake", Stat. 151; the type specimen).

Remarks. Great confusion has been reigning with regard to this species, due to the fact that Agassiz confounded with it the widely different *Calocidaris micans*, so that, in fact, the species was not recognizable from his description and figures. In the "description" in the "Blake" Echini it is only the first line of the second, and the middle part of the fourth paragraph that refer to the real *Sharreri*, the rest of it to *Calocidaris micans*, and — what is worse — the detail-figures of the test, Pl. IV. figs. 1—2, are likewise of *Calocidaris micans*. Only the figure on Pl. III really represents the true *Sharreri*, the type-specimen (in the Museum of Comparative Zoology). These facts necessarily must lead to confusion.

Having now had the opportunity of examining the type-specimen as well as the other specimens preserved under this name in the Museum of Comparative Zoology and in the U. S. National Museum, I think that not one of these latter specimens is really *Sharreri*, the type specimen being, in fact, the only specimen known with certainty till now. Of the three specimens mentioned by Agassiz in his "Preliminary Report on the Echini" (Bull. Mus. Comp. Zool. VIII. p. 71) the specimen from St. 297, off Barbados, is *Calocidaris micans;* the specimen from St. 152, off St. Kitts, (— as far as it can be identified with certainty; according to information from H. L. Clark it appears to have been mislaid, and got a wrong locality —) is, really, a *Histocidaris*, but differs so much from the type-specimen that it is, at least, very doubtful whether it can belong to this species. The ambulacra have no sunk, naked midline, and there is here and there a small inner tubercle, not forming, however, a regular inner series. Also the marginal

[1] In H. L. Clark's "The Cidaridæ" p. 226 this locality is erroneously referred to as "near Barbados".

series of tubercles is somewhat irregular (Pl. LXIX. 3). The primary spines are all broken; on two of the apical ones there are a couple of coarse thorns in the basal part, in addition to the usual fine serrations. (The pedicellariæ are in the main like those of the type, only the edge of the blade not reenteringly curved). These differences would seem to indicate that we have here really a third West Indian species of the genus *Histocidaris*. As the specimen is a small one and in a poor state of preservation, it does, however, not seem advisable to make it the type of a new species, and it may, therefore, suffice only to call attention to this form by future investigations.

H. L. Clark ("The Cidaridæ", p. 226) also states that *H. Sharreri* was taken off Georgia, 279 fms.; this is, however, as he informs me, an error. — Rathbun (Op. cit.) further gives a number of localities for *Sharreri*. It appears that not one of the specimens thus recorded by Rathbun was a true *Sharreri;* at least all those which I have seen (viz. all those preserved in the U. S. National Museum) are either *Calocidaris micans* or *Stereocidaris ingolfiana*. Most probably also Agassiz confounded *Stereocidaris ingolfiana* with *Sharreri* (cf. "Ingolf" Ech. II, p. 10 note). That the specimen recorded in 1918 by H. L. Clark (Op. cit.) as *Histoc. Sharreri* is quite another species (*Histoc. Nuttingii*) appears from my paper "A New West Indian Cidarid" 1926.

Döderlein (Japan. Seeigel; p. 43) suggests that this species rather belongs to the fossil genus *Pleurocidaris* Pomel, one of the main characteristics of which is the arrangement of the secondary tubercles in distinct horizontal rows. There is not the slightest doubt that it is the erroneous figure, Pl. IV, 1 of the "Blake" Echini (in reality *Calocidaris micans*, as we now know) which led Döderlein to this suggestion. — According to Agassiz (Panamic Deep-Sea Ech. p. 24) also Studer has suggested *Sharreri* to belong to the genus *Pleurocidaris*. I am unable to find any such statement in any of Studer's papers on Echinoderms and am inclined to think that "Studer" here is a slip of the pen for Döderlein.[1]

Judging from the character of the primary spines this species would seem to belong together with *crassispina, misakiensis* and *Cobosi*, from all of which it is very well distinguished, especially by the character of its ambulacra.

Histocidaris carinata Mrtsn.

Pls. VI; VII; LXIX. 1; LXXV. 11—13; LXXVII. 25—26.

Histocidaris carinata. Th. Mortensen. 1928. New Cidaridæ, p. 66.

h.d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.
65 mm	51 mm	29 mm (44.6 % h. d.)	21 mm (32.3 % h. d.)	8—9	13—15

Sides of test beautifully arched, upper side slightly flattened.

Ambulacra ca. 21. % of width of I. A. The interporiferous zone somewhat broader than a poriferous zone; the marginal series of tubercles regular, the tubercles small, not contiguous.

[1] As was his usual habit, Agassiz does not quote the place, where the said statement is found.

At the ambitus there are adradially to each marginal tubercle two smaller tubercles, which form, together with the marginal one, a rather regular, horizontal series; no naked or sunk median line. The pores are separated through a fairly broad, somewhat elevated wall; they are a little unequal, the inner one being rather distinctly the larger. Ridge fairly conspicuous, slightly elevated (Pl. LXIX. 1). — Interambulacra. Primary tubercles low, distinctly crenulate, the areoles not much deepened; only the 3—4 proximal ones confluent, the upper ones well separated, round, not transversely oval. The median area somewhat more than half as wide as an areole. Edge of areoles slightly thickened. The scrobicular circle of tubercles rather conspicuous, the tubercles being about twice the size of those of the marginal ambulacral series. Outside the scrobicular circle only few, small tubercles, leaving a very conspicuous, bare, sunk area in the midline. Also at the adradial side a conspicuous naked margin is left.

Apical system of the usual character; the few tubercles placed round the genital and ocular pores, leaving the rest of the plates bare, excepting a transverse line of about 4—6 tubercles in the inner part. Genital pores large, 2 mm, wholly within the plate. Ocular plates all excluded from the periproct, which latter is rather unusually small, only about half the diameter of the whole apical system (15 to 29 mm); it is distinctly elevated, well set with tubercles. — Peristome not more closely examined (in order to spare the fine specimen).

The primary spines up to 2 h. d. (longest 132 mm); they are slightly fusiform, the thickest (4—4.5 mm) about 1 cm above the collar, then tapering very gently, the end of the spine being, however, a little widened. The collar 3 mm long. Surface of the spines with numerous fine, very little prominent longitudinal ribs, more or less coarsely serrated, the serrations often growing into distinct thorns, now in the lower, thicker part, now somewhat farther out. Between the ridges the surface of the spine is very finely longitudinally ridged (transverse section, fig. 38. 8). The upper spines not yet fully formed, which indicates that the specimen has not yet reached its full size. The two first oral primaries are broad, curved as usual, coarsely serrate. The third has a club-shaped, longitudinally furrowed terminal part; in the fourth this terminal part is considerably longer than the serrate basal part, the serrations being also less conspicuous than in the proximal spines. In the fifth the serrations have disappeared, while the end of the spine keeps the same character as in the 3rd—4th, coarsely longitudinally furrowed, slightly widening towards the point, which is slightly trumpet-shaped, with a small peak within the terminal depression.

The secondary spines surrounding the base of the primaries are ca. 7 mm long, 1—1.5 mm broad, hardly narrowing towards the end, with a distinct median longitudinal keel along outer side and generally another similar, though somewhat less distinct on the inner side (Pl. LXXVII. 25—26). Sometimes the keel is double in the lower part of the spine. The ambulacral spines are rather erect, ca. 5 mm long, narrow, pointed, flattened in the basal part, but not carinate.

The large pedicellariæ are very thick-headed, the head reaching about 4 mm in length. The valves (Pl. LXXV. 11) are very broad, flattened, especially in the basal part, the head thus being triangular. The blade is concave; the whole of the valves is built up of a very thick, retic-

ulate calcareous network, arranged in fanshaped radiating lines, distinctly seen also on the outside of the valve. Also the apophysis is very broad and unusually short. The small form of pedicellariæ with elongate, narrow valves, the basal part of which is unusually narrow (Pl. LXXV. 12—13). Spicules of the tubefeet of the usual type, irregular, branched rods, developing into somewhat larger, fenestrated plates towards the end of the tubefeet.

Colour of test and secondary spines brown. The primary spines white, except the collar, which is brown like the secondary spines. The regenerating or not fully developed primary spines brown.

Occurrence. 16 M. W. to S. of Bonomisaki, Kiushiu, Japan; 360 m; sand. 13. V. 1914. 1 specimen.

Remarks. This very fine species has in general aspect great resemblance with the Hawaiian species *Histocidaris variabilis* (A. Agassiz & H. L. Clark); it is, however, easily distinguished from that species by various characters: more numerous ambulacral tubercles, the large, naked space in the interambulacral midline, the fewer tubercles on the apical system, the pedicellariæ and, especially, the carinate secondary spines. — As far as can be judged from the scanty material at present known the other species recorded from Japanese seas, *H. misakiensis*, is quite distinct from the present species; especially the characters of the ambulacra and the pedicellariæ would seem to preclude the idea of these two forms being identical. But so long as we know only one medium-sized specimen of *mikasiensis* and one large specimen of *carinata* it is, of course, impossible to have any idea of the range of variation of the two species, and it is only safe to say that at the present state of our knowledge we must regard them as two distinct species.

Judging from the character of the primary spines this species would seem to be the nearest related to *H. australiæ*, from which it differs, however, very markedly especially by its pedicellariæ.

Histocidaris australiæ Mrtsn.

Pls. X. 1—2; XI. 1—5; LXVIII. 1—3.

Histocidaris elegans. H. L. Clark. 1916. "Endeavour" Echinod. p. 105 (partim).
Histocidaris australiæ. Th. Mortensen. 1928. New Cidaridæ, p. 66.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	75 mm	56 mm	33 mm (44 % h. d.)	25 mm (33 % h. d.)	10—11	12—13	83 mm
2	72 —	55 —	35 — (48.6 —)	?	?	12—13	
3	65 —	40 —	31 — (47.7 —)	21 — (32.3 —)	9	11—12	
4	62 —	40 —	29 — (46.8 —)	19,5 — (31.5 —)	9	12—13	
5	77 mm	60 —	33 — (42.9 —)	25 — (32.5 —)	10—11	12—13	

Specimen 1 in the Museum of Comp. Zoology; specimen 4 is the type-specimen.

The test varying conspicuously in height, the sides beautifully arched in the low specimens (3 and 4), more vertical in the higher ones; upper side flattened. Circumference round.

Ambulacra varying in breadth from ca. 17—20 % of I. A., not conspicuously sinuate. The interporiferous area distinctly broader than the pore area. Marginal series of ambulacral tubercles regular, the tubercles rather well sized, but not quite touching each other. Inside the marginal series some very small tubercles, which may fill up nearly the whole space; in one specimen there is only one such small tubercle on each plate adradially to the marginal, in the others 2—3 on each plate, quite irregularly arranged. The inner pore usually distinctly larger than the outer. The wall between the pores rather narrow, elevated, in one specimen with a depression across the middle; ridge usually fairly conspicuous (Pl. LXVIII. 1—2).

Interambulacra. Primary I. A. tubercles distinctly crenulate, rather low. Areoles shallow, confluent to a various degree, the 3—5 upper ones well separated. Edge of areoles scarcely elevated. Scrobicular tubercles not very prominent; outside these there are numerous tubercles gradually decreasing in size, filling up the median area as well as the adradial part of the plate, leaving a more or less distinct median and adradial part naked; the median line scarcely sunk. Median area fairly broad, ca. $^3/_4$ the width of an areole.

Apical system rather large, nearly half h. d. Tubercles few and arranged as usual in the genus. ♀ genital pores large, 2—3 mm in diameter; ♂ pores ca. 1 mm in diameter, nearer to the middle of the plate than are the female pores. In the specimen of 65 mm h. d. all the oculars are exsert, though not very distant from the periproct, in two other specimens only the two oculars adjoining the madreporite are exsert, the rest rather broadly in contact with the periproct; in the specimen of 75 mm h. d. all oculars are insert, the one adjoining the madreporite not very broadly, the rest of them very broadly so (Pl. X. 1). Madreporite rather conspicuously enlarged in this same specimen. The ambulacral plates of the peristome so much widened over the I. A. as to leave hardly any room for interradial plates.

Primary spines not much exceeding h. d. (— complete only in the specimen 75 mm h. d.). They are cylindrical, not at all or only slightly tapering, 3 mm thick; they are provided with some rather coarse thorns in the basal part, mostly quite irregularly disposed, more rarely in distinct longitudinal series. In the outer part they may be provided with more numerous low, finely serrate longitudinal ridges. The surface of the spine otherwise with very fine furrows (Fig. 38. 4). The oral primaries rather broad and coarse, the outer ones (apparently the fourth and fifth) with the terminal part somewhat widened, trumpet-shaped, deeply furrowed. Some of the upper, shorter (but fully formed) spines with a slight terminal widening. — The secondary spines up to 10 mm long, gently narrowing towards the end, not pointed; they are flattened, slightly excavate and often with an indication of a longitudinal keel. Ambulacral spines of nearly the same length, but much narrower, slightly flattened in the basal part. Spines rather erect.

Pedicellariæ up to 5 mm length of head; valves narrow, with a sharply limited depression at the upper end of apophysis, not differing markedly from those of *H. elegans*. — A few

four-valved pedicellariæ have been observed in the specimen of 75 mm h. d. — Spicules of tube-feet of the usual form; the intestinal walls and genital organs almost entirely without spicules.

Colour dark brownish, primary spines white, excepting the collar which is brownish like the test and secondary spines.

Biology. In the intestine of one of the specimens was found a number of small fragments of bivalve and Gastropod molluscs, which had evidently been crushed by its teeth. Further a number of pieces of a large *Lytocarpus*-like Hydroid colony, and fragments of Pennatulids and Bryozoans. It thus appears that this sea-urchin is a rather voracious animal.

Occurrence. Three specimens of this species were taken by the author off the N. S. Wales Coast in 1914, (38° 15′ S. 149° 20′ E., 270—470 m, and 39° 10′ S. 149° 55′ E., 360—550 m). Further I found in the Museum of Comparative Zoology, Harvard College, a specimen from the "Endeavour" Collections, from the Eastern Slope of Bass Strait, 145—360 m, which had been identified as *Histocidaris elegans*.

Remarks. This species has much resemblance to *H. elegans;* it differs, however, so conspicuously from typical *H. elegans*, especially in the coarsely thorny primary spines and the coarser oral primaries, as also in the colour, in the — usually — finer tuberculation of the interporiferous zone, the larger ambulacral plates of the peristome, quite eliminating the interradial plates, the insert oculars (—not quite constant—), that it seems injustifiable simply to unite it with *H. elegans*. — If we are justified in seeing a character of greater value in the shape and ornamentation of the primary spines — as I am is inclined to think — then it has no nearer relation to *H. elegans*, but its nearest relation would be *H. carinata*.

The problem is made the more intricate by a specimen from the same locality as that at which two of the above specimens were taken (39° 10′ S. 149° 55′ E. 360—550 m.) (Pl. XI. 1,5). The measurements of this large specimen (specimen 5) are given above; they do not give the impression of very important differences from the other specimens; only the height is somewhat larger. Also the spines and pedicellariæ are like those of typical *H. australiæ*, and likewise the characters of the ambulacra are the same. But then the I. A. are very different: the areoles are not confluent, excepting, in a few places, 2—3 of the lowermost ones. The median I. A. space is unusually broad, broader than the areoles, the whole median space being covered by a very close and fine tuberculation. The apical system is remarkable through the very large ♀ genital pores, two of which are not wholly inclosed by the genital plate, an unusual thing for a *Histocidaris*. Only two of the ocular plates are insert. — There is no doubt that if this specimen were found as fossil, together with a specimen of the typical *H. australis*, they would unhesitatingly be referred to two distinct species, perhaps rather to two different genera. As it is, I feel compelled, though reluctantly, to regard it as belonging to *H. australiæ* as, at most, a separate variety.

Histocidaris magnifica Mrtsn.

Histocidaris magnifica. Th. Mortensen. 1928. "Albatross" Cidaridæ p. 245. Pls. **48—49; 76, 1—3.**

Mainly characterized by its perfectly smooth primary spines, (cf. transverse section, fig. 38, 9) which do not surpass ca. 1.5 h. d. The ambital spines somewhat downwards curving. Pedicellariæ with long and slender valves without a depression above the apophysis.

Full description is given in the work quoted.

The only specimen known was taken by the "Albatross" off Jolo (6° 09′ 20″ N. 121° 13′ 40″ E., 283 m). This species cannot be said to be very nearly related to any of the other *Histocidaris*-species.

Histocidaris formosa Mrtsn.

Pls. III. 1—2; IV; LXVIII. 9—10; LXXV. 8—10; LXXVII. 20—21.

Cidaris (Histocidaris) elegans. De Meijere. 1904. "Siboga" Ech. p. 24 (partim). Pl. XII. 135 b.
Histocidaris formosa. Th. Mortensen. 1928. New Cidaridæ, p. 65.

	h. d.	v. d.	Apical system	Peristome	I. A.	A. pro I. A.	Longest spines.
1.	83 mm	60 mm	30 mm (36 % h. d.)	c. 27 mm (32.5 % h. d.)	12	12—13	145 mm
2.	44 —	30 —	16 — (36 —)	16 — (36 —)	10	9—10	127 —
3.	44 —	29 —	17 — (39 —)	15 — (34 —)	9—10	10	

Specimen 2 is the type; specimen 1 from the "Siboga" St. 253.

Test of the large specimen almost spherical, in the smaller ones somewhat flattened above. — Ambulacra rather distinctly sinuate, ca. 21—23 % of width of I. A. at ambitus. Interporiferous zone not much broader than a poriferous zone. The marginal ambulacral tubercles rather small, but distinctly mamelonate, not contiguous; there is a rather pronounced irregularity in the series, now and then a tubercle being smaller or somewhat displaced or even quite wanting. The space inside the marginal series more or less filled up with small tubercles, which are not arranged so as to form regular longitudinal series; the median line not sunk. The pores are in the type specimen small, equal-sized, separated by a rather broad, sligthly elevated wall. In specimen 3 they are somewhat larger, and in the large specimen they are conspicuously larger, especially the outer pore, and the separating wall very elevated. The ridge low and inconspicuous (Pl. LXVIII. 9—10).

Tubercles of the Interambulacra strongly crenulate; the areoles are confluent, excepting the 2—3 upper ones; they are not deepened, broad transversely oval. The median part of I. A. at ambitus scarcely half as broad as an areole. Edge of areoles not elevated. The scrobicular circle of tubercles very inconspicuous; outside this circle some tubercles, partly of nearly the same size, partly smaller, leaving just a narrow, indistinctly sunk midline naked. The narrow adradial part of the I. A. plates similarly covered with tubercles unto the edge.

Apical system (Figs. 40, 1—2) rather bare, as usual in this genus, the tubercles being in the main confined to the part nearest to the genital and ocular openings. Oculars all widely exsert, in the large specimen they are deeply notched on the outside (Fig. 40. 2), thus very different in shape from those of the smaller specimens. Genital openings of both the smaller specimens small, evidently both are males; in the large, female specimen they are ca. 3 mm in diameter.

Peristome. There are ca. 7 ambulacral plates in a series; the interradial plates apparently reach to the mouth edge. The condition of the peristome in the large specimen has not been examined, in order not to damage the splendid specimen.

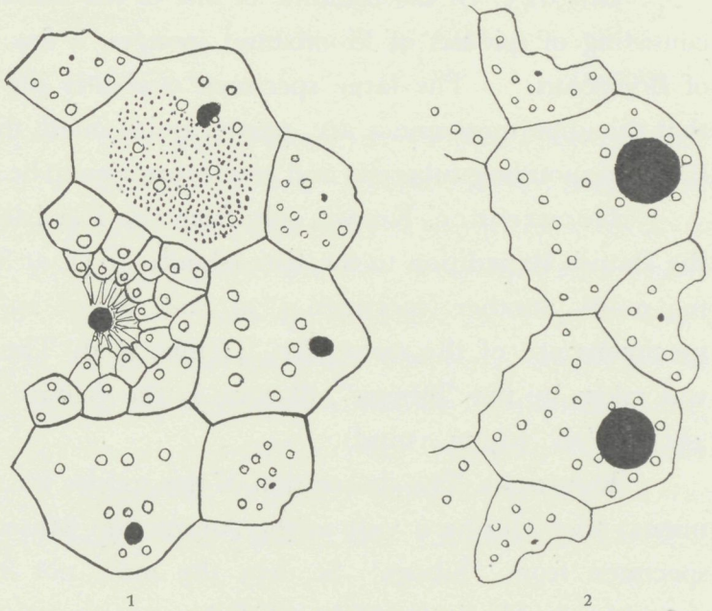


Fig. 40. Apical system of *Histocidaris formosa* Mrtsn. ♂ (1) and ♀ (2). 1×4; 2×3.

Primary spines reach a length of up to 3 times the h. d. in the type specimen; in the large specimen apparently not more than ca. 2 h. d. They are slightly curved upwards, ca. 3 mm thick at the base, somewhat tapering but with the point trumpet-shaped widened. There are usually a few — 5—6 — longitudinal series of rather sharp serrations, the two lateral being rather in the shape of keels, the spines thereby being more or less distinctly flattened. In the large specimen some of the spines are quite smooth, excepting the two lateral series of serrations. The surface of the spines otherwise shining, perfectly smooth, as seen especially in transverse sections (Fig. 38. 7). The collar is 3—4 mm long, increasing in thickness towards the rather ill-defined milled ring. — The oral primaries of the usual character, strongly serrate, curved; the proximal ones with only a few serrations; the fourth, and especially the fifth end in a more or less conspicuous crown. In the large specimen the 6th and 7th are transitional to the ambital spines.

The secondary spines in the large specimen up to 12 mm long, in the smaller specimens only ca. 8 mm long; they are flat or somewhat excavate on the outer side, rather broad in the lower part, tapering towards the rounded point (Pl. LXXVII. 20—21). The ambulacral spines almost setaceous, erect; in the large specimen they are up to 10 mm long.

Pedicellariæ (Pl. LXXV. 8) with very long, narrow valves, compressed in the lower part of the blade, which is filled up with a close meshwork, arranged so as to form longitudinal ridges; length of head up to 5 mm. Stalk 2—3 mm long. The small form (Pl. LXXV. 9—10) very slender, all intermediates between the largest and smallest being found. — Spicules of tubefeet slender, irregular, spiny rods, developing into more complicated fenestrated plates towards the

point of the tubefoot. Spicules in walls of genital organs and intestine very scarce, small irregular rods, in the mesenteries more numerous, irregular, fenestrated plates, as in *H. elegans*.

Colour of test, as covered with the skin, brownish, when denuded white or creamy white; the spines, secondaries as well as primaries, white, the latter with a slight greenish tint in specimen 3. The not fully formed primary spines of the upper side brownish as the test. The collar in the fully formed primaries white as the rest of the spine.

Biology. In the intestine of one of the smaller specimens were found some large pellets consisting of spicules of Monaxonid sponges, a few polyps of an Octocorallian, and fragments of Bryozoans. — The large specimen evidently has reached full size, as indicated by the fact that the uppermost spines are, partly, quite small, though fully formed; where the spines are lost the corresponding tubercles and areoles are seen to be conspicuously smaller than the ambital ones.

Occurrence. Known only from the Kei Islands. One specimen, the type, was taken by the Danish Expedition to the Kei Islands, 1922, at Stat. 41 (5° 28′ 40″ S. 132° 28′ 25″ E., 245 m., mud), another (specimen 3) at Stat. 58 (5° 29′ S. 123° 37′ E. 290 m., mud); both these specimens are of the same size, 44 mm h. d. The third, much larger specimen (specimen 1) was taken by the "Siboga", likewise in the vicinity of the Kei Islands (St. 253. — 5° 48′ 2″ S. 231° 13″ E. 304 m., mud).

Remarks. The description of this species was originally made from the two smaller specimens; then during a visit to the Amsterdam Museum in October 1926 I found that the large specimen from "Siboga" St. 253 (83 mm, not 85 mm, as stated by de Meijere), mentioned by de Meijere ("Siboga" Ech. p. 24) as an unusually fine specimen of *Histocidaris elegans*, very probably also belonged to *H. formosa*. The specimen was kindly sent me to Copenhagen for closer study and direct comparison with the type of *formosa*, and the result of the comparison did not leave any doubt of, at least, its close relation to *formosa*. That it is really the same species is also rather certain. The only reason for doubt as to this point is the character of the ambulacral pores and the shape of the ocular plates. The difference in the shape of the pores in the type specimen and the large specimen is really very conspicuous (Pl. LXVIII. 9, to comp. with Pl. LXVIII. 10); but the second of the smaller specimens is rather intermediate. That the difference in the shape of the ocular plates may be due to age alone is very well conceivable; whether also the differences in the pores are due to age seems less certain, especially as no such great difference is found between specimens of corresponding sizes of *Histocidaris elegans*. For the present, however, the only reasonable course seems to be this, to regard all three specimens as belonging to the same species, and I have little doubt that future investigations on richer material will prove this to be true.

That the species is not more nearly related to *H. elegans* seems clear enough, the irregular ambulacra, the character of the primaries and the pedicellariæ separating it very clearly from that species. It stands, on the whole, rather apart from the other *Histocidaris*-species, being perhaps the nearest related to *H. Nuttingi* and *recurvata*.

Histocidaris recurvata Mrtsn.

Pl. LXVIII. 8; LXXV. 5—7; LXXVII. 22.

Cidaris (Histocidaris) misakiensis. De Meijere. 1904. "Siboga" Echinoidea, p. 27. Taf. **II. 15—16; XII. 141—142.**
Porocidaris misakiensis. H. L. Clark. 1907. The Cidaridæ, p. 27.
Plegiocidaris misakiensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 134.
Histocidaris recurvata. Th. Mortensen. 1928. New Cidaridæ, p. 66.
NON: *Cidaris (Porocidaris) misakiensis.* Yoshiwara. 1898. Prel. Notice New Japan. Echin. Annot. Zool. Jap. II., p. 58.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines.
48[1] mm	31 mm	24 mm (50 % h. d.)	20 mm (42 % h. d.)	7	12—13	122 mm

Test slightly flattened above and below, sides beautifully arched, circumference round.

Ambulacra (Pl. LXVIII. 8) ca. 23 % of width of I. A. Interporiferous zone rather broad, about twice the width of a pore zone. Marginal tubercles fairly large, nearly contiguous, sometimes a little irregularity in the series, one or other of the tubercles being somewhat smaller than the others or pushed somewhat inwards. The space inside the marginal series rather naked, with some irregularly disposed small tubercles. Median line not sunk. The pores somewhat unequal sized, the inner one being generally the larger; the separating wall forms a rather sharp edge.

Interambulacra. Areoles fairly deep, the 3—4 proximal ones confluent. Scrobicular circle of tubercles not very prominent; only a single series of smaller tubercles outside the scrobicular ones, leaving a rather distinct, naked, slightly sunk median line. The median area about half the width of an areole.

Apical system 50 % of h. d. Oculars all exsert. Genital pores large, rather distant from the outer edge. Both oculars and genitals with rather numerous tubercles. (A figure of the apical system of this species cannot be given, as I do not feel entitled to denude this finely preserved part of the type specimen, but it resembles that of *H. mikasiensis* so much that it may suffice to refer to the fig. 39, representing the apical system of the said species). A dense tuft of spines covers the periproct. — Peristome ca. 42 % of h. d. The interradial plates only slightly developed, not reaching the mouth-edge.

Primary spines very long, reaching ca. 2.5 h. d. They are slender, ca. 3 mm thick, cylindrical, not tapering, but, at least the ambital ones, slightly flaring at the tip; further they are more or less distinctly flattened in the outer half or third, and, at least the ambital ones, slightly upwards curving towards the point. In the basal part they are set with rather coarse, not serially arranged thorns, mainly on the adapical side. The surface otherwise has ca. 15 finely serrate ridges, which become more marked in the outer part, the point of the spine being rather fluted. Between the ridges the surface is finely longitudinally striated (Fig. 38. 11). The collar is scarcely 3 mm long, slightly widening towards the rather prominent milled ring. The oral

[1] De Meijere gives the horizontal diameter as 50 mm, the height as 36 mm. The discrepancy in the height is probably due to de Meijere having measured to the top of the periproctal spines; the difference in the measurement of the h. d. must be due to inaccurate measuring, a shrinkage being out of question.

primaries are fairly broad, strongly serrate, curved, the second and third have a conspicuously furrowed terminal part. The fourth apparently (all lost) forms the transition to the very long ambital spines.

The secondary spines ca. 6 mm long, more or less distinctly excavate and often with a small keel in the basal part (Pl. LXXVII. 22). (Such keel is generally more distinctly developed on the side turning towards the base of the primary spine). The marginal ambulacral spines slender, pointed, slightly flattened.

Pedicellariæ. The large tridentate form conspicuous, head up to 3 mm long, the stalk very short; the valves (Pl. LXXV. 6) with a triangular depression above the short apophysis, the outer part rather distinctly convex. The small form (Pl. LXXV. 5 and 7) with fairly broad, rather flattened valves. — Spicules of the usual type.

Colour. The secondaries and the collar of the primaries brown, as is also the skin covering the test. Shaft of primaries white.

Occurrence. The type, and only known specimen was taken E. of Great Kei Island (5° 54′ S. 132° 56′ E., 984 m.) by the "Siboga" (St. 267).

Remarks. Thanks to the kindness of the Director of the Amsterdam Museum, Prof. L. F. de Beaufort, I have had the opportunity of examining this specimen and of comparing it with the type specimen of *Histoc. misakiensis* (Yoshiwara) with which species it was identified by de Meijere in his Report on the "Siboga" Echinoidea. That it has really nothing with that species to do is apparent enough from the descriptions of the two species given here; but by the poor and quite insufficient description of *misakiensis* at that time available it was not well possible to see how to distinguish the "Siboga" specimen from the said species. Also H. L. Clark (Hawaiian Ech. The Pedinidæ, etc. 1912. p. 383) expresses doubt as to this specimen being really identical with Yoshiwara's *misakiensis*.

By its very characteristic primary spines this species is very well distinguished from all the other species of *Histocidaris* known till now; it does not appear to be so very nearly related to *Histoc. elegans* as de Meijere thinks, who is even inclined to see in it only a variety of the latter species. It would seem to be the nearest related to *H. formosa* and *H. Nuttingi*. With the spines well preserved it must be a perfectly splendid form.

Histocidaris Nuttingi Mrtsn.

Pls. V; LXXVI. 8.

Histocidaris Sharreri. H. L. Clark. 1918. Rep. Crin. & Echin. Bahama Exp. (Bull. Laborat. Nat. Hist. Iowa VII. p. 21, Pl. **IV, 1**).

Histocidaris Nuttingi. Th. Mortensen. 1926. A new West Indian Cidarid. Univ. of Iowa Studies in Nat. Hist. XI, 7. Pls. **I—IV.**

The type, and only known specimen, measures 60 mm h. d., nearly 50 mm height, the longest spine being 155 mm long.

Ambulacra without a bare median area, numerous small, even minute spines being found

inside the marginal series. The interambulacra have 9 plates in a series; the median space densely covered with small spines (tubercles), leaving no bare space. — The apical system is 28 mm in diameter. The ocular plates are triangular, with a greatest width of 8 mm, apparently all in contact with the anal system, the two adjoining the madreporite only narrowly, the others broadly so. Genital pores very large and conspicuous, wholly inside the genital plates. The tubercles along the inner edge of the plates somewhat the larger.

The primary spines are cylindrical, some of them slightly flaring and fluted at the tip. The surface of the shaft is smooth, with ca. 10 not very prominent, longitudinal ridges, and some of them with scattered, sharp spinelets. The collar is ca. 4 mm long, distinctly thicker in the lower part. The oral primaries (three) are curved, elongate, slender, with very conspicuous serrations in the lower part, ending in a rather long, non-serrate point. The secondary spines are 8—9 mm long, gently tapering to a rounded point; they are markedly concave in their whole length. The ambulacral spines are of the same length, but, as usual, much more slender, scarcely flattened. The pedicellariæ are very slender, the valves narrow, without any deepening in the blade above the apophysis (Pl. LXXVI. 8). They reach a length of head of ca. 4 mm; smaller samples do not differ in structure from the larger ones. It is a curious fact that the valves are often of unequal length; this may not improbably be due to their point having been broken off and then regenerated, though not to its original length.[1] — Colour of both primary and secondary spines white, the collar only with a slightly darker tint.

Occurrence. Found on the "Pentacrinus ground" off Havana (Morro Castle bearing S. W. by W. ca. $2^1/_2$ miles), 225 m.

Remarks. Although not quite sufficiently known this species is very easily distinguished from the other West Indian *Histocidaris*-species, *H. Sharreri*, by the characters of its primary and secondary spines and pedicellariæ, as also by the character of its ambulacra and interambulacra, which prove beyond any doubt that it is not identical with *H. Sharreri*, under which name it was mentioned by H. L. Clark (Op. cit.). It is only fair to point out, however, that H. L. Clark is not solely responsible for the identification of the specimen with *H. Sharreri*, as it was not sent him for examination. He remarks that the photographic figure shows the spines to be much more slender than in the type of *H. Sharreri*, which fact does not, however, lead him to doubt their identity. The characteristic difference of the oral primaries appears to have evaded his attention.

H. Nuttingi may perhaps be the most nearly related to *H. formosa* and *recurvata*.

Histocidaris sp.

Histocidaris sp. Th. Mortensen. 1927 "Albatross" Cidaridæ, p. 254. Pls. **LI. 1—2; LXXVII. 5—8.**

Attention must here be called to the description of a young specimen of a *Histocidaris* species, given in the paper quoted. This would seem to represent a separate species; it recalls *H. recurvata* by the presence of some larger thorns on the adapical side at the base of the upper

[1] Figures of spines and pedicellariæ are given in the paper quoted above.

primaries, but differs from that species in various other characters, e. g. the shape of the secondaries and the pedicellariæ, and, therefore, can hardly belong to that species. But nothing more definite can be said about it, until more material is available.

Histocidaris acutispina Mrtsn.

Histocidaris acutispina. Th. Mortensen 1927. "Albatross" Cidaridæ, p. 248, Pls. **L. 1—2; LII. 2; LXXVII. 4.**

This species, characterized mainly by its very long (—ca. 4 times h. d. —) and slender primary spines, set with irregularly arranged coarse thorns, and by the long and slender pedicellariæ, with no depression above the apophysis, may not improbably be the same as *Histocidaris denticulata* Koehler from the Indian Ocean ("Valdivia", "Investigator"). As only a single, young specimen of *acutispina* is known (from between Leyte and Mindanao, 1785 m), and only larger specimens of *denticulata*, the question of their identity cannot be decided at present. In case they prove to be identical, the name *acutispina* has the priority, being published in September 1927; *denticulata* bears the date of November 1927.

For full description see the work quoted.

Histocidaris denticulata Koehler.

Pls. LXXV. 14—15; LXXVII. 19.

Histocidaris elegans. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 117 (partim). Taf. **XIII** (? 1—2) **4**; Taf. **XL, 3.**
Histocidaris denticulata. Koehler. 1927. "Investigator" Ech. III. p. 10. Pl. **I. 1—3, 6—7; II. 1; XXIII, 1.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	A. pro I. A.	Longest spines
1.	65 mm	52 mm	24 mm (36.1 % h. d.)	20 mm (30.7 % h. d.)	12	ca. 10—11	ca. 70—100 m
2.	55 —	47 —	20 — (36.4 —)	16 — (29 —)	11—12	11	

Specimen 1 ("Valdivia" St. 266) is in the Museum of Munich, where I had the opportunity of examining it in November 1926; specimen 2 is one of the specimens of the "Investigator", described by Koehler (Op. cit.).

Test nearly spherical in specimen 1, while specimen 2 is flattened on upper and lower side and pentagonal in circumference.

Ambulacra rather broad, ca. 30—31 % of width of I. A.; they are in the large specimen almost straight, while in specimen 2 they are sinuate. Marginal series of tubercles rather irregular, larger and smaller tubercles alternating irregularly, in the large specimen, apparently more regular in specimen 2, and apparently quite regular in another specimen figured by Koehler (Op. cit. Pl. I, Fig. 6). Tubercles not contiguous. Interporiferous zone about as broad as a pore zone, naked, only here and there a small inner tubercle; midline not sunk. Pores slightly unequal, the outer one the larger; the wall slightly elevated, the ridge low.

Interambulacra. Areoles confluent, only the upper ones separated, the subambital ones transverse-oval; they are shallow, the edge not elevated, the scrobicular tubercles not very pro-

minent. In specimen 1 there are only few tubercles outside the scrobicular circle, leaving the median area almost naked; also on the adradial side of the scrobicular circle a few small tubercles. Median area ca. $^1/_2$ the width of an areole, not sunk. In specimen 2 it appears that the median area is narrower, and wholly covered with tubercles — (nothing stated in the description, and the figures show the specimen only from the oral side).

Apical system only ca. 36 % h. d. in the two specimens, thus, as far as can be judged on the whole rather small. Ocular plates insert. Tubercles few, mainly arranged around the large genital pores, as usual in the genus. Peristome with 6—8 ambulacral plates, which do not, in specimen 2 at least, leave any room for interradial plates.

Primary spines slender, cylindrical, probably ca. 1.5 h. d. They are rather coarsely serrate, the serrations forming a pair of not very pronounced lateral edges, the rest of them being less distinctly serially arranged. At the end of the spine the serrations may form a more or less conspicuous crown (Ech. Deutsche Tiefsee Exp. Taf. XIII, 4). Surface of the shaft otherwise with numerous fine, sharp serrations (Fig. 38.12), or (in the "Valdivia" specimen) quite smooth. Collar ca. 4 mm long, increasing conspicuously in thickness towards the milled ring. The oral primaries are slender, curved, coarsely serrate; the 4th—5th transitional to the ambital primaries. — Secondary spines. According to Koehler's description, the scrobicular spines are very broad, flattened, with rounded point; judging from his figures they are, however, rather to be described as slender, which is also the case in the specimen in the Museum of Munich (Pl. LXXVII. 19). The marginal ambulacral spines are very slender, slightly flattened.

Pedicellariæ. The valves are very slender, without depression above the apophysis (cf. Döderlein. Op. cit. Taf. XL, 3); the blade is, indeed, almost cylindrical (Pl. LXXV. 15). A few bivalve pedicellariæ occur on the Munich-specimen, while Koehler did not observe any in his specimens. The larger samples reach a size of 5 mm length of head. The valves may be of unequal length (cf. *Histocid. Nuttingi*). — Spicules of the tubefeet of the usual type.

Colour. The Munich-specimen is simply white; Koehler's specimens were gray. According to Döderlein the colour is reddish, of a darker or lighter shade, also the primaries may show a tint of reddish.

Occurrence. Bay of Bengal, ca. 400—730 m. ("Investigator"); off the African East Coast, 2° 58′ N. 46° 51′ E. 1362 m.; 6° 44′ N. 49° 44′ E. 741 m. ("Valdivia"); probably also in the Nias-Channel, 614 m. ("Valdivia").

Remarks. There is no doubt that Koehler was right in separating this form from *H. elegans*, with which it was identified by Döderlein. Whether all the "Valdivia" specimens belong to *H. denticulata*, as Koehler seems inclined to think, is doubtful. Especially the specimen figured by Döderlein in his Taf. XIII, 3 looks very different from typical *denticulata*, and even the fact that it is a young specimen (13 mm h. d.) would not seem to account for the great difference in the shape of the primaries between this specimen and the typical *denticulata*; also the specimen represented in fig. 2 of the same plate looks more like a true *H. elegans*. But that the

specimen represented in fig. 1 of the said plate is a *denticulata* seems very probable. I have examined specimens from the stations 258 and 266 of the "Valdivia" and have no doubt that these are really identical with Koehler's *denticulata.*

Koehler regards as the more important characters distinguishing this species from *H. elegans* the small size of the apical system and the peristome, besides the more thorny primaries — characters which were already pointed out by H. L. Clark ("The Cidaridæ", p. 227) as indicating that Döderlein probably was wrong in identifying his "Valdivia" specimens with *H. elegans* (of which latter species there was no real description at the time when Döderlein wrote his report). The measurements given above of a number of specimens of *H. elegans* on the whole confirm this difference. Other distinguishing characters of *denticulata* are, to be found in the characters of the primary spines and the pedicellariæ, as also the insert oculars seem to be a good character. Possibly also the colour may be different; but this we do not know for sure at present, as there is no certainty that the more vivid colour given by Döderlein really refers to *denticulata.* While there is really no doubt that this species is quite distinct from *H. elegans*, it is more doubtful whether it may not ultimately prove to be identical with *H. acutispina.* For the present it is hardly possible to reach a definite result as to this question, the latter species being known only in a single young specimen, 20 mm h. d., while only a pair of larger specimens of *H. denticulata* have been studied more in detail. Judging from the material at present known the main difference would seem to be the much larger size of the apical system and peristome in *acutispina;* but whether this character will hold good, when larger specimens of *acutispina* become available, and smaller of *denticulata*, we cannot know now. The other differences to be gathered on a comparison of the description of the two species would hardly seem sufficient justification for regarding them as two different species.

Genus **Poriocidaris** Mrtsn.

Porocidaris. A. Agassiz. 1872. Rev. of Ech. p. 394.
Porocidaris. Wyv. Thomson. 1874. "Porcupine" Ech. p. 726.
Porocidaris. Döderlein. 1887. Japan. Seeigel. p. 44.
Poriocidaris. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 53.
NON: *Porocidaris.* Desor. 1858. Synopsis Ech. foss. p. 46.

Primary spines cylindrical, gently tapering, the point of the spine not widened. Collar long, up to 10—18 mm, especially in the apical spines, in which it may occupy $^1/_3$ the length of the spine or even more. It is not rarely swollen in the middle. Pedicellariæ of one kind only, large, strongly compressed, constantly bivalved.

Genotype: *Porocidaris purpurata* Wyv. Thomson.

The long collar of the primary spines and the remarkable bivalve pedicellariæ mark this form so distinctly from all the other species of the *Histocidarina* that it would seem quite inconsistent, in view of the characters otherwise acknowledged as of generic value in Cidarids, to include it simply in the genus *Histocidaris.* It is true that bivalve pedicellariæ are found also in *Histo-*

cidaris variabilis and *denticulata*, but only exceptionally, though not so very uncommonly in *variabilis*. It is also a noteworthy fact that the normal three-valved pedicellariæ of the small form in this latter species have very strongly compressed valves (Pl. LXXVI. 1). This would lead to the suggestion that the pedicellariæ of *Poriocidaris* only represent the small form of tridentate pedicellariæ, and it may well be supposed that *Histoc. variabilis* shows the way along which *Poriocidaris* has developed. However, the difference between *Poriocidaris* and the said *Histocidaris*-species is so conspicuous that, in my opinion, they could not simply be united in one genus. Perhaps it would be better to regard *Poriocidaris* merely as a subgenus of *Histocidaris*. This is a matter only of individual judgement.

The character of the female genital pores extending into the I. A., emphasized by Wyv. Thomson and Agassiz, is certainly not of generic value, since it is no constant feature and probably occurs only in old specimens. Also in *Histocidaris australiæ* this feature may be observed (comp. p. 93).

The name *Poriocidaris* was chosen in order to recall the name *Porocidaris* under which it has been known for so long a time — since the "Porcupine" Expedition — but to which it has no claim at all, as the fossil form for which the genus *Porocidaris* was established by Desor, on account of its characteristic depressions in the areoles and its conjugate pores, is something quite different, not even to be referred to the same group as the recent form. De Loriol (Mon. Ech. Couches Numm. Égypte p. 65) who maintains the correctness of referring the recent species *purpurata* to the same genus as the fossil *Porocidaris Schmiedelii*, of which he gives a detailed description from an excellently preserved specimen, argues that the impressions in the areoles so characteristic of the fossil species cannot claim so much importance, since they are hardly developed at all in the uppermost areole of his fossil specimen. The reason for this is simply — what De Loriol has not realized — that the uppermost areole has not yet reached its full development. Whatever the physiological or morphological meaning of these impressions (or pores) in the areoles of *Porocidaris* be, they form so conspicuous a feature that, even if the pores of the fossil form were not conjugate, but like those of the recent form, it would be quite unjustifiable to refer to that genus forms without any such radiating impressions or pores in the areoles. It is true, Wyv. Thomson states (p. 727) that faint indications of these impressions are really found in the recent form (as also in other recent Cidarids). I must maintain that the very slight traces of radiating impressions that may be found in this and many other Cidarids are so indistinct and irregular that it does not appear in any way justifiable to regard them as a homologon to the elaborate and highly characteristic formation in *Porocidaris*. The entirely different character of the pores in the two forms evidently has also evaded the attention of De Loriol, otherwise he would hardly have acknowledged the recent form as congeneric with the fossil, and moreover maintained that "même au point de vue spécifique, les deux espèces sont très voisines". P. Oppenheim ("Revision d. tertiären Echiniden Venetiens u. des Trentino", Zeitschr. Deutsch. Geol. Ges. 1902 p. 174) with full right opposes to De Loriol's acknowledging the recent forms as conge-

neric with the fossil *Porocidaris*. Also Lambert & Thiéry have opposed to referring the recent forms to the fossil genus (distributing them quite arbitrarily among *Plegiocidaris* and *Dorocidaris*). Finally H. L. Clark in his "Endeavour" Echinoderms acknowledges the necessity of a separate genus for the recent forms, viz. *Histocidaris*, with which he also unites *Poriocidaris*.

According to A. Agassiz (Panamic Deep-Sea Ech. p. 24) Studer has set forth some suggestions regarding the limitation of the genus *Porocidaris* so as not to include the recent species, at least *P. Cobosi* and *Sharreri*, the latter being associated with the fossil *Pleurocidaris* Pomel. After his usual fashion Agassiz does not quote the place where this suggestion was set forth. I have searched in vain for it in all Studer's papers on Echinoids (at least all those mentioned in the "Zool. Record"), and, therefore, as stated above (p. 89 sub *H. Sharreri*) I am inclined to believe that it must be due to a slip of memory by Agassiz, and that he meant to refer to Döderlein, who in his "Japan. Seeigel" (p. 43), relying on the erroneous figure of the test structure of "*Porocidaris*" *Sharreri*, given by Agassiz ("Blake" Ech. Pl. IV, 1 — in reality representing *Calocidaris micans*) expressed the opinion that *Sharreri* might belong to the fossil genus *Pleurocidaris*. As for this latter — be it now a well founded genus, or only a synonym of "*Leiocidaris*", as maintained by Lambert & Thiéry — the fact that it has conjugate pores proves that it is quite distinct from any of the *Histocidarina*.

Only one species of this genus known till now, but it does not seem improbable that the form stated to occur in the Indian Ocean, hitherto referred to the Atlantic species (only one young specimen known see below p. 107), will ultimately turn out to be a separate species — if it be not a mistake that it came from the Indian Ocean.

Poriocidaris purpurata (Wyv. Thomson).

Pls. I. 6; III. 3—5.

Porocidaris purpurata. Wyville Thomson. 1872.[1] On the Echinidea of the "Porcupine" Deep-sea Dredging Exp. Proc. R. Soc. p. 493. (Ann. Mag. N. Hist. 4. Ser. X. p. 302).
Porocidaris purpurata. A. Agassiz. 1872. Rev. of Ech. p. 152, 395. Pl. I. e. 37—41; XXIV, 11.
Porocidaris purpurata. Wyville Thomson. 1873. The Depths of the Sea; p. 102. fig. 11.
Porocidaris purpurata. Wyville Thomson. 1874. "Porcupine" Ech. p. 728. Pl. **LIX, 14—15; LXI.**
Porocidaris purpurata. P. de Loriol. 1880. Monogr. Ech. Couches nummul. Egypte. p. 65.
Porocidaris purpurata. Pomel. 1883. Class. méth. p. 112.
Porocidaris purpurata. Duncan. 1889. Revis. gen. Ech. p. 32.
Porocidaris gracilis. Sladen. 1890. Ech. S. W. Ireland. Proc. R. Irish Acad. 3. Ser. I. p. 699. Pl. XXIX, 1—5.
Cidaris purpurata. Hoyle. 1891. Rev. List. Brit. Echin. p. 405.
Cidaris purpurata. Bell. 1892. Cat. Brit. Ech. p. 141.
Cidaris gracilis. Bell. 1892. Cat. Brit. Ech. p. 142.
Porocidaris elegans. Koehler. 1896. Échinod. "Caudan". p. 89. (non = *Poroc. elegans* A. Ag.)
Cidaris gracilis. A. R. Nichols. 1902. List of Irish Echinod. Proc. R. Ir. Acad. XXIV. B. p. 259.
Porocidaris purpurata. Th. Mortensen. 1903. „Ingolf" Ech. I. p. 41. Pl. **VI, 12; VIII, 22; X, 1—2, 5; XI, 3, 21.**
Porocidaris purpurata var. *talismani.* Th. Mortensen. 1903. "Ingolf". Ech. I. p. 173. II. p. 169.
Cidaris gracilis. Stanley W. Kemp. 105. Mar. Fauna W. Coast Irel. Part. III. Echinoderms. p. 196.

[1] Not 1869, as it is usually quoted.

Porocidaris purpurata. Döderlein. 1905. Arktische Seeigel. p. 376.
Porocidaris purpurata. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 117. Taf. XL (XXXII), 4.
Porocidaris purpurata. H. L. Clark. 1907. The Cidaridæ, p. 226.
Porocidaris purpurata. Koehler. 1909. Echinod. Monaco. Fasc. XXXIV. p. 215. Pl. V, 4.
Parocidaris(sic!) purpurata. A. Nobre. 1909. Echinod. du Portugal. Ann. Acad. Polytechn. Porto. IV., p. 19.
Poriocidaris purpurata. Th. Mortensen. 1909. Ech. D. Südpolar Exp. p. 53, 55.
Plegiocidaris purpurata. Lambert & Thiéry. 1910. Ess. nom. rais., p. 134.
Porocidaris purpurata. Farran. 1913. Deep-water Ast. Oph. & Ech. W. Coast Ireland. p. 51.
Porocidaris purpurata. Grieg. 1921. Echinod. "Michael Sars". p. 40.
Histocidaris purpurata. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 38.
Poriocidaris purpurata. Th. Mortensen. 1927. Handbook Echinod. Brit. Isles, p. 274.
Poriocidaris purpurata. Th. Mortensen. 1927. Éch. "Travailleur" et "Talisman". Arch. Mus. d'Hist. Nat. 6. II. p. 24.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
45 mm	28 mm	20 mm (44 % h. d.)	18,5 mm (41 % h. d.)	8	9—10	90 mm
38 —	23 —	18 — (47.4 —)	15 — (39.4 —)	7—8	9—10	75 mm
32 —	22 —	16 — (50 —)	14,5 — (45.6 —)	7—8	9—10	62 — not com-
37 —	24 —	18 — (48.8 —)	14 — (38 —)	8	9	plete
42 —	27 —	20 — (47.6 —)	16 — (38 —)	8	9	
38 —	26 —	18 — (47.4 —)	18 — (47.4 —)	7—8	9—10	
9 —	5 —	5 —	4 —	5	5—6	28 (÷ the point)

Test somewhat flattened above and below, sides rounded, circumference circular or subpentagonal or even "decidedly" pentagonal (Wyv. Thomson). Sometimes the test is the widest near the upper side, from there narrowing gradually downwards; other specimens are widest in the middle of the ambitus, sloping gently both up- and downwards.

Ambulacra rather sinuous, about 25 % of width of I. A. Interporiferous zone slightly broader than the pore zone; marginal series of tubercles very regular, the tubercles small, not contiguous. The narrow space inside the marginal tubercles with an irregular double series of much smaller tubercles; median line not naked or sunk. Pores slightly oblique, the outer one slightly the larger (cf. „Ingolf" Ech. I. Pl. VI. 12). — Interambulacra. The upper 2—3 primary tubercles distinctly crenulate. Areoles only slightly deepened, the 3—4 proximal ones confluent. Median area scarcely half as wide as an areole. Tubercles of scrobicular circle distinctly larger than the rest of the secondary tubercles. The space outside the scrobicular circle quite filled up with tubercles, no naked median or adradial space being left. Median line not distinctly sunk.

Apical system generally 45—50 % h. d. Tubercles fairly numerous, covering the plates almost completely. Ocular plates generally exsert, more rarely one of them insert; probably old specimens have more of them insert (cf. "Porcupine" Ech. Pl. LXI, fig. 2). Male genital openings exceedingly small, scarcely as large as the ocular pores. (Pl. III. 5). Female openings large, ca. 2 mm wide, generally lying wholly within the genital plate, more exceptionally (probably only in old specimens) rupturing the edge of the plate so as to protrude into the midline of the

interambulacrum. Periproct generally somewhat raised. Periproctal plates not very numerous, gradually decreasing in size inwards. — Peristome varying rather conspicuously in size (38—47 % h. d.).[1] Interradial plates in a single, somewhat irregular series, generally reaching the mouth edge; near the peristomial edge the series may be irregularly double.

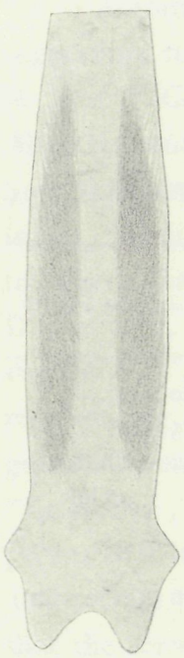


Fig. 41. Longitudinal section through the base and the collar of a primary spine of *Poriocidaris purpurata* (W. Th.). The dark part is the seat of the purple pigment. × 6.

Primary spines may exceed 2 h. d. (up to 2.5 h. d.). The larger ambital spines are nearly cylindrical, tapering very gently, probably to a simple, not widened point. The apical spines are much shorter, tapering to a sharp point. The oral primaries are rather broad, flattened, slightly curved, (paddle-like, Wyv. Thomson) with rather coarsely serrate edges; the serrations are, however, not very regular and less conspicuous than is generally the case in the allied *Histocidaris*. Only the two (three) proximal ones are true oral spines; the third (fourth) has as few inconspicuous serrations, but a long, distinctly furrowed terminal part; the point not widened. Surface of the spines rather smooth, but with more or less distinct longitudinal ridges, (comp. transverse section, "Ingolf" Ech. Pl. XI. 3), which may carry some more or less coarse serrations or thorns, mainly in the lower part.[2] Surface otherwise with very fine, but fairly distinct furrows. Collar of the ambital spines ca. 7—10 mm long, of the uppermost spines considerably longer, upto 18 mm, and may occupy up to about half the length of the spines, in the not fully formed spines even considerably more. The collar may be more or less swollen in the middle, being perfectly fusiform (Fig. 41).

Secondary spines flattened, not excavate or carinate, slightly narrowing towards the blunt point. Ambulacral spines thin, not flattened.

Pedicellariæ of one kind only, highly characteristic, bivalved, with strongly compressed blade. No apophysis (cf. "Porcupine" Ech. Pl. LIX, 14; "Ingolf" Ech. I. Pl. X. 1, 2, 5). They are fairly conspicuous, ca. 2 mm length of head. — Spicules of tubefeet of the usual type. Walls of intestine and genital organs almost entirely devoid of spicules, only in the mesentery some few fenestrated plates like those found in *Histocidaris*.

Colour of test and secondary spines light brown, the collar of the primaries brown or purplish-violet ("a rich deep purple" — W. Th.), very strongly constrasting against the white (or pale pink — W. Th.) shaft of the spine. On the whole, well preserved specimens are strikingly beautiful. The colour sometimes fades in alcohol, such specimens becoming ultimately quite white. This is in accordance with the fact that the colour is due to pigment in the living tissue, while the calcareous substance itself is uncoloured. The denuded test is white, but with

[1] When Bell (Op. cit.) gives the measurement of the peristome in a specimen of 47.5 mm h. d. as only 7.5 mm (16 % of h. d.), this is, no doubt, a mistake. Very probably this measurement refers to the mouth opening, as does evidently also the measurement 7 mm given by Wyv. Thomson (p. 728) for the "peristomial opening."

[2] I have not seen them so strongly serrate as figured by Wyv. Thomson.

more or less distinct traces of purple colour on the upper side, especially the 2—3 uppermost primary tubercles are more or less distinctly purplish violet.

Biology. It occurs on mud bottom. In a specimen, which was opened, the intestine was found to contain bottom material, the only recognizable thing being remnants of a decapod (?) Crustacean. It may be concluded from the size of the eggs, ca. 1 mm diameter, that the development is direct, without a pelagic larva. In one of the male specimens at hand genital 1 is divided into two, through a vertical line, each part having its own genital pore. In one of the female specimens the madreporite has two pores, but the plate itself is not divided.

A specimen of 9 mm h. d. (from the "Ingolf" Exp. St. 73) shows some characters of interest. Crenulation fairly distinct on the 1—2 uppermost tubercles. Pores very oblique; the adradial pore the larger, with a conspicuous notch for the foot nerve. No genital pores (in the specimen next in size, 23 mm h. d., the genital pores have appeared); only the outer circle of anal plates as yet developed. Peristome with three pairs of ambulacral plates in each radius; in two of the interradii a small interradial plate has appeared, in the three others none as yet. The longest primary spines slightly more than 3 h. d. They are rather densely serrate; the collar scarcely 3 mm. Oral primaries still very little specialized, but the coarse serrations have begun to appear. Secondary spines and pedicellariæ of the same form as in the adult. — Largest specimen on record 50 mm h. d.

Occurrence. Known only from the North-East Atlantic, from S. of Iceland and the Faroe Channel to the Canaries, from depths of 750—1804 m.

Remarks. The variety *Talismani*, established in the "Ingolf" Ech. I, p. 173, is nothing but an exceptionally fine and well developed specimen of *P. purpurata*, as was stated in Part II (p. 169) of the same work.

That Sladen's *Cidaris gracilis* is nothing but the young of *P. purpurata* must be regarded as definitely settled.

Döderlein (Ech. Deutsche Tiefsee-Exped. p. 117) records this species from the Indian Ocean, where a single small specimen was taken by the "Valdivia" at the Sombrero Channel, Nicobar Islands, 805 m. I have had the opportunity of examining this specimen and comparing it with specimens of corresponding size of the Atlantic form, and must agree with Döderlein that they cannot be distinguished from one another. But as the specimen is so young (13 mm h. d.) it would not be safe to conclude that specific differences could not be found, if adult specimens of the form from the Indian Ocean were available. Considering further the fact that no other specimens have ever been found in the Indian Ocean (— one might rather expect that the "Investigator" had found specimens of it, which is, however, not the case —), I cannot help hinting at the possibility that the label might be incorrect, so that the specimen perhaps really was taken in the Atlantic, where the "Valdivia" did make hauls in places where *P. purpurata* is known to occur. At any rate the occurrence of *P. purpurata* in the Indian Ocean cannot be regarded as definitely proven, until new material, also of adult specimens, has been found there.

Group *Ctenocidarina.*

This group, comprising the genera *Aporocidaris*, *Ctenocidaris* (including, as a subgenus, *Eurocidaris*), *Notocidaris*, *Homalocidaris*, *Rhynchocidaris*, *Austrocidaris* and *Ogmocidaris*, is characterised by its oblique pores, which are placed close together; very often the narrow wall is perforated so that the pores become confluent. The ocular pore is usually (less distinctly so in *Ogmocidaris* and not at all in *Austrocidaris*) surrounded by an elevated wall. The milled ring is usually rather prominent, sometimes very much so. Secondary spines cylindrical or club-shaped, or the scrobicular spines more or less distinctly flattened. Globiferous pedicellariæ without an endtooth, except the small form in *Ogmocidaris*. Tridentate pedicellariæ wanting.

Through *Austrocidaris* and *Ogmocidaris* this group is connected with the Goniocidarids, in some of which (*Goniocid. umbraculum*, *Rhopalocidaris*) the pores are also markedly oblique, separated only by a narrow wall.

With the sole exception of two species of *Aporocidaris* and of *Ogmocidaris* this group of Cidarids is confined to the Antarctic and Subantarctic Seas; no other Cidarids are known to occur in these regions. In the New Zealand Seas it meets (through *Ogmocidaris*) with the Goniocidarids, represented there by the species *Goniocidaris umbraculum*.

None of the fossil genera can with any reasonable degree of certainty be recognized as belonging to this group, whereas it is highly probable that the eocene "*Goniocidaris*" *jorgensis* de Loriol belongs to the genus *Austrocidaris*, representing the ancestor of the recent *Austrocidaris canaliculata*.

Key to the genera of the Ctenocidarina.

1. A conspicuous, sunken, median furrow in both ambulacra and interambulacra ..... 2.
   No sunken furrow in the ambulacra, at most an indistinctly limited, naked, slightly sunken median space in the interambulacra ..... 3.
2. Peristome with only 5—6 ambulacral plates in a series; small globiferous pedicellariæ with a distinct end tooth ..... *Ogmocidaris.*
   Peristome with 8—10 ambulacral plates in a series; globiferous pedicellariæ without end tooth ..... *Austrocidaris.*
3. Pores, at least on oral side, tripartite ..... *Rhynchocidaris.*
   Pores bipartite ..... 4.
4. Apical system ca. $^3/_4$ h. d. Primary spines very long and slender, oral primaries rather strongly serrate, but not much widened ..... *Aporocidaris.*
   Apical system scarcely exceeding half h. d. ..... 5.
5. Primary spines perfectly smooth; milled ring very large and prominent ..... *Homalocidaris.*
   Primary spines not perfectly smooth; milled ring not very prominent ..... 6.
6. Surface of primary spines covered by a spongy coat of anastomosing hairs ..... *Ctenocidaris.*
   Surface of primary spines very finely longitudinally ridged, the ridges being finely serrate along their free edge; no hairs ..... *Notocidaris.*

Genus **Aporocidaris** A. Agassiz & H. L. Clark.

A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 36.
H. L. Clark. 1907. The Cidaridæ, p. 214.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus., p. 36.

Test very thin and fragile; the apical system often so much raised that the shape of the test becomes subconical. Number of ambulacral plates small, scarcely exceeding ca. 30 in all. Porezone not sunken. Pores close together, separated only by a narrow, low wall; neuropore large. Areoles not deep; no crenulation. Scrobicular tubercles scarcely larger than the other secondary tubercles. Median interambulacral space rather bare, slightly sunken; a faint indication of pores or grooves at the admedian end of the ambital horizontal sutures. Apical system very large, usually ca. 60—75 % of the h. d. Oculars usually widely exsert. The madreporite not enlarged, the pores collected on a small, slightly elevated spot. Periproct with few plates. Peristome about half h. d.; number of peristomial ambulacral plates usually very small, 4—5 in a series, (in *A. incerta* as many as 8—9). Primary spines slender, cylindrical, usually very long, terminating in a simple point. Milled ring fairly prominent. Collar 1—2 mm long; a conspicuous smooth, shining neck, about twice the length of the collar. The shaft with rather sparse, sharp spinules usually not arranged in regular series except in the distal part. Surface of shaft covered, not very closely, with low hairs, simple or anastomosing, rather distinctly arranged in close longitudinal series; sometimes the hairs are almost entirely lacking. Oral primaries spear-shaped with rather strongly serrate edges and curved at the point. Secondary spines simple, cylindrical or slightly club-shaped, erect; the scrobicular spines not different from the other secondaries, not appressed around the base of the primaries. Pedicellariæ simple, without an end tooth; large and small type of globiferous of the same structure, differing only in size, and there is no sharp distinction between the two forms. Tridentate pedicellariæ appear to be lacking. Spicules of tubefeet of the usual simple Cidarid type; spicules of the intestinal wall small, more or less irregular, of the three-radiate type.

Genotype: *Porocidaris Milleri* A. Agassiz.

The species of this genus (excepting *antarctica*) were originally referred to the genus *Porocidaris* on account of their characteristic serrate oral primaries. That they have nothing with this genus (viz. *Histocidaris*) to do was first shown by the present author, who pointed out that their pedicellariæ are of the same type as those of *Stereocidaris*. Agassiz & Clark then created the new genus *Aporocidaris* for the two species *Milleri* and *fragilis*, to which Clark (Op. cit.) further referred Koehler's *Porocidaris incerta;* a fourth species, *A. antarctica* was added in 1909.

The genus, which is very well characterized by the characters of both test, spines and pedicellariæ, is related to the Stereocidarids, as shown by the character of the pedicellariæ; on the other hand it appears to be connected with the Goniocidarids through the genus *Psilocidaris*. The large neuropore leads to the condition existing in *Rhynchocidaris triplopora*, where the neuropore is almost as large as the pore itself.

Three of the species described are very pronounced deep-sea forms; the fourth is a sublittoral form from the Antarctic. It appears that all of them are small forms not reaching much more than ca. 30 mm h. d.

Key to the species of Aporocidaris.

1. Number of peristomial ambulacral plates only 4—5 in a series ..... 2.
   Number of peristomial ambulacral plates 8—9 in a series ..... *A. incerta.*
2. Primary spines almost without hairs ..... *A. antarctica.*
   Primary spines with a fairly close coat of low simple hairs ..... 3.
3. Periproctal plates almost in a single circle ..... *A. fragilis.*
   Periproctal plates in two circles or more ..... *A. Milleri.*

Aporocidaris Milleri (A. Agassiz).

Pls. XI. 11; LXVIII. 12; LXXVII. 1—4.

Porocidaris Milleri. A. Agassiz. 1898. Prel. Rep. Echini. "Albatross" 1891. Bull. Mus. C. Zool. XXXII., p. 74. Pl. **IV.**
? *Porocidaris Milleri.* Th. Mortensen. 1903. "Ingolf" Ech. I., p. 30; II., p. 16. (*Stereocidaris*).
Porocidaris Milleri. A. Agassiz. 1904. Panamic Deep-Sea Ech., p. 25; Pl. **6—8**; Pl. **10. 1—3.**
? *Porocidaris Milleri.* Döderlein. 1906. Ech. d. deutschen Tiefsee-Exp., p. 103.
Aporocidaris Milleri. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech., Cidaridæ, p. 37. Pl. **9.**
Aporocidaris Milleri. H. L. Clark. 1907. The Cidaridæ, p. 215.
Aporocidaris Milleri. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp., p. 54.
Plegiocidaris Milleri. Lambert & Thiéry. 1910. Ess. nom. rais., p. 134.
Aporocidaris Milleri. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 36.
Aporocidaris Milleri. Th. Mortensen. 1927. Postlarval devel. Cidarids. Mém. R. Acad. Copenhague 8. Sér. XI, p. 385.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines.
28 mm	15 (18) mm	17.5 mm (62.5% h. d.)	12 mm (42.9 % h. d.)	6 (7)	8—10	?
23 —	13 (18) —	16.5 — (71.7 —)	10 — (43.5 —)	5—6	7—10	?
21 —	11 (13 —	14.5 — (69 —)	9.5 — (45.2 —)	5 (6)	8—10	?
12 —	6 (9) —	8 — (66.6 —)	5.5 — (45.8 —)	5	6—8	43 mm
10 —	5 (7) —	7 — (70 —)	5 — (50 —)	5	5	23 —
8 —	4 (6.5) —	6 — (75 —)	4.5 — (56.2 —)	4—5	4	20 —

The two smallest specimens measured are in the Museum of Comp. Zoology.

Test usually strongly arched above, the apical system rising in direct continuation of the corona, the whole upper side thus having the shape of a rounded dome; more rarely the upper side is almost flat. The measurements of v. d. given above indicate the height of the corona alone, and, in parenthesis, the height of the whole test, measured to the centre of the periproct. The underside is flattened, often somewhat incurved at the peristomial edge. Circumference regular, circular. Test very thin and fragile.

Ambulacra almost straight, about $^1/_4$ the width of the interambulacra; interporiferous zone

not twice the width of a pore-zone. Marginal series of tubercles very regular; the tubercles are small, and low, with a small mamelon, not contiguous. At the ambitus there may be a secondary tubercle at the adradial corner of the plates, but not regularly; together these secondary tubercles form a single, incomplete, median series; only in the largest specimens there may be an almost regular double inner series of tubercles. Also one or a few miliary tubercles are found on each plate at the ambitus. Median line not sunken. The pores are relatively large, very close together; the wall is very narrow, somewhat sunken in the middle, not rarely so much so that the pores

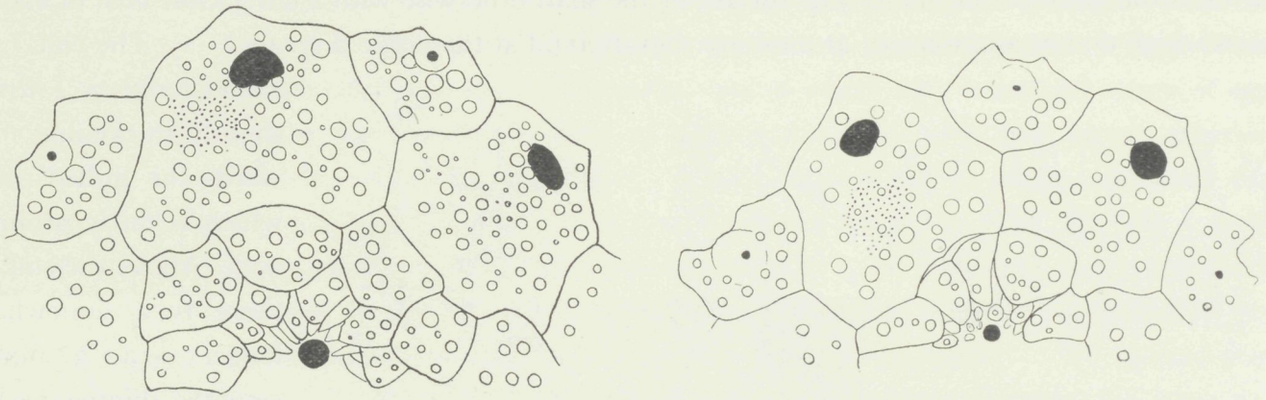


Fig. 42. Part of apical system of *Aporocidaris Milleri* (1) and *A. fragilis* (2). × 5.3.

become confluent. The neuropore is rather large. The ridge is very low, scarcely at all differentiated. The upper furrow is hardly at all distinguishable (Pl. LXVIII. 12).

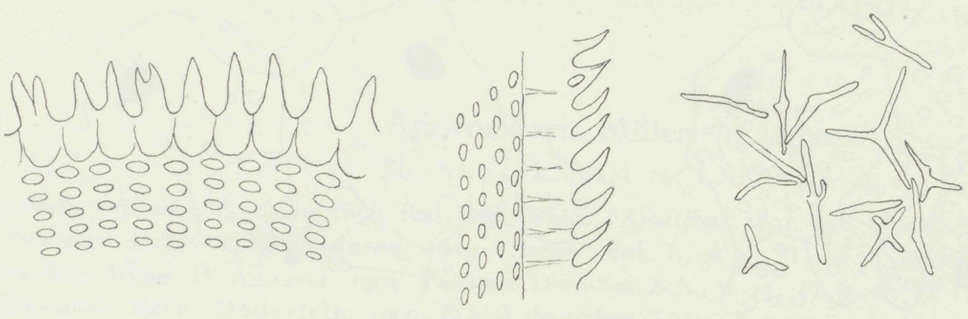
Interambulacra. Areoles rather small, the ambital ones fairly deep. The three proximal ones are confluent; only the proximalmost slightly transverse-oval. Faint traces of crenulation may be seen on the uppermost tubercles. Edge of areoles not raised; the scrobicular tubercles inconspicuous, not much larger than the secondaries which cover — not very closely — the rest of the plate, leaving a fairly conspicuous bare, scarcely sunken median line. Also on the adradial side there are, at the ambitus, a few secondary tubercles outside the scrobicular ones. The horizontal sutures are slightly sunken at the admedian end, forming an inconspicuous groove. Median space of interambulacra about $^2/_3$ the width of an areole.

Apical system. Oculars all exsert, their pore on a small elevation; genitals often somewhat irregular in shape (cf. Panamic Deep-Sea Ech. Pl. 7). Genital pores near the outer edge, rather large in the female. The whole apical system fairly closely covered with about equal-sized tubercles, among which small miliary tubercles may be rather distinct. There is usually a more or less conspicuous bare edge on the genital and ocular plates. In the larger specimens the ocular plates, together with the upper part of the ambulacra, often somewhat prominent. Periproct with a moderate number of plates, usually in two circles. (Fig. 42, 1).

Peristome flat, more or less sunken. There are five ambulacral plates in a series in adult specimens; the outer of these plates may be somewhat apart from each other, as shown in the

beautiful figure 5, Pl. 8 of the "Panamic Deep-Sea Echini". Interradial plates small and irregular, thin and without tubercles, excepting the proximalmost ones. This is good accordance with the fact that the eggs are hatched on the peristome[1].

Primary spines very slender, cylindrical, tapering only very slightly to a simple, not widened point; they are very long, in young specimens up to 4 times, in larger specimens up to 2.5 times the h.d. The shaft is sparsely set with fine thorns or spinules which are arranged in ca. 6 more or less distinct longitudinal series; sometimes they are distinctly arranged in series only in the distal part of the shaft. The surface of the shaft otherwise with a fairly close coat of short hairs which do not anastomose, at most are slightly bifid at the point (Fig. 43, 1—2). The collar is rather long, ca. 2 mm, slightly thickening towards the milled ring which is fairly prominent. Above the collar there is a somewhat longer (ca. 3 mm) smooth, shining neck. The oral primaries are usually spear-shaped, smooth, with distinctly serrate edges and curved at the point; sometimes there is a third row of spinules on their aboral side. The third — fourth has already the shape of the ambital spines, there being no transitional forms.



1 2 3

Fig. 43. *Aporocidaris Milleri;* part of transverse (1) and longitudinal section (2) of primary spine. Group of spicules in the intestinal wall (3). × 125.

Secondary spines all alike, simple, cylindrical and smooth; only those at the edge of the peristome are somewhat widened towards the end and form a cover over the distal, sunken part of the peristome, protecting the eggs and the young, which are hatched in this marsupium. The scrobicular spines are only somewhat longer than the other secondaries, ca. 5 mm, otherwise not at all differing from the latter in shape and they do not form a close cover around the base of the primaries. All secondary spines are erect; there is no indication of a glandular ampulla at their base.

Pedicellariæ. Globiferous pedicellariæ of various sizes fairly numerous. They are essentially alike, without or, more rarely, with an end tooth; there is thus no sharp distinction between the large and the small form of globiferous pedicellariæ. (I would not join Agassiz & Clark (1907, p. 37) in stating that the large globiferous form is wanting). The valves are very flat; the glandular cavity small. The opening may continue to the point of the valve or its edges may join distally; in the latter case there may be an end tooth, but it is always small and inconspicuous. The lip may be somewhat irregular. (Pl. LXXVII. 1—4). The stalk of the larger form is up to 2.5 mm

[1] The suggestion set forth by Agassiz (Pan. Deep-Sea Ech., p. 27) that the poor development of the oral interradials is a consequence of the large size of the auricules (apophyses) is evidently not the true explanation of this feature.

long, the head up to ca. 1 mm long. Tridentate pedicellariæ appear to be absent. — Spicules of the tubefeet of the usual Cidarid-type; the intestinal wall contains rather sparse, small, more or less irregular three-radiate or simple spicules. (Fig. 43.3). In the (female) gonads, which have only short, sac-shaped branches, each with one egg, apparently no spicules.

Colour of both test (denuded) and spines white. Some specimens in the Museum of Comp. Zoology show traces of a purple colour of the skin on the test.

Biology. In a specimen opened the intestine was found to contain mud with what would appear to be parts of muddy tubes of worms; otherwise no distinct organic remains — not even Foraminifera. — One of the gonads of the specimen opened was found to contain a large Nematode, wound up in the empty sac-shaped branches, one of which only contained traces of eggs. — On the primary spines a Polychæte worm in pergamentaceous tubes may occur; otherwise the spines are usually free of foreign organisms. — Some cases of genital plates with more than one (2—3) genital pore (♂) are represented in the "Panamic Deep-Sea Ech." Pl. VII. 1 and 4. As mentioned in my paper "On the postlarval development of some Cidarids" (1927) the species protects its brood which is carried on the peristome[1]. The young Cidarid has spines of very simple structure, not differing essentially in shape from those of the adult. — The genital pores appear at a size of ca. 13 mm. h. d. — It seems that the species does not reach any large size; the largest specimens on record are 30—31 mm h. d.

Occurrence. Known only from the deep water between Acapulco and Panama, and off the Galapagos Islands, in 3010—3385 m, and from S. and S. W. of Galapagos in 3610—3875 m. (Taken only by the "Albatross" 1891 and 1904—5).

Remarks. The statement in the first description of this species (Agassiz, 1898) that it is closely allied to "*Porocidaris*" *elegans* was occasioned only by the somewhat similar oral primaries, with their rather conspicuous lateral serrations. That it has nothing to do with the said species or, on the whole, with the genus *Histocidaris*, was shown in the "Ingolf" Echinoidea II, p. 16, through an examination of its pedicellariæ, from which it was concluded that it must be a *Stereocidaris*, probably nearly related to *St. japonica*. Though there is much resemblance in the main structure of the pedicellariæ of this species and those of *Stereocidaris*, the characters of the test and spines show that it is quite different from *Stereocidaris*. It was then with full right that Agassiz & Clark (Hawaiian Ech. Cidaridæ; 1907) made it the type of a new genus, *Aporocidaris*, characterized mainly by its large apical system.

The great variability in the primary spines emphasized in the "Hawaiian Ech." Cidaridæ, p. 37, some of them being very slender and almost perfectly smooth, others much stouter and provided with longitudinal series of "stout, hooked prickles", is quite evidently a misconception of the fact that the slender and smooth spines are as yet not fully developed, their outer layer having not yet been formed.

[1] The suggestion that this species would prove to be brood-protecting was made already in my report on the Echinoidea d. deutschen Südpolar-Exped. (1909, p. 26, Note).

The specimen of "*Porocidaris Milleri*" from Station 3359, which I have seen in the U. S. National Museum, is a *Cænopedina*, probably an undescribed species. The depth of this station is only 835 m, the lowest depth from which *A. Milleri* is otherwise recorded being 3010 m. This fact thus very considerably restricts the bathymetrical limits of *A. Milleri* and serves to emphasize its character as a pronounced deep-sea dweller.

Aporocidaris fragilis A. Ag. & H. L. Clark.

Pls. XI. 12; LXVIII. 13; LXXVII. 7.

Aporocidaris fragilis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech., Cidaridæ, p. 37. Pl. **10, 10—21; 23, 5—8.**
Aporocidaris fragilis. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. Bull. Mus. C. Z. LI., p. 115.
Aporocidaris fragilis. H. L. Clark. 1907. The Cidaridæ, p. 216.
Aporocidaris fragilis. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp., p. 54.
Plegiocidaris fragilis. Lambert & Thiéry. 1910. Ess. nom. rais., p. 134.
Dorocidaris fragilis. Lambert & Thiéry. 1925. Ibidem, p. 560.
Aporocidaris fragilis. Diakonov. 1923. Faune de Russie. Echinodermes. I. p. 127.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1.	23 mm	13 mm	15 mm (65.2 % h. d.)	10 mm (43.5% h. d.)	6—7	6—7	53 mm + ?
2.	21 —	12 (13) —	14.5 — (69 —)	10,5 — (50 —)	6—7	6—7	40 — + ?
3.	21 —	10 (13) —	14.5 — (69 —)	10 — (47.6 —)	6	7	?
4.	16 —	8 (10) —	12 — (75 —)	8 — (50 —)	6	5—6	28 — + ?
5.	15 —	9 (10) —	10.5 — (70 —)	8 — (53.3 —)	6	5—6	?
6.	12 —	7 (8) —	8 — (66.6 —)	7 — (58.3 —)	6	4—5	28 — + ?
7.	11 —	5 —	7 — (63.6 —)	6 — (54.5 —)	5—6	4	?
8.	6 —	3 (4) —	5 — (83.3 —)	4 — (66.6 —)	4—5	2—3	?

Specimen 1 in the U. S. National Museum, specimens 2—8 in the Museum of Comparative Zoology.

Test more or less conical, more rarely flattened above; oral side flattened, somewhat incurved at the peristomial edge. Circumference circular.

Ambulacra straight, about 1/4 the width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles small and low, unusually distant, the mamelon indistinct. At the ambitus there is in larger specimens adradially to the marginal tubercle a smaller secondary tubercle about at the middle of the plate, and a miliary tubercle at the lower edge; but these inner tubercles, which are very low and rather indistinct, do not occur regularly and do not form regular series. In smaller specimens there are only the marginal tubercles. Midline of ambulacra not sunken Pores rather large, equal sized, oblique and close together; wall very narrow, somewhat sunken in the middle; ridge not developed (Pl. LXVIII. 13).

Interambulacra. Areoles moderately large, very shallow; the 3—4 proximal ones confluent and slightly transverse-oval. Rarely there are traces of crenulation on the upper tubercles. Edge of areoles not raised. Scrobicular tubercles very inconspicuous, scarcely larger than the

other secondary tubercles; these latter few, alternating with the scrobicular tubercles, leaving a rather broad bare, slightly sunken, median space. On the adradial side only in the largest specimens a few secondaries outside the scrobicular ring. Median area about $^1/_2$—$^2/_3$ the width of an areole. At the admedian end of the ambital horizontal sutures a more or less distinct small pore-like depression or groove.

Apical system usually rather elevated, giving the test a subconical shape, sometimes quite conspicuously so; more rarely the apical system is nearly flat. Oculars all widely exsert; genital plates fairly regular. Female genital pores large, nearer the outer edge, while the small male pores are near the middle of the plates. Tubercles of uniform size, not very close set, leaving a rather broad bare edge all round the genital plates. Periproct small, with only a single circle of larger plates along the genital plates and a very few small scattered ones inside these (Fig. 42,2 cf. Fig. 42,1 of *A. Milleri*).

Peristome with 5 ambulacral plates in a series in the largest specimen; the outer ones may be rather widely separated. Interradial plates very feebly developed, only the proximalmost of them with a single tubercle. In the female the outer part of the peristome rather deeply sunken, evidently for serving as a marsupium.

Primary spines slender, cylindrical, probably a good deal more than twice the h. d.; they are set with scattered, sharp spinules, rarely arranged in regular series, except in the distal part, where they form ca. 6 fairly distinct series. The general surface of the spine covered with a fairly dense coat of very short, simple hairs. Collar ca. 2 mm long, slightly thickening towards the fairly prominent milled ring. The neck is very conspicuous, ca. 3 mm long. Oral primaries somewhat spear-shaped, with conspicuously serrate edges, sometimes with a series of thorns along the aboral surface; they are distinctly curved at the point. There are 3—4 of them; the outer of them is fairly long, but still a typical oral spine, there being no gradual transition between the oral and ambital spines.

Secondary spines simple, smooth, cylindrical or slightly club-shaped, more so towards the peristome. All of them alike, erect; the scrobicular spines ca. 5 mm long, the others not much shorter.

Pedicellariæ in the main like those of *A. Milleri*, only the valves of the largest scarcely so wide as in that species; there are often some crests in the blade (Pl. LXXVII. 7). Spicules of tubefeet of the usual type.

Colour. General colour reddish- or yellowish-brown. Primary spines, when clean, pure white, only the collar slightly brownish; the denuded test white.

Biology. It may be concluded rather safely from the facts of the large female pores and the sunken peristome over which the oral primaries and the secondaries on the peristomial edge form a rather close cover, that this species protects its brood in the same way as do both *A. Milleri* and *A. antarctica*. — The genital pores make their appearance at a size of ca. 12 mm h. d. — The largest specimen known measures 23 mm h. d. Probably the species does not grow to a much larger size. The primary spines are rather free from foreign organisms.

Occurrence. Known only from the Northern Pacific, where it was taken by the "Albatross" S. of Shumagin Isl., Alaska, and S. W. of Kamchatka, in 2800 — 3550 m.

Remarks. This species is so very closely related to *A. Milleri* that it may well be questioned whether it is not really the same species. In the Prel. Rep. Ech. "Albatross" 1906 (1907) Agassiz & Clark state that "the differences between *fragilis* and *Milleri* appear to be constant and little diversity is shown". The differences are not mentioned here; in the description in the "Hawaiian Ech. Cidaridæ" it is pointed out that *A. fragilis* is more flattened than *Milleri*, and that the valves of the pedicellariæ are somewhat more slender than in *Milleri*, which seems a very slight reason for distinguishing two different species — the more so as the difference in the shape of the test is not real; some specimens of *fragilis* are as high as any *Milleri*, and, on the other hand, some specimens of *Milleri* are as flat as any *fragilis*. In "The Cidaridæ", p. 215, Clark gives two other characters, viz. that in *fragilis* the number of the ambulacral plates is somewhat smaller than in *Milleri*, 15 against 20 in specimens of 15 mm h. d., and that the tubercles on the apical system are fewer in *fragilis* than in *Milleri*. While the latter difference is scarcely reliable, it would seem that the difference in the number of ambulacral plates is real enough. It also appears from the measurements here given that the peristome is in general slightly larger in *fragilis* than in *Milleri;* further the number of the periproctal plates is smaller in *fragilis* than in *Milleri*. Adding to this the small differences to be noticed in the pedicellariæ, it may, perhaps, be justifiable to retain *A. fragilis* as a separate species, at least until a richer material may prove that also these latter characters do not hold good. If so, there can be no doubt that *fragilis* is only a synonym of *Milleri*.

Aporocidaris antarctica Mrtsn.

Goniocidaris canaliculata A. Agassiz. 1881. „Chall." Ech. p. 43. (partim).
Aporocidaris antarctica. Th. Mortensen. 1909. Ech. Deutsch. Südpolar-Exp., p. 25. Taf. **III. 5, 7; V. 2, 9—11; VII. 4—5; X. 6, 9; XI. 10; XIII. 3, 6; XIV. 1, 16, 17; XV. 8, 12—13, 16, 24—28; XVI. 15.**
Dorocidaris antarctica. Lambert & Thiéry. 1910. Ess. nom. rais., p. 148.
Aporocidaris antarctica. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 36.

To the original description of this species (Op. cit. 1909) is only to be added that the collar of the primary spines is ca. 1 mm long, slightly increasing in thickness towards the rather prominent milled ring; it is fairly conspicuous, being brownish coloured, against the pure white shaft. The neck is ca. 2—2. 5 mm long, not very sharply marked off from the following part of the shaft, because the latter is on the whole shining, almost without hairs. — The number of the ambulacral plates is rather small, as in *fragilis*, ca. 15 in a specimen of 15 mm h. d. The periproct with two circles of plates as in *A. Milleri*.

The difference between this species and *Milleri* and *fragilis* is exceedingly slight. It seems that the test is on the whole somewhat lower than in the two other species; but the only more appreciable difference is in the primary spines which have the general surface almost smooth, almost without hairs. — The colour would seem to differ conspicuously from that of *A. Milleri*,

being dark violet, whereas it is white in *Milleri*. However, this colour difference is probably only apparent; as noted above (p. 113) traces of purple colour was observed in one of the specimens of *Milleri*, and, on the other hand, the dark colour of *antartica*, at least in the two specimens in the Copenhagen Museum, has now entirely faded away, the specimens being now as white as *Milleri*.

Thus it would seem that the only real difference from the two other species is that pointed out above, in the hairs on the primary spines — and in this regard the two specimens mentioned on p. 28 of the original description as a variety of *antarctica* are like *fragilis* and *Milleri*, with a rather close hair-coat.

After all it is very questionable whether the three species *Milleri*, *fragilis* and *antarctica* can be kept separate or whether they are rather to be regarded as one and the same species — which would then keep the name *Milleri*, — distributed all over the abyssal parts of the Pacific and Antarctic Seas. As long as we have only so little material available and only from the three widely separated localities — the Northern Pacific, the Galapagos region and off the Antarctic Continent, S. of the Indian Ocean — it may be the better course to keep them as separate species.

H. L. Clark (Op. cit.) has shown that the specimens from the "Challenger" St. 156 referred by Agassiz to *Goniocidaris canaliculata* are in reality *Aporocidaris antarctica*. Also those from St. 147 and 153 in all probability belong here. (cf. Th. Mortensen 1910. Ech. Swedish S. Polar Exp., p. 19). All of these specimens are quite young and, partly, in a very fragmentary condition, so that they cannot be identified with certainty.

Among some Cidarids sent me for examination from the R. Scottish Museum, Edinburgh, there is a specimen from the "Scotia", which I refer provisionally to *Aporocidaris antarctica*, though it may well ultimately prove to represent a distinct species. It agrees in general with *A. antarctica*, but in spite of its size, 22 mm h. d., the genital pores have not been formed, while in the typical *A. antarctica* the genital pores were found to be present already at a size of 14 mm h. d. The pedicellariæ are of the more slender form described from the specimens from St. 1. of the German S. Polar Exp. (Op. cit. p. 28). Also the apical system is of the same relatively small size (59 % h. d.) as in those specimens.

This specimen is labelled „Scotia" St. 346 (Burdwood Bank, 56 fms.). But this is no doubt due to a misplacing. *Aporocidaris antarctica* is not mentioned in the "Scotia" report, but *Notocidaris (Stereocidaris) Mortenseni* is recorded from 71° 22′ S. 16° 34′ W. 2540 m. From this locality there is — a typical *Austrocidaris canaliculata*. It is, of course, impossible that Koehler could have made this mistake; there is no doubt that the two specimens were interchanged. The specimen in question may, as I have said, rather be referred to *Aporocidaris antarctica*, not to *Notocidaris Mortenseni* (cf. p. 134).

Aporocidaris incerta (Koehler).

Pls. XI. 7—10; LXVIII. 14; LXXVII. 5—6.

Porocidaris incerta. Koehler. 1902. Res. Voyage "Belgica" 1897—99. Échinides et Ophiures, p. 7. Pl. **I. 2; III. 16.**
? *Stereocidaris incerta.* Th. Mortensen. 1903. "Ingolf" Ech. p. 23, 29. Pl. **VIII. 31.**
? *Stereocidaris incerta.* Döderlein. 1906. Ech. Deutsche Tiefsee-Exp., p. 102.
Aporocidaris incerta. H. L. Clark. 1907. The Cidaridæ, p. 216.
Aporocidaris incerta. Th. Mortensen. 1909. Ech. Deutsch Südpolar Exp., p. 29, 54. Taf. **XIII. 2.**
Dorocidaris incerta. Lambert & Thiéry. 1910. Ess. nom. rais., p. 149.

The whole of the material of this species has kindly been lent me by the curator of the Liège Museum, Mr. Fr. Carpentier. It has then seemed desirable to take the opportunity of giving here a full description and photographic figures of it.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1.	14 mm	6 mm	8 mm (57.1 % h. d.)	8.5 mm (60.7 % h. d.)	4—5	7—8	?
2.	12.5 —	6 —	6.2 — (50 —)	6.5 — (52 —)	5—6	5—6	?
3.	9 —	4 —	4.5 — (50 —)	5 — (55.5 —)	5	5—6	ca. 20 mm
4.	5 —	3 —	3 — (60 —)	2.5 — (50 —)	4—5	3—4	9 —

The specimen figured by Koehler (Op. cit. Pl. I. 2) is fallen completely to pieces, so that measurements cannot be made. Judging from the figure quoted it must have been ca. 14 mm h. d.

Test low, conspicuously flattened both above and below; sides strongly arched, circumference circular.

Ambulacra almost straight, about 30 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles fairly prominent, not contiguous. Adradially to the marginal tubercle there is, at the ambitus, a smaller tubercle a little below the middle of the plate, alternating on the two sides; also at the lower edge there may be a small miliary tubercle (Pl. LXVIII. 14). It has rather the appearance that there will be no naked median space in the adult specimens. The pores are confluent, the ridge not much raised.

Interambulacra. The areoles are of moderate size, shallow, the two—three (or even four) proximal ones confluent, and slightly transverse-oval. Slight traces of crenulation to be observed in specimen 2, not in specimen 1. Edge of areoles not raised. Scrobicular tubercles not larger than the marginal ambulacral ones. Outside the scrobicular ring the plates rather closely covered by secondary tubercles of about the same size as the scrobicular ones. Also at the adradial side of the scrobicular ring a few secondary tubercles. Only a narrow, naked, not distinctly sunken median space. At the admedian end of the horizontal sutures there may be an indication of a small groove. The median interambulacral area about $^2/_3$ the width of an areole.

Apical system about half h. d. or somewhat more (the small specimen 4 can scarcely be taken into consideration in this connection); it is slightly raised in specimen 1. Ocular plates all widely exsert (the specimen figured by Koehler (Op. cit. Pl. I. 2) has Oc. IV broadly

insert, but the apical system of this specimen was abnormal, as seen in the figure quoted). Periproct with two circles of plates. The whole apical system rather closely covered with tubercles of a uniform size, leaving, however, a conspicuous, bare edge to the genital plates (fig. 44).

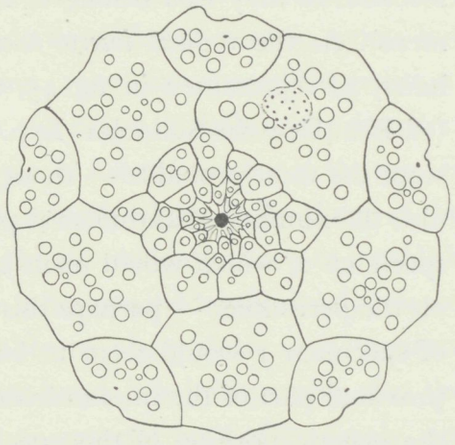


Fig. 44. Apical system of *Aporocidaris incerta*. × 8.

Peristome somewhat larger than the apical system (— but uncertain whether this will hold good also for the adult specimens —). In specimen 1 it is distinctly pentagonal, there being a conspicuous notch in each interambulacrum; in specimen 2 there is no interambulacral notch, the corners of the pentagon being, on the contrary, in the ambulacra. Specimen 1 has 8—9 ambulacral plates in a series, specimens 2 and 3 only 5—6. Interradial plates very slightly developed, only 2—3 in each interradius, widely excluded from the mouth edge.

Primary spines slender, cylindrical, probably much longer than h. d. — but all broken, except in specimen 4, which is too young for allowing any conclusions as to the characters of the adult. They are rather coarsely thorny, the spinules arranged in fairly distinct longitudinal series. The surface of the shaft covered with fine hairs which anastomose at their base so as to form a more or less close spongy coat (fig. 45 — cf. Ech. Deutsche Tiefsee-Exped. p. 29. Pl. XIII. 2). The collar is ca. 1 mm long, scarcely increasing in thickness towards the not very prominent milled ring; neck not distinctly limited. Oral primaries conspicuously serrate, with the point curved. — Secondary spines simple, club-shaped or more cylindrical, erect; the scrobicular spines scarcely longer than the other secondary spines, ca. 2 mm long.

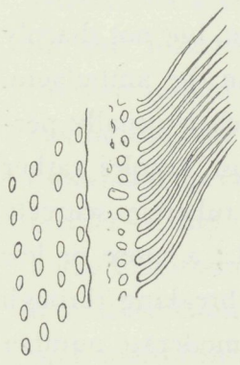


Fig. 45. Part of longitudinal section of a primary spine of *Aporocidaris fragilis*, showing character of the hairs. ×125.

Pedicellariæ of one sort only, small, simple, without an end tooth (Pl. LXXVII, Fig. 7). — Spicules of tubefeet rather strongly developed, of the usual type.

Colour. The preserved specimens are white, both on test and spines, only specimen 3 has the base of the primaries faintly pink. According to Koehler the living specimens were "badius", in places "testaceus"; one of the specimens was rosy coloured.

Biology. None of the specimens having their genital pores developed, it is clear that they are all young, immature specimens, and that, therefore, the species must attain a considerably larger size. — The specimen figured by Koehler had the apical system abnormal, the genitals 2 and 3 being subdivided.

Occurrence. Known only from the Antarctic littoral off S. America (ca. 70° S., ca. 81—88° E. — 100—300 m) ("Belgica").

Remarks. The fact that only young, immature, and rather poorly preserved specimens are known, makes it impossible to reach a definite result with regard to the generic position of

this species. It is even uncertain whether the specimens all really belong to the same species (specimen 3 with the pinkish base of the primary spines, and with the more distinctly club-shaped secondaries may well belong to another species (? *Ctenocidaris Perrieri*) than the two larger specimens). As the typical *incerta* should be regarded, in any case, those with the close coat of fine hairs, as represented in fig. 45, and with the larger number of peristomial ambulacral plates (cf. Ech. Deutche Südpolar Exp. p. 29). — The position within the genus *Aporocidaris* would seem the most probable — though the apical system is scarcely so large as typical of that genus; also the number of ambulacral plates on the peristome is unusual for an *Aporocidaris* — but then specimen 2, which would seem beyond doubt to be identical with specimen 1, has fewer plates on the peristome; — perhaps this may be a sexual difference. The small number of coronal plates of specimen 1 would seem to be an anomaly, a consequence of the unusual absorption of the proximal part of the interambulacra. Until fresh and better preserved material will be available, the generic position of this species must remain uncertain.

Genus **Ctenocidaris** Mrtsn.

Th. Mortensen. 1910. Echinoidea of the Swedish S. Polar Exp., p. 3.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 5, 35.

Subgenus **Eurocidaris** Mrtsn.

Th. Mortensen. 1909. Ech. d. deutschen Südpolar-Exp., p. 30.

Test low, rather thin and fragile. There may be a naked, more or less sunken, but not sharply limited median space in the interambulacra; no naked sunken median space in the ambulacra. Pores oblique, very close together, separated only by a very narrow wall which is usually perforated, the pores thus being confluent. Neuropore small and inconspicuous. Areoles rather deep, the proximal 4—5 usually confluent. No trace of crenulation. Scrobicular tubercles scarcely larger than the other secondaries. Apical system scarcely exceeding half h. d.; a more or less prominent elevated ring round the ocular pore; female genital pore usually breaking through the edge of the plate. Peristome somewhat smaller than apical system, with a moderate number of ambulacral plates, ca. 10—12 in adult specimens. Primary spines cylindrical, with numerous, more or less coarse thorns or spinules, usually not forming regular longitudinal series. General surface of spines covered with a rather thick coat of branching and anastomosing hairs. Oral primaries rather varying in shape, simple, or with strongly serrate edges, or spatulate with smooth edges. Secondaries club-shaped, only the scrobicular spines more or less flattened. Large and small globiferous pedicellariæ without an end tooth; the large form usually with rather elongate, slender valves. Tridentate pedicellariæ wanting.[1] Spicules of intestine small, simple or threeradiate.

[1] In his report on the Echinoids of the Australasian Antarctic Expedition Koehler has in the explanation of Plate CXIX "pédicellaires tridactyles" for *Eurocidaris rugosa*, *E. Geliberti* and *Notocidaris platyacantha*. The figures show, however, that it is all globiferous pedicellariæ, as also he states correctly in the text that the tridentate (or tridactyle, as he designates them) are wanting. It is thus only a lapsus calami which has happened in the explanation of the plate.

Genotype: *Ctenocidaris speciosa* Mrtsn.

The great question here is, whether *Ctenocidaris* and *Eurocidaris* can be maintained as two separate genera. As long as the two species *Eurocidaris nutrix* and *Ctenocidaris speciosa* were the only known, there could scarcely be any doubt that they represented two different generic types; but the rather considerable number of species made known since then (1910) has altered the position. The more conspicuous difference between the two genera was the shape of their oral primaries: strongly serrate, more or less widened in *Ctenocidaris*, quite simple in *Eurocidaris;* but in the species *Geliberti* and *rugosa* the oral primaries are spatulate, with quite smooth edges. If the shape of the oral primaries alone would suffice for a generic distinction, we should evidently have to establish a separate genus for these two species. As the two said species are otherwise evidently closely related to the other species of the group, I think it rather unjustifiable to place them in a separate genus merely for this character of their oral spines. On the other hand, it is indisputable that the species *nutrix* stands rather apart from the rest of the species, on account both of its simple, not at all specialized oral primaries and of its much flatter scrobicular spines. It would, therefore, seem the more reasonable course to keep the species *nutrix* as a subgenus *Eurocidaris* under the genus *Ctenocidaris*. It is true, the name *Eurocidaris* is the older of the two; but to make the much larger *Ctenocidaris*-group a subgenus of the much smaller *Eurocidaris*-group would be rather absurd, the more so as there is always the possibility of the species *nutrix* being again raised to generic rank.

The genus *Ctenocidaris* is evidently nearly related to *Notocidaris*, with which it agrees in the general characters of the test, especially the absence of a well marked sunken space in the ambulacral and interambulacral midlines, in the confluent pores, the club-shaped secondaries and in the structure of the pedicellariæ. The only essential difference is in the primary spines, *Notocidaris* having the oral primaries of a conspicuous spear-shape (this is also found to some degree in some *Ctenocidaris*-species, particularly *Ct. spinosa*) and the upper primaries usually more or less winged; further — and this is evidently the main character — the surface of the upper primaries is very finely longitudinally furrowed by sharp ridges which have their outer, free edge finely serrate, in marked contrast with *Ctenocidaris* in which the surface is covered by a spongy coat of branching and anastomosing hairs.

To the genus *Ctenocidaris*, which appears to be confined to the Antarctic Sea, I refer, besides the species hitherto referred to it, also the two species *Geliberti* and *rugosa*, referred by Koehler to *Eurocidaris*. It is very probable that besides the five (six) species hitherto described, at least one more exists, viz. the deep-sea form figured by Koehler in his report on the Echinoids of the Austral. Antarct. Exped. Pl. 101, under the name *Eurocidaris rugosa*. As the character of the surface of the primary spines is unknown, there is, however, no certainty that it is a *Ctenocidaris;* it may perhaps rather be a *Notocidaris*, or even a *Homalocidaris*.

In my report on the Echinoidea of the Swedish S. Polar Expedition (p. 25) I suggested that the *Cidaris julianensis* described by de Loriol (Notes p. s. à l'étude des Échinod. II. Sér. I. 1902. Pl. I. 13) from the Lower Patagonian formation (Eocene) might be nearly related to *Cteno-*

cidaris. I am not so much inclined to think so now; it is true, the character of the interambulacra is rather similar, but the more important character of the ambulacral pores would according to the figure seem less *Ctenocidaris*-like, since the pores are represented as placed horizontally, not obliquely as in the *Ctenocidaris*-group. The other fossil species described from Patagonia by de Loriol are known from spines alone, and it is too uncertain a basis for drawing any conclusions as to their affinities.

Key to the species of Ctenocidaris.

1. Oral primaries simple; secondary spines rather coarse, the scrobicular ones distinctly flattened; (Subgenus *Eurocidaris*) ..... 2.
   Oral primaries smooth, spatulate ..... 3.
   Oral primaries more or less coarsely serrate, more or less spear-shaped widened ..... 4.
2. Primary spines ca. 1—1.5 h.d. Oculars usually exsert ..... *Ct. (Eurocidaris) nutrix.*
   Primary spines ca. 2—2.5 h.d. Oculars all insert ..... *Ct. (Eurocidaris) nutrix*, var. *longispina.*
3. Ambital primaries apparently smooth; the very low spinules are indistinctly arranged in ca. 22 longitudinal series ..... *Ct. Geliberti.*
   Ambital primaries distinctly thorny; the spinules arranged more regularly in ca. 18 longitudinal series ..... *Ct. rugosa.*
4. Primary spines finely thorny, so as to appear nearly smooth ..... *Ct. speciosa.*
   Primary spines conspicuously thorny ..... 5.
5. Primary spines about 2 h.d., their spinules arranged very irregularly, not in distinct longitudinal series ..... *Ct. Perrieri.*
   Primary spines scarcely exceeding h.d., their spinules usually arranged in ca. 8 fairly distinct longitudinal series ..... *Ct. spinosa.*

Ctenocidaris speciosa Mrtsn.

Ctenocidaris speciosa. Th. Mortensen. 1910. Ech. Swed. S. Polar Exp., p. 4. Pls. **I—II; III. 1—2; IV. 1—3; XIII.**
Ctenocidaris speciosa. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 36.

To the original description may only be added that the ridge separating each two adjoining pore-pairs is fairly conspicuously elevated, rounded. The inner tubercle nearest the marginal tubercle may be as large as or even larger than the latter. As appears from the detail figure of part of an ambulacrum (Op. cit. Pl. XIII. 13) the marginal tubercles are rather small, not nearly contiguous; the marginal series quite regular.

The primary spines have a fairly conspicuous, smooth, shining neck, only slightly longer than the collar, which latter is ca. 1.5 mm long, increasing distinctly in thickness towards the milled ring; it is of a purplish-brown colour, very conspicuous against the whitish, faintly violet shaft.

The species was taken by the Swedish South Polar-Exped. off S. Georgia, on the Shag Rocks Bank and off Graham Land, in depths of 75—400 m. Further the "Terra Nova" and the "Discovery" found it at some other antarctic localities: off Coulman Isl. and S. of Balleny Isl. in corresponding depths. Thus the species would seem to be circumpolar in the Antarctic sublittoral region.

The nearest relatives of this species are *Ct. Perrieri* and *Ct. spinosa*, which both agree with it in the character of the oral primaries, though these appear to be more spear-shaped in *spinosa* than in the present species. *Ct. spinosa* is otherwise very well distinguished from it by its much more thorny ambital primaries, and by the insert oculars. *Ct. Perrieri* is evidently the nearest related to *speciosa*, differing from the latter mainly in its much longer and more coarsely thorny upper primaries. From the other species of the genus *Ct. speciosa* is at once distinguished by the shape of its oral primaries.

Ctenocidaris Perrieri Koehler.

Pl. LXIX. 23.

Cidaris canaliculata (partim). Bell. 1908. National Antarct. Exped. Nat. Hist. IV. Echinoderma., p. 5.

Ctenocidaris Perrieri. Koehler. 1912. Échinodermes nouveaux rec. dans les mers antarctiques par le "Pourquoi-Pas?" (Astéries, Ophiures et Échinides). Zool. Anz. XXXIX, p. 161.

Ctenocidaris Perrieri. Koehler. 1912. Deuxième Expéd. Antarctique Française. Échinodermes. p. 150. Pl. **XII. 4—8; XIII. 2—8; XIV. 9—14; XV. 1—10.**

Ctenocidaris Perrieri. Bell. 1917. Brit. Antarct. ("Terra Nova") Exp. 1910. Zoology. IV, p. 3.

Goniocidaris Perrieri. Lambert & Thiéry. 1925. Ess. nom. rais., p. 560.

Ctenocidaris Perrieri. Th. Mortensen. 1925. On a small collection of Echinoderms from the Antarctic Sea. Arkiv för Zool. 17. A., p. 2.

Ctenocidaris Perrieri. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus., p. 35.

This species is in general very like *Ct. speciosa*, but differs from the latter in its much longer and more slender spines, which are also much more coarsely thorny than in *speciosa*.

The differences between this species and *Ct. speciosa*, thought by Koehler to exist in the apical system, I do not think to be real; it should especially be pointed out that in a specimen (cotype) at my disposal the ocular pores are surrounded by an elevated ringwall as distinct as in *speciosa*. On the other hand, the difference in the tuberculation of the interporiferous zone seems to be real enough, only in the specimen at my disposal the inner tubercles do not form very regular series, as it is stated by Koehler (Pl. LXIX. 23).

As Koehler gives only the horizontal and vertical diameter and the length of the primaries of some specimens, it may be desirable here to give some measurements in the usual form.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1.	45 mm	27 mm	22 mm (48.8 % h. d.)	ca. 17 mm (37.7 % h. d.)	8—9	ca. 10	85 mm
2.	41 —	25 —	19 — (46.3 —)	16 — (36.6 —)	7—8	8—9	76 —
3.	27 mm	16 —	13 — (48.1 —)	12 — (44.4 —)	7—8	7—8	85 —

The specimens are all from the Expedition of the "Pourquoi Pas" (Paris Museum).

To the description given by Koehler I would add a few statements. In a large specimen (57 mm h. d.) from the Ross Sea (British Museum) the oculars appear to be all insert; the same is the case in the cotype at my disposal. The general surface of the primary spines is usually covered

by a thick, spongy coat of anastomosing hairs. The collar is ca. 3 mm long, slightly increasing in thickness towards the milled ring, the furrows of which, as in *speciosa*, continue halfway down the base. The neck is scarcely as long as the collar. The scrobicular spines are ca. 6 mm long, somewhat flattened and slightly concave in the distal part on the outer surface. The secondary spines at the peristomial edge rather strongly developed in larger specimens, forming 10 equally broad stripes or areas of secondaries, in accordance with the fact that the inner tubercles of the interporiferous zone continue in a regular double series even unto the peristome, as is the case also in *Ct. speciosa*, whereas in *Ct. spinosa* the inner tubercles disappear before the peristomial edge, the interporiferous zone being here distinctly narrower in *spinosa* than in the two other species. — The peristome is rather deeply sunken on the larger female specimens, which indicates that the species may be brood-protecting, carrying its young on the peristome.

The specimen of 22 mm diameter from the Ross Sea, mentioned in my paper of 1925 and stated to have as yet no genital openings, I find on a renewed examination to be infested by the parasite *Echinophyces mirabilis* — as also Koehler found some of his specimens thus infested. The genital pores Koehler found developed in a normal specimen of 16 mm h. d. The absence of genital pores in the said specimen of 22 mm h. d. thus evidently is due to the parasite; probably the pores would ultimately develop in the midline of the interambulacra as Koehler found it to be the case in his specimens, and as I found it in specimens of *Ct. speciosa* infested with this parasite.

The species is known only from the Antarctic Sea, where it was found by the "Pourquoi-Pas" in the region ca. 67°—68° S. ca. 70°—72° W. ca. 200—250 m; further it was taken S. of Balleny Island ("Discovery") and in the Ross Sea ("Terra Nova", Sten Wallin) in depths of 180—550 m. It would thus seem to be circumpolar in the sublittoral region of the Antarctic.

Ctenocidaris spinosa (Koehler).

Pls. XII. 13; LXXVII. 10—12.

Notocidaris spinosa. Koehler. 1926. Echinod. Echinoidea. Austral. Antarct. Exp. VIII. III., p. 14. Pl. **97. 1—6; 98. 1—7; 99. 1—3; 112. 7; 114. 7; 119. 6;**

As observed by Koehler, there is a rather great difference in the shape of the oral primaries in the specimens represented in Pl. 97. 3—4 and Pl. 98, — in the former distinctly spear-shaped, in the latter (apparently, at least) not spear-shaped. In a specimen which I have received from the Australian Museum, Sydney, the few oral primaries left are decidedly not spear-shaped either. As the primaries of these specimens are otherwise very similar, this difference may perhaps not mean so much — and since the specimen Pl. 97.3 is stated to be a female, the specimen at my disposal being a male, it may be allowed to hint at the possibility that this difference in the oral spines may be a sexual difference — though the fact that such sexual difference is not known to exist in the related brood-protecting species *Notocidaris gaussensis*, nor, indeed, in any other known species of Cidarids, makes this suggestion highly improbable. Perhaps we have rather two different species here (cf. *Ct. rugosa*).

To Koehler's description I may add a few remarks. The statement that the pores "sont jamais confluents" does not fit with my specimen (identified by Koehler himself as *N. spinosa*), in which the pores are very much confluent. In this specimen (Pl. XII. 13) the areoles are also a good deal smaller than in the denuded specimen figured by Koehler in Pl. 98. 4—7, and there is a rather conspicuous, naked median interambulacral space, which is not found in the specimen figured by Koehler.

The peristome is stated by Koehler (p. 15) to be covered with non-imbricated, even somewhat separated plates; only near the mouth they become imbricated. In my specimen it is only the interradial peristomial plates which may be said to be non-imbricating in the distal part. The distal ambulacral plates are unusually high, but still imbricating. The proximal ones carry 2—3 tubercles on the adradial side of the pore (in *Ct. rugosa* there are four adradial tubercles on each plate). The number of peristomial ambulacral plates is 9—10 (the specimen measuring 44 mm h. d.). — The collar of the primaries is a little more than 1 mm, increasing in thickness towards the prominent milled ring. The neck is about twice the length of the collar. — The large globiferous pedicellariæ may have very elongate, slender valves (Pl. LXXVII. 10—11). If we imagine the subterminal opening of such forms to disappear, we would get the type found in *Rhynchocidaris*, and it would therefore not seem unreasonable to suggest that it did originate in this way, since the other characters of *Rhynchocidaris* show it to be nearly related to the group of genera: *Ctenocidaris*, *Notocidaris*, *Aporocidaris*.

This species has only been taken by the "Aurora" at 64° 32′ S. 97° 20′ E. 200 m.

Koehler referred it to the genus *Notocidaris*, evidently because of the spear-shaped oral primaries in some of the specimens. However, the very thorny primary spines are rather different from the smooth spines of *Notocidaris* and more in accordance with those of *Ctenocidaris rugosa* and *Perrieri*, and especially the hairs of the spines are as in *Ctenocidaris*, anastomosing and forming a thick, spongy coat, very different from the small, simple serrations on the ridges in *Notocidaris*. There can, therefore, be no doubt that this species belongs to the genus *Ctenocidaris*, not to *Notocidaris*.

Another question is, whether all the specimens really belong to the same species, or whether perhaps those with the spear-shaped oral primaries represent another species than those with the oral primaries simply serrated, not spear-shaped widened. A definite answer to this question would require a reexamination of these specimens or the access to new material. The fact that both forms were taken in the same haul does not necessarily mean that they are the same species, though it is, of course, rather strongly in favour of Koehler's view that they are identical. Also the oral primaries of *Ct. speciosa* may show a tendency towards becoming somewhat spear-shaped widened.

This species appears to be the nearest related to *Ct. speciosa* and *Ct. Perrieri;* it differs from both in its much more thorny primaries, which are also considerably shorter than in *Ct. Perrieri*. From the rest of the species of *Ctenocidaris* it differs very markedly in the character of its oral primaries.

Ctenocidaris Geliberti (Koehler).

Pl. LXXVII. 9.

Eurocidaris Geliberti. R. Koehler. 1912. Échinodermes nouveaux rec. dans les mers antarct. par le "Pourquoi-Pas?" (Astéries, Ophiures et Échinides). Zool. Anz. XXXIX, p. 161.

Eurocidaris Geliberti. R. Koehler. 1912. Échinodermes Deuxième Exp. Antarct. Française. p. 146. Pl. **XIV. 1–8.**

Eurocidaris Geliberti. R. Koehler. 1926. Echinod. Echinoidea. Austral. Antarct. Exp. VIII. III. p. 22; Pl. **102.8; 119.3.**

To Koehler's careful description of the single specimen known I can only add that the collar of the primaries is rather unusually long, ca. 3 mm, gradually increasing in thickness towards the fairly prominent milled ring; the neck is very short and inconspicuous, scarcely 1 mm long. The scrobicular spines may be slightly concave on the outer surface. — Koehler's statement that none of the ocular plates are insert is in contradiction to his figure 2, Pl. XIV, which shows one of the oculars, apparently Oc. IV, broadly insert. A valve of a globiferous pedicellaria is represented in Pl. LXXVII. 9.

Till now only the single specimen, the type, is known, which was taken by the "Pourquoi-Pas" in Baie Marguerite at the Antarctic Coast off S. America, in a depth of 200 m.

This species, together with *Ct. rugosa*, differs markedly from the rest of the species in its smooth, spatulate oral primaries. From *rugosa* it differs mainly in the more smooth character of its ambital primaries (cf. under *Ct. rugosa*).

Ctenocidaris rugosa (Koehler).

Pl. LXXVII. 8.

Eurocidaris rugosa. Koehler. 1926. Echinodermata Echinoidea. Austral. Antarct. Exp. VIII. III. p. 17. Pl. **99.4–9; 100.1–6; 102.1–7; 119.2.** (?) Pl. 101. 1–7.

It would seem that there has occurred some confusion in regard to this species. On examining the figures given by Koehler we find that the specimens represented in Pl. 99. 1; Pl. 100. 3–4; and Pl. 102. 3 have the oral primaries of a very characteristic spatulate shape, whereas the one represented in Pl. 101 has them much more spear-shaped, recalling, in fact, more the characteristic oral primaries of *Notocidaris*. Koehler does not notice this difference, stating only (p. 20) that the oral primaries "offrent toujours une forme lancéolée". As the ambital primaries of this specimen with the spear-shaped oral primaries are also much smoother than those of the other specimens, I cannot help suggesting that we have here another, probably new species of the genus *Ctenocidaris* (see further below, p. 128); at least it would be very desirable to have this specimen reexamined. The specimens with the spatulate oral primaries, like Pl. 99. 4, must be regarded as the typical *rugosa*.

Also in the figures of the denuded test there may perhaps have occurred some confusion. In the text it is stated that the median space of the interambulacra is covered with secondary tubercles "qui atteignent la ligne interradiale médiane" which would seem to mean that there is no naked space in the ambulacral midline. But, as far as the, unfortunately rather poor,

reproduction (half-tone) will permit to ascertain, the figures 99. 7 and 100. 2 show a rather broad naked median space in the interambulacra. A specimen with the spatulate oral primaries, which I have received from the Australian Museum, Sydney, (labelled, quite evidently by mistake, *Notocidaris spinosa;* there can be no doubt that it is *Ctenocidaris rugosa*) has no naked median space, in accordance with the original description.

To Koehler's description I would further remark that his statement (p. 19) that the pores are "jamais confluents ou réunis" is in contradiction with his fig. 5, Pl. 102, where some of the pores are quite evidently confluent. — The peristome, about which no information is given by Koehler, is rather unusual in the ambulacral plates having no less than four tubercles (spines) adradially to the pore (two on the abradial side). In accordance herewith the interporiferous space here is unusually broad; in the distal part the pore series are conspicuously diverging (the 3—4 distal pores), then from the 4th—5th pore the series converge slightly unto the proximal end; but even the innermost pair is more widely apart than usual. There are 9—10 ambulacral plates in a series (by a size of 49 mm h. d.). The interradial plates are feebly developed, almost entirely devoid of tubercles, except the proximal ones. The ambulacra do not join at the mouth edge, leaving a fairly broad passage for the interradial plates. (The specimen at hand is a male).

As Koehler has remarked, this species is very closely related to *Ctenocidaris Geliberti*, with which it also agrees in the spatulate oral primaries; one might even be tempted to doubt whether they can really be regarded as separate species. But, in the opinion of Koehler "les doutes sont immédiatement levés par l'examen des pédicellaires". The difference emphasized by Koehler that large globiferous pedicellariæ are absent in *Geliberti*, present in *rugosa*, seems, however, very problematic. That the large globiferous type does not occur in the single specimen known of *Geliberti* is no proof that it does not occur at all in this species. It is a well known fact that particularly the large globiferous pedicellariæ may sometimes be quite absent in some specimens, nay even be absent in most specimens of certain species, occurring only now and then in a few specimens (— a particularly striking example of this is *Prionocidaris bispinosa* —). On the other hand Koehler is certainly right that the small globiferous pedicellariæ have more slender valves in *rugosa* than in *Geliberti* (Pl. LXXVII. 8 to compare with Pl. LXXVII. 9). Further the oculars are exsert in *Geliberti*, insert in *rugosa;* but, as pointed out by Koehler, this may very possibly be a difference due to age only, younger specimens of *rugosa* having them also all exsert. Finally the ambital primaries of *Geliberti* are more smooth than those of *rugosa* (cf. especially Pl. 100. 6 with Pl. 102. 8 of Koehlers' work); the spinules appear to be more distinctly arranged in longitudinal series in *rugosa* than in *Geliberti*, and also the number of these series seems to be a little smaller in *rugosa* (ca. 18) than in *Geliberti* (ca. 22); in regard to the collar and the neck there is no difference. We may thus for the present keep *Ct. rugosa* as a separate species besides *Ct. Geliberti*, but there is no small probability that, when more material of both becomes available, it will be found impossible to maintain *rugosa* as separate from *Geliberti*.

The species *Ct. rugosa* is known only from the Antarctic Sea, where it was taken by the "Au-

rora" at ca. 65° S. 95° 27′ — 96° 13′ E. 430—585 m. It is also recorded from 66° 32′ S. 141° 39′ E. 272 m and from 64° 34′ S. 95° 27′ E. 3060 m. The two specimens from the former of these localities were in poor condition, and, therefore the identification is perhaps less certain, though there is no improbability at all of their being really *Ct. rugosa*. From the latter locality there was only one specimen — the one represented in Pl. 101, which, as stated above, differs so conspicuously from the other specimens in its oral and ambital primaries. The much greater depth from which this specimen came is then an additional fact speaking against the correctness of referring it to *Ct. rugosa*.

Ctenocidaris (Eurocidaris) nutrix (Wyv. Thomson).

Cidaris nutrix. Wyv. Thomson. 1876. Notice of some peculiarities in the mode of propagation of certain Echinoderms of the Southern Sea. Journ. Linn. Soc. London. Zoology. XIII. p. 62—64.
Cidaris nutrix. Wyv. Thomson. 1877. The Atlantic. Voyage of the Challenger. II. p. 226—228.
Goniocidaris membranipora. Studer. 1876. Über Echinod. a. d. antarct. Meere "Gazelle". Monatsber. Ak. Berlin. p. 454.
Cidaris membranipora. Studer. 1880. Übersicht über die während d. Reise S. M. S. "Gazelle" um die Erde 1874—76 ges. Echinoiden. Ibid. p. 862.
Cidaris membranipora. Studer. 1880. Über Geschlechtsdimorphismus bei Echinodermen. Zool. Anz. Nr. 67.
Goniocidaris canaliculata (partim). A. Agassiz. 1881. "Challenger" Ech. p. 43.
Stereocidaris nutrix. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 25—27, 29, 173; Pl. **X. 3—4, 12, 14, 24,**
Goniocidaris canaliculata. A. Agassiz. 1904. Panamic Deep Sea Ech. p. 4.
Stereocidaris nutrix. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 96, 102.
Austrocidaris nutrix. H. L. Clark. 1907. The Cidaridæ, p. 213.
Eurocidaris nutrix. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 30—39. Taf. **III. 9; IV. 5—6; VI. 2, 4—9, 11—12; X. 7, 11; XI. 12; XIII. 7; XV. 17, 20—23.**
Goniocidaris nutrix. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Goniocidaris nutrix. Jackson. 1912. Phylogeny of the Echini, p. 99—102, 170. (Fig. 72).
Eurocidaris nutrix. Koehler. 1917. Échinodermes rec. par M. Rallier du Baty aux îles de Kerguelen, 1913—14. Ann. Inst. Océanogr. VII. Fasc. VIII. p. 72.
Austrocidaris nutrix. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 29.

To the description given in the report on the Echinoids of the German S. Polar-Expedition (1909) may be added that I have now seen a specimen with two oculars (IV and V) insert, as observed by Studer (cf. Op. cit. 1909. p. 32). — The collar of the primary spines is ca. 1 mm long, increasing conspicuously in thickness towards the fairly prominent milled ring, the furrows of which may continue more or less distinctly halfway down the base. The neck is only ca. 1 mm long, but rather conspicuous on account of its reddish colour which contrasts markedly against the white collar.

The species is known only from the Kerguelen, Crozet and Heard Islands, from the littoral down to ca. 225 m. — When Clark (Op. cit. 1925) still refers to this species the specimens from the "Challenger" St. 147 (1600 fathoms) and St. 156 (1975 fathoms) this is probably done inadvertently. The specimens from these stations are partly very small and in a so fragmentary condition that they are unidentifiable; very probably they are all identical with two larger specimens from St. 156 which are, quite correctly, identified by Clark as *Aporocidaris antarctica*

and mentioned under that species (Op. cit. p. 36). None of these specimens from the deeper "Challenger" stations (viz. St. 147, 153 and 156; cf. Chall. Ech. p. 46) have anything with *E. nutrix* to do.

It is worth mentioning that one of the specimens of *E. nutrix* from the "Challenger" (Christmas Harbour, Kerguelen) in the British Museum is embraced by two specimens of the 7-armed viviparous Ophiurid *Ophiacantha vivipara*, which have their arms twisted among the primary spines of the Cidarid. One of the Ophiurids again carries a couple of its young on its back. Some of the spines of the Cidarid are further covered with Bryozoans, among which some beautiful cup-shaped colonies of a *Lichenopora*-like form. The whole a magnificent little biocoenosis.

Var. **longispina** Mrtsn.

Pl. LXVII. 8.

Eurocidaris nutrix, var. *longispina*. Th. Mortensen. 1928. New Cidaridæ, p. 67.

The long-spined form from the "Challenger" St. 150 (W. of Heard Isl., 150 fms.). I have mentioned in the "Ingolf" Ech. I. (p. 27) and in the Ech. Deutsche Südpolar Exp. (p. 34) as perhaps rather representing a separate species; Clark, however, refers them without any doubt to *E. nutrix* (Cat. Rec. Sea-Urch. Br. Mus. p. 29). After a renewed examination of these specimens in the British Museum I cannot agree with Clark in simply regarding this form as a typical *E. nutrix*. Besides in the much longer primary spines, 2—2.5 h. d. against ca. 1—1.5 h. d. in the typical form, they differ in having all oculars insert (at least in one specimen, 22 mm h. d., placed at my disposal; I regret not having ascertained whether they are so also in the other specimens); further the genital pores have not yet developed in specimens of 14—16 mm h. d. (but in one of 18 mm h. d.), whereas in *E. nutrix* they appear at a size of ca. 9—12 mm h. d. Otherwise the general character of the apical system, in regard to tuberculation and shape of the plates, is much the same as in the typical form. In the interporiferous zone there is a regular double series of inner tubercles, in the typical form usually only a single irregular series. These differences certainly show that we have here not a true *E. nutrix;* it must, at least, be regarded as a separate variety.

The measurements of these specimens are as follows.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1.	31 mm	16.5 mm	14 mm (45 % h. d.)	14 mm (45 % h. d.)	7—8	5—6	65 mm
2.	22 —	13 —	11 — (50 —)	11 — (50 —)	7—8	6—7	52 —
3.	18 —	9 —	8.2 — (45.5 —)	9 — (50 —)	6	5—6	?
4.	16 —	8 —	7 — (43.7 —)	7.5 — (46.9 —)	6—7	5—6	43 —
5.	14 —	7.5 —	7 — (50 —)	7.5 — (53.6 —)	5—6	4—5	31 —

Specimen 2 is the type specimen. Specimen 1 is abnormal, one of the ambulacra reaching only halfway to the apical system.

From the other species of *Ctenocidaris* the present species differs rather conspicuously in its simple oral primaries, the more flattened scrobicular spines, as also by its smaller size. It forms a group of its own and may well keep the rank of a subgenus, if not of a separate genus (cf. above p. 121).

Genus **Notocidaris** Mrtsn.

Th. Mortensen. 1909. Echinoidea d. deutschen Südpolar-Exp. p. 17.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 6.

Test low, rather thin and fragile. Pore-zone not distinctly sunken. The pores close together, oblique, separated only by a very narrow, low wall, which may even be perforated, the pores thus being confluent. Neuropore of moderate size. A naked, somewhat sunk median line in the interambulacra, not in the ambulacra. Areoles rather deep, usually the 4—5 proximal ones confluent. No trace of crenulation. Scrobicular tubercles not larger than the other secondary tubercles. Apical system not raised, generally not exceeding half h. d. Madreporite not enlarged, pores confined to a small area. Peristome about the same size as the apical system; peristomial ambulacral plates not very few, ca. 9—10 in adult specimens. Primary spines often more or less flattened, sometimes widened to an extraordinary degree in the distal part, sometimes with wing-like expansions in the basal part. General surface of shaft with numerous fine, sharp, longitudinal ridges, continuing in forwards directed spinules on their free edge; otherwise there are no hairs on the surface of the shaft. Collar ca. 1—2 mm long; a conspicuous shining neck about twice the length of the collar. Oral primaries elegantly spear-shaped, usually with coarsely serrate edges. Secondary spines erect, slender, cylindric, more or less distinctly club-shaped, but not flattened. Both large and small globiferous pedicellariæ without an end tooth on the valves; the large form may have very elongate, slender valves. No tridentate pedicellariæ. Spicules of the intestinal wall small, more or less irregular, of the three-radiate type.

Genotype: *Goniocidaris Mortenseni* Koehler.

This genus is characterised by the beautiful, spear-shaped oral primaries, by the absence of hairs on the surface of the primaries, whereas the numerous fine, sharp, longitudinal ridges are finely serrate along their free edge; further by the slender, more or less club-shaped, not flattened secondaries. The characters of the globiferous pedicellariæ (no end tooth) and the absence of tridentate pedicellariæ, together with the character of the pores: oblique, separated only by a narrow, low, often perforated wall, are common to this whole group of genera. The nearest related genus is *Ctenocidaris*, from which it is distinguished by the characters of its primary spines.

Only four species are known of this genus, all from the Antarctic seas. A fifth species, *Notocidaris spinosa* Koehler, does not really belong to this genus, but to the genus *Ctenocidaris*.

Key to the species of the genus Notocidaris.

1. Upper primaries very flattened, strongly widening towards the end ..... *N. platyacantha.*
   Upper primaries not widening towards the end ..... 2.
2. Upper primaries with wing-like expansions at least at the base ..... 3.
   Upper primaries without wing-like expansions, but usually with some coarse thorns in the basal part ..... *N. gaussensis.*
3. Upper primaries very long, ca. 5 h.d., wing-like expansions of about the same width almost to the end of the spine ..... *N. hastata.*
   Upper primaries scarcely exceeding 3 h.d., wing-like expansions much broader in the basal part ..... *N. Mortenseni.*

Notocidaris Mortenseni (Koehler).

Pls. XI. 13—15; LXVIII. 15.

Goniocidaris Mortenseni. Koehler. 1900. Note prélim. sur les Échinides et les Ophiures de l'Expéd. antarct. belge. Bull. Ac. R. de Belgique. 1900, p. 816.

Goniocidaris Mortenseni. Koehler. 1902. Échinides et Ophiures. Res. du Voyage du "Belgica" 1897—99. p. 5. Pl. **I. 1; II. 11; III. 17; IV. 29; V. 30.**

Stereocidaris Mortenseni. Th. Mortensen. 1903. "Ingolf" Ech. p. 27, 29. Pl. **VIII. 34.**

Stereocidaris Mortenseni. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 102.

Austrocidaris Mortenseni. H. L. Clark. 1907. The Cidaridæ, p. 213.

?Stereocidaris Mortenseni. Koehler. 1909. Astéries, Ophiures et Échinides. Rep. Sc. Res. "Scotia". Vol. V., p. 280.

Notocidaris Mortenseni. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp., p. 21. Taf. **III. 1, 8, 10; XIV. 3, 6.**

Typocidaris Mortenseni. Lambert & Thiéry. 1910. Ess. nom. rais. p. 152.

Notocidaris Mortenseni. Koehler. 1912. Échinod. Deuxième Exp. Antarct. Franç. (1908—10), p. 207.

NON: *Notocidaris Mortenseni.* F. Jeffr. Bell. 1917. Echinoderma. Brit. Antarct. ("Terra Nova") Exped. IV., p. 3 (= *Notocidaris platyacantha* H. L. Clark)).

The whole material of this species having very kindly been lent me for reexamination by the curator of the Liège Museum, M. Fr. Carpentier, I have thought it desirable to give here a full description of the species, comparable to the other modern descriptions of Cidarids, the more so as this is the genotype of the genus *Notocidaris*.

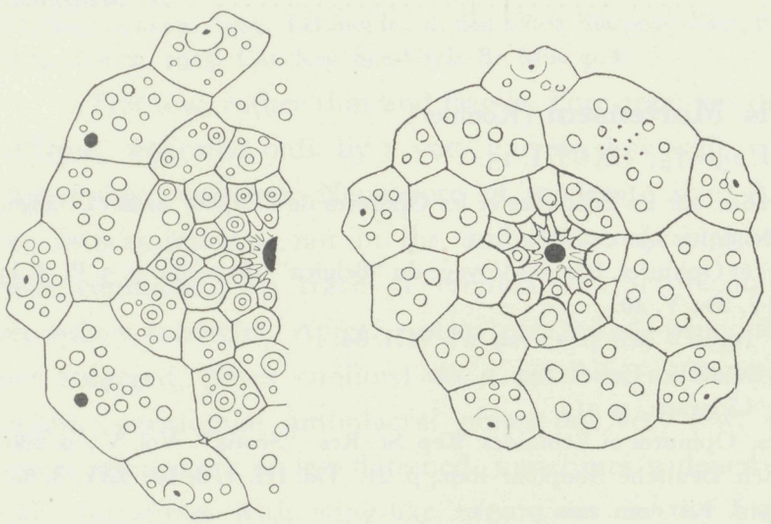
	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1.	29 mm	15 mm	16 mm (55.2 % h. d.)	14 mm (48.3 % h. d.)	7	6—7	54 mm
2.	25 —	14 —	13 — (52 —)	12.5 — (50 —)	6—7	6—7	63 —
3.	18.5 —	9 —	10 — (53.6 —)	10 — (53.6 —)	(5)—6	6	54 —
4.	14 —	7.5 —	8 — (57.1 —)	8 — (57.1 —)	5—(6)	5	48 —
5.	13 —	6.5 —	7 — (53.8 —)	7 — (53.8 —)	5—6	5	?

Test low, distinctly flattened above and below. Sides slightly subvertical. Circumference circular.

Ambulacra slightly sinuate, ca. 22 % of width of interambulacra; interporiferous zone a little more than twice the width of a pore zone. Marginal series of tubercles regular, the tubercles small, not nearly contiguous. Adradially to the marginal tubercle each plate carries a second,

not much smaller tubercle nearer to the lower edge, these inner tubercles forming also regular vertical series. In the two smaller specimens the inner tubercle is found only on a few of the plates at the ambitus. The median part of the interporiferous zone bare, but not sunken. Pores close together, as typical of the whole group, oblique, separated only by a quite narrow, sometimes perforated, not raised wall; ridge low and inconspicuous (Pl. LXVIII. 15).

Interambulacra. Areoles moderately deep, confluent, except the 2—3 upper ones, and distinctly transverse-oval, likewise except the 2—3 upper ones. The tubercle rather small, and the boss not very prominent; hardly any trace of crenulation to be observed, even in the smaller specimens. Edge of areoles not raised. Scrobicular tubercles very inconspicuous, not larger than the marginal ambulacral ones. Outside the scrobicular circle there are some not much smaller secondary tubercles, leaving a rather conspicuous, bare, slightly sunken median part. The median end of the upper horizontal sutures may be more or less distinctly sunken, even so as to form a fairly distinct groove. On the adradial side of the scrobicular circle there are, in the larger specimens, some few secondary tubercles; no bare adradial edge to the plates. The median interambulacral area about half the width of an areole.



1 2

Fig. 46. Part of apical system of *Notocidaris Mortenseni*, somewhat abnormal (1); apical system of a young specimen, where the genital pores have not yet appeared; also somewhat abnormal (2). 1.×5.3; 2.×8.

Apical system a little more than half h. d., flat, or the periproct somewhat raised. Ocular plates exsert, except Oc. I and V, which are narrowly insert in specimen 2; in specimen 1 one of the oculars is represented as just insert.[1] In the younger specimens all oculars are exsert. Genital pore (♂) small, near the outer edge. Tubercles rather sparse, leaving a more or less conspicuous bare edge. A fairly distinct, elevated wall round the ocular pore. The periproct with a moderate number of plates, their tubercles partly somewhat enlarged (Figs. 46.1—2).

Peristome in the larger specimens slightly smaller than, in the smaller ones of the same size as the apical system. There are 7—8 ambulacral plates in a series in the larger specimens, 6 in the small ones. The interradial plates form a rather irregular series of 5—6 plates, not reaching the mouth edge. The outer ones with only few tubercles (spines) or none. The peristome is

[1] This plate is probably Oc. I., but it cannot be ascertained definitely, as Koehler does not indicate the madreporite in his figure of this specimen (Op. cit. Pl. IV. 29), and half of the apical system, with the madreporite and the ocular plate in question, is now lacking in the specimen.

in the larger specimens slightly sunken in the outer part, in the two small specimens it is rather conspicuously protruding.

Primary spines. The upper primaries have a pair of conspicuous lateral, more or less serrate, wing-like crests in the basal part, generally confined to the basal third or fourth part; otherwise there are some inconspicuous, low spinules in the basal part, not distinctly serially arranged but from about the middle of the spine arranged in distinct series, sometimes to the number of ca. 12—14, sometimes only ca. 6—8 series; they are equally developed on both sides. The point appears to be quite simple, but it is not preserved quite intact in any of the spines. In general the spines are, not considering the wings, almost cylindrical, tapering only very slightly towards the point; rarely they are somewhat flattened towards the end. The collar is about 2 mm long, scarcely thickening towards the fairly prominent milled ring. The neck is rather conspicuous, about twice the length of the collar. Surface of the shaft as typical of the genus, with no hairs, only the ridges finely serrate. — The oral primaries are very elegantly spear-shaped, with a distinct median keel on both the adoral and the aboral side; they are slightly curved at the end. The third has already essentially the character of an ambital spine.

Secondary spines. The scrobicular spines ca. 4—5 mm long, simple, very slightly club-shaped. The other secondaries a little shorter, otherwise of the same shape as the scrobicular ones.

The pedicellariæ have been described and figured in my report on the Echinoids of the German S. Polar Exp. 1909 (p. 22. Pl. XIV. 3, 6) to which may be referred. The spicules rather strongly developed, both in the tubefeet and in the intestinal wall, the latter of the three-radiate type, though more or less irregular.

Colour. The primary spines of a beautiful purplish-violet, which may be very intense on the collar and neck, the intensity gradually diminishing outwards, the point being whitish. The secondaries a light brownish or cream colour. Test white.

Biology. In the two small specimens genital pores have not yet appeared, in specimen 3 the pores are just about to form. The two larger specimens evidently both are males (for specimen 2 I have been able to ascertain this definitely). We do not know, therefore, whether this species is brood protecting as *gaussensis*, but it is, certainly, highly probable that it will be so. — Whether it grows to a much larger size is uncertain, but the fact that the spines of all the specimens are almost quite free of foreign organisms indicates that none of them are very old. Also the fact that the genital pores do not appear until a size of ca. 18 mm h. d. indicates a form of fairly large size. — It is a curious fact that of the five specimens known no less than three show anomalies in the apical system. In specimens 2 and 3 genital 3 is divided into two parts by a vertical line (Fig. 46, 1); in specimen 5 both genital 1, 3 and 4 are split up into 2—3 parts (Fig. 46, 2).

Occurrence. Known only from the Antarctic, where it was taken by the "Belgica" at about 70—71° S., 80—92° W., 100—600 m.

The species is also recorded by Koehler in his report on the "Scotia" Echinoderms from 71° 22′ S. 16° 34′ W. 2540 m. In the collection of Cidarids lent me from the R. Scottish Museum there is a specimen, labelled *Stereocidaris Mortenseni*, from this locality — but it is a typical *Austrocidaris canaliculata*. On the other hand, there is a among some specimens of *A. canaliculata* from the Burdwood Bank, 56 fms., ("Scotia") a specimen of what appears to be *Aporocidaris antarctica*, a species not mentioned in Koehlers report. There can scarcely be any doubt that this is the specimen which Koehler identified as *Stereocidaris Mortenseni*, and which has then been misplaced and interchanged with a specimen of *Austrocidaris canaliculata*. The record of the occurrence of *N. Mortenseni* at a depth of 2540 m. thus appears to be unacceptable (cf. p. 117).

Remarks. Evidently the nearest relation of the present species is *Notocidaris hastata*, the difference between them being found only in the shape of the primary spines — so far as we can see from the material known at present (only young specimens of *N. hastata* are known).

When Lambert & Thiéry refer this species to the genus *Typocidaris* (while the closely related species *gaussensis* and *hastata* are referred to the genus *Dorocidaris*), this is evidently due to the fact that Koehler's drawing of the test shows the groove at the median end of the horizontal sutures rather exaggerated (cf. Koehler's fig. 17, Pl. III. with the photographic figure of the same specimen given here, Pl. XI. 13). But even as it was represented by Koehler there is no resemblance at all to the grooves of typical *Typocidaris*, and referring the species to this genus on base of the said figure is rather unpardonable.

Notocidaris gaussensis Mrtsn.

Notocidaris gaussensis. Th. Mortensen. 1909. Ech. deutsche Südpolar-Exp. p. 18. Taf. **I; II. 1—2; V. 13—16, 19—21; VII. 2; X. 5, 8; XI. 3; XIII. 1; XIV. 2, 4, 10, 15; XV. 10; XVIII. 9—11, 14, 17—18.**

Dorocidaris gaussensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

Notocidaris gaussensis. Th. Mortensen. 1911. Echinological Notes III. The central (sur-anal) plate of the Echinoidea. Vid. Medd. D. Naturh. Foren. 63., p. 33.

To the detailed original description of this species may be added that the marginal ambulacral tubercles are small, distant and only very indistinctly mamelonate. The regularity of the marginal series appears from the figure Taf. X, 8 (Op. cit.). The peristome may be conspicuously conically raised. The collar of the primary spines is ca. 1 mm long, increasing in thickness towards the fairly prominent milled ring. There is a conspicuous shining neck, about twice the length of the collar. As correctly stated, the fine longitudinal ridges on the shaft are set with fine, outwards directed points, but a figure may be added (Fig. 47.1) from a longitudinal section, showing these points on the ridges. The statement (p. 20) that the secondary spines are "fein dornig" is to be thus understood that it is by a microscopical examination that they are seen to be finely spinulose; by low magnification they appear quite smooth.

The statement (p. 21) that there is a single anal plate in the young specimens has been corrected in the paper quoted (1911); like in other young Cidarids there is from the first a various number of small plates on the periproct, not a single, large plate.

The fact that the upper primaries are sometimes flattened and a little widened towards the point leads the way to the extraordinary condition of these spines obtaining in *N. platyacantha*.

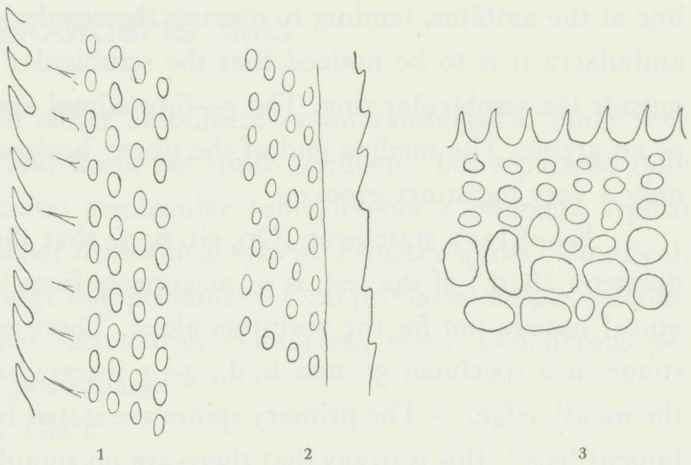


Fig. 47. Part of longitudinal section of primary spine of *Notocidaris gaussensis* (1) and of *N. platyacantha* (2); part of transverse section of *N. platyacantha* (3). × 125.

The species, which has been taken only by the German S. Polar Expedition, is known only from the sublittoral region of the Antarctic, 350—385 m.

From the closely related *N. Mortenseni* and *N. hastata* this species differs mainly in the character of its upper primary spines, as given in the key.

Notocidaris hastata Mrtsn.

Notocidaris hastata. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 23. Taf. **II. 3—4; V. 12, 17—18; XIII. 8; XIV. 7, 18. XVIII. 7, 13, 15, 19, 23.**

Dorocidaris hastata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

To the original description can only be added (no specimen being available) that the collar and neck of the primary spines are as in *N. gaussensis*.

The species which has been found only by the German S Polar Expedition, in the Antarctic Deep Sea, 2450—2725 m, is closely related to *N. Mortenseni*, from which it differs mainly in the character of the primary spines, as given in the key. Though only immature specimens are known, the distinctness of the species seems hardly doubtful.

Notocidaris platyacantha (H. L. Clark).

Pl. LXXVII. 15—17.

Cidaris canaliculata (partim). F. Jeffr. Bell. 1908. Echinoderma. National Antarctic Exped. Nat. Hist. IV. p. 5.

Notocidaris Mortenseni. F. Jeffr. Bell. 1917. Echinoderma. Brit. Antarct. ("Terra Nova") Exped. IV. p. 3.

Austrocidaris platyacantha. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 29. Pl. **II. 1.**

Notocidaris platyacantha. R. Koehler. 1926. Echinodermata Echinoidea. Austral. Antarct. Exp. VIII. III. p. 8. Pl. **XCIII; XCIV. 1—4, 6—7; XCV. 1—8; CXIX. 4.**

To the descriptions of this species given by Clark and, especially, by Koehler there is very little to add.

In the ambulacra there may, in larger specimens, be a few tubercles along the median

line at the ambitus, tending to obscure the regularity of the inner series of tubercles. In the interambulacra it is to be noticed that the scrobicular tubercles are not larger than the secondaries outside the scrobicular ring. The 5—6 proximal areoles are confluent; the median space as broad as an areole. The median end of the upper horizontal sutures only slightly sunken, forming thus only a very indistinct groove.

Koehler's statement (Op. cit. p. 9) that the diameter of the periproct surpasses half the diameter (h. d.) of the test, is — as appears from figures 7 and 8, Pl. 95 — meant for the whole apical system, not for the periproct alone. There are 8 ambulacral plates in a series on the peristome in a specimen 36 mm h. d., 4—5 interradial plates in fairly regular series, not reaching the mouth edge. — The primary spines are stated by Koehler to have the general surface "absolument lisse"; this is to say that there are no spinules on it, but otherwise it is very finely striated, the striæ being rather sharp and finely serrate, with forwards directed points as in the other *Notocidaris*-species (Fig. 47. 2—3). In the broad, flattened, outer part of the primary spines the layer of the radiating septa is much reduced, the greater part of the interior space being occupied by the central core, which extends throughout the whole breadth of the spine. The neck is rather short, not much longer than the collar, which is ca. 1 mm long, increasing somewhat in thickness towards the fairly prominent milled ring.

The valves of the large globiferous pedicellariæ are very slender, the large glandular cavity occupying the whole width of the blade; in the small form the glandular cavity is much narrower, and the lateral parts of the blade fairly broad (Pl. LXXVII. 15—17).

The colour of the denuded test is white.

Var. **contracta** Koehler.

Notocidaris platyacantha var. *contracta*. Koehler 1926. Echinodermata Echinoidea. Austral. Antarct. Exped. VIII. III. p. 13. Pl. **XCIV. 5; XCVI. 1—6; CXIX. 5.**

This variety is stated to differ from the typical form only in the primary spines being much less widened and somewhat more strongly spinulose in the basal part. No details of the structure of the test are given. (I have not had the opportunity of examining any specimens of this variety). — As there are transitional forms between those specimens with the very broad spines and those with the scarcely widened spines, it would seem that Koehler is right in not regarding these latter specimens as a separate species. — But it might have been desirable to know exactly how this variety is to be distinguished from such specimens of *Notocidaris gaussensis* in which the upper primary spines are also flattened.

Like the other *Notocidaris*-species *N. platyacantha* appears to be confined to the Antarctic Seas, where it was taken by the "Discovery" off Coulman Isl. (180 m) and by the "Terra Nova" S. of Balleny Isl. (depth not stated; recorded by Bell under the names of *Notocidaris Mortenseni* and *Ctenocidaris Perrieri*). Further some specimens were taken by the Australian Antarctic Exped. off the Antarctic Continent between 97° 20′ E. and 142° 6′ E. — ca. 200—640 m. — The species is thus known only from the region of the Antarctic to the South of the Pacific.

Genus Homalocidaris Mrtsn.

Th. Mortensen. 1928. New Cidaridæ, p. 67.

Test low. No naked, sunken midline in either ambulacra or interambulacra. Pores very close together, confluent. Areoles very large and deep, not quite confluent, but separated only by very narrow ridges. Tubercles not crenulate; scrobicular tubercles not prominent. Apical system less than h. d., peristome somewhat smaller than apical system. Primary spines cylindrical, perfectly smooth; milled ring extraordinarily large and prominent. Oral primaries simple, smooth. Scrobicular spines slightly flattened, the other secondaries cylindrical, erect. Globiferous pedicellariæ without end tooth. No tridentate pedicellariæ.

Genotype: *Austrocidaris gigantea* H. L. Clark.

This genus is nearly related to *Ctenocidaris*, *Notocidaris* and *Aporocidaris* etc., as appears from the characters of its pores and the secondary spines. It is the peculiar character of its primary spines which necessitates making it the type of a separate genus. It is an interesting analogy to the genus *Calocidaris*, which is likewise distinguished from its near relation *Cidaris* by its perfectly smooth spines. We have thus here an example of this nearly identical structure of the spines having developed along two different lines, as there is otherwise no nearer relation between the present form and the West Indian *Calocidaris micans*.

Homalocidaris gigantea (H. L. Clark).

Pls. XI. 6; LXXVII. 14; LXXXIII. 23.

Austrocidaris gigantea. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 28. Pl. **III. 1—2.**

Having had the opportunity of studying the two only specimens known of this species, in the British Museum, I can add several details to the description given by Clark; I have thought it preferable to do it in this way, giving a complete description in which are contained both the characters mentioned in the original description and the additional information derived from my reexamination of the two specimens. It would have been desirable to have given a detailed figure of the ambulacral structure; of this there was, however, no possibility; but anyhow the description gives the essential facts.

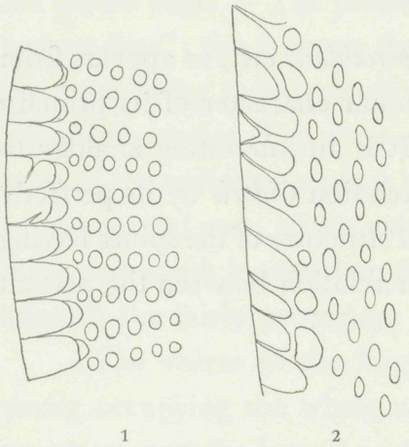
h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Spines
53 mm	32 mm	24 mm (45.3 % h. d.)	22.5 mm (42.5 % h. d.)	6—7	12—13	80 mm
53 —	33 —	23 — (43.4 —)	22.5 — (42.5 —)	6—7	12—13	

Test distinctly flattened, slightly incurving at the peristomial edge. Circumference circular.

Ambulacra distinctly sinuate, about $^1/_5$ the width of the interambulacra; interporiferous zone slightly more than twice the width of a pore-zone. Marginal series of tubercles regular, the tubercles small, not contiguous. Adradially to the marginal tubercle each plate carries a single tubercle about as large as the marginal one, situated about in the middle of the plate, these inner

tubercles also forming very regular vertical series. Sometimes there may be a small tubercle in the midline, and as a rule there is a small tubercle at the lower edge of the plate off the interspace between the two larger tubercles. No bare median line. The pores are small, the inner distinctly larger than the outer; the wall is very thin and perforated, the pores being thus confluent. Ridge low, rounded.

Interambulacra. Areoles very large and deep, transverse-oval, excepting the two uppermost ones. They are not quite confluent, but separated only by a very narrow ridge; even the proximal ones may be thus separated, though they may also be quite confluent. Apparently no trace of crenulation. Scrobicular tubercles inconspicuous. There are only a few smaller tubercles at the admedian side of the scrobicular ring, none at the adradial side. Median area scarcely $^1/_3$ the width of an areole. No naked median interambulacral space.



1 2

Fig. 48. Part of transverse (1) and longitudinal sections (2) of primary spines of *Homalocidaris gigantea*. × 105.

Apical system. Oculars widely insert; genitals small, only a little larger than the oculars. Periproct rather large, with about three circles of plates. The whole apical system rather closely covered by tubercles of uniform size. The ocular pore surrounded by a fairly distinct ringwall. — Peristome with ca. 10 ambulacral plates in a series. Interradial plates very feebly developed.

Primary spines slender, (ca. 2 mm in diameter), cylindrical, very slightly tapering to a blunt point. They are quite smooth, but not shining. On a microscopical examination they make the appearance of being very finely longitudinally striped. Sections, however, show that this is not the case; the surface is in reality perfectly smooth, without the slightest indication of hairs or ridges or other prominences. The apparent fine ridges are nothing but the radiating septa shining through the very transparent cortex layer. (Figs. 48. 1—2). There is, of course, no "neck". The collar is ca. 4 mm long, increasing slightly in thickness towards the milled ring, which is remarkably prominent, in correspondance with the extraordinary development of the muscles of the primary spines. The striæ of the milled ring continue horizontally inwards towards the collar, and also halfway down over the base (Pl. LXXXIII. 23). The oral primaries are simple, scarcely at all widened, not much flattened, and with smooth, not serrate edges. The third is transitional to the ambital spines; it is slightly widened in the point.

Secondary spines. The scrobicular spines are ca. 9 mm long, somewhat flattened, ending in a rounded point. The other secondaries simply cylindrical. All the secondaries erect.

Pedicellariæ. Only one sort observed, representing probably the small form of globiferous, reaching a size of ca. 1 mm length of head; the stalk very simple, usually somewhat exceeding the length of the head. The valves (Pl. LXXVII. 14) are rather broad and flat, with an irregular meshwork or some irregular crests in the outer part. The glandular cavity is very narrow. The

opening is more or less irregular, usually somewhat slit-like prolonged downwards; very often there is also an irregular slit in the outer wall. There is no end tooth; the edges of the opening on the whole very slightly dentate. — Spicules of the tubefeet partly (in the distal part of those on the oral side) developed into fenestrated plates.

Colour. Primary spines white, only the point yellowish or brownish. Secondary spines and (non-denuded) test yellow-brown.

Occurrence. The two only known specimens were taken by the "Discovery" off Coulman Isl., S. Victoria Land, at a depth of 180 m.

Remarks. This species, so strikingly different from all other antarctic Cidarids hitherto known, may perhaps be supposed, from the extraordinary development of its spine-muscles to possess the faculty of moving more swiftly than Cidarids usually do. At least it appears from the extraordinary development of the milled ring that the huge, swollen spine-muscles do not owe their striking appearance to preservation, a possibility hinted at by Clark (Op. cit.), but that they really are exceptionally well developed.

Genus **Rhynchocidaris** Mrtsn.

Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 5.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 6.

Test low. No naked median furrow in either ambulacra or interambulacra. Pores oblique; wall narrow, but generally not perforated. The neuropore unusually large and more or less completely separated off from the inner pore, so that there are three instead of two pores in each plate. Areoles rather small, not much sunken, the proximal ones confluent. No trace of crenulation. Scrobicular tubercles not enlarged. Apical system about half h. d. or a little more; there is an elevated ring round the ocular pore. Peristome somewhat smaller than the apical system, with 7—8 ambulacral plates in a series in the adult. Primary spines cylindric, rather coarsely thorny, the surface covered with a thick coat of anastomosing hairs. Oral primaries flattened, somewhat serrate. Secondary spines all cylindric, club-shaped, erect. Pedicellariæ without an end tooth; the large globiferous with only a small pore in the end of the valves, no subterminal opening. Tridentate pedicellariæ wanting. No spicules in the intestinal wall.

Genotype: *Rhynchocidaris triplopora* Mrtsn.

The peculiar tripartite pores and the character of the large globiferous pedicellariæ mark this genus very sharply from all other Cidarids. There is, however, no doubt that the affinities of *Rhynchocidaris* are with *Aporocidaris* and *Ctenocidaris*. In the former the neuropore is also unusually large and approaches the condition in *Rhynchocidaris*, and in *Ctenocidaris spinosa* the very slender and elongate valves of the large globiferous pedicellariæ evidently approach the structure of these pedicellariæ in *Rhynchocidaris* and show the way along which they have evolved.

The type species is the only one known.

Rhynchocidaris triplopora (Mrtsn).

Rhynchocidaris triplopora. Th. Mortensen. 1909. Ech. deutsche Südpolar Exp. p. 6. Taf. **III. 4, 6; IV. 1—4; V. 1, 3—8; X. 2—3, 10; XI. 1—2, 4—7, 9, 11; XII; XIII. 4—5, 9—10, 12—16, 18—20; XIV. 5, 8, 14, 20; XV. 3, 5—6, 9, 11; XVI. 11—13.**

Rhynchocidaris triplopora. Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.

Rhynchocidaris triplopora. Koehler. 1926. Echinod. Echinoidea. Austral. Antarct. Exp. VIII. III. p. 23. Pl. **103. 1—6; 119. 7.**

To the original description I may add that the collar of the primary spines is ca. 0.2—0.3 mm long, slightly increasing in thickness towards the milled ring, which is not very prominent, and the furrows of which do not continue distinctly on to the base. The neck is somewhat more than twice the length of the collar. The median interambulacral space is little more than the width of an areole. There is a fairly broad space covered with tubercles also on the adradial side of the areoles.

The species, which was dicsovered by the German South Polar Expedition off the Antarctic Coast at 90° E., in depths of 350—385 m, was taken again by the "Aurora" at 64 °32′ S. 97° 20′ E. 200 m.

The existence in the primary spines of this species of the curious parasite *Echinophyces mirabilis* Mrtsn. may be recalled, as also the astonishing transplacing of the female genital pores to the edge of the peristome in specimens infested with the parasite (Op. cit. 1909. p. 12—17; Pl. XII).

Genus **Austrocidaris** H. L. Clark.

H. L. Clark. 1907. The Cidaridæ, p. 212.

H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 4, 27.

Syn. *Temnocidaris* A. Agassiz (non Cotteau).

A. Agassiz. 1863. List of Echinod. p. 18.

Test low. A sharply limited, sunken median furrow in the interambulacra, usually also in the ambulacra. Pores oblique, close together; the wall narrow, but apparently never perforated, may even be somewhat raised. Neuropore small and inconspicuous. Areoles rather deep, well separated, at most the proximal 2—3 ones confluent. Slight traces of crenulation on the upper tubercles. Scrobicular tubercles scarcely larger than the other secondaries. Apical system less than h. d., periproctal plates rather numerous; peristome about the same size as the apical system, with ca. 10—11 ambulacral plates in a series in adult specimens. Primary spines cylindrical, on the whole rather short and slender, fairly smooth; the surface covered with bush-shaped, slightly anastomosing hairs. Oral primaries simple, not specialised. Secondary spines flattened, somewhat appressed. Large and small globiferous pedicellariæ without end tooth; tridentate pedicellariæ wanting. Apparently no spicules in the intestinal wall.

Rather small forms, apparently confined to the Subantarctic Seas.

Genotype: *Temnocidaris canaliculata* A. Agassiz.

This genus resembles in its pore-structure the various antarctic genera, *Ctenocidaris*, *Notocidaris*, *Aporocidaris;* particularly it has much general resemblance to the subgenus *Eurocidaris* of

Ctenocidaris. It differs markedly from the said genera by the sharply limited sunken, median furrow in both ambulacra and interambulacra, in its more flattened secondaries and also in the structure of the pedicellariæ. From *Ogmocidaris*, in which the sharp, sunken median furrows are equally well developed, it differs markedly in the character of the peristome (cf. Fig. 49. 1—2; p. 142) as well as in the structure of the pedicellariæ (Pl. LXXVII. 18 and 13). Through this latter genus *Austrocidaris* is connected with the Goniocidarids.

It seems highly probable that the *Goniocidaris jorgensis* of de Loriol (Notes p. s. à l'Étude des Échinod. II. Sér. I. 1902. p. 8; Pl. I. 14—15) (from the Lower Patagonian, Eocene) belongs to the genus *Austrocidaris*, as it appears to have had the conspicuous, sunken median furrow in the interambulacra so characteristic of this genus. We may well see in it the ancestor of the recent species, as I suggested in the report on the Echinoidea of the Swedish S. Polar Exped. (p. 25).

Only two species known with certainty till now; perhaps the "*Stereocidaris*" *Lorioli* Mrtsn. will prove to be a third valid species, but this needs reexamination. The various species referred by H. L. Clark to this genus (*nutrix*, *Mortenseni*, and *gigantea*) in my opinion belong to other genera (*Ctenocidaris*, subgen. *Eurocidaris*, *Notocidaris*, and *Homalocidaris*).

Key to the species of Austrocidaris.

1. Primary spines without larger thorns ..... 2.
   Upper primaries with some larger thorns in their basal part ..... *A. spinulosa.*
2. Primary spines scarcely exceeding h.d.; oral primaries rather coarse, thorny ..... *A. canaliculata.*
   Primary spines ca. 2 h.d.; oral primaries slender, smooth ..... *A. canaliculata*, var. *Lorioli.*

Austrocidaris canaliculata (A. Agassiz).

Pls. XVI. 14—15; LXXVII. 18.

Centrocidaris canaliculata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

Goniocidaris canaliculata. Jackson. 1912. Phylogeny of the Echini, p. 80, p. 99—102, 170, 184. (figs. 45, 73, 209); Pl. 2. 1—3, 17.

Austrocidaris canaliculata. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 27.

NON: *Cidaris canaliculata.* Bell. 1908. Echinoderma. National Antarct. Exp. Natural History. IV. p. 5. (= *Homalocidaris gigantea* (H. L. Clark) and *Notocidaris platyacantha* (H. L. Clark)).

— *Goniocidaris canaliculata.* Rudmose Brown. 1910. Echinoidea from the Kerimba Archipelago, Portuguese East Africa (Mozambique). Proc. R. Phys. Soc. Edinburgh. XVIII. p. 37 (= *Eucidaris metularia*).[1]

The older literary references for this species up to 1910 were given in my report on the Echinoidea of the Swedish S. Solar Exped. (p. 11—12), to which may be referred; it may only here be repeated that *Goniocidaris vivipara* Studer is a synonym of *A. canaliculata.*

[1] In his "Echinoderm Fauna of S. Africa" (1923. Ann. S. Afr. Mus. XIII. p. 369) H. L. Clark states in a note that there is no probability at all for the *Goniocidaris canaliculata* recorded by Brown (Op. cit.) from Portuguese East Africa to be really that species, but that it must almost certainly be *Eucidaris metularia*. Evidently, Clark overlooked that I have shown it definitely, after an examination of some of Brown's specimens, to be *E. metularia* (Ech. Swed. S. Polar. Exp. p. 19, note).

To the description given in the Echinoidea Swed. S. Polar Exped. may only be added that the collar of the primary spines is about 1 mm long, increasing in thickness towards the fairly prominent milled ring, the furrows of which continue downwards over the base. The neck is slightly longer than the collar.

A very curious anomaly was observed on a specimen (36 mm h. d.) in the Museum of Comp. Zoology, one of the primary spines being double. Both on the oral and aboral side of tubercle 3 from above a spine has developed, the two spines having, as it were, half of the base cut off, until just above the collar; here they very nearly meet, leaving like a gateway between them, in which is seen the tubercle. The shaft of each of the two spines is perfectly normal, only slightly shorter than the other ambital spines. It is no case of regeneration, the two spines having not each its own tubercle; it must have been the first rudiment of the spine which has split in the middle, above the tubercle.

In "Die Japanischen Seeigel" Döderlein figures (Taf. IX. 6) a young *A. canaliculata* with traces of imbrication of the coronal plates — a reminiscense of the condition obtaining in Palæozoic and Triassic Cidarids. (Op. cit. p. 36). I have no material of young specimens of the present species for reexamining this question; but there is some indication of a similar imbrication of the coronal plates to exist also in the young *Eucidaris metularia* — and then, probably, in young Cidarids in general.

The species is known with certainty to occur only in the littoral and sublittoral of the Magellanic region — from off La Plata to the Magellan Strait, the Falkland Isl., down to the Burdwood Bank, to a depth of ca. 270 m. — Apparently it does not occur on the West Coast of S. America, at least it has not yet been recorded from there. The numerous other localities from which the species is recorded are due either to erroneous identification or to unreliable labelling from old times. It may be pointed out that there are no specimens labelled Tasmania in the British Museum. Bell's statement (Echinoderma. Nat. Antarct. Exp. p. 5) of having specimens from there must then evidently rest on some mistake.

Whether the longspined specimen from the "Challenger" St. 320, off the mouth of La Plata, 1080 m, really belongs to *A. canaliculata*, or it represents a separate species *A. Lorioli* (Mrtsn). may still be regarded as uncertain (cf. Ech. Swed. S. Polar. Exp. p. 20) in spite of Clark's assertion (Cat. Rec. Sea-Urch. Br. Mus. p. 28) that he is satisfied that it is *canaliculata.* That the difference in the pedicellariæ from the typical form might be "associated with the depth at which it lived" does not seem very probable; we do not otherwise find that the shape of the pedicellariæ may vary according to depth. Besides in the character of the pedicellariæ and in the greater length of the primary spines — more than 2 h. d. — the specimen differs from the typical *canaliculata* also in its oral primaries being more smooth and slender and in the secondary spines being somewhat more slender. It is noteworthy that the specimen, in spite of its rather considerable size, 30 mm h. d., is not yet full-grown, the upper primaries being not fully formed. For the present it would seem unjustifiable simply to unite this form with *A. canaliculata;* until it has been

proven that it is connected with the typical *canaliculata* by transitional forms it may rather be kept as a separate variety, var. *Lorioli* (Mrtsn.), of that species.

There are two specimens from the said station; one of them is, however, so young (11 mm h. d.) that it can scarcely be taken into consideration in discussing the question of the classificatory value of this form. The large specimen measures as follows:

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
30 mm	17 mm	41.7 mm (41.7 % h. d.)	13 mm (43.3 % h. d.)	6	8—10	65 mm

Austrocidaris spinulosa Mrtsn.

Austrocidaris spinulosa. Th. Mortensen. 1910. Ech. Swed. S. Polar. Exp. p. 23. Pl. **III. 3—5; XIV. 3—5, 12—15.**

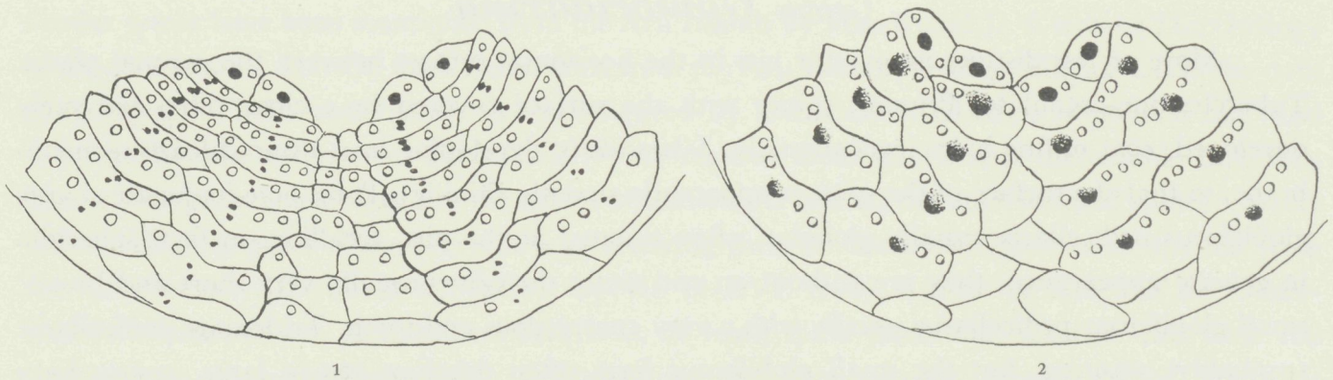
There is nothing to add to the description of this species, no new material being available. It seems to be a well characterised species, the coarse thorns at the base of the upper primaries being the main feature distinguishing it from *A. canaliculata.*

Known only from S. of the Falkland Isl., 197 m. (Swedish S. Polar Exped.).

Genus **Ogmocidaris** Mrtsn.

Th. Mortensen. 1921. Echinoderms of New Zealand and the Auckland-Campbell Isl. I. Echinoidea. (Papers from Dr. Th. Mortensen's Pac. Exp. 1914—16. VIII.) Vid. Medd. Dansk Nat. Foren. 73. p. 151.

Test low. A well marked median furrow in both ambulacra and interambulacra. Pores oblique, the wall narrow, but distinctly raised, never perforate; neuropore small and inconspicuous. Areoles rather deep, sunken, the proximal ones confluent. No trace of crenulation. Apical system about half h. d. or a little more. Peristome somewhat smaller, with only 5—6 high ambulacral plates in a series. Primary spines covered with short, slightly anastomosing hairs.[1] Oral primaries flattened, with fairly serrate edges. Scrobicular spines flattened, somewhat appressed, the other secondaries cylindrical. Globiferous pedicellariæ partly (large form) without, partly (small form) with an end tooth.



1 2

Fig. 49. Part of peristome of *Austrocidaris canaliculata* (1) and *Ogmocidaris Benhami* (2). × 12.

[1] The statement in the original description that the hairs are simple is not quite correct.

Genotype: *Ogmocidaris Benhami* Mrtsn.

This genus on the one hand recalls *Austrocidaris*, particularly by the deep median furrow in the ambulacra and interambulacra. It differs, however, from that genus so markedly in the character of its peristome (Fig. 49) and in its pedicellariæ, that it would seem out of question to unite them into one single genus. Through the end tooth of the small globiferous pedicellariæ and the widening of the median furrow into the admedian end of the horizontal sutures it recalls, on the other hand, *Goniocidaris*, and it would, indeed, seem quite natural to see in *Ogmocidaris* a connecting link between *Austrocidaris* and *Goniocidaris*.

Only the type species known.

Ogmocidaris Benhami Mrtsn.

Pl. LXXVII. 13.

Porocidaris elegans. Benham. 1909. Scientif. Res. N. Z. G. Trawling Exp. 1907. Echinoderma. Rec. Canterbury Mus. I. 2. p. 25.

Ogmocidaris Benhami. Th. Mortensen. 1921. Echinod. N. Zealand & Auckland-Campbell Isl. I. Echinoidea. p. 148. Pl. **VI. 3—6; VII. 1—2.**

Cidaris Benhami. Lambert & Thiéry. 1925. Ess. nom. rais. p. 558.

To the original description may be added that the collar of the primary spines is scarcely 1 mm long, only very slightly increasing in thickness downwards. Milled ring very inconspicuous, its ridges only very indistinctly continuing over the base. Neck about twice as long as the collar.

A couple of specimens, which I have examined in the Museum of Comp. Zoology measure as follows:

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
17 mm	9 mm	8 mm (47 % h. d.)	7.5 mm (44 % h. d.)	6—7	8—9	18 mm
17 —	9 —	10 — (58.8 —)	8.5 — (50 —)	6—7	8	25 —

Group *Goniocidarina.*

More or less distinct grooves or pits in the horizontal sutures between the coronal plates. Tubercles non-crenulate. Primary spines with the surface covered by a close, often extremely developed, coat of fine hairs (exceptionally, *Schizocidaris*, developing into a fine calcareous membrane, so that the surface of the spine is apparently smooth, shining). Pores non-conjugate. Large globiferous pedicellariæ usually globular, often situated at the pits, recalling, in fact, spheridia in general appearance; they are without an end tooth, the valves usually very short and broad; small globiferous pedicellariæ usually with a very conspicuous end tooth. Tridentate pedicellariæ (probably) wanting, but the small globiferous form often develops into a large, coarse form resembling the tridentate type.

This subfamily forms a very natural group, well characterized through the combination

of characters given in the above diagnosis. It is a very conspicuous fact that, excepting a single species in South African Seas, no Goniocidarid is known outside the Malay Archipelago, Japan and Australia—New Zealand; but here it is very richly represented, especially in the Malay Archipelago, where all the known genera occur; in Japanese waters it is also well represented, one genus (two subgenera, 6 species) being known from there, while from Australia only two, from New Zealand only one, species are known, all three belonging to one genus. Thus, it would appear that the original home of the whole group is in the Malay Archipelago, from where it has spread northwards to the Japanese Seas and, in a less degree, southwards as far as New Zealand.

The Goniocidarids are, on the whole, small and delicate forms scarcely exceeding a diameter of test of ca. 25—30 mm; alone *Goniocidaris tubaria* reaches a size of ca. 55 mm h.d. This species also is much coarser and stouter in general appearance than the rest of the group, probably in correspondance with the fact that it is a litoral form, while the other Goniocidarids are mainly deep-sea forms (— excepting *G. umbraculum*, which is likewise a comparatively stout, coarse, though small form). Some of the Goniocidarids (*Rhopalocidaris*) are real pygmies, scarcely exceeding 15 mm h.d., and represent the smallest forms of recent Cidarids. (Among the fossil Cidarids the Triassic genera *Mikrocidaris*, *Triadocidaris* and *Aplocidaris* are of a still smaller size).

It is of considerable interest to trace the history of the group back to former geological epochs. Several records of fossil Goniocidarids are found in literature. Duncan & Sladen (Monogr. Tert. Ech. of Kachh and Kattywar. Pal. Indica. XIV. 1883, p. 52) describe a *Goniocidaris affinis* from the Miocene of India and suggest that another species from the same formation, *Cidaris halaensis* d'Archiac & Haime is likewise a *Goniocidaris*. Lambert & Thiéry (Ess. nom. rais. p. 153) besides these two species also refer to *Goniocidaris* the species *Cidaris depressa* Duncan & Sl. and *C. granulata* Duncan & Sl., likewise from the Miocene of India (described in the same work by Duncan & Sladen). Further Duncan & Sladen describe in their Monogr. Foss. Ech. of the Makràn Series (Pal. Ind. XIV. 1886. p. 372 (from the Pliocene of the Persian Gulf)) a *Cidaris* sp., which they refer with doubt to *Goniocidaris*, and also a number of spines of Cidarids are described and figured (Pl. LVII) which are supposed to belong to *Goniocidaris*. Recently quite similar spines have been mentioned from the Aru Islands by Miss Ethel D. Currie (The Geology of the Aru Islands. III. On fossil Echinoidea from the Aru Islands. Geolog. Magaz. LXI. No. 716. p. 67. 1924). Their resemblance to those figured by Duncan & Sladen is pointed out, and they are likewise referred to *Goniocidaris*. — As regards these spines, it is undeniable that they bear a very great resemblance to the spines of *Goniocidaris tubaria*; but such isolated spines scarcely afford sufficient proof of the correctness of referring them to *Goniocidaris*, and as for the test from the same locality (Duncan & Sladen Op. cit. Pl. LVI. 1—2), it must be said that the Goniocidarid characters are so indistinct that it is, at least, quite uncertain, whether this form has anything to do with *Goniocidaris*. — Concerning the four miocene species named above, it can first be said that the species *Cid. granulata* (Op. cit. Pl. XIII. 4—6) through its rather distinctly crenulate tubercles differs so conspicuously from the Goniocidarids that it would seem quite

absurd to make a *Goniocidaris* of it, the more so as there is nothing in the test that recalls *Goniocidaris* especially — and the same holds good of *C. depressa* (Op. cit. Pl. XIII. 1—3). On the other hand *Goniocidaris affinis* (Op. cit. Pl. VIII. 9) through its distinctly deepened horizontal and vertical interambulacral sutures really recalls *Goniocidaris*, and the same may well be said of *C. halaensis* (Op. cit. Pl. VIII. 7—8). There are also figured some spines from the same formation, which likewise recall those of *Goniocidaris tubaria*. Thus it would seem that we have here the oldest known representatives of Goniocidarids, and their occurrence here in deposits of India, together with the fact that spines very closely resembling those of *Goniocidaris tubaria* occur in the Pliocene of the Persian Gulf, tend to indicate that the group was formerly distributed also over the Indian Ocean, where it is not known to exist in recent times, excepting the single, insufficiently known species which occurs in the South African Seas (cf. p. 154).

Fossil species of *Goniocidaris* have also been recorded from more distant localities, namely from S. America and Europe. P. de Loriol (Notes pour servir à l'Ét. d. Éch. 2 Sér. I. 1902) describes *Goniocidaris jorgensis* from the Miocene of Patagonia. It is, however, based only on isolated plates, and there is no proof at all that it is a true *Goniocidaris*; it is much more probable, indeed, that it belongs to the *Austrocidaris*-type.

Jackson (Fossil Echinoids of the West Indies. Publ. Carnegie Inst. No. 306. 1922. p. 17) describes a new species, *Cidaris foveata*, from the Eocene of Jamaica, which has a series of sharp, deep pits in the interambulacral midline; the interporiferous area is deeply channeled, the pores conjugate, and the tubercles strongly crenulate. Jackson thinks this species to have its nearest ally in the recent Australian *Goniocidaris tubaria*. He further figures spines of a *Cidaris* species b (p. 19) which "can be compared very closely with *Goniocidaris biserialis*". — It may well be agreed that the spine fig. 3 recalls *Goniocidaris biserialis*, or some other Goniocidarid; this, however, is scarcely proof enough of this species being a true Goniocidarid. As for "*Cidaris*" *foveata*, I do not think it a true Goniocidarid, in spite of the interambulacral grooves (— unfortunately the figures accompanying the description are so poor that hardly any details can be made out —). It is true, the crenulate tubercles are only what should be expected in the oldest Goniocidarid; but the conjugate pores are so decidedly a specialized feature that it is hard to see how this could be found in the oldest, but not in any of the recent forms of Goniocidarids. I therefore think this old West Indian form to represent a parallel development, having no real affinity to the Goniocidarids. Probably it ought to be made the type of a separate genus.

Lambert (Recherches sur les Échinides de l'Aptien de Grandpré. Bull. Soc. Géol. France. XX. 1892) refers to *Goniocidaris* the two species *Cidaris farringdonensis* Wright[1] (from the Cretaceous formation of France and Switzerland) and *Goniocidaris arduennensis* Lambert (Cretaceous,

[1] H. L. Hawkins (The Species of Cidaris from the Lower Greensand of Farringdon. Geol. Magaz. N. S. Dec. V. Vol. IX. 1912. p. 529) has shown that de Loriol and Lambert were wrong in identifying their species with Wright's *Cidaris farringdonensis* and gives it the new name *testiplana*. The true *farringdonensis* evidently has no grooves and is no Goniocidarid, and no *Typocidaris* either, to which latter genus *farringdonensis* is referred by Lambert & Thiéry in their Ess. nom. rais. p. 151.

France). Both species have distinct grooves in the interambulacral sutures, but differ from *Goniocidaris* in the outer groove being situated not at the admedian edge, but between the areoles (Op. cit. Pl. II), a feature entirely unknown in recent Goniocidarids. It is, for this reason alone, very improbable that they have anything to do with *Goniocidaris*; also their general appearance is rather unlike that of Goniocidarids. Lambert has then also himself changed his opinion regarding their generic position and refers them now (Ess. nom. rais.) to the genus *Typocidaris* Pomel, with which view I concur — apart from the fact that I do not recognize *Typocidaris* as a valid genus, but only as a synonym of *Stereocidaris*.

Another question is this, whether there is any real genetic relation between the Goniocidarids and the Stereocidarids. The grooves of the sutures in several Stereocidarids certainly recall those of the Goniocidarids, and neither would the rather unspecialized character of the pedicellariæ in Stereocidarids be opposed to the suggestion of a genetic relation between the two groups. The same, however, holds good of the group of the *Ctenocidarina*, and, as we have in fact a very gradual transition from the Ctenocidarids to the Goniocidarids (especially the genus *Ogmocidaris*) and there is, on the whole, a very considerable general resemblance between some of the Ctenocidarids and Goniocidarids, particularly the genera *Aporocidaris* and *Psilocidaris*, I rather think that there is a real relationship between these two groups, but not between Stereocidarids and Goniocidarids.

Döderlein (Jap. Seeigel, I, p. 13, 45) suggests the possibility of *Goniocidaris* having derived from the group of cretaceous and tertiary forms to which *Pleurocidaris canaliculata* (Duncan & Sladen[1]) belongs. The sole reason for this suggestion is the fact that *Goniocidaris biserialis* has the interambulacral miliary tubercles arranged in horizontal series, separated by narrow furrows, such as is the case in *canaliculata* Dunc. & Sl. and the other species which have been united into the genus *Pleurocidaris* Pomel. But it is quite certain that such arrangement of the miliary tubercles has developed separately in various groups (e. g. *Chondrocidaris*, *Calocidaris*) and can even scarcely be regarded as a character of generic value, so that the genus *Pleurocidaris* cannot be maintained (— I quite agree with H. L. Clark and Lambert & Thiéry herein —), and still less can afford proof of a genetic relation between recent and fossil forms. Further the conjugate pores of *canaliculata* Dunc. & Sl. and related forms decidedly speak against the Goniocidarids being derived from such forms, the conjugate type of pores being decidedly the more specialized. Also the complete lacking of the grooves in "*Pleurocidaris*" is decidedly against the suggestion of any closer relation between the Goniocidarids and the said group.

Quenstedt (1875. Petrefactenkunde Deutschlands. III. Echiniden, p. 216) calls attention to the fact that in the Jurassic Cidarid, which he made the type of the genus *Polycidaris*, *P. multiceps* Quenst., as also in another species, *P. nonarius* Quenst., there is a naked, sunk median line and a small groove at the median end of the horizontal sutures, recalling *Goniocidaris*. This suggestion of a relationship between *Polycidaris* and *Goniocidaris* is adopted by Döderlein (Op. cit.

[1] Duncan & Sladen. Monogr. foss. Ech. Sind. Part. III. Pal. Indica. XIV. 1884. p. 109. Pl. XXI. 1—9.

p. 45) and especially by H. L. Clark (The Cidaridæ, p. 199); the latter author declares that to him "it is clear that its (viz. *Polycidaris*) relationships are with *Goniocidaris*. Except for the narrow ambulacra and the merged areoles, *P. nonarius* is strikingly like *G. umbraculum*". Although I agree that this *Polycidaris nonarius* may well resemble a recent form like *G. umbraculum*, and in spite of the small pits in the test in *Polycidaris*, I think the genetic connection with the recent Goniocidarids rather problematic. First the very characteristic merging of the areoles would seem to be a rather specialized feature, not at all found in the Goniocidarids. And then there is the historical reason. If *Polycidaris* were really the ancestor of Goniocidarids it might well be expected that other Goniocidarid types were found in all the following geological formations. But this is by no means the case; not until the Miocene do we find forms which may with any degree of probability be referred to the Goniocidarids. It must certainly be agreed that this fact speaks very strongly against any genetic relationship between *Polycidaris* and the Goniocidarids, as it is hardly imaginable that not one of the numerous connecting links that must necessarily have existed, should have been preserved. Therefore, in my opinion, the bare, sunk median line and the small pits of *Polycidaris* are characters specially acquired by this form and lost with it — and again developed anew in the Goniocidarid type.

H. L. Clark (The Cidaridæ, p. 196) has further suggested the possibility that the origin of *Goniocidaris* might be found in such a form as "*Phyllacanthus verticillata* . . . . . the median ambulacral and interambulacral areas of that species could easily be transformed into those of *G. tubaria*, while perfectly horizontal pores are found in *G. biserialis*". It is a little bit hard to take this quite seriously. To seek the ancestor of Goniocidarids among recent forms does not seem very reasonable, and then what reasons are there for assuming any nearer relation between them? No grooves in the test in *verticillata*, subconjugate pores (at least in the larger specimens), spines and pedicellariæ different! The horizontal pores of *biserialis*, specially mentioned by Clark as an argument for such relationship, are by no means peculiar to these two forms but found in most adult Cidarids. Of course, we can imagine grooves also in *verticillata*, as any other changes necessary for the idea of such relationship. But there is — so far as I can see — no trace of nature having had this idea. — Finally, I would remark that seeking a genetic relation of *Goniocidaris* both with *Polycidaris* and *Plococidaris verticillata* — or even also with *Pleurocidaris*, would mean a polyphyletic origin of the Goniocidarids, for which the closer study of these latter lends no support at all.

The recent forms of Goniocidarids may be grouped into four genera, at least, viz. *Goniocidaris* Ag. & Des., *Schizocidaris* Mrtsn., *Rhopalocidaris* Mrtsn. and *Psilocidaris* Mrtsn.; the first of these is perhaps too extensive, and may be subdivided into four subgenera.

Key to the genera of Goniocidarina.

1. Apical spines in adult specimens forming a more or less extensive disk[1]; usually also a disk, more or less complete, at the base of the spine ..... *Goniocidaris.*
   Apical spines not widening in the point so as to form a terminal disk. No basal disk..... 2.
2. Surface of primary spines (between the thorns) apparently quite smooth, shining, in reality covered with a coat of hairs, which expand so as to form a roof all over the surface of the spine, with its thorns, resting on the basal part of the hairs as upon columns. Secondary spines smooth, flattened, not club-shaped..... *Schizocidaris.*
   Surface of primary spines (between the thorns) not smooth, shining ..... 3.
3. Primary spines moderately long, ca. 1—3 h.d., with a close coat of long, unbranched, not anastomosing hairs. Secondary spines club-shaped. Apical system not much larger than peristome..... *Rhopalocidaris.*
   Primary spines very long, ca. 3—5 h.d. or more, without long hairs, only with short, conical stumps. Secondary spines not club-shaped. Apical system conspicuously larger than peristome... *Psilocidaris.*

Genus **Goniocidaris** Agassiz & Desor.

L. Agassiz & Desor. 1846. Catalogue rais. des Éch. p. 33.
A. Agassiz. 1873. Rev. of Ech. p. 395.
Pomel. 1883. Class. méth. p. 110.
Döderlein. 1887. Jap. Seeigel. I. p. 44.
Duncan. 1889. Revis. gen. Ech. p. 32.
Th. Mortensen. 1903. "Ingolf" Ech. I. p. 29.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97, 102.
H. L. Clark. 1907. The Cidaridæ, p. 195.
Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 52, 54.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 5, 30.

Syn: *Stephanocidaris* A. Agass.

A. Agassiz. 1863. List of Echinod. p. 18.

Subgenus **Discocidaris** Döderlein.

Döderlein. 1885. Ech. v. Japan u. d. Liu-Kiu Ins. p. 10.
Th. Mortensen. 1903. "Ingolf" Ech. p. 29.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97—102.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 5, 32.

Subgenus **Petalocidaris** Mrtsn.

Th. Mortensen. 1903. "Ingolf" Ech. I. p. 25, 28.
A. Agassiz. 1904. Panamic Deep-Sea Ech. p. 22.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 94.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.

[1] In *Goniocidaris tubaria* there is scarcely a true disk on the apical spines, they are usually trumpet-shaped, or at least somewhat crown-shaped. — Whenever these spines do not fit very well with the key, the conspicuous grooves of the test of this large species will never leave any doubt of its place in the genus *Goniocidaris*.

Young specimens of *Goniocidaris* with the apical disks not yet developed will always be more or less difficult to identify, especially to the beginner. On the whole the identification of young Cidarids requires a very intimate knowledge of the whole group. To give sufficient characters in the keys for the identification also of young specimens would hardly be practicable.

Subgenus **Aspidocidaris** Mrtsn.

Th. Mortensen. 1928. New Cidaridæ, p. 67.

Subgenus **Cyrtocidaris.**

Th. Mortensen. 1927. Albatross Cidaridæ. p. 264.

Test usually flattened Ambulacra usually with rather broad interporiferous zone; pores rather close together, not conjugate, separated by a more or less distinctly elevated wall; the median part of the horizontal sutures sunk, so as to form a more or less conspicuous groove both in ambulacra and interambulacra, the grooves often being connected by a deepened furrow along the vertical midline. Primary tubercles perforate, non-crenulate. Apical system usually about half h.d.; madreporite not enlarged; periproct usually rather small, with few plates. Peristome usually distinctly smaller than apical system, with rather few ambulacral plates; flat or conical. Primary spines often expanded at their base into a disk and the apical spines usually expanded into more or less conspicuous disks. The surface of the spines covered with a fine coat of more or less anastomosing hairs, with free, prominent ends; often the hairs are exceedingly long and scarcely or not at all anastomosing at their base (Fig. 50). Collar very short. Secondary spines smooth or thorny, more or less flattened, sometimes rather club-shaped. On the peristome the interradial spines are usually distinctly smaller than those in the ambulacra. Large globiferous pedicellariæ mostly globular; no end tooth, no limb on the stalk. Small globiferous pedicellariæ with a distinct, often very long end tooth; the blade generally compressed, and the opening often narrow and elongate, slit-like. True tridentate pedicellariæ are not found, but the small globiferous often develop into a long slender form, recalling the usual tridentate form, but having the typical opening of a small globiferous pedicellaria, or into a large, coarse form, with the blade filled by a coarse network leaving only a narrow, slit-like, terminal opening, recalling the large tridentate pedicellariæ of *Histocidaris*. Spicules of intestine three-radiate.

Genotype: *Cidarites tubaria* Lamarck.

Even as limited by the above diagnosis, which excludes *Schizocidaris* and *Rhopalocidaris* — forms which are by H. L. Clark (Cat. Rec. Ech. Br. Mus. 1925) referred to *Goniocidaris* or *Discocidaris* — the genus is a very extensive one and comprises species of so very different aspect, that it would appear that they could not be regarded as congeneric. Thus the coarse, thick-spined *tubaria*, the delicate, slender-spined *tenuispina*, the downy-spined *mikado*, the coarsely thorny *biserialis* rather make the impression of deserving to form each the type of a separate genus. However, on comparing all the species and reviewing all their characters, it is seen that they are all connected by intermediate forms so that a satisfactory limitation of such genera is scarcely possible.

The littoral Australian species, *tubaria*, the type of the genus *Goniocidaris*, would appear to stand most apart, characterized by its coarse spines, with no basal disk and the terminal disk of the apical spines little differentiated, and by the usually large grooves on the test. But the

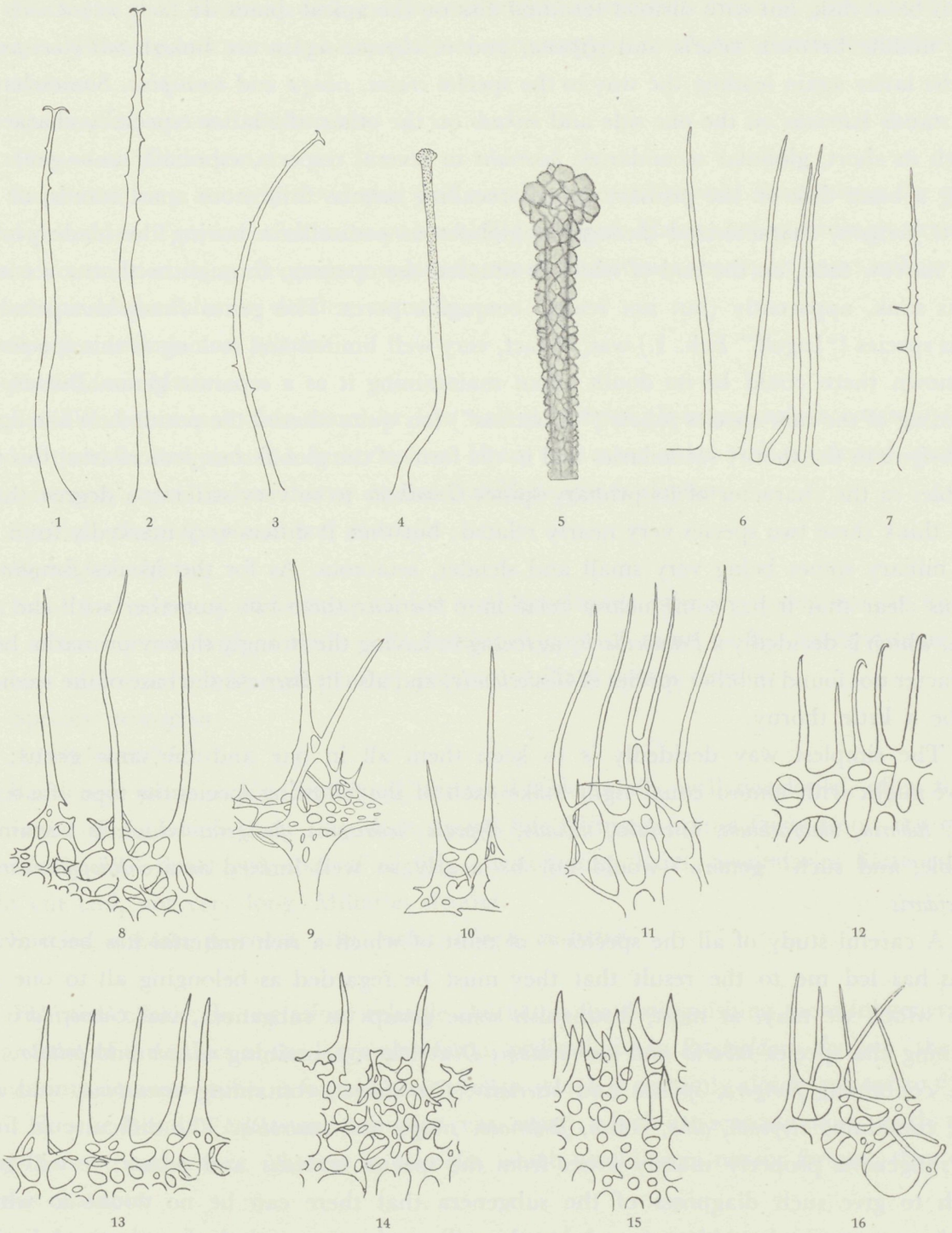


Fig. 50. Hairs from the primary spines of various *Goniocidaris*-species. 1—2. *G. biserialis*; 3. *G. florigera*; 4—5. *G. spinosa*; 6—7. *G. mikado*; 8—10. *G. clypeata*; 11. *G. crassa*; 12. *G. sibogæ*; 13. *G. alba*; 14. *G. australiæ*; 15. *G. tubaria*, var. *impressa*; 16. *G. fimbriata*. 1—4. × 105; 5. × 265; 6—7. × 40; 8—11. × 105; 12—16. × 125.

grooves may be nearly obliterated (var. *impressa*), and *umbraculum* has likewise coarse spines, without basal disk, but with distinct terminal disk on the apical spines. In fact, *umbraculum* stands in the middle between *tubaria* and *clypeata*, and to *clypeata* again are linked *australiæ*, *fimbriata*, *alba*, the latter again leading the way to the species *crassa*, *sibogæ* and *tenuispina*. Somewhat more apart stands *biserialis* on the one side and *mikado* on the other, the latter especially characteristic through its short, globular secondaries, *biserialis* in several respects, especially in — generally — lacking a basal disk on the primary spines, recalling *tubaria*. Still more apart stands, or rather stood *G. florigera*, characterized through its globiferous pedicellariæ having the blade prolonged into a narrow tube, on the end of which is situated the opening, through its thorny secondaries and its sunk, apparently (but not really) conjugate pores. The genus *Petalocidaris* established for this species ("Ingolf" Ech. I.) was, in fact, very well limited and so long as this species alone was known there could be no doubt about maintaining it as a separate genus. But especially the finding of the new species *peltata* ("Albatross") has quite altered the position. While agreeing with *florigera* in the thorny secondaries and in the form of the globiferous pedicellariæ, this species resembles in the character of its primary spines *G. mikado* to so very striking a degree that one would think these two species very nearly related; but then it differs very markedly from *mikado* in its miliary spines being very small and slender, setaceous. As for the species *florigera* itself, it seems clear that it has some nearer relation to *biserialis*, these two (together with the species *spinosa*, which is decidedly a *Petalocidaris*) agreeing in having the strongly thorny primaries banded, a character not found in other species of *Goniocidaris*; and also in *biserialis* the base of the secondaries may be a little thorny.

The simplest way decidedly is to keep them all in one and the same genus; otherwise we might with almost equal right make each of the following species the type of a separate genus: *tubaria*, *umbraculum*, *biserialis*, *mikado*, *clypeata*, *tenuispina*, *florigera*, which is certainly not desirable, and such "genera" would not be nearly so well limited as are *Rhopalocidaris* and *Schizocidaris*.

A careful study of all the species — of most of which a rich material has been available — thus has led me to the result that they must be regarded as belonging all to one genus, within which we may, at most, distinguish some groups as subgenera, viz. *Goniocidaris* s. str., containing the species *tubaria* and *umbraculum*; *Discocidaris*, containing *mikado* and *peltata*; *Petalocidaris*, containing *florigera*, *spinosa* and *biserialis*; *Cyrtocidaris*, containing *tenuispina*, and *Aspidocidaris*, containing *clypeata*, *alba*, *crassa*, *fimbriata*, *sibogæ* and *australiæ*. The difficulty in limiting these subgenera properly mainly arises from the species *biserialis* and *peltata*; it will be easy enough to give such diagnoses of the subgenera that there can be no doubt to which of them the two species should be referred, but this will not do away with the fact that such limitation will be quite arbitrary, the two said species in fact having characters of apparently equal value in common with two different groups. Upon the whole, the value of these subgenera is very problematic. — They may be briefly thus characterized.

Goniocidaris s. str. (Syn. *Stephanocidaris* A. Agass.)[1]

No basal disk; terminal disk usually not much developed; primary spines coarse, or at least coarsely thorny, not curved; hairy coat not very strongly developed. Secondary spines somewhat thickened.

Species: *tubaria* and *umbraculum*.

Discocidaris Döderlein.

Basal disk very strongly developed and usually repeated several times along the shaft of ambital primaries. Terminal disk more or less well developed. Hairy coat exceedingly developed, the hairs not anastomosing. Secondary spines flattened, sometimes thorny at base; miliary spines in the shape of granules or slender, conical.

Species: *mikado* and *peltata*.

Petalocidaris Mrtsn.

Basal and terminal disks more or less well developed. Primary spines coarsely thorny, banded with white and pink or a darker colour. Hairy coat more or less well developed. Secondary spines flattened, more or less thorny at base; miliary spines slender.

Species: *florigera*, *spinosa* and *biserialis*.

Cyrtocidaris Mrtsn.

Basal and terminal disks more or less well developed; primary spines usually long and slender, often curved, with a fairly well developed coat of more or less anastomosing hairs. Secondary spines very long and slender, pointed; miliary spines slender.

Species: *tenuispina*.

Aspidocidaris Mrtsn.

Basal disk more or less developed; terminal disk usually well developed, often forming large, round disks, which cover the whole apical side. Primary spines fairly stout, not curved, with a fairly well developed coat of slightly anastomosing hairs. Secondaries flattened, with straight cut end, not very long. Miliaries slender.

Species: *clypeata*, *fimbriata*, *alba*, *crassa*, *sibogæ*, *australiæ*.

The pedicellariæ do not afford reliable characters for distinguishing these subgenera. The peculiar form of the valves of the large globiferous pedicellariæ in *Petalocidaris florigera* (the blade produced into a narrow tube) is found also in *spinosa*, which is certainly closely related to *florigera*; but it is likewise found in *peltata* and *tenuispina* (var. *major*), which are scarcely more nearly related to *florigera*, or to each other, whereas in *biserialis*, which would seem nearer *florigera*, they do not show this character.

[1] If we want a separate name for this group it must be *Stephanocidaris* A. Agass., which was established for "*Cidaris tubaria*" Lamarck. In view of the fact that this name has been a cause of endless trouble to Echinologists it would seem preferable to drop it entirely, and it does not seem necessary either to have a separate subgenus-name for this group, the *Goniocidaris* proper.

The pores do not either offer characters of value for distinguishing the said subgenera. It is maintained by Lambert & Thiéry (Ess. nom. rais. p. 153) that *Petalocidaris* is to be regarded as a good genus, because it has conjugate pores, the authors having been informed by Bell that the type-specimen had the pores conjugate. This is, however, not really the case. The pores of *G. florigera* are unusually deeply sunk, and therefore on a superficial examination look as if they were conjugate; but the pores are close together, separated by a narrow, elevated wall, as in other Goniocidarids (Pl. LXIX. 10); the difference in this regard between *florigera* and *spinosa—biserialis* on one hand and *peltata* on the other is so gradual that it is absolutely out of question to see a valuable generic character in the sunk condition of the pores of *florigera*, and, in spite of Lambert & Thiéry, I am forced to give up my genus *Petalocidaris* as indistinguishable from *Goniocidaris*, and I thus agree with Döderlein and H. L. Clark[1] that the genus cannot be maintained — as stated already in Part II (p. 15) of my "Ingolf"-Ech.

The genus *Goniocidaris* is hitherto known only from the Japanese, the Malayan and the Australian-New Zealand Seas, the Malayan Sea apparently being its centre of distribution[2]. The rather numerous species may be thus distinguished.

Key to the species of Goniocidaris.

1. No basal disk on primary spines; secondary spines rather thick, more or less clavate (*Goniocidaris* s. str.) ..... 2.
   Basal disk on primaries more or less well developed; secondaries flattened or long and slender ..... 3.
2. Primary spines usually rather thick and coarse, more or less thorny, sometimes very strongly so, but the thorns disposed quite irregularly. Apical spines rather trumpet-shaped, the terminal disk not very specialized. Secondary spines chisel-like excavate at the end, especially those near the peristome. Grooves of test usually large and distinct; a continuous broad, naked, sunken median line in both ambulacra and interambulacra or (in the var. *impressa*) isolated grooves in a ladder-like arrangement ..... *tubaria*.

[1] A. Agassiz, who apparently also rejects the genus *Petalocidaris* (Panamic Deep-Sea Ech. p. 22. 1904) gives as his reasons against it that my figures appear to him not at all to show the characters upon which I originally based the genus. However, the figures which Agassiz quotes are not those of *Petalocidaris florigera*, but those of *Tretocidaris*. It is thus well imaginable that he did not find them to show the characters of *Petalocidaris*, but his objections, of course, are thereby quite irrelevant. The figures of the pedicellariæ of *Petalocidaris florigera* given in the Ingolf Ech. I. show the characters supposed to be peculiar to that genus well enough. That they were not really sufficient for basing a separate genus thereupon could scarcely be realized at that time; in fact, it is only now through the finding of the same type of pedicellariæ in *Goniocidaris peltata* and *tenuispina*, var. *major* that this character has been shown to be not of generic value.

[2] It seems rather probable that at least one more species of *Goniocidaris* exists, viz. in the South African Seas. From the South African Museum a Cidarid has been sent me, which, although in a very poor condition — a naked test, broken to pieces, and accompanied by a single primary spine stated to belong to it —, can be said rather definitely to be a *Goniocidaris*. The spine greatly resembles those of *Goniocidaris fimbriata*. As otherwise no *Goniocidaris* is known to exist outside the Japanese, Moluccan and Australian-New Zealand Seas it would be of very great zoogeographical interest to find a species in the South African Seas. The locality of the specimen in question is given as: Cape St. Blaize N × E ½ E. 68 miles, 105 fathoms; sand, shells or rock bottom (Agulhas Bank). "Piet Faure" collection.

Primary spines short, but rather coarse, with only a pair of lateral thorns at the base. Terminal disk of apical spines usually well developed, forming a round disk. Secondary spines rather thick, somewhat clavate, not chisel-like excavate at the end. A fairly broad, naked, sunk, median line in both ambulacra and interambulacra, the grooves of the interambulacra fairly conspicuous ..... *umbraculum.*

3. Primary spines banded with white and pink or a darker colour, usually very coarsely thorny (*Petalocidaris*) ..... 4.
   Primary spines of uniform whitish colour ..... 6.
4. Primary spines banded with white and pink; secondaries rather strongly thorny in most of their length; pores rather deeply sunk ..... *florigera.*
   Primary spines banded with white and a darker colour; secondaries more or less thorny only at their base; pores not distinctly sunk ..... 5.
5. Secondaries distinctly excavate, distinctly thorny at the base ..... *spinosa.*
   Secondaries not excavate, generally smooth, more rarely thorny at the base ..... *biserialis.*
6. Basal disk strongly developed, usually repeated several times in lower part of spine; hairy coat of primaries very strongly developed, hairs not anastomosing (*Discocidaris*) ..... 7.
   Basal disk more or less strongly developed, usually not repeated; hairy coat of primaries generally less developed, hairs more or less anastomosing ..... 8.
7. Miliary spines in the shape of rather thick, rounded grains ..... *mikado.*
   Miliary spines very small, slender ..... *peltata.*
8. Secondary spines flattened, with straight cut end (*Aspidocidaris*) ..... 9.
   Secondary spines long and slender, pointed (*Cyrtocidaris*) ..... *tenuispina.*
9. A fairly conspicuous naked vertical midline in the interambulacral areas; upper side of the test sometimes of greenish colour ..... 10.
   Only a very narrow and indistinct naked vertical midline in the interambulacral areas; test white ..... 12.
10. Apical disks of the outer circle distinctly eccentric, the outer side being the larger. Colour of test usually not greenish ..... *clypeata.*
    Apical disks of the outer circle not distinctly eccentric, or if so, the adapical side the larger .... 11.
11. Primary spines slender, nearly cylindrical. Test usually distinctly greenish on the upper side ..... *australiæ.*
    Primary spines stout, rather distinctly fusiform. No greenish tint on upper surface of test ... *fimbriata.*
12. Primary spines slender, cylindrical ..... *sibogæ.*
    Primary spines rather stout, tapering ..... 13.
13. Median area of interambulacra broader than half a corresponding areole, very closely and finely tuberculate. Upper areoles rather distant from each other, the adjoining scrobicular circles being separated by numerous miliary tubercles ..... *alba.*
    Median interambulacral area not broader than half an areole, less finely and closely tuberculate; upper areoles not distant, the adjoining scrobicular circles at most separated by a very few miliary tubercles ..... *crassa.*

Goniocidaris tubaria (Lamarck).

Pls. XII. 1—7; XIII. 10—11; LXIX. 4; LXXVIII. 1—6.

Cidarites tubaria. Lamarck. 1816. Hist. nat. an. s. vert. III p. 57. II Ed. 1840, p. 382.
?Cidarites geranioides. Lamarck. Ibidem, p. 56. II Ed. p. 380.
Goniocidaris geranioides. A. Agassiz & Desor. 1846. Cat. Rais. Ech. p. 33. Pl. **15. 1, 1. a.**
Goniocidaris Quoyi A. Agassiz & Desor. Ibidem, p. 33.
Cidaris spinulosa. Gray. 1855. Arr. Fam. Echinida. P. Z. S. p. 38 (teste A. Agassiz).
Goniocidaris geranioides. Desor. 1855. Synopsis Ech. foss. p. 48. Pl. I. 4, 4.a (copy of figure in Ag. & Desor. Cat. Rais.)
?Cidaris tubaria. Dujardin & Hupé. 1862. Hist. nat. Zooph. Ech. p. 471.
Goniocidaris geranioides. Dujardin & Hupé. Ibidem, p. 486 Pl. IX. 5 (copy of fig. in "Cat. Rais").
Stephanocidaris tubaria. A. Agassiz. 1863. List of Ech. p. 18.
Goniocidaris geranioides. A. Agassiz. Ibidem, p. 18.
Goniocidaris tubaria. Lütken. 1864. Bidr. Kundsk. Ech. p. 137.
Goniocidaris geranioides. Stewart. 1866. On the Spicula of Reg. Echinoidea. p. 367, Pl. XLVIII. 13—16.
Goniocidaris geranioides. Perrier. 1869. Rech. s. l. pédicell. p. 132. Pl. 3. 12.
Goniocidaris geranioides. A. Agassiz. 1872. Rev. of Ech. p. 131, 396. Pl. 1. c. 15—17; **I. g. 3, 4**; XXIV. 12, 13; XXXV. 5.
Goniocidaris tubaria A. Agassiz. Ibidem, p. 131, 397, Pl. I. e. 32—36; I. c. 9—14.
Goniocidaris geranioides. Tenison Woods. 1878. Ech. of Australia. Pr. Linn. Soc. N.S.W. II. p. 152.
Goniocidaris tubaria. Tenison Woods. Ibidem, p. 152.
Goniocidaris geranioides. H. W. Mackintosh. 1878. Acanthology of Desmosticha. I. p. 480. Pl. IX. 9.
Goniocidaris tubaria. A. Agassiz. 1881. „Challenger" Ech. p. 49. Pl. **XL. 1—25.**
Goniocidaris tubaria. Tenison Woods. 1881. On the habits of some Austral. Echini. Pr. Linn. Soc. N.S.W. V. p. 194.
Goniocidaris tubaria. McCoy. 1885. Prodr. Zool. Victoria. Dec. X. p. 33, Pl. **100.**
Goniocidaris tubaria. Ramsay. 1885. Cat. Ech. Austral. Mus. p. 44. II. Ed. 1891. p. 4, 46.
Goniocidaris geranioides. Ramsay. Ibidem.
Goniocidaris tubaria. Döderlein. 1887. Jap. Seeigel. I. p. 27. Taf. IX. 9. a—e.
Goniocidaris tubaria. Whitelegge. 1889. Mar. Invertebr. Fauna. Port Jackson. p. 41.
Goniocidaris tubaria. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 24, 29. Pl. X. 20. II. p. 15.
Goniocidaris geranioides. Th. Mortensen. Ibidem. I. p. 23, 24, 29.
Goniocidaris tubaria. T. S. Hall. 1904. Notes on some Victorian Echinoids. Victorian Naturalist. XXI. p. 70.
Goniocidaris tubaria. Döderlein. 1906. Ech. Deutsche Tiefsee Exped. p. 97—102.
Goniocidaris geranioides. Döderlein. Ibidem. p. 102.
Goniocidaris geranioides. H. L. Clark. 1907. The Cidaridæ. p. 197, 198.
Goniocidaris tubaria. H. L. Clark. Ibidem. p. 197, 198. Pl. **X.** p. 5. Pl. **XI.**
Goniocidaris tubaria. H. L. Clark. 1909. "Thetis" Ech. p. 553.
Goniocidaris tubaria. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 52, 54.
Goniocidaris geranioides. Th. Mortensen. Ibidem.
Goniocidaris geranioides. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Goniocidaris tubaria. Lambert & Thiéry. Ibidem.
Goniocidaris tubaria. Jackson. 1912. Phylogeny of Echini, p. 100, 101.
Goniocidaris tubaria. H. L. Clark. 1914. Ech. W. Austral. Mus. p. 162.
Goniocidaris tubaria. Döderlein. 1914. Echinoidea. Fauna Südwest Austr. p. 453.
Goniocidaris tubaria. H. L. Clark. 1916. "Endeavour" Ech. p. 103.
Goniocidaris geranioides. H. L. Clark. Ibidem. p. 102.
Goniocidaris tubaria. Th. Mortensen. 1918. Ech. N.W.Austral. (Mjöberg), p. 9, Pl. **VI. 1—2,**
Goniocidaris geranioides. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. M., p. 31.
Goniocidaris geranioides, var. *tubaria.* H. L. Clark. Ibidem. p. 31.
Goniocidaris impressa. Koehler. 1926. Echinod. Echinoidea. Austral. Antarctic Exped. p. 24. Pl. **91. 1—8; 92. 1—2, 4—5, 8—10, 12—14; 119. 1.** (Non: Pl. 92. 3, 11. = *Goniocidaris australiæ* Mrtsn).
Goniocidaris geranioides. Koehler. Ibidem. Pl. 92. 6—7 (= the typical *tubaria*).

Goniocidaris tubaria. Jackson. 1927. Studies of Arbacia punctulata and allies, and of non-pentamerous Echini. Mem. Boston Soc. Nat. Hist. VIII. p. 507—9. Figs. 48—49.

Goniocidaris geranioides, var. *tubaria.* H. L. Clark. 1928. Sea-Lilies, Sea-Stars, Brittle Stars and Sea-Urchins of the S. Australian Museum. Rec. S. Austr. Mus. III. p. 455.

NON: *Cidaris tubaria.* Agassiz & Desor. 1846. Cat. Rais. Ech. p. 23 (= *Prionocidaris baculosa*).

Cidaris tubaria. Hutton. 1872. Cat. Echinod. New Zealand, p. 10 (= *Goniocidaris umbraculum*).

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Width of I. A.	Width of A.	Longest spines
58 mm	42 mm	c. 20 mm (c. 34 % h.d.)	19 mm (32.8 % h.d.)	12	10—11			30 mm
57 —	39 —	18 — (31.6 —)	17 — (30 —)	12 (13)	10—11			35 —
56 —	35 —	18 — (32.1 —)	c. 18 — (32.1 —)	11	11			27 —
50 —	28 —	18 — (36 —)	17 — (34 —)	11	11			
44 —	30 —	15 — (34 —)	15 — (34 —)	10	10—11			
42 —	27 —	15 — 35.7 —)	14.5 — (34.5 —)	10	10—12	20 mm	6 mm	
41 —	37—33 —	17—14 — (41.5—34 —)	15.5 — (38 —)	12—13	10—11	19 —	6 —	
41 —	29 —	16.5 — (40 —)	15 — (36.6 —)	10	10—11	19 —	6 —	
39 —	22 —	16 — (41 —)	c. 15 — (38.5 —)	9	10—12	19 —	4 —	28 —
37 —	21 —	14.5 — (39.1 —)	14 — (38 —)	8	10—12	18 —	5.5 —	29 —
36 —	20 —	14 — (39 —)	c. 13 — (36 —)	7	10—12	18 —	5 —	37 —
33 —	17 —	14 — (42.4 —)	15 — (45.4 —)	7 (8)	11—12	15 —	5 —	
27 —	15 —	12 — (44.4 —)	c. 10.5 — (39 —)	7	12	c. 13 —	c. 3 —	34 —
23 —	11 —	11 — (48 —)	9 — (39 —)	6—7	10—11	11 —	4 —	
20 —	11 —	10 — (50 —)	8 — (40 —)	7	10—11	9.5 —	3 —	
14 —	7 —	7.5 — (53.6 —)	7 — (50 —)	5—6	6—7			18 —
13 —	6.5 —	7 — (53.8 —)	6 — (46 —)	6—7	6—7			15 —
7 —	3.5 —	4 — (57 —)	3.5 — (50 —)	6	4—5			8 —
6 —	3 —	3 — (50 —)	3 — (50 —)	5 (6)	4			6 —

The five largest specimens are in the British Museum; they are all of the short-spined form like Pl. XII. 1—2.

Test as a rule rather low, flattened above and below. There is, however, a considerable variation in this regard; generally the height is a little more than half h. d., but it may be less than half h. d. or, on the other hand, nearly as much as h. d. (cf. Pl. XII. 3—7). The sides are generally beautifully arched, but in the higher specimens they tend to be more vertical. Circumference mostly regularly round, but it may sometimes be subpentagonal.

Ambulacra (Pl. LXIX. 4) only slightly sinuate. Interporiferous zone about twice the width of a pore zone. The marginal series of tubercles very regular, the tubercles being contiguous, but small and low. Inside the marginal series there are generally some few, ca. 3—5 small tubercles, placed close together so as to cover the part of the plate nearest the marginal tubercle, no serial arrangement being discernible. The median part of the plate is naked and sunk, forming thus a very conspicuous sunk median part of the ambulacra, the horizontal sutures being more deeply sunk, forming grooves separating the plates. Sometimes the tubercles continue more or less inwards over the median part of the plate; in such cases the horizontal grooves give more the impression of a ladder-like arrangement; this is carried to the extreme in the variety *impressa*. Pore zones

not sunk; the pores are rather small, of equal or subequal size. The wall between the pores narrow, slightly elevated, the ridge rather sharp.

Interambulacra. Coronal plates rather numerous, generally 8—10 in larger specimens, but there may be even as many as 13. The areoles are on the whole small, not much deepened, the ambital and subambital ones more or less distinctly transverse-oval; they are well separated, at most the 2—3 proximal ones being confluent. The tubercle and mamelon rather small; no trace of crenulation. The scrobicular tubercles fairly conspicuous; outside, alternating with them, some smaller tubercles are found, one or two series, and then the rest of the plate is closely covered with quite small tubercles, leaving as a rule a conspicuous naked and sunk median part, continuing as a deep groove outwards along each horizontal suture. Also on the adradial part of the plate the horizontal sutures are deepened, there being thus a series of small grooves along the adradial suture. More rarely (var. *impressa*) the tubercles cover the whole plate so as to leave only a groove at the median end of each horizontal suture. In such cases the tubercles may show a rather distinct arrangement in transverse series ("Rev. of Ech." Pl. I g. Fig. 4). The whole median part of the interambulacra as broad as or distinctly broader than an areole. In the specimen of 57 mm h. d. (S. Australia) the inner and outer grooves on the upper side widen so much as to become continuous, the whole horizontal suture being broadly deepened. In this specimen the median interambulacral area is twice as broad as an areole.

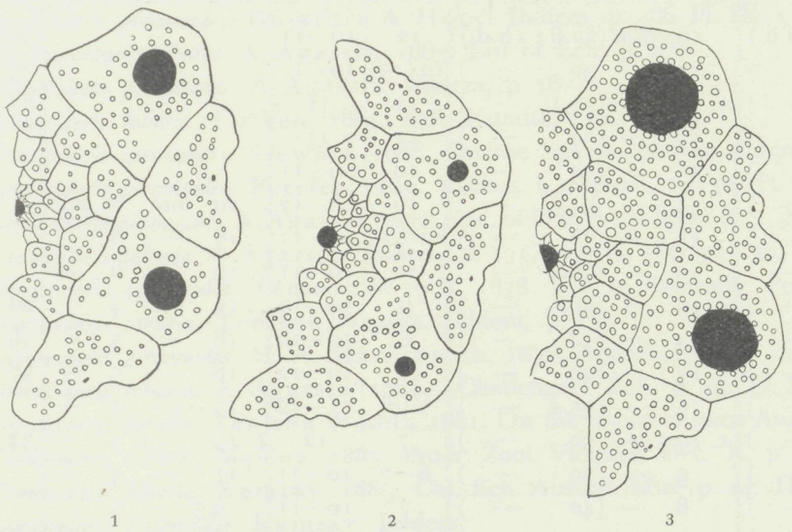


Fig. 51. Part of apical system of *Goniocidaris tubaria*, ♀ (1) and ♂ (2), and of *G. tubaria*, var. *impressa* ♀ (3). × 4. 5.

Apical system (Fig. 51. 1—2) varying from ca. 35—50 % h. d. The ocular plates may be all insert, or partly exsert; in the specimen of 20 mm h. d. they are even all exsert. It appears that the condition of all being insert is the more common, as was also found by Jackson (Op. cit.)[1]. The oculars are, on the whole, broad and low, the genitals high and narrow, the madreporite scarcely larger than the other genitals. The periproct comparatively small, periproctal plates rather few. Small tubercles of rather uniform sizes, leaving a conspicuous bare inner edge,

[1] Jackson has examined 17 specimens, 41 % of which had all oculars insert, 12 % all exsert, while 35 % had oculars II and III exsert. It may perhaps be pardonable to feel rather sceptical with regard to these percentage values, based on so scarce material. What a change in these values might have been caused by only one specimen more. And 41 % of 17 — does it not sound a little comical?

mainly on the genital plates, or (var. *impressa*) covering the plates completely (Rev. of Ech. Pl. I. g. Fig. 3). The female genital pores fairly large, more or less close to the edge; the male pores, which are rather unusually large, usually nearer the middle of the plates[1].

Peristome as a rule somewhat smaller than the apical system, ca. 35—45 % h. d., quite exceptionally I have found it larger than the apical system (specimen 33 mm h. d.). The ambulacra do not quite join, leaving thus a free, though narrow passage for the interradials unto the mouth edge. There are 12—13 ambulacral plates in a series in the larger specimens, in the specimen of 20 mm h. d. only 6—7. The interradials generally in an irregular double series.

Primary spines exceedingly variable in form, from nearly smooth, cylindrical, with a very slight flaring at tip, to such as are very coarsely thorny, the point having the shape of a large crown; they may be distinctly fusiform. Sometimes the upper ones are quite trumpet-shaped. (Cf. figures given in the "Rev. of Ech.", "Challenger" Ech., Clark's "Cidaridæ" and Pls. XII. 1—2; XIII. 10—11 of the present work). In the distal part of the shaft the thorns, or serrations, may unite into low, but sharp, smooth ridges, recalling *Acanthocidaris*. The length of the primaries varies from ca. $^2/_3$ h. d. or even less, to ca. 1.3 h. d., the more thorny forms being on the whole the shorter. They may be conspicuously flattened in the outer part, the point being often obliquely worn, apparently as a consequence of the animal walking on these spines, as seen on the beautiful figure given by McCoy (Op. cit.). Surface of shaft of fresh, but fully formed spines covered with a thick spongy layer of anastomosing hairs, each ending in a rather long, curved point, generally distalwards directed. Fresh, well cleaned spines (at least in the var. *impressa*), may have a beautiful silvery lustre due to these hairs. Collar short, ca. 1.5—2.5 mm long, slightly widening towards the very inconspicuous milled ring. The oral primaries more or less widened and flattened, the point more or less fluted, or crown-shaped. They may be rather stout or exceedingly slender (Pls. XII. 1; XIII. 10—11), but all transitional forms occur. The third and fourth form the transition to the ambital spines.

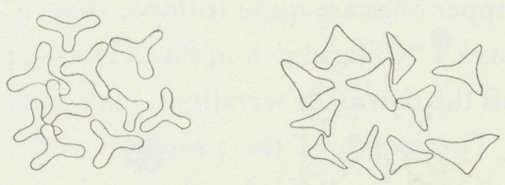
Secondary spines. The scrobicular spines (Pl. LXXVIII. 2) ca. 4 mm long, not very tightly appressed; they are a little flattened, slightly widening towards the point, which is chisel-like excavate; the ambulacral spines more slender, but likewise with a small excavation at the point, particularly towards the peristome. The miliary spines very slender, slightly club-shaped, especially those on the apical system. No glandular swelling ("ampulla") of the skin at the base of the small spines. On the apical system the spines form a tuft around the genital openings and the anal opening.

Pedicellariæ. The large globiferous pedicellariæ (Pl. LXXVIII. 5—6) are remarkably globular, with a short stalk without a limb. They are mainly found along the naked median line and the horizontal grooves in the interambulacra, the head lying down in the groove, thus recalling to some degree the sphæridia of other Echinoids; they were, indeed, also mistaken as such by Pomel

[1] Döderlein's statement (Jap. Seeigel, p. 27) that the female pores are in the middle of the plate, the male pores somewhat outside the middle, would seem to be due to a slip of the pen.

(Classif. méth. p. 110). Also in the ambulacra and on the apical system they may occur. The valves are very broad (Cf. "Ingolf" Ech. Pl. X. 20). The small globiferous pedicellariæ are sometimes exceedingly richly developed, from quite small to very large forms, head up to 1.5 mm long, having the appearance of tridentate pedicellariæ, but, as seen on the distinct terminal opening and the end tooth, still of the small globiferous type (Pl. LXXVIII. 1 and 3—4). True tridentate pedicellariæ not observed. — Spicules of tubefeet of the usual type. In the intestine (also in the aboral part) the spicules are triradiate (Fig. 52. 1). (Cf. Stewart. Op. cit.). The characteristic glassy disks so numerous e. g. in *Prionocidaris* and *Stylocidaris*, are not found here.

Colour of secondary spines brownish; the primaries, when clean, whitish, with the thorns brown. Sometimes however, they are darker violet or even nearly black (especially in the var. *impressa*); the skin on the naked parts of the test dark brownish. The denuded test whitish with the naked, sunk median lines more or less purplish, especially the ambulacral midline conspicuous through its darker colour; sometimes, however, the denuded test is white with a faint greenish tint (perhaps mainly in specimens from deeper water; var. *impressa*). — Regarding the variety *impressa* (*geranioides*) see below.



1 2

Fig. 52. Spicules from the intestinal wall of *Goniocidaris tubaria* (1) and *G. umbraculum* (2). × 125.

Occurrence. Appears to be distributed all round Australia except, probably, the North Coast; further at Tasmania; it occurs from the littoral region down to ca.150 m. Statements in older literature of its occurrence in "East India" or Malacca are, evidently, erroneous, resting on unreliable labelling or misidentification (e. g. the "*Cidaris tubaria*" from Malacca in Agassiz & Desor's Catalogue Raisonné, p. 23; this specimen is *Prionocidaris baculosa* (examined by the author in the Paris Museum, 1902). The variety *impressa* appears to be more common in the Tasmanian Seas, but it occurs also in the Bass Strait, while it is not known with certainty from the N. S. Wales coast or from West Australia.

The biology of this species is little known. Tenison Woods mentions that it is occasionally washed up on the beach after storms and that it is often covered with "Bryozoa". It would appear as if it loved sandy situations, and from the fact that the specimens come ashore singly we may suppose that it is not gregarious (Op. cit. p. 194). I have myself dredged several specimens in Port Western, Victoria, on grass-bottom — where they appeared to be rather gregarious — and Ramsay records having got specimens from a rocky bottom; thus it would seem not to prefer any special kind of bottom. The specimens that I dredged all had the spines much overgrown especially by Hydroids, sponges and incrusting algæ. The contents of the intestine I have found to be mainly Bryozoa and Algæ, but also rather coarse bottom material, with Foraminifera.

The development is unknown, but the fact that the eggs are large (ca. 0.5 mm) and full of yolk indicates that it has probably not a typical pelagic larva. The genital pores have appeared at a size of about 14—15 mm h. d. The largest size recorded is 60 mm h. d. (Jackson.

Op. cit. 1927); it thus appears that this species does not grow to any very large size; still, it is by far the largest of all Goniocidarids, the second in size, *Goniocidaris biserialis*, not reaching more than ca. 35 mm h. d. Distinct growth lines are sometimes seen in the naked, sunk median part of the interambulacra.

Abnormalities apparently are not very rare. The exceptionally high specimen (No. 2 in the measurements, Pl. XII. 7) has the two genitals 4 and 5 coalesced, this side of the test being also noteworthily higher than the opposite side. H. L. Clark (Cat. Rec. Sea-Urch. Br. M.) records a specimen with genitals 2 and 3 fused together to form the madreporite. In the specimen figured by Clark in his "Cidaridæ" (Pl. XI. 1), one of the genitals, apparently gen. 3, has two pores. Finally it would appear to rest on an abnormality, when McCoy describes and figures this species as having double ocular pores. In one specimen I have observed some double, coalesced ambulacral plates. A four-rayed specimen is described by Jackson (Op. cit. 1927).

No Parasites have been recorded from this species.

Remarks. The question whether this form contains two separate species, *tubaria* and *geranioides*, or it is all only one very variable species has been much discussed. Already Lütken (Op. cit.) points out that the *Goniocidaris geranioides* as described and figured in Agassiz & Desor's "Catalogue Raisonné" is indistinguishable from Lamarck's *Cidarites tubaria*, and that it should then be named *Goniocidaris tubaria* (Lamarck), the species *geranioides* of Lamarck being not with certainty recognizable as a *Goniocidaris*. In the "Revision of Echini" A. Agassiz maintains the two species as quite distinct, easily distinguished by the structure of the primary spines and also "the differences in the size of the genital plates and abactinal system giving excellent characters" by which to distinguish them. From the description he gives there of the two species it appears that the differences are not found in the size of the genital plates and the abactinal system as said in the quoted sentence, but in the size of the genital pores, these being in *geranioides* large, placed near the edge of the plates, in *tubaria* small, placed near the centre of the genital plates. Further in *geranioides* the plates are completely covered by small tubercles, in *tubaria* the tubercles are confined to the middle of the plate, leaving a broad, bare margin. Also in the test a conspicuous difference is found; *geranioides* has the plates nearly completely covered with small tubercles, only the horizontal sutures being bare, terminating in a deep pit at the median angle, while in *tubaria* there is a continuous broad, bare, sunk median area, also the vertical sutures being naked and sunk as are the horizontal sutures. Excellent figures are given of *geranioides*, but unfortunately not of *tubaria*, which fact, together with the misleading statement of the specific differences and the uneven, not easily comparable descriptions, to some degree accounts for the trouble which these forms have caused naturalists. — In the "Challenger" Ech. (p. 49) Agassiz has come to the result that the primary spines cannot be relied upon for a distinction of the species; he even goes so far there as to maintain "the utter impossibility of distinguishing the species of this family by any differences in the shape of the primary radioles".

McCoy suggests that *geranioides*, with the large genital openings may be the female,

tubaria, with the small genital openings, the male of one and the same species, and Hall (Op. cit.) thinks that the discrepancies between the two species "are due to a forced attempt at species-making, and not to constant differences in the objects themselves". In his "Cidaridæ" H. L. Clark finds the differences between the two species very constant, but in his "Catalogue of Recent Sea-Urchins in the British Museum" (p. 31) he comes to the result, after examining nearly five hundred specimens of the two forms, that they intergrade completely, and accordingly he now regards all as one species, *G. geranioides*, the form *tubaria* with the broad, naked, vertical suture and the bare margin of the apical plates being maintained only as a variety. It would appear that Clark is right in his result that the two forms cannot be regarded as distinct species; the existence of transitional forms makes it impossible to draw a sharp limit between the otherwise so well characterized extremes. As regards the names, however, I cannot agree with Clark. As pointed out by Lütken it is, indeed, very questionable whether Lamarck's *Cidarites geranioides* was a true *Goniocidaris* at all. Lamarck identifies this species with Seba's "*Echinometra singularissima*" (the figure from Seba reproduced in the Encyclopédie méthodique Pl. 136. 1), and says "les stries longitudinales de ses grandes épines sont lisses". This statement is in good accordance with the figure, but very hard to reconcile with the Australian *Goniocidaris*. Further it is hardly conceivable that Lamarck should have overlooked the grooves on the test which he describes for *C. tubaria*. — Therefore, as it is rather doubtful which species Lamarck's *C. geranioides* really represents, while there is not the slightest doubt about his *C. tubaria*, it seems to me the only correct thing to designate *tubaria* as the main type of the species, which is then to be named *Goniocidaris tubaria* (Lamk.) and to regard the form with the many tubercles and the naked sunk median area reduced to horizontal grooves as a variety. This is also in agreement with the fact that the type with the broad, naked and sunk median line is the more original, while that with the naked median line reduced to small angular pits, evidently, is the more specialised form.

As name of this variety *geranioides* ought not to come into consideration, since, as a matter of fact, we have no idea which species was really meant with that name, and the type is no longer in existence[1]. Therefore, it is evidently a much better course to drop the name *geranioides* entirely, and we must then adopt for the variety the name *impressa* Koehler. Under this name Koehler describes in his report on the Echinoidea of the Australian Antarctic Expedition a *Goniocidaris* from Maria Island, Tasmania, which he thinks to be a new species, but which is, as a matter

[1] It is hard to explain how L. Agassiz & Desor in their "Catalogue Raisonné" came to identify the specimen figured by them as *Goniocidaris geranioides* with Lamarck's *C. geranioides*, and thus also with Seba's "*Echinometra singularissima*" (Encycl. méth. Pl. 136, 1), which does not resemble the Australian species at all. To assume with Lütken (Op. cit.) that this species might "on a less fortunate representation" get an appearance like the said figure seems to me a perfect injustice towards Seba's artist, whose figures, though not fulfilling the requirements of modern echinological science, are certainly not so bad as to justify Lütken's assumption. The fact that Agassiz & Desor mistook a *Prionocidaris baculosa* for Lamarck's *C. tubaria* (cf. above p. 160), an identification no less difficult to understand, rather leads to the suggestion that some slip of the pen has caused the two authors to interchange the two names.

of fact, nothing but the bespoken variety of *tubaria*, as the very careful description and the excellent figures given by Koehler prove beyond doubt. (I have also myself had the opportunity of examining a couple of Koehler's specimens).

Var. **impressa** Koehler.

Pl. XII. 8—9; LXIX. 5—6.

Goniocidaris impressa. Koehler. 1926. Echinod. Echinoidea. Austral. Antarct. Exp. p. 24. Pl. **91. 1—8; 92. 1—2, 4—5, 8—10, 12—14; 119. 1** (Non Pl. 92. 3, 11 = *Goniocidaris australiæ* Mrtsn).

The variety *impressa* Koehler (= *geranioides* auct., non Lamarck) is, to resume the matter, distinguished from the typical *tubaria* by its more extensive tuberculation which leaves scarcely more than the admedian part of the horizontal sutures bare, in both ambulacral and interambulacral areas; there is thus no continuous sunk median line, but only isolated grooves, in a more or less conspicuous ladder-like arrangement (Pl. LXIX. 5—6). In the apical system the genital and ocular plates are more completely covered with tubercles of uniform size. — The colour is stated by Koehler to be gray or rosy-grayish; often a purple median line in the ambulacra, and the limits between the apical plates likewise purple; the grooves of the interambulacra redbrown. Spines gray, rosy-gray or rosy.

It may be pointed out that evidently not all the figures given by Koehler refer to this variety (or species). Pl. 92, Figs. 3 and 11 represent the species *Goniocidaris australiæ* Mrtsn., also otherwise known from the Tasmanian Sea (cf. p. 203). I have had the opportunity of examining also a specimen of this form, and can, therefore, give this statement without reservation.

Regarding the suggestion of McCoy that *geranioides* (viz. *impressa*) might only be the female, *tubaria* the male of one of the same species, it may not be superfluous to point out that specimens with large pores are found as well among the typical *tubaria* as in the var. *impressa*. On the other hand it would appear, from the material available to me, that the female genital pores are somewhat larger in the var. *impressa* than in the typical *tubaria* (Figs. 51. 1, 3). This might perhaps indicate a difference in the mode of development which might again speak for the specific validity of *impressa* (= *geranioides* auct.) — but this is merely a suggestion for future investigations. In case it is found that they differ in regard to their development, we shall, of course, have to regard them as two separate species, in spite of the existence of — what appears to us — transitional forms. The possibility of such forms being hybrids between *tubaria* and *impressa* must then also be taken into consideration.

Goniocidaris umbraculum Hutton.

Pls. XII. 10—12; LXIX. 15; LXXIX. 1.

Cidaris tubaria. Hutton. 1872. Catalogue Echinod. New Zealand, p. 10.

Goniocidaris umbraculum. Hutton. 1878. Notes on some New Zealand Echinoderms, with descr. of new species. Trans. N. Z. Inst. XI. p. 306.

Goniocidaris umbraculum. Farquhar. 1898. Echinoderm Fauna of New Zealand. Pr. Linn. Soc. N.S.W. XXIII. p. 316.

Goniocidaris umbraculum. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 24, Pl. X. 13, 21.

Goniocidaris umbraculum. H. L. Clark. 1907. The Cidaridæ, p. 198, Pl. X. 3—4.

Goniocidaris umbraculum. W. B. Benham. 1909. Sci. Res. N. Z. G. Trawling Exped., 1907. Echinoderma. Rec. Canterbury Mus. I. p. 105.

Goniocidaris umbraculum. H. L. Clark. 1916. "Endeavour" Echinod. p. 104.

Goniocidaris umbraculum. Th. Mortensen. 1921. Echinod. New Zealand and the Auckland-Campbell Isl. I. Echinoidea. Vid. Medd. Bd. 73. p. 145. Pl. **VI. 1—2**; Ibid. Bd. 79, 1925, p. 390.

Goniocidaris umbraculum. Maxwell Young. 1924. Occurrence of the Echinoderm Goniocidaris umbraculum Hutton. N. Z. Journ. Sci. & Technology. VII. 3. p. 189.

Goniocidaris umbraculum. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 32.

Goniocidaris umbraculum. Th. Mortensen. 1926. Goniocidaris umbraculum, a brood-protecting species. N. Z. Journ. Sci. & Technol. VIII. p. 192.

Goniocidaris umbraculum. Th. Mortensen. 1927. On the postlarval development of some Cidarids. Mém. Acad. Sc. Copenhague. 8. Sér. XI. p. 383—384; figs. 15—16.

h. d.	v. d.	Apical system	Peristome	Number of		Width of		Longest spines
				I. A.	A. pro I. A.	I. A.	A.	
♂ 26 mm	15.5 mm[1]	10.5 mm (40.4 % h.d.)	11 mm (42.3 % h.d.)	9—10	6	13 mm[1]	3.5—4 mm	13 mm
♂ 21 —	12 —	8.5 — (40.5 —)	9.5 — (45.2 —)	8—9	6	10 —	3 —	13 —
♀ 21 —	11 —	9 — (42.9 —)	10 — (47.6 —)	9	6	10 —	3 —	12 —
♀ 15 —	7.5 —	7 — (46.6 —)	7 — (46.6 —)	7—8	5	7 —	2.5 —	
♀ 13 —	7 —	6.5 — (50 —)	6.5 — (50 —)	7—8	5	6 —	2 —	

Test more or less flattened above and below, slightly incurved at the peristome; sides strongly arched, circumference round. Ambulacra scarcely sinuate, ca. $^1/_3$ the width of the interambulacra. Interporiferous zone much wider — ca. 3 times — than the pore zone. Marginal series of tubercles regular, the tubercles scarcely contiguous. Close inside the marginal tubercle each plate carries a single smaller tubercle at the lower edge of the plate, forming a not very conspicuous inner series of tubercles at each side, in larger specimens there may be, on some of the ambital plates, also another small tubercle at the upper edge of the plate, tending to obscure the serial arrangement of these inner tubercles. The larger median part of the interporiferous zone bare and somewhat sunk. Pore area very narrow, the pores small, oblique, subequal, separated only by a very narrow, slightly elevated wall; the ridge rather broad and low (Pl. LXIX. 15). In the largest specimens the ambulacral plate opposite each horizontal inter-

[1] In my paper on the New Zealand Echinoidea, p. 146, the height of this specimen is given as 16 mm and the width of the interambulacra as 8 mm. While the statement 16 instead of 15.5 mm height may well be due to a slight inaccuracy in the measuring, the statement 8 mm instead of 13 for the width of the interambulacra cannot thus be accounted for — it is an error which is rather inexplicable.

ambulacral suture at the ambitus may carry a tubercle, sometimes nearly as large as those of the marginal series, at the outer end of the ridge, above the pores.

Interambulacra. Areoles rather small, fairly deep; the 4—6 proximal ones confluent. These subambital areoles transverse-elliptical, the upper ones regularly round. Tubercles rather small and low, without any trace of crenulation. Scrobicular tubercles not prominent, the tubercles outside the scrobicular circle about the same size and scarcely diminishing towards the rather broad naked, sunk, median line. Also the inner end of the horizontal sutures distinctly sunk, whereas the adradial end of the horizontal sutures only in the largest specimens may be slightly sunk. The median area a little more than the width of an areole.

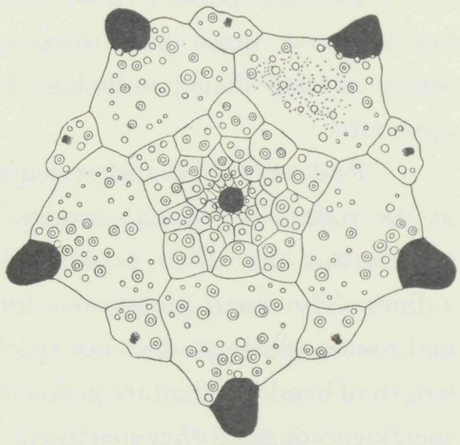


Fig. 53. Apical system of *Goniocidaris umbraculum*, ♀. × 6.

Apical system ca. 40—50 % h. d., apparently relatively larger in the younger specimens. Oculars all widely exsert. Genitals with a rather conspicuous outer angle, which is, in the female, cut off by the large genital pore that lies partly outside the genital plate, in the interradial midline (Fig. 53). In the male the small genital pore lies nearer the middle of the plates. (Cf. Fig. 1, p. 146, of the author's paper on the New Zealand Echinoidea). The tuberculation rather scarce, more close around the genital pores. Periproct rather small, but not otherwise peculiar.

Peristome in larger specimens distinctly larger than the apical system, ca. 42—50 % h. d., in smaller specimens as large as the apical system; it is distinctly sunk, especially in the female, in accordance with the habit of this species of carrying the young ones on the peristome. There are 9—10 ambulacral plates in a series in the larger specimens, the 3—4 outer ones being much higher than the proximal ones, and nearly bare, while the proximal ones are covered by spines as usual. The interradial plates are arranged in a more or less regular double series; they do not reach the peristome, the 3—4 inner ambulacral plates of each two neighbouring radii joining in the interradial midline.

Primary spines as a rule only $^1/_2$—$^3/_4$ the h. d.; only in a single specimen in hand (from Cook Strait) they are somewhat longer, 23 mm against 18 mm h. d. The larger ambital spines slightly fusiform, tapering to a blunt point; as a rule they have a pair of large lateral thorns at the base[1], the shaft being otherwise smooth or more rarely with few very indistinct longitudinal ridges and some indistinct serrations. The surface of the shaft on fully formed spines, not yet overgrown by foreign organisms, covered by a not very thick, woolly coat of fine anastomosing hairs, which terminate in a fine, forwards directed point. The collar is very short, scarcely more than half a mm long, passing directly into the inconspicuous milled ring. The

[1] Also in *G. tubaria* such larger basal thorns may occur, but never so conspicuous or constant as in *G. umbraculum*.

apical primaries, one or two of each series, are quite short, with the point widened into a flat or slightly concave, rounded, eccentric disk (the adapical side the broadest); the edge is perfectly smooth. They may be as large as 5—6 mm in diameter, and in such case cover the whole apical side; but often they are much smaller (cf. Pl. VI. figs. 1—2 of the author's Echinoidea of New Zealand). The size of these disks has no relation to the sex of the animal. — The oral primaries are only little specialized, scarcely curved, somewhat flattened and with slightly serrate edges. The 3rd and 4th form the transition to the ambital spines. They are as a rule fairly distinctly serrate.

The secondary spines around the primaries ca. 2.5 mm long; they are slightly flattened, but with the distal part thickened, not excavate; the end is straight cut. The smaller ones are of similar shape, only less distinctly thickened at the end. The secondaries not strongly appressed.

Pedicellariæ rather scarce. The large globiferous form, which is not especially found at the naked horizontal sutures as in *G. tubaria*, not as globular as are those of the latter species, and the valves, accordingly, not so broad (cf. Ingolf Ech. Pl. X. 21); stalk short, without a limb. The small globiferous form ("Ingolf" Ech. Pl. X. 13) of the usual type, with a distinct end tooth; this form does not reach nearly so large a size as in *G. tubaria*, scarcely beyond 0.5 mm length of head. Tridentate pedicellariæ: only one sample was found among the spines of a denuded specimen; on the other specimens in hand none could be observed; thus this form of pedicellariæ evidently occurs only very rarely in this species. The valves (Pl. LXXIX. 1) are long, leaf-shaped, filled with irregular meshwork, leaving only a small, irregular slit at the point, which shows that it is in reality only a transformed small globiferous pedicellaria, as is the case also in other species of *Goniocidaris*, in which apparent tridentate pedicellariæ occur. Spicules of the tubefeet of the usual type; in the intestine numerous spicules of the three-radiate type, as in *Goniocidaris tubaria*, only more clumsy in shape (Fig. 52. 2).

Colour of primary spines whitish, the basal part with a pinkish tint; secondaries may be of a brownish-reddish tint. The naked test greenish on the upper side, especially on the apical system and the upper part of the interambulacra.

Biology. Judging from the content of the intestine of a pair of specimens opened, the food consists mainly of Bryozoa, hard *Hornera*-like forms. It seems to be rather gregarious in places, according to Maxwell Young's observations.

Development. In the paper on the New Zealand Echinoidea I suggested (p.147) that the species might perhaps protect its brood, as do so many other Cidarids of the antarctic and subantarctic regions. This suggestion has been found to hold good, a pair of specimens among a lot received afterwards from Prof. Benham, carrying, in fact, some young ones on the peristome, covered by the oral primaries. The rather naked and sunk outer part of the peristome is in good accordance with this function as a marsupium. The few embryos found are not sufficient for studying the development, only the interesting observation could be made thereon that

the spines stand in bundles of ca. 4—10, each bundle on an elevation (cf. the author's paper "On the postlarval development of some Cidarids", 1927).

Concerning the growth it can only be stated that already in the youngest specimen in hand, 13 mm h. d., the genital pores are developed (evidently a female). It appears that this species does not reach any large size, the largest specimens known measuring only ca. 25 mm h.d.

No parasites are known from this species; but the primaries are nearly always overgrown by various incrusting organisms, Bryozoa, Sponges etc. — No abnormalities known, excepting a bifurcating tubefoot, mentioned in the author's Echin. of New Zealand, p. 148.

Occurrence. The species appears to be confined to the New Zealand Seas, where it has been recorded only from the Cook Strait and off the East coast of the South Island, down to Stewart Island. The bathymetrical distribution appears to be limited to the sublittoral region, down to ca. 100 m.

Remarks. The nearest relation of this species would seem to be *tubaria*, from which it is, however, very distinct and easily distinguished by various important characters, in the test, primary and secondary spines and pedicellariæ. The suggestion of H. L. Clark ("Endeavour" Ech. p. 104) that it might really be the same species as *geranioides* (= *tubaria*), or at most a subspecies, is due only to the fact that at that time *umbraculum* was very insufficiently known. In fact *umbraculum* through its well developed terminal disks and its small size forms a connecting link with the *Aspidocidaris*-group, especially the species *australiæ* (the small Tasmanian form), from which, however, the entirely different secondaries distinguish it very clearly.

Goniocidaris (Petalocidaris) florigera A. Agassiz.

Pls. XIII. 7; LXIX. 10; LXXVIII. 26—28.

Goniocidaris florigera. A. Agassiz. 1879. Prel. Rep. Chall. Ech. p. 198.
Goniocidaris florigera. A. Agassiz. 1881. "Challenger" Ech. p. 46 (partim). Pl. **I. 12—20.** (?) Pl. XXXVIII. 11; Pl. XLII. 2—3; XLIV. 4—5. Non: Pl. I. 7—11. (= *Schizocidaris serrata* Mrtsn).
Goniocidaris florigera. F. Jeffr. Bell. 1884. Notes on the structural character of the spines of Echinoidea (Cidaroidea), J. R. Micr. Soc. 2. Ser. IV. p. 846. Pl. 13.
Goniocidaris florigera. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ. p. 14—15, 44.
Petalocidaris florigera. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 18, 24, 30. Pl. X. 27, 29. II. 1907. p. 15.
Goniocidaris (Discocidaris) florigera. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97, 102.
Goniocidaris florigera. H. L. Clark. 1907. The Cidaridæ. p. 197, 198.
Goniocidaris (? Petalocidaris) florigera. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 52, 54.
Petalocidaris florigera. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Discocidaris florigera. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 33. (pro parte).
NON: *Cidaris (Petalocidaris) florigera.* De Meijere. 1904. "Siboga". Ech. p. 21. Taf. XII. 128—132. (= *Goniocidaris (Aspidocidaris) sibogæ* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	24 mm	17 mm	12.5 mm (52 % h.d.)	11.5 mm (48 % h.d.)	6—7	10—12	57 mm
2	24 —	16 —	12.5 — (52 —)	11 — (45.8 —)	7	11—13	72 —

Specimen 1 is the type-specimen.

Test rather high, flattened above, but not below; sides arched, gently sloping towards the peristome. The shape of test, in fact, recalls that of *Echinostrephus*, as pointed out by Agassiz.

Ambulacra rather conspicuously sinuate in specimen 2, much less so in the type specimen. Interporiferous zone ca. twice the width of a pore zone. Marginal series of tubercles very regular; tubercles rather small, not contiguous. Adradially to the marginal tubercle each plate carries a number of small tubercles, not regularly arranged, covering the whole of the median part of the plate, the vertical midline scarcely remaining distinct. The horizontal sutures are deepened so as to form distinct grooves. Pores equal-sized; the wall between them scarcely elevated. The ridge between the pore pairs high, which produces the impression of the pores lying unusually deep and being apparently conjugate, which they are not really (Pl. LXIX. 10). The pore area scarcely at all sunk; the interporiferous zone gently sloping towards the midline.

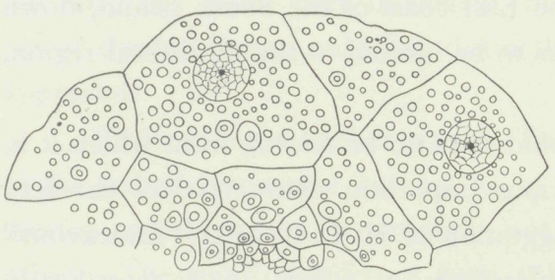


Fig. 54. Part of apical system of *Goniocidaris florigera*, ♀. × 6.

Interambulacra. Areoles moderately deep, only narrowly separated, at most the 3—4 proximal ones confluent, in the type specimen none at all. The subambital ones are rather distinctly transverse-oval. Scrobicular circle of tubercles fairly prominent, the tubercles distinctly larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates are closely covered by small, equal-sized tubercles which are arranged in transverse series, separated by deepened furrows. The transverse series continue from one plate to another across the median line, which is thus not at all naked or deepened. The inner ends of the horizontal sutures form small, but fairly distinct grooves; at the adradial end of the sutures no groove exists (— i. e. in specimen 2; in places there is a small, rather indistinct groove also at the adradial end of the sutures in the type-specimen). The median area about half the width of an areole.

Apical system 52 % h. d., flat, not thickened, only the periproct slightly elevated. Ocular plates all rather broadly insert. Genital pores large, not very close to the edge; they are covered with a finely plated membrane, leaving only a very small central pore. The genital plates are covered by small tubercles with a few (1—3) larger ones (comma-shaped in the type) near the inner edge. The ocular plates somewhat inwards produced, the inner tubercles partly somewhat larger (Fig. 54). Periproctal plates not very numerous, with some larger, irregularly shaped tubercles at the inner edge. — Peristome distinctly smaller than apical system, elevate, conical. Number of ambulacral plates in a series 8—9; they join with their neighbour at the mouth edge, excluding the interradial series from the mouth edge. There are 4—5 well developed interradial plates in a series. Tubercles (and spines) on the interradial plates distinctly smaller than those on the ambulacral series.

Primary spines very long, 2—3 times as long as h. d. They are in the main cylindrical, scarcely tapering, the point being generally widened into a small crown; they are more or less

conspicuously downwards curved. At the base of the shaft there is a well developed disk, in the main confined to the adapical side, but also fairly distinct on the adoral side; the disk consists of coalesced, widened thorns, rather deeply indented in the edge. Shaft not very closely set with a number of rather coarse, straight, not forwards directed thorns, those in the lower part of shaft more or less widened and ending in some coarse serrations; the thorns are not regularly arranged, at most there is an indication of two lateral series. The adoral side of the spine, as usual, without any larger thorns. The surface of the shaft and the thorns in fully formed, not worn spines closely covered with a more or less thick coat of fine hairs[1], which do not anastomose, but are to a various extent set with very small, outstanding prominences; the point is (? always) slightly bifid (Fig. 50. 3). Collar very short, only as long as the very inconspicuous milled ring. The apical spines developed into a small, irregular disk, adapically produced. The specimen in hand has only five apical disks, while in the type-specimen ("Challenger" Ech. Pl. I. 12) there are 10 such disks, those of the inner circle being distinctly smaller than the outer ones. The oral primaries with conspicuous lateral serrations and also some small thorns on the aboral side; they are scarcely curved. The third and fourth form the transition to the ambital spines.

Secondary spines. Scrobicular spines ca. 3 mm long, nearly rectangular, or narrowing slightly towards the straight cut end. They are flattened, rather distinctly inwards curving (concave, as seen in profile), and strongly thorny in their basal part, the serrations continuing more than half way to the end along the sides (Pl. LXXVIII. 26). The marginal ambulacral spines are ca. 2 mm long, slender, nearly setaceous, with only a few thorns on the basal part (Pl. LXXVIII. 27). Those at the edge of peristome not widened. The miliary spines slender, pointed, generally with a few basal thorns (Pl. LXXVIII. 28); they are, upon the whole, very small, mostly only ca. 0.1—0.2 mm.

Pedicellariæ. The large globiferous pedicellariæ fairly common along the midline of the interambulacra. The valves are characteristic through the opening being placed on a distinct tube-formed prolongation (the "blade") above the basal part. Stalk short, simple. Small globiferous pedicellariæ not numerous, on the whole small and inconspicuous, the head scarcely exceeding 0.2 mm, while the stalk may be up to 0.6 mm long. The valves are of the usual type, compressed, with a fairly well developed narrow, elongate opening (cf. "Ingolf" Ech. I. Pl. X. 27, 29). Tridentate pedicellariæ not observed. — Spicules of tubefeet small, simple rods, only near the sucking disk they are of the usual shape, irregular, thorny rods.

Colour. Test and secondary spines whitish. The primaries, when clean, beautifully banded

[1] Agassiz' statement that the primaries are smooth is due to the fact that the spines of the type specimen are not so well preserved. Still, it is easily seen that they were really covered by a similar hairy coat as on the specimen in the Copenhagen Museum; especially on the apical spines this is fairly distinct. The hairs seem to be slightly coarser than in the second specimen.

pink and white[1]. On the naked test the apical system has a distinct greenish tint, which continues faintly on to the ambulacra. Test otherwise white.

Biology unknown. The specimen in hand had the spines very much overgrown with sponges a. o. foreign organisms. This, together with the fact that in the type specimen all the ten uppermost primaries are developed into disks, indicates that the species is fullgrown at a size of ca. 25 mm h. d.

Occurrence. Known only from the Kei Islands. The type specimen was taken by the "Challenger" at 5° 42′ S. 132° 25′ E., 232 m. (St. 192). A second specimen was dredged by the author in 1922, during the Danish Expedition to the Kei Islands, at 5° 31′ S. 132° 38′ E., 250—290 m. These two specimens are the only ones known till now.

Remarks. This species has been subject to a great deal of confusion. First A. Agassiz ("Challenger" Ech.) confounded at least two, probably three different forms under his "*Goniocidaris florigera*", as I pointed out in my work on the "Ingolf" Echinoidea I (1903), after having had the opportunity of seeing his material in the British Museum, viz. besides the typical form, represented in Pl. I. 12 of the "Challenger" Ech., the form represented in Pl. I. 7 of the same work, designated by me as *Discocidaris serrata*, and a third species, which was made the type of a separate genus, *Schizocidaris assimilis*. The former of these I find now to belong likewise to the genus *Schizocidaris* and to be nearly related to *assimilis*, though, as it would appear, a distinct species. Recently H. L. Clark (Cat. Rec. Echini Brit. Mus. 1925, p. 34) after having reexamined the "Challenger" material in the British Museum, maintains that Agassiz was right in uniting all these forms into one species. The material of both *serrata* and *assimilis* at my disposal, that of the latter species collected by myself at the Kei Islands, a specimen of *serrata* collected by the "Albatross" at the Philippines, does not leave the slightest doubt but that these two forms are perfectly distinct from *florigera*, as the figures and descriptions of the said forms given in the author's "Albatross" Cidaroidea (*serrata*) and in the present work (*assimilis*) will show at a glance. The character especially distinguishing them from *florigera* is the structure of the primary spines (cf. the description of *Schizocidaris*). In the work quoted H. L. Clark further states as his opinion that *florigera* cannot really be distinguished from *clypeata*. This surprising statement can only be due to insufficient examination. The differences in both the primaries and secondaries of the two species, as well as in the shape and structure of the test and also in the pedicellariæ, are so striking that it is hard to understand how Clark could think of uniting them into one species; the explanation probably must be sought in the fact that he had no clear conception of the real characters of *D. clypeata* on account of various species having been confounded also under that name.

The specimens from the "Siboga" Expedition referred by de Meijere to *D. florigera*

[1] Agassiz' statement that the primaries are white is probably due to his confounding of *Schizocidaris* with *florigera*. The type specimen of *florigera* has, indeed, the spines banded pinkish and white, as the specimen in hand, though not so beautifully, evidently faded. (Cf. also Clark. Cat. Rec. Sea-Urchins Brit. Mus.).

("Siboga" Ech. p. 21) are not the true *florigera*. The three specimens, which were sent me for examination by the Director of the Amsterdam Museum, Prof. L. F. de Beaufort, represent a separate species, *Gonioc. (Aspidocidaris) sibogæ* Mrtsn. (cf. p. 198, Pl. XVI. 6—9). — On the other hand, the single primary spine from "Siboga' Stat. 12 (E. of the Madura Strait, 298 m.) mentioned by de Meijere ("Siboga" Ech. p. 21, Taf. XII. 129) as probably belonging to *G. florigera*, may well be correctly identified. That the red bands are lacking does not speak against this identification, as the spine is old, stained brownish from the bottom on — or in — which it must have been lying for a long time. We may see herein an indication that *G. florigera* is not confined to the area off the Kei Islands, where the two only known specimens were taken, but that it must be distributed over a larger part of the Malay Archipelago, at least as far West as the Madura Strait.

It may be pointed out that the plating of the membrane covering the genital pores is rather unique among Cidarids, as far as known till now; there is an indication of a similar condition also in *G. spinosa*.

Goniocidaris (Petalocidaris) spinosa Mrtsn.

Pls. XIII. 8—9; LXIX. 8; LXXVIII. 7—11.

Goniocidaris spinosa. Th. Mortensen. 1928. New Cidaridæ p. 67.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
20 mm	12 mm	9 mm (45 % h.d.)	c. 8 mm (40 % h.d.)	6—7	10—11	40 mm

Test slightly flattened above and somewhat less so below. Sides arched; circumference round. Ambulacra rather strongly sinuate. Interporiferous zone ca. twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles rather small, not contiguous. Inside the marginal tubercle each plate carries a number of small tubercles variously arranged (Pl. LXIX. 8), so that no vertical series are distinguishable. The median part of the horizontal lines rather distinctly sunk, the grooves thus formed being contiguous, through the narrow, deepened median line. The whole interporiferous zone gently sloping towards the median line. The pores are rather small, the outer one slightly the larger. They lie very deep; the wall between the pores narrow, scarcely at all elevated, while, on the other hand, the ridge between each two adjoining pore pairs is high. It thus has much the appearance that the pores are conjugate, which they are, however, not really. The pore zone, upon the whole, scarcely sunk.

Interambulacra. Areoles rather deep, at most the two lowermost ones confluent; those below the ambitus apparently transverse-oval. Scrobicular tubercles fairly prominent, about twice as large as the marginal ambulacral tubercles. Outside the scrobicular circle the plates are closely covered with smaller tubercles, leaving no naked median line; neither is there any naked part on the adradial side of the plates, the scrobicular circle reaching almost to the edge of the plate.

The median area scarcely at all sunk, only at the inner end of the horizontal sutures there is a small, but distinct groove. The median area scarcely half as broad as an areole.

Apical system 45 % h. d.; all oculars narrowly insert. All the plates nearly bare, each with only one or two large, usually somewhat irregular tubercles, some smaller ones in a circle around the genital opening and a few miliaries scattered on the rest of the plates (Fig. 55). Genital opening large, near outer edge; there is a faint trace of plates in the genital membrane. Periproctal plates few, those of the outer circle rather unusually large. The whole apical system slightly elevated. Peristome ca. 40 % h. d., distinctly elevated, conical; there are 7—8 ambulacral plates in a series. The character of the interradial plates not to be ascertained without damaging the specimen, which would not be desirable, and not worth the while either, the value of this character being rather problematic.

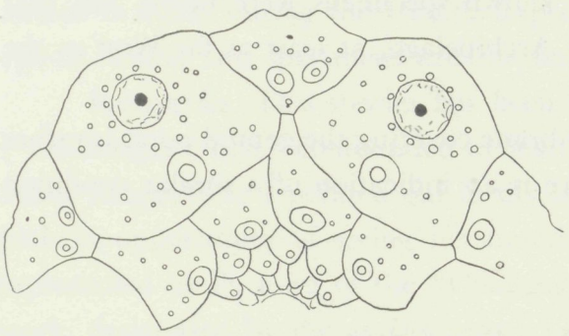


Fig. 55. Part of apical system of *Goniocidaris spinosa*, ♀. × 8.

Primary spines. The longest ambital spines twice the h. d., tapering to a rather acute point; in the upper ones the point may be widened into a small crown. At the base of the shaft there is a rather well developed disk on the adapical side; the shaft otherwise set with very coarse thorns, arranged mainly in a conspicuous, more or less regular series along each side; the thorns are obliquely outwards directed, not curved, not rarely bifid, or even trifid; a few thorns are irregularly placed on the adapical side, mainly in the outer part, while the whole of the adoral side remains smooth. The surface of the shaft covered with a coat of rather coarse, irregularly curved, not anastomosing hairs, with a slight widening at the point. While the basal part of the hairs is perfectly smooth, the surface in the outer part is peculiarly warty, rugose, giving much the impression that it is covered with fine crystals; also the terminal widening is of this warty character (Fig. 50. 4—5). Collar very short and inconspicuous, scarcely longer than the likewise very inconspicuous milled ring. The five uppermost spines transformed into a not very large, but coarse, clumsy disk, adapically produced into a rather long and coarse thorn, the edge of the disk also being more or less thorny. The five other adapical spines are still in a quite embryonal condition, merely represented by small tubercles; whether they are also developed into disks in fullgrown specimens is, of course, uncertain; but the appearance of the specimen in hand rather indicates that it is fullgrown. — The oral primaries are very characteristic, strongly thorny on the aboral surface, unusually long, straight; the third or fourth forms the transition to the ambital spines.

Secondary spines not very strongly appressed. The scrobicular spines are ca. 2 mm long, somewhat widened basally, narrowing gently towards the straight cut end; they are rather strongly excavate in their whole length and slightly thorny on the milled ring (Pl. LXXVIII. 10). The ambulacral spines are narrow, simply flattened, scarcely excavate; those near the peristome

not different from the rest of them. The miliary spines are slender, pointed, with finely serrate ridges (Pl. LXXVIII. 9, 11).

Pedicellariæ. Large globiferous pedicellariæ fairly numerous; the valves (Pl. LXXVIII. 7) are not very wide and the blade rather produced beyond the basal part. The stalk is very short, less than length of head. The small globiferous form rather scarce, generally small, scarcely exceeding 0.2 mm, the stalk somewhat longer. The valves are of the usual type, with a well developed end tooth and slightly elongate opening, the blade being somewhat compressed (Pl. LXXVIII. 8). Tridentate pedicellariæ not observed. — Spicules of tubefeet small, rather scarce, mainly smooth rods; nearer the sucking disk they are coarse and more thorny, of the usual irregular form.

Colour. Ground colour of test and secondary spines yellowish-white. Primaries on the upper side banded with purplish-red, the lateral thorns in the main whitish, as is also the underside of the spines; also the oral primaries of a reddish colour. The scrobicular spines on the adapical side of the primaries dark greenish at the base. Also the apical system, especially the oculars, the periproctal plates and the outer part of the genital plates, dark greenish. This colour continues as a slight greenish tint along the pore zones of the ambulacra, the colour being mainly located in the ridges separating the pore pairs.

Occurrence. The single specimen known was dredged by the author in the Bay of Ambon in a depth of ca. 200 m., on hard ground.

Remarks. This very distinct species bears a good deal of resemblance to *G. biserialis* on the one hand, to *G. florigera* on the other, while differing from both in a number of characters, both in test, spines and pedicellariæ, as appears sufficiently from the descriptions and figures. But it seems quite evident that it forms a natural group together with the two said species.

Goniocidaris (Petalocidaris) biserialis (Döderlein).

Pls. XIV. 12—20; LXIX. 17; LXXVIII. 29—30.

Stephanocidaris biserialis. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu Inseln. Arch. f. Naturgesch. 51. p. 80.
Goniocidaris biserialis. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ, p. 10, 49. Taf. **V. 1—27**; Taf. **VIII. 8. a—h.**
Goniocidaris biserialis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 24. Pl. IX. 10.
Cidaris (Goniocidaris) biserialis. Yoshiwara. 1906. Japanese Echini. Pl. III. 3—6.
Goniocidaris biserialis. Döderlein. 1906. Echin. Deutsche Tiefsee-Exped., p. 97.
Goniocidaris biserialis. A. Agassiz & H. L. Clark. 1907. Hawaiian Echini. Cidaridæ, p. 26. Pl. X. 22—25.
Goniocidaris biserialis. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. Bull. M. C. Z. LI. p. 114.
Goniocidaris biserialis. H. L. Clark. 1907. The Cidaridæ, p. 199.
Goniocidaris biserialis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Goniocidaris biserialis. Jackson. 1912. Phylogeny of Echini, p. 100, 102.
Discocidaris biserialis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus., p. 32.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Width of I. A.	Width of A.	Longest spines
29 mm	16 mm	14 mm (48.3 % h.d.)	12 mm (41.4 % h.d.)	7	10—11	13.5 mm	4.2 mm	34 mm
30 —	17 —	15 — (50 —)	13 — (45 —)	7	10—11	13 —	5 —	28 —
29 —	15 —	14 — (48.3 —)	11.5 — (39.7 —)	7	10—12	13 —	4.5 —	29 —
27 —	16 —	13.5 — (50 —)	11 — (40.7 —)	7	10—11	13 —	4 —	33 —
23 —	12.5 —	10 — (43.5 —)	9 — (39.1 —)	7	9—11	10 —	3.5 —	35 —
19 —	10 —	9 — (47.1 —)	8 — (42.1 —)	6—7	9—10	9 —	3 —	
11 —	5.5 —	5.5 — (50 —)	5 — (50 —)	6	8—9	5.5 —	2 —	

Test low, flattened above and below; sides beautifully arched, sometimes more gently sloping towards the oral side. Circumference round. — Ambulacra rather distinctly sinuate. Interporiferous zone about twice the width of a pore zone. Marginal tubercles not very prominent, nearly contiguous, forming quite regular series. Inside the marginal tubercle each plate — at the ambitus — carries two fairly regular horizontal series of each three small tubercles, leaving no naked median part of the plate. Sometimes a few more tubercles are found, causing a more irregular arrangement; in the largest specimens there may even be three horizontal series of such small tubercles; on the other hand, there are fewer of them in the younger specimens, forming only one horizontal series at the lower edge, or there is no arrangement in horizontal series at all distinct. The horizontal sutures are rather sharply, but narrowly deepened; the vertical midline is not distinct, but the whole interporiferous zone is somewhat sunk, sloping gently towards the midline. The pore areas somewhat sunk. The pores are subequal, separated by a small, but distinctly elevated tubercle. The wall above the pores a narrow sharp keel (Pl. LXIX. 17).

Interambulacra. The adult specimens have 7 or in the largest specimens 8 (Döderlein, p. 49) coronal plates in each series. The tubercles are rather small, without any trace of crenulation. The areoles rather small, fairly deep, the subambital ones slightly transverse-oval; only the 2—3 proximal ones confluent, the upper ones in the adult specimens so well separated that there is room for several small tubercles between each two adjoining scrobicular circles of tubercles. Outside the not very prominent scrobicular circle there are, in larger specimens, a few tubercles scarcely half that size, alternating with the scrobicular ones; the median part of the plate is wholly covered with very small tubercles of uniform size, arranged in distinct transverse series which are separated by very narrow, but distinct furrows. No naked space is left along either the median or the adradial suture. The horizontal sutures are well marked, slightly deepening towards the median edge. The median part is ca. $^2/_3$ the width of an areole, only slightly sunk. In younger specimens the small tubercles of the median part are not yet so numerous and leave the median line bare to some extent. There is upon the whole some variation in the extent to which both ambulacral and interambulacral plates are covered with these small, miliary tubercles.

Apical system usually ca. 47—50 % h. d., more rarely less (43.5 % h. d.). Oculars to a various degree insert: in the largest specimens they are as a rule all insert, in the younger specimens all exsert; but even in adult specimens one or more, or even all the oculars may be exsert. Tubercles very scarce, mainly confined to a group around the genital pores and a more or less distinct series of somewhat larger ones along the inner edge of the genital plates; the rest of the plates naked. Periproct small, sometimes elevated, the plates usually with a single tubercle at the inner edge. Genital pores fairly distant from the edge, the female pores ca. 1—1.5 mm in diameter, male pores much smaller; no plates in the genital membrane. (Figures of apical system at various ages are given by Döderlein, Op. cit. Taf. V). The apical system upon the whole thin.

Peristome as a rule distinctly smaller than the apical system, ca. 39—45 % h. d.; in quite young specimens it is relatively larger, as large as the apical system. Adult specimens have 8—9 ambulacral plates in a series, younger specimens 6—7; a specimen of 11 mm h. d. has only five. The outer of these plates are rather high. The ambulacra do not join with their neighbours at the mouth edge, leaving thus a narrow passage for the interradial plates, which may, but do not always reach the mouth-edge; there are 3—5 of them in a single series, but sometimes they form a more or less irregular double series.

The primary spines vary considerably in length, from somewhat less than h. d. to about 1.5 h. d., the length being as a rule proportionately larger in the younger specimens. They are rather slender, ca. 2 mm thick, very nearly cylindrical, only very slightly tapering, but generally with the end widened into a small, irregular crown. The shaft carries some very strong, slightly forwards directed thorns, which are in the main arranged in a more or less regular series along each side; sometimes they may coalesce to some degree, especially the proximal ones may coalesce across the adapical side of the spine, forming thus a sort of basal fringe or disk (Pl. XIV. 17). The collar is short, ca. 1—1.5 mm long, gently widening towards the very inconspicuous milled ring. The surface of the shaft, and of the large lateral thorns, covered with a coat of long, smooth, fine, not anastomosing hairs, usually bifid at the point, and provided with a various number of small outgrowths; they may be nearly erect or more or less forwards directed (Fig. 50. 1—2). It is a curious fact that these hairs are nearly always worn off on the adoral side of the spine. The uppermost spines in adult specimens generally widened into an irregular, deeply serrate, not very large crown; more rarely the edge of the crown is entire along the adapical side. This crown, as a rule, does not begin to develop until the specimen has reached a size of ca. 25 mm h. d.; quite exceptionally I have found it well developed at a size of only 24 mm h. d. The length of these upper, widened spines rather varying, sometimes quite short, sometimes not much shorter than the ambital spines. The quite smooth primaries which are often found on the upper side of the test (cf. Döderlein. p. 11) are young, developing spines, which have not yet assumed their definite shape. — The oral primaries are slightly flattened or widened, not curved. They are distinctly furrowed mainly on the outer (aboral) side, the ridges being rather coarsely serrate. The third and fourth form the transition to the ambital spines.

Secondary spines. The scrobicular spines ca. 3 mm long, flattened, slightly concave in the basal part (as seen in profile), narrowing a little towards the straight cut end. They are usually quite smooth, but not rarely there are a few thorns on the upper (outer) side of the basal ring (Pl. LXXVIII. 30). The marginal ambulacral spines narrower, less flattened, but otherwise on the whole of the same character; they are ca. 2 mm long. The small spines of the interporiferous zone and the median interambulacral zone are simple, finely thorny, pointed stumps; when numerous they give the median ambulacral and interambulacral zones a somewhat velvety appearance. (Döderlein. Op. cit. Taf. VIII. 8. g.).

Pedicellariæ. Large globiferous pedicellariæ of the usual globular, short-stemmed form occur in fair numbers in the median interambulacral space, and also between the upper areoles. The valves not prolonged (Pl. LXXVIII. 29; see also Döderlein, Op. cit. Taf. VIII. 8., A. Agassiz & H. L. Clark, Op. cit. Pl. X. 22—25). The small globiferous with an end tooth which is, as a rule, not very strongly developed — not justly to be termed "powerful" ("Ingolf"-Ech.; loc. cit.) —; it may even be wanting. Tridentate pedicellariæ have not been found. — Spicules of tubefeet of the usual, non-characteristic type. The intestinal wall full of small triradiate spicules, as in *G. tubaria*.

Colour. The general colour is a more or less light brownish. The primaries are, when not overgrown by foreign organisms, dark greenish-brown with white bands; the thorns are as a rule white. The secondaries surrounding the base of the primaries are dark greenish-brownish or olive-green in the basal part, a coloration which is very characteristic and apparently constant; it is found already in quite small specimens. The naked test is whitish, the apical system dark greenish-brown, of which colour an indication may be found also on the upper part of the test, especially on the ambulacra.

Biology. The food appears to consist of small bottom organisms, worms, Bryozoa, Foraminifera, which are swallowed together with the sand. It seems to prefer a hard bottom. According to Yoshiwara it is often found attached to fishing nets from deep waters near Misaki. The development is unknown; the eggs are not very large, ca. 0.2—3 mm.

The growth changes have been described by Döderlein (Op. cit. p. 12); it may only be recalled that the statement given there: that the periproctal plates originate through the splitting up of a single primordial, large anal plate does not hold good (cf. the author's paper "Echinological Notes" III. The central (sur-anal) plate of Echinoidea. Vid. Medd. D. Naturh. Foren. Bd. 63. 1911, p. 31). The genital pores appear at a size of ca. 12 mm. The species does not grow to a large size, the largest size recorded being 34 mm h. d. The larger specimens as a rule have the spines very much overgrown by various sorts of organisms — Sponges, Bryozoa, worms, *Polytrema*, and also some Bivalves, while, curiously enough, no barnacles have been found attached to them; only in one case a single *Scalpellum* was found attached to a spine.

No parasites are known from this species. — One specimen offers the abnormality of having the genitals 3 and 4 coalesced, and also the madreporite irregularly widened (Fig. 56).

Occurrence. This species is known from the Sagami Sea, the Suruga Gulf, and from the Eastern Channel, Korea Strait, off the Goto Islands and off the Kagoshima Gulf, ca. 80—360 m. Döderlein (Op. cit. 1885) reports having got the characteristic spines of this species also from off Tango, Japan, in ca. 70 m. The present author found the species in good numbers off the Goto Islands in ca. 100—160 m., and also in the Sagami Sea to a depth of ca. 500 m.[1]. Outside the Japanese Seas it is not known to occur.

Remarks. The position of this species has hitherto been rather apart within the *Goniocidaris*-group, and I have previously suggested (Ech. Deutsche Südpolar Exp. p. 52, 54) that it ought, perhaps, to form a separate genus. The finding of the new species *spinosa*, however, seems to solve the question of its position, as it is thereby connected with *florigera*. In my opinion it seems now evident that it forms a natural group together with the two said species, the subgenus *Petalocidaris*, the group being especially characterized by the coarsely thorny and banded primary spines.

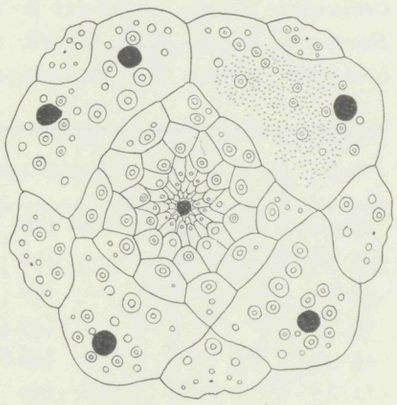


Fig. 56. Abnormal apical system of *Goniocidaris biserialis*, ♀. × 5.

Döderlein (Jap. Seeigel, p. 13) suggests that it may be nearly related to the fossil "*Pleurocidaris*" *canaliculata* (Duncan & Sladen) from the Eocene of India. As explained above (p. 147) this suggestion seems altogether unacceptable, the only character on which it is based — the arrangement of the interambulacral miliaries in horizontal lines — being a character of very little value and one which has developed separately in various forms. The fact that *Pl. canaliculata* has distinctly conjugate pores speaks decidedly against any closer relation with Goniocidarids, in which the pores are never really conjugate but always rather close together, separated only by a narrow, more or less elevated wall. Even for *G. florigera*, with apparently conjugate pores, this holds good, the apparently conjugate character here being due to both the pores and the separating wall being sunk, while the ridge above the pores is unusually high. The fact that the young *canaliculata* has not conjugate pores is thought by Döderlein to do away with the difficulty of the conjugate — i. e. more specialized — pores in the supposed ancestor of *Goniocidaris*, in which pores are non-conjugate, i. e. less specialized. But this simply means a verification of the undoubted fact that forms with conjugate pores descend from such with non-conjugate pores, a fact of which Döderlein himself (Op. cit. p. 30—31) has given the main proof.

[1] The statement in H. L. Clark's "Cat. Rec. Ech. Brit. Mus." p. 32, that two of the specimens of this species in the collection of the British Museum came from a depth of only 2 fathoms (Sagami Sea, 35° 7′ N 139° 44′ E.) evidently is a writing or a printing error, probably for 200 fathoms; the locality quoted is in the middle of a deep-sea area, where a so dangerous shoal, with only 2 fathoms of water, would not pass unnoticed.

Goniocidaris (Discocidaris) mikado (Döderlein).

Pls. XIV. 1—11; LXIX. 16; LXXIX. 7—8.

Discocidaris (Cidaris) mikado. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu-Inseln, p. 8.
Goniocidaris mikado. Döderlein. 1887. Japan. Seeigel. I. p. 15. Taf. **VII. 1—6; VIII. 6. a—f. 9—18.**
Goniocidaris (Discocidaris) mikado. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 24, 29.
Goniocidaris (Discocidaris) mikado. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97, 102.
Cidaris (Goniocidaris) mikado. Yoshiwara. 1906. Japanese Echini. Pl. III. 1—2.
Goniocidaris mikado. A. Agassiz & H. L. Clark. 1907. Hawaiian Echini. Cidaridæ, p. 28. Pl. X. 26.
Goniocidaris mikado. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. Bull. Mus. C. Zool. LI. p. 115.
Goniocidaris mikado. H. L. Clark. 1907. The Cidaridæ, p. 197, 199.
Goniocidaris mikado. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Discocidaris mikado. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 35.
Goniocidaris mikado. Th. Mortensen. 1927. Postlarval developm. Cidarids. p. 16 (382).

h. d.	v. d.	Apical system	Peristome	Width of I. A.	Width of A.	Number of I. A.	Number of A. pro I. A.	Longest spines
26 mm	18 mm	13 mm (50 % h.d.)	11 mm (42.3 % h.d.)	13 mm	3.5 mm	7—8	8—10	34 mm
23 —	14.5 —	11.5 — (50 —)	10 — (43.5 —)	11 —	3.2 —	7	9—10	42 mm
22 —	13 —	11 — (50 —)	10 — (45.5 —)	10.5 —	3 —	6—7	9—10	38 —
19 —	11 —	9 — (47.4 —)	8 — (42 —)	8.5 —	3 —	6—7	8—9	
15 —	8.2 —	7 — (46.6 —)	7 — (46.6 —)	7 —	2 —	6	7—8	40 —
11 —	7 —	5.5 — (50 —)	6 — (54.5 —)	5 —	2 —	5—6	7—8	
8 —	4.5 —	4 — (50 —)	4 — (50 —)	3.5 —	1.5 —	5—6	5—6	25 —

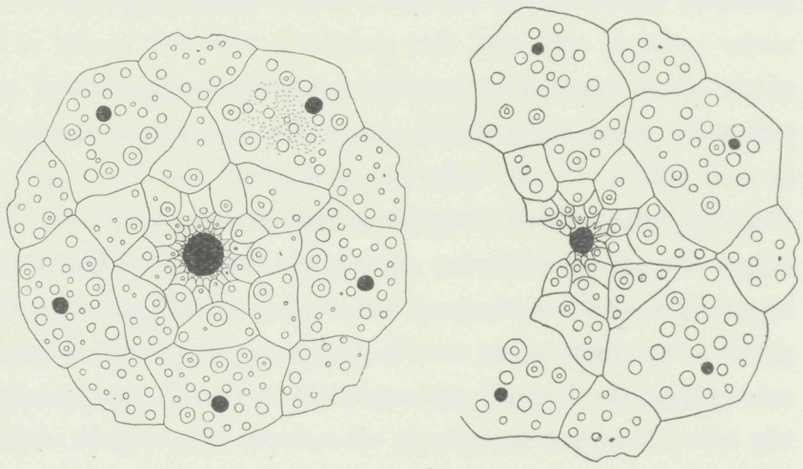
Test flattened above, as a rule more gently sloping downwards. Circumference round. Test upon the whole rather fragile.

Ambulacra slightly sinuate. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, but the tubercles are small, not contiguous; as stated by Döderlein, there may even be some very small tubercles in between the marginal tubercles. Also outside the pores, on the ridge, there may be small tubercles. Inside the marginal series each plate carries, at the ambitus, in the larger specimens, several small tubercles of uniform size, which do not show any regular arrangement, either in vertical or horizontal series, and leave no bare median space. The horizontal sutures are slightly deepened at their median end; the whole interporiferous zone gently sloping towards the midline. In younger specimens there are, of course, relatively fewer of the small inner tubercles, but no distinct naked median part. Pores subequal, the outer one slightly the larger. The wall between them is narrow and low, the ridge separating the subsequent pairs rather high. Pore zone scarcely sunk (Pl. LXIX. 16).

Interambulacra. There are, as a rule, not more than 7 coronal plates. The tubercles are not very prominent, without any indication of crenulation; the areoles fairly deep, scarcely at all transverse-oval below the ambitus, at most the three proximal ones confluent. Between the upper ones there is room for several small miliary tubercles between the adjoining scrobicular circles. The scrobicular tubercles scarcely larger than the marginal ambulacral tubercles; outside the scrobicular circle some slightly smaller tubercles alternating therewith, and

then the rest of the plate covered closely by small, uniform tubercles which do not show any regular arrangement and leave no horizontal lines between them. There is no naked part along the vertical median line or along the horizontal sutures, these latter showing a small, but rather distinct deepening towards the median line, below the ambitus, while above the ambitus there is no indication of a deepening in the horizontal sutures. The median part of the interambulacrum about as wide as an areole; it slopes gently towards the median line.

Apical system almost constantly exactly half as wide as h. d., rarely slightly less. It is flat, but fairly thick, its edges somewhat rising above the test; consequently it is very well marked off against the test. As a rule all the oculars are insert; in the youngest specimens they are, of course, all exsert, but already at a size of 10—11 mm h. d. they may all be insert. On the other hand, in the largest of the specimens, the measurements of which are given above, the oculars only just touch the periproct, so that in this specimen they must have been exsert till a rather late stage of growth. The plates are all rather closely covered with tubercles, those along the inner edge of the genital plates being generally somewhat the larger (Fig. 57. 1.). The female genital pores fairly large, ca. 1 mm in diameter, (cf. Döderlein. Op. cit. 1887, Taf. VII. 4; VIII. 9) rather close to the edge; the small male pores are nearer the middle of the plate.



1 2

Fig. 57. Apical system of *Goniocidaris mikado*, ♂ (1) and of a hybrid (?) between *G. mikado* and *G. clypeata* (2). 1 × 6; 2 × 8.

Peristome as a rule distinctly smaller than the apical system, only in the younger specimens it is as large as or even larger than the peristome. There are 7—9 ambulacral plates in a series, this number being found already at a size of 10—11 mm h. d. The neighouring ambulacral series generally, but not quite constantly, join at the mouth edge, excluding the interradial plates from the mouth edge. The interradial plates may form a single regular or an irregular double row; there are 5—6 in a series in adult specimens. Both ambulacral and interradial plates rather high. The peristome as a rule rather strongly conically protruding.

Primary spines in adult specimens generally about twice, more rarely only 1.5 the h. d., in young specimens relatively longer, up to ca. 3 times the h. d. They are slender, gently tapering, the point often widened into a small crown. At the base they carry a large flat disk, exactly recalling the guard-plate of a dagger; it is generally finely serrate in the edge, and is often incomplete, developed only on the adapical side of the spine. Farther out on the shaft follow more or less numerous strong thorns, which may be developed into similar, only less com-

plete disks. These thorns are often arranged biserially, recalling the condition in *Goniocidaris biserialis*, but they may also be irregularly distributed all over the adapical side of the spine, while as a rule no such thorns are found on the under (adoral) side of the spine. Towards the end of the shaft the thorns become smaller and arranged in more or less regular longitudinal series, which pass into the ridges that form the terminal crown. The surface of the shaft, in fully formed, well preserved spines, is covered by a thick coat of long, fine, outstanding hairs, which do not anastomose even at their base[1]; they may be set with small, very fine, outstanding side branches (Fig. 50. 6—7.). Both the shaft and the thorns are covered with this coat of hairs, which gives the spine a most delicate, almost fluffy appearance. The hairs are less developed on the under (adoral) side, and they gradually diminish in size in the outer part of the shaft. The collar of the spine very short, scarcely longer than the milled ring itself. The upper spines are very generally found to be naked, not yet fully formed, contrasting very markedly to the hairy fully formed spines. In the fullgrown specimens the five uppermost spines are short, with the point widened into a fairly large, eccentric crown, wider on the adapical side, with deeply serrate edges, the serrations being coarser on the outer edge. I have not found the crowns developed in specimens of less than 18 mm h. d.; on the other hand I have found them undeveloped as yet in a specimen of 22 mm h. d. The oral primaries somewhat flattened, with distinctly serrate ridges, the lateral ones especially rather conspicuous; often with a pair of larger thorns at the base. They are scarcely at all curved. The second and third form a gradual transition to the ambital primaries.

The secondary spines surrounding the base of the primaries are rather thick, flattened, scarcely narrowing towards the rounded point. They are only ca. 2 mm long, appressed. The marginal ambulacral spines of the same general shape, only somewhat narrower and shorter. The small spines of the median part of interambulacra and ambulacra are transformed into very characteristic short granules, which, as seen under the microscope, are provided with sharp, glassy, very finely serrate ridges (Pl. LXXIX. 8). As in *Goniocid. biserialis* the spines of the outer part of the interradii on the peristome are distinctly smaller than the ambulacral spines and those nearer the mouth, recalling the condition in *Chondrocidaris*.

Pedicellariæ. Only the small globiferous form appears to exist; it is characteristic through its strong end tooth (Pl. LXXIX. 7; cf. also Döderlein, Taf. VIII. 6. a—d and Agassiz & Clark, Op. cit. Pl. X. 26). They are fairly numerous, scarcely larger than 0.5 mm length of head, with the stalk of about the same length or even shorter. — The spicules of tubefeet of the usual form, those of the intestinal wall of the characteristic three-radiate form.

Colour whitish, the upper primaries sometimes with a slight greenish or pinkish tint on the adapical side. The naked test white, only the apical system usually with a very slight pinkish tint.

[1] According to Döderlein (Op. cit. 1887, p. 16) these hairs are "vielfach anastomosirend". I have not found them anastomosing, so that the type-specimen would seem to have been exceptional in this regard, if Döderlein's observation be correct.

Biology. This species evidently prefers a hard bottom. In the intestine I have found pieces of Bryozoans and Polytrema. — It does not grow to a large size; the largest of the several specimens in hand measures 26 mm h. d. The genital pores appear at a size of 10—11 mm h. d. In the larger specimens the spines are very much overgrown with sponges, Bryozoans, tubiculous Amphipods, Hydroids; a few Scalpellum have been found on them, but no Balanids. — No parasites are known from this species, and no abnormalities have been observed.

Occurrence. Known only from the Japanese Seas, where it is, evidently, common in the Sagami Sea in depths of ca. 150—ca. 700 m. It was taken by the "Albatross" also in the Suruga Gulf and off the Goto Islands, while the present author did not find it by his trawlings at the latter locality.

A fine specimen was taken by the "Vega"-Expedition off Jeddo, in 65 fathoms, 1879 (Mus. Stockholm); this is really the first specimen found of this species, but it remained unidentified till now.

Remarks. This species stands rather isolated among the *Goniocidaris*-species, especially through the peculiar character of the miliary spines having been transformed into rounded granules, a character distinctly developed already in the young specimens. Perhaps it ought rather to form a separate genus — at least it is perfectly justifiable to regard it as a separate subgenus, *Discocidaris*. From the *clypeata*-group, which is likewise designated as *Discocidaris* by H. L. Clark (Cat. Rec. Sea-Urch. Brit. Mus. 1925) it is very clearly distinguished, by the said character of its miliary spines, as well as by its primary spines with the unusual development of the hairs and the successive basal disks. In regard to its primaries it resembles very much the species *peltata* from the Philippines and the Kei Islands. In view of the undeniable fact that the characters of the primary spines are of the greatest systematic value within the group of the Goniocidarids it therefore seems reasonable to regard these two species as forming one separate group, the subgenus *Discocidaris*. But, on the other hand, the two species are so sharply distinguished through the totally different character of their miliary spines that their relationship would appear to be not so very close.

Goniocidaris mikado × clypeata (?)

Pl. XV. 16.

From the Sagami Sea, ca. 500—700 m., the author has brought home a few specimens which present so curious an intermingling of the characters of *D. mikado* and *D. clypeata* that the conclusion seems evident that they are really hybrids of the said two species. If not, they must represent a separate species; but as the two species occur together in the same localities, one of them in great numbers, the existence of hybrids would not be too surprising. Some other specimens are perhaps rather to be regarded as hybrids between *mikado* and *Rhopalocidaris rosea*, as mentioned below; but as for the larger specimens described here the characters decidedly point towards *clypeata* as one of the sources; that *mikado* is the other part seems beyond doubt.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
14 mm	8.5 mm	8 mm (57.1 % h.d.)	7.5 mm (53.6 % h.d.)	6—7	5—6	25 mm
14 —	8.5 —	8 — (57.1 —)	7.5 — (53.6 —)	6	5—6	30 —
12.5 —	8 —	7 — (56 —)	7 — (56 —)	6—7	5—6	26 —
11 —	6.5 —	6 — (54.5 —)	6 — (54.5 —)	6	5	25 —

In regard to the general shape and structure of the test they are nearest the typical *mikado*, with which they also agree in the very characteristic secondary spines, transformed into rounded granules. The primaries in the main as in *mikado*, only the hairy coat less strongly developed; the hairs are simple as in *mikado*, not anastomosing as is the case in *clypeata*. The apical system differs from *mikado* in being not elevated above the level of the corona, such as is characteristic of *mikado*. The oculars are only partly insert, in the fourth specimen widely exsert. The figures (Fig. 57. 2 to compare with Fig. 57. 1, of *mikado*, and Fig. 59. 1, of *clypeata*) scarcely convey in a satisfactory way the impression of the difference between their apical systems, the main feature, the elevation (thickness) of the apical system in *mikado*, not showing in simple outline figures. The main feature in which these specimens recall *clypeata* is, however, the existence of a well developed crown on the upper spines already at so small a size as 13—14 mm h. d., the crown otherwise not developing in *mikado* till at a size of at least 18 mm h. d. Also the shape of the crown is, in two of the specimens, much more like that of *clypeata*, large and round, with fine serrations along the edge; in the third specimen the crown is deeply serrate and more like that of *mikado*. In all of them, however, the adapical side of the crown is the wider, against what is the rule in *clypeata*. (The fourth specimen, that of 11 mm h. d., has not yet the crown developed). The pedicellariæ are not peculiar, as was to be expected. The small globiferous are as in *mikado* and *clypeata*. Large globiferous pedicellariæ are not found. The colour of the primaries is a light brownish-pinkish, more recalling *clypeata* than the usually white primaries of *mikado*.

It is, of course, a difficult matter to decide whether some specimens are really hybrids; but in the case of the above specimens the suggestion decidedly lies at hand that they are hybrids between the two said species.

Also a younger specimen, 10 mm h. d., as yet without the "crowns", but with the genital pores well developed, I would be inclined to regard as a hybrid between the two species. For the rest it is undeniable that it is, as a rule, very difficult to distinguish between the young *clypeata* and the young *mikado* (before the characteristic secondaries have appeared in the latter), in spite of the conspicuous differences existing between the adult specimens of these two species; in fact, I have in some cases had to leave it undecided whether such young specimens belong to *mikado* or to *clypeata* — or perhaps are hybrids between the two.

Goniocidaris mikado × Rhopalocidaris rosea (?)

Pl. XV. 15.

Two small specimens, 9 mm h. d., from the Sagami-Sea (Okinose, 360 m., 1. VII. 1914) recall through the colour of their primary spines, banded pink and white, so strikingly *Rhopalocidaris rosea*, that one would on a superficial examination decidedly refer them to that species. However, the character of the secondary and miliary spines are decidedly those of *mikado*, and there is also a distinct indication of basal disks on the primaries. As both species live here together in good numbers, the suggestion that we have here hybrids between them lies at hand. To give the definite proof of the correctness of this suggestion is, of course, impossible for the present. Only direct experiments can give such proof.

Goniocidaris (Discocidaris) peltata (Mrtsn.).

Pl. XV. 17—18.

Goniocidaris (Petalocidaris) peltata. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 261. Pls. **55—56; 74. 4—5; 78. 9—12.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	25 mm	15 mm	c. 12 mm (c. 50 % h.d.)	11.5 mm (46 % h.d.)	7—8	10—11	63 mm
2	19 —	13 —	9 — (45 —)	9 — (45 —)	7	9—11	70 —

Specimen 1 is the type-specimen from the "Albatross" (cf. Op. cit.).

Test rather high, flattened above, but not so below; sides arched, gently sloping towards the peristome. Circumference round. Shape of test recalling, to some degree, that of *Echinostrephus*, as does that of *G. florigera*. — Ambulacra rather distinctly sinuate. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles small, not contiguous, sometimes small miliaries between them. Inside the marginal tubercle the plates covered by small, more or less irregularly arranged tubercles, no naked median line being left. The horizontal sutures deepened, forming rather distinct grooves. The whole interporiferous zone sloping gently towards the midline. Pores (in the smaller specimen) rather small and in the upper part of the test distinctly oblique. The separating wall narrow, scarcely elevated; the ridge separating the adjoining pore-pairs high, the pores thus apparently deep-lying, though less so than in *florigera*. Pore-zone not sunk.

Interambulacra. Areoles fairly large, moderately sunk, the 3 proximal ones confluent, but the separating wall upon the whole narrow, except between the two uppermost ones; the subambital areoles rather distinctly tranverse-oval. Scrobicular tubercles fairly conspicuous, somewhat larger than the marginal ambulacral tubercles. The space outside the scrobicular circle closely covered by small irregularly arranged tubercles, the vertical median line just remaining distinct. In the larger specimen the miliaries also partly occupy the median line, leaving only a vertical series of small, slightly sunk grooves. Median end of the horizontal sutures only very

slightly deepened, forming thus only a very indistinct groove. No deepening at the adradial end of the horizontal sutures. The median area very narrow, only about half the width of an areole; it slopes gently towards the midline.

Apical system 45—50 % h. d., flat, not thickened, only the periproct slightly elevated. Oculars only partially insert; in the specimen 2 I—II exsert, III and V insert, IV excluded on account of the abnormal coalescence of genitals 3—4 (Fig. 58). Genital pores, ♀ fairly large, ♂ small, not very close to the edge. The plates closely covered with tubercles of a fairly uniform size; in the larger specimen there is a series of larger tubercles along the inner edge of the genital plates. — Peristome of the same size as the apical system, distinctly conical. 8—9 ambulacral plates in a series, the ambulacra joining more or less at the mouth-edge; the interradial plates form a regular series of 4—5 (6) plates, the outer one usually double.

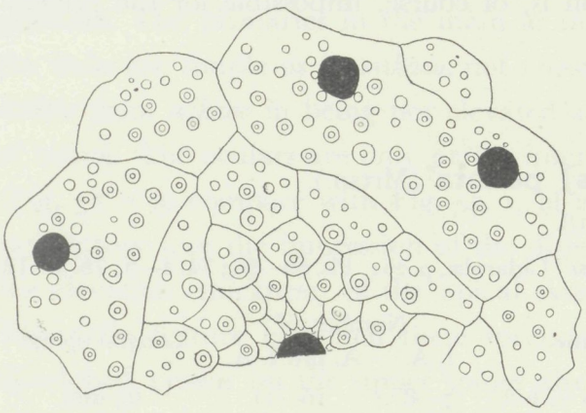


Fig. 58. Part of abnormal apical system of *Goniocidaris peltata*. × 8.

Primary spines 2.5—3.5 the h. d., distinctly curved downwards, gently tapering, the point with a very small crown. At the base of the spine there is a well developed disk all round, not showing the component, widened thorns. The edge is very finely serrate or entire. The shaft otherwise closely set with straight, not forwards directed thorns which are in the basal part flattened and widened, deeply serrate in the outer edge, forming more or less complete disks, as repetitions of the basal disk. The thorns are not arranged in regular series; only towards the point an indistinct serial arrangement is distinguishable. The adoral side of the spine nearly smooth. The whole surface of the shaft and the thorns closely set with erect, not anastomosing hairs, which are set only with some few small, fine excrescences; the point of the hairs is simple, not bifid. These hairs, rising vertically from the surface of the spine and from all sides of the thorns, make a perfectly wonderful bristling coat, equalling that of *D. mikado* in beauty, but scarcely so delicate as in that species. The collar is quite short, scarcely exceeding the inconspicuous milled ring. The uppermost spines of the smaller specimen as yet not wholly developed. In the larger specimen they are developed into large disks of oval shape, with rather coarsely serrate edge. They are all eccentric, the adapical side being the larger. The basal disk scarcely indicated on these apical spines. — The oral primaries are short, conspicuously serrate along the edges and also with a few thorns on the outer side. They are scarcely curved. The 3rd—4th forms the transition to the ambital spines.

Secondary spines. The scrobicular spines scarcely widened in the lower part, with sides almost parallel unto the straight cut end. They are more or less flattened (less so in the smaller specimen), the basal part somewhat inwards bent, concave, as seen in side view; the basal part thorny. The ambulacral marginal spines in the main like the scrobicular spines,

only much narrower. Those near the peristome more or less widened. The miliary spines very small, conical.

Pedicellariæ. The large globiferous pedicellariæ of the usual Goniocidarid shape, in the larger specimen dark pigmented and thus rather conspicuous on the white test; they are placed more or less regularly in the grooves of the interambulacra. The blade usually has a narrow, tube-shaped prolongation. The stalk quite short, no limb. The small globiferous form rather richly developed, with narrow, compressed valves, more or less elongate; the larger ones (head up to 0.5 mm) may resemble tridentate pedicellariæ, the more so as the valves may be more or less apart in the basal part. That they are, however, true globiferous pedicellariæ is evident, since the end tooth and the opening remain of the typical form. No large, coarse form of (apparent) tridentate pedicellariæ observed. — Spicules of the usual type.

Colour white, both on the primaries and on the naked test; only the young apical spines are of a reddish tint.

Occurrence. The type-specimen of this species was taken by the "Albatross" off Ternate, 235 m. (Stat. 5617). A second, younger specimen was dredged by the author at the Kei Islands, 5° 37′ S. 132° 23′ E., 245 m., sandy bottom (3. V. 1922). These two are the only specimens known till now.

Remarks. It seems scarcely doubtful that the specimen from the Kei Islands is a not yet adult specimen of *Goniocidaris* (*Discocidaris*) *peltata*, described in my report on the Cidarids collected by the "Albatross" in the Philippine Seas. The main difference, the lacking of the apical disks in the specimen from the Kei Islands, is decidedly only due to age — although the difference in size — 19 and 25 mm h. d. — is rather small; the undeveloped character of the upper spines in the Kei-specimen is proof that it has not reached its full size. — The other differences are: the more naked character of the median ambulacral and interambulacral area and a very slight difference in the secondary spines, which are slightly narrower in the Kei-specimen than in the type. The character of the more naked median area is again decidedly a juvenile character. Thus the only difference that seems real is in the slightly more slender secondaries. But that this is insufficient for creating a new species on that ground, I think will be generally agreed. Thus, at least until more material is at hand — and especially until the adult has been found also of the Kei-form — it seems to me the only reasonable course to regard them as identical.

The main reason for referring this species to the subgenus *Discocidaris* is the very great resemblance of the primary spines with those of *Gonioc. mikado*.

Goniocidaris (Aspidocidaris) clypeata Döderlein.

Pls. XV. 1—7; LXIX. 9; LXXVIII. 17—20.

Goniocidaris clypeata. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu-Inseln, p. 10.
Goniocidaris clypeata. Döderlein. 1886. Eine recente "Cidaris Buchi". N. Jahrb. f. Mineral. I. p. 192.
Goniocidaris clypeata. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ, p. 13, Taf. **VI. 1—19; VIII. 7. a—f.**
Goniocidaris (Discocidaris) clypeata. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 24, 29.
Goniocidaris (Discocidaris) clypeata. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97, 102.
Cidaris (Goniocidaris) clypeata. Yoshiwara. 1906. Japanese Echini. Pl. II. 11—12.
Goniocidaris clypeata (partim). A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 26. Pl. 10. (27)—31 (The fig. 27 is *Rhopalocidaris gracilis*).
Goniocidaris clypeata. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. p. 114.
Goniocidaris clypeata. H. L. Clark. 1907. The Cidaridæ, p. 196, 197.
Goniocidaris clypeata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
NON: *Discocidaris clypeata.* H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 33. (= *Rhopalocidaris rosea* Mrtsn.).
Goniocidaris clypeata. H. L. Clark. 1916. "Endeavour" Echinod. p. 102. (= *Goniocidaris australiæ* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	20 mm	10.5 mm	10 mm (50 % h.d.)	10 mm (50 % h.d.)	7	7—8	26 mm
2	20 —	11 —	10 — (50 —)	9 — (45 —)	7—8	8	27 —
3	15.5 —	9 —	9 — (58 —)	7 — (45 —)	6	7	21 —
4	13 —	7 —	7.5 — (57.7 —)	6.5 — (50 —)	6—7	7—8	16 —
5	12 —	7 —	c.7 — (c. 58 —)	6 — (50 —)	6	6—7	26 —
6	11 —	6 —	5.5 — (50 —)	5.5 — (50 —)	6—7	6—7	16 —

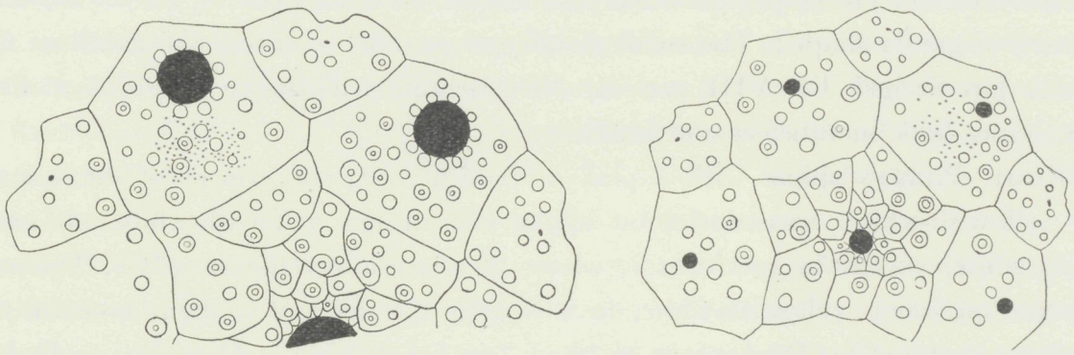
Specimen 3 is the type specimen; measurements copied from Döderlein. Specimen 2 and 4 in the Mus. Comp. Zool., the other specimens in the Copenhagen Museum.

Test flattened above and below; sides beautifully arched; circumference round or, in specimen 1, slightly subpentagonal. Ambulacra in the largest specimen rather distinctly sinuate. Interporiferous zone twice as wide as a pore zone; marginal series of tubercles very regular, the tubercles not quite contiguous in the largest specimens, more distant in the younger specimens. Inside the marginal tubercle there is one or, in the largest specimens, two tubercles at the lower edge, forming more or less regular vertical lines, sometimes also a tubercle on the middle of the plate causing some irregularity in the vertical serial arrangement of the inner tubercles. The median part of the plates otherwise naked and sunk; the horizontal sutures sunk so as to form rather distinct grooves. The pores equal-sized, separated by a narrow, elevated wall (Pl. LXIX. 9); the ridge fairly prominent. Pore zone not distinctly sunk.

Interambulacra. Areoles rather deep, small, round, well separated excepting only the two—three proximal ones. Tubercles not very prominent, without any trace of crenulation. Tubercles of scrobicular ring not much larger than the marginal ambulacral tubercles. The median space bare and sunk, only in the largest specimens the small tubercles outside the scrobicular circle fill up nearly the whole inner part of the plate unto the median line, the horizontal sutures,

however, remaining as fairly distinct, sunk grooves. The median part of the interambulacra about as wide as an areole.

Apical system about half h. d., or as much as 58 % h. d. Oculars as a rule exsert, only in specimen 1 Oc. V, in specimen 2 Oc. IV and V narrowly insert. The whole apical system fairly densely tuberculated (Fig. 59), not elevated above the test, as is usually rather distinctly the case in *D. mikado*. Female genital pores large, near the edge, male pores small, nearer the middle of the genital plates. — Peristome of the same size as the apical system, or somewhat smaller (45 % h. d.); it may be conspicuously protruding, as is usually the case also in *D. mikado*. There are 7—8 ambulacral plates in a series in specimen 1, 6—7 in specimen 2, but also 6—7



1 2

Fig. 59. Part of apical system of *Goniocidaris clypeata*, ♀ (1) and ♂ (2). 1 × 8; 2 × 10.

in the specimen of 11 mm. The adjoining radii may or may not join at the mouth edge; the interradial plates 3—4 in a series, sometimes irregularly double.

The primary spines up to ca. 1.3—2.3 h. d. The longer ambital ones are tapering to a rather fine point, more rarely with a slight crown-shaped widening at the point. At the base there is as a rule a disk-shaped widening, but not nearly as strongly developed as in *D. mikado*, and generally confined to the adapical side. Then follow some rather strong thorns, often hook-shaped, outwards curved, in the main bilaterally arranged. In about the outer half the spine is distinctly longitudinally furrowed, the ridges more or less distinctly serrate. The adoral side of the spines remains nearly smooth. The surface of the shaft covered with a coat of fine, anastomosing hairs (Fig. 50. 8—10), not nearly as strongly developed as in *mikado*. The anastomoses are in the main in a single plane a little above the base, thus forming something like a roof resting on low columns (viz. the base of the hairs), a long free point projecting from the anastomoses. Collar very short, scarcely longer than the very inconspicuous milled ring. — The uppermost spine in each series, or, in the largest specimens, the two uppermost spines, have the point widened into a usually very large, slightly concave disk, with finely serrate edge, and with the surface covered by fine hairs. The disk is eccentrical, the outer (abapical) side being the broader, especially on the outer ones of these spines; the innermost (nearest the apical system) are less eccentric or may have the adapical side of the terminal disk the broader, apparently

because there is no room for their widening outwards. These large terminal disks in adult specimens may form a complete covering over the upper side of the animal (Pl. XV. 6). — The oral primaries more or less strongly bilaterally serrate, otherwise smooth, slightly curved; the third forms the transition to the ambital spines.

The secondary spines around the base of the primaries simple, smooth, slightly flattened, not narrowing towards the straight cut end. They are scarcely more than 2 mm long, not very closely appressed. The ambulacral spines are similar, only narrower and somewhat shorter. The small spines outside the scrobicular circle, in the ambulacra and on the apical system are of the same main shape, but provided with high, serrate ridges (Pl. LXXVIII. 18—19).

Pedicellariæ. The large globiferous pedicellariæ (Pl. LXXVIII. 17, 20) are not very broad and not very elegantly shaped. The small globiferous as those of *mikado* (cf. excellent figures in Döderlein. Jap. Seeigel. Taf. VIII. 7. c—d). No tridentate pedicellariæ[1]. Spicules of the usual *Goniocidaris*-type, both in tubefeet and intestine.

Colour. Primary spines with a pink or reddish tint; the crowns of the apical spines white or yellowish-white. Secondaries on upper side of test yellowish-white, on under side more pure white, except in specimen 1, where they are also yellowish-white. The naked test in the larger specimens yellowish-white, in a smaller specimen of a slight greenish tint. The type-specimen is stated by Döderlein to be of "ein lichtes grau". According to H. L. Clark (The Cidaridæ, p. 197) the colour may also be "brown of some shade"; this holds good of specimen 2.

Biology. It appears to prefer a hard bottom. In one of the larger specimens the intestine was found to contain pieces of Bryozoa. The large size of the female genital pores indicates a large size of eggs and direct development. The suggestion set forth by Döderlein (Eine recente "Cidaris Buchi", 1886, p. 194) that the species might be viviparous, the shield-shaped apical spines serving to protect the brood, there is nothing to support. On the contrary, the fact that *Goniocidaris umbraculum*, although having similar shield-shaped apical primaries, carries its young on the peristome, would seem to indicate that these shield-shaped spines in the *Goniocidaris*-group as a whole are a peculiarity of that group, apparently without any special function.

The species does not appear to grow to a larger size than 20 mm h. d., the specimen of that size present in the material at hand, as also the specimen of the same size in the Mus. Comp. Zool., making the impression of being old and worn out. In the younger of the specimens of which measurements are given above, 11 mm h. d., the terminal crown of the upper spines are fully formed; in another, 10 mm h. d., the outer circle of crowns are still fairly small, the inner circle having just begun to appear. The genital pores are apparently fully developed at this size.

[1] The two peculiar forms of pedicellariæ figured in Agassiz & Clark's "Hawaiian Ech. Cidaridæ", Pl. 10. 27—28 are evidently not of *clypeata*, but of *Rhopalocidaris gracilis*, which species was confused with *clypeata* by the said authors. Probably also the large globiferous pedicellaria figured there (Pl. 10. 29) is not really of *clypeata*; but this is not so characteristic as to allow referring it definitely to some other species.

In the largest specimens the spines are somewhat overgrown by incrusting organisms, Bryozoa, worm-tubes, sponges. — No parasites are known from this species, and no abnormalities.

Occurrence. The species was originally found in the Sagami Sea, where it was again found by the "Albatross" in 1902 and 1906, and also by the present author and Dr. Sixten Bock in 1914 (ca. 360—700 m.). H. L. Clark also records it from off the Goto Islands and off Kagoshima Gulf ("Albatross" 1906), as well as from the Uraga Strait, Gulf of Tokyo. Although the "*Goniocidaris clypeata*" of these authors comprises also *Rhopalocidaris gracilis* (Död.) and *Rh. rosea* Mrtsn., the true *clypeata* is also represented from these localities, as I have been able to ascertain by my visit to the Museum Comp. Zool. and the U. S. National Museum in 1926. The statement of H. L. Clark, "The Cidaridæ", p. 197, that the species was also taken by the "Siboga", in the Malay Archipelago, rests on his identification of de Meijere's *Cidaris hirsutispinus* with *D. clypeata*. That this is an error is shown below (see under *Rhopalocidaris hirsutispina*). Also the Australian form referred by H. L. Clark, "Endeavour" Echinoderms, p. 102, to *D. clypeata* is a separate species, *G. australiæ* Mrtsn. (see that species). Accordingly the true *D. clypeata* is till now known only from the Japanese Seas from depths of ca. 100—ca. 700 m.

Remarks. The widened shield-shaped apical spines of this species to some degree recall the fossil *Anaulocidaris* Zittel, as pointed out by Döderlein (Eine recente "Cidaris Buchi", 1886; Japan. Seeigel, p. 14); that it is, however, only a parallel development, not indicating any nearer relation between the recent species and the Triassic *Anaulocidaris* was duly emphasized by Döderlein (loc. cit.); also Bather (Triassic Echinoderms of Bakony, 1909, p. 170) after his most careful study of *Anaulocidaris*, states that the two are quite different, being "extreme end-forms of two totally distinct evolutionary series, which have attained an outward similarity in this respect".

That the present species is not identical with de Meijere's *Cidaris hirsutispinus*, from the Malay Archipelago, as maintained by H. L. Clark, and not with the Australian form, *G. australiæ* Mrtsn. either, appears from the description of these species. The former of these species, indeed, makes the type of a very distinct genus, *Rhopalocidaris*, and has no nearer relation at all to *clypeata*. On the other hand, *clypeata* has doubtless a close relation to another of de Meijere's species, *Cidaris fimbriata*, which is regarded by H. L. Clark (The Cidaridæ, p. 199) as identical with *florigera*, which latter species Clark is recently (Cat. Rec. Sea-Urch. Brit. Mus., p. 34) likewise inclined to regard as identical with *clypeata*. That *florigera* is really quite different from either *clypeata* or *fimbriata* has been made sufficiently clear above and is, indeed, seen at a glance on comparing the figures given of the said species; the questionable thing as regards *clypeata* and *florigera* is not their specific difference, but whether they can really be referred to one and the same genus (cf. p. 152). Here need only be discussed the question, how *clypeata* and *fimbriata* may be distinguished. The differences between these two forms are, indeed, not very important, only the primary spines are thicker and more thorny in *fimbriata* than in *clypeata*, and the apical disks of the outer circle are scarcely at all eccentric in *fimbriata*, while in *clypeata* they are distinctly

eccentric, the outer part being much the stronger. However, as it appears from the material available that these characters are constant, it would seem beyond doubt that these two forms are really different species. (See further under *G. fimbriata*).

Goniocidaris (Aspidocidaris) fimbriata (de Meijere).

Pl. XV. 8—13; LXIX. 14; LXXVIII. 12—13.

Cidaris (Petalocidaris?) fimbriata. De Meijere. 1904. "Siboga" Echin. p. 22. Taf. **III. 20; XII. 133—134.**
Goniocidaris fimbriata. Döderlein. 1906. Ech. Deutsche Tiefsee-Exped. p. 102.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
15 mm	10 mm	7 mm (46.6 % h.d.)	7 mm (46.6 % h.d.)	7 (8)	7—8	20 mm
13 —	7 —	c. 7 — [1] (c. 54 —)	6 — (46.1 —)	6—7	7—8	22 —
11 —	6 —	5.8 — (52.7 —)	5 — (45.4 —)	6 (7)	7	20 —
10 —	5 —	5 — (50 —)	5 — (50 —)	6	6—7	19 —

The two smaller specimens are de Meijere's types.

Test flattened above and below; sides arched, circumference round. Ambulacra nearly straight. Interporiferous zone a little more than twice as broad as a pore-zone. Marginal series of tubercles very regular, the tubercles small, not contiguous. Inside the marginal tubercle each plate carries a smaller tubercle at the lower edge, and as a rule, at the ambitus, another tubercle higher up, nearer the inner corner, the two tubercles thus forming an obliquely upwards going series; sometimes there is a small miliary tubercle between two adjoining marginal tubercles (Pl. LXIX. 14); the naked median area hardly sunk, and the median end of the horizontal sutures forms only a very shallow and indistinct groove. The pore zone not sunk; the pores small, equal-sized, separated by a narrow, raised wall. The ridge rather low.

Interambulacra. Areoles not very deep, only the two-three proximal ones confluent. Tubercles not very large or prominent. Scrobicular circle of tubercles fairly prominent, the tubercles slightly larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates are uniformly covered with very small tubercles, leaving a rather broad, distinctly sunk, naked median line. Inner end of horizontal sutures deepened so as to form a fairly distinct groove. Median space about $^2/_3$ the width of an areole[2].

Apical system about half h. d. (46.6—ca. 54 %). All oculars exsert; female genital pores

[1] The apical system not to be measured exactly in this specimen on account of the widened apical spines; exact measurement would require the removing of some of these spines. But this measurement is scarcely sufficiently important for justifying the deterioration of the fine specimen.

[2] In the not dried and denuded specimens the naked median ambulacral and interambulacral space has the appearance of being relatively wider, on account of the somewhat shining skin which covers up also the small miliary tubercles, the spines of which lie close along the marginal or scrobicular spines. This applies also to other species with naked median lines.

large, about in the middle of the genital plate (Fig. 60). Periproct small. The ocular plates rather closely tuberculated, genital plates nearly bare, except for a ring of tubercles round the genital opening; it is flat, but may be somewhat thickened and raised (in the specimen of 11 mm, not so in the largest specimen). — Peristome of about the same size as the apical system, or somewhat smaller (the specimen of 11 mm h. d.). It is quite flat. There are 7—8 ambulacral plates in a series in the larger specimen, 5—7 in the second, only 4—5 in the two smaller ones. Interradial plates 4—5 in a single or double series in the largest specimen, nearly reaching the mouth edge, the ambulacra not joining at the mouth edge. In the smaller specimens there are only 3—4 interradial plates.

Primary spines ca. 1.5—2 h. d., rather thick at the base, tapering to a point, which is, however, in the adult specimens widened into a smaller or larger crown in the largest ambital spines. At the base of the shaft there is a fairly well developed disk on the adapical side of the spine; the shaft otherwise closely set with rather long, outwards curved thorns, which may be partly flattened, serrate in the point; as a rule they are not arranged in longitudinal series, except towards the end of the spine, and even there not always so. In the larger specimens the largest spines have the lateral thorns stronger; on the adoral side of the spine the thorns are smaller. The surface of the shaft otherwise covered with a close coat of fine hairs, which form a few anastomoses at their base. The collar very short, scarcely as wide as the milled ring, which is very inconspicuous. The apical spines in the two larger specimens widened into a large, slightly concave disk, the edge of which is only very finely serrate. These disks form a rather close, low roof over the apical part of the test, the shaft of these widened spines being very short. In the largest specimen there are two circles of them, the outer, larger, scarcely eccentrical, the inner, smaller, eccentrical, the broadest part of the disk being on the adapical side; in the second specimen only one circle of disks has appeared, that is to say only one in each interambulacrum, while in the fully adult the upper spine in both series of plates in each interambulacrum develops into such a disk. The upper surface of the disk with some rather coarse, simple hairs or thorns, especially in the middle. — The oral primaries rather coarsely serrate, the two proximal ones otherwise smooth, slightly curved; the third forms a transition to the ambital spines.

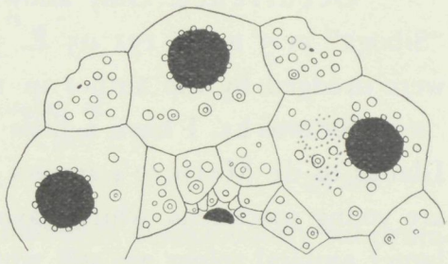


Fig. 60. Part of apical system of *Goniocidaris fimbriata*. ♀ × 8.

Secondary spines. The scrobicular spines ca. 2 mm long, flattened, not narrowing towards the straight cut end or, at most, (in the younger specimens) only very slightly narrowing. The marginal ambulacral spines narrower, otherwise similar; close to the peristome some of the marginal ambulacral spines may be widened towards the end, like those on the peristome. The small, miliary spines slender, with prominent serrate ridges.

Pedicellariæ. Only the small globiferous form has been found. The valves (Pl.

LXXVIII. 12—13) are rather elongate, the blade compressed; end tooth well developed. In general the end tooth is longer in the type than in the specimens from the Kei Islands; but it may be exactly as long in the latter — and I have observed samples of pedicellariæ of which one valve had a very long end tooth, the two others a much shorter one. — Spicules of tubefeet of the usual type.

Colour. Primaries and secondaries on apical side of test with a more or less distinct pinkish tint; the naked test (in the largest specimen) with a slight greenish-yellow tint. In the two smaller specimens the primaries pure white (as far as they are not obscured by the mud-particles attached to the fine hairs), the secondaries and the skin of the test somewhat more pinkish, while the denuded test is white.

Biology. The species would appear to prefer a muddy bottom. The large female genital pores indicate large eggs and direct development.

Occurrence. Only known from the Malay Archipelago; the types were taken by the "Siboga" at 3° 27′ S. 131° 05′ E. 567 m. (off the East end of Ceram). The two larger specimens were dredged by the author in 1922 at the Kei Islands, 5° 34′ S. 132° 50′ E. 370—400 m.

Remarks. I have a little hesitation in referring the two larger specimens from the Kei Islands to de Meijere's species *fimbriata*. It is quite evident that the two "Siboga" specimens are young specimens, which have not yet developed the shield-shaped apical spines, as also the larger ambital spines are still without any widening at the tip. This, of course, gives the young and the adult form a rather different aspect. The difference in general aspect is further increased through the slight pinkish tint of the primaries in the two adult specimens. Beyond this, however, I cannot find any noteworthy differences. The curious fact that in the largest specimen the general surface of the spines is smooth, entirely devoid of the usual coat of fine hairs, I cannot explain. As these hairs are developed in the typical way in the second specimen, though to a somewhat less extent, this is, evidently, no normal feature — probably due to the hairs having been worn off in one way or another.

H. L. Clark (Cidaridæ, p. 199) declares de Meijere's *fimbriata* the young of *G. florigera*, in which he is followed by Lambert & Thiéry (Bull. Soc. Sc. Nat. Haute Marne. VI, 1909, p. 25). That it has some relation to de Meijere's *florigera* (= *sibogæ* Mrtsn.), cannot be doubted, while to the true *florigera* it has certainly no nearer relation. Also to *D. crassa* Mrtsn. it has some resemblance but differs from both in its much smaller size, besides in other characters (see further under the said species). The species to which it is the nearest related is, however, *G. clypeata*. The only noteworthy differences from this species are found in the primary spines, which are conspicuously thicker and more thorny in *fimbriata* than in *clypeata*. The apical disks are very large and conspicuous in both forms, but it would appear to be a rather constant difference that the disks of the outer circle in *clypeata* are very distinctly eccentrical, the outer side being much the stronger, while in *fimbriata* they are scarcely at all eccentrical, and, if anything, the adapical side the more developed. These differences, judging from the material available, seem to afford characters important enough for regarding the two forms as distinct species. At least, until the

study of new material may have proved that the differences do not hold good, it would be unjustifiable to unite them into one and the same species.

A specimen of *G. clypeata* from 10—20 miles S.W. of the Goto Islands, 139 fathoms ("Albatross" Stat. 4900), which I have seen in the U. S. National Museum, has the primary spines almost as thick as those of *fimbriata*, and thus gives additional probability of *fimbriata* being identical with *clypeata*. As it has, however, no apical disks developed as yet, there is still no certainty that the two are really identical, and, therefore, it may be the more safe course to keep them separate for the present. If they are ultimately found to intergrade completely, *fimbriata* becomes a synonym of *clypeata*.

Goniocidaris (Aspidocidaris) alba Mrtsn.

Pl. XV. 14; LXIX. 7; LXXIX. 6.

Goniocidaris alba. Th. Mortensen. 1928. New Cidaridæ, p. 67.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
25 mm	16 mm	11.5 mm (46 % h.d.)	8.5 mm (34 % h.d.)	8—9	10—11	45 mm

Test flattened above and below; sides rounded; circumference conspicuously subpentagonal, the interambulacra bulging out rather strongly.

Ambulacra nearly straight. Interporiferous zone rather more than twice as broad as a pore zone. Marginal series of tubercles very regular, the tubercles small, not contiguous. Inside the marginal tubercles each plate carries a number of smaller tubercles not regularly arranged, no arrangement in vertical series being discernible. A couple of small miliary tubercles are found between each two adjoining marginal tubercles. The interporiferous zone as a whole scarcely sunk, but the horizontal sutures form fairly distinct, though shallow grooves, which are connected along the median sutures, there being thus a, not very distinct, sunk zigzag-line in the midline of the ambulacral area. The pores are rather small, equal-sized, separated by a narrow, raised wall. The ridge fairly sharp and high; the pore-zone not sunk (Pl. LXIX. 7).

Interambulacra. Areoles rather deep, round, well separated, only the three lower ones confluent; the tubercle rather small and not very prominent. Scrobicular tubercles small, scarcely larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates closely covered with very small tubercles, which show an indication of an arrangement in horizontal lines. Only a narrow median line remains naked and slightly sunk; a fairly distinct, but shallow, groove at the median end of the horizontal sutures, not at the outer, adradial end of the sutures. The median, ambulacral area somewhat more than half as wide as an areole. The upper areoles widely separated from each other so as to give room for rather numerous miliary tubercles between each two adjoining circles of scrobicular tubercles.

Apical system 46 % of h. d.; somewhat elevated, like a low rounded cone. Oculars all rather widely exsert; genital pores (female) large, about in the middle of the plate. Both oculars,

genitals and periproctal plates closely covered by small, uniform tubercles (Fig. 61). — Peristome remarkably small, only 34 % h. d.; it is not at all conically protruding. There are only 5—6 ambulacral plates in a series, the outer ones being unusually high; the neighbouring ambulacra join at the mouth edge. Only 2—3 interradial plates in a series.

Primary spines reach nearly twice the length of the h. d. They are rather thick and robust, gently tapering, with a small, very inconspicuous widening at the point. The longest of them are slightly curved downwards. At the base of the shaft there is a small disk, confined to the adapical side, and also incomplete in that the flattened thorns of which it is composed are only partly coalesced. The shaft with numerous, smaller, distalwards curved thorns, generally not showing any distinct arrangement in longitudinal series; on the adoral side of the shaft the thorns are somewhat smaller; near the point of the spine the thorns increase somewhat in size. The surface of the shaft otherwise covered with a fine coat of, at their base anastomosing, hairs (Fig. 50.13), these hairs being, however, low and not very conspicuous. Collar very low, not higher than the very inconspicuous milled ring. The uppermost primaries widened into large, eccentrical, somewhat excavate disks, with the edge entire or very slightly serrate. The broader part of the disk is turned towards the apical system; surface of the disk only very sparsely set with small hairs. The oral primaries very smooth, shining, slightly curved; the proximal ones with only 2—3 obsolete lateral thorns, the fourth, which forms, more or less distinctly, a transition to the ambital spines, with a conspicuous series of lateral thorns.

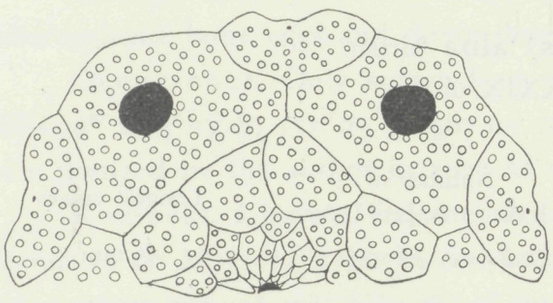


Fig. 61. Part of apical system of *Goniocidaris alba*, ♀. × 6.5.

The secondary spines. The scrobicular spines are flattened, slightly widened at the base and narrowing towards the end, which is broadly rounded; they are ca. 3 mm long. Ambulacral spines, as usually, narrower, more simply spiniform, ca. 2 mm long; those near the peristome somewhat widened towards the point. The miliary spines are slender, with prominent ridges, as those of *clypeata*. The secondaries, on the whole, not appressed.

Pedicellariæ. Only the small globiferous form present, but in good numbers and of fair size, up to ca. 1 mm length of head, and the stalk of about the same length. The valves are compressed, with a narrow opening and a not very large end tooth (Pl. LXXIX. 6). Spicules of tubefeet of the usual type.

Colour. Test and primary spines pure white; the secondaries of the apical side with a slight yellowish tint.

Biology unknown. The large genital pores suggest a large size of eggs and direct development.

Occurrence. The type and only specimen known was dredged by the author 21 miles W.$^1/_2$ S. of Bonomisaki, Satsuma, Japan, 400 m., on a sandy bottom. 13. V. 1914.

Remarks. From *clypeata* and *fimbriata*, with which species it agrees in the large size of the terminal disks, the present species differs so very conspicuously in several characters, especially the much closer and finer tuberculation of the test and apical system, the smaller size of the peristome, the different character of the primaries, that it is wholly out of question that it could be identical with any of those species. It is much more nearly related to the two following species, *crassa* and *sibogæ*, with which it forms a special group. From *crassa* it differs mainly in the characters of the test, which is much more finely and closely tuberculated than in the said species; also the median interambulacral area is conspicuously larger in *alba* and likewise the wall between the upper areoles much broader in *alba* than in *crassa*. In these regards *alba* comes nearer *sibogæ*, from which it differs, on the other hand, through its thicker and more closely and finely thorny primaries, as also in its larger apical disks.

Goniocidaris (Aspidocidaris) crassa Mrtsn.

Pl. XIII. 1—6; LXIX. 13; LXXIX. 2—5.

Goniocidaris crassa. Th. Mortensen. 1928. New Cidaridæ, p. 68.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
24 mm	15 mm	10.5 mm (43.8 % h.d.)	8 mm (33.3 % h.d.)	7—8	10—11	50 mm
23 —	14 —	10 mm (43.5 —)	8 mm (34.8 —)	8	10—11	48 —
20 —	12 —	9.2 — (46 —)	7 mm (35 —)	7—8	11—12	47 —
19 —	12 —	9 — (47.7 —)	7 — (37.2 —)	7—8	12—13	45 —

Test flattened above and below, sides rather high, but arched; circumference round. — Ambulacra rather conspicuously sinuate. Interporiferous zone somewhat more than twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles fairly prominent, nearly contiguous. Inside the marginal tubercle each plate carries as a rule two tubercles, one near the median corner; the outer of these tubercles form a regular vertical series, the median is so near that of the opposite plate that the arrangement in vertical series is somewhat obscured. Sometimes there are three tubercles, arranged in an oblique line, on the median part of the plate, the vertical arrangement being then still more indistinct. There is only a narrow, naked median line or none at all, and the median part of the horizontal sutures is moderately deepened, forming thus a not very conspicuous groove. The whole median area slightly sunk. The pores subequal, the outer one slightly the larger; they are placed rather obliquely and close together, the separating wall very narrow, but high (Pl. LXIX. 13). The ridge separating each two adjoining pairs of pores low and inconspicuous. The pore zone on the whole unusually narrow, slightly sunk.

Interambulacra. Areoles rather deep, only the 2—3 proximal ones confluent; only the subambital ones slightly transverse-oval. Tubercles not very prominent. Scrobicular tubercles scarcely larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates

are covered by fairly coarse tubercles, decreasing somewhat in size towards the median line; no naked median line is left, or merely an indication of it, and the median end of the horizontal sutures is only very slightly deepened, forming a very small and inconspicuous groove. Median area only half the width of an areole. The upper areoles rather close together so as scarcely to give room for any miliary tubercles between each two adjoining circles of scrobicular tubercles.

The apical system rather compact, the plates somewhat thickened so as to be slightly raised above the level of the test (recalling the condition in *G. mikado*); anal system flat. Oculars more or less widely exsert; in two of the specimens Oc. I is just in contact with the periproct, in another Oc. V is nearly insert. The inner corners of the genital plates may be somewhat sunk, there being thus a small groove separating the oculars from the periproct. Female genital pores large, close to the edge of the plate, male pores more distant from the edge. The whole apical system closely covered with tubercles of a rather uniform size (Fig. 62).

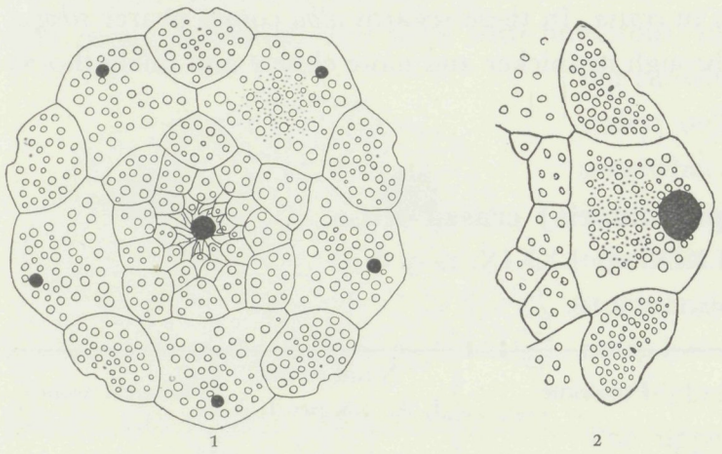


Fig. 62. Apical system of *Goniocidaris crassa*, ♂ (1) and ♀ (2). × 6.

Peristome distinctly smaller than apical system, only ca. 33—37 % h. d. against ca. 43—48 % h. d. in the apical system, and quite flat. There are only 4—5 ambulacral plates in a series, and usually 4 interradial plates in a single or an irregular, double row, reaching nearly to the mouth edge, the ambulacra not joining there. The outer ambulacral plates fairly high; tubercles very scarce.

Primary spines slightly more than twice the h. d. The ambital spines are rather thick and robust, tapering gently to a blunt point, which is only exceptionally widened into a small crown. At the base of the shaft a fairly large disk, on the adapical side only. The shaft closely set with rather large, slightly outwards curved thorns, which do not as a rule show any serial arrangement, scarcely so even at the end of the spine; as usual they are smaller on the adoral side of the spine. The surface of the shaft otherwise covered by a close coat of fine hairs, which anastomose at their base (Fig. 50. 11). The collar is somewhat more developed than usual in the *Aspidocidaris*-species, nearly 1 mm long, distinctly more than the very inconspicuous milled ring. In none of the specimens is there any indication of shield-shaped widened apical spines. Whether such will ultimately appear is a little uncertain, but as the uppermost spine in one series in each interambulacrum is still undeveloped, the possibility remains, and from analogy with the other species of the genus it is, indeed, most likely that the full grown specimens will prove to have 5 or rather 10 shield-shaped spines at the apex. The oral primaries are very slender, curved, smooth, with inconspicuous lateral serrations; the second and third often bifid at the point. The fourth forms the transition to the ambital spines.

Secondary spines. The scrobicular spines ca. 2.5 mm long, flattened, scarcely narrowing towards the straight cut, sometimes more or less distinctly bifid end. Marginal ambulacral spines narrower and short, but otherwise similar; those nearest the peristome somewhat widened and excavate towards the end. Miliary spines rather broad, but of the usual type, with serrate ridges. — Spicules of the usual type, both in tubefeet and intestine.

Pedicellariæ. Only the small form of globiferous pedicellariæ has been observed. It is of the type with elongate, compressed valves, and a fairly large opening and end tooth (Pl. LXXIX. 2 and 5). They reach a size of up to 0.5 mm length of head; stalk about the same length. Further "tridentate" pedicellariæ occur sparingly, on the test — also one seen on the periproct — a large, coarse form, with the blade filled up with meshwork that forms fairly distinct, finely serrate, longitudinal ridges, leaving a small, irregular space, like an indistinct terminal opening, near the point (Pl. LXXIX. 3—4); this form measures ca. 1 mm length of head, the stalk being slightly shorter.

Colour. Test and secondaries yellowish-white; primary spines white, only with a slight tint of pinkish on the collar. The naked test pure white.

Biology. Appears to live on a muddy bottom. In the intestine of one specimen was found bottom-material, with Globigerina and remains of worm tubes. — The large female pores indicate large eggs and direct development.

Occurrence. Only known from off Mindanao, S.E. of Dumanquilas Point (7° 25′ N. 123° 14′ E., ca. 450 m.), where four specimens were taken in one haul, 9. III. 1914 (the author).

Remarks. This species has some general resemblance to *fimbriata* de Meijere, from which it is, however, at once distinguished through its much larger size; and this difference is not simply due to age. The fully adult *fimbriata* measures only 15 mm h. d., while the specimens in hand of *crassa* measure 19—24 mm h. d. though having not yet the apical disks developed and therefore not yet adult; thus the adult *crassa* must be expected to be about twice the size of *fimbriata*. A fully formed spine, with its hair-coat developed, of plates 5—6[1] in *fimbriata* is at most ca. 20 mm long, ca. 2.5 mm thick; in *crassa* a fully formed spine of plate 5 is ca. 35—40 mm, of plate 6 ca. 45 mm long, ca. 3 mm thick. It is perfectly evident that there is no possibility of these fully formed spines of *fimbriata* ever reaching the size of those from the corresponding plates of *crassa*. This difference in the primaries, together with the difference in the oral primaries (much more smooth in *crassa*), in the apical system (much more closely tuberculated in *crassa*) sufficiently shows that the resemblance between *crassa* and *fimbriata* is only apparent.

The species to which *crassa* bears the most general resemblance is *alba*, from which it differs, however, very conspicuously in the characters of the test, as set forth under the said

[1] As the number of ambulacral plates on the peristome in *fimbriata* (the type) is 5—6 in a series, it cannot be doubted that the real (serial) number of the coronal interambulacral plates is the same in both *fimbriata* and *crassa* (cf. the author's paper "On the postlarval development of some Cidarids"). The different length of the primaries, therefore, is not due to their belonging to plates of different numerical value.

species. Also to the species *sibogæ* it has a good deal of resemblance, but differs from it in its much larger and thicker spines, its narrower and less closely tuberculated median interambulacral space and its peculiar narrow pore-zones.

The three species *alba*, *crassa* and *sibogæ* evidently form a separate group within the subgenus *Aspidocidaris*; possibly it will ultimately be found that they cannot be kept as separate species. With the material at present available there is, however, no difficulty in distinguishing them from each other, and it would, therefore, be unjustifiable to unite them into one species.

Goniocidaris (Aspidocidaris) sibogæ Mrtsn.

Pls. XVI. 6—9; LXIX. 11; LXXVIII. 14—16.

Cidaris (Petalocidaris) florigera A. Ag. De Meijere. 1904. "Siboga"-Ech. p. 21. Taf. XII. 128—132.
Goniocidaris sibogæ. Th. Mortensen. 1928. New Cidaridæ, p. 68.
NON: *Goniocidaris florigera*. A. Agassiz. 1881. "Challenger" Ech. p. 46. Pl. I. 7—20.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
22 mm	13.5 mm	11 mm (50 % h.d.)	8 mm (36.3 % h.d.)	8	10—11	c. 32 mm
22 —	13 —	11 — (50 —)	8 — (36.3 —)	(7) 8	10—11	31 —
20 —	13.5 —	10 — (50 —)	7.5 — (37.5 —)	8	10—11	31 —

Test slightly flattened above and below; sides arched; circumference subpentagonal or round. — Ambulacra slightly sinuate. Interporiferous zone a little more than twice the width of a pore-zone. Marginal series of tubercles very regular, the tubercles not quite contiguous. Inside the marginal tubercle each plate carries 2—3 tubercles of about equal size, somewhat irregularly disposed so that an arrangement in vertical series is not discernible. The inner end of the horizontal sutures is somewhat sunk and thus forms not very conspicuous grooves which are more or less distinctly connected along the vertical midline. The whole interporiferous zone (inside the marginal series) somewhat sunken. Pores subequal, the outer one slightly the larger; in one specimen they are equal-sized. They are separated by a narrow, but high and conspicuous wall. The ridge rather low. Pore zone scarcely sunk (Pl. LXIX. 11).

Interambulacra. Areoles fairly deep, well separated, only the two—three proximal ones confluent; the subambital ones scarcely a little transverse-oval. Scrobicular tubercles not very prominent, scarcely larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates closely covered by tubercles gradually diminishing in size towards the midline, which is not naked. The tubercles are thus disposed as to form rather conspicuous horizontal ridges, separated by furrows. The median end of the horizontal sutures forms a small, but fairly distinct groove. Median area slightly more than half the width of an areole.

Apical system just half h. d., flattened or a very little elevated. The plates are not so

thick as to be raised above the level of the test. Oculars all exsert. Female genital pores large, ca. 1.5 mm, close to the edge; male pores more distant from the edge, relatively large, ca. 0.3 mm. The whole apical system closely covered with tubercles of a rather uniform size (Fig. 63).

Peristome only ca. 36—38 % h. d., thus very considerably smaller than the apical system; it is slightly sunk. There are 5—6 ambulacral plates in a series; the interradial plates 1—3 in a series, or even none, not reaching the mouth edge; the ambulacra do not join at the mouth edge in two of the specimens, but are joining there in the third specimen.

Primary spines. Ambital spines ca. 1.5 h. d. They are rather slender, nearly cylindrical or slightly fusiform, gently tapering in the distal part to a blunt point, which is not crown-shaped widened. At the base of the shaft there is a small, but distinct disk on the adapical side of the spine, generally consisting of two lateral parts, not united in the middle. The shaft otherwise set with small outwards bent thorns which may be more or less distinctly arranged in longitudinal series, especially in the distal part; sometimes the serial arrangement is not at all distinct. The surface of the shaft (in not worn spines) covered by a close coat of low hairs, which anastomose at their base; the point is usually incurved (Fig. 50. 12). The collar about the same length as the inconspicuous milled ring. The apical spines are widened into a not very large disk with more or less coarsely serrate edge (in one specimen the two disks left appear to have had the edge scarcely at all serrate). The disk is eccentric, the broader part on the adapical side. The oral primaries have the edges distinctly, but obtusely serrate. The proximal ones short, somewhat widening in the distal part, which ends square cut or broadly rounded; they are slightly curved. The fourth forms the transition to the ambital spines.

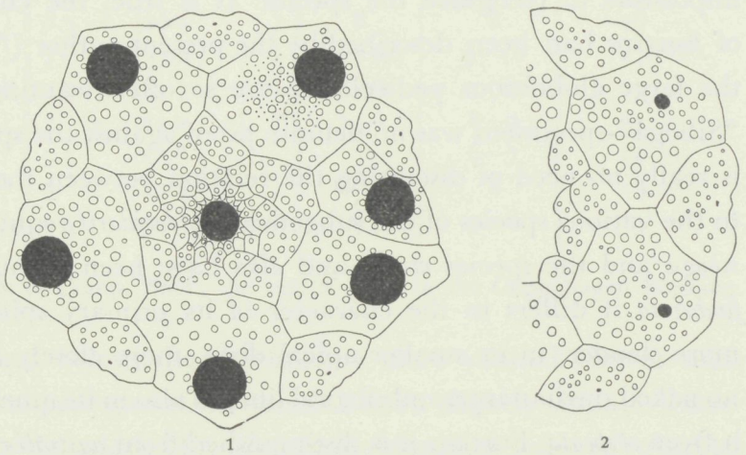


Fig. 63. Apical system of *Goniocidaris sibogæ*, ♀ (1) and ♂ (2). × 5.

Secondary spines. The scrobicular spines are ca. 3 mm long, flattened, scarcely at all narrowing towards the straight cut end. The marginal ambulacral spines are shorter and narrower, but distinctly flattened. Those near the peristomial edge are widened and excavate at the point. The miliary spines slender, with serrate ridges, as usual.

Pedicellariæ. Large globiferous pedicellariæ not found. The small globiferous with rather elongate valves, with compressed blade, fairly large opening and a more or less conspicuous end tooth (Pl. LXXVIII. 14—15). Tridentate pedicellariæ fairly common, with short, thick valves, filled with meshwork, except for an irregular slit at the end (Pl. LXXVIII. 16); the head ca. 0.7 mm long, stalk about the same length. Spicules of tubefeet rather smooth.

Colour. Primaries and the naked test white; secondaries and the skin of test of a slight pinkish tint.

Abnormalities. One specimen has genital 1 divided into two separate plates, each with its fully developed pore (Fig. 63. 1).

Occurrence. Only the three specimens known, dredged by the "Siboga" at 5° 3′ S. 119° E., 450 m.

Remarks. That this species has no nearer relation to *florigera*, to which it was referred by de Meijere[1], is perfectly evident, as the merest glance at the figures of the two species given here will show; but it is only just to point out that the characters of the true *florigera* were at the time when de Meijere wrote his work so insufficiently known that it was, indeed, rather impossible to recognize the species. It is true, the characteristic large globiferous pedicellariæ of *florigera* had been described by the present author ("Ingolf" Ech. I. p. 18. Pl. X. 27), but as the large globiferous pedicellariæ are so often wanting in Cidarids, their non-existence in the "Siboga"-specimens was no definite proof against the specimens belonging to *florigera*. While there is really no need of discussing the relation between the present species and *florigera*, its relations to the various species of the subgenus *Aspidocidaris* require some remarks. The differences between *sibogæ* and the species *crassa* and *alba* have been pointed out under the said two species. From *fimbriata* it differs in the character of its primary spines, which are more cylindrical and also more slender, in its smaller apical disks, more closely tuberculated apical system and in having no naked median interambulacral line, as also in its much larger size. The same features distinguish it from *clypeata*. Further it is distinguished from *australiæ* mainly through lacking the characteristic green colour of the test usually — though not quite constantly — found in that species, and through having no naked median line. Also the oral primaries are more smooth than in *australiæ*. Otherwise its general resemblance with *australiæ* is very great, and it forms, upon the whole, a connecting link between the latter and the species *crassa* and *alba* on one side and *clypeata* and *fimbriata* on the other side. Possibly it will ultimately, when a richer material is available, be found that the differences pointed out do not hold good. But judging from the material at hand it would be perfectly inadmissible to unite all these forms into one species.

[1] The single spine from Stat. 12 which de Meijere refers to *G. florigera* appears to be correctly identified (see under *G. florigera*, p. 169).

Goniocidaris (Aspidocidaris) australiæ Mrtsn.

Pl. XVI. 1—5; LXIX. 12; LXXVIII. 21—25.

Goniocidaris clypeata. H. L. Clark. 1916. "Endeavour" Ech. p. 102.
Goniocidaris australiæ. Th. Mortensen. 1928. New Cidaridæ, p. 68.
NON: *Goniocidaris clypeata* (Döderlein).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	24 mm	15 mm	11 mm (45.8 % h.d.)	9 mm (37.5 % h.d.)	8	9	36 mm
2	24 —	15 —	11.5 — (48 —)	9 — (37.5 —)	8 (9)	8—9	31 —
3	23 —	14 —	11 — (47.8 —)	8 — (36.1 —)	8	9—10	32 —
4	22 —	14 —	10 — (45.4 —)	8.5 — (38.6 —)	7—8	9—10	
5	21 —	13.5 —	10.5 — (50 —)	8.5 — (40.5 —)	8	8	28 —
6	18.5 —	12 —	9 — (48.7 —)	7 — (37.8 —)	6—7 (8)	9—10	27 —
7	18 —	10.5 —	9 — (50 —)	7.5 — (41.7 —)	7—8	7 (6)	21 —
8	17 —	10 —	8.5 — (50 —)	7 — (41.2 —)	7—8	8—9	33 —
9	12 —	7 —	6.5 — (54.2 —)	5.5 — (45.8 —)	7	6—7	14 —
10	11 —	6.5 —	6 — (54.5 —)	5 — (45.4 —)	6—7	6	13 —
11	8.5 —	5 —	5 — (58.8 —)	4.5 — (53 —)	6	5—6	13 —

Specimens 2, 5—7, 10, 11 in the Museum of Comp. Zool., the rest of them in the Copenhagen Museum.

Test somewhat flattened above and below, the specimen 2 more vaulted above; sides arched, circumference round or slightly subpentagonal. — Ambulacra slightly sinuate. Interporiferous zone somewhat more than twice the width of a pore zone. Marginal series of tubercles very regular; tubercles nearly contiguous. Close inside the marginal tubercle there is one or two tubercles, forming a rather indistinct longitudinal series, and generally a smaller one (or two such) towards the median end of the plate, forming a sort of elevated ridge, limited by the rather broad, deepened horizontal sutures and the likewise deepened, naked midline. Pores equal sized, separated by a fairly broad wall, raised into a distinct tubercle. Ridge not very prominent, rounded, not sharp (Pl. LXIX. 12).

Interambulacra. Areoles fairly deep, well separated, only the two proximal ones confluent; the subambital ones at most with a slight indication of being transverse-oval; tubercles rather small, not very prominent. Scrobicular tubercles not very prominent, only slightly larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates closely covered with smaller tubercles, gradually diminishing in size towards the rather conspicuous, sunk, naked, median line. The limit between the sunk median part and the innermost tubercles usually quite distinct, the tubercles forming like raised, sharply limited ridges into the sunk part. The median end of the horizontal sutures forms rather conspicuous grooves. Median area ca. $^3/_4$ the width of an areole.

Apical system ca. 45—50 % h. d., somewhat larger in the smaller specimens, flattened or somewhat raised. Oculars all exsert. The whole apical system closely covered with rather

uniform tubercles (Fig. 64). Female genital pores about 1 mm wide, not very close to the edge; male pores smaller, more distant from the edge.

Peristome ca. 36—41 % h. d., thus distinctly smaller than apical system. There are 5—7 ambulacral plates in a series, and a single or an irregular double series of interradial plates reaching the mouth edge, or at least very near to it. The outer ambulacral plates rather high, with only few tubercles along the inner edge.

Primary spines ca. 1.5 the h. d.; they are rather slender, tapering very gently towards the point, which is obtuse, more rarely widened into a small crown. At the base of the shaft there are some coarse thorns, which usually unite across the adapical side so as to form a more or less distinct disk, in which, however, the single component thorns remain distinct. The disk is developed only on some of the spines. Beyond the disk the thorns may continue a little distance as a pair of more conspicuous lateral series, the shaft of the spine being otherwise not very closely set with smaller thorns, arranged in distinct longitudinal series. Surface of well preserved spines covered with a close coat of fine, anastomosing hairs (Fig. 50. 14). Collar about the length of the milled ring, which is, as usual in this group, very inconspicuous. Apical primaries widened into a usually rather small disk with the edge entire or very slightly serrate. The disk is nearly concentrical or sometimes eccentrical, more developed on the adapical side; the "stalk" rather long. The largest specimens have (— as far as can be seen; spines partly lost —) only 5 of the apical spines developed into disks; but specimen 6 has all the spines no. 1, and in a pair of the interambulacral series even the two upper ones developed into disks; also in specimen 10 all the spines no. 1 are developed into disks, and even in specimen 11 there are five well developed disks. The oral primaries with rather conspicuous lateral serrations, also often with some small thorns on the aboral side, thus not very smooth. They are slightly curved towards the end, which is straight cut. They are, upon the whole, rather short. The third, more exceptionally the fourth, forms the transition to the ambital primaries.

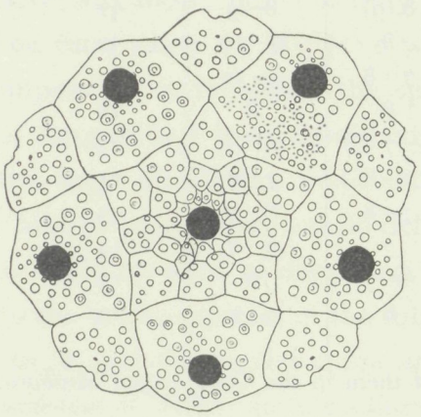


Fig. 64. Apical system of *Goniocidaris australiæ*, ♀. × 5.

Secondary spines. The scrobicular spines ca. 2 mm long, flattened, somewhat widened in the lower part, gently narrowing towards the straight cut end. Marginal ambulacral spines likewise more or less distinctly flattened, but of the same width in their whole length; those near the edge of peristome not widened towards the point. Miliary spines of the usual form, flattened, with prominent, serrate ridges.

Pedicellariæ. The large globiferous form not globular, with rather narrow valves (Pl. LXXVIII. 21, 23). The small form of globiferous pedicellariæ not especially characteristic, the blade not strongly compressed, the end tooth well developed (Pl. LXXVIII. 24—25). They reach a size of ca. 0.5 mm length of head, with the stalk of about the same length. The only two

samples of tridentate pedicellariæ observed are perhaps not quite fully formed; but in any case they are of the usual Goniocidarid type, in reality, as seen very plainly in the figure, Pl. LXXVIII. 22, transformed globiferous pedicellariæ. — Spicules of the usual type in tubefeet and intestine.

Colour. Primary spines (when clean) white, with a more or less distinct pinkish tint on the basal part, especially the collar; the oral primaries with a more or less distinct greenish tint. Secondaries and test yellowish. The denuded test generally distinctly greenish on upper side, especially on the apical system; this green colour is generally discernible also on the not denuded test.

Biology. In a specimen of 10 mm h. d. the genital pores have not yet appeared; in two others of 11 and 12 mm h. d. they are fully formed (female). It would appear that the species does not grow to a much larger size than ca. 25 mm h. d., the largest specimens in hand having the appearance of being old, with the spines much overgrown by foreign organisms, Bryozoans, Hydroids, sponges etc. It is remarkable that specimens of 11—12 mm h. d. are already fully mature, though the full size is about twice as much. Still I do not think it possible to distinguish these smaller specimens from the larger ones; at least, I cannot see other distinct differences than the size. It would seem rather probable that specimens as that of 11 mm h. d. with all the upper spines developed into disks would never have attained a much larger size — being, perhaps, dwarfish specimens. This, of course, is a mere suggestion which can only be verified on living material. — The large size of the female genital pores indicate large and yolky eggs and, therefore, a direct development. — The contents of the intestine in a specimen opened were mainly pieces of Bryozoa, but also some Foraminifera.

No Parasites are known from this species.

Occurrence. Some specimens of this species were found by the author during his trip with the "Endeavour" in September 1914 off the S. E. Australian coast, viz. 38° 10′ S. 149° 55′ E. c. 340—430 m. 1 specimen; 38° 15′ S. 149° 20′ E. c. 270—360 m. 2 specimens; 38° 12′ S. 149° 40′ E. c. 180—290 m. 1 specimen; 38° 05′ S. 150° E. c. 360—470 m. 2 specimens; 37° 45′ S. 150° 10′ E. c. 270—470 m. 4 specimens.

To this species belong also the specimens recorded by H. L. Clark in his "Endeavour" Echinoderms, p. 102, under the name of *Goniocidaris clypeata* Döderlein, excepting those from Cape Pillar, which are young *Goniocidaris tubaria*.

To the present species likewise belong the specimens from the Tasmanian Sea (Maria Isl., 135 m) figured by Koehler in his Report on the Echinoids of the Australian Antarctic Expedition, Pl. 92.3 and 11, under the name of *Goniocidaris impressa* (cf. above, p. 163).

Bathymetrical distribution ca. 70—470 m.

Remarks. That this Australian form is not identical with the Japanese *Gonioc. clypeata*, as it is stated to be in the work of H. L. Clark quoted, is in my opinion beyond doubt. Especially the primaries are different — the disk much less developed and the hairs on the surface of the shaft quite different. Also the smaller peristome and the conspicuous green colour of the naked test in

australiæ marks the latter very conspicuously. The nearest related species appears to be *sibogæ*, from which it differs in its conspicuous naked median line, in the green colour of the test and in the more coarse character of its oral primaries (cf. the remarks under *sibogæ*, p. 200).

Goniocidaris (Cyrtocidaris) tenuispina Mrtsn.

Goniocidaris (Cyrtocidaris) tenuispina. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 264. Pls. **57, 1—2; 58, 1; 59, 2; 61, 6—8; 63, 5; 75, 5—6; 79, 1—3.**

This species (and subgenus) is characterized by the long and slender, rather strongly spinous and somewhat downwards curving primary spines, by the very smooth, curved and rather long oral primaries, and by the slender and pointed secondary spines. The basal disk of the primary spines not very much developed; the apical disks well developed, generally with a more or less indented edge.

For the full description of this species, as well as of the two following varieties, see the work quoted.

Var. **tuberculata** Mrtsn.

Op. cit. p. 269. Pls. **57, 3; 59, 1; 61, 9—11; 73, 7—8; 79, 4—8.**

Differs from the typical form in the closer tuberculation of ambulacra, interambulacra and apical system, as also in the somewhat different shape of the ocular plates.

Var. **major** Mrtsn.

Op. cit. p. 270. Pls. **58, 2; 79, 9.**

Characterized by its larger size and its coarser primary spines, the thorns of which are, on the other hand, smaller than in the typical form, but increase in size towards the end of the spine, which they do not in the typical form.

Both the typical form and the varieties known only from the Philippine Seas, in depths of 570—1411 m.

Genus Schizocidaris Mrtsn.

Th. Mortensen. 1903. "Ingolf" Ech. I. p. 25, 28.
L. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 94.
H. L. Clark. 1907. The Cidaridæ, p. 175.
Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 55. Note.
Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 275.

Test low, flattened both above and below. Apical system about half h. d., peristome somewhat smaller, flat. Grooves of test small, but fairly distinct. Usually no distinct naked mid-line in either ambulacral or interambulacral area. Pores not sunk. Primary spines more or less thorny with no disk at base, and apical spines not widened into a terminal disk. Surface of primary spines apparently smooth and shining, in reality covered with a close coat of hairs, which widen at their ends into a flat, fenestrated plate, coalescing with the neighbours so as to

form a close, smooth roof covering the whole surface of the spine and the larger thorns, resting on the basal part of the hairs as upon columns. Collar short and inconspicuous. Secondaries smooth, flattened. Miliary spines slender. Large globiferous pedicellariæ unknown; small globiferous of the typical Goniocidarid form, or with a long, narrow, slit-like opening. True tridentate pedicellariæ unknown, but the small globiferous form may develop into a large, coarse form, resembling tridentate pedicellariæ. Spicules of intestine three-radiate.

Genotype: *Schizocidaris assimilis* Mrtsn.

The character upon which this genus was originally based ("Ingolf" Ech. I. p. 24—25), the peculiar long, slit-like opening of the pedicellariæ is decidedly not of generic value; in this I agree completely with Döderlein and H. L. Clark, who both reject the genus. Nevertheless the genus is perfectly valid, characterized especially through the rather unique[1] character of the hair-covering of the primaries, as also through the total absence of both basal and apical disks.

Besides the type-species *assimilis* also the species which I designated in the "Ingolf" Ech. I. (p. 25) as *Discocidaris* (?) *serrata* and a third species, *fasciata* Mrtsn., collected by the "Albatross" at the Philippines, belong to this genus. While this latter species, although known in only a single small specimen, is very distinct and beyond doubt well distinguished from the two others, the difference between *assimilis* and *serrata* is rather inconsiderable, so that it may perhaps be ultimately found that they cannot be held as separate species. If so, the name *serrata* as the first of them is the one to be retained.

A. Agassiz & H. L. Clark (Prelim. Rep. Echini, 1906, "Albatross". Bull. Mus. C. Z. LI. p. 112) express the opinion that, if the genus *Schizocidaris* is to be recognized, *Stereocidaris sceptriferoides* Döderl. should also be referred to it, because its pedicellariæ are of a similar structure as that originally thought peculiar to the genus *Schizocidaris*. This, of course, is out of question, the narrow pedicellariæ being not the real and essential character of *Schizocidaris*, while *Stereocidaris sceptriferoides* is not at all a Goniocidarid and has no indication of the structure of spines characteristic of *Schizocidaris*.

This genus is hitherto known only from the Malay Archipelago.

Key to the species of Schizocidaris.

1. Primary spines tapering to a point, of a uniform white colour ..... 2.
   Primary spines nearly cylindrical, ending in a small crown; colour of primaries white with red bands ..... *fasciata.*
2. Globiferous pedicellariæ with long, narrow, slit-like opening ..... *assimilis.*
   Globiferous pedicellariæ with short, rather broad opening ..... *serrata.*

[1] Only in *Centrocidaris* a similar structure occurs.

Schizocidaris assimilis Mrtsn.

Pls. XVII. 1—9; LXIX. 18—19; LXXIX. 25—33.

Goniocidaris florigera, pro parte. A. Agassiz. 1881. "Chall." Ech. p. 46.
Schizocidaris assimilis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 25. Pl. X. 25, 28.
Cidaris (Discocidaris) serrata Mrtsn. De Meijere. 1904. "Siboga" Ech. p. 19.
Schizocidaris assimilis. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 55. Note.
Discocidaris florigera, pro parte. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 33, 34.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	23 mm	14 mm	12 mm (52.2 % h.d.)	10 mm (43.6 % h.d.)	8	8—10	42 mm
2	22 —	13 —	11 — (50 —)	9 — (40.9 —)	8	9—10	35 —
3	21 —	12 —	10 — (57 —)	8.5 — (40.5 —)	7	9—10	c. 35 —
4	21 —	12 —	10.5 — (50 —)	9 — (42.9 —)	7—8	9—10	c. 40 —
5	20.5 —	12 —	10.5 — (52 —)	9 — (44.4 —)	8	9—10	c. 30 —
6	19 —	11 —	9.5 — (50 —)	8 — (42.1 —)	8	8—9	
7	18 —	9 —	9 — (50 —)	7 — (39 —)	7—8	9—10	
8	17 —	10 —	8 — (47 —)	7 — (41 —)	7—8	8—9	
9	15 —	7 —	6.5 — (43.3 —)	6 — (40 —)	7	8—9	36 —
10	11.5 —	5.5 —	6 — (52 —)	5 — (43.4 —)	6—7	8—9	26 —
11	8 —	4 —	4 — (50 —)	3.5 — (43.7 —)	6—7	6—7	14 —

Specimen 4 is the type specimen (in the British Museum).

Test low, conspicuously flattened both above and below; sides arched, circumference round or slightly subpentagonal. — Ambulacra only slightly sinuate. Interporiferous zone ca. twice the width of a pore-zone. Marginal series of tubercles very regular, the tubercles rather small, not contiguous. Inside the marginal tubercle there is a somewhat smaller one at the lower edge of the plate and then, according to age, one or more small tubercles on the median part; in the largest specimen the plate is thus wholly covered by a number of tubercles, leaving only the horizontal sutures bare and deepened into grooves, the vertical suture scarcely remaining distinct. In the smaller specimens (also in the holotype) the whole median zone is deepened, excepting the part occupied by the tubercle at the lower edge; in such specimens the arrangement in vertical series is also distinct (Pl. LXIX. 18—19). The pores are equal sized, separated by a moderately narrow, but high wall; the ridge low. Pore area not sunk.

Interambulacra. Areoles moderately deep, somewhat deeper in the middle at the upper and lower edge; the subambital ones transverse-oval; usually the three—four lower ones, sometimes also the fourth and fifth, confluent. The horizontal suture between the two uppermost plates in each series usually somewhat deepened. The scrobicular ring rather prominent, the tubercles distinctly larger than the marginal ambulacral tubercles. Median part of plates closely covered with very small tubercles which are fairly distinctly arranged in horizontal lines, separated by furrows. The vertical median line, however, remains distinct, slightly deepened. The horizontal

sutures form fairly distinct grooves. The whole median part sinking gradually towards the midline; no naked part along the adradial edge of the plates. The median zone about $^2/_3$ the width of an areole. In younger specimens the arrangement of the miliary tubercles in horizontal rows is not yet distinct.

Apical system usually about half the h. d., but varies from ca. 57 % to 47 % h. d.; exceptionally it was found as small as 43.3 % h. d. It may be quite flat or slightly elevated, but is never thickened so as to be raised with its edges above the level of the test. The oculars are as a rule all insert, more or less widely (scarcely so in the type specimen). Female genital pores large, ca. 1.2 mm diameter, not far from the outer edge; male pores small, in the middle of the plate. Madreporite not enlarged. Periproct with only few, rather large plates. All the plates of the apical system closely covered with small tubercles of a rather uniform size, leaving only a more or less narrow space along the edge bare; at the adapical corner of the larger periproctal plates there is usually a single larger tubercle (Fig. 65). — Peristome distinctly smaller than the apical system, flat, not prominent.

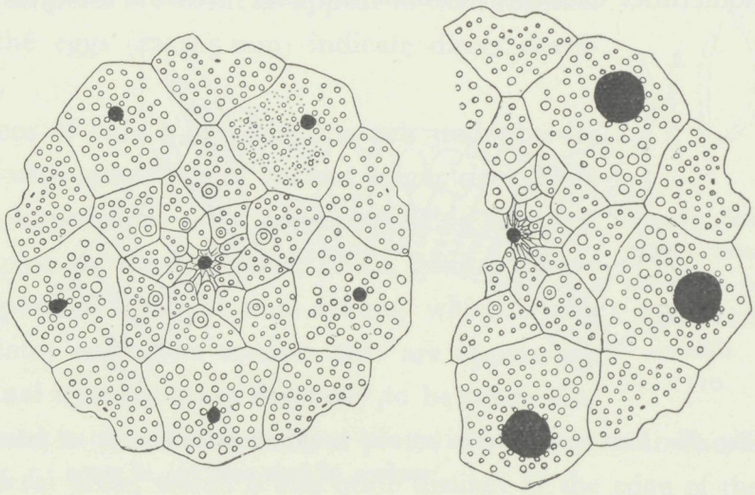


Fig. 65. Apical system of *Schizocidaris assimilis*, ♂ (1) and ♀ (2). × 6.

The number of ambulacral plates in a series is, in the larger specimens, 7—8; in the specimen 11.5 mm h. d. there are 6 of them, at a size of 8 mm h. d. only 4, of 6 mm h. d. only 3. The ambulacra join more or less closely at the oral end, thus excluding the interradial series from the mouth edge. There are 3—5 interradial plates in a single series or they are more or less broken up, so as to form irregular double series.

Primary spines ca. 1.5 to twice the h. d., in younger specimens sometimes a little more than twice the h. d. They taper very regularly to a rather fine point, which is not widened into a crown; usually the longer spines are slightly curved downwards. No trace of a disk at the base; the shaft set with numerous sharp, rather coarse, slightly outwards directed thorns, forming two very conspicuous lateral series and often one prominent median series on the adapical side; more rarely there are numerous thorns on the adapical side, arranged more or less distinctly in 3—5 longitudinal series. Adoral side of the shaft nearly smooth; the thorns which may be found there, more or less numerously and usually not distinctly arranged in longitudinal series, are much smaller than those of the adapical side. Surface of the shaft otherwise shining and perfectly smooth — apparently. In reality it is covered with a dense coat of hairs, but these hairs are branching and anastomosing at their top so as to form a quite uniform surface, under the microscope seen

to be finely fenestrated. The hairs thus form like a roof over the whole surface of the spine and its thorns, a roof supported by the basal part of the hairs like columns (Fig. 66). The collar is quite short, not exceeding the very inconspicuous milled ring. The apical spines of adult specimens of the same shape as the ambital spines, only much shorter, about half the length of these latter; there is thus no trace of the apical disks so characteristic of *Goniocidaris*. The oral primaries are very slender, scarcely curved, smooth, except for the distinct lateral serrations. The 3rd or 4th transitional to the ambital spines.

Secondary spines. The scrobicular spines are scarcely 2 mm long, smooth, flat and thin, sometimes excavate towards the end, which is straight cut, sometimes finely serrate; the sides

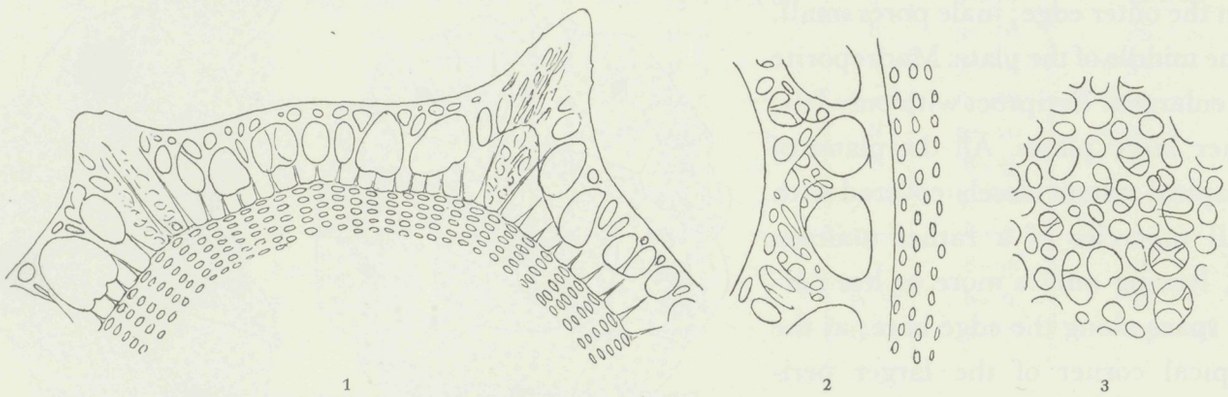


Fig. 66. Part of transverse (1) and longitudinal section (2) of primary spine of *Schizocidaris assimilis*; part of outer surface of hair-coat (3) of same. 1 × 65; 2—3 × 125.

nearly straight. Marginal ambulacral spines much more slender, sometimes slightly widened towards the point; those near the peristome not different from the others. Spines of the interradii of peristome distinctly shorter and more slender than the ambulacral ones. Miliary spines slender, pointed, with finely serrate ridges.

Pedicellariæ. Large globiferous pedicellariæ not observed in any of the specimens at hand, thus — if at all present in this form — of very rare occurrence. The small globiferous pedicellariæ fairly numerous, and of various sizes, up to ca. 1 mm length of head, generally with a long and narrow, slit-like opening (Pl. LXXIX. 27—28, 30—32); the stalk usually scarcely as long as the head. The larger samples have quite the appearance of tridentate pedicellariæ, the blade being filled with a dense, irregular meshwork, leaving only a narrow slit at the point, as in the tridentate pedicellariæ of *Goniocidaris*. That they are, in reality, transformed globiferous pedicellariæ, appears from the fact that all transitional forms are found from the small, typical globiferous, with their well developed end tooth and well limited, rather short opening, to such as have a long, slender blade, with a long, slit-like, but well formed opening, and further to the large coarse forms with the blade filled up with meshwork and the opening reduced to an irregular, terminal slit (Pl. LXXIX. 25—26, 29, 33). Spicules of tubefeet nearly perfectly smooth, curved rods (Fig. 67), those of intestine of the usual triradiate form.

Colour. Primary spines pure white. Secondaries and test yellowish-white. The naked test

of a more or less pronounced greenish tint, the periproct and the genital plates being the darkest, forming thus a more or less conspicuous starshaped figure. The green colour continues to a various degree on to the interambulacra, the colour especially concentrating at the upper and lower edge of the areoles. Sometimes the green tint may continue nearly to the peristome, which latter is, however, always white. Tubefeet white.

Biology. In the intestine of one specimen were found numerous Foraminifera, together with bottom-material. Another specimen was quite empty. — The largest of the specimens in hand have decidedly the appearance of being full grown, thus the species may well be supposed not to exceed ca. 25 mm h. d. The genital pores are about to appear in the specimen of 11.5 mm h. d. The large size of the eggs (ca. 0.5 mm) indicate direct development.



Fig. 67. Spicules from tubefeet of *Schizocidaris assimilis*. ×110.

A couple of very young specimens of only 3 mm h. d., which undoubtedly belong to this species (found together with specimens of various larger sizes, from 6 mm to adult, Station 46 of the Kei-Expedition) offer some interesting features. The apical side is almost wholly occupied by the five large, green, genital plates. The oculars are very small, widely separated from the anal system, which is also very small; there are 5 (? 6) anal plates and some smaller ones are apparently about to develop in the middle. The anal opening is not distinctly to be made out, it rather appears not to have been formed as yet. There are four plates in each interambulacral series, besides the primary interambulacral plate, which is still quite distinct at the edge of the peristome. There are only ca. 8 ambulacral plates in each series, and on the peristome there is, besides the first pair, only one plate in each radius. In two of the interradii a small plate has already appeared, proximally to the primary interambulacral plate, which is only beginning to be absorbed. The primary spines are somewhat fusiform, simply thorny, still without the cortex-layer. The secondary spines are partly of an embryonal character, terminating in a spiny crown. These embryonal spines are found on the apical system, the peristome and the proximal ambulacral plates; those of the other plates are of the final type, only, of course, still very small and slender. The pedicellariæ and the spicules of tubefeet are of the typical form. — At a size of 6 mm h. d. the primary interambulacral plate has disappeared; there are three plates in each ambulacral series on the peristome, 17—18 ambulacral and 5—6 interambulacral plates in each series; the primary spines have the typical hair-coat — on the whole the specific characters are already fairly distinct at this size.

The spines of the larger specimens are not much overgrown with foreign organisms, only now and then a small *Scalpellum* or a barnacle, a few Serpulid-tubes or a few Bryozoa and Foraminifera, but scarcely ever a sponge. A species of Ophiurid (*Ophiothamnus* sp.?) is not rarely found attached to the apical spines, and several specimens carry a commensal Polynoid worm. One specimen is infested with a parasitic snail, a *Pelseneeria*. — A few small abnormalities were observed: coalesced ambulacral plates or a quite irregular arrangement in an ambulacral

series, apparently caused by a wound (Fig. 68). Worth mentioning is also a case of a bifid primary spine, which is a rather unusual case among Cidarids (Pl. XVII. 9).

Occurrence. The type of this species was taken by the "Challenger" at Station 192, at the Kei Islands, recorded as *Goniocidaris florigera*. Here it was found again by the "Siboga" Expedition, recorded as *Cidaris* (*Discocidaris*) *serrata* Mrtsn, and finally the author found it in various places at the Kei Islands during the Danish Expedition to these Islands in 1922 (Station 2. 180—220 m.; St. 3. 245 m.; St. 4. 250 m.; St. 5. 250—290 m.; St. 13. 275 m.; St. 32. 260 m.; St. 41. 245 m.; St. 42. 225 m.; St. 45. 270 m.; St. 46. 300 m.; St. 49. 245 m.; St. 63. ca. 250 m. Bottom sand—mud). These stations (the exact place of which may be found in the author's Report on the Danish Expedition to the Kei Islands 1922. Vid. Medd. Dansk Naturh. Forening. Bd. 76. 1923) are situated between Little Kei and the Tajando Islands, where the species must be very common. As yet it is known only from this single small area, off the Kei Islands; but it must, of course, be expected that it will be found to have a wider distribution in the Malay Archipelago.

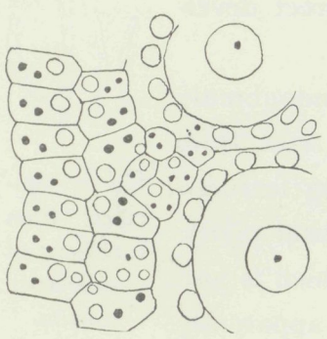


Fig. 68. Part of abnormal ambulacrum of *Schizocidaris assimilis*. × 12.

Remarks. This species was originally referred by A. Agassiz ("Challenger" Ech. loc. cit.) to his *Goniocidaris florigera*, being regarded only as an individual variation of this supposedly exceedingly variable species. The present author, having had in 1901 the opportunity of examining the various specimens identified by Agassiz as *Goniocidaris florigera*, separated this form, under the name *Schizocidaris assimilis*, from *G. florigera* not only as a distinct species, but also as a separate genus, while another form (from St. 204) was distinguished as a second species, designated as *Discocidaris* (?) *serrata*[1]. H. L. Clark in his "Cidaridæ" 1907 (p. 198) with full right declared that if these species "are to be accepted, more adequate descriptions are necessary and the differences between the three species made more tangible". I perfectly agree that the few characters brought forth in the "Ingolf" Ech. I. are by no means sufficient for proving their distinctness; the reserved position of Clark therefore was fully justified. But in 1925 Clark declares (Cat. Rec. Sea-Urch. Br. Mus. p. 33—34) after having had the opportunity himself of examining these same specimens, that he agrees with Agassiz in regarding them all, viz. the typical *florigera*, *serrata* and *assimilis*, as one and the same highly variable species. I am perfectly unable to account for this result except on assuming that Clark did not examine the specimens except in a very cursory way, thus failing to discover the very conspicuous difference found in the structure of both their tests and spines; indeed, one has the impression that the fact that the apical system is greenish coloured in all of them to Clark outweighs the structural differences of both test and spines. — And it may be especially emphasized that the rich material in hand

[1] The fact that I had then no time to undertake a more detailed study of these forms, but had to confine myself mainly to the study of their pedicellariæ must account for my failing to discover the peculiar character of the primary spines of these forms, and, therefore, of realizing that the two species belonged to the same genus.

of *assimilis* does not in the slightest way support the assertion of the very great variability of these forms. On the contrary, there is a remarkable constancy of their characters and general appearance so that one could never mistake one for the other, or, when seeing specimens of the two forms together, think of regarding them as one and the same species. It is true, I have only seen one specimen of *florigera* besides the type-specimen in the British Museum; but these two specimens agree very completely in their various characters, and there is not the slightest reason to suppose that this species should be so very much more variable than the other species of this whole group.

Schizocidaris serrata (Mrtsn.).

Pls. XVII. 10; LXXIX. 23—24.

Goniocidaris florigera A. Agassiz. 1881. "Chall." Ech. p. 46. (partim). Pl. **I. 7—11.**
Discocidaris (?) *serrata.* Th. Mortensen. 1903. "Ingolf" Ech. I. p. 25, 29. Pl. X. 6—7.
Schizocidaris serrata. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 276. Pls. **61. 1; 74. 1—2; 78. 1.**

This species is very closely related to *Sch. assimilis*, the main difference being found in the pedicellariæ, which have only a short opening, not long and slit-like as in *assimilis* (Pl. LXXIX. 23—24 to compare with Pl. LXXIX. 27—28, 30—32). The large tridentate-like form of pedicellariæ has not been observed in this species. Further the interporiferous zone of the ambulacra is somewhat more closely tuberculated and the primary spines less strongly thorny than in *assimilis*; also the dark brownish colour of the tubefeet on the oral side appears to be a good character distinguishing it from *assimilis*.

For the full description of this species see Op. cit. 1927.

Known only from the Philippine Seas, ca. 160—185 m.

Schizocidaris fasciata Mrtsn.

Schizocidaris fasciata. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 280. Pls. **61. 3; 74. 3; 78. 2.**

Differs conspicuously from the two other species in its primary spines being nearly cylindrical, ending in a small crown and banded with red. Also the pedicellariæ are different from those of the other species; the valves are very short, with a very short opening and a large end tooth. The brownish colour of these pedicellariæ makes them rather conspicuous, in spite of their small size.

For the full description of this species see Op. cit.

The single, young specimen known was taken by the "Albatross" off the Sulu Islands (6° 09′ N. 121° 14′ E., 283 m.).

Genus **Psilocidaris** Mrtsn.

Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 282.

Fairly conspicuous grooves and a naked, sunk, median line in the interambulacra, scarcely so in the ambulacra. Pores rather close together, separated by a slightly raised wall. Primary tubercles perforate, non-crenulate. Apical system somewhat more than half h. d., conspicuously

larger than peristome. Primary spines very long and slender, without basal disk; apical spines without terminal widening. General surface of spines with short, conical stumps. Secondary spines slender, setaceous, not appressed. Globiferous pedicellariæ with slender valves in apparently both the large and the small form.

Genotype and only known species: *Psilocidaris echinulata* Mrtsn.

This genus bears great resemblance to the subgenus *Cyrtocidaris* of *Goniocidaris* and, on the other hand, to the genus *Aporocidaris*, and thus appears as a connecting link between the two groups: *Goniocidarina* and *Ctenocidarina*.

Psilocidaris echinulata Mrtsn.

Psilocidaris echinulata. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 283. Pls. **60. 1—2; 61. 4—5; 63. 4; 73. 3—4; 78. 3—5.**

The species is mainly characterized by its very long (3—5 h. d.), slender primary spines, which are covered with small, rather erect spinules, only very indistinctly arranged in ca. 8 longitudinal series. Small globiferous pedicellariæ partly much elongated, so as to resemble tridentate pedicellariæ.

For the full description of this species see Op. cit.

Known only from the Philippine Seas (off the Sulu and Palawan Isl.), 1400—1751 m.

Genus **Rhopalocidaris** Mrtsn.

Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 272.

Test flattened or spherical. Ambulacra and interambulacra with a very conspicuous, naked, sunk, median area, into which the grooves of the horizontal sutures are merging. Pores more or less close together, separated by an elevated wall. Primary tubercles perforate, non-crenulate. Apical system about half h. d.; madreporite not enlarged. Periproct small, with a moderate number of periproctal plates. Peristome of the same size as or somewhat smaller than the apical system, more or less conical, with fairly numerous ambulacral plates, very compact. Primary spines without basal disk; the apical primaries simple or, at most, with a very small terminal widening. Surface of primaries covered with a well developed coat of simple, not branching or anastomosing hairs (Fig. 69); the hairs are much longer in the basal than in the outer part. The primary spines otherwise usually with fairly conspicuous longitudinal ridges and furrows, rather strongly thorny in the basal part; collar very short. Secondary spines club-shaped, not appressed. Globiferous pedicellariæ, both the large and small form, of the typical Goniocidarid structure. A larger form of the small globiferous pedicellariæ occurs, with elongate valves, recalling tridentate pedicellariæ (Pl. LXXIX. 9, 11, 15, 16). The large, coarse form of "tridentate" pedicellariæ usually found in *Goniocidaris* and *Schizocidaris* apparently does not occur here. Spicules of tubefeet rather strongly thorny; those of the intestine three-

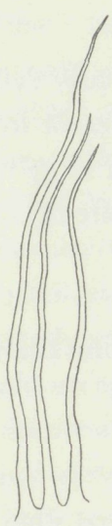


Fig. 69. Hairs from a primary spine of *Rhopalocidaris gracilis*. × 125.

radiate, but very slender and somewhat irregular, and very scarce. Very small forms, scarcely exceeding 20 mm h. d.

Genotype: *Cidaris* (*Discocidaris*?) *hirsutispinus* de Meijere.

It is maintained by H. L. Clark (The Cidaridæ, p. 197) that this species is "evidently a young example" of *Goniocidaris clypeata*, the secondaries of *clypeata* being "frequently exactly like de Meijere's figure". Also Lambert & Thiéry ("Notes Échinologiques I. Sur le genre Cidaris. Bull. Soc. Sc. nat. Haute Marne. VI. 1909, p. 25) state that "Cidaris hirsutispinis .... n'est que le jeune Goniocidaris clypeata", probably relying on the above statement of H. L. Clark. In spite of these statements there can be no doubt but that *hirsutispina* has nothing to do with *clypeata*, and the supposed frequent existence of similar club-shaped secondary spines in *clypeata* is simply due to the confounding of species of the genus *Rhopalocidaris* with *Goniocidaris clypeata*. The study of the fairly rich material of these forms at the author's disposal leaves no doubt but that these are perfectly valid species, very constant in their characters and quite different from *clypeata*.

The three, perhaps five, species (— two are for the present distinguished as varities only —) of the genus known till now all agree in the main characters of the genus: the peculiar club-shaped, secondary spines, the lacking of both basal and apical disks on the primaries, the broad naked, sunk median area in both ambulacra and interambulacra, the genus thus being very well circumscribed. — All of them are very small forms, representing, besides such *Goniocidaris*-species as *clypeata* and *fimbriata*, real pygmies, the smallest of all recent Cidarids.

Key to the species and varieties of Rhopalocidaris.

1. Primary spines white ..... 2.
   Primary spines banded with red ..... 4.
2. Primary spines scarcely exceeding h.d., only the 2—4 proximal areoles confluent; apical system rather closely tuberculated ..... 3.
   Primary spines about twice the h.d.; the 4—6 proximal areoles confluent; apical system with very few tubercles ..... *gracilis*
3. Colour of test white ..... *hirsutispina*
   Colour of test green ..... *hirsutispina*, var. *viridis*
4. Red bands of primary spines confluent; secondary spines rather coarse, the adapical ones in most of the scrobicular circles distinctly brownish-green ..... *rosea*
   Red bands of primary spines separated by rather broad, whitish or greenish bands; secondary spines very slender, the adapical ones in the upper scrobicular circles scarcely with an indication of greenish colour ..... *rosea*, var. *tenuis*

Rhopalocidaris hirsutispina (de Meijere).

Pls. XVI. 13; LXIX. 21; LXXIX. 9—11.

Cidaris (Discocidaris?) hirsutispinus. De Meijere. 1904. "Siboga" Ech. p. 20. Taf. XII. 124—127.
Goniocidaris (Discocidaris) hirsutipinnis (sic!). Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 102.
Goniocidaris clypeata, partim. H. L. Clark. 1907. The Cidaridæ, p. 197.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
1	14 mm	8 mm	7 mm (50 % h.d.)	7 mm (50 % h.d.)	7	5	14 mm
2	10 mm	6 —[1]	5 — (50 —)	5 — (50 —)	6—7	5	16 —

The specimen 2 is the type-specimen.

Test flattened above, not, or scarcely so, below, the test more sloping towards the raised peristome. Sides in the smaller specimen rather vertical, in the larger specimen beautifully arched. Circumference round.

Ambulacra scarcely sinuate. Interporiferous zone about three times the width of a pore-zone. Marginal series of tubercles very regular; the marginal tubercles with a well developed mamelon; they are not contiguous, but separated by a smaller tubercle. Inside the marginal tubercle each plate carries, in the larger specimen, another tubercle at the lower edge of the plate, not much smaller than the marginal one; the rest of the plate is otherwise entirely naked and sunk, there being thus a very conspicuous bare, sunk median part, in which the grooves at the horizontal sutures are scarcely marked separately. This sunken part is finely, but distinctly horizontally striped. In the small specimen there is only here and there a smaller tubercle inside the marginal series, the interporiferous zone being thus almost wholly naked, as correctly stated by de Meijere. The pores are, in the larger specimen, fairly large, separated by a narrow, elevated, oblique wall (Pl. LXIX. 21); in the smaller specimen the pores are smaller and the separating wall narrower. The ridge rather low.

Interambulacra. Areoles rather small, not very deep, the 3—4 proximal ones confluent; only the lowermost one slightly transverse oval. The scrobicular circle not very prominent, the tubercles scarcely larger than the marginal ambulacral tubercles. Outside the scrobicular ring there are, on the median part of the plate one or two half-circles of tubercles nearly as large as the scrobicular ones, alternating with these latter; the rest of the median part entirely bare and sunk; the horizontal grooves scarcely separately marked off. On the adradial side there is at most a single series of small tubercles alternating with the scrobicular tubercles, and there is scarcely an indication of a groove at the adradial end of the horizontal sutures. The median area is about 1.5 times as broad as an areole.

Apical system half h. d., flat, not raised above the level of the test. Ocular plates all

[1] De Meijere (Op. cit.) states the height to be 7 mm; this evidently depends on his having included the elevated peristome in the measurement, while here, as everywhere in the present work, the "height" means solely the height of the corona.

exsert, more widely so in the larger than in the smaller specimen. Female genital pores large, about in the middle of the plate. Whether the small genital pores in the small specimen mean that it is a male specimen or only that the pores are just about to appear, cannot be decided. Periproct small, with few, comparatively large plates. The whole apical system moderately closely tuberculated, a fairly broad edge of the genital plates remaining bare (Fig. 70).

Peristome of the same size as the apical system, conically raised. There are 8—9 ambulacral plates in a series in the larger, 7—8 in the smaller specimen; the ambulacra join at the mouth edge. 4—6 plates in the interradii, partly irregularly doubled.

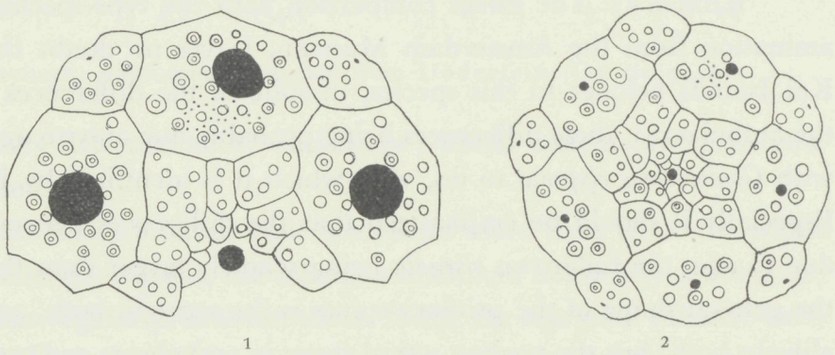


Fig. 70. Apical system of *Rhopalocidaris hirsutispina*, ♀ (1) and ♂ (2). × 8.

Primary spines in the larger specimen rather coarse, not more than h. d., tapering gently to a blunt point. In the smaller specimen they are more slender and finely pointed, and also longer, ca. 1.5 h. d. They are provided with some irregularly arranged coarse, outstanding thorns, which continue almost to the end of the spine, gradually diminishing in size. The outer part of the spine with some rather prominent ridges. The surface otherwise covered with a close coat of rather long, fine, not anastomosing hairs, which give the spines a rather shaggy appearance, as expressed in the species-name; they diminish in size along with the thorns, the outer part of the spine being almost naked. The apical spines of the larger specimen with a small crown. — The oral primaries small, straight, with rather distinct lateral serrations. The third is transitional to the ambital spines.

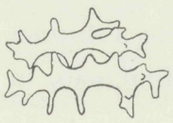


Fig. 71. Spicules from tubefeet of *Rhopalocidaris hirsutispina*. × 230.

Secondary spines scarcely more than 1 mm long, the scrobicular and marginal ambulacral spines being of the same size, all of them very distinctly club-shaped and more or less distinctly curved near the tip. Also the miliary spines of the same form, only more slender and shorter. All the secondaries more or less erect.

Pedicellariæ. Large globiferous form not observed; the small globiferous form with a conspicuous end tooth and a fairly large opening (Pl. LXXIX. 10), the valves scarcely compressed. Besides this form (length of head ca. 0.2 mm) a much larger form (head ca. 0.6 mm) occurs, which recalls tridentate pedicellariæ, though retaining its globiferous structure (Pl. LXXIX. 9, 11); the valves are apart in the lower part of the blade. — Spicules of tubefeet rather coarsely serrate (Fig. 71).

Colour. Primary spines slightly pinkish at the base, otherwise whitish or yellowish, as are also the secondary spines. In the smaller specimen there is a trace of a pinkish band near

the end of one of the primary spines. The naked test white, in the larger specimen with a trace of greenish on the genital plates.

Occurrence. The type-specimen was found off Waigeu (130° 5′ E. 0° 29′ S. 469 m., sand, shells. "Siboga", St. 156). The second specimen was taken by the author at the Kei Islands (5° 28′ S. 132° 36′ E. 385 m. coral, sponges). — The species thus is known hitherto only from the Eastern part of the Malay Archipelago.

Remarks. The direct comparison with the type-specimen of *hirsutispina*, lent me for examination from the Amsterdam Museum, leaves no doubt that the larger specimen from the Kei Islands belongs to this species, in spite of the differences pointed out above (especially in the ambulacra), these differences being probably due only to age. — That the species has nothing with *Goniocidaris clypeata* to do, with which it is identified by H. L. Clark, is perfectly evident. Especially it should be emphasized that the differences between *hirsutispina* and *clypeata* are not due to age, the fullgrown *clypeata* being scarcely larger than the adult *hirsutispina*. True enough, the general shape of the primary spines is the same in both, and the apical system is very much alike in both; but the median naked space in ambulacra and interambulacra is not nearly as deep and sharply limited in *clypeata* as in *hirsutispina*; then the difference in the secondary spines, the total lacking of both basal and apical disks in *hirsutispina*, while in *clypeata* they are so exceedingly developed, the hairs, anastomosing in *clypeata*, not so in *hirsutispina*, are so striking features that the identity of the two forms must be out of question.

Rhopalocidaris hirsutispina, var. **viridis** Mrtsn.

Rhopalocidaris hirsutispina, var. *viridis*. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 273. Pls. **61.2; 73.1—2; 78. 6—8.**

Differs from the typical *Rh. hirsutispina* mainly in the greenish colour of the test and in the primary tubercles being somewhat larger. — Probably it will be found to represent a distinct species. The single specimen known was taken by the "Albatross" off northern Mindanao, in a depth of 296 m.

For full description see the work quoted.

Rhopalocidaris gracilis (Döderlein).

Pls. XVI. 10—12; XVII. 11—12; LXIX. 22; LXXIX. 12—17.

Dorocidaris (?) *gracilis*. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu Inseln. p. 6.
Porocidaris gracilis. Döderlein. 1887. Japan. Seeigel. I. p. 8. Taf. **IV. 8—20; VIII. 5. a—e.**
Porocidaris gracilis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 30.
Goniocidaris (?) *gracilis*. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 97, 102.
Goniocidaris clypeata, A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 27. partim.
Goniocidaris clypeata, H. L. Clark. 1907. The Cidaridæ, p. 197. partim.
Dorocidaris gracilis. Lambert & Thiéry. 1925. Ess. nom. rais. p. 560.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
19 mm	12 mm	9.5 mm (50 % h.d.)	9.5 mm (50 % h.d.)	8	7—8	32 mm
17 —	10 —	8.5 — (50 —)	8.5 — (50 —)	7—8	8	23 —
17 —	11 —	8.5 — (50 —)	8.5 — (50 —)	7	7—8	38 —
16 —	10.5 —	8 — (50 —)	8 — (50 —)	7—8	6—7	
13 —	8.5 —	6.5 — (50 —)	7 — (54 —)	6—7	6—7	32 —
7.5 —	4.7 —	5 — (66 —)	4.1 — (54.7 —)	6	3	22 —

The small specimen the type-specimen; measurements quoted from Döderlein (Op. cit. p. 49).

Test rather spherical, scarcely flattened above and below; apical system and peristome slightly raised. Circumference round.

Ambulacra slightly sinuate. Interporiferous zone somewhat more than twice the width of a pore-zone. Marginal series of tubercles regular, the tubercles small and not nearly contiguous; a small tubercle is found, more or less regularly, between them. Inside the marginal tubercle each plate carries another, somewhat smaller tubercle at the lower edge of the plate; the rest of the plate is naked, sunk, forming thus a conspicuous bare, sunk median part, in which the horizontal grooves are scarcely separately marked off. There is no distinct horizontal striation in the median area. Pores equal-sized, or the outer somewhat the larger, rather close together, the wall between them rather narrow, elevated; ridge low. The poriferous zone somewhat sunken (Pl. LXIX. 22).

Interambulacra. Areoles rather deep, the 4—5 or even 6 proximal ones confluent; only the 2—3 proximal ones slightly transverse-oval. Tubercle small in comparison with the size of the areole. The scrobicular ring rather inconspicuous, the tubercles not larger than the marginal ambulacral tubercles. Outside the scrobicular circle there is on the median part of the plate usually only a single half-circle of tubercles alternating with the scrobicular tubercles, scarcely smaller than the latter. The rest of the plate bare, sunk, only here and there a tubercle, more or less distinctly separated from the raised, tubercle-bearing part of the plate. The horizontal sutures slightly deepened, so that the horizontal grooves are just marked separately in the broad sunk median part of the interambulacra. On the adradial side there is a more or less regular series of tubercles alternating with the scrobicular ones. There is scarcely an indication of a groove at the adradial end of the horizontal sutures. The median part of the interambulacra about as wide as an areole.

Apical system rather constantly exactly half h. d., only in the young comparatively much larger. Oculars all rather widely exsert. Female genital pores large, generally near the edge of the plate, sometimes even rupturing the edge; in one of the specimens they are, however, nearer the middle of the plate; male pores small, near the middle of the plate. The genital plates remarkably bare, with only a few tubercles round the genital pores (Fig. 72). Periproct small, with few plates, rather closely covered with small tubercles. — Peristome of the same size as

the apical system, more rarely slightly larger. There are 9—10 plates in a series in the ambulacra; these latter join at the mouth edge. Interradial plates 4—6 in a fairly regular series.

Primary spines varying in length, ca. 1.5—2.5 h. d. They are rather slender, gently tapering to a rather fine point. In the basal part they are set with some outstanding thorns, irregularly or, more rarely, indistinctly bilaterally arranged; towards the end of the spine they diminish in size, gradually disappearing. Surface of the spine in the basal part covered with a close coat of long, simple, not anastomosing hairs; like the thorns the hairs diminish in size outwards, the outer half or third part of the spine being naked, but deeply furrowed as usual in this genus. The apical spines somewhat shorter than the ambital spines and, in the adult specimens, with the point widened into a small crown. Oral primaries straight, or very nearly so, scarcely flattened, not at all widened, with fairly large lateral serrations. The third—fourth transitional to the ambital primaries.

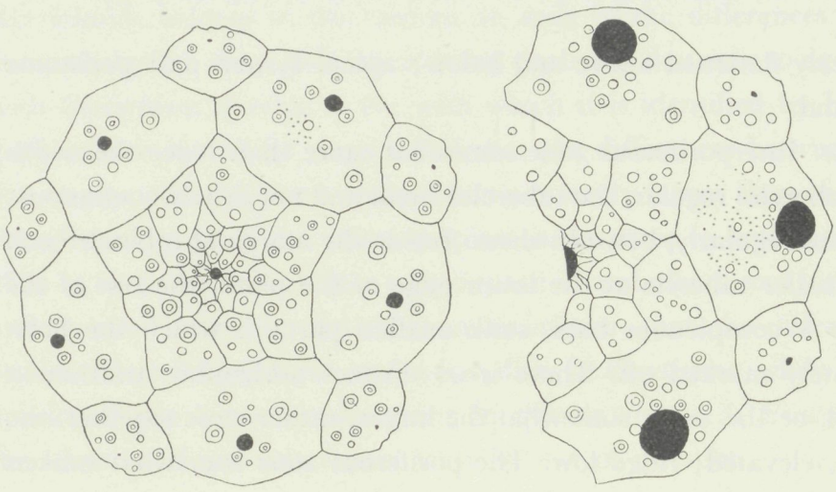


Fig. 72. Apical system of *Rhopalocidaris gracilis*, ♂ (1) and ♀ (2). × 8.

Secondary spines of scrobicular circle ca. 2 mm long, the marginal ambulacral spines slightly shorter and more slender, but all distinctly club-shaped, very finely thorny, not appressed.

Pedicellariæ. Large globiferous form rarely occurring; valves not very broad. The form figured by Döderlein, Op. cit. Pl. VIII. 5. b. c., is not the typical large form, rather intermediate between the large and the small form (Pl. LXXIX. 13—14). Small globiferous form with narrow blade and a rather wide opening (Pl. LXXIX. 12). Besides there is a large, slender form of pedicellariæ, with the valves wide apart basally; they look very much like true tridentate pedicellariæ, but the large end tooth shows them to be a form of the small globiferous pedicellariæ (Pl. LXXIX. 15—16). They reach a size of ca. 0.8 mm length of head. — Spicules of tubefeet rather coarsely thorny. Intestinal walls with the three-radiate spicules characteristic of Goniocidarids; they are, however, rather scarce, more slender than usual and more or less irregular (Fig. 73).

Colour. The primary spines white, only the collar faintly pink. Test and secondaries whitish or yellowish-reddish. The naked test white, at most with the merest indication of a purplish tint on the apical system; in the specimen of 13 mm h. d. there is a small patch of green on the genital plates.

Biology. In one of the specimens was found bottom material in the intestine, with no

identifiable remains of animals. — Döderlein found the genital pores developed already in his two specimens, of 7.5 and 8.5 mm h. d. The larger of the specimens in hand (Pl. XVII. 12) have the spines rather much overgrown, mainly by Bryozoans, and make very much the impression of having reached full size. The large female genital openings indicate direct development.

Occurrence. The specimens in hand were all taken by the author in the Sagami-Sea, Japan, in depths of ca. 180—700 m (1914). Döderlein's specimens came from the same locality and depth. — These are the only specimens of the species known till now.

Remarks. It can scarcely be doubted that the specimens in hand really are identical with the species described by Döderlein as *Porocidaris gracilis*. They agree very completely with Döderlein's specimens in the main characters: the primary and secondary spines, the peculiar naked apical system, the unusually great confluence of the areoles, the general structure of test and the pedicellariæ. The smaller number of ambulacral plates — only 3 — corresponding to an interambulacral plate in Döderlein's specimens and the apparent total lacking of miliary tubercles are differences evidently due to age, these specimens being only about half the size of the specimens in hand. The only noteworthy differences appear to be in the colour and the shape of the primary spines. Döderlein states the colour of test in his specimens to be "ein lichtes Violet"; but as there is a trace of violet on the apical system in at least two of the specimens in hand, while another has some faint green colour on the genital plates, this difference would seem to be of no very great importance. More weight may be put on the difference of the primary spines, which are described by Döderlein as being strongly swollen above the collar and at the same time flattened here. But his figures (Taf. IV. 16—17) show them very much like those of the present specimens, so that it would seem that it was not the shaft of the spine that was thus swollen in his specimens, but the shaft with its thorns and hairs — and this is in perfect agreement with the specimens in hand. In this way the spines may also well be described as flattened in the basal part. Döderlein also states that the hairs are anastomosing; judging from his figures they are, however, exactly like those of the specimens in hand. The differences thus, according to the description, existing between the specimens in hand and the type specimen of "*Porocidaris*" *gracilis* are either due to age (tuberculation of the test), or probably due to a different mode of description (the primary spines) or probably inconstant (the colour), and thus evidently altogether too unimportant for making the identity of the specimens in hand with Döderlein's *Porocidaris gracilis* questionable.

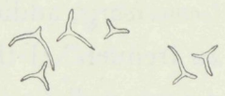


Fig. 73. Spicules from intestinal wall of *Rhopalocidaris gracilis*. × 125.

H. L. Clark (The Cidaridæ, p. 197) maintains that the material collected by the "Albatross" shows "beyond question" that the *Porocidaris gracilis* of Döderlein is a small example of *Goniocidaris clypeata* "in which the spines with enormously expanded tips are wanting". This statement indicates that Clark has confounded specimens of *Rhopalocidaris* with *Goniocidaris clypeata*, as I was able to substantiate by an examination of the specimens of "*clypeata*" in the Mus. Comp. Zool. and the U. S. Nat. Museum. The fig. 27. Pl. 10 of Agassiz & Clark. Hawaiian

Ech. Cidaridæ represents the elongate type of small globiferous pedicellariæ of *Rhopalocidaris gracilis*, does not belong to *Goniocidaris clypeata*. That the present species has nothing with *G. clypeata* to do is quite evident, as set forth under *Rh. hirsutispina;* it differs from *clypeata* in the same main characters as does *hirsutispina*. It resembles, upon the whole, very much *hirsutispina*, but differs from that species in the more naked apical system, the much more confluent areoles and the fewer interambulacral secondaries; further in its longer primaries, besides some slight differences in the pedicellariæ. It would appear also that its size is a good deal larger. These differences evidently are too important for regarding the two forms as identical.

After it was shown by the present author ("Ingolf" Ech. I.) that this species has nothing with *Porocidaris* to do, Döderlein in 1906 (Op. cit.) correctly pointed out its affinities with *Goniocidaris*, adding that "als selbständige Gattung wäre sie aber nur sehr schwer von *Goniocidaris* zu trennen". I think it has been made evident that, together with *hirsutispina* and *rosea*, it forms a very well limited genus, very distinctly separated from *Goniocidaris*.

Rhopalocidaris rosea Mrtsn.

Pls. XVII. 13—18; LXIX. 20; LXXIX. 18—22.

Discocidaris clypeata. H. L. Clark. 1925. Cat. Rec. Sea-Urchins Brit. Mus. p. 33.
Rhopalocidaris rosea. Th. Mortensen. 1928. New Cidaridæ, p. 68.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
15 mm	10.5 mm	7.5 mm (50 % h.d.)	8 mm (53.3 % h.d.)	7—8	7—8	30 mm
14 —	9 —	7.5 — (53.6 —)	7.5 — (53.6 —)	7	6—7	
13 —	8.5 —	6.5 — (50 —)	6 — (46 —)	6—7	6—7	30 —
12 —	8 —	6 — (50 —)	5.8 — (48.3 —)	7	6	28 —
10 —	5.5 —	5 — (50 —)	5 — (50 —)	6	5—6	32 —
8 —	4.5 —	4 — (50 —)	4 — (50 —)	6	5	25 —

Test almost spherical, only slightly flattened above, while on the oral side it slopes very gently towards the somewhat raised peristome. Circumference round or, sometimes in the larger specimens, slightly subpentagonal. In the young specimens the test is distinctly flattened.

Ambulacra slightly sinuate. Interporiferous zone somewhat more than twice the width of a porezone. Marginal series of tubercles very regular, the tubercles small, not at all contiguous. Inside the marginal series each plate carries a second tubercle, about as large as the marginal one, at the lower edge of the plate. The rest of the plate naked, forming thus a very conspicuous, broad, bare, sunk median part, in which the horizontal grooves are only slightly marked off separately; it is not distinctly horizontally striated. In the larger specimens there may here and there be a third inner tubercle, slightly smaller than the second (Pl. LXIX. 20). The pores are

small, equal-sized, close together, the separating wall slightly elevated; the ridge separating the pore-pairs is rather low. The pore-zone distinctly sunk.

Interambulacra. Areoles small, round, even the lowermost ones scarcely with an indication of being transverse-oval. They are well separated, at most the 2—3 proximal ones confluent. Areoles rather deep; tubercles small. Scrobicular ring fairly conspicuous, the tubercles somewhat larger than the marginal ambulacral tubercles. Outside the scrobicular circle the median part of the plate carries fairly numerous tubercles of about the same size as the scrobicular ones; there is, however, left a conspicuous, bare, sunk median part, in which the horizontal grooves are more or less distinctly marked off separately. At the adradial edge there is a single series of secondary tubercles, alternating with the scrobicular ones. There may be a fairly distinct groove at the adradial end of the sutures. Median area about 1.5 the width of an areole.

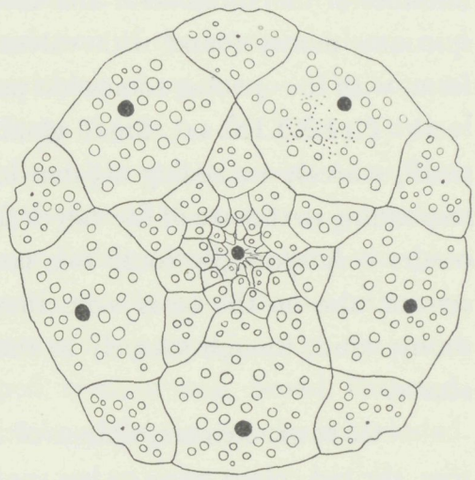


Fig. 74. Apical system of *Rhopalocidaris rosea*, ♀. × 8.

Apical system almost constantly exactly half h. d. Oculars exsert or, in the larger specimens, merely in contact with the periproct. Genital and ocular plates rather closely covered with small, equal-sized tubercles. Female pores unusually small, scarcely 0.5 mm in diameter, about in the middle of the plate (Fig. 74), like the male pores. Periproctal plates fairly numerous, closely covered with small, equal-sized tubercles; the periproct usually slightly elevated.

Peristome about the same size as the apical system. There are 8—9 ambulacral plates in a series in the larger specimens, 6 in a specimen of 8 mm h. d. The ambulacra join at the mouth edge. 5—6 interradial plates in a fairly regular series in the larger specimens. The peristome on the whole very compact.

Primary spines usually long and slender, 2—3 times h. d. They taper gently, the point often widening into a very small crown; in the basal part they are set with some strong thorns, indistinctly biserially arranged, outwards gradually diminishing in size[1]; no thorns on the adoral side of the spine, which thus gets a somewhat flattened appearance, the shaft being, however, cylindrical. Surface of the spine in the basal part covered with a dense coat of hairs almost as long as the thorns; farther out the hairs become much shorter, like the thorns, giving the surface of the spine a rather velvety appearance and concealing the longitudinal ridges, which are here less prominent than in the other species. The hairs are outwards curved at the point. The apical spines not much shorter than the ambital ones, of the same general shape, but with a slightly more developed terminal crown. The oral primaries nearly straight, with rather conspicuous

[1] Clark's statement (Op. cit.) that the spines have an "expanded guard" at the base, as in *mikado*, is not correct; also in these specimens there is only a pair of larger lateral thorns at the base, not united into a guard.

lateral serrations and also with thorns on the aboral side; generally they end in a small terminal crown; the third or fourth is transitional to the ambital spines. Usually the oral primaries are erect, giving thus a rather characteristic appearance to the oral side.

Secondary spines. The scrobicular spines ca. 1.5 mm long, more or less erect, not fitting close together; they are usually slightly curved, the point not much widened, often hardly so at all; usually they are distinctly thorny in their whole length (Pl. LXXIX. 18). The marginal ambulacral and the miliary spines all of a similar appearance, only somewhat shorter and more slender.

Pedicellariæ. Large globiferous pedicellariæ usually numerous, especially in the bare midlines of the ambulacral and interambulacral areas, but also on the apical system, very conspicuous, mostly found with valves wide open; they are of the typical globular, Goniocidarid form, with the opening somewhat protruding beyond the blade, only with few downwards directed teeth (Pl. LXXIX. 21). Small globiferous also often found with the valves open. They are usually small, scarcely exceeding 0.3 mm length of head; the opening more or less short and wide, corresponding to the size of the valves (Pl. LXXIX. 22). A large tridentate-like form (Pl. LXXIX. 19) occurs very sparingly (only two samples found). The valves are rather coarsely and irregularly serrate, also on the outer side; they are 0.6—0.7 mm long. — Spicules of tubefeet of the usual thorny kind, though scarcely so thorny as in the other species; spicules of intestine exceedingly scarce.

Colour. Primary spines of a delicate white, banded on the adapical side with pink or rose, the red colour more or less confluent. Secondary spines on the apical system usually greenish, and usually also 1—3 of the scrobicular spines, on the adapical side of the primaries, greenish or brownish, the other secondaries generally white; these darker upper scrobicular spines form a very marked feature of this species. On the naked test the apical system is of a conspicuous greenish colour, usually with a white edge on the genital and ocular plates. The green colour may continue a little over the upper part of the interambulacra, being then confined to the upper and the admedian part of the scrobicular edge.

Biology. In the intestine only bottom material with no identifiable remains has been found. The small size of the genital openings might indicate that the development may differ from that of the other species, with their large female genital openings; however, the eggs are rich in yolk, so that the existence of a typical pelagic larva in this species does not seem probable. The genital pores have appeared already at a size of 8 mm h. d. — It appears that the species does not reach a larger size than ca. 15 mm h. d., specimens of this size having a rather old appearance, their spines being much overgrown by foreign organisms, especially Bryozoans and Hydroids (no barnacles found on any of the specimens in hand). Not rarely the primary spines are more or less closely set with a dark Folliculinid, *Lagotia viridis* Wright[1], attached between the hairs; sometimes the spines are quite dark-spotted thereby.

[1] I am indebted to the eminent specialist in Folliculinids, Mr. C. Dons, Trondhjem, for the identification of this species.

Occurrence. Hitherto found only in Japanese Seas, viz. the Sagami Sea, in depths of ca. 180—700 m, and off the Goto Islands (32° 15′ N. 128° 12′ E. 160 m), all collected by the author, and also by Dr. Sixten Bock, in May—July 1914. I have also found in the U. S. National Museum specimens from off Kagoshima Gulf and the Goto Islands ("Albatross" Stat. 4893 and 4936) identified as *Goniocidaris biserialis* or (Stat. 4894) *Goniocidaris clypeata*. — To this species also belong the specimens mentioned as "*Discocidaris clypeata*" in H. L. Clark's Catalogue Rec. Sea-Urchins Br. Mus. p. 33 (possibly one of them is *Rh. gracilis* — not examined in details).

Remarks. From the other species of *Rhopalocidaris*, *hirsutispina* and *gracilis*, the present species is distinguished at a glance through the very characteristic colour of both primaries, secondaries and test, as also the shape of the test, the tuberculation of the interambulacra and apical system, besides the pedicellariæ afford excellent distinguishing characters. — On account of the sometimes rather distinct biserial arrangement of the large thorns on the primary spines and the colour of the secondary spines it may have a superficial likeness to young *Goniocidaris biserialis*; but the strongly developed coat of hairs in the basal part of these spines, as well as the character of the secondary spines, clubshaped, thorny, not fitting closely around the base of the primaries, at once distinguish it from *biserialis*, with no conspicuous hair coat on the primaries, and with flat, smooth secondaries, fitting closely around the base of the primaries. Also the spines of the periproct are conspicuously different, slender, clubshaped, erect in *rosea*, broad, flattened, closely appressed in *biserialis*. Thus on a closer inspection a mistake of the two species is excluded.

Rhopalocidaris rosea, var. **tenuis** Mrtsn.

Pl. LXXIX. 20.

Rhopalocidaris rosea, var. *tenuis*. Th. Mortensen. 1928. New Cidaridæ, p. 68.

At the Kei-Islands (5° 47′ 20″ S. 132° 13′ E. 300 m., clay, mud; 2. V. 1922) was found a young specimen of a Cidarid, which is evidently closely related to *Rhopalocidaris rosea*. It differs, however, in some regards rather conspicuously from the said species, specimens of the same size being compared, so that it cannot simply be identified with that species. Most probably it will ultimately be found to represent a distinct species, but from the single, young specimen in hand it is impossible to give the characters of such species in a satisfactory way, and it is therefore thought preferable to designate it, for the present, as only a variety of *Rh. rosea*.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest spines
7 mm	3.5 mm	3.5 mm (50 % h.d.)	3.5 mm (50 % h.d.)	6	4—5	15 mm

The test is conspicuously flattened above, as is also the case in young *Rh. rosea*. In the Ambulacra a small tubercle has appeared inside the marginal tubercle, in the usual place at the lower edge of the plate; in the Interambulacra only a single series of tubercles has appeared

on the median part of the plates, outside and alternating with the scrobicular tubercles. Only the 2—3 proximal tubercles confluent. A group of tubercles on the middle of the genital plates (Fig. 75); genital pores not yet present. 5 ambulacral plates in a series on the peristome; two interradial plates.

Primary spines with a few strong, bilaterally arranged thorns in the basal part and with a well developed coat of hairs. Further outwards the thorns diminish in size and the hairs gradually disappear, the outer part of the spine having a shining surface, without distinct longitudinal ridges. Oral primaries slightly bilaterally serrated. — Secondary spines very slender, erect, finely thorny (Pl. LXXIX. 20) the scrobicular ones scarcely exceeding 1 mm length. Of pedicellariæ only the small globiferous form occurs; it does not differ from the corresponding form in *rosea*. Spicules not peculiar, essentially as in *rosea*. Colour: primary spines with 2—3 well separated bands of red and white, often also with a greenish band proximally, as also the interval between the red bands may be greenish-white. Secondaries yellowish-white, the upper ones of the upper scrobicular circles with an indication of a greenish tint. The skin of the test slightly reddish. The naked test is white, with a green spot between each two adjoining scrobicular circles (the 3—4 upper ones); the apical system greenish, especially the outer half of the genital plates dark green.

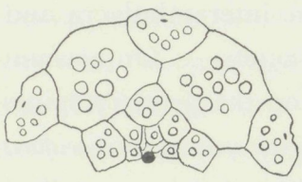


Fig. 75. Part of apical system of *Rhopalocidaris rosea*, var. *tenuis*. × 12.

Particularly the colour of the primaries distinguishes this specimen so markedly from the typical *Rh. rosea*, that it would be quite unjustifiable to identify it simply with that species. (The difference in the secondary spines may be, in the main, due to age). The fact that *rosea* is known only from Japan also must make us very cautious with regard to the specimen from the Kei-Islands. Probability is for its representing a separate species, but for the present it seems preferable to designate it only as a variety of *Rh. rosea*, with which species it is, at any rate, the most nearly related.

Group *Stereocidarina.*

This group is characterized by its globiferous pedicellariæ, both large and small, lacking an end tooth; the opening subterminal, not with a well formed lower lip. Pores non-conjugate or sub-conjugate. Primary tubercles usually non-crenulate. The upper primary spines and tubercles more or less rudimentary. Usually there are more or less distinct grooves in the upper horizontal sutures of the interambulacra, more rarely on the plates or in the ambulacra. Secondary spines flattened, more or less appressed.

To this group belongs only the genus *Stereocidaris* of recent forms. Of the fossil genera *Temnocidaris* evidently belongs here also, the species *Stereocidaris stylifera* forming a connecting link between the two genera.

Genus **Stereocidaris** Pomel.

Pomel. 1883. Class. méth. p. 110.
Döderlein. 1887. Japanische Seeigel. I. Cidaridæ, p. 42.
Th. Mortensen. 1903. "Ingolf" Ech. I. p. 29. II. (1907) p. 17.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 96, 102.
H. L. Clark. 1907. The Cidaridæ, p. 216.
Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp., p. 55.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 152.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 25.

Syn. *Typocidaris* Pomel.

Pomel. 1883. Class. méth. p. 111.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 151.

Syn. *Phalacrocidaris* Lambert.

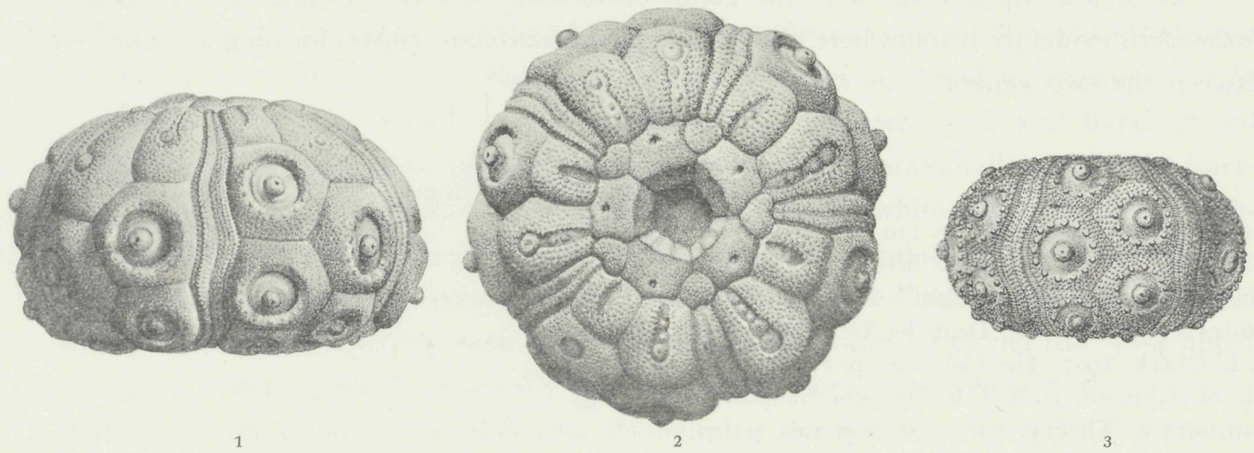
Lambert. 1902. Description des Ech. de la Prov. de Barcelone, p. 27.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

Syn. *Anomocidaris* Agassiz & H. L. Clark.

Agassiz & Clark. 1907. Hawaiian Ech. I. Cidaridæ, p. 30.
H. L. Clark. 1907. The Cidaridæ, p. 221.

Test solid, usually very closely tuberculate. Rarely more than 7 interambulacral plates in a series. 1—3 of the upper interambulacral plates with areole and primary tubercle (spine) usually rudimentary. The areoles deep, generally well separated, even those on the oral side; especially the upper interambulacral plates usually very high, there being thus a broad space covered with small miliaries between each two successive areoles. Tubercles often with fairly distinct traces of crenulation. Usually one or several more or less distinct grooves or impressions in the upper horizontal sutures of the interambulacra, and usually a small but fairly distinct groove at the admedian end of the ambital horizontal sutures of the interambulacra; rarely (*St. stylifera*) grooves are found also on the interambulacral plates and in the ambulacra. Ambulacra in general conspicuously sinuate. Pores non-conjugate, the wall usually forming a low, rounded

crest. Madreporite not distinctly enlarged. Pores on peristome in a single, regular series. Primary spines often conspicuously flaring at the tip; the shaft usually with a spongy coat of hairs, more rarely with simple, unbranched hairs. Collar short, neck very conspicuous, about twice as long as the collar. The scrobicular spines form a close mail round the base of the primaries. Miliary spines scale-like, appressed, or spiniform, erect. Large globiferous pedicellariæ without end tooth and without a limb on the stalk; small globiferous usually without end tooth, but sometimes with a distinct, though small, end tooth; they may be very elongate and slender, resembling tridentate pedicellariæ, and in this case true tridentate pedicellariæ are lacking. Spicules of tubefeet may



1 2 3

Fig. 76. *Stereocidaris sceptrifera* (Mantell), in side view (1) and from the aboral side (2), and *Stereocidaris malum* (A.Gras), in side view (3). 1—2. After Wright. Monogr. Brit. fossil Echin. of the Cretaceous Formations. Pl. VI. 1. a, 1. c. 3. From Pal. Franç. Terr. Crétacé. Pl. 1045, 1.

be transformed into larger fenestrated plates; spicules of intestinal wall numerous, small, triradiate, or reduced to very small rods, simple or slightly branched, in which case they are exceedingly scarce.

Genotype: *Cidaris cretosa* (Mantell) Cotteau.

Pomel, as is usual in his "Classification méthodique", does not indicate which species should be regarded as the type of the genus *Stereocidaris*, but names some species, the first of which is *cretosa*. Döderlein, the next author to discuss this genus does not either select a genotype. In their "Essay de nomenclature raisonnée" Lambert & Thiéry have selected *Cidaris Merceyi* Cotteau; but in their "Notes Échinologiques" I. Sur le genre Cidaris, p. 31, *Cidaris cretosa* Mantell is selected as the type. As the latter paper was published January—February 1909, the first part of the "Essai de nomencl. rais." not until March 1909 (according to information given me by my late friend P. Thiéry), it is evident that *C. cretosa* should remain the type of the genus. (This species was also given as the genotype in the Ech. d. deutschen Südpolar-Exp. p. 55, likewise published in 1909). The question is, however, further complicated through the fact that the species represented by Cotteau (Pal. Franç. Terr. Crét. VII. Pl. 1067) under the name of *C. cretosa* Mantell, and the one to which Pomel no doubt refers, appears to be not really

identical with Mantell's *C. cretosa*, which is again, according to Schlüter (Ech. d. Norddeutschen Kreide. II. 1892, p. 110) the same as *C. sceptrifera* Mantell. Lambert (Revision de quelques Cidaridæ de la Craie. Bull. Soc. l'Yonne. I. 1908, p. 53) is of opinion that Cotteau's *C. cretosa* is only a variety of *sceptrifera*. I shall not enter on the question of the possible identity of these fossil species. The matter is in the main a question of names. Whether we make *Cidaris cretosa* of Mantell (= *sceptrifera* in the sense of Schlüter, which is perhaps not the same as the *sceptrifera* of Wright (Fig. 76. 1—2)) or the *Cidaris cretosa* of Cotteau the genotype is for the definition of the genus *Stereocidaris* of no importance — whereas it might be different, if *C. Merceyi* (without grooves in the sutures, cf. Fig. 8, p. 18) were taken as the type of the genus.

Contrary to H. L. Clark's statement (The Cidaridæ, p. 216) that this is "the most poorly defined and unsatisfactory genus in the family" I would say that this is a very well characterized genus, especially through the characters of the test — the rudimentary upper primary tubercles and the very close tuberculation, besides the pedicellariæ, whereas the presence of grooves in the upper horizontal sutures is too inconstant for a generic character. These characters give the test so striking an appearance that there is no reason to doubt that the recent forms are really congeneric with the fossil species on the base of which the genus was established, even though we do not know the pedicellariæ of the fossil species[1]. In his translation of H. L. Clark's "The Cidaridæ" Thiéry has added a note (p. 216 — in the separate copy p. 172) stating that the recent species referred to the genus *Stereocidaris* do not rightly belong there, because they lack the impressions in the upper interambulacral sutures characteristic of the fossils[2]. — However, as a matter of fact, these grooves do occur also in the recent forms, or, at least, in most of them, were only left unnoticed in the older descriptions, or not sufficiently emphasized. (Döderlein, in his description of *Stereocidaris grandis* mentions these grooves as "eine eigenthümliche narbenartige Vertiefung am oberen Rande der Coronalplatten", while it is not seen distinctly in his figures[3]).

The question now is: do all the numerous recent (and fossil) species really belong to one and the same genus? An answer to this question was given first by Pomel (1883) through the creation of the genus *Typocidaris* for some of the fossil forms, next by Lambert in 1902, who

[1] When Agassiz (Panamic Deep-Sea Echini, p. 32) states that he cannot understand my reasons for referring some living species to genera established for fossil species, like *Stereocidaris*, as this is contrary to my principles, this probably does not mean that he disagrees as to the referring of the recent species to this genus, but is only meant to prove my infidelity to my "principles".

[2] Curiously enough Thiéry in pointing out here that there are two groups of species, one without sutural impressions (*Phalacrocidaris* Lambert) and one with such impressions (*Stereocidaris* Pomel) names under the second group the species *Carteri* (Wright) and *Merceyi* (Cotteau), both of which are devoid of these sutural impressions. The same mistake is made in the "Ess. nom. rais." p. 152, where under *Stereocidaris*, which "ne diffère de *Typocidaris* (— with sutural impressions —) que par ses tubercules périapicaux atrophiés", is given as type *C. Merceyi* Cotteau, and further named *C. Carteri* Wright, both without grooves, besides other species e. g. *Lallieri* Lambert and *hannoverana* Schlüter with distinct grooves.

[3] In the diagnosis of the genus *Stereocidaris* (Op. cit. p. 42) Döderlein mentions *grandis* among the species with grooves in the sutures.

established the genus *Phalacrocidaris* with the species *japonica* as the type, and finally by Agassiz & Clark in 1907, who established the genus *Anomocidaris*, taking the species *tenuispina* (= *japonica*) as the genotype.

As regards first *Typocidaris* (the genotype of which is the Cretaceous *Cidaris malum* A. Gras (Fig. 76. 3), it is quite evident, especially from the study of the recent species of this group, that it cannot be maintained as a separate genus. The only character supposed to distinguish it from *Stereocidaris* is this that the upper areoles are not rudimentary, as they are in *Stereocidaris*. But, as a matter of fact, there are all intermediate stages among the recent as well as among the fossil forms, so that it is quite impossible to draw a natural limit between them. The grooves of the sutures (cf. Fig. 10, p. 19) cannot afford a reliable distinguishing character either, as they are, on the whole, so very varying, both as regards their number and their distinctness, that they can even hardly be relied upon for specific distinctions[1].

According to Lambert the genus *Phalacrocidaris* is characterized by "l'atrophie des tubercules périapicaux et l'absence des fossettes suturales"; according to Agassiz & Clark the genus *Anomocidaris* "can at once be distinguished from all other Cidarids by the sharp, deep sutures separating the plates of the abactinal system, and of the interambulacral areas, and the deep median vertical suture of the ambulacral area". In the end of the "diagnosis" it is said more in passing that the genus is "notable for its conical test and the presence of rudimentary abactinal primary tubercles"; that it is related to *Stereocidaris* was, evidently, not clear to the authors, as appears also from the fact that it is placed far away from the genus *Stereocidaris* in their report, as also they did not see that the species *tenuispina* of Yoshiwara is identical with Döderlein's *St. japonica*. This is to some degree explained by the fact that they had only a single specimen, even somewhat unusual in shape. When later on a more rich material became available to the authors, they recognized the identity of *tenuispina* and *japonica* but retained the genus *Anomocidaris* on account of the bare aboral surface of the test (Prel. Rep. Ech. "Albatross", 1906. Bull. Mus. C. Zool. LI. p. 112). In his Catalogue of the Recent Sea-Urchins of the British Museum 1925, Clark has evidently again given up the genus *Anomocidaris*, since he records the species *japonica* simply as a *Stereocidaris*.

In the "Essai de Nomenclature Raisonnée" Lambert & Thiéry retain both *Stereocidaris* and *Phalacrocidaris*, as subgenera of the genus *Cidaris* (= *Eucidaris*). To *Stereocidaris*, of which *C. Merceyi* Cotteau is made the type (incorrectly for *C. cretosa* Mantell, as stated above), no recent species is referred; to *Phalacrocidaris* are referred, besides *japonica*, the type, the following recent species: *grandis*, *microtuberculata*, *sceptriferoides* and *tricarinata*, while the following species are referred to *Dorocidaris*, likewise made a subgenus under *Cidaris*: *Alcocki*, *capensis*, *ingolfiana*, and *leucacantha*

[1] Lambert & Thiéry (Ess. nom. rais.) refer *Notocidaris Mortenseni* to the genus *Typocidaris*, founding on a slight exaggeration of the "grooves" of the sutures in Koehler's original figure of this species, and disregarding all the striking differences distinguishing this species from the *Stereocidaris*. There is no reason to enter on a discussion of this absurdity. (Cf. p. 134).

— together with a varied assemblage of other recent forms like e. g. *Tretocidaris Bartletti*, *Cidaris Blakei*, *Stylocidaris bracteata*, *calacantha* and *tiara*, *Notocidaris gaussensis*, *Calocidaris micans*. This is such glaring nonsense that it cannot be discussed; it may suffice to mention further that the species *japonica* is referred to three different genera in the same work, viz. to *Phalacrocidaris* on p. 149, to *Dorocidaris* on p. 560, and, under the name *tenuispina*, to *Cidaris* on p. 559.

Looking now on the recent species of *Stereocidaris* with the view of an eventual subdivision into subgenera or genera, it is at once clear that the species *japonica* stands somewhat apart in having the atrophy of the upper primary tubercles and spines carried farther than any of the other species. Also in its general appearance it differs rather markedly from the other species. On the other hand it agrees with *sceptriferoides* and the *indica*-group in the marginal ambulacral tubercles being not contiguous, in the characters of the pedicellariæ (small globiferous with long, slender valves, no tridentate pedicellariæ) and in the triradiate spicules of the intestinal wall. Further the fossil species *Merceyi* has an equally great reduction of the upper primary spines and tubercles and has likewise no impressions in the upper horizontal sutures. Otherwise the general appearance of *Merceyi* is very like a typical *Stereocidaris*. (If *Merceyi* be taken as the genotype of *Stereocidaris* this would then involve *Phalacrocidaris* being a simple synonym of *Stereocidaris*, as *japonica* and *Merceyi* must evidently belong to the same genus).

The presence or absence of grooves in the upper horizontal sutures, according to Lambert & Thiéry the main distinguishing character of *Stereocidaris* and *Phalacrocidaris*, is, as already stated, an exceedingly variable character and so intergrading that it must be out of question to make it a generic character.

In the recent species a rather conspicuous difference is found in the character of the miliary spines, whether they are broad and scale-like, appressed, or slender, setaceous and erect. The latter is the case in *indica*, with its various varieties and in *Alcocki*, *capensis*, *sceptriferoides*, and *leucacantha* (*japonica* is rather intermediate in this regard). Together with this character go some other characters: the marginal ambulacral tubercles are not contiguous, the small globiferous pedicellariæ are elongate and slender, tridentate pedicellariæ are lacking, the spicules of the tubefeet are fenestrated plates and there are numerous three-radiate spicules in the intestinal wall — except in *leucacantha*.

In my opinion there is then no sufficient reason for referring the recent forms to various genera; they intergrade in all their characters to such a degree that we must include them all in one genus. At most we can distinguish some groups of species. Thus it is evident that the species *indica*, *Alcocki*, *capensis*, and *ingolfiana* form one group; another group is formed by *microtuberculata* and *tubifera*, to which *granularis* and *purpurascens* may perhaps also be attached, and also *squamosa* and *hawaiiensis*. With regard to *grandis* there is the great question what the irregularity of the ambulacra on the oral side may mean, — perhaps this will remove the typical *grandis* from the group, while the variety (?species) *hyatorina* would join the *microtuberculata*-group. Another group forms *japonica*, and also *sceptriferoides* may represent a group it is own.

The subgenus *Phalacrocidaris* (syn. *Anomocidaris*) may then perhaps rightly be retained for *japonica* (and *Merceyi*), but I do not see any reason for establishing new subgenera for the other more or less well defined groups of species.

The genus *Stereocidaris* is especially interesting in being the only genus of Cidarids established for fossil species which can be retraced with any certainty among the recent species, as was first recognized by Döderlein. The genus is not known before the Cretaceous; from the Tertiary it is known only from the Eocene, viz. *Stereocidaris Gauthieri* Lambert (Descr. Ech. foss. Prov. Barcelone. Mém. Soc. Géol. Fr. IX. 1902. Pl. IX. 21—27) and *St. di Stefanii* d. Innocenti (Due nuovi Echinidi dell' Eocene Istriano. Riv. Ital. di Pal. Anno XXX. 1925. p. 41. Tav. II. 1—6). From the later Tertiary formations the genus has not been recorded, but its existence through these periods is sufficiently proven by the fact of its existence in recent times, even in a flourishing condition, it being, together with *Histocidaris* and *Stylocidaris*, among the largest genera of recent Cidarids.

It is interesting to see that, while in the Cretaceous period and in the Eocene it was richly represented in the European deposits (also the American species *Cidaris texanus* W. B. Clark may not improbably belong to the genus *Stereocidaris*) in recent time only a single species, *St. ingolfiana* is known to occur in the Atlantic (none in the Mediterranean); the great majority of recent species are confined to the Indo-Pacific, from Japan to S. Africa. This may, in connection with the fact that no species of *Stereocidaris* are known from later deposits than the Eocene, well lead to the suggestion that the genus in the main died out in the European-American Seas about the end of the Miocene, while it survived in the Indo-Pacific. The fact that no fossil species of the genus have been recorded from the Indo-Pacific region[1] may well be due to a less intense exploration of the deposits there — though it is remarkable that no species of the genus are found in the rich strata of Sind (cf. Duncan & Sladen's great work). It is, of course, a possibility that the genus originated in the European Seas and, when it was about to vanish there, found its way to the Indo-Pacific to reach there the flourishing condition of recent days.

That no species is known to occur in the Australian Seas may perhaps be due to insufficient research; it would, at least, not be unreasonable to expect some species to occur both off East and West Australia. On the other hand there is very little probability of finding any *Stereocidaris*-species off the West American coasts.

The existence of more or less distinct grooves at the median end of the horizontal interambulacral sutures is very interesting and suggests Goniocidarid affinities of *Stereocidaris*. Also the structure of the pedicellariæ and the character of the spicules in the intestinal wall suggest affinities with the Goniocidarids. The suggestion, therefore, lies at hand that the Goniocidarids may have derived from *Stereocidaris*-like forms. The fact that *Goniocidaris* is a very recent type, not known with certainty as fossil, is in good accordance with such suggestion. Still, I

[1] The spine from the Tertiary deposits of Java identified as "*Dorocidaris papillata*" by Martin (Unsere palæozool. Kentniss von Java. 1919. p. 53), however, seems to be a *Stereocidaris* (cf. p. 300).

think it more probable that the Goniocidarids represent a further development from the Ctenocidarids (cf. above, p. 147). Possibly also the Ctenocidarids may have developed from the Stereocidarids; but the more primitive condition of the pores in Ctenocidarids are against such suggestion.

Döderlein (Jap. Seeigel, p. 42) is of opinion that *Stereocidaris* has developed as a specialized branch from the "Dorocidaris"-group. But the pedicellariæ of *Stereocidaris* decidedly represent a more primitive type than those of the *Cidarina* and it would therefore seem more probable that the Cidarina developed from the Stereocidarids, viz. such in which the upper primary tubercles had not yet been reduced, this being, of course, a specialized feature. The fact that pedicellariæ with an end tooth do occur in some *Stereocidaris*-species, e. g. *St. japonica, indica* (Clark no doubt is right in maintaining this against Döderlein — The Cidaridæ, p. 217) shows the way in which the pedicellariæ with an end tooth may have evolved from the Stereocidarid-type.

Key to the recent species and varieties of Stereocidaris[1].

1. Grooves in the interporiferous zone of the ambulacra, besides in the upper horizontal sutures of the interambulacra and on the interambulacral plates. Marginal ambulacral spines (usually?) cylindrical, sharply pointed ..... *St. stylifera.*
   No grooves in the ambulacra, at most in the upper interambulacral sutures, sometimes quite indistinct. Marginal ambulacral spines flattened, not sharply pointed ..... 2.
2. The 2—3 upper interambulacral plates in each series with the primary tubercle rudimentary, no primary spines beyond the ambitus. Primary spines very slender, cylindrical, the larger ambital ones usually flattened at the point ..... *St. japonica.*
   Only 1—2 of the upper interambulacral plates in each series with rudimentary primary tubercle; primary spines also beyond the ambitus, usually not very slender, not flattened at the point ..... 3.
3. Miliary spines slender, erect ..... 4.
   Miliary spines broad and flat, more or less scale-like, usually appressed ..... 14.
4. Primary spines distinctly carinate ..... 5.
   Primary spines not distinctly carinate ..... 7.
5. Peristome usually not more than 20—30 % of h. d.; oral primaries slender, smooth ..... 6.
   Peristome usually ca. 35—40 % of h. d.; oral primaries not very slender, usually with serrate edges ..... *St. ingolfiana.*
6. Usually only a single keel on the primary spines; small globiferous pedicellariæ not very elongate ..... *St. indica*, var. *carinata.*
   Usually three keels on the primary spines; small globiferous pedicellariæ very slender and elongate, resembling tridentate pedicellariæ ..... *St. alcocki.*

[1] As always with keys to such larger genera it should be emphasized that the key cannot do more than lead the way to the identification. It is impossible to give all the characters and combinations of characters in the key; as a rule only some of the more conspicuous characters are mentioned — and it may even not always be easy to decide in some of the main divisions of the key, to which group a specimen should be referred, e. g. whether the miliary spines are slender or broad and scalelike, or whether the transition between scrobicular and miliary spines is abrupt or not. Therefore, it will always be necessary to compare the specimens with the descriptions and figures, and even thus the identification may sometimes prove difficult enough, particularly as the material available of several of the species is too small for giving satisfactory information of the range of variation of the species.

7. Peristome usually not more than 25 % h. d. ..... 8.
Peristome usually more than 30 % h. d. ..... 10.
8. Small globiferous pedicellariæ very slender and elongate, resembling tridentate pedicellariæ ..... *St. alcocki*, var. *teretispina*.
Small globiferous pedicellariæ not so very slender and elongate as to resemble tridentate pedicellariæ ..... 9.
9. Hairs on primary spines very short and simple, or even lacking ..... *St. indica*, var. *philippinensis*.
Hairs on primary spines anastomosing, forming a spongy coat ..... *St. indica*.[1]
10. Marginal ambulacral tubercles contiguous. Usually a dark ring on the limit between the collar and the neck ..... *St. leucacantha*.
Marginal ambulacral tubercles not contiguous; no dark ring on the limit between the col ar and the neck ..... 11.
11. Primary spines with numerous sharp, prominent lamellæ in the basal part *St. sceptriferoides*, var. *lamellata*.
Primary spines not conspicuously lamellate ..... 12.
12. Large globiferous pedicellariæ with short, globular stalk ..... *St. sceptriferoides*, var. *lamellata*.[2]
Large globiferous pedicellariæ with long, slender stalk ..... 13.
13. Scrobicular spines broad, almost rectangular ..... *St. sceptriferoides*.
Scrobicular spines slender, pointed ..... *St. sceptriferoides*, var. *lanceolata*.
14. Secondary spines on oral side very thick; marginal series of ambulacral tubercles on oral side very irregular ..... *St. grandis*.
Secondary spines on oral side not very thick; marginal series of ambulacral tubercles on oral side quite regular ..... 15.
15. Primary spines with sharp, smooth ridges, and deeply channeled between the ridges *St. sulcatispinis*.
Primary spines not so ..... 16.
16. Transition from scrobicular to miliary spines fairly gradual ..... *St. grandis*, var. *hyatorina*.
Transition from scrobicular to miliary spines rather abrupt ..... 17.
17. Primary spines on oral side conspicuously widened, trumpet-shaped ..... 18.
Primary spines on oral side not trumpet-shaped ..... 20.
18. Ambital primary spines with low, smooth, narrow ridges which do not come very close together ..... *St. microtuberculata*.
Ambital primary spines with series of low granules ..... 19.
19. Genital plates distinctly higher than broad; median space of interambulacra not sunken *St. tubifera*.
Genital plates not higher than broad; median space of interambulacra conspicuously sunken ..... *St. tubifera*, var. *impressa*.
20. Primary spines rather coarsely serrate ..... 21.
Primary spines finely serrate ..... 22.
21. Only the upper side of test faintly reddish ..... *St. granularis*.
The whole test, and the spines, conspicuously red ..... *St. granularis*, var. *rubra*.
22. Apical system more or less brownish; young primary spines of a conspicuous purple colour ..... *St. purpurascens*.
Apical system more or less greenish; young primary spines not purple ..... 23.
23. Primary spines cylindrical; a dark ring between collar and neck ..... *St. squamosa*.
Primary spines fusiform; no dark ring between collar and neck ..... *St. hawaiiensis*.

[1] The varieties *africana* and *sumatrana* of *St. indica* are so indefinitely characterized that it would hardly be possible to give the difference between them in the short terms of a key. For these two varieties reference must be made to Döderlein's work (Op. cit. 1906).

[2] This refers to the form from the Kei Islands (cf. p. 278), which may perhaps not really belong to the var. *lamellata*, but rather represents a separate variety or species.

Stereocidaris grandis (Döderlein).

Pls. XVIII. 4—6; XIX. 1—3; LXX. 1—2; LXXX. 35.

Dorocidaris grandis. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu Inseln, p. 5.
Stereocidaris grandis. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ p. 3. Taf. **I, 1—6; II, 1—11; VIII, 2. a—m.**
Stereocidaris grandis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 29.
Stereocidaris grandis. Döderlein. 1906. Ech. d. deutschen Tiefsee Exp., p. 102.
Stereocidaris grandis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ p. 22. (partim; Pl. **V. 18—20; XXXVI**; non Pl. XXXIII).
Stereocidaris microtuberculata. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. Bull. M. C. Z. LI. p. 112.
Stereocidaris microtuberculata. H. L. Clark. 1907. The Cidaridæ, p. 220 (partim).
Stereocidaris grandis. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 55.
Phalacrocidaris grandis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.
NON: *Stereocidaris grandis.* H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 26
= *Stereocidaris indica*, var. *philippinensis* Mrtsn. ("Chall." St. 210)
— *sceptriferoides* Död. (Misaki).
Cidaris (*Stereocidaris*) *grandis.* De Meijere. 1904. "Siboga" Ech. p. 17.
= *Stereocidaris sulcatispinis* Mrtsn. St. 90.
— *granularis* Mrtsn. St. 139, St. 262.
— *purpurascens* Mrtsn. St. 251.
Stereocidaris grandis. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 299.
= *Stereocidaris granularis* Mrtsn. and *St. stylifera* Mrtsn.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Width of I.A.	Width of A. (% of I. A.)	Longest Spines
1	82[1] mm	53 mm	35 mm (42.7 % h.d.)	28 mm (34.1 % h.d.)	8—9	19—20	42 mm	8 mm (19 —)	? 65 mm
2	61 —	42 —	28 — (46 —)	21 — (34.4 —)	6—7	18—19	30 —	7 — (23.3 —)	85 —
3	49 —	28 —	25 — (51 —)	18 — (36.7 —)	6	21—23	25 —	6 — (24 —)	56 —

Spec. 1 in the Museum of Comp. Zoology; (recorded by Agassiz & Clark, Op. cit. 1907. p. 112, as *Stereocidaris microtuberculata*); specimens 2—3 Döderlein's cotypes.

Test rather high, arched; circumference circular.

Ambulacra rather conspicuously sinuate; they are ca. 19—28 % of the width of the interambulacra[2]. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very irregular in the proximal part ; in the aboral part it is regular. The tubercles are contiguous or even compressed for lack of space. The space inside the marginal tubercles is covered by irregularly arranged secondary tubercles, the outer of which are the larger and form an indistinct series along the marginal series; the tubercles in the median part are a good deal smaller, but

[1] Agassiz & Clark (Op. cit.) give the size of this specimen as 86 mm h. d. This is probably a misprint, the specimen is only 82 mm h. d.

[2] H. L. Clark (The Cidaridæ, p. 218) gives the width of the ambulacra of this species as 25—33 % of the interambulacra, in contradistinction to *St. microtuberculata* in which the width is stated to be 18—25 %. This does not hold good. In the specimens here dealt with the width of the ambulacra is only 19—24 % of the I. A., in the type-specimen (viz. specimen b of Döderlein, Jap. Seeigel, p. 49, as I am informed by Döderlein, in a letter to me) it is 28 % of I. A. Clark's statement is due to a confusion of the two species *grandis* and *microtuberculata*, as shown in the present work.

may also be arranged in fairly regular series (Pl. LXX. 1—2). Interporiferous zone flat, not sunken along the midline. The pores are rather small, wall fairly high and sharp, the ridge low, rounded. Pore-zone slightly sunk.

Interambulacra. Areoles of moderate size, very deep, well separated, except, at most, the two proximal ones; those on the oral side more or less distinctly transverse-oval (conspicuously so in the cotype specimen 3). Edge of areoles rather thickened and raised; the scrobicular tubercles fairly prominent, somewhat sloping towards the areole. Outside the scrobicular ring the plates closely covered by rather coarse, more or less distinctly mamelonate secondary tubercles which decrease very gradually in size towards the midline of the area, as also towards the horizontal and adradial sutures. In specimen 3 these secondary tubercles are particularly conspicuous on the oral side, where they are as large as the scrobicular tubercles. In this specimen there is hardly any room for secondary tubercles on the adradial side of the scrobicular ring, whereas in the other specimens there is a fair number of secondary tubercles here on the adradial side of the areole. Fine lines radiating from the scrobicular edges produce a more or less distinct linear arrangement of the secondary tubercles. The sutures rather conspicuously sunken, the plates being on the whole thick and arched. Impressions in the horizontal sutures more or less distinct, and varying in number. The width of the median area is about $^2/_3$ of an areole.

Apical system about half h. d. Oculars all narrowly insert, more or less inwards produced. Genital pores small, the male pores nearer the middle of the plates than are the female pores. The whole apical system closely covered by tubercles of uniform size, arranged in more or less distinct series on account of fine radiating lines. There may be a fairly conspicuous naked edge on the genital plates.

Peristome conspicuously smaller than apical system, flat. There are in the largest specimen 12—13, in specimen 3 13—14 ambulacral plates in a series, the pores being rather irregularly arranged. There are 8—9 interradial plates rather irregularly arranged, not reaching the mouth edge.

The primary spines are in the main cylindrical, they may be slightly thickened in the basal part and more or less conspicuously flaring at the tip, as shown in Pl. I. 1—3 of Döderlein's work (Pl. XIX. 2—3). In the cotype, specimen 3, they are, however, simply pointed, i. e. the few of the ambital spines which are not broken. The shaft is set with rather coarse, rounded warts, arranged in ca. 12—15 longitudinal series, which form more or less conspicuous ridges in the distal part; in the basal part there is usually some irregularity, sometimes so much that the serial arrangement is quite obscured. The general surface of the shaft covered with a rather thick coat of anastomosing hairs of the same character as in *St. microtuberculata* (cf. Fig. 83. 1, p. 259). In finely preserved spines the hair-coat almost completely covers the warts in the basal part, the spine thus looking almost quite smooth; in the distal part the ridges remain distinct. The collar is ca. 1.5—2 mm long, increasing markedly in thickness towards the inconspicuous milled ring; above the collar there is a conspicuous, well limited, smooth, shining neck

about twice as long as the collar. The oral primaries are little specialized, rather coarsely ridged, scarcely flattened, usually not flaring at the tip.

Secondary spines. The scrobicular spines ca. 4—5 mm long; those on the aboral side flat, rather distinctly excavate towards the end. The secondary spines outside the scrobicular spines decrease very gradually in size till a length of ca. 1 mm; they are all closely appressed, more or less scale-like. On the oral side the secondary spines are of quite a different character, thick and irregularly club-shaped. This also holds good of the marginal ambulacral spines, while on the aboral side they have the usual character of simple, flat spines, ca. 2 mm long.

The pedicellariæ have been carefully described and figured by Döderlein to whose work may be referred. It should only be pointed out that the supposed fourth form (Op. cit. Taf. VIII. 2. h.) is only a developmental stage of a large globiferous pedicellaria. The tridentate pedicellariæ with broad and flat valves, joining in almost their whole length; they have some irregular, serrated crests in the basal part of the blade[1] (Pl. LXXX. 35). — Spicules of the tubefeet simple rods of the usual Cidarid type. In the intestinal wall (in the var. *hyatorina*) the usual small rods occur, very sparingly.

Colour. According to Döderlein the general colour is yellowish-gray, the dried test being leather-brown with the areoles of a lighter colour. The primary spines are of a uniform reddish-pink colour (in the largest specimen however more yellowish-white (?faded)). The secondary spines have a fairly conspicuous greenish-brown midline, the miliary spines are of a uniform olive or more reddish colour.

Var. **hyatorina** Mrtsn.

Pls. XIX. 4—6; XX. 3; LXX. 3; LXXX. 28—34.

Stereocidaris grandis. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 22. (partim) Pl. XXXVI.
Stereocidaris grandis, var. *hyatorina.* Th. Mortensen. 1928. New Cidaridæ. p. 69.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	56 mm	34 mm	28 mm (50 % h.d.)	18 mm (32.1 % h.d.)	6—7	21—23	?
2	49 —	29 —	24 mm (49 —)	17.5 — (35.7 —)	6 (7)	20—21	?
3	32 —	18 —	16 — (50 —)	13.5 — (40.9 —)	(6) 5	16—18	55 mm
4	29 —	18 —	14 — (48.3 —)	13 — (44.8 —)	5—6	16—17	46 —
5	26 —	15 —	15 — (57.6 —)	11 — (42.3 —)	5	15—17	45 —

Specimens 1—2, the types, from off Kiushiu (taken by the author, on board the "Hyatori Maru"); specimens 3—5 from the Sagami Sea, off Suno Saki, "Albatross" Stat. 3749. Specimen 3 is the one figured in Pl. 36 of the Hawaiian Ech. Cidaridæ.

[1] The statement by Agassiz & Clark (Op. cit. 1907. p. 112) that the pedicellariæ of this species (*St. microtuberculata*, as they erroneously name it) are very similar to those of *St. leucacantha* and cannot be distinguished from them with certainty I am at a loss to understand, since the pedicellariæ of *leucacantha* are really rather conspicuously different (cf. Pl. LXXXI. 21—27) to compare with those of *St. grandis*, as represented by Döderlein, Op. cit. Pl. VIII. 2). I have not myself found any tridentate pedicellariæ on the said specimen of Agassiz & Clark.

This variety differs from the typical *grandis* in the marginal ambulacral tubercles continuing in a quite regular series unto the peristome (Pl. LXX. 3) and in the secondary spines on the oral side not being thick and club-shaped. Also the primary spines are more intensely red coloured; in the largest specimen they are conspicuously flattened towards the end. In the pedicellariæ (Pl. LXXX. 28—34) no essential differences from the typical *grandis* appear to exist.

The striking difference in the ambulacra and the secondary spines on the oral side would seem to preclude the idea of this form being identical with the typical *grandis*. However, so long as we do not know whether the said characters are constant features of *grandis*, it seems to me the only reasonable course to designate the specimens with the simple ambulacra and not thickened secondary spines as a variety only of *St. grandis*.

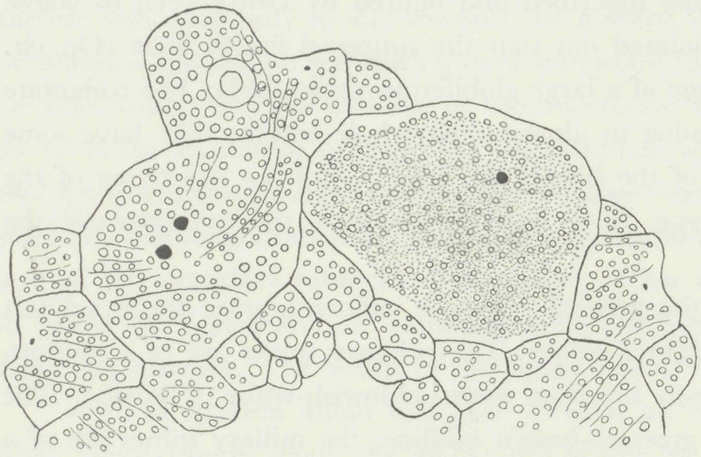


Fig. 77. Part of abnormal apical system of *Stereocidaris grandis* Död. × 3.

Biology. In a specimen of the variety the contents of the alimentary canal was found to be bottom material, with monaxonid sponges as only directly recognizable remains. — The primaries are rather much overgrown by arenaceous Zoanthids, Barnacles and Serpulids. A young specimen of 10 mm h. d. (from the Sagami Bay, ca. 350 m, collected by the author in 1914) which may almost with certainty be referred to this species, either the typical form or the variety, has only 4 interambulacral plates in each column, the fifth having merely begun to appear. There are 8—10 ambulacrals to each of the larger interambulacrals; 6 ambulacral plates in the peristomial series. All the oculars are excluded from the periproct; no genital pores (in a specimen of 20 mm h. d. ("Albatross" St. 3749) they have appeared). The primary spines have in the main the typical form and the same pinkish colour as in the adult. The globiferous pedicellariæ like those of the adult; tridentate pedicellariæ not found. — The species reaches a very considerable size, as documented by specimen 1, and thus well deserves its specific name. — This latter specimen shows some very remarkable anomalies in its apical system (Fig. 77), especially the coalescing of Ocular III with the uppermost plate of interambulacrum 3, is unique[1].

Occurrence. The type and cotypes are from the Sagami Sea, ca. 200 m, the large specimen (1) from between Hakodate and Sado Isl. 70—75 m. The two specimens 1 and 2 of the var. *hyatorina* were collected by the author off Kiushiu, 128° 11′ E. 32° 17′ N., 200 m (spec. 1) and 21 M. W. 1/3 S. of Bonomisaki, 400 m (spec. 2); both on a sandy bottom. The other specimens of the variety were taken in the Sagami Sea, off Suno-Saki, ca. 120—250 m ("Albatross").

[1] A similar case is found also in the type-specimen of *St. stylifera* (cf. Fig. 80, p. 249).

Outside the Japanese Seas the species is not known, those recorded under the name of *St. grandis* from the Malayan and Hawaiian Seas being not really that species (see below).

Remarks. This is a rather perplexing species. It is quite probable that already in the original description two different species were included. The specimen b of Döderlein (Op. cit. p. 49) which Döderlein has (according to information in a letter to me) designated as the holotype, and of which I have received an excellent photograph, agrees completely with the cotype placed at my disposal by Prof. Döderlein (specimen 3 of the above measurements) and with the large specimen 1 in the striking characters of the ambulacra and the secondary spines. The two other of Döderlein's original specimens, of which he has also sent me photographs, do not show the irregularity of the ambulacra, and it may then well be concluded that their secondary spines were not thickened either (— both are naked tests). It would then seem probable that these two specimens are identical with the var. *hyatorina*.

That these characters of ambulacra and secondaries are not alone due to difference in age is proven by the fact that the two larger specimens of the var. *hyatorina*, of about the same size as specimens 2—3 of the typical *grandis*, do not show any sign thereof. It seems therefore necessary to confine *St. grandis* to comprise the specimens showing these characteristics. Whether it will ultimately be found, when a richer material shall be avaible, that these characters hold good, we do not know, of course; but it seems quite probable and then the consequences will be that the variety *hyatorina* must be regarded as a separate species. For the present it does not seem safe to regard it as more than a variety of *grandis*.

Concerning this variety is to be noticed the rather conspicuous difference shown by the two larger specimens (1 and 2), one being almost flat on the upper side, the other more spherical with thick, arched plates; also the shape of the oculars and the outlines of the upper interambulacral plates are different (Pl. XIX. 4, 6). If the tests of these two specimens had been found as fossils, they would rather certainly have been regarded as two distinct species; but there can be no doubt that they represent only individual variations.

As has been explained under *St. hawaiiensis* the specimens of the var. *hyatorina* (specimens 3—5) from the "Albatross" St. 3749 bear a great resemblance to the Hawaiian specimens which were by Agassiz & Clark identified as *St. grandis*, and they show that the Hawaiian species is very nearly related to *St. grandis*, viz. to the var. *hyatorina*. On the other hand, it seems also evident that there is a rather close relation between *St. grandis* var. *hyatorina* and the species *St. granularis* Mrtsn. from the Philippine and Moluccan Seas, which latter was provisionally recorded in my Report on the Cidaridæ of the "Albatross" Philippine Expedition (p. 299) under the name of *Stereoc. grandis*. It differs from *St. granularis* in various features: the much coarser granulation of the test and the quite gradual decrease in size of the tubercles (and secondary spines) from the scrobicular ring outwards (in *granularis* there is a much more abrupt passage from the scrobicular tubercles to those outside the scrobicular ring). Also the ocular plates, the primary spines and the colour afford more or less conspicuous distinguishing characters (cf. under *St. granularis*).

When working out the report on the "Albatross" Cidarids, I had not yet had the opportunity of a more close study of the genus *Stereocidaris*, and I could only suggest that there had been made some mistake with the species *grandis* and *microtuberculata*. This I have now been able to ascertain definitely, having had the opportunity of directly comparing the form regarded by H. L. Clark as *Stereocidaris microtuberculata* with the typical *St. grandis*, (of which a cotype was sent me from Döderlein), and being at the same time in possession of specimens of the true *St. microtuberculata*.

The result is that the specimen ("Albatross" St. 4807) recorded by Agassiz & Clark (Op. cit. 1907. p. 112) and mentioned and figured by H. L. Clark in his "Cidaridæ" p. 220, Pls. I—II as *Stereocidaris microtuberculata* is the typical *St. grandis*, agreeing perfectly with the cotype (and type), especially in the characters of the ambulacra and the secondary spines. This, however, leads to another difficulty. H. L. Clark (Hawaiian Ech. Pedinidæ etc. p. 383) has examined the type-specimen of Yoshiwara's *Stereocid. microtuberculata* and takes it to be identical with the above mentioned specimen, which is, as said, a true *St. grandis*. If he were right, the *Stereocid. microtuberculata* Yoshiw. would be a synonym of *St. grandis*, and the species described here as *St. microtuberculata* would then be a new species. A reexamination of the type-specimen of *St. microtuberculata*, which has been lent me from the Tokio Museum, has, however, given the result that it is really identical with the species here designated as *Stereocid. microtuberculata*. That Clark, in spite of his examination of this type-specimen, failed to see the difference between *microtuberculata* and the true *grandis* also appears clearly from the fact that a large specimen of *St. microtuberculata* in the U. S. National Museum ("Albatross" St. 3719 — so far as I can see this specimen is nowhere mentioned in literature —) has been named, in H. L. Clark's hand 1907, *Stereocidaris microtuberculata*, as a correction of a former identification by me, as "probably *Stereocidaris grandis*". Here Clark's identification is the right one, but it is thus proven that he has identified both a typical *grandis* and a typical *microtuberculata* under the latter name.

The records of the species *St. grandis* as occurring at the Hawaiian Islands (Agassiz & Clark, Op. cit.) and in the Malay Archipelago and the Philippine Seas (De Meijere "Siboga" Ech., Th. Mortensen. "Albatross" Cidaridæ, H. L. Clark. Cat. Rec. Sea-Urch. Brit. Mus.) rest on a confounding of other species with the true *St. grandis*, viz. *St. hawaiiensis* Mrtsn. (the Hawaiian specimens), *St. granularis* Mrtsn. ("Albatross" and "Siboga" St. 139), *St. stylifera* Mrtsn. ("Albatross" St. 5392 and 5283), *St. sulcatispinis* Mrtsn. (the specimens from "Siboga" St. 90), *St. purpurascens* Mrtsn. ("Siboga" St. 251), *St. tubifera*, var. *impressa* Mrtsn. ("Siboga" St. 262), and *St. indica*, var. *philippinensis* Mrtsn. (H. L. Clark. Cat. Rec. Sea-Urch. Brit. Mus., "Challenger" St. 210; the second specimen mentioned by Clark there, from Misaki, is *Stereocidaris sceptriferoides* Döderlein. Clark himself expresses some doubt, whether these two specimens really belong to *St. grandis*).

Döderlein's suggestion (Op. cit. 1885) that *St. grandis* may perhaps be only the old *St. japonicus* is, of course, out of question, as also Döderlein himself dropped this suggestion in the final work (1887).

Stereocidaris hawaiiensis Mrtsn.

Pls. XXI. 4—6; LXX. 10—11; LXXX. 6—9.

Stereocidaris grandis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 22. (partim) Pl. **XXXIII.** (non: Pl. V, 18—20; XXXVI).

Stereocidaris grandis. H. L. Clark. 1907. The Cidaridæ, p. 220. (partim).

Stereocidaris hawaiiensis. Th. Mortensen. 1928. New Cidaridæ, p. 69.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	39 mm	24 mm	19 mm (48.7 % h.d.)	15 mm (38.5 % h.d.)	5 (6)	18—19	62 mm
2	38 —	25 —	19 — (50 —)	16 — (42.1 —)	5	19—20	?38 —
3	34 —	19 —	18 — (52.9 —)	15 — (44.1 —)	4—5	19—20	62 —
4	33 —	20 —	15.5 — (47 —)	13 — (40 —)	4—5	19—21	56 —

Specimen 2 is the type-specimen (in the Museum of Comp. Zool.). Specimen 3 is the specimen represented in Pl. XXXIII of the Hawaiian Ech. Cidaridæ.

Shape of test almost regularly spherical or, as in the type-specimen, more low and distinctly flattened on the oral side.

Ambulacra rather conspicuously sinuate, about 18—23 % of width of I. A. The interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles scarcely contiguous. Adradially to the marginal tubercle each plate carries a somewhat smaller tubercle, sometimes (as in specimen 3) two small tubercles placed one above the other, in both cases the inner tubercles form regular vertical series. In the largest specimen there is, at the ambitus, a series of smaller tubercles along the midline. The pore zones rather distinctly sunken; pores equal-sized, the wall only slightly elevated, ridge low (Pl. LXX. 10—11).

Interambulacra. Areoles fairly large and deep, the two proximal ones scarcely confluent, and only the proximalmost slightly transverse-oval. Edge of areoles somewhat raised (conspicuously so in specimen 2), the scrobicular ring of tubercles fairly conspicuous. The rest of the plate covered rather closely by secondary tubercles, decreasing very gradually in size towards the horizontal and vertical sutures. There is an indication of fine lines going from areole to areole, across the vertical sutures. On the adradial edge there is only room for a single series of small tubercles outside the scrobicular tubercles. The upper horizontal sutures have one or more rather conspicuous deepenings, the ambital sutures are somewhat deepened at the admedian end. The median space, which is quite distinctly sinking towards the midline, is about half the width of an areole.

Apical system about half h. d., usually high and arched, the plates themselves being also thick and arched (less so in specimen 3), the sutures distinctly sunken. Ocular plates all exsert, rather varying in shape (cf. Pl. XXI. 5 of the present work with Pl. XXXIII. 2 of the Hawaiian Ech.). The genital pores almost in the centre of the plates in specimen 3 (♂), somewhat nearer the outer edge in the other specimens; the female pores not much larger than the

male pores. There may be a rather conspicuous naked inner edge to the genital plates. Periproct with a moderate number of plates. The whole apical system uniformly and rather closely covered with tubercles, which are somewhat smaller in specimen 3 than in the other specimens.

Peristome distinctly smaller than apical system, flat. There are 10—11 ambulacral plates in a series, 4—6 interradial plates arranged more or less irregularly, they may reach almost to the mouth edge.

Primary spines distinctly fusiform, tapering, the point not widened. The shaft is set with about 16—18 series of low, rounded spinules. Only towards the point these series assume the shape of low ridges; in well preserved spines (in the type-specimen the spines are rather worn), the spinules are almost concealed by the hair coat, the spines appearing thus nearly smooth. The hairs anastomose and are of the same character as in *St. microtuberculata* (cf. Fig. 83. 1 p. 259). The collar is only 1—1.5 mm long, slightly increasing in thickness towards the milled ring, which is rather inconspicuous, not prominent. Above the collar there is a very conspicuous, smooth, shining neck, twice or more the length of the collar. The oral primaries are quite simple, slightly fusiform, not widening in the point. The second—third is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 4 mm long, flattened or slightly convex on the outer side, not excavate towards the point, which is a little rounded. The miliary spines are rather scale-like, appressed, at least sometimes with a distinct glandular ampulla. There is an abrupt difference in size between the scrobicular spines and those following immediately outside. The marginal ambulacral spines are rather broad, flat; on the aboral side they are ca. 2 mm long, towards the peristomial edge they gradually increase somewhat in length, being at the same time a little more slender and curving obliquely adorally.

Pedicellariæ. Large globiferous pedicellariæ of the usual type (Pl. LXXX. 6, 9), with short, thick stalk. Small globiferous form not peculiar. The tridentate pedicellariæ with very slender, narrow, straight valves, joining only in the outer third; no serrate crests in the basal part of the blade (Pl. LXXX. 7—8). They reach a size of ca. 1.5 mm length of head. — Spicules of the tubefeet of the usual Cidarid type; in the intestinal walls only very few small rods of the type peculiar to *Stereocidaris*.

Colour. General colour a pale olive-gray. The primaries pale gray with a rather conspicuous olive tint on the neck, or they may be faintly pink or whitish. The secondaries a more or less dark olive-greenish. The denuded test whitish, the apical system olive-gray or greenish, this colour continuing a little over the upper interambulacrals.

Biology. In the intestinal canal was found bottom-material with Foraminifera and monaxonid sponges as only recognizable animal remains. On a dried specimen (from the station 4044) in the U. S. National Museum I observed some small, oval bodies in grooves in the sutures between the apical plates. They are almost certainly egg-capsules, most probably of a parasitic Gastropod; no such was, however, observed on the specimen. Some of the specimens have their primary

spines invested by Polychæte tubes composed of coarse sand-grains. — It has much the appearance that the larger specimens have reached full size.

From each of the "Albatross" Stations 3835 and 4096 there is before me a specimen rather intermediate between *hawaiiensis* and *leucacantha*. In general they resemble more *hawaiiensis*, but their primary spines are slender like those of *leucacantha*, though without the dark ring between the collar and neck so characteristic of the latter species. The tridentate pedicellariæ are of the *hawaiiensis*-type. It would seem rather probable that these specimens are hybrids between *hawaiiensis* and *leucacantha*.

Occurrence. Known only from the Hawaiian Seas, where it was taken by the "Albatross" in depths of ca. 285—455 m.

Remarks. This is the species recorded by Agassiz & Clark (Op. cit. 1907) under the name of *Stereocidaris grandis* — excluding the specimens from Station 3794, which I must regard as belonging to *St. grandis* var. *hyatorina*.

That this Hawaiian form is not identical with the true *Stereocidaris grandis* is evident enough, the differences in both test and spines being quite conspicuous: secondary spines of the oral side not thickened and no irregularity in the ambulacra, primary spines not widened at the point; also the tridentate pedicellariæ are very conspicuously different.

The said specimens from Station 3749, off Suno Saki, Sagami Sea (Pl. 36 of the Hawaiian Ech. Cidaridæ) have in general much resemblance to the Hawaiian species, and make it conceivable that the authors referred both the Japanese and the Hawaiian form to *St. grandis*. But I do not think they are really identical, and what makes me doubt this identity is mainly the difference in the shape of the tridentate pedicellariæ, which are much more slender in the Hawaiian than in the Japanese form (cf. LXXX. 7—8 with LXXX. 33—34). The tridentate pedicellaria represented in Pl. 5, Fig. 20 of the Hawaiian Ech. evidently is from the Japanese form). Also the primary spines are not so distinctly fusiform as in the Hawaiian form, and partly, at least, widened in the end, which they are not in the Hawaiian form. Whether the Japanese specimens are then identical with the true *grandis* must remain questionable, until we have learned whether the irregularity of the oral part of the ambulacra and the thickened secondary spines on the oral side are really constant characters of *St. grandis* or not. But I do not see any reason to doubt their identity with the form which I have designated as a variety of *St. grandis*, the var. *hyatorina*. — That the species *Stereocidaris hawaiiensis* is closely related to the Japanese *St. grandis*, var. *hyatorina* is certain enough.

Stereocidaris granularis Mrtsn.

Pls. XXV. 2—7; LXVII. 12; LXX. 4—5; LXXXII. 1.

Cidaris (Stereocidaris) grandis. De Meijere. 1904. "Siboga" Ech. p. 17. (partim).
Stereocidaris grandis. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 299. (partim).
Stereocidaris granularis. Th. Mortensen. 1928. New Cidaridæ, p. 69.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	41 mm	27 mm	20 mm (48.8 % h.d.)	15 mm (36.6 % h.d.)	6—7	18—20	60 mm
2	37 —	23 —	20 — (54 —)	15 — (40.5 —)	5—6	18—20	62 —
3	33 —	18 —	18 — (54.5 —)	13 — (39.3 —)	5—6	18—20	48 —
4	30 —	16 —	16 — (53.3 —)	13 — (43.3 —)	5—(6)	16—18	46 —
5	27 —	15 —	15 — (55.5 —)	12 — (44.4 —)	5	15—16	47 —
6	25 —	15 —	13 — (52 —)	11 — (44 —)	5	15—16	48 —
7	21 —	12.5 —	11 — (52.4 —)	10 — (47.6 —)	5	12—14	47 —

Specimen 1—3 from the Philippines, "Albatross" St. 5459 (1) and 5325 (2—3); specimens 4—5 and 7 from the "Siboga" Exped. (Stat. 139); specimen 6 from the Danish Expedition to the Kei Islands.

Test rather flattened both above and below; sides beautifully arched. Circumference circular or slightly subpentagonal.

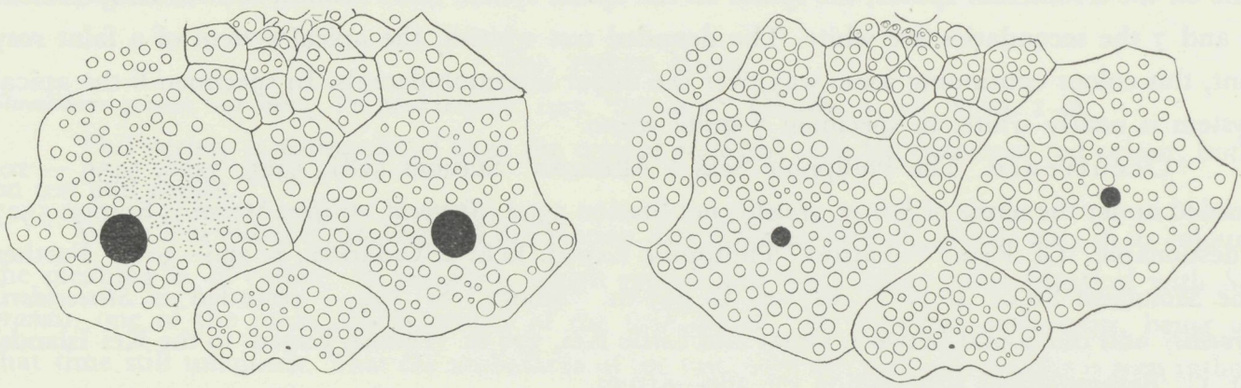
Ambulacra ca. 1/4 the width of the interambulacra (in specimen 5 up to 29 % that width), rather conspicuously sinuate. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles more or less irregular in shape, contiguous. The space inside the marginal series quite filled up by secondary tubercles; those nearest the marginal tubercles are the largest, not much smaller than the marginal ones, and form fairly regular vertical series. In specimens 2—3 there are only the two inner series, which are here very regular. The interporiferous space not sunk towards the median line. Pores of equal size; the wall forms a low rounded crest, the ridge rather sharp (Pl. LXX. 4—5).

Interambulacra. Areoles moderately large, fairly deep, at most the two proximal ones confluent; the subambital ones slightly transverse-oval. There are fairly distinct traces of crenulation on the upper tubercles. Edge of areoles not raised, the scrobicular tubercles low and rather inconspicuous, their mamelon rather somewhat smaller than usual. The whole plate outside the scrobicular ring closely covered by small secondaries, those nearest the scrobicular tubercles scarcely a little larger than the others. Fine lines radiating from the areoles, across the median line, produce an arrangement of the secondaries in more or less regular series; particularly on the uppermost plates an arrangement in horizontal series is usually very conspicuous. Also on the adradial side there is room for some few secondaries outside the scrobicular tubercles. Impressions in the upper horizontal sutures fairly distinct; in the ambital sutures there is a small, not very distinct groove at the median end. The median area scarcely half as wide as an areole, scarcely sunken towards the median line, as, on the whole, the interambulacral plates are almost

flat; in specimen 6 the median area is somewhat narrower and more distinctly sunken towards the midline.

Apical system flat or rising slightly towards the centre. Oculars low, all exsert, except in specimen 4, where they are narrowly insert. Genital plates generally distinctly broader than long (in specimen 4 not broader than long), closely covered by small tubercles of uniform size leaving a not conspicuous bare inner edge. Male genital pores about in the middle of the plates, female pores, which are ca. 1 mm in diameter, nearer the outer edge (Figs. 78. 1—2). Periproct with a fairly large number of plates. The plates of the whole apical system flat, not thick and arched (as typical in *St. grandis*).

Peristome distinctly smaller than apical system, flat or, in specimen 5, slightly bulging



1 2

Fig. 78. Part of apical system of *Stereocidaris granularis* Mrtsn., ♀ (1) and ♂ (2). × 6.

out. There are 10—11 ambulacral plates in a series. Interradial plates rather irregularly arranged in ca. 8 transverse series, reaching almost to the mouth edge.

Primary spines slender, nearly cylindrical, or slightly fusiform, tapering very gradually. The point simple or, more generally, with a small, oblique, terminal widening, the obliquity downwards directed. The shaft set with fairly sharp spinules arranged in ca. 14 longitudinal series; in the outer part of the spines they form more distinct ridges, particularly in the subambital ones. The general surface of the shaft covered by a rather thick coat of anastomosing hairs, which do not, however, conceal the spinules, the spine thus looking rather thorny, even when fresh and well preserved. The collar is ca. 1 mm long, thickening very markedly towards the milled ring, which is very little prominent. A very well marked, smooth, shining neck above the collar, ca. 2 mm long. The oral primaries are simple, scarcely flattened or widened, but with distinct longitudinal ridges; the second—third transitional to the ambital ones.

Secondary spines. The scrobicular spines are ca. 4 mm long, flat or slightly convex on the outer side, not curved, only slightly narrowing towards the straight cut end. The miliary spines rather scale-like, appressed (in specimens 4—5 more erect, which is evidently due to preservation), with a conspicuous glandular ampulla. There is no very gradual transition from the

scrobicular to the miliary spines, and no special thickening of the spines towards the peristome. The marginal ambulacral spines are about 2 mm long, slightly increasing in length towards the peristome, but scarcely curved here.

Pedicellariæ in the main like those of *St. grandis*, the large globiferous with short, globular stalk, the tridentate with serrate crests in the basal part of the valves (Pl. LXXXII. 1). — Spicules of the tubefeet rather strongly developed, thorny, but generally not developed into fenestrated plates.

Colour. General colour cream-yellowish. The primary spines (when clean) are white, sometimes with an indication of a dark purplish ring at the limit between the collar and the neck, recalling the condition in *St. leucacantha*; in the "Siboga" specimens they have a faint reddish hue. The secondary spines have a greenish-olive tint which may form a fairly conspicuous mid-line on the scrobicular spines; the spines on the apical system more reddish-brown. In specimens 6 and 7 the secondaries are white. The denuded test whitish, the apical system of a faint rosy tint, this colour continuing some way over the upper interambulacrals. In specimen 6 the apical system is nearly white, in specimen 7 quite white.

Occurrence. The Philippine Seas ("Albatross" Stations 5281, 5325, 5326, 5459 — recorded under the name of *Stereoc. grandis*; not Station 5392 (*Stereocid. stylifera* Mrtsn.); Station 5527 questionable. Cf. Rep. "Albatross" Philippine Exped. Ech. I. Cidaridæ, p. 299—301). Further the Moluccan Strait (0° 11′ S. 127° 25′ E. 397 m. "Siboga" St. 139 — recorded as *Stereocidaris grandis*) and the Sound between Great and Little Kei, 370 m. (Danish Exped. to the Kei Islands, St. 1). Bathymetrical distribution ca. 360—510 m.

Remarks. The question of the specific validity of this form is a rather difficult one. There is no doubt that it is nearly related to *Stereocidaris grandis*, var. *hyatorina*, but it differs from the latter in various characters: the flat, not thick and arched plates of the aboral side, the not sunken median line in the interambulacra, the much lower oculars, which are usually not insert, the abrupt passage from the scrobicular to the other, much smaller, secondary spines, the finer granulation of the test, the more slender, white primary spines and the rosy colour of the apical system. Also the size appears to be smaller. — From the typical *St. grandis* it differs in its ambulacra being quite regular and the secondary spines on the oral side not thickened. — However, one of the "Siboga" specimens (spec. 5) is to some degree intermediate, the granulation of the test being somewhat coarser than in the other specimens, and even the plates of the upper side are slightly arched. It is, therefore, not easy to decide whether the specimens from the Philippine and the Moluccan Seas should be regarded only as a variety of *St. grandis*, besides the var. *hyatorina*, or as a separate species. The main thing is, however, that it is evidently not justifiable simply to identify them with the Japanese *Stereocidaris grandis*. If the character of the irregular ambulacra and the thick secondary spines of the oral side in the typical *grandis* proves to be a constant character, there is no doubt that neither *hyatorina* nor *granularis* belong to *grandis* but represent separate species.

The specimen from "Albatross" Stat. 5527 differs from the typical *granularis* in the primary

spines being more pointed than usual, as also the thorns are finer, the general appearance of the spines thus being somewhat more smooth. Possibly this specimen should rather be regarded as a separate variety of *granularis* (Pl. LXVII. 12).

The specimen from the "Siboga" St. 262 (the Sound between Great Kei and Little Kei, 560 m.) (Pl. XXV. 7) is also referred to this species with some doubt, its general appearance being somewhat different from what is usual. But as it is a young specimen with the genital pores as yet undeveloped, the differences may well be due to age. It also seems to have faded somewhat, since De Meijere (Siboga Ech. p. 17) mentions that it had a violet tinge on the collar of the primaries, of which there is now no trace. The specimen has also much likeness to *Stereocidaris purpurascens*, but especially the character of the primary spines forbid referring it to that species.

Var. **rubra** Mrtsn.

Stereocidaris grandis, var. *rubra*. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 301. Pl. **68. 1—2.**

This variety is distinguished from the typical *granularis* only by its intense red colour, both on test and spines.

When it is stated in the original description that it differs from *St. grandis* only in its colour, the meaning is, of course, *St. granularis*, which species was there taken to be identical with *St. grandis*, one of the main characteristics of the true *grandis*, the irregular ambulacra, being at that time still unknown. That the ambulacra of the var. *rubra* are perfectly regular is seen rather distinctly on fig. 2 of Pl. 68 (Op. cit.), in spite of the half tone reproduction, and a reexamination of the negative of the said figure gives absolute certainty that it is so.

Stereocidaris squamosa Mrtsn.

Pls. XX. 4—6; LXX. 7; LXXX. 10—16.

Stereocidaris indica. Bell. 1909. Rep. Echinod. coll. by Stanl. Gardiner in the Western Parts of the Indian Ocean. Trans. Linn. Soc. London. 2. Ser. Zool. XIII. p. 21.

Stereocidaris indica. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 26.

Stereocidaris squamosa. Th. Mortensen. 1928. New Cidaridæ, p. 70.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	47 mm	29 mm	22 mm (47 % h.d.)	19 mm (40.4 % h.d.)	5—6	20—21	ca.50 mm
2	42 —	26 —	20.5 — (48.8 —)	17 — (40.5 —)	5 (6)	21—23	50 —
3	41 —	25 —	20 — (48.8 —)	19 — (46.3 —)	5—6	20—22	61 —
4	38 —	24 —	18 — (47.4 —)	16 — (42 —)	5	19—22	59 —
5	36 —	20 —	17 — (47.3 —)	16 — (44.4 —)	5—6	18—19	?
6	30 —	18.5 —	14 — (46.6 —)	13 — (43.3 —)	5—6	19—22	ca.50 —

Specimens 1—4 in the British Museum, 5 in the Museum of Comp. Zoology, 6 in the Copenhagen Museum.

Test rather low, gently arched both above and below, not incurved at the peristomial edge. Sides strongly arched; circumference regularly circular.

Ambulacra distinctly sinuate, about $^1/_3$ the width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles perfectly regular, the tubercles rather large, contiguous. Adradially to the marginal tubercle each plate carries usually a single tubercle, almost as large as the marginal one, the interporiferous zone thus carrying in all four very regular series of tubercles, filling the whole space so that no naked or sunk median line is left. Sometimes there may be two somewhat smaller inner tubercles instead of one large; more rarely there may be a single series of tubercles along the midline. The pores are rather small, separated by a moderately broad wall, raised into a small tubercle; ridge low (Pl. LXX. 7).

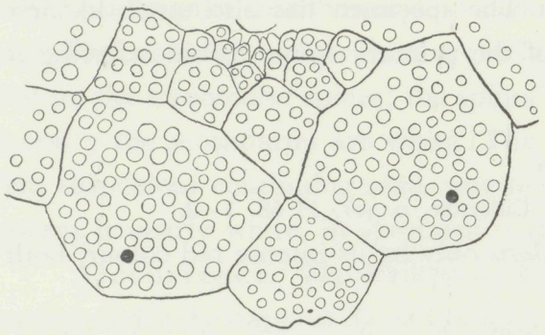


Fig. 79. Part of apical system of *Stereocidaris squamosa* Mrtsn. ♂. × 6.

Interambulacra. Areoles of moderate size and depth, all well separated, even the lowermost ones not confluent; only the proximal ones slightly transverse-oval. The mamelon fairly large; the uppermost tubercles faintly crenulate. Edge of areoles not distinctly raised, the scrobicular tubercles not very conspicuous. Outside the areoles the plates are closely covered with small tubercles of uniform size; fine furrows produce a more or less distinct linear arrangement of these secondary tubercles. Also on the adradial side of the areole there is room for some secondary tubercles outside the scrobicular circle. The upper horizontal sutures with 3—4 rather distinct, small grooves, besides one at the admedian edge, the latter being also distinct on the ambital sutures. The median line rather conspicuously sunk, the plates thus somewhat elevated. Median area about half the width of an areole.

Apical system. Oculars in specimen 1 all narrowly insert, in the other specimens exsert or partly narrowly insert. Genital plates rather low, with the genital opening nearer the outer edge. Periproct with a moderate number of plates. The whole apical system closely covered with small tubercles of uniform size, leaving at most a narrow inner edge of the genital plates bare (Fig. 79). Peristome flat or slightly protruding. There are 11—12 ambulacral plates in a series; the interradial plates may be rather numerous, 3—4 in a transverse series in the outer part, reaching almost to the edge of the mouth, or they may be more regular, in a single or double series.

Primary spines cylindric, tapering only very slightly; the point scarcely widened; judging from the few intact ones they do not exceed 1.5 h. d. Shaft with ca. 15 series of low, slightly pointed granules or warts. The narrow space between the series covered by anastomosing hairs which form a smooth, shining surface, somewhat recalling the condition in *Schizocidaris* and *Centrocidaris*. This is, however, seen distinctly only in some of the better preserved spines. The spines on the whole give the impression of being very smooth. The collar is scarcely 1 mm long, gradually increasing in thickness downwards and passing directly into the very in-

conspicuous milled ring. The neck is quite conspicuous, 2—3 mm long, smooth and shining. — The oral primaries rather coarse, distinctly longitudinally ridged, not smooth and curved as in *St. indica*; they may be slightly flaring at the point. The 2nd and 3rd transitional to the ambital spines.

Secondary spines. The scrobicular spines 3—4 mm long, almost rectangular, very smooth, slightly excavate on the outer surface. They fit very close together so as to form a close mail round the base of the primary spine. Marginal ambulacral spines only ca. 1.5 mm long, rather broad, rectangular, flat or slightly excavate. Miliary spines short, scale-like, appressed, apparently without a glandular ampulla at the base. There is no gradual transition from the scrobicular to the miliary spines.

Pedicellariæ. Large globiferous pedicellariæ with very short stalk; valves rather coarse, not very slender (Pl. LXXX. 14). The small globiferous mainly of the elongate type, looking rather like tridentate (Pl. LXXX. 10—12). What appears to be a real tridentate form also occurs, with coarsely serrate valves (Pl. LXXX. 16); also the large globiferous sometimes have a shape recalling a short tridentate form — a "hybrid", as it were, between a tridentate and a large globiferous pedicellaria (Pl. LXXX. 13). — Spicules of the tubefeet in the main simple rods of the usual Cidarid type, not fenestrated plates.

Biology. According to Bell (Op. cit.) the spines are covered by "what is, apparently, one species of Cirripede. Wormtubes and Ophiurids may also find a home on the spines".

Colour yellowish-greenish on the upper side, the scrobicular spines partly more or less purplish, especially towards the point. Primary spines white, sometimes with a very faint tint of reddish in the basal part, the collar dark purplish or, at least, the border between collar and neck marked by a dark purplish ring. The naked test with a tint of greenish on the upper side, more conspicuous on the periproct and the upper primary tubercles.

Occurrence. Saya de Malha, Indian Ocean, 270 m.

Remarks. That the present species has no nearer relation to *St. indica*, to which species it was referred first by Bell, then by Clark, is perfectly evident, particularly on account of the much larger size of the peristome, as also of the characters of the miliary spines and the oral primaries. It recalls to some degree *Stereocidaris granularis*, but is perfectly distinct from the latter, and at once distinguished from it by its greenish colour (reddish in *granularis*). Also with *hawaiiensis* it has some general resemblance, but differs therefrom by the characters of its primary spines, the tridentate pedicellariæ, the colour. It seems clear that the species *granularis*, *squamosa*, *hawaiiensis*, together with the var. *hyatorina* of *St. grandis* form a group of nearly related species.

Stereocidaris stylifera Mrtsn.

Pls. XXIX. 1—4; LXX. 13; LXXX. 17—21.

Stereocidaris grandis. Th. Mortensen. 1927. Rep. "Albatross" Cidaridæ, p. 299. (partim).
Stereocidaris stylifera. Th. Mortensen. 1928. New Cidaridæ, p. 69.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
55 mm	32 mm	26 mm (47.3 % h.d.)	20 mm (36.4 % h.d.)	7	20—21	?

Test low, gently arched above, more flattened below; sides strongly arched. Circumference circular.

Ambulacra fairly distinctly sinuate, rather broad, ca. 30 % of width of interambulacra. Interporiferous zone about twice the width of a pore-zone. Marginal series of tubercles on the whole regular, the tubercles not very prominent, contiguous, partly somewhat irregular in outline, mamelon rather unusually small; the interporiferous zone wholly covered by tubercles which are here and there rather distinctly arranged in transverse series; only the outer ones may show an indistinct arrangement in vertical series; they are not mamelonate. No naked or sunken median line, but there is in the midline a rather conspicuous irregular series of small grooves (in which large globiferous pedicellariæ are lodged). The pores are rather broad, separated by a narrow, slightly raised wall which is flat above; ridge low and narrow (Pl. LXX. 13). The pore zones slightly sunken.

Interambulacra. Areoles rather large, but not very deep, well separated, even the proximal ones. The boss is rather small and low; no trace of crenulation observable. Edge of areoles not raised. The scrobicular tubercles fairly conspicuous. Outside the scrobicular ring the plates closely covered by small tubercles of uniform size, those close to the scrobicular tubercles scarcely a little larger than the rest. Fine, but distinct furrows, continuing from areole to areole across the vertical sutures, produce an arrangement of the tubercles in fairly regular horizontal series. On the adradial edge of the plates only few secondaries outside the scrobicular ring. Median line only slightly sunken, not naked. A number of fairly distinct, small grooves in the upper and ambital horizontal sutures, and also a few small grooves here and there on the plates themselves in the median space. The upper rudimentary plates may be wholly enclosed by the next following plate, so as to be excluded from both the median and the adradial sutures (Pl. XXIX. 1—4). This is, however, not the case in all the interambulacra. Median interambulacral space ca. half the width of an areole.

Apical system nearly half h.d., rising very slightly towards the centre. Ocular plates rather broadly triangular, with a deep notch in the outer edge and the inner end truncated, except in Oc. II, which is not insert, the other four being well insert. Genital plates conspicuously higher than broad; the genital pore, which is fairly large (♀), rather distant from the edge. Periproctal plates moderately numerous. The whole apical system closely covered by small tubercles of uniform size; fine furrows produce a fairly distinct linear arrangement of the tubercles (Fig. 80).

Peristome distinctly smaller than apical system, flat. There are 16 ambulacral plates in a series, the proximal ones somewhat crowded and showing a slight irregularity in the pore series. 6—7 interradial plates in a fairly regular series, not reaching the mouth edge.

Primary spines slender, cylindrical, apparently rather short (none of the ambital spines complete); the only complete one of the uppermost spines terminates in a small but distinct crown-shaped widening. The shaft has ca. 14 regular series of low spinules, the surface otherwise being covered by a rather thick, spongy coat of anastomosing hairs, which does not appear to conceal the series of spinules, the spine thus not appearing smooth. The collar ca. 2 mm long, conspicuously increasing in thickness towards the fairly prominent milled ring. There is a quite conspicuous neck, somewhat longer than the collar. The oral primaries slender, not widened and scarcely flattened or curved. They are more or less distinctly fluted in the distal part; the 3rd—4th is transitional to the ambital spines.

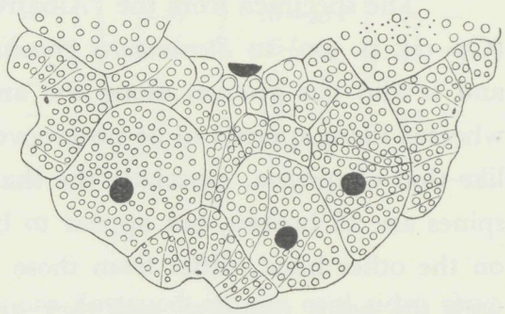


Fig. 80. Part of apical system of *Stereocidaris stylifera* Mrtsn. × 2.5.

Secondary spines. The scrobicular spines are ca. 6—7 mm long, distinctly tapering to the narrow, rounded point. They are flattened, slightly convex in the basal part. The marginal ambulacral spines are unusually long, ca. 4 mm, reaching some way beyond the pore zone; they are not flattened, as is otherwise the rule in *Stereocidaris*, but round, tapering to a fine point. (The species name *stylifera* refers to this character). The miliary spines rather broad, scale-like, appressed. The passage from the scrobicular to the other secondary spines quite abrupt. — As far as can be concluded from the single, dried specimen available, there is no glandular ampulla at the base of these spines.

Pedicellariæ. The large globiferous pedicellariæ are fairly numerous, situated in the above mentioned grooves of the test. They have a very short, globular stalk, the valves are rather short and broad, simple (Pl. LXXX. 17—18). Small globiferous of the usual simple form, not very elongate (Pl. LXXX. 20—21). Tridentate(?) pedicellariæ with rather coarse, flat valves, ca. 1 mm long (Pl. LXXX. 19). Spicules of tubefeet of the usual Cidarid type.

Colour of secondary spines a dull grayish-olive, with an indistinct brownish midline in he basal part. The miliary spines on the aboral side, and especially on the apical system, red-brown or pinkish. The primary spines appear to be dull gray, the neck nearly white, the collar grayish-olive. The naked test is whitish, the apical system a fairly conspicuous reddish-pink, especially on the inner part of the genital and ocular plates.

Biology. The specimen in hand gives much the impression of being full grown, and it may thus be concluded that the species does not reach a much larger size. The spines, as far as preserved, are rather free of foreign organisms; only a Scalpellid is found attached to one of the spines. Several of the miliary spines, especially on the apical system, have a small round

hole in the basal part, evidently bored by a foreign organism; which kind of organism cannot be ascertained, the specimen being dried; it can only be said that it is not a shell-bearing mollusc.

The sole specimen at hand shows the anomaly of genital 1 being divided by a vertical line into two, about equal halves, each with a genital pore; further Ocular II is coalesced with the upper rudimentary plate to the left of it.

Occurrence. The type-specimen was taken by the "Albatross" Philippine Expedition, at Station 5392 (12° 12′ N. 124° 02′ E., 247 m.). In the Report on the Cidaridæ of the Albatross Philippine Expedition this specimen was erroneously recorded under the name of *Stereocidaris grandis*.

The specimen from the "Albatross" Station 5283 also referred in my "Albatross" Cidaridæ (Op. cit. p. 300) to *Stereocidaris grandis* bears a considerable general resemblance to *St. stylifera*, and it also has grooves along the ambulacral midline, though less distinct than in the type, whereas there appears to be no grooves on the interambulacral plates. The apical system is very like that of *stylifera*, especially the shape of the ocular plates, which are all insert. The primary spines are all broken, but appear to be like those of the type. The marginal ambulacral spines, on the other hand, differ from those of the type in being not pointed, styliform, but flattened, with the point rounded, and they are only ca. 3 mm long. These spines have a darker band in the distal part. The colour otherwise as in the type, only there is no trace of red on the apical system. The pedicellariæ in general like those of the type, but the small globiferous occur mainly in the long, slender form, and the coarse tridentate-like form, which is quite numerous, is here seen distinctly to be a form only of the small globiferous.

I am rather convinced that, in spite of the differences pointed out here, this specimen also belongs to *St. stylifera*.

Remarks. This species is of very considerable interest, being intermediate between *Stereocidaris* and the fossil (Cretaceous) genus *Temnocidaris*. Like the latter it has grooves in the ambulacral midline and also on the interambulacral plates, besides rather numerous grooves in the horizontal interambulacral sutures, such as are usually found, in varying number, in other *Stereocidaris* species. In each of these grooves, as a rule, a large globiferous pedicellaria is situated — and we have then here evidently the explanation of the function of the grooves in *Temnocidaris*. The character of the rudimentary upper interambulacral plates show that this species really belongs to the genus *Stereocidaris*; from its other characters it might equally well be designated as a *Temnocidaris*.

Stereocidaris purpurascens Mrtsn.

Pls. XXVI. 1—6; LXXI. 3; LXXX. 22—27.

Stereocidaris microtuberculata. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 302. (partim).
Stereocidaris purpurascens. Th. Mortensen. 1928. New Cidaridæ. p. 70.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	43 mm	26 mm	19 mm (44.1 % h.d.)	16 mm (37.2 % h.d.)	6	21—24	87 mm
2	40 —	24 —	19 — (47.5 —)	15 — (37.5 —)	6	20—22	73 —
3	40 —	23.5 —	18 — (45 —)	14 — (35 —)	6	20—22	74 —
4	35 —	21 —	15.5 — (44.3 —)	13 — (37.1 —)	5—6	21—22	74 —
5	28 —	15.5 —	13 — (46.4 —)	12 — (42.9 —)	5—6	18—20	65 —
6	24 —	13 —	11.5 — (47.9 —)	10.5 — (43.8 —)	5—6	16—19	53 —
7	21 —	12 —	10 — (47.6 —)	9 — (42.9 —)	5	16—18	52 —
8	18 —	10 —	8.8 — (48.8 —)	7.5 — (41.7 —)	5	14—16	45 —
9	15 —	8.5 —	8 — (53.3 —)	7 — (46.6 —)	(4)—5	13—16	35 —
10	11 —	6 —	6 — (54.5 —)	5.5 — (50 —)	4—5	10—11	20 —

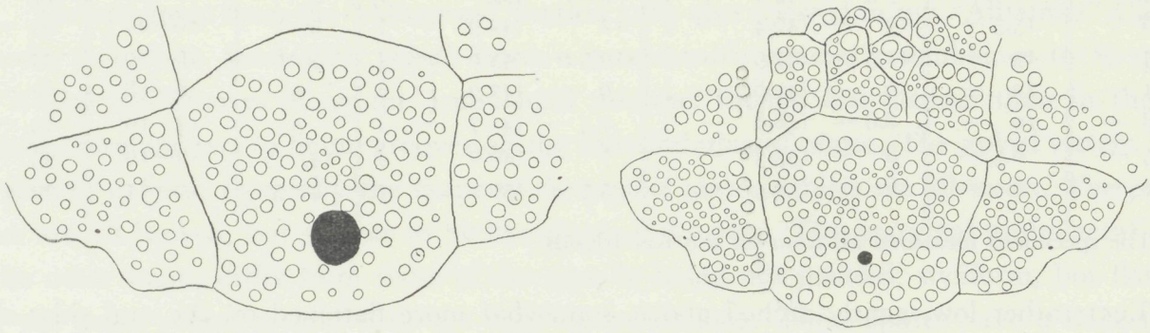
The specimens measured all from off the Kei Islands.

Test rather low, gently arched above, somewhat more flattened on the oral side; sides arched; circumference round. — Ambulacra distinctly sinuate; interporiferous zone about twice the width of a pore zone. Marginal series of tubercles perfectly regular, the tubercles contiguous, with a distinct, but small mamelon. Adradially to the marginal tubercle there is generally a secondary tubercle, about half the size of the marginal tubercle, but not mamelonate, placed almost on the middle of the plate; there is thus a pair of rather conspicuous series of inner tubercles in the interporiferous zone, filling up most of the space; only along the midline there are at the ambitus, in the larger specimens, some small tubercles, arranged in a rather irregular series. There is no naked or sunken space along the ambulacral midline. Pores of equal size, separated by a narrow, slightly raised, rounded wall; ridge low. The pore zone is somewhat sunken (Pl. LXXI. 3).

Interambulacra. Areoles rather large, moderately deep, well separated, even the proximal ones usually not confluent, or at most the two proximalmost ones confluent here and there, not in all the interambulacra. The areoles of the oral side slightly transverse oval. Traces of crenulation on the tubercles. Scrobicular ring not very conspicuous, the scrobicular tubercles rather small; there are ca. 18—20 of them at the upper areoles. Outside the areoles the plates closely covered by small tubercles leaving no naked median line; they show an indication of a serial arrangement only on the uppermost plates. On the adradial side of the areoles there is scarcely room for any secondary tubercles outside the scrobicular ring. Median interambulacral area (between the upper fully developed areoles) scarcely more than $^1/_3$ the width of an areole. The median line slightly sunken, the interambulacral plates on the whole rather flat. The upper horizontal sutures usually with a series of 3—5 small, but distinct grooves, in each of which a

large globiferous pedicellaria is generally attached. At the ambitus there is usually a small groove only at the median end of the suture. The upper first rudimentary plate rectangular, broadly in contact with both the median line and the adradial edge; a second rudimentary plate is not found even in the largest specimen.

Apical system in the larger specimens a little less than half h.d.; in younger specimens slightly exceeding h.d. The plates are flat, not arched. The ocular plates are wholly exsert, or, in the larger specimens, sometimes Oc. I, IV and V narrowly insert. The genital plates not very high. Periproct small, the periproctal plates few, only in two circles. Male genital pores small, rather near the middle of the plates, the female pores larger, ca. 1 mm, somewhat nearer the



1 2

Fig. 81. Part of apical system of *Stereocidaris purpurascens* Mrtsn. ♀ (1) and ♂ (2). × 6.

edge of the plate. The whole apical system closely covered with small tubercles of uniform size, leaving a fairly conspicuous bare edge on the genital plates (Figs. 81. 1—2). — Peristome distinctly smaller than the apical system, ca. 35—44 % h. d., in younger specimens somewhat larger, up to half h.d. There are 10—12 ambulacral plates in a series in the larger specimens. The interradial plates generally in 2—3 irregular series, more rarely in a single, regular series of 6—7 plates; they reach to the mouth edge, the neighbouring ambulacral series not joining there.

Primary spines usually about twice the h.d., slender and cylindric, tapering very slightly towards the point, which is simple or ends in a very small and inconspicuous, crown-shaped widening. The shaft is, on the whole, smooth; it is finely longitudinally ridged by ca. 14 low ridges formed by low, rounded spinules. Towards the end of the shaft the ridges become a little higher and are here rather distinctly serrate. Between the ridges are small, irregularly arranged warts, set with somewhat anastomosing hairs, which may unite into a continuous coat of anastomosing hairs, as is generally the case in this genus; often this is, however, not the case, each wart remaining separate. The collar is ca. 2 mm long, increasing very conspicuously in thickness towards the milled ring which is otherwise not prominent. Above the collar there is a rather conspicuous smooth neck, a little longer than the collar. — The oral primaries slightly widened, flattened, with the edges scarcely at all serrate; they have fairly distinct longitudinal ridges, better developed on the aboral than on the adoral side. The second and third, which are transitional to the ambital spines, may end in a small crown.

Secondary spines. The scrobicular spines are ca. 5 mm long, somewhat narrowing towards the end, which is a little rounded. They are rather thick, and join so as to form a close mail round the base of the primaries; but they are flat or, more generally, somewhat concave on the outer surface and curve a little outwards towards the point. The spines outside the scrobicular ones are much smaller, there being no gradual transition from the scrobicular to the miliary spines. Marginal ambulacral spines ca. 3 mm long, simple, flattened. Miliary spines simple, flattened, rather broad, appressed; they have no conspicuous glandular ampullæ at their base.

Pedicellariæ. Large globiferous pedicellariæ fairly common, especially along the horizontal interambulacral sutures; they are of the usual Stereocidarid type (Pl. LXXX. 24). Small globiferous not very numerous; they are, as usual, especially well developed on the peristome, where they reach a larger size than elsewhere on the test (Pl. LXXX. 25). Tridentate pedicellariæ rather numerous, in all sizes up to 1.5 mm length of head. They are somewhat compressed in the basal part of the blade (Pl. LXXX. 22—23, 26). — Spicules of the tubefeet simple rods of the usual Cidarid structure. In the intestinal wall and the genital organs only few, scattered, small, slightly branching rods; in the organs of Stewart apparently no spicules at all.

Colour whitish, only the upper side yellowish-brown. The primary spines white, sometimes darker towards the point, but the young, not fully developed primaries are usually of a conspicuous dark purplish colour (— to which very characteristic feature the species name *purpurascens* refers). In conformity herewith the central core of the fully formed spines remains more or less distinctly purplish. Also regenerating primaries are thus coloured. The scrobicular spines have a brownish median stripe, gradually disappearing towards the end of the spine. The miliary spines on the apical system yellowish-brown. The denuded test whitish, sometimes with a faint pinkish tint. The apical system yellowish-brown, only the ocular plates somewhat lighter coloured. The brown colour continues more or less conspicuously on to the uppermost interambulacral plates.

Biology. In the intestine of a specimen opened was found bottom material with fragments of shells and Serpulid-tubes. — The moderate size of the eggs, ca. 0.5 mm diameter, may perhaps indicate development through a pelagic larval stage. The genital openings appear rather late, at a size of ca. 20 mm h. d. The larger of the specimens in hand make the appearance of having attained their full size. The spines of these specimens are not much overgrown by foreign organisms, only some few barnacles and scalpellids being attached to the point of a couple of spines.

No parasites have been observed. One specimen shows the anomaly of genital 1 being divided by a longitudinal line into two parts, the smaller part having, however, no genital pore.

Occurrence. Some specimens of this species were dredged by the author at the Kei Islands (Stations 8, 44, 45, 49, 50 and 59, all in the area between Little Kei and the Tajando Islands)[1] in depths of 233—385 m. Further the specimen from the "Siboga" Stat. 251,

[1] For the exact locality of these stations see: Th. Mortensen. The Danish Expedition to the Kei Islands. 1922. Vid. Medd. Dansk Naturh. Foren. Bd. 76. 1923.

referred by de Meijere to *Stereocidaris grandis*, likewise belongs to the present species[1]. This station (5° 28′ S. 132° 0′ E., 204 m) is also near the Tajando Islands. The bottom on these stations was rather varied, from muddy, sandy, with shells, to coral bottom. Further one of the two specimens from the "Albatross" Philippine Exped., which I have referred to *Stereocidaris microtuberculata* ("Albatross" Cidaridæ, p. 302) belongs to the present species, namely the specimen from Stat. 5162 (5° 10′ N. 119° 47′ 30″ E., 414 m). (At the time when the report on the "Albatross" Cidarids was worked out, I had not yet had the opportunity of studying more profoundly the *Stereocidaris*-species, and still regarded the specimens of *St. purpurascens* from the Kei Islands as belonging to *St. microtuberculata*).

Remarks. This species is very well characterized and easily recognizable by its long, slender, smooth, cylindrical primary spines. Also the colour of the young primaries and of the apical system and its spines is a conspicuous feature of this species. It would not seem to be very closely related to any of the other known species of this genus. The comparatively large size of the rudimentary upper tubercles indicates it to be one of the less modified forms.

Stereocidaris sulcatispinis Mrtsn.

Pls. XVIII. 1—3; LXXI. 9—10; LXXX. 1—5.

Cidaris (Stereocidaris) grandis. De Meijere. 1904. "Siboga" Ech. p. 17 (partim).
Stereocidaris sulcatispinis. Th. Mortensen. 1928. New Cidaridæ, p. 70.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	48 mm	27 mm	22 mm (45.8 % h.d.)	20 mm (41.7 % h.d.)	5—6	21—23	68 mm
2	43 —	24 mm	21 — (49 —)	18 — (41.9 —)	5—6	19—20	52 —
3	30 —	19 —	16 — (53.3 —)	15 — (50 —)	5	20—21	56 —
4	12 —	7 —	6.2 — (51.6 —)	6 — (50 —)	4	10—11	15 —

Specimens 1—3 from the "Siboga" Expedition, specimen 4 from the Danish Expedition to the Kei Islands.

Test rather low, more flattened below than above; sides rather strongly arched (in specimens 1—2), circumference circular.

Ambulacra ca. 22 % the width of the interambulacra, rather distinctly sinuate. Interporiferous zone scarcely twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles contiguous. Adradially to the marginal series each plate carries in specimens 1 and 3 only a single secondary tubercle, almost as large as the marginal one, there being thus two fairly regular inner series of tubercles which fill up completely the interporiferous zone. In

[1] The suggestion by H. L. Clark (The Cidaridæ, p. 220, under *St. grandis*) that this specimen and the one from St. 262 might possibly belong to *St. leucacantha* is absolutely unacceptable, and would certainly not have been set forth by Clark, if he had had an opportunity of comparing these specimens directly with the Hawaiian species *leucacantha*. — The said specimen from "Siboga" S. 262 I must refer to *St. tubifera*, var. *impressa* (see under that species).

specimen 2 there is still room for some smaller tubercles, forming an irregular series along the midline of the area. Also the inner tubercles distinctly mamelonate. The pores rather distant, about equal-sized; the wall forms a low crest; the ridge is very well marked off, rather high (Pl. LXXI. 9—10). The pore zone not much sunk. In specimen 3 the pores are more close together, and the ridge not so marked. This difference is, probably, due to age.

Interambulacra. Areoles large, fairly deep, well separated, at most the two proximal ones confluent. The subambital ones distinctly transverse-oval. In the younger specimens there are fairly distinct traces of crenulation on the uppermost tubercles. Edge of areoles not elevated; the scrobicular ring of tubercles rather conspicuous. Outside the scrobicular ring the plates closely

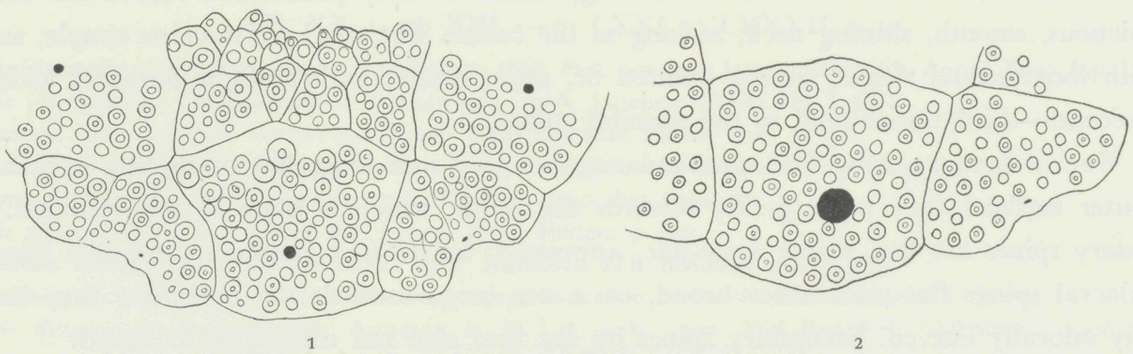


Fig. 82. Part of apical system of *Stereocidaris sulcatispinis* Mrtsn. ♂ (1) and ♀ (2). 1 × 4; 2 × 5·5.

covered by small tubercles of rather uniform size, those nearest the scrobicular tubercles only slightly the larger. There is just room for a few small tubercles on the adradial edge outside the scrobicular ring. Impressions in the upper horizontal sutures very inconspicuous, the median end of the ambital horizontal sutures forming, however, a fairly distinct little groove. Narrow striæ, producing a linear arrangement of the secondaries, are distinct only on the uppermost plates. Median area about half the width of an areole, only slightly sunk towards the midline; the plates, on the whole, flat.

Apical system gently rising towards the centre of the periproct. Oculars of specimen 2 all narrowly insert, in specimen 1 only Ocular I barely insert, and in specimen 3 they are all exsert. Genital plates about equally broad and high, the genital pores near the middle of the plates; the female pores not very large (Figs. 82. 1—2). Periproct with a moderate number of plates. All the plates of the apical system closely covered with rather small tubercles of uniform size.

Peristome slightly prominent; 14—16 ambulacral plates in a series in the larger specimens. Interradial plates in somewhat irregular double series, reaching almost to the mouth edge.

Primary spines ca. 1.5—2 h. d., cylindrical, slightly tapering, the end being simple, not widened. In the two larger specimens the end of the spines is generally somewhat obliquely worn, as if they had served for walking on (which is by no means improbable). The shaft of

the spines has usually 12 longitudinal ridges, which are rather low and quite smooth, or only very faintly serrate. They may be somewhat more prominent towards the end of the spine (specimen 2). Between the ridges the surface of the shaft is covered by a low, very dense coat of anastomosing hairs; the surface of this coat is quite dense and smooth, so that it is only on transverse sections one sees definitely that it is a hair-coat (Fig. 83. 2 to compare with fig. 83. 1, representing a section of a spine of *St. microtuberculata*, the same structure as in the latter being found in the other species related to *St. microtuberculata* and *St. grandis*). The hair-coat is low, not nearly as high as the ridges, which thus remain distinct, also in quite fresh spines; this gives the spines in general a characteristic, channelled aspect. The collar ca. 2 mm long, increasing very considerably in thickness towards the milled ring, which is fairly prominent. Above the collar a conspicuous, smooth, shining neck, as long as the collar. The oral primaries simple, smooth or with longitudinal ridges, simply pointed or, more rarely, with a slight terminal widening. The second—third transitional to the ambital spines.

Secondary spines. The scrobicular spines ca. 5 mm long, flat or slightly excavate on the outer surface; they taper gently towards the point, which is more or less rounded. The secondary spines are flat, rather scale-like, appressed; no distinct glandular ampulla. Marginal ambulacral spines flat and rather broad, ca. 2 mm long; towards the peristome they become slightly adorally curved. Secondary spines on the oral side not distinctly thickened.

Pedicellariæ. Large globiferous pedicellariæ of the usual form, with very short, nearly globular stalk (Pl. LXXX. 3—4); the small globiferous also of the usual form. Tridentate pedicellariæ of the two larger specimens of a somewhat peculiar shape, the valves narrowing towards the point so as to recall to some degree the shape of the small globiferous pedicellariæ (Pl. LXXX. 5). There are, however, no transitional forms. They reach a size of ca. 1 mm length of head. In specimen 3 the tridentate pedicellariæ have the more usual form (Pl. LXXX. 1—2). The spicules of the tubefeet are of the usual Cidarid type, but have a tendency to develop into fenestrated plates at their ends. In the intestinal walls there are the usual, very scattered, simple rods.

Colour. The primary spines of a slight pinkish tint at the base, otherwise white. The secondaries white, with a faint olive-greenish or red-brown midline. The naked test white, with a faint reddish tint on the apical system, continuing a little over the upper interambulacral plates. In specimen 3 the apical system is more intensely red-brown.

Biology. In one of the specimens the intestinal canal was found to contain bottom-material with fragments of shells, Hydroids, Sponges, and Foraminifera. — Genital pores have not yet appeared in the small specimen 4. — The spines are very clean, only in specimen 2 with a few Serpulid tubes and a single barnacle. — Specimen 1 shows the little anomaly of Ocular V being divided into two plates (Fig. 82. 1).

Occurrence. The three larger specimens were taken by the "Siboga" in the Strait between Borneo and Celebes (St. 90; 1° 17′ N. 118° 53′ E. 231 m); the small specimen was taken

at the Kei Islands, 5° 28′ N. 132° 36′ E. 385 m. (Danish Expedition to the Kei Islands, St. 59). The species may then be supposed to be widely distributed in the Malay Archipelago.

Remarks. This species is very easily distinguished by the character of its primary spines, a character which is distinct already in the specimen of only 12 mm h. d. and thus makes it possible to identify this young specimen with full certainty. — In the other characters there is nothing very striking. The species would seem to be not so very nearly related to any of the other *Stereocidaris*-species.

Stereocidaris microtuberculata (Yoshiwara).

Pls. XX. 1—2; XXI. 1—3; LXXI. 7; LXXXII. 2—4.

Cidaris (Stereocidaris) microtuberculatus. Yoshiwara. 1898. Prel. not. new Japan. Echinoids. Annot. Zool. Jap. II. p. 57.
Cidaris (Stereocidaris) microtuberculatus. Yoshiwara. 1906. Japanese Echini. Pl. **I. 6—7.**
Stereocidaris microtuberculata. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 102.
Stereocidaris microtuberculata. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 55.
Phalacrocidaris microtuberculata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.
Cidaris microtuberculata. Lambert & Thiéry. 1925. Ibidem p. 559.
Stereocidaris microtuberculata. H. L. Clark. 1912. Hawaiian Ech. Pedinidæ etc. p. 383.
Stereocidaris microtuberculata. A. M. Diakonov. 1923. Faune de la Russie. Echinodermes I. p. 150.
NON: *Stereocidaris microtuberculata.* Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. "Albatross" 1906. p. 112. (= *St. grandis*).
Stereocidaris microtuberculata. H. L. Clark. 1907. The Cidaridæ, p. 220. Pls. 1—2. (= *St. grandis*).
Stereocidaris microtuberculata. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 302. Pls. 69—70. (= *St. tubifera* Mrtsn. and *St. purpurascens* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	79 mm	55 mm	36 mm (45.6 % h.d.)	30 mm (38 % h.d.)	7—8	17—18	80 mm
2	75 —	50 —	33 — (44 —)	30 — (40 —)	7—8	18—19	74 —
3	66 —	42 —	31.5 — (47.7 —)	26 — (39.4 —)	7	20—21	66 —
4	64 —	43 —	29 — (45.2 —)	26 — (40.6 —)	6—7	20—21	ca.72 —
5	42 —	25 —	21 — (50 —)	18 — (43 —)	5—6	18—21	73 —

Specimen 1 in the Museum of Munich, specimen 2 in the U. S. National Museum, specimens 3 and 5 in the Copenhagen Museum, specimen 4, the type specimen, in the Tokio Museum.

Test gently arched above, slightly flattened below. Sides very beautifully arched. Circumference circular.

Ambulacra slightly sinuate, 18—20 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone, or slightly more, in the larger specimens. Marginal series of tubercles not very prominent, with a slight irregularity in the larger specimens, a tubercle here and there being a little smaller than the others. The tubercles are contiguous. The interporiferous zone is completely filled up by smaller tubercles, the outer of which are slightly the

larger and form a fairly distinct longitudinal series along the marginal series. The tubercles are, in the larger specimens, separated by narrow transverse lines, which correspond only partly to the sutures between the plates; there is thus an arrangement in irregular transverse series of these tubercles. No naked or sunk median line; the whole interporiferous zone flat. Pore zones slightly sunk. Pores fairly large, the wall and ridge low, rounded (Pl. LXXI. 7).

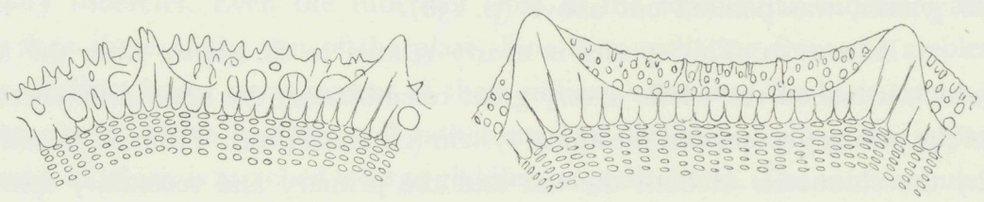
Interambulacra. Areoles rather small, but deep, all of them, even the proximalmost ones, well separated; only those nearest the peristome transverse-oval. In specimen 4 a slight trace of crenulation is seen on some of the uppermost tubercles. Scrobicular tubercles not prominent, rather sloping towards the areole; edge of areoles not raised. Outside the scrobicular ring the plates closely covered with miliary tubercles of uniform size, those close to the scrobicular tubercles only slightly larger than the rest. Also on the adradial side of the areoles there is a rather broad space covered with miliary tubercles. Fine lines radiating from the scrobicular ring make an arrangement of the miliary tubercles in mainly horizontal series evident; these lines pass across the vertical and (upper) horizontal sutures, continuing directly into the corresponding lines of the adjoining plates. No naked midline. The median part, which is about as broad as an areole, slopes gently towards the midline, the plates being on the whole rather flat. No distinct impressions in the upper horizontal sutures.

Apical system ca. 44—50 % of h. d., more or less rising towards the apex. Genital plates large, more or less distinctly hexagonal or heptagonal; they may be distinctly broader than high, as stated in the original description by Yoshiwara. The madreporite is not markedly larger than the other genital plates. Oculars all insert, more or less produced inwards, and with a small notch in the outer edge. Genital pores rather small, ca. 1 mm diameter in the female (the specimen in the Munich Museum), rather distant from the edge. Periproct of the usual appearance. The whole apical system closely covered by small, miliary tubercles of uniform size. Fine radiating lines may occur, both on the oculars and genitals, and on the outer circle of periproctal plates, making an arrangement of the tubercles in corresponding radiating series evident. — Peristome distinctly smaller than the apical system, may be somewhat protruding. There are 14—15 ambulacral plates in a series in specimen 3, 12 in spec. 4; in the interradii there is a fairly regular series of ca. 8 plates, reaching very near to the mouth edge.

Primary spines varying considerably in length, from as much as h. d. to nearly twice h. d. The shaft is cylindrical, rather smooth, with 12—14 series of low spinules which unite, especially in the outer part of the spine, into rather sharp, low ridges, recalling those of *Acanthocidaris*. The end of the (complete) spine is somewhat flaring, sometimes with a small central peg, and with the edge more or less dentate; it is obliquely downwards cut, which seems to indicate that they serve for walking on, at least the subambital ones. The general surface of the shaft otherwise covered by a close coat of anastomosing hairs (Fig. 83. 1). The collar is ca. 2 mm long, increasing in thickness towards the milled ring, which is not at all prominent. Above the collar there is a conspicuous smooth, shining neck of about the same length. — The oral primaries are simple, more

or less flaring at the end; especially the third, which is transitional to the ambital spines, may be conspicuously flaring. In specimen 4 most of the oral primaries are simply pointed.

Secondary spines. The scrobicular spines are 5—6 mm long, flat, not excavate on the outer side, and may be more or less distinctly outwards curving. They taper slightly towards the rounded end. The secondary spines following immediately outside the scrobicular spines much shorter, ca. 2 mm; the transition from the scrobicular to the miliary spines thus is rather abrupt. The miliary spines, which are only ca. 0.5—1 mm long, form a close coat on the whole upper side and in the median interambulacral space almost to the edge of the peristome, though the transition between the miliary and the scrobicular spines is here less abrupt. The marginal ambulacral spines are 2—3 mm long, simple, flattened. There is a very conspicuous glandular ampulla at the base of the miliary spines.



1 2

Fig. 83. Part of transverse sections of primary spines of *Stereocidaris microtuberculata* Yosh. (1) and *St. sulcatispinis* Mrtsn. (2). × 55.

Pedicellariæ. Large globiferous pedicellariæ not very numerous; small globiferous rather numerous. The tridentate pedicellariæ — which are fairly common in specimen 4 — reach a size of ca. 1.5 mm length of head. The pedicellariæ on the whole of the typical form, showing no distinct specific characteristics (Pl. LXXXII. 2—4). — Spicules of the tubefeet simple rods of the usual Cidarid type.

Biology. The spines are not much overgrown by foreign organisms, even in the largest specimens — only a few Bryozoans, a Serpulid, and a Sea-Anemone are found here and there. — In specimen 3 is seen a very interesting case of regeneration — a new tubercule (and spine) forming in an old areole, but much smaller than the original one and thus filling out only about half of it; the space left inside the old scrobicular ring is filled up by small miliary tubercles (Pl. XXI. 3). — It seems evident that the large specimens 1—2 have reached full size.

Colour. The general colour is creamy whitish, with a slight tint of reddish-brown or greenish. The primaries of a more or less conspicuous pink hue, with the point white; also in the basal part they may be more whitish, the darker coloured median part may thus have the character of a broad band. The aboral side of the spines is more strongly coloured than the adoral side; the collar may be slightly darker, even of a faint olive tint; the neck usually darker than the collar. The scrobicular spines with a fairly conspicuous redbrown midline. The miliary spines on the apical system may be a trifle darker than those on the corona. On the denuded test the apical system is slightly redbrown, this colour continuing over the upper interambulacrals; the test otherwise whitish.

Occurrence. Hitherto known only from the Japanese Seas, and only the Sagami Sea,

from where the type specimen came, and where the author got a couple of specimens (the above spec.s 3 and 5) in a depth of ca. 700 m. Specimen 1 is only labelled "Japan" (Coll. Doflein) and thus very probably also came from the Sagami Sea. The known bathymetrical distribution is ca. 140—700 m. — The specimens recorded in the report on the Cidaridæ of the "Albatross" Philippine Expedition under the name of *Stereocidaris microtuberculata* are not really this species, but belong to *Stereocidaris tubifera* Mrtsn. (the specimen from St. 5475), and to *St. purpurascens* Mrtsn. (the specimen from St. 5162) these species having at that time not yet been recognised as distinct from *microtuberculata*. That the specimen from Albatross St. 4807, between Hakodate and Sado Isl., recorded by Agassiz & Clark (1907) as *St. microtuberculata*, is not really this species, but *St. grandis*, was pointed out above (p. 238).

Remarks. This species is nearly related to *St. tubifera* from the Malay Archipelago, to which it has on the whole a very great resemblance; the main differences are in the characters of the primary spines and the apical system (cf. *St. tubifera*). From *St. grandis* it is well distinguished by the characters of both the test and the primary and secondary spines.

Concerning the confusion of this species with *St. grandis* in literature see above, p. 238, under *St. grandis*.

Stereocidaris tubifera Mrtsn.

Pls. XXII; XXIII; XXIV. 1—3; LXXI. 2; LXXXII. 5—10.

Stereocidaris microtuberculata. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 302. Pls. **69—70.**
Stereocidaris tubifera. Th. Mortensen. 1928. New Cidaridæ, p. 70.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	71 mm	45 mm	31 mm (43.7 % h.d.)	24 mm (33.8 % h.d.)	7	20—22	100 mm
2	69 —	45 —	33 — (47.8 —)	25 — (36.2 —)	6—7	22—24	?
3	67 —	42 —	32 — (47.7 —)	23 — (34.3 —)	7 (8)	22—24	100 —
4	53 —	32 —	25 — (47.1 —)	21 — (40 —)	6—7	18—20	82 —
5	44 —	28 —	21 — (48 —)	17 — (38.6 —)	6—7	20—23	ca. 70 —

Specimens 1—3 and 5 are in the Copenhagen Museum, specimen 4 in the U. S. National Museum (Albatross, St. 5475). Specimen 5 is the var. *impressa* Mrtsn.

Test flattened above, more gently sloping downwards. Sides strongly arched; circumference circular.

Ambulacra not much sinuate, ca. 20 % of width of interambulacra. Interporiferous zone twice the width of a pore zone. Marginal series of tubercles very regular, but not prominent; the tubercles are contiguous, somewhat outward produced, rather low, with a small mamelon. The space inside the marginal tubercles quite filled up with smaller, not distinctly mamelonate tubercles, the outer of which form a fairly distinct vertical series along the marginal series. Fine

transverse furrows go (in the larger specimens) across the interporiferous zone, whereas the real sutures are indistinct. The whole interporiferous zone flat, scarcely sloping towards the midline. Pore-zone not sunken; the pores are rather large, the wall narrow, but rather sharp; ridge low, rounded (Pl. LXXI. 2).

Interambulacra. Areoles fairly large and deep, all of them well separated. Scrobicular edge not raised; the scrobicular tubercles are somewhat sloping towards the areole, low, rather elliptical, with a small mamelon; they are not very large, still quite conspicuous on account of the much smaller size of the miliary tubercles which cover, very closely and uniformly, the whole of the plates outside the scrobicular ring. Also on the adradial side of the areole there is a fairly broad space covered by miliary tubercles. Even the tubercles close to the scrobicular tubercles are scarcely a little larger than those of the rest of the plate. Fine lines radiating from the areoles produce a more or less distinct linear arrangement of these miliary tubercles, the lines crossing the sutures between the plates. There is a series of rather marked depressions along the upper horizontal sutures, in each of which is attached a large globiferous pedicellaria. The interambulacral plates on the whole very flat, scarcely at all sloping towards the midline of the area. The median zone about half the width of an areole. None of the specimens with two rudimentary plates (or tubercles) in a series.

Apical system, which is slightly less than h. d., very flat. The genital plates are distinctly higher than broad, almost rectangular; the genital pore almost in the middle of the plate, or at least rather distant from the outer edge. All the oculars insert; they are almost triangular, with a rather deep notch in the outer edge. The whole of the apical system closely covered by small miliary tubercles of uniform size, of the same character as those on the interambulacra; also here narrow lines produce the appearance of a more or less linear arrangement of the tubercles. The female genital pores rather small, only ca. 1 mm in diameter. — Peristome flat, or slightly bulging out. There are ca. 16 ambulacral plates in a series. Interradial plates in a rather irregular double series of ca. 8—10, reaching the mouth edge, or very nearly so.

The primary spines, which are about 1.5 the h. d., are slender, cylindrical, tapering only very slightly; the ambital spines usually with an inconspicuous terminal widening, whereas the subambital spines have a very conspicuous terminal widening which gives them much the appearance of a trumpet — the species name refers to this feature. Sometimes the ambital spines are compressed and may be more or less conspicuously widened; this is especially the case in specimen 4 (the one figured in the Albatross Cidaridæ, Pl. 69—70). There are in the larger ambital spines ca. 18—20 series of low spinules, the general appearance of the spines being rather smooth; this is very much the case in specimen 4, where the spinules are almost completely worn off. The surface of the shaft covered with a coat of anastomosing hairs, of the same general character as in *St. microtuberculata*. The collar ca. 2.5 mm long, increasing conspicuously in thickness towards the milled ring, which is not very prominent. Above the collar there is a smooth, shining neck of corresponding length. — The oral primaries: The proximalmost are slightly

flattened and widened, with or without a terminal widening; but already the second flares conspicuously at the end, the widening gradually increasing on the 3rd and 4th.

Secondary spines. The scrobicular spines are ca. 6 mm long, flattened, generally slightly excavate in the outer part, and slightly narrowing towards the straight cut end. They do not curve distinctly outwards. At the base of the scrobicular spines there are a few spines ca. 2 mm long, and then all the rest is covered with a close, uniform coat of flat, miliary spines of ca. 1 mm length, with a large glandular ampulla at the base. The marginal ambulacral spines are simple, flattened, ca. 3 mm long.

Pedicellariæ. Globiferous pedicellariæ of the usual type (Pl. LXXXII. 5—8); the large ones especially occur along the upper horizontal sutures of the interambulacra. The tridentate pedicellariæ with rather broad valves, sometimes with a serrate crest in the distal part and usually irregularly serrate in the basal part (Pl. LXXXII. 9—10). They reach a size of ca. 1.5 mm length of head. — Spicules of tubefeet partly widened into irregular, fenestrated plates.

Colour. General colour a creamy white. The primary spines, when fresh and clean, of a faint pinkish tint; the scrobicular spines of a faint olive-greenish. The denuded test quite white; in specimen 4 a faint greenish-olive tint on the apical system.

Biology. The larger of the specimens in hand make the impression of having reached full size; still, the fact that nowhere a second rudimentary upper plate has appeared may indicate that the species may grow to a still larger size. The trumpet-shaped spines of the oral side apparently are an adaptation for walking on soft bottom. — Clusters of barnacles are found on several of the spines. A Polynoid worm was found at the base of one of the ambital spines in one specimen.

Occurrence. The sound between Great and Little Kei (Station 28; 5° 37′ S. 132° 54′ E., 400 m., mud). Further the specimen from "Albatross" Stat. 5475 (12° 55′ 26″ N. 124° 22′ 12″ E., 351 m.), mentioned in the Report on the Echinoidea of the "Albatross" Philippine Exped., I. Cidaridæ, p. 302, Pls. 69—70, under the name of *Stereocidaris microtuberculata* also belongs to the present species.

Remarks. This species is evidently closely related to *Stereocidaris microtuberculata*, from which it differs, however, markedly in the general shape of the test, the shape of the genital plates, the more distinct grooves of the upper horizontal sutures, the larger areoles, in the primary spines having more numerous series of spinules (whereas the hair coat is alike in both), in the more conspicuous terminal widening of the primaries of the oral side, and in the colour. These differences, of course, forbid regarding the two as identical. Whether it will be found, when a richer material shall be available, that the characters intergrade, we do not know. On the base of the material available till now we must evidently regard them as two distinct species. The specimen 4 has the oral primaries less conspicuously widened, and the ambital spines, on the other hand, more conspicuously compressed and widened in the end. But also in the other specimens, especially the one figured in Pls. XXII—XXIII, the ambital spines are partly distinctly compressed at the end. I do not see any reason for not regarding this specimen as identical with the typical form from the Kei Islands.

Var. **impressa** Mrtsn.

Pls. XXIV. 4—5; LXX. 8.

Th. Mortensen. 1928. New Cidaridæ, p. 70.

This variety is based on specimen 5 (see measurements above).

This specimen agrees with the typical *tubifera* in the character of its primary and secondary spines. Only there was no distinct glandular ampulla observed on the small secondary spines, (this was particularly noticed before drying the specimen), while in the typical *tubifera* these spines have a large, conspicuous ampulla. Also the pedicellariæ are in the main alike. But in the characters of the test there are some noteworthy differences from the typical *tubifera*. The ambulacral pores are distinctly smaller than in *tubifera* (Pl. LXX. 8 to compare with Pl. LXXI. 2); the tuberculation of the interporiferous zone in the main alike, or what difference there is rather seems to be due to the difference in size of the specimens. In the interambulacra the median area is somewhat narrower in the variety and conspicuously sunk along the midline. Finally the apical system is not so flat as in *tubifera*, and the shape of the genital and ocular plates and the place of the genital pore is conspicuously different from that of *tubifera* (Pl. XXIV. 5 to compare with Pl. XXIV. 1), and there is a faint pinkish tint on the apical system, while in *tubifera* it is white as the test.

The specimen was taken at the Kei Islands, in the sound between Great Kei and Little Kei, not far from the place, where the typical form was found (Stat. 56), in a depth of 245 m.

Remarks. The question whether this latter specimen is really a separate form, and not simply identical with *St. tubifera*, cannot be decided on the base of the material available at present. It is mainly the difference in the shape of the genital and ocular plates which speaks against the identity as it seems rather incredible that this difference could be due to age, or that there could be so great variation in the shape of the apical plates as the identity of the specimen in question with the typical *tubifera* would imply. For the present it seems the only safe course to designate this specimen as a variety of *tubifera*. The character of its primary spines forbid referring it to *St. microtuberculata*, with which it has otherwise much general resemblance.

Stereocidaris indica Döderlein.

Pls. XXV. 1; LXXI. 4—5; LXXXI. 15—20.

Stereocidaris indica. Döderlein. 1901. Diagn. einiger v. d. Valdivia-Exped. gesamm. Seeigel-Arten a. d. Ind. Ocean. Zool. Anz. XXIV. p. 19.

Stereocidaris indica. Th. Mortensen. 1903. "Ingolf" Ech. p. 29, 41.

Stereocidaris indica. De Meijere. 1904. "Siboga" Ech. p. 18. Taf. **I, 1**; Taf. XI, 119—120; Taf. XII, 121.

Stereocidaris japonica. De Meijere. 1904. Ibidem, p. 16. Taf. XI. 117—118.

Stereocidaris indica. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 104. Taf. **X, 1—2; XI, 1—6; XII, 3—10; XXXVI, 5—9; XXXVII, 2—7.**

Stereocidaris indica. H. L. Clark. 1907. The Cidaridæ, p. 218.

Stereocidaris indica. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp., p. 55.

Dorocidaris indica. Lambert & Thiéry. Ess. nom. rais. p. 149.

Stereocidaris indica. Koehler. 1922. Anomal. et irrég. du test des Échinides. Bull. Inst. Océanogr. No. 419. p. 95. (Fig. 15).
Stereocidaris indica. Koehler. 1924. Anomalies, irrégularités et déformations du test chez les Échinides. Bull. Inst. Océanogr. N. S. I. p. 441—460. Pl. **XXXII, 1—15.**
Stereocidaris indica. Koehler. 1927. "Investigator" Ech. III. p. 25. Pl. **II, 3—7; IV, 3, 10; XIX, 5—11; XX, 1—8; XXI, 1—7; XXIII, 5.**
Stereocidaris indica. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 303.
Stereocidaris indica. Jackson. 1927. Studies of Arbacia punctulata and allies, and of nonpentamerous Echini. Mem. Boston. Soc. Nat. Hist. VIII. p. 537.
NON: *Stereocidaris indica.* F. Jeffr. Bell. 1909. Rep. Echinoderma coll. by Stanley Gardiner in the W. Parts of the Ind. Ocean. Trans. Linn. Soc. Zool. 2. Ser. XIII. p. 21. (= *St. squamosa* Mrtsn).
Stereocidaris indica. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 26. (= *St. squamosa* Mrtsn.).

This species, so characteristic, especially through its very close and fine tuberculation, its small peristome (only ca. 25 % h. d.), its slender, smooth oral primaries, and the slender, setaceous secondary spines, has been so carefully described and excellently figured by Döderlein that it would seem rather superfluous to describe it here again. — Also Koehler has recently given a series of figures of this species in his "Investigator" Ech. III. Only a few details, not mentioned by Döderlein, may be added here.

Ambulacra. The marginal tubercles are small, not contiguous. The pores are sometimes rather broad; the wall is narrow and forms a low crest; ridge rather sharp. The ambulacral midline may show impressions quite as in *Goniocidaris* (Pl. LXXI. 4—5) — Interambulacra. The primary tubercles are rather unusually small, the boss low. There may be slight traces of crenulation on the upper tubercles (observed in a specimen from the Philippines). Impressions in the upper horizontal sutures indistinct or entirely absent, whereas the median end of the ambital and subambital sutures may have a rather distinct impression; the midline more or less conspicuously sunk, sometimes very conspicuously so (on the oral side). — Peristome. The small number of plates is a very noteworthy feature. Thus, in a specimen of 42 mm h. d. there are only 4—5 ambulacral plates in a series, and only 1 small interradial plate. In a specimen 44 mm h. d. there are 6—7 ambulacral plates in a series, and 1—2 interradial plates.

The primary spines may — in specimens from the Philippines — have more than 30 longitudinal series of spinules, which have sometimes the shape of rounded, more or less pointed granules, not uniting into distinct ridges. The hairs, which are, on the whole, rather delicate, form in the specimens from the Indian Ocean (var. *integra*, *africana* etc.) the usual spongy coat, though not strongly developed. In the specimens from the Philippines the hairs are as a rule very small and simple, not anastomosing; in the specimens from Japan the hairs are almost entirely absent. — In regard to the secondary spines it should be mentioned that the marginal ambulacral spines are in general more slender in the specimens from the Indian Ocean than in those from the Philippine and the Japanese Seas. The small, slender, secondary or miliary spines have a rather distinct glandular ampulla. — The spicules of the intestinal wall are triradiate and very numerous. — Colour of the denuded test white.

Biology. The alimentary canal of a specimen from the Philippines was found to contain

bottom material, with Foraminifera. Genital pores have not yet appeared in a specimen of 18 mm h.d., but in a specimen of 22 mm h. d. ("Siboga" St. 297) they have appeared.

Anomalies appear to be rather common. Koehler (Op. cit. 1922, 1924, and 1927) has given detailed descriptions and figures of some extraordinary malformations, evidently due to the presence of parasitic Gastropods (*Mucronalia*). Also Döderlein mentions and figures a couple of anomalous specimens (Taf. X. 1—2). Another curious anomaly is found in a specimen from off Kiushiu, one of the uppermost interambulacral plates being divided into two by a vertical line (Pl. XXV. 1).

Variations. As shown by Döderlein, this is an extraordinarily variable species. Döderlein describes in his preliminary notice (1901) the varieties *capensis*, *integra*, *africana*, *carinata*, and *tricarinata*. In the final, great work on the Echinoids of the German Deep-Sea Expedition, 1906, he further adds the variety *sumatrana*. While *capensis* and *tricarinata* (— which is a synonym of *St. Alcocki* (Anderson) —) are here regarded as separate, though very closely related, species, he thinks that the varieties *integra*, *africana*, and *carinata* may perhaps not even deserve to rank as local varieties, on account of the extraordinary inconstancy of the characters of their primary spines — and other characters there are not. Only the variety *sumatrana* he thinks better characterized by the primary spines having many fine, sharp, serrated lamellæ in the basal part and by the larger pedicellariæ. I can in the main accept Döderlein's conclusions. The form *integra* should rather be regarded as the typical *St. indica* (Döderlein does not designate any form as the typical and describes only the varieties).

Var. **philippinensis** Mrtsn.

Pl. LXXXI. 15—20.

Stereocidaris indica, var. *philippinensis*. Th. Mortensen. 1928. New Cidaridæ, p. 71.

As a well marked variety I must regard the specimens from the Philippine and Japanese Seas, characterized by the more numerous series of spinules on the spines, and by the hairs of the primary spines being quite low and simple (anastomosing in the forms from the Indian Ocean). The large globiferous are rather unusually slender (Pl. LXXXI. 18). Further, as pointed out in the Report on the "Albatross" Philippine Echinoidea; I. Cidaridæ (p. 304), "tridentate" pedicellariæ are usually fairly numerous (absent in the typical *indica*)[1].

This form night perhaps rather, like *St. Alcocki*, be regarded as a separate species. If the specimens from the Japanese Seas prove constantly to lack entirely hairs on the surface of the primary spines, we may have there another local form or variety.

[1] Probably, these tridentate pedicellariæ are, in spite of their size — up to 1 mm length of head — in reality only an extraordinary development of the elongate type of small globiferous pedicellariæ so characteristic of the *indica*-group; at least, there is always what appears to be a lower limit of the opening and also the thick edge of the blade rather suggests a globiferous pedicellaria (Pl. LXXXI. 15—16, 19—20). The same holds good of the "tridentate" pedicellariæ of *St. Alcocki*.

Occurrence. The species, with its varieties, appears to be distributed all over the Indian Ocean, from the African Coast to the Sunda Islands, and the Philippines. Further a couple of specimens were taken by the author in the Japanese Seas, off Kiushiu (21 miles W.$^1/_2$ S. of Bonomisaki, ca. 400 m.). The known bathymetrical distribution is 400—1289 m.

Remarks. Through its extraordinary variation this species becomes a parallel case to that of *Prionocidaris baculosa*, which has about the same geographical distribution.

There is no doubt that the *Stereocidaris "japonica"* of de Meijere's report on the "Siboga" Echinoidea is really *St. indica* (var. *philippinensis*), not at all the true *japonica*. To *St. indica*, var. *philippinensis* also belongs the specimen from "Challenger" St. 210 referred by Clark (Cat. Rec. Sea-Urch. Br. Mus. p. 26) to *St. grandis*; (by Agassiz it was identified as *Dorocidaris papillata*). On the other hand, the specimens from the Saya de Malha Bank recorded by Bell (Op. cit.) as *Stereocidaris indica* represent a very distinct species, *Stereocidaris squamosa* Mrtsn. It is not so remarkable that Bell failed to see how different it is from *St. indica*, rather it is surprising that he hit upon the right genus. But that H. L. Clark in his Catalogue of the Recent Sea-Urchins of the British Museum (p. 26) again records these specimens as *Stereocidaris indica* is very remarkable; one is tempted to suggest that he did not know then the true *St. indica* and did not compare the specimens with Döderlein's descriptions and figures.

Stereocidaris Alcocki (Anderson).

Pls. LXXI. 8; LXXXII. 18.

Dorocidaris alcocki. A. R. S. Anderson. 1894. Nat. Hist. Notes "Investigator". Ser. II. Echinoidea, coll. 1893—94. Journ. Asiat. Soc. Bengal. LXIII. II. p. 191.

Dorocidaris alcocki. A. R. S. Anderson. 1895. Illustr. Zool. "Investigator". Echinoderma. Pl. **V, 3, 3a.**

Stereocidaris indica, var. *tricarinata.* Döderlein. 1901. Diagn. einiger v. d. Valdivia Exp. ges. Seeigel-Arten a. d. Ind. Ocean. Zool. Anz. XXIV. p. 20.

Stereocidaris tricarinata. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 112. Taf. **IX, 1—3; X, 7; XII, 1; XXXVI, 1—2.**

Stereocidaris tricarinata, var. *teretispina.* Döderlein. Ibidem. p. 115. Taf. **X, 7; XXXVI, 3.**

Stereocidaris tricarinata. H. L. Clark. 1907. The Cidaridæ, p. 219.

Stereocidaris alcocki. H. L. Clark. Ibidem, p. 219.

Stereocidaris tricarinata. Th. Mortensen. 1909. Ech. Deutsch. Südpolar Exp. p. 55.

Stereocidaris Alcocki. Th. Mortensen. Ibidem.

Dorocidaris Alcocki. Lambert & Thiéry. 1910. Ess. nom. rais. p. 148.

Phalacrocidaris tricarinata. Lambert & Thiéry. Ibidem. p. 150.

Stereocidaris Alcocki. Koehler. 1927. "Investigator" Ech. III. p. 27; Pl. **VI, 2—4, 7—9; XXIII, 6.**

This species was at first regarded by Döderlein as a variety only of *Stereocidaris indica*, but in the final report on the "Valdivia" Echinoids he thinks it preferable to regard it as a separate species, distinguished from *St. indica* by its usually — but not constantly — tricarinate and slender primary spines, and by the presence of numerous, very slender, tridentate pedicellariæ. The identity of *tricarinata* with *Alcocki* Anderson was ascertained by Koehler (Op. cit. 1927), who had the opportunity of examining Anderson's type.

To the very careful description and excellent figures of this species given by Döderlein there is only little to be added.

The marginal ambulacral tubercles are small and not contiguous; the pores are somewhat more distant from each other than in *St. indica* (Pl. LXXI. 8). Impressions in the upper horizontal sutures of the interambulacra lacking or reduced to a small groove at the admedian end of the sutures. Also the subambital sutures with a similar groove at the admedian end, recalling the condition in Goniocidarids. The vertical suture rather conspicuously sunk. As in *St. indica* there are only 6 ambulacral plates in a series on the peristome (in a specimen of 33 mm h.d., peristome only 6.8 mm). — The primary spines with a dense coat of anastomosing hairs, which also proceeds over the wing-like crests. The scrobicular spines are rather broadly carinate and distinctly longitudinally furrowed (Pl. LXXXII. 18); the marginal ambulacral spines flattened, or even slightly concave. — The colour of the denuded test white. The secondary spines in the specimens in hand white.

The character of the scrobicular spines as mentioned above seems to afford a very good distinctive feature. It is true, Döderlein describes the scrobicular spines simply as flat, but I am informed by him that a specimen in his collection shows the same character of the scrobicular spines as do the two specimens at my disposal. (Koehler does not say anything about these spines; Anderson describes them as flat).

As stated above, under *St. indica*, var. *philippinensis*, the "tridentate" pedicellariæ of this species are rather a very elongate form of the small globiferous type.

The var. *teretispina* Döderl. appears to differ from the typical *Alcocki* (*tricarinata*) only in its primary spines entirely lacking the wing-like crests. The only specimen known is, however, monstrous on account of its being infested with parasitic Gastropods.

Stereocidaris ingolfiana Mrtsn.

Pl. XXVII. 1—3; LXX. 6.

Stereocidaris ingolfiana. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 38. Pl. **VI, 1—5, 11; VIII, 4, 10, 11, 16, 19—21, 23, 26, 28, 30, 36; XI, 12, 16, 17, 23, 28, 30, 32, 33; XVI, 1.** — II. 1907. p. 9.
Stereocidaris ingolfiana. Döderlein. 1905. Arktische Seeigel. Fauna Arctica. IV. p. 376.
Stereocidaris ingolfiana. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 110.
Stereocidaris ingolfiana. H. L. Clark. 1907. The Cidaridæ. p. 219.
Stereocidaris ingolfiana. Koehler. 1909. Res. Camp. Scientif. Monaco, Fasc. XXXIV. p. 216.
Dorocidaris ingolfiana. Lambert & Thiéry. 1910. Ess. nom. rais., p. 149.
Stereocidaris ingolfiana. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 26.
Stereocidaris ingolfiana. Th. Mortensen. 1927. Handbook Echinod. British Isles. p. 270.

In spite of the complimentary statement by H. L. Clark (The Cidaridæ, p. 219) that the original description of this species "lacks nothing", a few additional remarks may be useful, the great number of species of this genus recently made known making it desirable to have some

few points worked out more in detail. I have also thought it desirable to give a couple of figures of one of the better preserved specimens.

First, as regards the shape of the test, Clark doubts the correctness of the height given for one of my specimens, as it is 90 % of the h. d., the specimen being thus nearly spherical; this Clark thinks impossible, as his own, West-Indian, specimens have a height of only 54—58 % of h. d. It is true that the height of this specimen was measured to the top of the periproct, not to the upper edge of the corona as is always measured in the present work (and as is a much better measure, since the height of the periproct is liable to individual variations). Nevertheless the measure of the specimen is in the main correct, and the specimen is, as a matter of fact, nearly spherical, as is also the specimen Pl. XXVII. 3. — On the other hand Clark is right in pointing out that the size of the apical system 10.5 mm in a specimen 28 mm h. d. must be an error. I do not find the exact specimen any more, but there is no doubt that this is a printing error (or a slip of the pen); specimens of that size have an apical system of ca. 14—15 mm.

The marginal ambulacral tubercles are not contiguous. The wall separating the pores rises into a fairly distinct prominence; the ridge fairly high, sometimes with a distinct tubercle (Pl. LXX. 6). — The statement in the original description that the edge of the areoles is raised is not very appropriate; it may rather be said that it is not raised, the interambulacral plates being, on the whole, rather flat. No traces of crenulation seen, even in the young specimens. Impressions in the upper horizontal sutures very indistinct or entirely lacking. There are 8—9 ambulacral plates in a series on the peristome in adult specimens. The primary spines may have a small widening at the point. The oral primaries rather short, flattened, with more or less distinctly serrate edges. The 3rd—4th is transitional to the ambital spines. The scrobicular spines are usually simply flattened on the upper side of the test, more or less distinctly excavate on the oral side of the test. — The colour of the naked test whitish; the secondary spines may be of a rather distinct olive-brownish colour in the basal part. The primary spines, when fresh and clean, of a faint pinkish hue.

A specimen from off S. Iceland (62° 57′ N. 19° 58′ W., 915 m., "Thor" 1903) shows the very interesting case that some of its primary spines have been lost entirely, and not regenerated, the whole areole having been occupied by small miliary tubercles (spines) (Pl. XXVII. 3).

Occurrence. Apparently distributed all over the Northern Atlantic, from the Danmark Strait to the West-Indies and to the Cape Verdes on the Eastern side, in depths of ca. 300—1745 m.

Remarks. It seems beyond doubt that the West Indian form is really identical with that from the Northern Atlantic; only it would appear that in the West Indian form the test is in general somewhat lower than in the more northern specimens (cf. Clark, Op. cit.).

That *St. ingolfiana* is nearly related to *St. indica* seems beyond doubt. Döderlein (Op. cit.) even suggests that it may perhaps be identical with *St. indica*; only the small differences to be noted in their pedicellariæ he thinks to afford sufficient reason for keeping them separate. As

Döderlein has only had a single specimen of *ingolfiana* for comparison with *St. indica* it is not so surprising that he has failed to see other differences than those of the pedicellariæ. But as a matter of fact, there are several other differences. Especially the peristome (ca. 36—40 % h.d.) and the number of its ambulacral plates are conspicuously larger in *ingolfiana*; further the oral primaries are not of the very slender, smooth, curved form so characteristic of *indica*, but shorter, with rather distinctly serrate edges. Also the number of ambulacral plates corresponding to an interambulacral plate is greater in *indica*; — in the var. *carinata*, which in regard to the primaries particularly resembles *ingolfiana*, there may be as many as 18—20 plates corresponding to one of the larger upper interambulacral plates, while in *ingolfiana* there are hardly more than 12, the upper interambulacral plates being also less widened than in *indica*. Also *ingolfiana* appears to be a much smaller species than *St. indica*. These differences leave no doubt but that *ingolfiana* is perfectly distinct from *indica*, should it even ultimately be found that the areas of their geographical distribution may not be so far separated from each other as they seem to be at the present state of our knowledge of the distribution of the two species.

Stereocidaris capensis Döderlein.

Pl. LXXI. 1.

Stereocidaris indica, var. *capensis*. Döderlein. 1901. Diagn. einiger v. d. Valdivia Exp. ges. Seeigel-Arten a. d. Ind. Ocean. Zool. Anz. XXIV. p. 19.

Stereocidaris capensis. Döderlein. 1906. Ech. Deutsche Tiefsee Exped. p. 110. Taf. **X, 3—6; XII, 2; XXXVI, 4; XXXVII, 1.**

Stereocidaris capensis. H. L. Clark. 1907. The Cidaridæ, p. 218.

Stereocidaris capensis. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp., p. 55.

Dorocidaris capensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

Stereocidaris capensis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus., p. 25 (partim).

NON: *Stereocidaris capensis*. H. L. Clark. 1923. Echinod. Fauna of S. Africa, p. 371. (See p. 270).

This species was, like *tricarinata*, at first regarded by Döderlein as merely a variety of *St. indica*; but in his final report he gave it the rank of a separate species, distinguished by its peculiar short, almost conical primary spines, and by the larger, fenestrated spicules of its tubefeet. The little material I have had an opportunity of examining seems to me to support Döderlein's conclusion that it should be regarded as a separate species, though I rather agree with Clark (Op. cit. 1907) that the character of the spicules, emphasized by Döderlein, is scarcely of much value. The main character of the species, I think, is that of the shape of the primary spines.

To the description given by Döderlein there is only little to be added. In the ambulacra the marginal tubercles are small, not contiguous; the pores are small, rather close together, the wall a low, rounded crest, the ridge rather high (Pl. LXXI. 1). The upper horizontal interambulacral sutures on the whole rather broad, sunk, but there are no separate grooves; the ambital sutures with a fairly distinct groove at the median end; the vertical suture not forming

a sunk space subambitally, such as may be so conspicuous a feature in *St. indica* and *Alcocki*. The primary spines covered by a coat of anastomosing hairs. Scrobicular spines slightly keeled, but not ridged as in *Alcocki*; marginal ambulacral spines rather broad and flat, not so slender as in *indica*. The naked test white. Döderlein's statement that the large globiferous pedicellariæ are long and slender and not to be distinctly separated from the small form of globiferous pedicellariæ is most probably due to the fact that he has not seen the true large form; what he describes and figures as such is, in my opinion, only the small form. The large globiferous pedicellariæ of this species, therefore, are still unknown.

Of the two specimens mentioned by Clark in his Cat. Rec. Sea-Urch. Brit. Mus. (p. 25) as *St. capensis* the smaller, 31 mm h.d., appears to be a true *capensis*, though differing from the typical form in its longer primary spines (2 h.d., in the typical form only ca. 1—1.5 h.d.). The statement that the second interambulacral plate has a large imperforate tubercle scarcely means that this species has its upper primary tubercles really imperforate (— which would be a rather extraordinary character —), but is most probably due to this tubercle being covered by the rudiment of the corresponding primary spine, like a cap, the tubercle itself not being seen. The second, larger specimen is certainly not a true *St. capensis*. Its ambulacral structure is quite different; the marginal ambulacral tubercles are larger and contiguous, and there is a single inner tubercle on each plate, almost as large as the marginal one (— in *capensis* the interporiferous zone is covered by numerous small tubercles —). On the whole this specimen much more resembles *St. squamosa* in the ambulacra and interambulacra, in the narrowly insert oculars and in the pedicellariæ (the tridentate form not observed); it differs, however, from that species in the primary spines being somewhat more coarsely serrate, in the oral primaries being distinctly coarser, in the scrobicular spines being slightly convex and the miliary spines somewhat narrower. Also the general colour is different — grayish-brown, not greenish; the marginal and miliary spines are grayish-brown at their base. On the whole, I think this specimen near to *St. squamosa*, either a variety of this species or, perhaps, a new, but related species.

The measurements are:

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
51 mm	32 mm	24 mm (47 % h.d.)	22 mm (43.1 % h.d.)	5	21—24	60 mm

The large specimen mentioned by Clark in his Echinoderm Fauna of S. Africa as *St. capensis* can, in my opinion, not belong to that species. The specimen, which has kindly been lent me for examination from the South African Museum, is in a very poor condition, only the corona with a few of the scrobicular spines still in situ. The accompanying loose primary spines are quite different from those of *capensis*, but agree with those of *Stereocidaris indica*, var. *africana*. I do not think, however, that the specimen is really identical with the said form, because the peristome is much larger than in the various forms of *Stereocidaris indica*, viz. 45 % h. d., against 32 % h. d. in the var. *africana* (Döderlein, Op. cit. 1906, p. 116). In all probability we have

here an undescribed species of *Stereocidaris*, but the single, poorly preserved specimen available does not allow characterizing it sufficiently, or, on the whole, to reach any safe conclusion as to its relations to the other species of *Stereocidaris*; we may only say that it belongs undoubtedly to the genus *Stereocidaris*. I give here a figure (Pl. XXVII. 4) of the specimen which, when alive, must have been a splendid sample of a Cidarid.

The measurements are:

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
62 mm	48 mm	29 mm (47.6 % h.d.)	28 mm (45 % h.d.)	7—8	16—17	75 mm

Stereocidaris leucacantha A. Ag. & H. L. Clark.

Pls. XXVIII. 11; LXXI. 11—13; LXXXI. 21—27.

Stereocidaris leucacantha. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 23. Pls. **6**; **15**; **32**.
Stereocidaris leucacantha. H. L. Clark. 1907. The Cidaridæ, p. 221.
Stereocidaris leucacantha. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 55.
Dorocidaris leucacantha. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	55 mm	37 mm	25 mm (45.5 % h.d.)	20 mm (36.4 % h.d.)	7 (8)	17—18	70 mm
2	51 —	32 —	25 — (49 —)	16,5 — (32.4 —)	6—7	17—18	72 —
3	38 —	22 —	18 — (47.4 —)	15.5 — (40.8 —)	5—6	19—20	70 —
4	37 —	23 —	18 — (48.6 —)	16 — (43.2 —)	5	19—20	76 —
5	37 —	20 —	17.5 — (47.3 —)	16 — (43.2 —)	5—6	18—19	69 —
6	34 —	18 —	17 — (50 —)	16 — (47 —)	5—6	16—17	?
7	34 —	19 —	16.5 — (48.5 —)	14.5 — (42.4 —)	5	16—17	(?) 58 —
8	29 —	17.5 —	14 — (48.3 —)	12 — (41.4 —)	5	17—18	59 —
9	28 —	15 —	13 — (46.4 —)	12 — (42.9 —)	5	16—17	59 —
10	26 —	15 —	13 — (50 —)	12 — (46.2 —)	4—5	15—17	57 —

The specimens measured are in the U. S. National Museum and the Museum of Comparative Zoology. Specimen 2 is the one figured on Pl. 32 of the Hawaiian Ech. Cidaridæ.

Test rather low, sometimes distinctly flattened above and below, sometimes regularly arched above; sides beautifully arched, in the largest specimen slightly subvertical. Circumference circular.

Ambulacra distinctly sinuate, ca. $^1/_4$ the width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, only in specimen 2 there is a slight irregularity at the proximal end; the tubercles contiguous, not very prominent. The median space closely covered by tubercles, 2—4 to each plate, the outer ones somewhat the larger, forming a distinct series parallel to the marginal series. Median line slightly sunken, but not naked. In younger specimens the inner tubercles are, of course, less numerous, generally only 1—2 on each plate; but there is always no naked median space; in one specimen

the inner tubercles form a single median series (Pl. LXXI. 11—13). The pores generally equal-sized, sometimes the outer distinctly the larger; the wall narrow, forming a rather sharp crest, the ridge low, rounded.

Interambulacra. The areoles of moderate size, fairly deep; at most the two proximal ones confluent, and only these slightly transverse-oval. Edge of areoles not thick or raised, except in specimen 2. The scrobicular tubercles not very conspicuous; outside the scrobicular ring the plates closely covered by small, secondary tubercles, which decrease rather gradually in size towards the median and the horizontal sutures. On the adradial edge of the areoles there is in

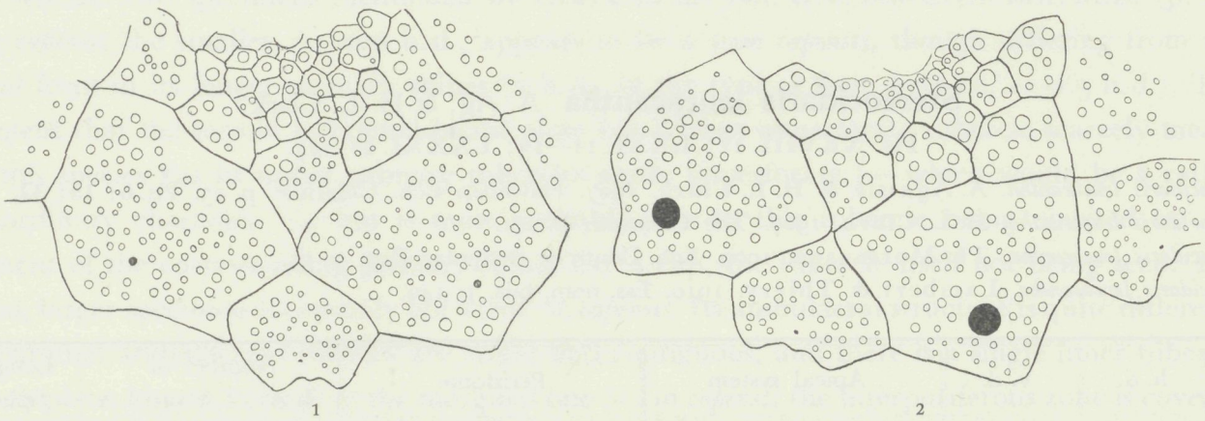


Fig. 84. Parts of apical system of *Stereocidaris leucacantha* A. Ag. & H. L. Cl. ♂ (1) and ♀ (2). × 6.

the larger specimens room for several, in the smaller specimens only for a single series of small secondaries. Fine lines radiate from the scrobicular edge, passing directly across the vertical sutures, and produce an arrangement in mainly horizontal series of the secondary tubercles. The midline is usually only slightly sunk, in specimen 2 however rather conspicuously so. As a rule a not very conspicuous impression in the upper horizontal sutures; the subambital sutures may have a slight impression at the adradial end. Median interambulacral area $^1/_2$—$^2/_3$ the width of an areole.

Apical system about half the h. d., usually rising very slightly towards the middle. The genital pore situated nearer the outer edge, on a sometimes rather conspicuous elevation, otherwise these, and all the other plates of the apical system, flat. Oculars usually all narrowly insert, especially in the larger specimens. They are generally of a characteristic heart-shape, as well seen on Pl. 32, 1 of the Hawaiian Ech. The ocular and genital plates, as also the outer periproctal plates covered with numerous small tubercles, decreasing in size towards the middle of the genital plates. A rather broad edge is sometimes left bare. The periproct, inside the usual larger plates along the edge, covered with fairly numerous, small plates. Female genital pores distinctly larger than the male pores (Fig. 84).

Peristome flat, not protruding. There are 10—12 ambulacral plates in a series; the interradial plates rather irregular, reaching almost to the mouth edge.

The primary spines are cylindrical, slender, about 1.5—2 h.d.; they taper very gently to a simple point, sometimes, however, they may be somewhat expanded at the tip, especially the subambital ones (Pl. XXVIII. 11). There are ca. 12 rather marked longitudinal series of spinules which, in well preserved spines, are slightly pointed, not only simple, rounded warts; towards the end of the spine these longitudinal series become more prominent ridges. The surface between the ridges covered by a coat of anastomosing hairs, which is, however, scarcely so high as to conceal the series of spinules. The collar is only about 1 mm long; it increases very markedly in thickness towards the milled ring, which is not prominent. There is a conspicuous, smooth neck above the collar, about twice as long as the latter. The oral primaries are slightly flattened, distinctly fluted towards the end; the collar is longer than in the ambital spines, up to 2 mm long. The second—third is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 4 mm long, flat, or even with a slight indication of a concavity on the outer surface; they are only slightly narrowing towards the point, which is straight cut or slightly rounded. The miliary spines are fine, pointed, not scale-like, appressed, apparently with glandular ampulla. There is a fairly gradual transition from the scrobicular to the miliary spines. The ambulacral spines are ca. 2 mm long, flat, but more slender than in *hawaiiensis*. On the oral side they gradually become somewhat longer and obliquely adorally curved.

Pedicellariæ. The large globiferous pedicellariæ are rather unusually slender (Pl. LXXXI. 21—23)[1]. The small globiferous form not peculiar. The tridentate pedicellariæ are characteristic in having rather broad, flat and usually slightly curved valves, which join only in the distal part; they are not so slender as in *hawaiiensis* (Pl. LXXXI. 24—27 to compare with Pl. LXXX. 7—8); they reach a size of about 1.5 mm length of head. The valves often with irregular, serrate crests. — Spicules of the tubefeet simple rods of the usual Cidaroid type. In the intestinal wall only very few small, simple rods.

Colour. The primary spines are white, when clean, more rarely of a faint pinkish hue. The collar usually of a more or less dark purple, and at the limit between collar and neck there is, as a rule, a rather conspicuous narrow, dark purple ring. The scrobicular spines greenish-olive in their basal part, as also the secondary and miliary spines in general have a more or less distinct band of this colour in their basal part. According to Clark (Op. cit.) they may range from almost yellowish-white to deep purplish-gray. In specimen 7 the scrobicular and smaller

[1] The representation of the pedicellariæ of *Stereocidaris leucacantha* given by Agassiz & Clark on Pl. 6 of their Hawaiian Ech. Cidaridæ is not satisfactory, especially that of the highly characteristic tridentate pedicellariæ. Perhaps some confusion has taken place (the fig. 1 rather resembles a tridentate pedicellaria of *St. hawaiiensis*), but this can hardly be cleared up. Their statement (in the Prel. Rep. Ech. Albatross, 1906, p. 112) that the pedicellariæ of *St. microtuberculata* are so very like those of *St. leucacantha* as not to be distinguished from them with certainty, is also due to some confusion. In reality the pedicellariæ of *St. leucacantha* are (especially the tridentate) so characteristic as not to be confounded with those of any other *Stereocidaris*-species.

secondaries (not the marginal ambulacral) spines are reddish-brown. The denuded test is white, with a slight tint of olive grayish; in specimen 7 it is a faint redbrown on the upper side.

Biology. In the alimentary canal of a specimen was found bottom material, with Hydroids and Foraminifera (Globigerina) as the only distinct animal remains. The spines of the oral side are not rarely invested by a number of Cirripedians of the genus *Alepas*, probably *A. minuta* (Phil.)[1]. Other spines are covered by an arenaceous Zoanthid; often also sandy tubes of Polychætes are attached to the spines. — Some very curious anomalies are mentioned by Agassiz & Clark, a specimen with an unpaired upper interambulacral plate between the two usual plates being particularly interesting (Op. cit. Pl. 32. 1).

Occurrence. Only known from off the Hawaiian Islands. Bathymetrical range ca. 300—950 m.

Remarks. This species evidently is related to *St. hawaiiensis*, from which it is, however, very well distinguished by various characters, as the slender, more serrate primary spines, with the characteristic dark purple ring at the outer end of the collar, the more pointed miliary spines, and the characters of the large globiferous and especially the tridentate pedicellariæ.

The differences from *St. grandis* pointed out by Agassiz & Clark evidently refer not to the true *grandis* but to the Hawaiian species erroneously identified as *St. grandis* (viz. *St. hawaiiensis*). It may here only be pointed out that when the authors state that "the plates on the angles of the anal pentagon are much larger than the corresponding plates of *grandis*" this does not hold good. There may perhaps in general be some more periproctal plates in *leucacantha* than in *hawaiiensis* (sometimes they are very numerous and small, fig. 84. 1); but a reliable difference between the two species is scarcely to be found in their periproctal plates.

The suggestion by H. L. Clark (The Cidaridæ, p. 220; under *Stereoc. grandis*) that the "Siboga" specimens identified as *St. grandis*, in which the collar has a violet tinge, may rather belong to *St. leucacantha*, does not hold good. They belong partly to *Stereoc. purpurascens*, partly to *St. tubifera*, var. *impressa*. (See under those two species, and under *St. grandis*).

Stereocidaris sceptriferoides Döderlein.

Pls. XXIX. 5—7; LXVII. 1—3, 13; LXX. 12; LXXXI. 1—4.

Cidaris (Stereocidaris) sceptriferoides. Döderlein. 1887. Japan. Seeigel, I. Cidaridæ p. 5. Taf. **II, 12—17; III, 3 a—e.**
Stereocidaris sceptriferoides. Th. Mortensen. 1903. Ingolf Ech. I. p. 23, 29.
Stereocidaris sceptriferoides. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 102.
Cidaris japonica. Yoshiwara. 1906. Japanese Echini, Pl. I. 4—5.
Cidaris japonica. H. L. Clark. 1907. The Cidaridæ, p. 221.
Cidaris japonica. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Echini "Albatross". 1906. p. 112.
Phalacrocidaris japonica. Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.
Stereocidaris grandis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 26. (partim).

[1] Identified by Mr. K. Stephensen.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	33 mm	19 mm	15 mm (45.5 % h.d.)	12.5 mm (38 % h.d.)	6—7	14—15	ca.45 mm
2	25 —	14 —	12.3 — (49 —)	11.5 — (46 —)	5—6	14—15[1]	51 —
3	21 —	12 —	10 — (47.6 —)	9 — (43 —)	5	12—14	47 —
4	13 —	7 —	7 — (53.8 —)	6 — (46 —)	5	8—10	35 —
5	9 —	4 —	4.5 — (50 —)	4.5 — (50 —)	4	7—8	18 —

Specimen 2 is the type specimen, specimens 1, 3 and 5 in the Museum of Copenhagen, and specimen 4 in the U. S. National Museum. Specimen 3 is the type of var. *lanceolata* Mrtsn.

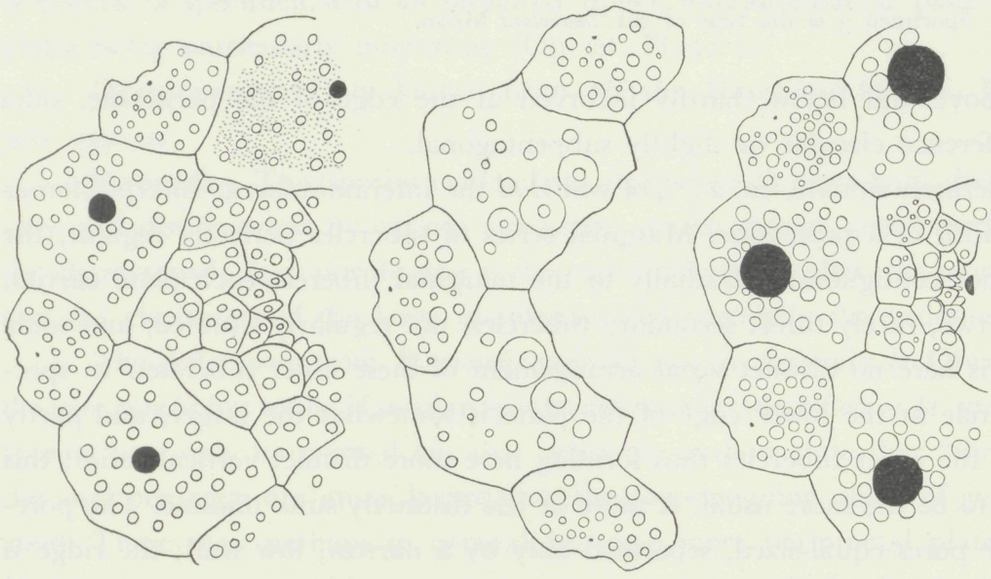
Test flattened above and below, hardly incurved at the edge of the peristome, sides strongly arched, circumference circular or slightly subpentagonal.

Ambulacra moderately sinuate, ca. 25 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles perfectly regular, the tubercles rather small, not contiguous. Adradially to the marginal tubercle each plate carries, in the largest specimen, two, rarely three, secondary tubercles, not regularly situated, and some miliary tubercles; there is here no distinct serial arrangement of these inner tubercles. In specimens 2 and 3 the tubercle at the lower edge of the plate is somewhat the larger, and partly the only one developed, the inner tubercles thus forming here more distinct vertical series; this latter condition appears to be the more usual. A more or less distinctly sunk midline. The pore-zones rather sunken; the pores equal-sized, separated only by a narrow, low wall; the ridge is somewhat unusually high, distinctly higher than the wall, though not so in specimen 3. (See below) (Pl. LXX. 12).

Interambulacra. Areoles of moderate size and depth, well separated, at most the two proximal ones confluent; only the lowermost ones slightly transverse-oval. Only one of the upper tubercles in each series rudimentary; often there is a rudimentary tubercle only in one series of each I.A. There are sometimes slight traces of crenulation on the upper tubercles. Edge of areoles slightly raised, the scrobicular ring of tubercles not very conspicuous. Outside the scrobicular ring the plates rather closely covered by secondary tubercles decreasing in size towards the sutures, those along the median sutures being very small. An arrangement in horizontal series, continuing across the sutures, fairly distinct in the largest specimen. On the adradial side of the scrobicular ring a fairly broad space, covered with small tubercles in the largest specimen; in the others there is room only for few small tubercles here. The median space about half the width of an areole. The midline usually rather conspicuously sunken. The upper horizontal sutures straight, with a single, rather broad, but not well limited impression. The horizontal sutures more or less sunk, especially at the median end, where there is often a rather conspicuous groove.

[1] When Döderlein (Op. cit. p. 49) gives the number as 12, this is due to the fact that he counts the ambulacral plates off an ambital interambulacral plate, while in the present work the number given is that of the ambulacral plates corresponding to one of the upper interambulacral plates.

Apical system almost flat. Oculars all exsert, except in specimen 1, which has Ocular I barely insert. Male genital pores rather large, sometimes almost in the centre of the plates, female pores ca. 1 mm, nearer the outer edge (Pl. LXVII. 13); the specimens 3—5 have the genital pores not developed as yet. Madreporite scarcely enlarged. Periproctal plates moderately numerous. The whole apical system rather sparsely covered with tubercles of somewhat unequal size, leaving a rather broad, bare inner and lateral edge on the genital plates; as further the sutures are generally somewhat sunken, this gives the apical system a rather characteristic appearance. In specimen 3 there are one or two much larger tubercles on the inner edge of the genital plates (Figs. 85. 1—2). — Peristome flat, nearly as large as the apical system; there are 9—10 ambulacral plates in a series in specimen 1, only 5 in specimen 5. Interradial plates fairly regularly arranged in a single series, reaching very nearly to the mouth edge. There may sometimes be a considerable number of miliary tubercles (for pedicellariæ) on the peristomial plates.



1 2 3

Fig. 85. Parts of apical system of *Stereocidaris sceptriferoides* Död., ♂ (1), *St. sceptriferoides*, var. *lanceolata* Mrtsn. (2) and *St. sceptriferoides*, var. *lamellata* Mrtsn. ♀ (3). × 6.

Primary spines rather thick, usually slightly fusiform, gently tapering, the point rather conspicuously flaring (not so in specimen 1, but evidently because they are worn). There are ca. 12—15 longitudinal series of low, rounded spinules or rather granules, which, in well preserved spines, have a very small, outwards directed point. In the distal part they form more conspicuous ridges, while in the basal part of the shaft the serial arrangement may be somewhat indistinct. The surface of the shaft, is covered with a coat of anastomosing hairs, which, however, is not thick enough to conceal the spinules, and the spines therefore, even when perfectly fresh, do not appear smooth. The collar is scarcely 1 mm long, increasing somewhat in thickness toward the not very prominent milled ring; above the collar there is a conspicuous smooth, shining neck, twice as long as the collar. — The oral primaries are slightly widened, with the edge faintly serrate. The proximalmost ones are smooth, the following with longitudinal ridges; the third or fourth is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 3—4 mm long, in general, but not

constantly, somewhat broader than usual in the genus *Stereocidaris*, and almost rectangular, the end being slightly rounded. The outer surface is slightly convex or flat, even now and then concave. In specimen 3 they are much narrower, tapering nearly to a point — in fact they are here lancet-shaped (Pl. LXXXI. 10, to comp. with Pl. LXXXI. 1). There is a fairly gradual transition between the scrobicular and the smaller secondary spines, the latter being rather slender, not scale-like as in several other *Stereocidaris*-species, and not appressed. There is a small glandular ampulla in specimen 3. The marginal ambulacral spines flat and rather broad, very slender, setaceous, in specimen 3. They are not markedly elongate or curved on the oral side. In specimen 3 there is a very conspicuous tuft of spines round the anal opening, much less so in the other specimens.

Pedicellariæ. The large globiferous pedicellariæ (Pl. LXXXI. 2—3) have slender valves, and the stalk is slender, about as long as the head, not very short and globular as in *St. grandis* and most of the other species of *Stereocidaris*. The small globiferous pedicellariæ are remarkably slender and elongate, and have often a rather distinct end tooth (Pl. LXXXI. 4). Tridentate pedicellariæ have not been observed and would appear not to exist in this species. — Spicules of tubefeet transformed into large, fenestrated plates (Fig. 86. 1). The spicules of the intestinal wall are triradiate, as in the Goniocidarids (Fig. 86. 2). Hardly any spicules in the gonads or in the Stewart's organs.

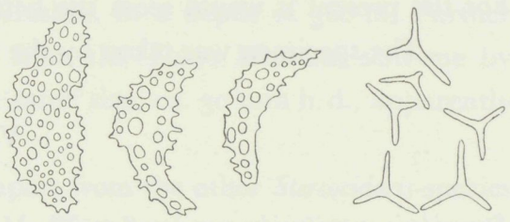


Fig. 86. Spicules from tubefeet (1) and from intestinal wall (2) of *Stereocidaris sceptriferoides* Död. 1 × 120; 2 × 150.

Colour. Primary spines a light pink, gradually turning into whitish towards the end of the spine. The secondaries whitish, or with a faint tinge of olive-greenish or brown. The naked test white. The statement by Agassiz & Clark (1907, p. 112) that the test is distinctly brown applies not to the naked test, but to the test covered with skin and spines.

Biology. The large specimen was found to contain bottom material, with Foraminifera and sponge-spicules as only recognizable organic remains. — The species appears not to reach a larger size than ca. 30—33 mm h.d.; the specimen 1 makes very much the impression of being an old one, its primaries being rather much worn. The primary spines are not rarely wholly invested by an arenaceous Zoanthid; clusters of Hydroids may also be found attached to the end of the spines.

Var. **lanceolata** Mrtsn.

Pls. XXIX. 8—9; LXXI. 6; LXXXI. 5—10.

Stereocidaris sceptriferoides, var. *lanceolata*. Th. Mortensen. 1928. New Cidaridæ, p. 71.

As pointed out in the above description, the specimen 3 differs markedly from the typical form in the character of its scrobicular and marginal ambulacral spines, and particularly in the existence of some large tubercles (and spines) on the inner edge of the genital plates. There is also a slight difference from the typical form in the ambulacra (Pl. LXXI. 6 to compare with

Pl. LXX. 12), but this is probably in the main due to the difference in age. Also the large globiferous pedicellariæ are somewhat different (Pl. LXXXI. 5—6 to compare with Pl. LXXXI. 2—3). Further it is very remarkable that, while specimen 1, of a horizontal diameter of only 33 mm, appears to be an old and worn specimen, the specimen 3 of 21 mm h.d. has not yet the genital pores developed, which would seem to indicate that it is the young of a species reaching a much larger size. (The size at which the genital pores appear in the typical form cannot be ascertained from the material available). These facts make it very doubtful, whether the said specimen really is identical with *St. sceptriferoides*, though it agrees well with that species in its other characters. For the present it would seem the better course to regard it as a variety of *sceptriferoides*.

The specimen was taken by the author in the Sagami Sea (1914) in a depth of 700 m.

Var. **lamellata** Mrtsn.

Pl. LXXXI. 11—14.

Stereocidaris sceptriferoides, var. *lamellata*. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 304. Pls. **71; 72; 74, 8—9; 78, 13—14.**

This variety is characterized mainly by its fusiform, strongly lamellate primary spines; also the large globiferous pedicellariæ differ from those of the typical *sceptriferoides* in having a short stalk and in the valves being somewhat more slender and with a smaller, somewhat irregular opening.

A specimen from the Kei Islands, 370—400 m. (Danish Expedition to the Kei Isl., Stat. 1) should probably be referred to this variety in spite of its differing in some regards from the specimen taken by the "Albatross" at the Philippines (St. 5630, 0° 56′ 30″ S. 128° 05′ E., 1040 m.). The measurements of this specimen are as follows:

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
23 mm	13 mm	12 mm (52.2 % h.d.)	9 mm (39.1 % h.d.)	5—6	12—13	34 mm

In the characters of the test it is in accordance with the type specimen; the grooves in the upper horizontal sutures rather distinct, especially those at the median end. In the apical system there is some difference in the size of the genital openings which are conspicuously larger in the present specimen (Fig. 85. 3), which may mean that the type specimen is a male, the present specimen being no doubt a female. On the peristome the interradial plates are arranged mainly in a single series. The primary spines are shorter, not so conspicuously lamellate and with a smaller terminal widening, otherwise they are as in the type specimen; this also holds good of the secondary spines, except that there is no keel on the inside of the scrobicular spines. The large globiferous pedicellariæ have a short, globular stalk; the opening of the valves is remarkably small (Pl. LXXXI. 11—13). The colour as in the type specimen, only the scrobicular spines more light coloured.

Possibly this specimen rather represents another separate variety — or species. From the

scanty material of both the typical *sceptriferoides* and the varieties available at present, it is, however, impossible to judge of the range of variation of the *sceptriferoides*-group, as we may call it, and it therefore seems desirable for the present to regard this specimen as belonging to the var. *lamellata*.

Occurrence. Known only from the Japanese Seas (viz. the typical form). The exact locality of the type-specimen is unknown. The "Albatross" took one specimen at Station 4968, between Kobe and Yokohama, 455 m., and the present author took a small specimen in the Sagami Sea, at at depth of ca. 700 m., and one specimen, the largest known (specimen 1 in the above measurements) 16 miles W. to S. of Bonomisaki, Kiushiu, in a depth of 360 m. Further some specimens were found in a collection of Echinoids from the Tokio Museum sent me by Prof. Goto. These specimens, which are all of nearly the same size, ca. 30 mm h.d., apparently all came from the Sagami Sea.

Remarks. This very distinct species stands rather apart from the other *Stereocidaris*-species and can hardly be said to be more nearly related to any of them.

The specimen figured by Yoshiwara (Op. cit.) under the name of *Cidaris japonica* Död. have decidedly nothing with Döderlein's *Stereocidaris japonica* to do (— which species Yoshiwara described as a supposed new species, naming it *Cidaris tenuispinus* —); it is *St. sceptriferoides*, as I can ascertain, having had the opportunity of examining this specimen. The fact that Yoshiwara failed to recognize the true *St. japonica* explains that in his description o "*Cidaris japonica*" he could state: "the two new urchins, C. grandis, C. sceptriferoides, named by Döderlein, are synonymous with the present species" (after a translation of the Japanese text kindly given me by Prof. H. Ohshima). — That the specimen from Misaki, identified by Clark (Op. cit. 1925, p. 26) as *St. grandis*, is really *St. sceptriferoides* (an adult female) is beyond doubt, as I may ascertain having examined this specimen in the British Museum.

It is a very interesting, and incontestable, fact that the small globiferous pedicellariæ have a distinct unpaired end tooth, as is otherwise unknown in *Stereocidaris*. — Agassiz & Clark (Op. cit.) point out the rather striking resemblance between the small globiferous pedicellariæ of this species and those of *Schizocidaris assimilis*, and state that "if that genus (*Schizocidaris*) is to be recognized, this species (viz. *sceptriferoides*) must certainly be placed in it, although it is in other respects very evidently a *Stereocidaris*". As shown in my report on the Cidaridæ of the "Albatross" Philippine expedition, the genus *Schizocidaris* is not really characterized by the elongate valves of the small globiferous pedicellariæ, and the existence of such a form of pedicellariæ in both *Schizocidaris assimilis* and *Stereocidaris sceptriferoides* is an evident case of convergence, which cannot prove any nearer relation between the two species.

Stereocidaris (Phalacrocidaris) japonica (Döderlein).

Pls. XXVIII. 1—10; LXX. 9; LXXXII. 11—17.

Dorocidaris japonica. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu Inseln. p. 4.
Cidaris (Stereocidaris) japonica. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ. p. 6. Taf. **III., VIII, 1. a—h.**
Cidaris (Stereocidaris) tenuispinus. Yoshiwara. 1898. Prel. Notice new Jap. Echinoids. Annot. Zool. Japon. II. p. 57.
Phalacrocidaris japonica. Lambert. 1902. Descr. Ech. fossiles Prov. Barcelone. Mém. Soc. Géol. France. IX. p. 26.
Stereocidaris japonica. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 29.
Stereocidaris tenuispina. Th. Mortensen. Ibidem.
Cidaris tenuispinus. Yoshiwara. 1906. Japanese Echini. Pl. I. 8—10.
Stereocidaris japonica. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 102.
Stereocidaris tenuispina. Döderlein. Ibidem.
Anomocidaris tenuispina. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ p. 30. Pl. **11, 6—11; 12, 18—30; 31, 5—8;** 1912. Pedinidæ etc. p. 383.
Anomocidaris japonica. A. Agassiz & H. L. Clark. 1907. Prel. Rep. "Albatross" Ech. 1906. p. 112.
Anomocidaris japonica. H. L. Clark. 1907. The Cidaridæ, p. 222.
Phalacrocidaris japonica. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Cidaris tenuispina. Lambert & Thiéry. 1925. Ibidem, p. 559.
Dorocidaris japonica. Lambert & Thiéry. 1925. Ibidem, p. 560.
Anomocidaris japonica. Diakonov. 1923. Faune de la Russie. I. p. 136.
Stereocidaris japonica. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 17.
NON: *Cidaris (Stereocidaris) japonica.* De Meijere. 1904. "Siboga" Ech. p. 16. Taf. XI, 117—118 (= *Stereocidaris indica*, var. *philippinensis* Mrtsn.).
Cidaris (Stereocidaris) japonica. Yoshiwara. 1906. "Japanese Echini", Pl. I, 45 (= *St. sceptriferoides* Döderl.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	37 mm	19 mm	17 mm (46 % h.d.)	13 mm (35 % h.d.)	8[1]	9—11	?
2	34 —	19 —	17 — (50 —)	13 — (38 —)	7—8	8—10	?
3	32 —	16 —	16 — (50 —)	11 — (34.4 —)	7—8	9—10	43 mm
4	27 —	14 —	13 — (48.1 —)	10 — (37 —)	7	9—10	44 —
5	19 —	9 —	9.5 — (50 —)	7 — (36.8 —)	6 (7)	8—10	35 —
6	16 —	9 —	8 — (50 —)	7 — (43.7 —)	6 (7)	8—9	24 —
7	13 —	6.5 —	7 — (53.8 —)	6 — (46 —)	5—6	8—9	25 —
8	9 —	4.5 —	4.5 — (50 —)	4 — (44.4 —)	5—6	7—8	16 —
9	7 —	3.5 —	4 — (57 —)	3.2 — (45.7 —)	5—6	5—7	12 —

All the specimens measured are in the Museum of Copenhagen.

Test low, generally rising gently towards the middle, or even subconical, more rarely quite flat above; the oral side flattened, slightly incurved at the edge of the peristome. Sides strongly arched, circumference circular.

Ambulacra almost straight, ca. 21—28 % of width of the interambulacra; interporiferous zone about, or a little more than, twice the width of a pore zone. Marginal series of tubercles quite regular; the tubercles are very low, only indistinctly mamelonate, not contiguous. Adradially

[1] According to Agassiz & Clark the largest specimens may have 9 interambulacral plates in a series.

to the marginal tubercle there is an almost equally large secondary tubercle, nearly on the middle of the plate, these inner tubercles forming also regular vertical series. In larger specimens there is usually a smaller tubercle at the lower, inner corner, these tubercles forming a fairly regular median series. No naked or sunk median line. In some specimens the inner tubercles are, however, less regularly arranged, there being two smaller tubercles, one above the other, instead of the single larger one in the middle of the plate. In such cases the serial arrangement of the inner tubercles is much less regular. The pores are rather small, separated by a moderately broad wall, raised into a low crest; the ridge is somewhat higher than the wall (Pl. LXX. 9).

Interambulacra. Areoles rather small, usually well, though narrowly separated, excepting the lowermost ones; in specimen 1 they are, however, nearly confluent, all of the fully developed ones. They are distinctly transverse-oval, except for only the uppermost one, which has an almost straight underside, while its upper side is regular, semicircular. The areoles are usually rather deep. Slight traces of crenulation observable in young specimens. Edge of areoles scarcely raised. Scrobicular circle of tubercles inconspicuous, these tubercles being only little larger than the secondary tubercles which cover uniformly the whole plate outside the areole. Also on the adradial side of the areoles there is room for a few secondary tubercles outside the scrobicular circle. Fine transverse lines produce a more or less distinct arrangement in horizontal series of the secondary tubercles. The upper 2—3 plates in each series carry only a very rudimentary areole, which may even have disappeared altogether on the uppermost plate. The sutures between these uppermost plates are straight, more rarely slightly upwards curving; they are fairly deep but show no distinct impressions, excepting, at most, a faint groove at the admedian end of the ambital horizontal sutures. The median suture may be more or less distinctly sunken and sometimes naked, and the plates correspondingly quite flat or slightly arched. Median area varying conspicuously in width: in specimen 1 as broad as, in specimen 2 only half as broad as an areole.

Apical system usually somewhat raised, about half h.d. Oculars all exsert, the genital plates rather unusually high, somewhat outwards produced. The sutures sometimes rather deep. Genital pores near the outer edge in both sexes, the female pores conspicuously larger than the male pores. Madreporite slightly enlarged. Periproct rather small, with a moderate number of plates. The whole apical system closely covered with small tubercles of uniform size, leaving a more or less conspicuous bare edge to the plates.

Peristome distinctly smaller than apical system, quite flat. In the larger specimens there are 7—8 ambulacral plates in a series, in the interradii 3—4 fairly regular plates; they do not reach the mouth edge.

The primary spines very slender, cylindrical, usually slightly flaring and flattened at the point. The shaft has ca. 12 irregular longitudinal series of rounded granules which do not form prominent ridges even in the distal part of the spine. A coat of anastomosing hairs almost covers the granules, in fresh, well preserved spines, such spines having an almost smooth appear-

ance. The oral primaries are flattened, smooth, sometimes with distinctly serrate edges. The 3rd—4th is transitional to the ambital spines[1].

Secondary spines. The scrobicular spines are ca. 3 mm long, flat, gently tapering towards the rounded point. The smaller spines rather slender, not appressed, with a small but rather thick glandular ampulla at the base. Marginal ambulacral spines ca. 2 mm long, flat; on the oral side they become gradually somewhat longer and somewhat widened in their distal part, but are scarcely curved.

Pedicellariæ. The large globiferous pedicellariæ which are in some specimens quite rare or even wanting, have a fairly slender, not globular stalk which may be about as long as the head. The valves may have a small end tooth, due to the curious fact that one side of the opening does not continue to the end of the valve; the apparent end tooth is thus formed by only one side of the opening (Pl. LXXXII. 15). The small globiferous form may have very elongate valves, as in *St. sceptriferoides*, and may, as in that species, have a small end tooth (Pl. LXXXII. 13). The stalk of the small globiferous pedicellariæ may be rather long, up to 2 mm. — In a couple of specimens from off Kiushiu both large and small globiferous pedicellariæ are shorter and thicker than usual (Pl. LXXXII. 14, 16—17), and there are no elongate samples of the small globiferous type. Tridentate pedicellariæ apparently do not occur in this species.

Spicules of the tubefeet mainly fenestrated plates as in *St. sceptriferoides*. In the intestinal wall numerous small triradiate spicules, as in *St. sceptriferoides*; also a few such spicules in the walls of the genital organs.

Colour. General colour brownish or light greenish. The primary spines are of a brownish-olive tint, the distal part lighter, almost white; the underside of the spines is as a rule of a distinctly lighter colour than the upper side, also the collar is somewhat lighter coloured, whereas the neck is usually the darkest part of the spine. Very rarely there may be a rosy-red tinge on the primaries. Sometimes, in younger specimens, there is an indication of the spines being banded. The secondary spines are of a slight brownish-olive colour, or, in younger specimens, more whitish. Yoshiwara (Japanese Echini, 1906) states in his description of his *Cidaris tenuispinus* (translated for me from the Japanese text by my friend, Professor H. Ohshima) that the "miliary spines all over the test are enclosed in thick membrane of dark violet colour, giving the animal a characteristic feature". Evidently this statement rests on observation of the living specimens and is thus very valuable. The denuded test has a faint greenish tinge on the aboral side, otherwise it is white.

Biology. Appears to live gregariously in places, and both on hard and on mud bottom. The alimentary canal of a specimen opened was found to contain, besides rather coarse bottom material with Foraminifera, an Ophiurid which could still be recognized almost certainly as being an *Ophiothrix*. — The genital pores appear rather late, at a size of ca. 15 mm h.d. The

[1] It may be pointed out that the figure of an ambital, primary spine, given by Agassiz & Clark (Op. cit. Pl. 12. 19) and reproduced by Diakonow (Op. cit. p. 139) is rather unfortunate, resembling, in fact, rather more a verticillate spine of a Diadematid than a Cidarid spine.

species apparently does not grow to any large size, the largest specimens recorded being only 40 mm h.d. The spines are, on the whole, rather free from foreign organisms — only some incrusting Bryozoa being found on some of the larger specimens. Parasites are unknown from this species. Anomalies are not very rare. Döderlein (Op. cit. Taf. III. 12) figures a curious case of an abnormal apical system, the genitals V, I and III—IV being coalesced, these coalesced plates having each only one genital pore. In a specimen in the U. S. National Museum (Pl. XXVIII. 2) the madreporite has been divided into two parts, one of these parts occupying the place of Oc. II which has disappeared. There are two genital openings in this part, the madreporite thus having three genital pores. In another specimen in the U. S. Nat. Museum (Pl. XXVIII. 1) the uppermost right plate of Interambulacrum 1 occupies the whole width of the area, which is somewhat narrower than usual; genital 1 and ocular II have coalesced into one plate, which carries both the ocular and the genital pore.

Variations. As stated above, a couple of specimens from off Kiushiu differ from the typical form in their pedicellariæ being shorter, and especially in having none of the elongate, small, globiferous pedicellariæ otherwise so characteristic of the species. As for the rest they do not differ noteworthily from the typical form, and we have thus probably merely a local variation in these specimens.

Occurrence. Known only from the Japanese Seas, where it evidently occurs all round the Islands from off Hakodate to the Sagami Sea and the Korea Strait. The author took some specimens in the Sagami Sea at ca. 350—700 m., and at 128° 50′ E. 33° 41′ N., 135 m. The known bathymetrical distribution is ca. 70—700 m. The record of the species as occurring in the Malay Archipelago ("Siboga"-Ech., p. 16) is due to erroneous identification, these specimens being in reality *Stereocidaris indica*, var. *philippinensis*.

Remarks. This species in some regards approaches *St. sceptriferoides*, with which it agrees in the characters of the ambulacra, of the spicules and pedicellariæ; on the other hand, the very reduced upper areoles is a character distinguishing it sharply from that species. Among the fossil species *St. Merceyi* Cotteau agrees with it in the strong reduction of the upper areoles and in the lacking of distinct impressions in the upper sutures.

The character of the large globiferous pedicellariæ, as described above, is of very great interest, showing the way in which the type of pedicellariæ with a single end tooth, as found in the genera *Cidaris*, *Calocidaris* and *Tretocidaris* may have evolved from the more simple Stereocidarid type with no end tooth.

Lambert (Op. cit. 1902) made *St. japonicus* the type of a separate genus, *Phalacrocidaris*, and afterwards it was again made the type of a new genus, *Anomocidaris*, by Agassiz & Clark (Op. cit. 1907); the latter, of course, becomes a synonym of Lambert's name *Phalacrocidaris*. Another question is, whether the genus *Phalacrocidaris* can be maintained besides the genus *Stereocidaris*. As explained above (p. 229) this seems not well possible, because of the intermingling of the characters in the recent species of the Stereocidarid-group. Still, as the species *japonicus* stands

somewhat apart, it may be justifiable to regard it as a subgenus, *Phalacrocidaris*, to which then also the fossil species *Merceyi* Cott. should be referred.

The sometimes distinctly serrate oral primaries to some degree recall *Histocidaris*, as pointed out by Döderlein (who, of course, still has the name *Porocidaris*); that there is no real affinity between this species and the Histocidarinæ was well recognized by Döderlein "wenn eine solche Ansicht auch nicht absolut abzuweisen wäre".

Yoshiwara (Japanese Echini, 1906) quite mistook this species. His new species *tenuispinus* is identical with *japonica* Död., whereas what he calls *japonicus* is partly *St. microtuberculata*, partly *sceptriferoides*. (cf. p. 279, under *St. sceptriferoides*).

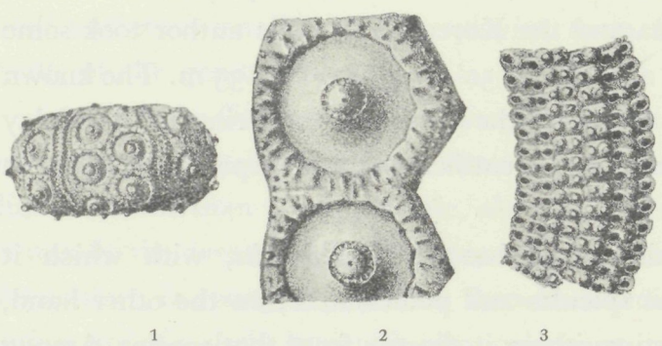
Genus **Sinæcidaris** Fourtau.

Fourtau. 1921. Catalogue des Invertébrés foss. de l'Égypte. Terr. Crétacés. III. Échinodermes (Suppl.), p. 9. Pl. III, 11.

Differs from *Stereocidaris* (*Typocidaris*) only in having distinctly crenulate primary tubercles. (Spines unknown).

Genotype and only known species: *Sinæcidaris Gauthieri* Fourtau. Cretaceous (Fig. 87).

This genus apparently is very closely related to *Stereocidaris* with which (viz. with *Typocidaris*) it was made synonymous by Lambert & Thiéry (Ess. nom. rais. p. 560). As pointed out under the genus *Alpicidaris* this is an evident inconsistency on the part of Lambert & Thiéry, who maintain *Alpicidaris* as a separate genus besides *Paracidaris* from which latter it differs only in having smooth tubercles. If *Alpicidaris* is regarded as a separate genus, certainly *Sinæcidaris* must be so too. Also in some of the recent *Stereocidaris* species there may be traces of crenulation.



1 2 3

Fig. 87. *Sinæcidaris Gauthieri* Fourtau. 1. A complete test, natural size; 2. two interambulacral plates; 3. part of ambulacrum; magnified. After Fourtau. Op. cit.

Genus **Temnocidaris** Cotteau.

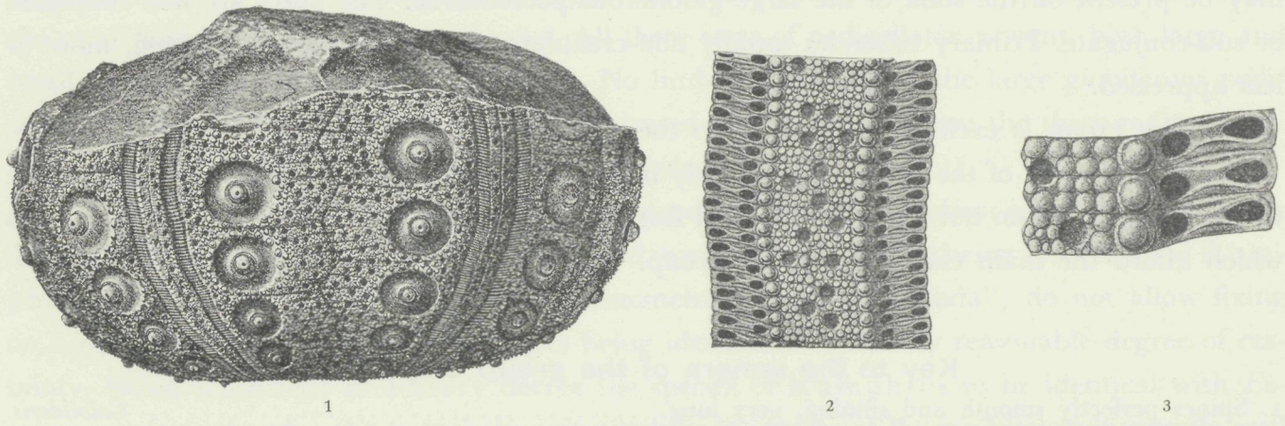
Cotteau. 1863. Paléontol. Française. Terr. Crétacé. VII. Échinides, p. 355.
Pomel. 1883. Classif. méth. p. 111.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 43.
Duncan. 1889. Revis. gen. Ech. p. 34.
H. L. Clark. 1907. The Cidaridæ, p. 195.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 156.

NON. *Temnocidaris* A. Agassiz. (= *Austrocidaris* H. L. Clark).
A. Agassiz. 1863. List of Echinod. p. 18.

Pores sub-conjugate. Primary tubercles perforate, non-crenulate. Marked pore-like impressions in the test, not especially in the sutures but all over the coronal plates. Primary spines cylindrical, slender, finely thorny.

Genotype: *Temnocidaris magnifica* Cotteau. Cretaceous (Senon) (Fig. 88)
Other species — *Baylei* Cotteau. Cretaceous (Pal. Franç. Crét. Pl. 1087).
— *danica* (Desor) — (Ibidem. Pl. 1087. bis. 7—8)[1].

No primary spines have been found attached to the test of a *Temnocidaris*; but my friend J. P. J. Ravn informs me that he finds some slender, cylindric spines rather constantly together



1 2 3

Fig. 88. *Temnocidaris magnifica* Cotteau (1); part of ambulacrum of same (2—3), the latter figure more magnified. After Paléontologie Française, Terr. Crétacé, Pl. 1085 and 1086, 2, 4.

with the fragments of *Temnocidaris danica*, so that he does not doubt that they belong together (cf. Op. cit. p. 27). The spine of *Temnocidaris magnifica* figured by Cotteau (Op. cit. Pl. 1085. 4—5) is so small that it must be one of the secondary spines, possibly an ambulacral marginal spine.

Duncan (Op. cit.) thinks there may be a suspicion of the grooves of the test of *Temnocidaris* being of post-mortem origin. There is not the slightest support of such suggestion. The grooves are real enough, and quite constant, though varying in number. The discovery of a recent Cidarid, *Stereocidaris stylifera* Mrtsn., with similar grooves in the test gives the explanation of the grooves. They are the seat of large globiferous pedicellariæ; the pedicellaria is attached to the edge of the groove, its head resting in the groove. The said species, *Stereocidaris stylifera*, represents a transition from *Stereocidaris* to *Temnocidaris* and leaves no doubt that these two genera are very closely related, so closely, indeed, that the generic distinction of the two may be disputable.

[1] See further J. P. J. Ravn. De Regulære Echinider i Danmarks Kridtaflejringer. Mém. Ac. R. Sc. Copenhague. 9. Sér. I. 1928. p. 26. Tav. III. 1—6.

Group *Cidarina.*

This group, comprising the genera *Cidaris*, *Calocidaris* and *Tretocidaris*, is characterized by its pedicellariæ, both the large and small globiferous having a well developed end-tooth; a limb may be present on the stalk of the large globiferous pedicellariæ. The pores are non-conjugate or sub-conjugate. Primary tubercles usually non-crenulate. Secondary spines flattened, more or less appressed.

This group is exclusively confined to the Atlantic and the West Indies.

Whether any of the genera known only in a fossil state belong to this group is impossible to ascertain, as we do not know in the fossil forms the finer details of the pedicellaria-structures which afford the main characters of the group.

Key to the genera of the group Cidarina.

1. Spines perfectly smooth and shining, very long ..... *Calocidaris.*
   Spines with more or less distinct spinules, arranged in longitudinal series; if nearly smooth (*C. abyssicola*), they are not shining, and not very long ..... 2.
2. Areoles deep. Opening of large globiferous pedicellariæ fairly large ..... *Cidaris.*
   Areoles shallow. Opening of large globiferous pedicellariæ very small, pore-like ..... *Tretocidaris.*

Genus **Cidaris** Leske.

Leske. 1778. Additamenta ad J. Th. Kleinii nat. disp. Echinodermatum. p. XVII.
Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 53.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 2, 17.
Th. Mortensen. 1927. Handbook Ech. Brit. Isles. p. 271.

Syn. *Orthocidaris* A. Ag. (non Cotteau).

A. Agassiz. 1863. List of Echinod. p. 17.

Syn. *Dorocidaris* A. Agassiz.

A. Agassiz. 1869. Prel. Rep. Echini & Starfishes dredged in deep water between Cuba and the Florida Reef. Bull. Mus. Comp. Zool. I. p. 254.
— 1872. Rev. of Ech. p. 254.
Pomel. 1883. Classif. méth. p. 110.
Döderlein. 1887. Jap. Seeigel. Cidaridæ. p. 41.
Duncan. 1889. Revis. genera Ech. p. 31.
Th. Mortensen. 1903. "Ingolf" Ech. I. p. 28.
H. L. Clark. 1907. The Cidaridæ. p. 207.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 147.

Test usually somewhat flattened above and below, but may be almost spherical. Pores not conjugate, separated by a rather narrow wall, which forms a rounded, but not much elevated crest. Primary tubercles smooth, exceptionally (*C. nuda*) rather distinctly crenulated. Areoles generally deep, well separated. Apical system about half h.d., peristome somewhat smaller. Oculars usually exsert. Primary spines with more or less distinct spinules arranged in fairly regular longitudinal series, which may form conspicuous ridges. The point as a rule simple, but may be widened into a small crown; sometimes (*C. blakei*) the upper spines are very conspicuously widened, fan-shaped. General surface of spines covered with a spongy coat of anastomosing hairs. Oral primaries flattened, smooth, with slightly serrate edges. Secondary spines flattened, appressed, sometimes the small miliary spines almost setaceous. All three sorts of pedicellariæ present, both large and small globiferous with a distinct end-tooth. No limb on the stalk of the large globiferous pedicellariæ. Spicules of intestinal wall small fenestrated plates, derived from the three-radiate type.

Genotype: *Echinus cidaris* Linn. (= *Dorocidaris papillata* (Leske)).

The question which species is to be understood by Linnæus' *Echinus cidaris* has been much discussed. The references to various figures in old works, the first quoted being Pl. XIII. 3 of Rumphius' D'Amboinsche Rariteitkamer ("Echinometra digitata 2 rotunda") do not allow fixing on a definite species, none of these figures being identifiable with any reasonable degree of certainty. When Lambert & Thiéry decree the species of Rumphius to be identical with *Eucidaris metularia* (Lamk.) this is entirely unjustifiable; the figure of Rumphius may equally well (— or rather equally badly —) represent *Prionocidaris baculosa* or any other Cidarid; and when the two authors on the base of this bold identification proceed to overthrow Cidarid nomenclature, this is a most objectionable action, resulting only in considerable harm to science.

While thus the *Echinus cidaris* of 1758 is unidentifiable, it is absolutely certain that the species mentioned under this name by Linnæus in his "Fauna Suecica" 1761, p. 513 is identical with the species for so long a time designated as *Dorocidaris papillata*, — because he states that it occurs "in oceano norvegico", where this species is rather common and well known to the fishermen. There cannot thus be the slightest doubt that this species, the only one which occurs in the Norwegian Sea, must be regarded as Linnæus' *Echinus cidaris*, and accordingly gets the name *Cidaris cidaris* (Linn.) and becomes the genotype of the genus *Cidaris*. This has been made perfectly clear through the discussion between Bather, H. L. Clark and myself in the "Annals & Magaz. Nat. Hist." 1908—10.[1]

As restricted by the above diagnosis, which was first set forth in the "Ingolf" Ech., the genus contains only the species *cidaris*, *abyssicola*, *rugosa*, *blakei* and *nuda* (the species *micans*, which

[1] F. A. Bather. The Echinoid name Cidaris and its modern application. Ann. Mag. Nat. Hist. 8. Ser. I. 1908. p. 284—288.
H. L. Clark. The type of Cidaris. Ibidem. p. 532.
F. A. Bather. The genotype of Cidaris. Ibidem. 8. Ser. II. 1908. p. 134—136.
H. L. Clark & F. A. Bather. The type of Cidaris. Ibidem. 8. Ser. III. 1909. p. 88.
Th. Mortensen. On some points in the nomenclature of Echinoids. Ibidem. 8. Ser. V. 1910. p. 118—119.

was placed with some doubt in the genus, having later on justly been made the type of a separate genus *Calocidaris* by H. L. Clark). The genus is thus seen to be represented only in the Atlantic (with the Mediterranean and the West Indies).

Whether any of the numerous fossil species referred by Lambert & Thiéry (Op. cit. 1910) to "*Dorocidaris*" really belong together with the genus *Cidaris* in the sense of the above diagnosis is quite uncertain. No doubt, it is highly probable that some of these species are really related to and congeneric with the recent *Cidaris*-species, but we have no means of ascertaining this beyond doubt. It is a fact that we cannot by means of the test and spines alone identify with certainty the recent species of such genera as *Cidaris* and *Stylocidaris*, which by the characters of their pedicellariæ are shown to belong to two quite distinct groups. Accordingly we cannot expect to be able to decide with certainty the generic position of the much less known fossil forms, which, on account of their non-conjugate pores and non-crenulate tubercles, and on account of the absence of other special characteristics in the test or the spines, are designated as "*Cidaris*" or "*Dorocidaris*"[1]. We may, or rather must, go on designating such fossil forms simply as *Cidaris*; but it must always be kept in mind that "*Cidaris*" here is meant in a broad sense, not in the restricted sense of the recent genus *Cidaris*[2]. It is, of course, not excluded that some day the structure of the pedicellariæ of some fossil species may be discovered and thus the exact generic position of such species be established — as there has now and then been made unexpected discoveries of these minute structures, even in palæozoic forms. But till then we must simply acknowledge that these fossil forms are insufficiently known for ascertaining their exact generic place. (— This also applies especially to the numerous forms referred by Lambert & Thiéry to the genus *Plegiocidaris*).

Key to the recent species of the genus Cidaris.

1. Primary spines very smooth, their spinules usually discernible only on microscopical examination ..... *Cid. abyssicola.*
   Primary spines distinctly thorny ..... 2.
2. Secondary spines dark brown or purple, showing very conspicuously against the white test ..... *Cid. nuda.*
   Secondary spines whitish or with a faint greenish or reddish tint, not showing conspicuously against the whitish test ..... 3.
3. Upper primary spines usually more or less fan-shaped widened. Secondary spines very slender, almost setaceous; the secondary interambulacral tubercles very small ..... *Cid. blakei.*

[1] Founding on their principle that characters which cannot be expected to be preserved in the fossil forms must not be used in classification of recent Cidarids, Lambert & Thiéry have the boldness of making the genera *Tretocidaris*, *Calocidaris*, *Stylocidaris*, *Aporocidaris*, and (partly) *Notocidaris* and *Stereocidaris* synonymous with *Dorocidaris*. The recent species referred by the two authors to *Dorocidaris* form an assemblage so disorderly that a discussion is perfectly out of question.

[2] It might perhaps be desirable to go on using the name *Dorocidaris* for these fossils, and likewise the name *Leiocidaris* for the fossils with conjugate pores and non-crenulate tubercles. These two names, as synonyms, cannot be used for the recent forms (viz. respectively *Cidaris* and *Phyllacanthus*), but since we must have a name for all those numerous fossil forms which cannot, at our present stage of knowledge, be referred with certainty to any of the known genera, it may be practical here to keep these names, which will then not mean much more than the old designation "*Cidarites*".

Upper primaries not fan-shaped widened; secondary tubercles not very small, their spines not very slender, setaceous ..... 4.

4. A distinct naked median space in the interambulacra; interporiferous zone rather naked *Cid. cidaris.*
No naked median interambulacral space, interporiferous zone closely tuberculated ..... *Cid. rugosa.*

Cidaris cidaris (Linn.).

Pls. XXX. 3—4; XXXI. 1—10; LXVII. 5; LXXII. 20—22.

Echinus cidaris. Linnæus. 1758. Systema Naturæ, Ed. X. p. 664; Ed. XIII. 1788 (Gmelin), p. 3174.
Echinus cidaris. Linnæus. 1761. Fauna Suecica. Ed. II. p. 513.
Cidaris papillata. Leske. 1778. Additamenta ad I. Th. Kleinii Nat. disp. Echinodermatum, p. 61. Pl. XXXIX. 2.
Echinus cidaris, var. a. Sowerby. 1805. The British Miscellany. p. 89. Pl. 44.
Cidarites hystrix. Lamarck. 1816. Hist. nat. anim. s. vertèbres. III. p. 55. II. Ed. 1840, p. 379.
Echinus cidaris, S. Nilsson & A. L. Holst. 1817. Collectanea Zoologiæ Scandinavicæ, p. 11.
Cidarites hystrix. Deslongchamps. 1824. Encycl. méth. II. p. 194. Pl. 136. 6—7 (Figure not recognizable)[1].
(?) *Cidaris histrix.* Risso. 1826. Hist. nat. l'Europe merid. V. p. 278. (Rather *Stylocidaris affinis*, judging from the statement: "son test est rougeâtre").
Cidaris papillata. Fleming. 1828. A History of British Animals, p. 477.
Cidaris hystrix. Blainville. 1834. Manual d'Actinol. p. 231. Pl. XX. bis, fig. 5.
Cidarites (Echinus) hystrix. M. Sars. 1835. Beskrivelser og Iagttagelser. p. 40, 46.
Cidaris hystrix. Desmoulins. 1837. Mém. s. l. Éch. III. p. 166.
Cidaris papillata. Desmoulins. Ibid. p. 166.
(?) *Cidaris hystrix.* Grube. 1840. Actinien, Echinod. u. Würmer d. Adriat. u. Mittelmeers, p. 32. (Rather *Stylocidaris affinis*, judging from the description of the colour).
(?) *Cydaris* (sic!) *hystrix.* Delle Chiaje. 1841. Descr. e notomia d. animali invertebr. d. Sicilia citeriore. Vol. V. p. 120—121. Tav. 118. 1—9, 12—14, 20; 119, 1—4, 22; 121. 13, 15, 16, 20—22; 124. 5, 6, 11. (May just as well be *St. affinis*; figures of no value).
Cidaris papillata. Forbes. 1841. Hist. Brit. Starfishes, p. 146.
Cidaris histrix. Forbes. 1844. Report on the Mollusca and Radiata of the Ægean Sea (1843). Rep. Brit. Assoc. p. 150.
Cidaris borealis. Düben. 1844. Norriges Hafsfauna. Öfvers. K. Sv. Vet. Ak. Förh. p. 114.
Cidaris papillata. Düben & Koren. 1844. Öfversigt af Skand. Echinodermer. K. Sv. Vetensk. Akad. Handlingar (1846) p. 255. Pl. **IX. 25—30.**
Cidaris papillata. Philippi. 1845. Beschr. neuer Echinod. etc. Arch. f. Naturgesch. XI. 1. p. 353.
Cidaris hystrix. Philippi. Ibidem.
Cidaris hystrix. Agassiz & Desor. 1846. Cat. Rais. p. 326.
Cidaris papillata. Agassiz & Desor. Ibidem.
Cidaris papillata. Gray. 1848. List Brit. Animals in the coll. Br. Mus. p. 2.
(?) *Cidaris hystrix.* Aradas. 1853. Monogr. Ech. viv. e foss. di Sicilia. Atti Ac. Gioenia Sci. Nat. Catania. VIII. p. 162. (Probably *St. affinis*; impossible to decide).
Cidaris hystrix. M. Sars. 1857. Middelhavets Littoral-Fauna, p. 109.

[1] As Desmoulins (Op. cit.) has justly remarked, these old figures are, indeed, hopelessly irrecognizable, the only fairly good figure of the species being that given by Scilla in his work "De corporibus marinis" (1752), Tav. XXII. 1 — though I would not go so far as to designate this figure "optima", as does Desmoulins. Further it is very probable that this figure rather represents *Stylocidaris affinis*, not *Cidaris cidaris.*

In G. de Favannes. Conchyliogie. III. Ed. 1780, are figured some sea-urchins (Pl. 56. A. 1, A. 2, A. 3, C. 1, and C. 2) which may probably represent Cidarids. Pl. 57. F. 2 is certainly a Cidarid, but no more identifiable than so many other old figures. The text does not give scientific names.

In E. Pontoppidan's "Norges naturlige Historie". Vol. 2. 1753. p. 278 is also given a very poor figure of a Cidarid, which is, from the description and locality (Norway), seen to represent *Cidaris cidaris.* Pontoppidan gives it the name *Erinaceus marinus.*

Cidaris papillata. M. Sars. 1861. Norges Echinod. p. 93.
Leiocidaris hystrix. Dujardin & Hupé. 1862. Hist. Nat. Zooph. Éch. p. 484.
Leiocidaris papillata. Dujardin & Hupé. Ibidem, p. 485.
Orthocidaris hystrix. A. Agassiz. 1863. List of Echinod. p. 17.
Orthocidaris papillata. A. Agassiz. Ibidem.
Cidaris hystrix. Heller. 1863. Unters. Litt. Fauna d. Adr. Meeres. Sitz.Ber. Ak. Wiss. Wien. XLVI. p. 444.
Cidaris hystrix. Heller. 1868. Zooph. u. Echinod. d. Adr. Meeres. p. 69.
Leiocidaris papillata. Perrier. 1869. Rech. s. l. Pédicellaires, p. 129. Pl. 3. 11. a—c.
Dorocidaris papillata. A. Agassiz. 1872—74. Rev. of Ech. p. 105, 254—258, 386 (partim). Pl. **I. b; I. c. 25—30;** II. a. 1—13; **II. b. 1—5; II. c. 7—12; XXIV. 1—8** (non Pl. I. = *Cid. abyssicola*) (*Cid. abyssicola* and *Stylocidaris affinis* included in the description).
Dorocidaris papillata. Gauthier. 1874. S. l. Échinides des environs de Marseille. C. R. 79. p. 401.
Cidaris hystrix. Lovén. 1874. Ét. s. les Éch. p. 29. Pl. **XX. 166—167.**
Cidaris papillata. Lovén. Ibidem. p. 29, 65, 66, 80. Pl. **XX. 168—169.**
Cidaris papillata. Wyv. Thomson. 1874. "Porcupine" Ech. p. 722. Pl. **LIX. 1—13.**
(?) *Dorocidaris papillata.* Manzoni. 1878. Gli Echinod. fossili delle Schlier di Bologna. Denkschr. Akad. Wien. 39. p. 153. Tav. III. 25—27. (Some test fragments and a small fragment of a spine, not with any certainty identifiable as *Dorocid. papillata*).
Dorocidaris papillata. Ludwig. 1879. Die Echinod. d. Mittelmeeres, p. 554.
Dorocidaris papillata. Stewart. 1880. On certain organs of the Cidaridæ. Trans. Linn. Soc. 2. Ser. Zool. I. p. 569. Pl. **70. 1—5.**
Dorocidaris papillata. Greeff. 1881. Echinod. beobachtet a. e. Reise n. d. Guinea Insel São Thomé. Zool. Anz. p. 7.
Dorocidaris papillata. A. Agassiz. 1881. "Chall." Ech. p. 38. (partim).
Dorocidaris papillata. A. Agassiz. 1882. In Murray & Tizard. Explor. of the Faeroe Channel 1880 in "Knight Errant". Proc. R. Soc. Edinbourgh. XI. 1882. p. 697.
Dorocidaris papillata. Ludwig. 1880. Über Asthenosoma varium Grube, u. über ein neues Organ bei den Cidariden. Z. w. Zool. XXXIV. p. 85. Pl. III. 8—10. (Morph. Studien an Echinod. II. p. 32).
(?) *Dorocidaris papillata.* Verrill. 1882. Notice remark. marine Fauna New England, Amer. J. Sc. XXIII. p. 135.
Dorocidaris papillata. Koehler. 1883. Rech. s. l. Échinides des Côtes de Provence. Ann. Mus. Hist. nat. Marseille. Zool. I. p. 113. Pl. III. 17—18; VII. 49—51.
Dorocidaris papillata. Carus. 1885. Prodr. Faunæ Mediterr. I. p. 98.
Dorocidaris papillata. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ, p. 41, 50. Taf. **IX. 5.**
Dorocidaris papillata. Prouho. 1888. Rech. s. l. Dorocidaris papillata. Arch. de Zool. expér. et génér. 2. Sér. V. Pl. XIV, XV, XVII—XXI, XXIII—XXV. (Great anatomical monograph). (Note prél. sur le syst. vasculaire du Dorocid. papillata. C. R. 1886. Vol. 102. p. 1403).
Dorocidaris papillata. Sladen. 1890 (1891). Ech. S.W.Coast Ireland. Proc. R. Irish Ac. 3. Ser. I. p. 699.
Cidaris papillata. Bell. 1890. Notes on the Echinod. coll. by Mr. Bourne in Deep Water off S.W.Ireland. Journ. Mar. Biol. Ass. N. Ser. I. p. 326.
Cidaris papillata. Hoyle. 1891. Rev. List. Brit. Ech. Proc. R. Phys. Soc. X. p. 404.
Cidaris papillata. Lovén. 1892. Echinologica. p. 18—19, 52—53. Pl. **VI. 39—46.** (Dental apparatus).
Cidaris papillata. Bell. 1892. Cat. Brit. Ech. p. 139.
Cidaris papillata. Bell. 1892. Echinod. coll. by the "Fingal" & "Harlequin" off W. Coast Ireland. Sci. Proc. R. Dublin Soc. N. S. 7. p. 526.
Dorocidaris papillata. Danielssen. 1892. Echinida. Norw. N. Atl. Exp. p. 6.
Dorocidaris papillata. F. Leipoldt. 1893. Das angebliche Exkretionsorgan d. Seeigel, unters. an Sphærechinus granularis u. Dorocidaris papillata. Z. w. Zool. 45. p. 602.
Dorocidaris papillata. Marenzeller. 1893. Zool. Ergebn. I. Echinodermen, ges. 1890—92. Ber. Comm. für Erforsch. d. östl. Mittelmeeres. Denkschr. Akad. Wiss. Wien. LX. p. 12.
Dorocidaris papillata. Marenzeller. 1895. Zool. Ergebn. V. — Ibid. Bd. LXII. p. 20, 24.
Dorocidaris papillata. Koehler. 1894. Échinod. rec. à la Ciotat pendant l'été 1894. Mém. Soc. Zool. Fr. p. 417. (*Dorocid. papillata* = "Oursin judiou").

Dorocidaris papillata. Sluiter. 1895. Die Echiniden Samml. d. Mus. Amsterdam. p. 67.

Dorocidaris papillata. Bernard. 1895. Liste des Échinides du "Travailleur" et du "Talisman". Bull. Mus. d'hist. nat. Paris. I. p. 208.

Dorocidaris papillata. Koehler. 1896. Échinod. du "Caudan". p. 89.

Dorocidaris papillata. Uexküll. 1896. Über die Function d. Polischen Blasen am Kauapparat d. Reg. Echiniden. Mitt. Zool. Stat. Neapel. XII. p. 468.

Dorocidaris papillata. Pallary. 1898. Enumération des oursins vivant dans la Golfe d'Oran. Feuille d. jeunes Naturalistes. 3. Sér. XXVIII. p. 152.

Dorocidaris papillata. Koehler. 1898. Res. Camp. Monaco. Fasc. XII. p. 8.

Dorocidaris papillata. Th. Mortensen. 1898. Die Echinodermenlarven d. Plankton-Exp. p. 78. (Also in: Systematiske Studier over Echinodermlarver. Vid. Medd. Nat. Foren. København. 1898. p. 110).

(?) *Dorocidaris papillata.* Airaghi. 1899. Echinidi del Pliocene Lombardo. Atti Mus. Milano. XXXVII. p. 362. Pl. f. 1. (Only fragment of a test, impossible to identify with certainty. Referred to again 1908 in his Revis. d. Asteroidi e d. Echinidi lombardi. Rendic. Ist. Lombard. (2) 41. p. 256).

Dorocidaris papillata (partim). Lo Bianco. 1899. Notizie biologiche anim. del Golfo di Napoli. Mitt. Zool. Stat. Neapel. XIII. p. 473.

Dorocidaris papillata. Hesse. 1900. Mikrostr. d. foss. Seeigelstacheln. p. 226.

Dorocidaris papillata. Th. Mortensen. 1901. Echinodermenlarven. Nordisches Plankton. IX. p. 23.

(?) *Dorocidaris papillata* Airaghi. 1901. Echinidi Terziari dell Piemonte e della Liguria. Pal. Ital. VII. p. 171. Pl. XIX. (Rather *Stylocidaris affinis*).

Dorocidaris papillata. Grieg. 1902. Overs. nordl. Norges Echinod. Bergens Mus. Aarbog. p. 31.

Cidaris papillata. Nichols. 1902. List of Irish Echinod. Proc. R. Irish Acad. XXIV. p. 258.

Cidaris papillata. Nobre. 1903. Subsidios para o estudo da fauna marinha do norte de Portugal. Ann. Sci. nat. Porto. VIII. p. 54. 1904. Fauna Portugueza. Annuar. Ac. Porto. p. 134.

Dorocidaris papillata. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 31—35, 171; Pl. **VI. 6—7; VIII. 1, 3, 12, 14, 27; IX. 3, 5, 7, 13—15, 20, 25, 27; XI. 14, 26, 31.** Part II. 1907. p. 14.

Dorocidaris papillata. Döderlein. 1905. Arktische Seeigel. Fauna Arctica. IV. p. 375.

Cidaris papillata. St. W. Kemp. 1905. The marine fauna of the W. Coast of Ireland, III. Ann. Rep. Fish. Ireland. Pt. II. App. VI. p. 196.

Dorocidaris papillata. Checchia-Rispoli. 1906. Gli Echinidi viv. e fossili della Sicilia. I. Pal. Ital. XII. p. 87. Tav. IV. 27—28. Parte II. Ibid. XIII. 1907. p. 202. Parte IV. Ibid. XXII. 1916. p. 232. Tav. XXVI. 28—41.

Dorocidaris papillata. Lo Bianco. 1906. Azione della pioggia di cenere, caduta durante l'eruzione dell' Vesuvio apr. 1906 sugli anim. marini. Mitt. Zool. Stat. Neapel. XVIII. p. 92.

Cidaris papillata. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 103.

Dorocidaris papillata. H. L. Clark. 1907. The Cidaridæ, p. 209.

Dorocidaris papillata. Koehler. 1909. Res. Camp. Monaco. XXXIV. p. 214.

Dorocidaris papillata. Aug. Nobre. 1909. Echinodermes du Portugal. Ann. Acad. Polytechn. do Porto. IV. p. 18.

Cidaris cidaris. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 54.

Dorocidaris papillata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 147.

Dorocidaris papillata. Süssbach & Breckner. 1910. Seeigel, Seesterne u. Schlangensterne d. Nord- u. Ostsee. p. 174.

Dorocidaris papillata. Lambert. 1910. Descr. Éch. des Terrains Néogènes du Bassin du Rhône. Mém. Soc. pal. Suisse. XXXVII. p. 16. Pl. I. 37—38.

Cidaris cidaris. Jackson. 1912. Phylogeny of Ech. p. 96, 100.

Dorocidaris papillata. G. Stefanini. 1913. Ech. raccolti nel Mediterr. dalla R. N. Ital. "Washington". Archivio Zool. VII. p. 9.

Dorocidaris papillata. Farran. 1913. Deep-water Ast., Oph. and Ech. West Coast Ireland. Fisheries Ireland. Sci. Invest. 1912. VI. p. 49.

Cidaris cidaris. Th. Mortensen. 1913. Ech. d. Mittelmeeres. p. 10.

Cidaris papillata. W. de Morgan. 1913. Echinod. coll. by the "Huxley" in the Bay of Biscay 1906. Journ. Mar. Biol. Ass. IX. p. 536.

Dorocidaris papillata. Nordgaard. 1915. Havstrømningerne og den norske marine Fauna. K. Norske Vid. Selsk. Skr. 1914. p. 4.

Dorocidaris papillata. Koehler. 1921. Faune de France. I. Échinod. p. 109.

Dorocidaris papillata. Koehler. 1921. Échinod. des dernières camp. de la Princ. Alice et de l'Hirondelle II. Bull. Inst. Océanogr. No. 396. p. 3.

Dorocidaris papillata. Koehler. 1922. Anomalies et irrégularités du test des Échin. Bull. Inst. Océanogr. No. 419. p. 22.

Dorocidaris papillata. Grieg. 1923. Echinodermata. Rep. Sci. Res. "Michael Sars" N. Atl. Exp. 1910. III. p. 40.

Dorocidaris papillata. Checchia-Rispoli. 1923. Gli Ech. del Pliocene di Anzio. Mem. p. servire alla descr. d. Carta Geol. d'Italia. IX. p. 10. Tav. I. 5; II. 9—11.

Dorocidaris papillata. Koehler. 1924. Anomalies, irrégularités et déformations du test chez les Échinides. Ann. Inst. Océanogr. I. V. p. 184, 287, 377. Pl. I. 2; VIII. 17—18; XV. 10, 14—15; XXIV. 5—10.

Dorocidaris papillata. Pawsey & Davis. 1924. Rep. Explor. Voyages to Lousy Bank and adjacent areas. Ministry of Agricult. & Fisheries. Fishery Investigations. Ser. II. Vol. VII. p. 15.

Cidaris cidaris. Th. Mortensen. 1924. Observ. on some Echinod. from the Trondhjem Fjord. Kgl. Norske Vid. Selsk. Skr. 1923. 3. p. 21.

Cidaris cidaris. Th. Mortensen. 1924. Echinodermer. Danmarks Fauna. 27. p. 173.

Cidaris cidaris. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 18.

Cidaris cidaris. Th. Mortensen. 1925. Échinod. du Maroc et du Mauretanie. Bull. Sci. nat. Maroc. V. p. 179.

Dorocidaris papillata. Le Danois. 1925. Rech. s. l. fonds chalutables des côtes de Tunisie. Ann. Stat. Océanogr. Salammbô. I. p. 20, 54.

Dorocidaris papillata. Bonnet. 1926. Rech. s. la constitution des plaques, la disposition des pores . . . chez les Éch. Reguliers. Ann. Inst. Océanogr. III. V. p. 249.

Dorocidaris papillata. Fr. Deutler. 1926. Üb. d. Wachstum d. Seeigel-Skelets. Zool. Jahrb. Abt. f. Anat. Bd. 48. p. 177.

Cidaris cidaris. Th. Mortensen. 1927. Handbook Ech. British Isles, p. 272.

Cidaris cidaris. Th. Mortensen. 1927. Sur les Échinides rec. par l'Exp. du "Travailleur" & du "Talisman". Arch. Mus. d'hist. nat. 6. Sér. II. p. 23.

Dorocidaris papillata. Koehler. 1927. Échinodermes des mers d'Europe. II. p. 16. Pl. XII. 19; XVIII. 15.

Cidaris cidaris. Jackson. 1927. Studies of Arbacia punctulata and allies and of non-pentamerous Echini. Mem. Boston Soc. Nat. Hist. VIII. p. 511, 537, 550.

NON:

Cidaris papillata. Parkinson. 1804—11. Organic Remains of a former world. III. Tav. I. 9. (= *Plegiocidaris coronata* (v. Schlotheim)).

Cidaris papillata. Mantell. 1822. Geology of Sussex, p. 189. Tav. XVII. 18.

Cidaris papillata. Reuss. 1846. Die Versteinerungen d. böhm. Kreideform. II. p. 57. Tav. XX. 22.

Cidaris papillata. A. Alth. 1850. Geogn.-palæontol. Beschr. d. Umgeb. v. Lemberg. Haidinger Naturw. Abhandl. Wien. 1850. p. 261. Tav. XIII. 11.

Cidaris papillata. R. Kner. 1850. Versteiner. d. Kreidemergels v. Lemberg u. seiner Umgebung. Ibid. p. 33.

Dorocidaris papillata. A. Agassiz. 1878. Rep. Res. "Blake". Bull. Mus. Comp. Zool. V. p. 185. Ibidem. VIII. 1880. p. 70 (*Cidaris abyssicola*, perhaps also *C. rugosa*).

Dorocidaris papillata. Studer. 1880. Echin. Corv. Gazelle. Monatsber. Ak. Berlin. p. 862. (= *Cidaris nuda*).

Dorocidaris papillata. A. Agassiz. 1883. "Blake" Echini. p. 12. (*Cidaris abyssicola* and, probably, *C. rugosa*).

Dorocidaris papillata. Verrill. 1883. Res. Explor. Albatross. Rep. U. S. Fish Comm. p. 551. (Probably *Cidaris abyssicola*).

Dorocidaris papillata. Rathbun. 1885. Rep. Ech. "Albatross". Proc. U. S. Nat. Mus. p. 84, 611. (*Cidaris abyssicola*, *C. rugosa*).

Dorocidaris papillata. Rathbun. 1886. Catal. Echini. Proc. U. S. Nat. Mus. p. 26. (*Cidaris abyssicola*, *C. rugosa*).

(?) *Dorocidaris papillata.* Simonelli. 1889. Terreni e fossili dell' Isola di Pianosa nell Mar Tirreno. Boll. Comm. Geol. Ital. (2). X. p. 228. (No certainty that it is not *Stylocidaris affinis*).

Cidaris papillata. Tommasi. 1892. Contrib. allo Studio della fauna Cretacea del Friuli. I. Fossili senoniani. Atti Ist. Veneto. 38. (7. Ser. II). p. 1115.

Dorocidaris papillata. Fr. Toula. 1893. Die Miocänablagerungen v. Kralitz in Mähren. Vorl. Mitteil. Ann. Hofmus. Wien. VIII. p. 291.

Dorocidaris papillata. Russo. 1893. (1894). Echinod. racc. nel Mar Rosso d. Uff. d. R. Marina Ital. Boll. Soc. Nat. Napoli. I. p. 159. (= *Prionocidaris baculosa*).

Dorocidaris papillata. Mazzetti. 1895. Catalogo Ech. foss. d. coll. Mazzetti esistente nella R. Univ. di Modena. Mem. Ac. Modena. 2. Ser. XI. p. 417.

(?) *Dorocidaris papillata.* Vinassa de Regny. 1897. Echinidi neogenici del Museo Parmense. Atti. Soc. Toscana. Memorie. XV. 1897. p. 144. (Only spines, not figured).

Dorocidaris papillata. H. L. Clark. 1900. Echinod. Porto Rico. Bull. U. S. Fish Comm. 1900 II., p. 252. (Probably *Stylocidaris affinis*).

Dorocidaris papillata. Agassiz. 1904. Panamic Deep-Sea Ech. p. 3. fig. 14. (Probably *Cidaris abyssicola*).

Cidaris papillata. Favre. 1905. Sur les fossiles crétacés au district de Slavianosserbsk du Gouv. Ekaterinoslaw. Trud. Kharkov Univ. (2) 38. p. 99. (No figures; only a little Russian text).

Dorocidaris papillata. B. Nelli. 1910. Fossili miocenici di Kasos nel mare Egeo. Boll. Soc. geol. Ital. 29. p. 371. (Probably *Stylocidaris affinis*).

Cidaris papillata. A. Frič. 1911. Illustr. Verzeichn. d. Petrof. d. Cenomanen Korycaner Schichten. Studien im Gebiete d. Böhm. Kreideform. Ergänzung zu Bd. I. Arch. Naturw. Landesdurchf. Böhmen. Prag. 15. p. 72. fig. 309.

Cidaris (*Dorocidaris*) *papillata.* Vadàsz. 1914. Magyaroszág mediterran tüskésbörni. Geol. Hungarica. I. 1914—15. p. 90. Pl. II. 16. (Only a spine, probably *Stylocidaris affinis*).

Dorocidaris papillata. K. Martin. 1919. Unsere palæozool. Kenntn. von Java. (Leiden). p. 53. (= *Stereocidaris* sp.).

Dorocidaris papillata. A. Bell. 1920. Notes on later Tertiary Invertebrata. Rep. Yorks. Phil. Soc. (Only the name; no proof at all of the correctness of the identification).

On account of the confounding of *Stylocidaris affinis* with *Cidaris cidaris* (*Dorocidaris papillata*) it is usually impossible to decide, in the case of most of the older literary references, whether they refer to one or the other, or both of these species. — Otherwise the list of literary references is, I think, fairly complete. A few preliminary reports are not included, as they do not give anything not found in the final reports. This applies to Steindachner, in Sitzber. Ak. Wiss. Wien, 1891. p. 446 (final reports by Marenzeller) and to Koehler's various preliminary notices of the Echinoderms of the "Hirondelle" and "Princesse Alice" (final reports in Res. Camp. Monaco, Fasc. XII. 1898 and Fasc. XXXIV. 1909). Further I have omitted reference to Brandt's "Prodromus" 1835 (p. 68), where *Cidarites hystrix* is mentioned among the species which he will refer to his (subgenus) *Phyllacanthus*, and to de Loriol's "Cat. Rais. Ech. Maurice" 1883 (Mém. Soc. Phys. Hist. nat. Genève XXVIII, p. 7) in which he proposes a new, widened diagnosis of *Rhabdocidaris* after which this genus would comprise also "*Cidaris hystrix*", and, indeed, most of the recent Cidarids.

As for the literature on fossil Echinoids, I have not included all the papers which give the name *Dorocidaris* (or *Cidaris*) *papillata* simply in lists of names, without any documents whatever; such statements are quite valueless, at least for our purpose. Those papers which permit a conclusion as to whether the "*Dorocidaris papillata*" mentioned is identical with the recent *Cidaris cidaris* or not are quoted, as completely as it has been possible. Unfortunately the unsatisfactory method adopted in later years by the "Zoological Record" of quoting in the main only the genera, not the species mentioned in the literature recorded, makes it probable that some papers of importance may have been overlooked.

The species was very carefully described by Wyv. Thomson (Op. cit. 1874), additional notes being given in the "Ingolf" Ech. p. 31. There is, however, reason for giving here a full description of it, as it may well be desirable once to have a complete, easily accessible description of the species which has, as a consequence of the historical development, become the prototype of recent Cidarids, as is expressed in its name — *Cidaris cidaris*. Though its specific characters

are now, on the whole, well known, a complete description comparable to other modern descriptions of Cidarids, does not exist in the previous literature.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	59 mm	40 mm	24 mm (40.7 % h.d.)	23 mm (39 % h.d.)	8—9	10—12	?
2	57 —	34 —	24 — (42.1 —)	20 — (35 —)	8—9	13—14	ca. 100 mm
3	56 —	40 —	22.5 — (40.1 —)	21 — (37.5 —)	8—9	11—12	?
4	55 —	39 —	21.5 — (39 —)	18.5 — (33.6 —)	8 (9)	13—14	?
5	42 —	28 —	20 — (47.6 —)	18 — (42.9 —)	6—7	11—13	80 —
6	41 —	30 —	19 — (46.3 —)	17 — (41.5 —)	6—7	12—13	90 —
7	38 —	26 —	19 — (50 —)	16 — (42.1 —)	6—7	11—12	90 —
8	36 —	21 —	16.5 — (45.8 —)	15.5 — (43 —)	6—7	13—14	90 —
9	35 —	24 —	17 — (48.6 —)	14.5 — (40.1 —)	6—7	12—14	90 —
10	22 —	14 —	11 — (50 —)	9 — (40.9 —)	5—6	10—11	75 —
11	19 —	12 —	9.5 — (50 —)	9 — (47.4 —)	5—6	10—12	58 —
12	53 —	42 —	25 — (47.1 —)	20.5 — (38.6 —)	8—9	11 (12)	ca. 80 —
13	49 —	32 —	20 — (40.8 —)	18 — (37 —)	7—8	13—14	95 —
14	47 —	35 —	21.5 — (45.7 —)	17 — (36.1 —)	8—9	11—12	?
15	47 —	33 —	21.5 — (45.7 —)	20 — (42.5 —)	7—8	13—15	82 —
16	44 —	33 —	20 — (45.4 —)	17 — (38.6 —)	7—8	12—13	96 —
17	29 —	19 —	13 — (45 —)	12 — (41.4 —)	6—7	10 (11)	58 —
18	23 —	14 —	11 — (48 —)	10.5 — (45.6 —)	6	10—11	49 —
19	18 —	11 —	9 — (50 —)	8.5 — (47 —)	5—6	9—10	50 —
20	49 —	35 —	23 — (47 —)	17 — (34.9 —)	7—8	13—14	?
21	45 —	30 —	21.5 — (47.7 —)	17.5 — (38.8 —)	7—8	13—14	?
22	42 —	26 —	19 — (45.2 —)	16 — (38.1 —)	6—7	14—15	?
23	39 —	25 —	16.5 — (42.3 —)	14 — (35.9 —)	6—7	13—14	63 —
24	38 —	24 —	18 — (47.4 —)	15 — (39.8 —)	6—7	13—15	?
25	31 —	18 —	15 — (48.4 —)	12 — (38.7 —)	6—7	13—14	?

Specimens 1—4 from the N. Atlantic (S. of Iceland, Faroe Isl.); specimens 5—11 from off S.W.Ireland; specimens 12—19 from the Mediterranean, specimens 20—25 from off the Canaries—Cape Verde, (var. *meridionalis*).

Test of very variable shape. It may be high, with almost vertical sides and flattened above and below, or almost spherical, or rather flattened. Clark (Op. cit. 1925, p. 18) mentions a specimen 63 mm h.d. of 59 mm v.d., thus unusually high. The circumference is usually circular, but it may sometimes be almost pentagonal. The peristomial edge is not incurved.

Ambulacra distinctly sinuate, ca. 20—22 % of width of the interambulacra. Interporiferous zone about twice the width of a porezone. Marginal series of tubercles regular, more rarely, in larger specimens (specimen 2), slightly irregular, especially in the adoral part; the tubercles are not very prominent, as a rule not quite contiguous, and often — in larger specimens, in the ambital region — separated by a series of small (pedicellaria-bearing) granules. Adradially to the marginal tubercle each plate bears, as a rule, in larger specimens, in the ambital part, a single secondary tubercle somewhat smaller than the marginal one, placed about in the middle of the plate; there is thus a fairly regular double series of secondary tubercles in the interpori-

ferous zone, which is otherwise rather bare, usually with a rather distinct, naked median line, which may be slightly sunken. More rarely there is some irregularity in this arrangement; there may be two smaller secondary tubercles instead of one, the regularity of the inner series being thus partly lost, or there may be an inner tubercle developed only on one side, in which case there is only a single median series of these inner tubercles. This may occur also in larger specimens, whereas it is the rule in smaller specimens, the inner tubercle being then found irregularly alternating on the two sides of the area. The pores are about equal-sized, separated only by a narrow wall, simply elevated, forming a fairly sharp crest; the ridge is rather prominent, sometimes rising into a prominent knob in the middle (Pl. LXXII. 22). The pores are relatively smaller in younger specimens, and the wall correspondingly broader. The pore-zones may be rather conspicuously sunk.

Interambulacra. The areoles are rather large and deep, well separated, at most the 2—4 proximalmost ones confluent, but even those latter may be distinctly separated. The subambital ones usually distinctly transverse-oval. The mamelon is rather large, but the boss rather low. Fairly distinct crenulation is sometimes observable on some of the uppermost tubercles in younger specimens. The "basal terrace" is somewhat unusually well marked. Edge of areoles rather conspicuously elevated. The scrobicular tubercles are generally not very conspicuous. Outside the scrobicular ring the plates closely covered with smaller tubercles which decrease gradually in size towards the adradial and the median edge. Usually there is a distinct, naked median and adradial part, both conspicuously sunk and both with rather distinct, fine, horizontal furrows (in which, as shown by Prouho, the cutaneous nerve-branches are lying). The admedian and the horizontal sutures may even, in younger specimens, be so much sunk as to form a rather distinct groove. An arrangement of the secondary tubercles in horizontal series is scarcely indicated. The median space is narrow, sometimes scarcely more than one third, rarely exceeding half the width of an areole.

Apical system. Oculars usually all exsert, but in large specimens Oc. V or V, I, and IV may be narrowly insert. More rarely all may be insert, as in a specimen of 33 mm h.d. from the Mediterranean. The madreporite is scarcely larger than the other genital plates[1]. Genital pores rather distant from the edge, sometimes almost in the middle of the plate; female genital pores not much larger than the male pores. The whole apical system rather closely covered with small tubercles of uniform size, generally leaving a fairly conspicuous bare edge to the plates. The periproct covered with a moderate number of plates, and usually quite flat. One specimen (spec. 2, Pl. XXXI. 1) is exceptional in having the periproct covered by numerous quite small plates, one small plate to each tubercle, inside the outer ring of periproctal plates.

Peristome distinctly smaller than the apical system, usually distinctly pentagonal; it is generally flat, but sometimes it is somewhat protruding. There are ca. 15—17 ambulacral plates

[1] Wyville Thomson ("Porcupine" Ech. p. 723) states the madreporite to be "much larger" than the other "ovarial" plates (as he names the genital plates). This does not hold good and is not seen either in his Pl. 59. 1.

in a series in larger specimens, the proximalmost of the pores showing sometimes a more or less irregular arrangement. The interradial plates form a fairly regular single or double series of 4—6 plates, which do not reach the mouth edge.

Primary spines generally rather long, ca. 2—2.5 times the h.d.; in younger specimens they are relatively longer, sometimes considerably exceeding 3 h.d. They are slender, cylindrical, ca. 3 mm thick at the base, tapering very gently; but they may also be more robust, up to 5—7 mm thick, and more distinctly tapering, being rather fusiform. The point is usually quite simple, but there may be a small terminal widening; sometimes, when the spines do not taper, they may be somewhat compressed at the point, or they end in a rather conspicuous widening (Pl. XXX. 3—4). The shaft is provided with fine, more or less sharp spinules arranged in ca. 12—16 regular, rather sharp, longitudinal ridges, which do not become more prominent towards the point. The general surface of the shaft in well perserved spines covered with a fine, spongy coat of anastomosing hairs, not so thick as to make the ridges indistinct. The collar is ca. 1—2 mm long, increasing somewhat in thickness towards the not very prominent milled ring. The furrows of the latter continue, more or less distinctly, some way down on the base. The neck of about the same length as the collar, not very distinctly limited. The oral primaries simple, slightly widened, usually with finely serrate edges and often with the end more or less fluted. The 3rd is transitional to the ambital spines.

Secondary spines. The scrobicular spines are 5—6 mm long, rather slender, tapering to a rounded point. They are generally somewhat excavated on the outer side, with a narrow median, sunken line. In specimen 2 they were, on the oral side of the test, rather thick and very conspicuously excavated. On the whole, the scrobicular spines do not form a very close mail around the base of the primary spines. The marginal ambulacral spines are about half the length of the scrobicular spines, usually very slender and pointed, slightly flattened in the basal part. The smaller secondary spines on the whole like the marginal ambulacral ones, slender and pointed, and usually erect. There is a very well developed glandular ampulla at the base of these spines.

Pedicellariæ. Both large and small globiferous usually present in fair numbers, the former especially on the apical system and the upper interambulacral plates. Tridentate pedicellariæ usually more numerous on the oral side of the test. For description and figures of the pedicellariæ may be referred to the "Ingolf" Ech. I. p. 33. Pl. IX. 3, 5, 7, 13—15, 20, 25, 27. — Spicules of the tubefeet of the usual Cidarid type. The intestinal wall is studded with small, irregular, fenestrated plates, as well represented by Wyv. Thomson (Op. cit. Pl. 59. 11). In the genital organs the spicules are in the main of the three-radiate type.

Colour. Preserved specimens are usually of a uniform cream-yellowish tint. The primary spines, when fresh, are faintly pinkish. According to Düben & Koren (Op. cit.) the living specimens are grey on the test, yellowish-gray on the primary spines, the point and the base being greenish ("verdi-gris"); also the secondary spines are greenish, the greenish colour being thus the dominant colour, which, however, usually disappears on preservation. Grube's state-

ment (Op. cit.) that the Mediterranean specimens are of a reddish colour probably refers to *Stylocidaris affinis*, as in general the older literature on "*Dorocidaris papillata*", as far as Mediterranean specimens are concerned, are unreliable because of the confusion of this species with *Stylocidaris affinis*[1]. Specimens from the Canary—Madeira—Cap Verde region appear to have in general a more redbrown tint; in some specimens the secondaries are of a uniform brownish-purplish tint, while the young, not yet fully formed primaries are more redbrown (see below, under var. *meridionalis*). The denuded test is white.

Biology. In the alimentary canal of some specimens from deeper water I have found bottom material, with Foraminifera (*Globigerina*), Sponges, Bryozoa, and some few shell fragments. According to Prouho it appears that Sponges and Gorgonids form its main food, but that it will feed on any sort of animals that it can find. (Cf. the interesting observations on the habit of this species recorded by Prouho, Op. cit. p. 12—23). — The larval development has been studied by Prouho, who found this species to have a typical *Echinopluteus*-larva (cf. Op. cit. Pl. XXV. 2; Th. Mortensen. Handbook Ech. Brit. Isles, fig. 152, p. 273). The genital pores develop at about a size of 15—16 mm h.d.[2]. The largest size recorded is 65 mm h.d. (Wyv. Thomson, Op. cit.[3]). The larger specimens do not have their spines much overgrown by foreign organisms, though barnacles, arenaceous Zoanthids or Serpulids are fairly commonly found on them; more rare are Scalpellids. Marenzeller (Anz. Akad. Wiss. Wien, 1895, p. 191) has described a Hermellid Polychæte, *Phalacrostemma cidariophilum*, which appears to have its special

[1] Clark states (The Cidaridæ, p. 209) that the colour may be brick-red on the apical system. I have not seen any other statements to this effect, and none of the specimens available to me show the apical system more intensely coloured than the rest of the test. May not this statement by Clark be due to a lapsus memoriæ, so that it was really meant for *Cid. abyssicola*, about which species — hitherto confused with *Cid. cidaris*, but here reinstalled into its specific rights by Clark himself — he states immediately above that "the abactinal system is sometimes quite red"?

[2] Agassiz (Rev. of Ech. p. 257) states that "the tubercles are not perforated in small specimens, and it is only long after all the specific characters (Pl. II. c. f. 8) are well developed, that the perforation appears". This statement is recalled by Süssbach & Breckner (Op. cit. p. 175), as also by Stefanini (Echinidi del Miocene medio dell'Emilia. I. Pal. Ital. XIV. 1908, p. 67), who thinks this supposed fact a proof that the imperforate tubercles of *Tylocidaris* are not so extraordinary a character as generally thought to be. Although I have no specimens so small (2.4 mm) as that figured by Agassiz (my smallest specimen is 7 mm h.d.), I venture to maintain that this statement by Agassiz must rest on an error, as it is not well imaginable that this species should differ so markedly from other Cidarids in a structure of such primary importance. It is true that the figure quoted by Agassiz shows the tubercles imperforate, but this very probably means simply that the figure is wrong, and that Agassiz made the statement after the figure, not after the specimen itself. — Needless to say that my youngest specimens, 7—9 mm h.d., have the tubercles perforate. It may be added here that a specimen of 5 mm h.d. of *Cidaris abyssicola* (— probably it is in reality a young specimen of this species, not of *Cid. cidaris*, which is represented in the said figure in the Rev. of Ech. —) has its primary tubercles all distinctly perforate, even the proximalmost ones. The figure 8 of Pl. II. c of the "Rev. of Ech." is stated to represent "the abactinal system of same", viz. the specimen fig. 7, which was 2.4 mm h.d. But here in fig. 8 the genital pores have appeared — thus this figure cannot have been drawn from the young specimen fig. 7, but must have been made from a specimen at least ca. 15 mm h.d.

[3] Checchia-Rispoli (Op. cit. 1923) mentions fragments of a test from the pliocene deposits of Anzio (Italy) which he reckons must have been not less than 75 mm h.d.

habitat on the spines of *Cidaris cidaris*, in the Mediterranean. A rather common feature is the presence of large tufts of ctenostome Bryozoans, attached to the point of the primary spines, as seen very beautifully on Pl. I. b of the "Revision of Ech.". — Parasites have not been recorded from this species. — Various anomalies have been recorded by Koehler (Op. cit. 1924) and Jackson (Op. cit. 1927). A curious case of a coronal plate lacking entirely the primary tubercle is shown in Pl. XXXI. 10. The peculiar character of the periproct of specimen 2, — a great number of very small plates (cf. p. 295) — I must regard as an individual anomaly. Stewart (Op. cit. 1880. p. 571) records to have "often" found 4-valved samples of the large globiferous pedicellariæ.

Variations. The very conspicuous differences to be observed in the shape of the primary spines, from the slender, cylindrical spines of the Mediterranean form, as represented in the beautiful figure Pl. I. b of the "Rev. of Ech." to the thick tapering, or non-tapering spines, as represented in Pls. XXX. 3—4 of the present work, may well lead to the suggestion that we might here have different varieties, if not separate species. It seems, however, impossible to distinguish these forms as varieties, still less as species, as no other characters can be found to combine specially with one or other sort of spines; specimens with the various types of spines may be found in one and the same haul.

If the character of the periproct in specimen 2 — a great number of very small plates (cf. p. 295), should prove to occur in a number of specimens, we might well regard this as a separate variety, or species, the more so as its low test and the thick and rather deeply excavate scrobicular spines on the oral side of the test, and the irregularity of the marginal ambulacral tubercles near the peristomial margin are also rather unusual characters. Had this specimen come from a less well known area of the ocean, I should probably have regarded it as representing a separate species. But as it comes from a very well known region of the N. Atlantic (S. of Ireland), we cannot venture to regard such a single specimen as representing a new species, which would in any case be very closely related to the common *Cidaris cidaris*, and accordingly we must regard it, for the present, as merely an individual aberration.

Var. **meridionalis** Mrtsn.

Pls. XXXI. 8—10; LXVII. 5; LXXII. 20—21.

Cidaris cidaris, var. *meridionalis*. Th. Mortensen. 1928. New Cidaridæ, p. 71.

The specimens from the region of the Bay of Biscay[1]—Canaries—Madeira differ from the typical form in the darker, brownish-purplish colour of the secondary and the young, not fully developed primary spines. There are also some other characters: the shape of the test is somewhat lower than usual in the typical form, and the sides not subvertical as is so often the case in the latter; but the difference is not at all constant, specimens of the same shape of test being found also among typical *C. cidaris*. The interporiferous zone of the ambulacra is somewhat more

[1] The "Talisman" took specimens of this form off the North Coast of Spain, 44° N. 8° W., 900—1000 m.

closely tuberculated than in the typical form, the inner tubercles being on the whole smaller and the miliary tubercles more developed than in the typical form; but in some other specimens from the same region ("Valdivia", St. 31) the interporiferous zone is scarcely different from that of the typical form (Pl. LXXII. 20—21). The primary spines appear to be on the whole somewhat shorter than in the typical form; I have not seen any longer than ca. 65 mm — but most of them are broken in the specimens examined. In the pedicellariæ I do not find any noteworthy differences; the small globiferous form may be very elongate so as to resemble, and hardly to be distinguished from the tridentate form; but this may be the case also in the typical *C. cidaris*. Thus the only more reliable character would seem to be the colour of the secondary spines; this difference may be rather conspicuous, though, in preserved specimens, sometimes more indistinct.

There may thus be some reason for distinguishing this form as a separate variety, but it is not so that all specimens from this region can be regarded as belonging to the variety. There are in the material collected by the "Travailleur" & "Talisman" perfectly typical *Cidaris cidaris* from off Cape Verde.

Occurrence. The species is known with certainty only from the North-Eastern Atlantic, from S. of Iceland and the Norwegian coasts, as far North as Bodö, to the Azores and Cape Verde. Further it occurs in the Mediterranean. The "Challenger" specimen from off St. Paul's rock, which Clark (Cat. Rec. Sea-Urch. Br. Mus. p. 18) maintains to be a true *Cidaris cidaris*, against his former suggestion (The Cidaridæ. p. 209) that it might prove to be *Cidaris rugosa*, I must, after having reexamined the specimen, regard as being a *Cidaris rugosa*. The species does not appear to occur in the Western part of the N. Atlantic, off the American coasts[1], the records of its occurrence there, and in the West Indies being probably all due to the former confusion of *Cid. abyssicola* and *rugosa* — not to speak of *Stylocidaris affinis* — with *Cid. cidaris*. Likewise the statements of the occurrence of this species outside the Atlantic, viz. at the Philippines ("Challenger" Ech.) and in the Red Sea (Russo, 1893) are due to confusion with other species (cf. "Ingolf" Ech. I. p. 35).

The bathymetrical distribution is ca. 50—2000 m.

The species has been recorded from various deposits, from the Pliocene to the Cretaceous period. While there is no reason to doubt the correctness of the identification as far as the Pliocene deposits are concerned (cf. especially Checchia-Rispoli, Op. cit. 1906, 1923, and Lambert, Op. cit. 1910), the identifications of specimens (i. e. isolated spines or plates) from older deposits are either quite uncertain or evidently erroneous. The latter is especially the case with the cretaceous remains referred to "*Dorocidaris papillata*" e. g. by Parkinson, Mantell, Reuss, Kner, Alth, Tommasi, Toula (cf. the literature list). Most of these statements refer to isolated

[1] Grieg's statement (Op. cit. 1921. p. 40) that it "occurs on the east as well as on the west side of the (North Atlantic) ocean" rests, as I am informed by him, on no new observations, but is due to his having overlooked the more recent statements in literature about this subject, and thus does not alter the fact that the species is not known with certainty to occur in the western part of the N. Atlantic.

spines which may well have some general resemblance to the spines of *Cidaris cidaris*, but which may equally well — or rather — belong to other species, e. g. of the genus *Stereocidaris*. To give definite statements of the occurrence of this (or other) recent species in the various older deposits on such poor evidences may well be said to be objectionable, leading, as it does, to conclusions which are either quite erroneous or, at least, not supported by facts. It is only fair to state that Reuss (Op. cit.) says about the spines in question that "es ungewiss ist ob sie wirklich dieser species angehören"; but then he ought not to have given the name "Cidaris papillata" without a question mark. — Of the spines figured by Frič (Op. cit.) as "*Dorocidaris papillata*" there is one short, crown-shaped, recalling the upper spines of a *Goniocidaris!* The "*Cidaris papillata*" of Parkinson (Op. cit.) is referred to by v. Schlotheim (Petrefactenkunde. 1820. p. 313) under his "*Echinites coronatus*" and thus has become the type of the later *Plegiocidaris coronata*. Special mention must be made of the record of "*Dorocidaris papillata*" from Miocene deposits of Java (Martin, Op. cit. 1919). The fact that the species and even the genus *Cidaris* on the whole, does not occur in the Indo-Pacific makes it a priori rather certain that the statement must rest on erroneous identification. Through the kind help of my friend Dr. H. Boschma, I have had the original material (two spine fragments) sent for examination. There is really a considerable general resemblance between these spine-fragments and typical *Cidaris cidaris*-spines, so that it was not so very unreasonable to refer them to the latter species, in view of the (false) statement by an authority like A. Agassiz of the species also now living in the East Indian Seas. However, there are several differences: the milled ring is scarcely at all indicated (quite distinct and fairly prominent in *C. cidaris*), the spinules scarcely form longitudinal ridges, and the spongy coat (— which is in places remarkably well preserved) coarser than in *C. cidaris*. As a matter of fact these spine fragments much more recall e. g. *Stereocidaris granularis* than *Cid. cidaris*. I will not definitely maintain that it belongs to the said *Stereocidaris*-species, the character of the spines alone being, in my opinion, too insufficient a basis for such important statement; but I think it rather probable that we have here an ancestor of some recent *Stereocidaris* of the Indo-Malayan region. And, above all, it may be said definitely that it is not *Cidaris cidaris* which we have represented in this Miocene deposit of Java.

Remarks. The discussion referred to above, under the genus *Cidaris* (p. 287) between Bather, H. L. Clark, and the present author in "Ann. Mag. Nat. Hist." has settled the question: which species is to be understood by Linnæus' *Echinus cidaris*. It is the present species, the only one that occurs off the Scandinavian coasts, and this species accordingly must be named *Cidaris cidaris* (L.) and becomes the type of the genus *Cidaris*. It is rather regrettable that the well known name *Dorocidaris papillata* cannot be preserved, but there is no help for it. We cannot even think of making the latter name a nomen conservandum, since we must have a genus *Cidaris* s. str., and according to the rules this is the only species which can come into consideration. To take the *Cidaris Mauri* of Rumphius as type of the genus *Cidaris*, as do Lambert & Thiéry, is out of question, partly because the species is really unrecognizable, partly because it is pre-Linnean.

As for the Mediterranean form *Cid. hystrix* Lamk., I do not see the possibility of distinguishing it from the Atlantic form, even as a variety. Perhaps observations on living specimens may disclose characters by which to distinguish the Mediterranean from the Atlantic form; but judging from the available preserved material I must regard them as identical. According to Wyville Thomson (Op. cit. p. 726) "frequently a single locality yields a complete series, including characteristic examples of both extremes" of the typical *Cid. cidaris* and *Cid. hystrix*.

Cidaris abyssicola (A. Agassiz).

Pls. XXXI. 11—14; XXXIII. 4.

Dorocidaris abyssicola. A. Agassiz. 1869. Prel. Rep. Echini and Starfishes dredged in deep water between Cuba and Florida. Bull. Mus. Comp. Zool. I. 9. p. 253.

Dorocidaris papillata. A. Agassiz. 1872—74. Rev. of Ech. p. 254. (partim) Pl. **I. 1—4; I. c. 29—33.**

Dorocidaris papillata. A. Agassiz. 1878. Rep. Res. Dredging of the "Blake". Rep. on the Echini. Bull. Mus. Comp. Zool. V. p. 185. — 1880. Ibid. Vol. VIII. p. 70.

Dorocidaris papillata. A. Agassiz. 1883. "Blake" Echini. p. 12.

Dorocidaris papillata. Verrill. 1883. Res. Explor. "Albatross". Ann. Rep. Comm. of Fish & Fisheries for 1883. p. 551.

Dorocidaris papillata. Rathbun. 1885. Rep. Ech. coll. by the "Albatross" in the Caribbean Sea and Gulf of Mexico. 1884. 1885. Proc. U. S. Nat. Mus. 1885. p. 84, 611.

Dorocidaris papillata. Rathbun. 1886. Catalogue of the coll. Rec. Echini in the U. S. Nat. Mus. — Ibidem, 1886. p. 261.

Dorocidaris abyssicola. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 34. Pl. IX. 14.

Dorocidaris abyssicola. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 7. Pl. **12. a. 1—5.**

Dorocidaris abyssicola. H. L. Clark. 1907. The Cidaridæ, p. 208.

Cidaris abyssicola. Th. Mortensen. 1909. Ech. deutsche Südpolar-Exp. p. 54.

Cidaris abyssicola, var. *teretispina.* Th. Mortensen. 1910. Some West Indian Echini. Bull. U. S. Nat. Mus. 74. p. 13. Pl. **VII. 1—2; VIII—X; XIV. 2—4; XV. 3—6, 9—11; XVI. 11; XVII. 2—3, 5, 9—11.**

Dorocidaris abyssicola. Lambert & Thiéry. 1910. Ess. nom. rais. p. 148.

Cidaris abyssicola. Jackson. 1912. Phylogeny of the Echini, p. 96, 100.

Cidaris abyssicola. H. L. Clark. 1918. Rep. on the Crinoidea and Echinoidea coll. by the Bahama Exp. Univ. of Iowa in 1893. Univ. of Iowa Monogr. Bull. Lab. Nat. Hist. VII. p. 17.

Cidaris abyssicola. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 17.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	70 mm	43 mm	27 mm (38.6 % h.d.)	21 mm (30 % h.d.)	7—8	14—16	85 mm
2	47 —	26 —	21 — (44.5 —)	18.5 — (39.9 —)	6—7	12—13	ca. 70 —
3	45 —	28 —	21 — (46.6 —)	18 — (40 —)	6—7	12—13	
4	35 —	23 —	17 — (48.6 —)	13 — (37.1 —)	6—7	13—(14)	ca. 55 —
5	27 —	16 —	13 — (48.1 —)	11.5 — (42.6 —)	6	12—14	ca. 30 —
6	27 —	16 —	14 — (51.9 —)	12 — (44.4 —)	5—6	11—13	44 —
7	24 —	14 —	13 — (54.2 —)	12 — (40 —)	5—6	10—11	32 —
8	21 —	11 —	11 — (52.4 —)	9.5 — (45.2 —)	5—6	11—12	32 —
9	16 —	9 —	7 — (43.8 —)	7.5 — (46.9 —)	5—6	9—11	18 —
10	9 —	5 —	5 — (55.5 —)	4.5 — (50 —)	4—5	7—8	16 —

Specimen 1 in the U. S. National Museum, the rest in the Copenhagen Museum.

Test. The shape of the test is rather low, generally flattened above and below, but not rarely gently rising towards the apex so as to be more spherical; the sides strongly arched. Circumference usually circular, but sometimes distinctly subpentagonal (cf. Th. Mortensen, Op. cit. 1910. Pl. X. 2).

Ambulacra slightly sinuate, ca. 21—24 % of width of interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles usually very regular; only in the largest specimen (spec. 1) some slight irregularities were observed. The tubercles are rather inconspicuous, usually not contiguous; adradially to the marginal tubercle each plate carries one, somewhat smaller, secondary tubercle a little below the middle of the plate, these inner tubercles forming regular vertical series. In specimen 1 there are mostly three inner tubercles on each plate, the two next to the marginal one placed one above the other and forming a fairly regular vertical series. At the lower edge of the plate one or more miliary granules are generally found; in larger specimens there may be a series of such granules below the marginal tubercle (cf. Th. Mortensen. Op. cit. 1910. Pl. XIV. 2—4). There is no distinct naked or sunken median space. The pores are rather small, equal-sized or the outer one slightly the larger; the wall is narrow, simply rounded, the ridge as a rule fairly prominent, rounded.

Interambulacra. Areoles of moderate size and depth, well separated, at most the two proximal ones confluent; those on the oral side more or less distinctly transverse-oval. In larger specimens the two upper areoles (tubercles) in one or both interambulacral series are usually rudimentary (Pl. XXXIII. 4). (This is not the case in larger specimens of *Cid. cidaris*). Tubercle rather small, the boss low; only very indistinct traces of crenulation observed, even in young specimens. Edge of areoles in general not much raised; scrobicular tubercles not very conspicuous. Outside the scrobicular ring the whole plate rather closely covered with secondary tubercles which decrease gradually in size towards the median line. As a rule there is no bare median or adradial space left, and the median line is only slightly sunken. Fine horizontal lines are seen on the admedian and adradial part of the plates, as in *Cid. cidaris*, though they are sometimes rather indistinct — as may also be the case in *Cid. cidaris*. The median space is about $^1/_2$—$^2/_3$ the width of an areole.

Apical system ca. 45—55 % h. d., in larger specimens (spec. 1) it may be somewhat smaller. Ocular plates generally all exsert, rarely all narrowly insert (cf. Jackson, Op. cit. p. 96). All the plates rather closely covered with small tubercles of fairly uniform size, leaving a more or less conspicuous bare edge. Genital pores small, rather nearer the middle than the outer edge of the genital plates. Periproct with a moderate number of plates.

Peristome ca. 37—45 % h. d., or in larger specimens (spec. 1) somewhat smaller, in young specimens (spec. 9—10) relatively larger. There are 12—14 ambulacral plates in a series in larger specimens. It is more or less distinctly pentagonal as in *Cid. cidaris*, usually quite flat.

Primary spines scarcely exceeding 1.5 h. d., more or less distinctly fusiform or quite cylindrical, ending with a slight widening in the point (Pl. XXXI. 14) or in a simple, obtuse point.

They are of rather varying thickness, from fairly stout, ca. 4 mm thick, to rather slender, ca. 1.5—2 mm thick (in adult specimens — var. *teretispina*). The shaft is very smooth, though not shining; in fresh samples very low spinules or warts are observable, arranged in regular series, ca. 18—24 in number, which do not form prominent ridges, not even towards the point of the spine. The surface between the wart-series usually without a hair-covering, but on closer inspection there may be seen some very low, simple hairs (Op. cit. 1910. Pl. XVI. 11) in well preserved, not worn spines; the usual spongy coat, formed by the anastomosing hairs, may be observed on the spines of the oral side in younger specimens, these spines being somewhat more coarsely thorny. In the basal part the surface becomes gradually more shining, forming a not well marked neck. The collar is ca. 2 mm long, increasing in thickness towards the not very prominent milled ring. — The oral primaries are scarcely widened, but generally with fairly distinct lateral serrations. The third is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 4 mm long, tapering to a rounded point; they are flattened, sometimes rather distinctly concave on the outer side. Marginal ambulacral spines about half that length, more slender, pointed, as are also the smaller spines on the upper surface of the test. Glandular ampullæ on the secondary spines not distinct in the specimens available, but this is evidently due to poor preservation, as I have formerly (Op. cit. 1910. p. 15) found such ampullæ on material from the U. S. National Museum.

Pedicellariæ. Concerning the pedicellariæ it may suffice to refer to the description and figures given in my memoir "On some West Indian Echini" (1910, p. 15. Pl. XVII. 2, 3, 5, 8—10). Spicules of the alimentary canal, as in *Cid. cidaris*, small irregular plates, though more or less distinctly of the three-radiate type. In the genital organs few, large, but slender, three-radiate spicules.

Colour. According to H. L. Clark (The Cidaridæ, p. 209) the colour of the test is pale brown or yellowish, the apical system sometimes quite red[1]. In the specimens available to me there is no indication of the apical system being of a darker colour. The primary spines are a more or less pure white, rarely with a faint pinkish tint; the collar is often somewhat darker and distinctly marked off from the shaft by a darker ring. There is sometimes an indication of a darker, greenish-olive midline on the scrobicular spines. The denuded test is a pure white.

Biology. In the alimentary canal I have found only bottom-material with Foraminifera (Globigerina etc.) and Pteropods, fragments of shells and sponge-spicules. The genital pores have not appeared at a size of 9 mm h.d.; at the next size represented in my material, 16 mm h.d., they are well developed. The small size of the genital openings indicates a small size of the eggs, so that the species may probably have a pelagic larva like *Cid. cidaris*. The largest size recorded

[1] In the "Rev. of Ech." (p. 255) Agassiz states that according to information from Pourtalès the live specimens are "more or less straw color, with a tendency to a dull greenish-brown color, quite well developed in some of the specimens". As Agassiz here comprises under his "*Dorocidaris papillata*" both *Cid. abyssicola*, *rugosa* and *Stylocidaris affinis*, it is not safe to refer the above statement definitely to *Cid. abyssicola*, since at least both *abyssicola* and *Stylocidaris affinis* are common on the Pourtalès Plateau (cf. H. L. Clark. Rep. on the Crin. and Echin. coll. by the Bahama Exp. Univ. of Iowa in 1893. Bull. Lab. Hist. Iowa. VII. 5. 1918, p. 19).

is 70 mm h.d. (spec. 1). The older specimens may have their primary spines rather much overgrown with worm-tubes composed of Foraminifera and grains of sand. Also barnacles are rather common on the spines. — Parasites are not known to infest this species. No anomalies have been recorded; I have, however, found one specimen, 35 mm h.d., with three pores in genitals 1—2, and 2 pores in genitals 3—5, placed obliquely to each other (Fig. 89).

Variations. In the memoir "On some West Indian Echini" 1910 (p. 13—16) I established a separate variety, *teretispina* Mrtsn., for the specimens with cylindrical spines, the specimens with fusiform spines being regarded as the typical form. According to H. L. Clark (Op. cit. 1918. p. 18) all transitional forms exist, which fact makes it impossible to regard the form with the cylindrical spines as a separate variety. However — as Clark agrees — the difference between the two types is very striking. It may be added that the small terminal widening of the primaries seems to be characteristic of the form with the fusiform spines[1]; also the colour, in the preserved specimens, is, on the whole, more pure white in this form than in the one with the cylindrical spines. It would, therefore, seem desirable still to maintain the form with the cylindrical spines as a separate variety, even though there are some specimens which are intermediate between the variety and the typical form.

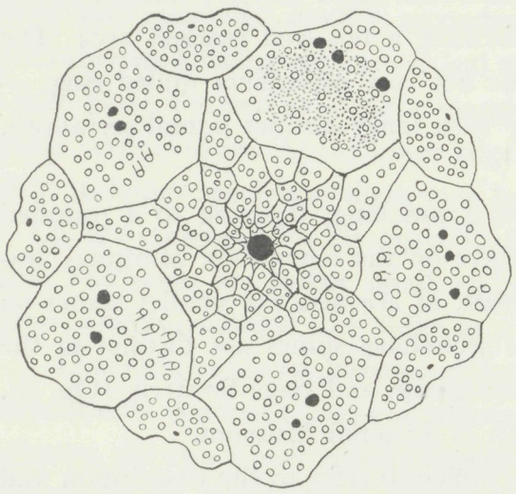


Fig. 89. Apical system of *Cidaris abyssicola* (A. Ag.), with abnormal number of genital pores. × 3.5.

Occurrence. Known only from off the American East coast, from S. of Martha's Vineyard to the West Indies (St. Lucia). It is usually found in depths of ca. 200—400 m., but it has been recorded (H. L. Clark, Op. cit. 1918) from as small depths as 32 m. Probably it goes a good deal deeper down than 400 m., but on account of the former confusion with *Cid. cidaris* and *Stylocidaris affinis*, the older records of the occurrence of "*Dorocidaris papillata*" in the West Indian seas (from the "Blake" and the "Albatross"), some of which give considerably greater depths, are not with certainty referable to the present species.

Remarks. This species is so easily distinguished from all the other species of the genus *Cidaris*, especially by its very smooth primary spines, that its specific value is quite beyond doubt, in spite of the fact that it has for so long a time been regarded as identical with *Cid. cidaris*. As a matter of fact, this species stands rather apart from the other species of the genus. — Larger specimens with the upper areoles (tubercles) rudimentary may recall *Stereocidaris japonicus* in general appearance. Though quite superficial, this resemblance is interesting as a typical instance of the development of a feature like the rudimentary condition of the upper tubercles along different and entirely independent lines.

[1] It is, therefore, rather unfortunate when H. L. Clark (The Cidaridæ, p. 208) in the key to the species of *Dorocidaris* expressly states that the primary spines of *abyssicola* are not flaring at the tip.

Cidaris rugosa (H. L. Clark).

Pl. XXX. 1—2.

Dorocidaris (Cidaris) papillata. A. Agassiz. 1881. "Chall." Ech. p. 38 (partim).
Dorocidaris rugosa. H. L. Clark. 1907. The Cidaridæ, p. 210. Pl. **IV—V; VII. 5—8.**
Cidaris rugosa. Th. Mortensen. 1909. Ech. Deutsche Südp. Exp. p. 54.
Cidaris rugosa. Th. Mortensen. 1910. On Some W. Indian Echin. p. 16. Pl. **XIV. 11; XVI. 1.**
Dorocidaris rugosa. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Cidaris rugosa. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 19.

The description of this species given by Clark (Op. cit.), together with the additional information given in my paper of 1910, make it superfluous to give a full description of it here again. Only a few remarks may be added, based on the study of the specimens in the collections of the Museum of Comp. Zoology and the U. S. National Museum. Further a series of measurements may be given here, for comparison with the other species, no such measurements having hitherto been published.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	61 mm	42 mm	27.5 mm (45 % h.d.)	22 mm (36 % h.d.)	8	12—14	74 mm
2	43 —	28 —	21 — (48.8 —)	17 — (39.5 —)	6—7	11—12	68 —
3	40 —	25 —	20 — (50 —)	17 — (42.5 —)	7	13—14	77 —
4	38 —	22 —	17 — (47.4 —)	15 — (42.1 —)	7—8	12—13	
5	35 —	25 —	15.5 — (44.3 —)	15.5 — (44.3 —)	6—7	13—14	66 —
6	34 —	21 —	16 — (47 —)	15 — (44.1 —)	6 (7)	13—14	
7	31 —	19.5 —	16 — (51.6 —)	13 — (42 —)	6	12—13	
8	25 —	15 —	12.5 — (50 —)	12 — (48 —)	5—6	12	53 —
9	23 —	13.5 —	11.5 — (50 —)	10 — (43.5 —)	5—6	12	52 —
10	15 —	9 —	7 — (46.6 —)	7 — (46.6 —)	5—6	9—10	30 —

Specimens 1—2 in the U. S. National Museum, spec. 3—10 in the Museum of Comp. Zoology. Specimen 3 is the holotype, spec. 5 and 8 paratypes.

In the larger specimens the interporiferous zone of the ambulacra is wholly filled up with tubercles, 3—5 on each plate, showing no distinct serial arrangement; in younger specimens there is only one inner tubercle on each plate, but even so the interporiferous zone is completely filled, not bare as in *Cid. cidaris*, and while in the latter the inner tubercles are irregularly developed in younger specimens, occurring in irregular alternation, only on one or the other side, so as to form a single median line, we have here a regular double inner series already in specimens little more than 20 mm h.d. The marginal series is quite regular, the tubercles almost contiguous. The pore-structure as in the other species. Slight traces of crenulation may be seen on the upper primary tubercles. Only the 2—3 proximal areoles confluent, and only these slightly transverse-oval. Scrobicular tubercles rather conspicuous (cf. Clark, The Cidaridæ, Pl. VII. 7—8). No naked median space, and no distinct horizontal lines as so characteristic of *Cid. cidaris*. Median inter-ambulacral space ca. $^1/_2$ the width of an areole, or slightly more. In the apical system it is a

noteworthy, but not constant feature that the ocular pore is placed rather far from the edge, sometimes even near the middle of the plate, surrounded by a more or less conspicuous elevated wall. The genital pores have just appeared in the specimen of 15 mm h.d.

Primary spines sometimes very conspicuously fusiform (Pl. XXX. 2); in larger specimens they may be distinctly compressed in the distal part. The surface of the shaft, between the rather prominent series of spinules, covered with a very well developed spongy coat of anastomosing hairs, much as in *C. cidaris*. The collar is ca. 1 mm long, slightly increasing in thickness towards the not very prominent milled ring. The neck is very well marked, about twice the length of the collar. — The secondary spines ca. 4 mm long, somewhat convex, not excavate on the outer surface; they taper gently towards the simply rounded point. Marginal ambulacral spines ca. 2 mm long, rather coarse, scarcely flattened, obtusely pointed. Smaller secondary spines of the same shape.

The primary spines sometimes incrusted by an arenaceous Zoanthid. A specimen from off Porto Rico ("Albatross" 6070) in the U. S. National Museum carries a number of Crepidulas on its spines, which latter are rather more slender than usual (Pl. XXX. 1).

Occurrence. The species is known only from Western Atlantic, from 32° N. to Barbados and St. Paul's rock[1], in depths of ca. 130—540 m. It appears to be more common in the West Indies, in ca. 260—540 m.

Remarks. This species is very closely related to the East Atlantic *Cidaris cidaris*, of which it is, as said by Clark, "clearly the representative" in the Western Atlantic. If the areas of distribution of the two species are found to overlap, it may perhaps be doubtful, whether it will be possible always to distinguish the two species with certainty.

H. L. Clark (Op. cit. 1907, p. 210) records having found one specimen of this species in the U. S. National Museum, labelled by me *Stereocidaris ingolfiana*; he finds this "a very natural mistake, as small specimens of the two species are very difficult to distinguish". I cannot agree that this is a very natural mistake. The specimen in question is the one figured in Pl. XXX. 2, 35 mm h.d., thus not a young one, and it is so different from *Stereocidaris ingolfiana* that I cannot explain the mistake except by a miswriting or a misplacing of labels.

[1] This refers to the specimen of the "Challenger" from that locality identified by Agassiz as *Dorocidaris papillata*, and also recently maintained by Clark (Cat. Rec. Sea-Urch. Br. Mus. p. 18) to belong to the said species, i. e *Cidaris cidaris*. On a reexamination of the specimen in the British Museum I find it to agree much better with *Cid. rugosa* in the characters of both test and spines, so that I can have no doubt that it really belongs to the latter species, as it was to be expected from the geographical position of the said locality.

Cidaris Blakei (A. Agassiz).

Pls. XXXII. 1—6; LXXI. 16; LXXXII. 37—40.

Dorocidaris Blakei. A. Agassiz. 1878. Rep. Res. Dredging of the "Blake". Rep. on the Echini. Bull. Mus. Comp. Zool. V. p. 185. Pl. **IV.**

Dorocidaris Blakei. A. Agassiz. 1883. "Blake" Echini. p. 10. Pl. **I; II. 1—15** (?**16**).

Dorocidaris Blakei. Rathbun. 1885. Rep. Ech. coll. by the "Albatross" 1884. Proc. U. S. Nat. Mus. 1885, p. 84.

Dorocidaris Blakei. Rathbun. 1886. Cat. Ech. U. S. Nat. Mus. Ibidem. 1886. p. 261.

Dorocidaris Blakei. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 16, 28. Pl. **IX. 16.**

Dorocidaris Blakei. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 9. Pl. 12. b. 4—6.

Dorocidaris Blakei. H. L. Clark. 1907. The Cidaridæ, p. 209.

Cidaris Blakei. Th. Mortensen. 1909. Ech. Deutsche Südp. Exp. p. 54.

Dorocidaris Blakei. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

Cidaris Blakei. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 18.

NON: *Dorocidaris blakei*. Del Bue. 1900. Contributo alla conoscenza dei terreni miocenici di Castelnuovo nei Monti. Riv. ital. di Paleontol. VI. p. 129. (cf. p. 310).

Dorocidaris blakei. Nutting. 1895. Narrative of the Bahama Exp. Univ. Iowa. Bull. Univ. Iowa Lab. Nat. Hist. III. p. 173 (= *Cid. abyssicola* (A. Agassiz)).

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
36 mm	22 mm	19 mm (52.8 % h.d.)	14.5 mm (40 % h.d.)	7	13—15	47 mm
34 —	21 —	16.5 — (48.5 —)	13.5 — (40 —)	7—8	11—12	48 —
30 —	19 —	15 — (50 —)	12 — (40 —)	7—8	12—13	46 —
25 —	15 —	12 — (48 —)	11 — (44.4 —)	6	12—13	46 —
21 —	18 —	10 — (47.5 —)	9 — (43 —)	6—7	11—12	54 —
18 —	10.5 —	9 — (50 —)	8 — (44.4 —)	5—6	10—11	48 —

All the specimens measured are in the Museum of Comp. Zoology.

Test only slightly flattened above and below, sometimes not at all so; more or less incurved at the peristomial edge. Sides much arched. Circumference regular, round.

Ambulacra rather distinctly sinuate, ca. 21—23 % the width of the interambulacra. Interporiferous zone about twice the width of pore zone[1]. Marginal series of tubercles very regular; the tubercles are small, not contiguous. Adradially to the marginal tubercle there are, though not constantly, two tubercles forming thus four more or less regular, vertical series of inner tubercles (Pl. LXXI. 16). In smaller specimens there are only two series of inner tubercles (cf. Th. Mortensen. "On some West Indian Echini". 1910. Pl. XIV. 7). There is no naked or sunk median space. The pores as in the other *Cidaris*-species.

Interambulacra. Areoles rather deep, the 3—4 proximal ones more or less confluent, the subambital ones fairly distinctly transverse-oval. The boss low, the mamelon rather small; no traces of crenulation observed. Edge of areoles not raised, the scrobicular tubercles fairly

[1] Agassiz's statement that the pore zone is about as broad as the interporiferous zone, in contradistinction to "*Dorocidaris papillata*" where it is narrower, does not hold good; this also appears from H. L. Clark's statement (Op. cit. 1907) that the poriferous zones are narrow, only ca. 20 % of the ambulacra.

conspicuous, though low. Outside the scrobicular ring the plates rather closely covered by uniform, small tubercles, those nearest the scrobicular tubercles being only very slightly the larger. There is a faint indication of these tubercles being arranged in horizontal rows, separated by fine lines. No naked or sunk median or adradial part. On the adradial side of the areole there is room for only quite few secondary tubercles. The median interambulacral space narrow; only about half the width of an areole.

Apical system about half the h.d. Oculars all rather widely exsert; the ocular pore surrounded by a fairly distinct elevated wall. Genital pores small, somewhat distant from the outer edge of the plate. The whole apical system rather closely covered by small tubercles; only along the inner edge of the genital plates and the periproctal plates a few somewhat larger tubercles (Fig. 90). Only an inconspicuous bare space along the inner edge of the genital plates. Periproct with fairly numerous plates, usually slightly elevated.

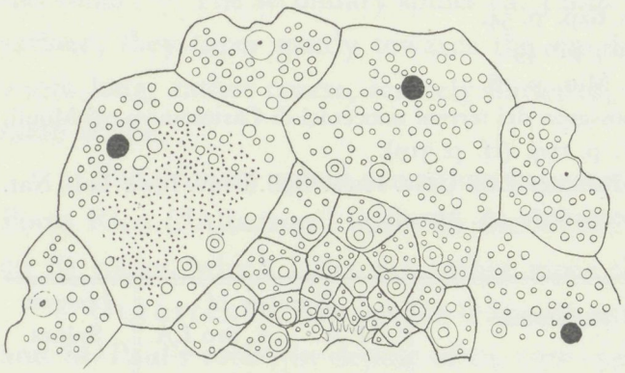


Fig. 90. Part of apical system of *Cidaris Blakei* (A. Ag.). × 6.

Peristome distinctly smaller than apical system, flat, rather distinctly pentagonal. There are 12—14 ambulacral plates in a series in the larger specimens, 5—6 interradial plates in a more or less regular series, not reaching quite to the mouth edge.

Primary spines. The upper primaries often compressed and widened, even to an extraordinary degree, so as to become quite fan-shaped; the widening stands in the vertical plane. All degrees of widening occur (Pl. XXXII. 1—6); some specimens even show no widening at all, or merely a slight compression of the distal part of the upper spines. The ambital spines are simply cylindrical, tapering gently to a simple point. The shaft is set with rather coarse spinules, arranged more or less distinctly in ca. 16—18 longitudinal series, but not forming prominent ridges. In the widened part the series become more numerous, new series being intercalated as the widening proceeds. The spinules, however, become more and more obsolete, the widened part thus being almost smooth distally. The surface of the shaft otherwise covered with the usual spongy coat of anastomosing hairs; in the distal widened part of the spines the hairs gradually become more simple or quite disappear. As in the other recent species with similarly widened spines, *Notocidaris platyacantha*, the layer of the radiating septa is much reduced in the widened part, whereas the central core occupies the central part in undiminished width throughout the whole flat lamina. The collar is ca. 1—2 mm long, increasing slightly in thickness towards the not very prominent milled ring. The neck is very well marked, shining, a little longer than the collar. — The oral primaries are slender, smooth, slightly flattened, with the edges fairly distinctly serrate. The fourth—fifth transitional to the ambital spines. (An excellent representation of the various shapes of the primary spines is given in Pl. II. 3—15 of the "Blake Echini").

Secondary spines. The scrobicular spines are ca. 5 mm long, flattened and slightly concave on the outer surface, gently narrowing towards the rounded point. The marginal ambulacral spines ca. 2 mm long, also distinctly flattened, pointed. The miliary spines very slender, setaceous. No glandular ampullæ were to be observed on the single alcoholic specimen examined.

Pedicellariæ. The large globiferous form fairly numerous, of the typical shape (Pl. LXXXII. 37; cf. also "Ingolf" Ech. Pl. IX. 16). I have not seen any samples with the opening so elongate as shown in Pl. 12. b. 6 of Agassiz & Clark's Hawaiian Ech. Cidaridæ. The small globiferous form remarkably rare and small (Pl. LXXXII. 38), whereas the tridentate pedicellariæ are numerous, in all sizes, up to ca. 2 mm length of head. It has much the appearance of the tridentate pedicellariæ having here taken over the rôle of the small, globiferous pedicellariæ. They are in general very slender, only the larger ones with a slight indication of serrate crests at the base of the blade (Pl. LXXXII. 39—40). The larger samples may, however, be somewhat more coarse than shown in these figures. — Spicules of tubefeet of the usual type.

Colour. According to Agassiz the colour of the living specimens is a brilliant vermilion; also the dried specimens may still show distinct traces of red. It cannot be seen from Agassiz's description whether also the primary spines are red in the living specimens; in the preserved specimens they are white or whitish, only the collar may be more brownish, generally limited against the shaft by a narrow darker ring. The denuded test is white.

Biology. On seeing the extraordinary, fanshaped spines of a specimen like the one represented in Pl. XXXII. 1 one is naturally led to inquire whether these spines can have any special function relating to the biology of the animal. It is at least out of question that they could be used for swimming by the animal; the muscles of these spines are in no way more developed than those of the normal, cylindrical spines. Anybody, who has seen the slow movements of the spines of a living Cidarid, will feel quite convinced that these spines can have no function relating to the way of moving of the animal. Whether they have any other function is hard to say without direct observations of the living animals; but it is most probable that they have no special function — as is also apparent from the fact that there is such an extraordinary variation in the development of these spines, many specimens showing no traces at all of such widening. — Another thing is that these fanshaped spines serve as a support to a number of foreign organisms, especially Serpulids, as seen on the beautiful figures on Pl. I of the "Blake" Echini. A specimen in the U. S. National Museum has the widened spines covered by thick layers of a sponge. Also barnacles may occur on the spines, and an arenaceous Zoanthid may sometimes invest the simpler spines completely.

Occurrence. The species is known only from the West Indies, from Havana to Barbados, in 315—420 m.

Remarks. As pointed out by Agassiz, the extraordinary shape of some of the upper spines of this species recall to a striking degree that of some fossil forms of the genus *Rhabdocidaris*. Again in the recent, antarctic *Notocidaris platyacantha* (H. L. Clark) we have a quite

similar form of spines. The fact that this shape of spines has thus developed independently in three different groups of Cidarids[1] proves, as justly emphasized by Agassiz, that we cannot rely too confidently on the identical shape of the spines as indicating natural relationship; especially we must be cautious in referring fossil species, known from isolated spines alone, to the same genus for the reason of a more or less pronounced similarity of the spines. (Cf. e. g. the genera *Balanocidaris* (p. 483), and *Cyathocidaris* (p. 484).

From the other species of the genus *Cidaris* this species is very easily distinguished by its more or less fanshaped upper spines and by the much finer interambulacral secondary tubercles and almost setaceous secondary or miliary spines. This latter character, of course, becomes the more important in such cases where none of the primary spines are widened. Also the colour of the living specimens appears to differ markedly from that of the other species. The difference, pointed out by Clark, that the apical system is larger than in the other species, does not hold good, as seen by the measurements given here for the various species. Likewise the characters pointed out by Agassiz ("Blake" Ech. p. 11) as distinguishing this species from "*Dorocidaris papillata*": a smaller number of interambulacral plates, broader poriferous zones, a smaller periproct, are either unreliable or erroneous.

The record by Del Bue (Op. cit.) of the occurrence of this species in the Miocene deposits of Italy is rather startling, particularly in view of the fact that it appears now to be confined to the West Indies. Del Bue gives only the name in a list, but he refers to V. Simonelli. "Fossili tortoniani di Castelnuovo ne' Monti" (Riv. Ital. di Pal. II. 1896, p. 257) who mentions, but does not figure, spines which he cannot distinguish from *C. blakei*. Similar spines were described as *Rabdocidaris* (sic!) *Rosavendai* n. f., by C. Airaghi in his "Echinidi Terziari del Piemonte e della Liguria" (Pal. Ital. VII. 1901 p. 171. Tav. XIX. 34—40) who recognizes their great resemblance to those of *Cid. blakei*, but finds that they must be kept distinct from the latter on account of their larger size and thickness as well as their finer ornamentation. Also their resemblance to *Rhabdocidaris remus* Desor is pointed out. — Vinassa de Regny (Echinidi neogenici del Museo Parmense. Atti Soc. Toscana. Memorie. XV. 1897. p. 146) also mentions under the name *Dorocidaris* cf. *Blakei* Al. Ag. plates and spines identical with those mentioned by Simonelli (Op. cit.).

It is undeniable that there is a considerable resemblance between the said fossil forms (to which may be added *Cidaris oxyrine* Meneghini) and *Cid. blakei*. Though there is no proof at all that the fossils were really identical with the recent *C. blakei*, it seems very probable that they are really nearly related, and that formerly such forms were distributed all over the Atlantic from the Mediterranean to the West Indies, in which latter region alone one of their descendants has survived til recent times.

[1] Also in the genus *Phymosoma* similar widened spines occur.

Cidaris nuda (Mrtsn.).

Pls. XXXIII. 5—8; LXXI. 14.

Dorocidaris papillata. Studer. 1880. Übers. Ech. "Gazelle". Monatsber. Akad. Berlin. 1880. p. 862.
Dorocidaris nuda. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 171. Fig. 9. — II. p. 7.
Dorocidaris nuda. H. L. Clark. 1907. The Cidaridæ, p. 209.
Cidaris nuda. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 43. Taf. **VII, 1, 6, 8; X, 13; XI, 8; XIII, 11; XV, 2, 4, 7, 14.**
Cidaris nuda. Th. Mortensen. 1927. Sur les Ech. du "Travailleur" et du "Talisman". Arch. Mus. d'hist. nat. Paris. 6. Sér. II. p. 23.

The examination of the three specimens from the Expedition of the "Travailleur" and the "Talisman" in the Paris Museum enables me to give some additions to the description, given in 1909 (Op. cit.), based on the type specimen in the Berlin Museum. The measurements of the three specimens are as follows:

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	22.5 mm	13 mm	11 mm (48.8 % h.d.)	10 mm (44.4 % h.d.)	6—7	9—10	38 mm
2	14 —	7.5 —	6.5 — (46.4 —)	6 — (43 —)	5—6	8—9	31 —
3	10 —	5 —	5 — (50 —)	5 — (50 —)	5	7—8	21 —

In specimen 2 the inner ambulacral tubercles are not yet regularly developed, occurring only at the ambitus and only on one side; in the smallest specimen they are still entirely absent. The pore structure is that typical of *Cidaris*. — The upper primary interambulacral tubercles are rather distinctly crenulate; the boss is fairly large. There are somewhat unusually distinct radiating impressions in the ambital areoles (in specimen 1). The genital pores have appeared in specimen 2, but not yet in specimen 3. They are, in specimen 1, somewhat nearer to the centre of the plate than in the type specimen (cf. Taf. XI. 8, Op. cit. 1909). It appears that there is a fairly well developed genital papilla; the skin covering the genital opening is dark, like the secondary spines, which makes the pores very conspicuous against the light colour of the plate itself. In specimen 1 there are 10 peristomial ambulacral plates in a series, 4—5 interradial plates in a single or double series.

Concerning the spines it may be added that the collar is ca. 1—1.5 mm long, slightly thickening towards the inconspicuous milled ring. The neck is well marked, about the same length as the collar. In specimen 1 the longitudinal ridges are rather distinctly serrate, in the two smaller specimens almost perfectly smooth. As there are no glandular ampullæ observable on the secondary spines of any of the three specimens, it seems that these ampullæ are really lacking in the present species.

There is a tinge of green colour on the apical system and the upper part of the test in these specimens, the test being thus not pure white as in the type specimen. The primary spines

of the two smaller specimens are of a very light pinkish tint, those of the largest specimen more purplish, the neck and collar being of the same colour as the shaft.

The largest specimen shows evident signs of having been attacked by some Gastropod. Its primary spines are rather much overgrown by Polytrema.

The species is still known to occur only in the Cape Verde region, in depths of ca. 70—450 m.; the depth 1550 m. given in my report on the Echinoids of the "Travailleur" & "Talisman" is probably erroneous. The label says: Cap Vert, 150—275 m., but the rest cannot be made out with certainty.

The examination of these specimens has served to emphasize the distinctness of this species, although it is seen that there is no difference in the size of the apical system between this and the other species of this genus, as the type specimen seemed to indicate. The main character distinguishing this species at a glance from the other species of *Cidaris* is the colour of the spines, both primary and secondary. Another character of importance is the more conspicuous crenulation of the upper primary tubercles; some noteworthy differences in the pedicellariæ were pointed out in the original description.

Genus **Calocidaris** H. L. Clark.

H. L. Clark. 1907. The Cidaridæ, p. 211.

Differs from the genus *Cidaris* only in the character of the primary spines, which are cylindrical, perfectly smooth and shining, without the slightest trace of hairs. The characters of the test, secondary spines and pedicellariæ like those of the genus *Cidaris*.

Genotype and only known species: *Dorocidaris micans* Mrtsn.

Although the author of the genus has himself later on dropped it as a synonym only of *Cidaris*, I think the character of its primary spines so important that the genus *Calocidaris* should be regarded as valid. It is a parallel to *Homalocidaris* in the group of the *Ctenocidarina*, and an interesting document of the fact that this remarkable structure of the primary spines has developed separately along different lines in two quite different groups.

Calocidaris micans (Mrtsn.).

Porocidaris Sharreri. A. Agassiz. 1883. "Blake" Echini, p. 12 (partim); Pl. **IV. 1—2.**
Dorocodaris (?) *micans.* Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 28. Pl. **IX, 26; XI, 28;** II. 1907. p. 9—10.
Cidaris (?) *micans.* Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 101.
Calocidaris micans. H. L. Clark. 1907. The Cidaridæ, p. 211. Pl. **III.**
Calocidaris micans. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 54.
Calocidaris micans. Th. Mortensen. 1910. On some West Indian Echinoids, p. 2. Pl. **I; XIV. 5—6; XV. 1—2, 7; XVI. 3—5, 7—8, 10, 13—14; XVII. 12—13.**
Dorocidaris micans. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Cidaris micans. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 19.

To the detailed description, given in my paper of 1910, I have very little to add. The examination of the specimens preserved in the Museum of Comp. Zoology and the U. S. National Museum enables me to give here measurements of some specimens of a larger size than those measured in the said work.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	60 mm	40 mm	27.5 mm (45.8 % h.d.)	24 mm (40 % h.d.)	7—8	18—19	?
2	52 —	39 —	22 — (42.3 —)	22 — (42.3 —)	8—9	16—17	155 mm
3	50 —	39 —	23 — (46 —)	22 — (44 —)	7	17—18	88 —

Specimen 1 is the one represented by H. L. Clark (Op. cit. 1907. Pl. III). Specimen 2 the one represented in Pl. I of my memoir "On some West Indian Echinoids".

The ambulacra with the spines preserved make the impression of being nearly bare, as stated by Clark. This is due to the secondary spines being very small and slender, setaceous; on the denuded test the ambulacra do not make the impression of being bare, though the inner tubercles may be somewhat smaller than shown in fig. 6. Pl. XIV of the "West Indian Echinoids" and the interporiferous zone thus somewhat more bare than shown in this figure. The upper primary tubercles may show fairly distinct traces of crenulation, as also seen — rather more distinctly — on the base of the spines.

Specimen 3 has all oculars exsert. In specimen 1 the apical system is somewhat elongate (H. L. Clark, Op. cit. 1907. Pl. III. 2), the longer diameter being 27.5 mm, the shorter only 25 mm (41.7 % of h.d.); in this specimen all oculars are insert. In specimen 2 Ocular III is slightly exsert, the others insert. The genital pores are rather small in all the specimens, which means evidently that the species has small eggs, like *Cidaris cidaris*, and probably a pelagic larva.

The primary spines of specimen 3 are considerably shorter than those of specimen 1 — but not broken; this shows that the great length of the spines, up to 3 times h.d., is no constant feature of the species. In specimen 2 the long primary spines end in a little widening with a small conical prominence in the centre; in specimen 3 the point is quite simple, apparently somewhat worn. In this latter specimen the longer spines are slightly upwards curving. The collar is ca. 3 mm long, increasing very considerably in thickness towards the otherwise not prominent milled ring. The striæ of the milled ring continue more or less distinctly over the base; sometimes they are marked conspicuously off from the collar in being white, while the collar is always pinkish. The neck is, of course, not well marked from the shaft in these smooth and shining spines.

The spines are almost entirely free of foreign organisms. The species is known to occur only in the West Indies, from Barbados to Cuba, in ca. 200—330 m.

Remarks. It is difficult to understand how Agassiz could come to regard two so strikingly different forms as *Calocidaris micans* and *Histocidaris* ("*Porocidaris*") *Sharreri* as identical, which — in spite of his emphatic protest (cf. "Ingolf" Ech. II. p. 9—10) — he really did. As pointed out

above, under *Histocidaris Sharreri*, the "description" of this latter species in the "Blake" Echini is mixed up from both these species, and the figures Pl. II. 1—2 of the latter work, stated to represent part of the test and apical system of "*Porocidaris*" *Sharreri* are really of *Calocidaris micans*, — indeed, it seems to be the same specimen as that represented by H. L. Clark in his "Cidaridæ" Pl. III (in both the apical system is abnormally elongate). The erroneous statement of the said figures of the "Blake" Echini being of "*Porocidaris*" *Sharreri* has been the main cause of the confusion reigning for so long a time with regard to *Histocidaris Sharreri* and of the numerous misidentifications of various other Cidarids as "*Porocidaris*" *Sharreri*.

Genus **Tretocidaris** Mrtsn.

Th. Mortensen. 1903. "Ingolf" Ech. I. p. 16, 28.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 92.
H. L. Clark. 1907. The Cidaridæ. p. 200.
Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 51, 54.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 3, 19.

Test usually somewhat flattened above and below. Pores non-conjugate or subconjugate, the wall rather broad but flat. Primary tubercles smooth or with traces of crenulation; areoles very shallow, well separated. Oculars generally insert. Primary spines cylindrical, rather coarsely thorny, the spinules arranged in distinct, longitudinal series; the point sometimes conspicuously widened. Surface of shaft covered with simple hairs, which are at most slightly branched but do not anastomose to form a spongy coat. Oral primaries simple, smooth, with edges not serrate. Secondary spines slender, flattened, not closely appressed, the smaller ones almost setaceous. Pedicellaries of all three kinds. Both sorts of globiferous pedicellariæ with a conspicuous end tooth; the opening, especially in the large form, reduced to a small pore. Stalk sometimes with a limb of freely projecting rods, the limb, however, never very elaborately formed. Spicules of intestinal wall small fenestrated plates, with a tendency to developing into round glassy plates.

Genotype: *Dorocidaris Bartletti* A. Agassiz.

The approaching of the pore-structure to the conjugate type (cf. *Tr. spinosa*) as well as the extreme character of the globiferous pedicellariæ show this genus to be the highest specialized of the group Cidarina.

The unfortunate circumstance that the specimen of *Tr. Bartletti* used by H. L. Clark for the study of the pedicellariæ happened to be abnormal, probably a hybrid, and unique in having both types of large globiferous pedicellariæ, such with a well developed end tooth, of the typical *Tretocidaris*-form, and such without an end tooth, more like those of *Stylocidaris affinis*, caused Agassiz & Clark to reject the use of the characters of pedicellariæ in Cidarid classification. The genus *Tretocidaris* was accepted by Clark in his "Cidaridæ", but made to comprise besides *Tr. Bartletti* (*Tr. spinosa* was not recognized as sufficiently characterized) the species now referred

to the genera *Stylocidaris* and *Hesperocidaris*. Gradually H. L. Clark has, however, come to be convinced of the value of pedicellariæ in classification, and in his important work from 1925 he recognizes the genus *Tretocidaris* as originally limited. — In the apical system in which Clark (Op. cit. 1907) thought to find essential characters I cannot find any character of generic value.

That the genus is not recognized by Lambert & Thiéry is a natural consequence of their principle that the recent forms have to be classified after those characters only, which are liable to be found in the fossils. There is no reason to discuss this matter here again. — Among the fossils there are no species which can with any reasonable degree of certainty be referred to this genus.

Key to the species of Tretocidaris.

Colour of secondary spines light greenish or whitish, with a darker midline. Large globiferous pedicellariæ with irregular meshwork and serrate crests at the base of the blade..... *Tr. Bartletti.*
Colour of secondary spines redbrown, darker towards the point; no irregular meshwork or serrate crests at base of the blade..... *Tr. spinosa.*

Tretocidaris Bartletti (A. Agassiz).

Pl. LXXXII. 41.

Dorocidaris Bartletti. A. Agassiz. 1880. Prel. Rep. Ech. "Blake" 1878—79. Bull. Mus. Comp. Zool. VIII. p. 69.
Dorocidaris Bartletti. A. Agassiz. 1883. "Blake" Echini, p. 9. Pl. **II, 17—27.** (Non fig. 16; probably *Cid. Blakei*).
Dorocidaris Bartletti. Rathbun. 1885. Rep. Ech. "Albatross", 1885. Proc. U. S. Nat. Mus. p. 610.
Dorocidaris Bartletti. Rathbun. 1886. Cat. Ech. U. S. Nat. Mus. Ibidem 1886. p. 261.
Tretocidaris Bartletti. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 16, Pl. **X, 23, 30**; II. 1907 p. 169—170.
Tretocidaris annulata. Th. Mortensen. Ibidem I. p. 16; Pl. IX, 4; X, 22, 31; II. 1907. p. 169—170.
Tretocidaris Bartletti. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 101.
Dorocidaris Bartletti. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 8. Pl. 12. a, 6—13.
Tretocidaris Bartletti. H. L. Clark. 1907. The Cidaridæ. p. 203. Pl. **8—9.**
Tretocidaris Bartletti. Th. Mortensen. 1909. Ech. Deutsche Südpol. Exp. p. 47, 54.
Tretocidaris Bartletti. Th. Mortensen. 1910. On some West Indian Ech. p. 5. Pls. **II—III; VII. 6; XIV. 8—9; XV. 8, 12—14; XVI. 2, 12; XVII. 1, 6.**
Dorocidaris Bartletti. Lambert & Thiéry. 1910. Ess. nom. rais. p. 148.
Tretocidaris Bartletti. H. L. Clark. 1918. Rep. Crin. and Ech. Bahama Exp. Univ. Iowa. Univ. Iowa Monogr. Bull. Lab. Nat. Hist. VII. p. 21.
Tretocidaris Bartletti. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 19.

The study of the material of this species preserved in the Museum of Comp. Zoology, the U. S. National Museum and the British Museum does not necessitate any noteworthy corrections or additions to the description given in my memoir "On some West Indian Echinoids". It may, however, be desirable to give some additional measurements, especially of some of the larger specimens.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	67 mm	42 mm	27 mm (40.3 % h.d.)	26 mm (38.8 % h.d.)	9—10	15—16	75 mm
2	56 —	32 —	22.5 — (40.2 —)	22.5 — (40.2 —)	7—8	18—19	86 —
3	47 —	28 —	20 — (42.6 —)	20 — (42.6 —)	7—8	17—18	88 —
4	45 —	26 —	20 — (44.4 —)	20 — (44.4 —)	7	17—18	ca. 65 —
5	25 —	15 —	12 — (48 —)	10 — (40 —)	6—7	13—14	47 —
6	13.5 —	7 —	7.5 — (56.3 —)	6.5 — (48 —)	5 (6)	8—9	21 —

Specimen 1 in the U. S. National Museum, 2 in the British Museum (the type of *Tr. annulata*), 3—6 in the Museum of Comp. Zoology.

In connection with the suggestion set forth in my report on the Echinoidea of the German S. Polar Expedition (Op. cit. 1909, p. 47) that the specimen represented in H. L. Clark's "Cidaridæ" Pl. 8—9, with the slender, nearly smooth spines, and with the two sorts of large globiferous pedicellariæ, might be a hybrid between *Tr. Bartletti* and *Stylocidaris affinis*, I would emphasize that none of the specimens which I have seen carry both this sort of spines and the coarsely thorny form typical of *Bartletti*. I therefore rather adhere to the said suggestion as, apparently, the only reasonable explanation both of the unusual type of spines and of the extraordinary and unique fact that two sorts of large globiferous pedicellariæ occur in this specimen.

The collar of the primary spines is ca. 3 mm long, scarcely increasing in thickness downwards. The milled ring very inconspicuous. A figure of a tridentate pedicellaria (Pl. LXXXII. 41) is given here, in addition to the figure of a valve given in my paper of 1910.

The colour is stated by Clark (The Cidaridæ, p. 204) to be brown on the test "varying from fawn-color to deep red-brown, or even deep red on the abactinal system". It appears that the brown colour is restricted to the dorsal side, and mainly around the areoles, whereas the sutures are more light coloured, whitish, as also the ambulacra are whitish in the midline. There is also a conspicuous white border on the ocular plates. The ground colour of the conspicuously brown-banded primary spines is either greenish or whitish. The scrobicular spines have a greenish-brown midline.

The species is known to occur only in the West Indies, in depths of ca. 140—635 m.

That *Tr. annulata* is identical with *Bartletti* was recognized by myself ("Ingolf" Ech. II. p. 169—170), when I had had the opportunity of studying the material of *Tr. Bartletti* in the U. S. National Museum. The establishing of the supposed new species was due to the fact that the fig. 16. Pl. II of the "Blake" Echini, stated to represent the ambulacral and interambulacral structure of *Bartletti*, does not really represent this species, but probably *Cidaris Blakei*.

Vinassa de Regny (Echinidi neogenici del Museo Parmense. Atti Soc. Toscana. Memorie. XV. 1897. p. 146) mentions under the name *Dorocidaris* cf. *Bartletti* A. Ag. a spine which — apart from its much smaller size — has a very great resemblance to the spine of "*Dorocidaris*" *Bartletti* figured in the "Blake" Ech. Pl. II. 20. It must be said that a spine resembling the figure

quoted, and, moreover, of much smaller size, is so uncharacteristic that it might belong to almost any Cidarid; it cannot give any reasonable proof that a relative of *Tretocidaris Bartletti* ever lived in the Mediterranean.

Tretocidaris spinosa Mrtsn.

Pls. XXXIII. 1—3; XXXIV. 1—2; LXVII. 9; LXXI. 15; LXXXII. 32—36.

Tretocidaris spinosa. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 28, Pl. **X. 10, 11, 16.**
Tretocidaris spinosa. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 101.
Tretocidaris spinosa. Th. Mortensen. 1909. Ech. Deutsche Südpol. Exp. p. 54.
Tretocidaris spinosa. Koehler. 1909. Astéries, Ophiures et Échinides de l'expéd. nat. antarct. écossaise. Rep. Sc. Res. "Scotia". V. p. 300, Pl. **XVI. 163—164.**
Tretocidaris spinosa. H. L. Clark. 1925. Cat. rec. Sea-Urch. Br. Mus. p. 20.

Having recently had the opportunity of a more detailed examination of the type specimen in the British Museum, and having also received, some years ago, from the late Dr. W. S. Bruce a couple of specimens from the "Scotia" Expedition, and as further some specimens have been lent me for examination from the R. Scottish Museum, Edinburgh, I think it desirable to give here a full description and figures of this species; the description and figures given by Koehler do not appear to me to make this superfluous.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	57 mm	34 mm	25 mm (43.9 % h.d.)	22.5 mm (40.9 % h.d.)	8—9	14	ca. 60 mm
2	49 —	33 —	21 — (42.9 —)	19.5[1] — (40 —)	9—10	ca. 14	60 —
3	47 —	28 —	22 — (47 —)	18 — (38.3 —)	7—8	13—14	55 —
4	38 —	23 —	17 — (44.7 —)	14 — (37 —)	8	12	?
5	24 —	14 —	11 — (46 —)	11 — (46 —)	6	10—11	42 —

Specimens 1 and 4 in the R. Scottish Museum; specimen 2, the type-specimen, in the British Museum; specimens 3 and 5 in the Copenhagen Museum.

Test in the type specimen scarcely flattened above or below, in the other specimens more distinctly so. The sides are beautifully arched; in specimens 1 and 3 the circumference is distinctly subpentagonal, in the others round.

Ambulacra slightly sinuate, scarcely 25 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles not very prominent, but nearly contiguous and well mamelonate. Adradially to the marginal tubercle there is a much smaller tubercle at the lower edge of the plate, forming regular vertical series; the median part remains bare. In the specimens there is, however, at the ambitus, more or less regularly a second inner tubercle higher up on the plate, obscuring thus the regular series arrangement. A pair of small, miliary tubercles are usually found at the lower edge, on both sides of the marginal tubercle. Median area not sunken. Pores rather distant, about equal-sized,

[1] Not 22 mm, as states H. L. Clark (Op. cit.).

they may well be termed subconjugate. The wall is flat, the ridge somewhat elevated, rounded (Pl. LXXI. 15). The pore zone scarcely sunken.

Interambulacra. Areoles shallow, of moderate size, well separated, only the 2—3 proximal ones confluent, the subambital ones rather distinctly transverse-oval. The boss is fairly large and prominent, the mamelon rather small. More or less distinct traces of crenulation on some of the upper tubercles. Edge of areoles not elevated. The scrobicular tubercles are rather small, usually only to the number of 12—14 and, accordingly, somewhat more spaced than usual. Tubercles outside the scrobicular ring not very numerous or close, gradually decreasing in size towards the midline. There is an indication of fine horizontal lines but no distinct arrangement of the secondary tubercles in transverse series. Some secondary tubercles also at the adradial side of the scrobicular ring, particularly in the larger specimens. There is a fairly distinct, naked, slightly sunken median space. Median interambulacral area slightly more than half the width of an areole, in the largest specimen as wide as an areole.

Apical system a little less than half h.d., not elevated. The oculars may be all insert, as in specimens 3 and 4 (narrowly in the latter), but more generally, as in the type specimen, Oculars II and III are exsert. The madreporite not enlarged. Genital pores small, rather near the outer edge. Periproct with fairly numerous plates. The whole apical system covered rather closely with small, uniform tubercles.

Peristome slightly raised, somewhat smaller than apical system, in the larger specimens rather distinctly subpentagonal. There are (in the largest specimens) 16—18 ambulacral plates in a series, ca. 7 interradial plates in a more or less regular series, not reaching quite to the mouth edge.

Primary spines. In the type specimen (Pl. XXXIV. 1—2) the primary spines are rather conspicuously widened at the point, forming an irregular crown, in the middle of which there is usually a small peg. The shaft has ca. 15 series of low spinules. On the other specimens the primary spines are cylindrical or slightly tapering to a simple, not crown-shaped point; there are also ca. 15 series of spinules, but these are distinctly coarser than in the type specimen. The surface of the spines is covered by rather coarse, simple, rarely slightly branching, but not anastomosing hairs. The collar is ca. 1.5—2 mm long, slightly increasing in thickness towards the milled ring; the latter is in the type specimen very inconspicuous, in spec. 2 rather sharp and prominent. The neck is not well marked. — The oral primaries are simple, flattened, with square cut, a little thickened end. The side edges are smooth. The third is transitional to the ambital spines.

Secondary spines. Scrobicular spines ca. 6 mm long, narrow, slightly widening towards the straight cut end, where they are somewhat concave, chisel-like. They are not closely appressed, and do not fit close together round the base of the primary spines. Marginal and ambulacral spines about half the length of the scrobicular spines, very slender, almost setaceous, pointed, as are also the smaller secondary spines. Those on the periproct somewhat coarse, forming a rather conspicuous tuft.

Pedicellariæ. The large globiferous pedicellariæ fairly numerous and conspicuous, both on account of their size, up to ca. 1.8 mm length of head, up to 3 mm length of stalk, and their redbrown colour. The valves without any irregular meshwork or serrated crests, such as is usually found in *Tr. Bartletti*, and the blade on the whole broader, less compressed than in the latter species (Pl. LXXXII. 32, 34). The stalk may have a more or less distinct limb. The small globiferous essentially of the same shape as the large ones; as a matter of fact, there is no clear distinction between the two forms, as also all intermediate sizes occur (Pl. LXXXII. 33, 35—36). No tridentate pedicellariæ observed.

Spicules of the tubefeet of the usual type; in the intestinal wall numerous small, irregular, fenestrated plates, partly passing into the shape of small rounded plates with few small central holes, such as are typical of *Prionocidaris* (Fig. 91). The spicules in the internal organs on the whole strongly developed.

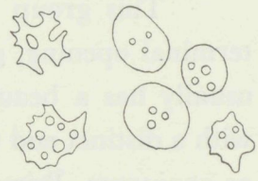


Fig. 91. Spicules from intestinal wall of *Tretocidaris spinosa* Mrtsn. × 125.

Colour. Primary spines of the type specimen of a faint redbrown with scarcely an indication of darker bands. On the other specimens the primaries are more distinctly banded, ca. 5—6 brownish bands on a whitish ground colour. The collar is a pale reddish, the neck more purplish red, with faint longitudinal whitish lines, in direct continuation of the series of spinules which are also whitish. The secondary spines are redbrown, usually darker towards the point. The denuded test is faintly yellowish-brown[1], also on the marginal ambulacral tubercles. The pore zones and interporiferous zone, as well as the interambulacral sutures white. Apical system a darker redbrown, the oculars paler, with white edges.

Biology. In the alimentary canal of one of the smaller specimens were found fragments of shells and incrusting organisms; some other specimens were quite empty. — The spines often overgrown by small Hydroids. A couple of parasitic Gastropods are found on the smallest specimen, and also some of the other specimens show signs of having been attacked by Gastropods. — A very curious anomaly is shown by the largest specimen in the uppermost primary tubercle in each series being double (Pl. LXVII. 9). There is no trace of spines on these tubercles, still some of them are distinctly perforate. It seems evident that this specimen has reached full size, and that spines would never have developed on these tubercles. Possibly this is no anomaly, but a normal feature of the fullgrown specimens.

Occurrence. The type specimen is labelled St. Helena; some specimens were taken by the "Scotia" at Ascension in a depth of ca. 70 m.

Remarks. This species is nearly related to the West Indian *Tr. Bartletti*, differing from it in the less thorny primaries, in the somewhat different shape of the globiferous pedicellariæ, and especially in the colour of both the primary and the secondary spines.

The conspicuous difference between the type specimen and the specimens from Ascension

[1] This appears also to be the case with the type specimen, the test of which is scarcely greenish, as Clark states it to be.

in the shape of the primary spines might indicate that we have here rather two different species. Also the greater number of coronal plates in the type specimen is a noteworthy feature. In the other characters there are no essential differences. So long as we do not know whether the said differences are constant, it is impossible to say definitely whether we have here two different or only one, more variable species. For the present I prefer to regard them as the same species; perhaps the Ascension form should rather be regarded as a local variety of the typical *spinosa*. In any case, it is certain that the Ascension form stands nearer to *Tr. spinosa* than to the West Indian *Tr. Bartletti*.

Group *Stylocidarina*.

This group is characterized by its large globiferous pedicellariæ having a well formed terminal opening, generally bordered by a fairly regular lip with teeth-like serrations. The stalk usually has a beautiful limb of freely projecting rods. Small globiferous pedicellariæ as a rule with a distinct end tooth; tridentate pedicellariæ on the whole well developed. Pores non-conjugate or conjugate. Primary tubercles crenulate or non-crenulate. Secondary spines flattened, usually not appressed or scale-like.

This large group, comprising the recent genera *Acanthocidaris*, *Stylocidaris*, *Eucidaris*, *Hesperocidaris*, *Centrocidaris*, *Actinocidaris*, *Plococidaris* and *Prionocidaris*, is mainly confined to the tropical and subtropical regions of the Indo-Pacific; in the Atlantic it is represented only by two species of *Stylocidaris* and two species of *Eucidaris*, while it has no representatives in the Antarctic seas.

As there are no very striking peculiarities in the structure of the test or the spines it is not possible to decide with certainty which of the fossil forms belong to this group. But it seems reasonable at least to regard *Balanocidaris* as nearly related to *Eucidaris*. Anyhow, it may be practical to deal with the fossil genera, as far as they cannot be definitely referred to any other group or subfamily, in addition to the present group.

Key to the genera of recent Cidarids of the group Stylocidarina.

1. Tubercles distinctly crenulate; primary spines very long, flattened, with a long collar.. *Acanthocidaris*.
   Tubercles non-crenulate, or only with faint traces of crenulation. Primary spines not flattened, or if so, not with a long collar ..... 2.
2. Primary spines distinctly verticillate; test green-mottled ..... *Plococidaris*.
   Primary spines not distinctly verticillate; test not green-mottled ..... 3.
3. Pores, in adult specimens, distinctly conjugate. Collar of primary spines usually with red or purple spots or stripes ..... *Prionocidaris*.
   Pores not conjugate or at most sub-conjugate; collar of primary spines not spotted or striped with red or purple (but sometimes with brown stripes) ..... 4.
4. Primary spines very smooth, with a shining surface, formed by the coalescing hairs..... *Centrocidaris*.
   Primary spines not so ..... 5.
5. Pores sub-conjugate. Peristomial ambulacral pores in single series. Primary spines thick and coarse, the surface covered by a coarse reticulation formed by the anastomosing hairs *Actinocidaris*.
   Pores non-conjugate. Peristomial ambulacral pores in single or double series..... 6.

6. Primary spines slender, usually tapering to a rather fine point; hairs on surface of shaft usually simple, not anastomosing, sometimes totally lacking. Peristomial ambulacral pores in single series ..... *Stylocidaris.*
Primary spines slender or coarse, usually not tapering; if so, the peristomial ambulacral pores partly in double series; hairs on surface of shaft anastomosing and forming a thick spongy coat ..... 7.
7. Primary spines coarse, usually cylindrical, not tapering, ending in a small crown with a central prominence; sometimes the spines are very conspicuously thickened in the distal part, more rarely they taper to a rather fine point. Pores on peristome partly in double series (not in *E. metularia*). Large globiferous pedicellariæ usually with a limb ..... *Eucidaris.*
Primary spines slender, cylindrical, not tapering, sometimes conspicuously widened and flattened towards the end. Pores on peristome in single series. Large globiferous pedicellariæ without a limb on the stalk ..... *Hesperocidaris.*

Genus **Acanthocidaris** Mrtsn.

Th. Mortensen. 1903. "Ingolf" Ech. I. p. 21, 29.
H. L. Clark. 1907. The Cidaridæ, p. 222.
A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 38.
Lambert & Thiéry. 1914. Ess. nom. rais. p. 273.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 6, 37.

Tubercles perforate and strongly crenulate. Areoles not sunk, not confluent, except the lowermost ones. Ocular plates insert, all of them, or only Oc. II excluded. Pores subconjugate. Primary spines flattened, slightly upwards curving, with a more or less distinct median keel on upper side. Collar very broad and long, 2—3 cm, with longitudinal ridges which are, mainly in the basal part, set with rounded elevations or tubercles. The ridges continue along the shaft as narrow, low, perfectly smooth ridges, which are very conspicuous through their darker colour. Surface of spine otherwise of a velvety appearance produced by fine, anastomosing hairs. Lower limit of cortex layer generally irregular, sinuate. Oral primaries more or less serrate. Secondary spines long, flattened, erect, not appressed. Large globiferous pedicellariæ without end tooth, lower limit of the terminal opening often irregular. Stalk sometimes with a limb. Small globiferous pedicellariæ with a more or less distinct end tooth or without an end tooth. Tridentate pedicellariæ with irregular longitudinal lamellæ in the blade.

Genotype: *Cidaris curvatispinis* Bell.

A. Agassiz & H. L. Clark (Op. cit.) state in their diagnosis of this genus that "the shaft of the spine is not more than one third the length of the shoe" evidently using here "shaft" for the collar, and "shoe" for the shaft of the spine, being induced to this use of terms from the similarity of the primaries of *Acanthocidaris* to those of *Coelopleurus*. The spines of the latter are morphologically perfectly similar to those of Cidarids, so that no special designation ought to be used for the spines of this form, or, upon the whole, the Arbaciids.

Jackson, in his "Studies of Arbacia punctulata and allies" (Mem. Boston Soc. Nat. Hist. VIII. 1927, p. 453) emphasizes that the condition of Oculars I, V, IV, III insert is "very com-

mon, even a generic character, in the primitive group of the Cidaroida", and that, according to H. L. Clark (1907) it is "the generic character of *Acanthocidaris*". To this may be remarked first that Clark did not give this as "the" character of the genus *Acanthocidaris*, but as one of the characters, and secondly that it is not at all a generic character, since in the two species *curvatispinis* and *maculicollis* the oculars are all insert; only in *Ac. hastigera* it is a rule that Oc. II is exsert. Further the condition Oc. II alone exsert is by no means "very common in the primitive group of the Cidaroida", but on the contrary very rare; besides in *Acanthocidaris hastigera* it is found in *Stereocidaris stylifera* and may occasionally occur in *Eucidaris tribuloides*, and *Prionocidaris baculosa*, but I do not remember having observed it in any other species.

This very well marked genus, characterized especially by its primary spines, would seem through its pore-structure to be related with the forms with conjugate pores, especially *Prionocidaris*. Among the species of this latter genus *Pr. glandulosa* recalls *Acanthocidaris maculicollis* so much (by its upwards curving primaries, crenulate tubercles and subconjugate pores) that it may almost be said to form a transition between the two genera.

The strongly crenulate tubercles characterize *Acanthocidaris* as a more primitive form. Also the large globiferous pedicellariæ of *A. hastigera* and *curvatispinis* would appear to be of a somewhat primitive, one might be tempted to say unfinished structure, the opening being irregularly limited downwards. There is, however, a possibility of the form, usually regarded as the large globiferous pedicellaria in these two species, being in reality only large samples of the small form; the existence of a large globiferous form of the typical structure in *A. maculicollis* at least leads to the supposition that a corresponding form may prove to occur also in the two other species, though not yet found there, and if so, the form hitherto known from these species can only represent the small form.

The three (? four) species of *Acanthocidaris* hitherto known are all from the Indo-Pacific, no species of the genus being known to occur in the Atlantic or in the Antarctic Seas.

Key to the species of Acanthocidaris.

1. Collar of primary spines on the upper side with five or more longitudinal series of red spots. Shaft of spines banded with reddish and whitish..... *A. maculicollis.*
   Collar whitish or olive, without distinct series of red spots..... 2.
2. Collar olive with white spots..... *A.* sp.
   Collar whitish..... 3.
3. Primaries, in adult specimens, uniform in colour; secondaries dark reddish-brown (Hawaii) *A. hastigera.*
   Primaries slightly banded at the point, secondaries cream-coloured or yellowish (Mauritius) *A. curvatispinis.*

Acanthocidaris curvatispinis (Bell).

Pl. LXXXIII. 16—18.

Cidaris curvatispinis. F. Jeffr. Bell. 1892. Description of a remarkable new Sea-Urchin of the genus Cidaris from Mauritius. Trans. Zool. Soc. XIII. p. 303. Pl. **XXXVIII.**

Cidaris curvatispinis. De Loriol. 1893. Cat. rais. Échinod. rec. par M. V. de Robillard à l'île Maurice. III. Ophiurides & Astrophytides. Mém. Soc. Phys. & d'hist. nat. Genève XXXII. p. 60.

Acanthocidaris curvatispinis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 21, 173. Pl. VIII. 37. Pl. X. 9.

Acanthocidaris curvatispinis. H. L. Clark. 1907. The Cidaridæ, p. 223, 224.

Acanthocidaris curvatispinis. Lambert & Thiéry. 1909. Notes Échinologiques. I. Note sur le genre Cidaris. Bull. Sc. nat. Haute Marne VI. p. 31. Pl. **I.**

Acanthocidaris curvataspina. Lambert & Thiéry. 1914. Ess. nom. rais. p. 273.

Acanthocidaris curvatispinis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 37.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
55 mm	40 mm	27 mm (49 % h.d.)	ca. 22 mm (ca. 40 % h.d.)	9	12—13	ca. 160 mm

The measurements are from the specimen in the Paris Museum.

Test distinctly flattened above, scarcely so below; sides subvertical. Circumference round.

Ambulacra slightly sinuate. Marginal series of tubercles very regular, the tubercles fairly conspicuous, contiguous. Inside the marginal tubercle there is, at the lower edge of the plate, a very small tubercle, forming regular series. The interporiferous zone otherwise perfectly naked, flat. The median end of the horizontal sutures slightly deepened, almost so as to form a small pore, recalling *Salmacis*. The interporiferous zone is slightly broader than a pore-zone. Pores fairly distant, separated by a rather broad, flat wall; the ridge is not elevated so as to rise above the wall. Pore zone not sunk.

Interambulacra. Areoles scarcely at all deepened; the 2—3 proximal ones confluent, the rest of them distinctly separated, but the wall separating them is narrow, and only on the apical ones a few small miliaries are found intercalated between the two adjoining scrobicular circles. It appears that all the areoles, except the uppermost one, are distinctly transverse-oval. The boss is low, distinctly crenulate on the adapical side; the mamelon is rather small. Edge of areoles not elevated, the scrobicular tubercles not very prominent. Outside the scrobicular ring some scattered, small miliary tubercles, both on the median and on the adradial side; the median area on the whole rather bare, though without distinct naked or sunk median line.

Apical system very nearly half h.d. All the oculars are broadly insert. The madreporite somewhat enlarged. Genital pore not close to the edge, small, situated on top of a small cone. The plates are uniformly, but not closely covered by tubercles, those along the inner and outer edge of the genitals and outer edge of the oculars somewhat larger, their spines forming a not very conspicuous fringe. Spines of periproctal plates distinctly larger, forming a rather distinct tuft.

Primary spines ca. 3 times h.d. The collar ca. 25 mm long, flattened and, on the upper spines, widened in the basal part so as to be somewhat spear-shaped, especially so on the young apical spines. There is a conspicuous median keel on the upper side, and 2—4 lateral keels, the median keel reaching nearly to the shaft, the lateral ones shorter, especially the outer ones. These keels are all more or less distinctly serrate[1], while the sides of the collar are smooth. Underside of collar flat, smooth, on the uppermost spines even somewhat concave. The shaft tapers very gently towards a simple point; it is distinctly flattened, with ca. 10 low, narrow, smooth, longitudinal ridges on both sides. The whole spine is distinctly upwards curved. The oral primaries are flat, scarcely widened, with slightly serrate edge.

Secondary spines. The scrobicular spines are ca. 8 mm long, lancet-shaped, pointed, somewhat concave in the basal part; they are not much appressed and do not form a close mail around the base of the primaries. Marginal ambulacral spines ca. 5 mm long, almost setaceous, but slightly flattened in the basal part. Miliaries simply setaceous.

Pedicellariæ. The globiferous pedicellariæ have no end tooth, the large opening reaching to the point; the lower border of the opening is remarkably irregular; sometimes there seems to be no definite border at all, the calcareous inner wall of the blade continuing into irregular dentations, as if it were broken off. There may also be irregular crests on the inside of the blade (Pl. LXXXIII. 16—17). In smaller samples the lower border of the opening is often a regular transverse line (Pl. LXXXIII. 18). The stalk has no limb. (Possibly these globiferous pedicellariæ all represent only the small form — cf. *A. maculicollis*). The tridentate pedicellariæ ("Ingolf" Ech. I. Pl. X, 9) are peculiar in having in the blade some large dentate crests, in the shape of thin, irregular, longitudinal lamellæ. — Spicules of tubefeet of the usual form.

Colour of test apparently white, but the interporiferous zone (— not the marginal tubercles —) brown, forming thus five rather conspicuous, narrow meridian stripes. Also the median part of the interambulacra and the apical system apparently brownish. Primary spines with the shaft brown, a few of them with a slight indication of whitish bands near the point; the collar whitish, with a faint greenish tint towards the base. In the specimen in the Paris Museum there are faint reddish-olive spots on the collar, particularly along the median keel. Secondary spines yellowish.

Occurrence. Known only from Mauritius. According to De Loriol (Op. cit.) it was taken on fishing lines at a depth of 200 m.

Remarks. The above description is based in the main on the specimen (the second known) in the Paris Museum, which the author had the opportunity of examining during a visit to Paris in October 1926. The splendid condition of both this specimen and the type-specimen in the British Museum makes it undesirable to denude parts of the test, and for this reason it has been

[1] These serrations are what is meant by Bell's statement in his original description that "this ridge (viz. the median keel of the collar) may be dentate and ornamented by a few minute tubercles".

impossible e. g. to examine the peristome, or to make drawings of the apical system or of the ambulacral structure.

Regarding the relations between the present species and the very closely related (— if indeed not identical! —) Hawaiian species, *A. hastigera* A. Ag. & H. L. Cl., see under the latter (p. 328).

Lambert & Thiéry (Op. cit. 1914) change the name *curvatispinis* into *curvataspina*, because in their opinion the former is a barbarism. This is a gross mistake. As I am informed by a very prominent authority in Latin (and many other languages), Professor Holger Pedersen, University of Copenhagen, curvatispinis is perfectly correct Latin (formed like e. g. imberbis, from barba, beard); "the man who formed curvatispinis, he knew Latin", says Holger Pedersen. The form *curvataspina* of Lambert & Thiéry, on the contrary, is a glaring barbarism.

Acanthocidaris hastigera A. Agassiz & H. L. Clark.

Pl. LXXXIII. 11.

Acanthocidaris hastigera. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 39. Pl. 11, 1—5; 12, 1—17; 12, b, 18—19. Pls. **37—42.**

Acanthocidaris hastigera. H. L. Clark. 1907. The Cidaridæ. p. 224.

Acanthocidaris hastigera. Lambert & Thiéry. 1914. Ess. nom. rais. p. 273.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	51 mm	36 mm	24 mm (47 % h.d.)	18.5 mm (36.3 % h.d.)	8	15—16	146 mm
2[1]	50 —	32 —	21.5 — (43 —)	20 — (40 —)	7—8	15	
3	48 —	33 —	20 — (41.7 —)	19 — (39.6 —)	7—8	15	
4	45 —	28 —	18.5 — (41 —)	18 — (40 —)	7—8	15	
5	42 —	28 —	19 — (45 —)	17 — (40.5 —)	7—8	15—16	
6	32 —	19 —	14 — (43.8 —)	14 — (43.8 —)	6—7	11—13	103 —
7	26 —	15 —	12 — (46.1 —)	11 — (42.3 —)	6—7	14	
8	18 —	9 —	8 — (44.4 —)	8 — (44.4 —)	5—6	11—12	57 —
9	12 —	6 —	5 — (41.4 —)	5 — (41.4 —)	5	8—9	27 —
10	5 —	2 —	2 — (40 —)	2.5 — (50 —)	4	5	8 —

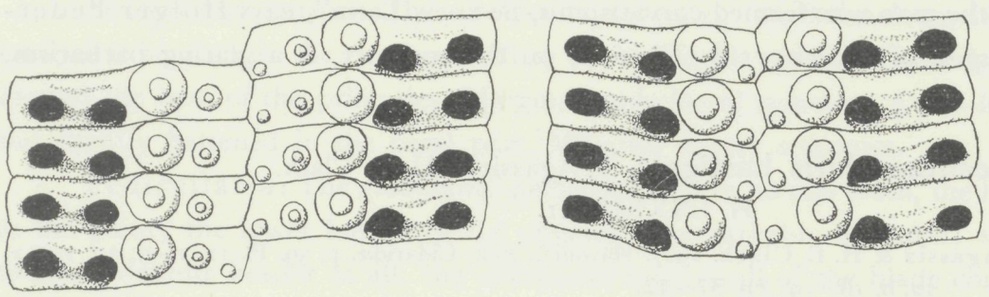
The specimens 1, 6 and 8 are in the U. S. National Museum, the specimen 6 being designated as the type. The other specimens, excepting No. 5, are in the Museum of Comparative Zoology.

Test flattened above and, somewhat less so, below. Sides arched, sometimes, in the higher specimens, rather vertical. Circumference more or less pentagonal, the I.A. being often somewhat swollen.

Ambulacra distinctly sinuate; the interporiferous area slightly wider than the pore zone. The marginal series of tubercles very regular, the tubercles being rather small and low, but con-

[1] A specimen of 50 mm h.d. is stated by Agassiz & Clark (Op. cit.) to be 40 mm high, with the apical system 25 mm, the peristome 18 mm.

tiguous. Adradially to the marginal series there is on each side a very regular series of much smaller tubercles, placed in the lower inner corner of each plate. Otherwise the interporiferous area is naked, but the median line is not sunk, and the whole ambulacral area very nearly flat. The pores (Fig. 92.2) are equal-sized[1], rather wide apart, with a broad, scarcely elevated wall between them; ridge low, scarcely as high as the wall, nearly flat. The pores are very nearly horizontal. The plates upon the whole very low and numerous, 15—16 corresponding to an I. A. at the upper side of test in the larger specimens. — Interambulacra. Primary interambulacral tubercles rather high, strongly crenulate, excepting the 2 (3) proximal ones. Areoles not at all sunk, well separated, excepting (not always), the 2—3 proximal ones. Rather distinct radiating impressions are usually seen, in well cleaned specimens, in the upper areoles, (much more distinct and regular than those sometimes found in *Poriocidaris purpurata*). Median interambulacral space about half as wide as the areoles; it is rather densely covered with tubercles, diminishing gradually in size from the scrobicular circle, the tubercles of which are not very prominent, scarcely twice the size of the marginal ambulacral tubercles. No distinct naked median or adradial space; median line somewhat sunk.



1 2

Fig. 92. Part of ambulacra of *Acanthocidaris maculicollis* (1) and *A. hastigera* (2). × 12.

Apical system 45—50 % of h.d. All ocular plates, usually excepting the right anterior (II), in contact with the periproct. They are somewhat heart-shaped, with a deep notch in the outer edge, and scarcely project beyond the genital plates, the circumference of the apical system being, therefore, rather regularly rounded. Genital pores wholly within the plate, sometimes on a slight elevation. The genital pores being of about the same size in all the specimens examined, it is evident that also the female genital pores are small, which means small eggs, and, probably, the existence of a pelagic larva in this species. Both ocular and genital plates closely covered with tubercles; those near the inner edge of the genital plates being usually elongate, comma-shaped. The anal plates with only a few tubercles near the inner edge. — Peristome with a regular series of 6—7 interradial plates, reaching the mouth edge. The peristomial ambulacral plates rather numerous, 12—13 in larger specimens; they are bent so as to form an obtuse angle (the apex outwards), the pore being situated in the apex of the angle. All peristomial plates with a close, regular series of tubercles along the inner edge. In young specimens the peristome

[1] A. Agassiz & H. L. Clark (Op. cit.) state the outer pores to be larger than the inner. This is not the case in the specimens examined by me, and also in the fig. 1. Pl. 40 of the said work the pores are seen to be of equal size. In the same figure it appears that the pores are more close together than usual in this species.

may be relatively a little larger than in adult specimens, sometimes even larger than the apical system.

Primary spines up to 3 times h.d., gently tapering but ending in a shallow grooved socket, slightly upwards curving. The collar is 3—3.5 cm long, indistinctly furrowed on the upper side, the ridges being more or less distinctly tuberculate, or rather rounded serrate, near the base, which may be conspicuously widened; milled ring very inconspicuous. The lower limit of the cortex layer generally produced in the upper and lower midline. The shaft has 7—8 fine, but distinct longitudinal ridges on the upper side (Pl. LXXXIII. 11), ca. 10 on the under side. In transverse sections it is seen that the anastomosing network, to which the velvety appearance of the surface of the shaft is due, is comparatively open, leaving generally a larger inner hole (Fig. 93. 1).

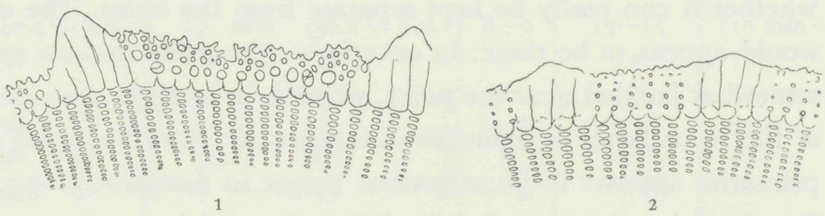


Fig. 93. Part of transverse sections of primary spines of *Acanthocidaris hastigera* (1) and *A. maculicollis* (2). × 66.

The oral primaries are short and broad, not very serrate along the edges. On account of the long collar the short outer part provided with the cortex layer (viz. the shaft) looks more like a shoe with which the spine is tipped (cf. A. Agassiz & H. L. Clark. Op. cit. Pl. 12, b. 18—19). The two proximal spines are true oral primaries, the third—fourth being intermediate between the oral and the ambital primaries.

The secondary spines are slender, up to 6 mm long, flattened, very slightly excavate, gently tapering to a rather sharp point. The marginal ambulacral spines are simple, spiniform, not flattened; they are much more slender than the scrobicular spines, ca. 5 mm long; all the secondaries are rather erect, not appressed. Miliary spines simple, setaceous.

Pedicellariæ. The large, globiferous form with a very irregular lower edge of the terminal opening, with irregular ridges and elevations on the inner side of the valve. The stalk has a distinct limb and is about the same length as the head (0.8 mm). The smaller globiferous pedicellariæ with a more or less distinct end tooth; the stalk, up to 3 times the length of the head. Tridentate pedicellariæ with irregular longitudinal ridges in the blade; head up to 1.55 mm long (cf. A. Agassiz & H. L. Clark. Op. cit. Pl. 11, 1—5. Pl. 12, 1). — Spicules of tubefeet few and irregularly arranged, nearly smooth (Fig. 95. 3).

The colour of the secondary spines uniform brown or with a brown midline, the primary spines of a lighter colour, with a pinkish tinge, sometimes, in younger specimens, slightly banded; the basal part yellowish. The denuded test of a grayish tinge, the interporiferous zone brown, even unto the peristome, very conspicuous against the perfectly white pore-areas. Apical system somewhat darker than the test. Younger specimens have the peristome greenish and the apical system dull greenish-red.

Growth. The specimen of 5 mm h.d. has only 3 ambulacral plates in a series on the peristome, and one interradial plate. In the ambulacra the pore pairs are oblique, the pores close together. At a size of 7 mm h.d. the oculars are already partly insert. The genital pores appear at a size of 17—18 mm h.d. The largest specimen known is 52 mm h.d.

Biology. A specimen was found to contain in its intestinal canal bottom material, with Foraminifera (Polytrema a. o.), small pebbles with Bryozoa, and fragments of a sea-urchin (evidently from the bottom material, not from a sea-urchin that had been eaten by it).

Occurrence. Hawaiian Islands, 57—355 m. Sandy bottom.

Remarks. This species is so closely related to *A. curvatispinis* that it is, in fact, very doubtful, whether it can really be kept separate from the latter. The only characters to distinguish them would appear to be these: in *curvatispinis* the primaries are somewhat more slender and may be somewhat banded near the point, whereas in *hastigera* they are uniform in colour, and the colour of the secondaries is yellowish in *curvatispinis*, dark brown in *hastigera*. Further the collar of the primaries appears to be somewhat longer in *hastigera* (3—3.5 cm) than in *curvatispinis* (2.5 cm). But the primaries may also be slightly banded in *hastigera*, and there is no certainty at all that the yellowish colour of the secondaries in *curvatispinis* is not due to fading (— both the known specimens are dried —). The character pointed out by H. L. Clark (The Cidaridæ) that in *curvatispinis* the primaries are somewhat serrate at the base, while in *hastigera* they are perfectly smooth, is only due to the inadequate description given by Bell; in reality there is no difference at all here. — However, as long as our knowledge of *curvatispinis* is not quite satisfactory, and in view of the fact that one is known only from Mauritius, the other only from Hawaii, it may be preferable to keep them separate for the present.

We have here a very interesting parallel to the case of another Cidarid, *Chondrocidaris gigantea*, likewise known only from Hawaii and Mauritius. Also in this case it is hardly possible to distinguish the two forms, not even to regard one as a variety of the other (See under *Chondrocidaris gigantea*).

The apparently constant character of four oculars being insert, Oc. II alone remaining exsert, is very rare among Cidarids (cf. p. 321—22).

Acanthocidaris maculicollis (de Meijere).

Pls. XLIII. 1—2; XLIV. 1; LIV. 5—6; LXXXIII. 12—15.

Porocidaris maculicollis. De Meijere. 1904. Vorl. Beschr. "Siboga"-Ech. Tijdschr. Ned. Dierk. Vereen. (2) VIII. p. 1.
Cidaris (Cidaris) maculicollis. De Meijere. 1904. "Siboga"-Ech. p. 15, Taf. III. 18, 19, XI, 111—116.
Acanthocidaris maculicollis. H. L. Clark. 1907. The Cidaridæ, p. 224.
Acanthocidaris maculocollis. Lambert & Thiéry. 1914. p. 273.
Acanthocidaris maculicollis. Koehler. 1927. "Investigator" Ech. III. p. 23. Pl. **V. 2, 3; XXIII. 4.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	47 mm	29 mm	19 mm (40.4 % h.d.)	17 mm (36.2 % h.d.)	8—9	13—15	110 mm
2	42 —	28 —	15.5 — (37 —)	18 — (43 —)	8	14	77 —
3	28 —	19 —	ca.14[1] — (ca.50 —)	ca.13[1] — (ca.46 —)	7	12	77 —
4	17 —	10 —	8,5 — (50 —)	8 — (47 —)	6—7	10—11	43 —
5	12 —	7 —	5.5 — (46 —)	5.5 — (46 —)	5	8—9	40 —
6	7 —	3.5 —	3.8 — (54 —)	3 — (43 —)	4—5	6	18 —

Specimen 1 from the Sagami Sea; specimen 2 from the Bay of Ambon, the rest from the Bonin Islands; specimen 1 is in the Tokio Museum.

Shape of test in the larger specimens, so far as can be concluded from not denuded specimens, gently arched, very flattened above, less so below. Apparently circular in circumference, not subpentagonal. — Ambulacra 24—32 % of I.A., the interporiferous zone about twice the width of the pore zone. The marginal series of tubercles very regular, the tubercles being rather small, but nearly contiguous. Inside the marginal series another regular series of tubercles, half the size of the marginal ones; further a quite small tubercle may be found in the lower corner of the plate, the three tubercles of each plate forming an oblique series. In the largest specimen each plate carries three small inner tubercles not regularly arranged. Median line not sunk. The pores are equal-sized, rather wide apart, subconjugate, the separating wall slightly more elevated than in *A. hastigera* (Fig. 92. 1).

Interambulacra. Primary tubercles strongly crenulate, excepting the two—three proximal ones. Areoles well separated, excepting the 2 (3) lower ones. Radiating impressions may be rather distinct as in *hastigera*. Median space about half as wide as the areoles, rather densely covered with tubercles, very much as in *hastigera*.

Apical system of the largest specimens only 37—40 % h.d. otherwise about 50 %. — All the oculars are insert, also the right anterior (II), contrary to *A. hastigera*; in the specimen 12 mm h.d. Oc. II is still exsert, and in the specimen 7 h.d. both II and III are exsert. In a very young specimen of only 2.5 mm h.d. all the oculars are exsert. The ocular plates are of the same shape as in *hastigera*. The genital pores are ca. 1 mm wide in the larger specimens, which thus evidently are females; in the specimen of 28 mm h.d. they are much smaller, this

[1] Cannot be measured exactly without damaging the specimen.

being in all probability a male (Fig. 94); the genital pores have been formed in the specimen of 12 mm h.d. but not in that of 7 mm h.d. In specimen 1 there is a distinct genital papilla, not in specimen 2. In specimen 2 the larger spines on the genital plates are arranged very regularly, forming a beautiful fringe along the outer and inner edge, the rest of the plate covered with small, erect spines, not regularly arranged; the ocular plates with the spines along the inner border somewhat larger, though not forming such a conspicuous fringe as on the genital plates. In specimen 1 the arrangement of the spines on the apical system is less distinct (due to preservation). The tubercles along the edge, especially the inner edge of the genital plates, very conspicuously elongate, comma-shaped, like radiating from the middle of the plate; this is (in specimen 2) made the more conspicuous through the colour, the tubercles being brownish, the plate itself whitish. The anal plates fairly numerous, each with a tubercle at the inner edge. The whole anal area somewhat elevated, arched, not conical. — The peristome usually slightly smaller than the apical system, only in the specimen 2 somewhat larger. It has in the largest specimens ca. 12 ambulacral, 8 interradial plates. In the specimen of 17 mm there are 7—8 ambulacral and 3 interradial plates, in the youngest specimen 4 ambulacral and 2 interradial plates. The peristomial plates otherwise, in regard to shape and tuberculation, like those of *hastigera*.

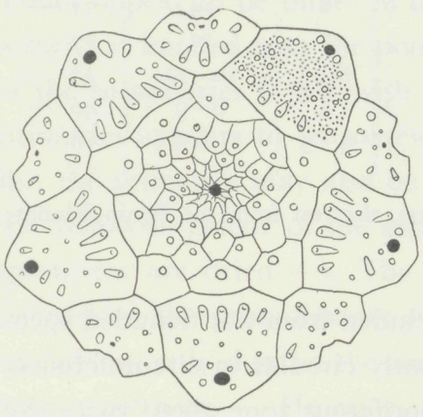


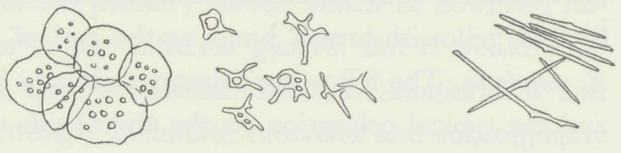
Fig. 94. Apical system of *Acanthocidaris maculicollis*. × 6.

The primary spines are a little more than 2 h.d. in the largest specimen, nearly 3 times h.d. in the specimen of 28 mm h.d., while in younger specimens they may somewhat exceed 3 h.d. They are nearly straight, only some of the longest being faintly upwards bent; they taper very gently from the broad base to a simple rounded point. The collar varies in length from ca. 1.5—3 cm in the larger ambital spines; it has on the upper side generally 5 rather indistinct longitudinal ridges, the 3 median, the longest, may reach to the shaft, the two outer ridges being short; sometimes there may be still another, quite short ridge on each side. The ridges may be provided with rounded serrations or elevations, looking rather like small tubercles. The coloration makes this ornamentation very conspicuous, the elevations being white, separated by more or less angular dark-red spots; these serially arranged spots form a very marked characteristic of the species. The lower limit of the cortex layer fairly regular. The shaft is provided with ca. 16 low, but very distinct, dark coloured longitudinal ridges. The anastomosing network of the surface layer more dense than in *hastigera*, only few small holes being seen in transverse sections (Fig. 93. 2). The oral primaries are flattened, rather distinctly serrate along the edges and slightly curved; only the two proximal ones in each series are true oral primaries; the third has a faint indication of serrations along the edges and forms the transition to the ambital spines.

The secondary spines around the primaries are ca. 5—6 mm long, flattened, not ex-

cavate, gently tapering to a point. The ambulacral spines are narrower, but likewise flattened[1]. All erect, not appressed.

Pedicellariæ. The large globiferous pedicellariæ have a terminal, regular opening, without end tooth, and the inner side of the valve without irregular ridges or elevations (Pl. LXXXIII. 12—13). The stalk has a distinct limb of projecting thorns at the upper end. The largest samples reach a size of 0.5 mm length of head, the stalk being ca. 2 mm long. In the small globiferous there is usually a rather distinct end tooth (Pl. LXXXIII. 14). The larger samples of the tridentate pedicellariæ have the characteristic serrate longitudinal lamellæ in the blade (Pl. LXXXIII. 15). They reach a size of 1 mm length of head, the stalk nearly 2.5 mm. — The tridentate pedicellariæ are numerous in specimen 2, the globiferous pedicellariæ being rather scarce. The inverse holds good for the specimens from Japan and the Bonin Islands. — Spicules of tubefeet as in *hastigera*. The intestinal wall partly, in the upper part, with closely packed, overlapping small plates with few holes in the middle, partly, in the lower part, with more widely spaced irregular spicules (Figs. 95. 1—2). The genital organs with very long, slender spicules more recalling sponge spicules than Echinoid spicules (Fig. 96).



1 2 3

Fig. 95. Spicules from intestinal wall of *Acanthocidaris maculicollis* (1—2); spicules from tubefoot of *A. hastigera* (3). 1.—2. × 120; 3. × 150.

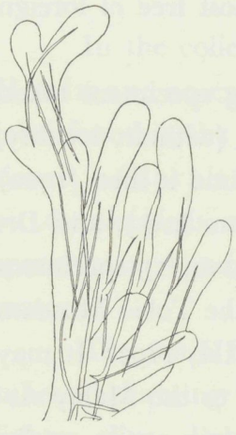


Fig. 96. Part of genital organ of *Acanthocidaris maculicollis*, showing the slender spicules. × 30.

Colour. The primary spines are usually conspicuously banded with red-brown and whitish, on both sides; in the largest specimen they are less distinctly banded, and only on the upper side. The collar has a slight greenish tint and is very markedly designed on the upper side with 5 or (in specimen 1) more longitudinal series of small angular, redbrown spots (cf. above); on the underside of the collar there may be a pair of indistinct transverse bands of reddish-brown, in continuation of the bands on the shaft of the spine; in the largest specimen there is usually a single median series of red spots. The secondary spines are greenish-whitish, with a brownish-red median line; this darker line is distinctly stronger on those spines covering the upper and lower side of the base of the primary spines. In the larger specimen from the Bonin Islands and the one from the Sagami Sea these spines are uniformly reddish-brown, contrasting markedly to the much lighter coloured spines along the lateral sides of the primary tubercles (spine-bases). — On the naked test the interporiferous zone of the ambulacra is dark brown, the test apparently otherwise whitish, the upper side and the apical system darker, brownish-green. In the young specimens there is a greenish tint on the peristome, as in *hastigera*.

[1] De Meijere states that the secondary spines are provided with long and sharp teeth along their longitudinal ridges. These are seen only by a higher magnification and is nothing characteristic of this species, but a common feature in Cidarids.

Development. A very young specimen, only 2.5 mm h.d. is interesting in having the oral primaries of the embryonal type, as known from *Eucidaris metularia* (cf. the author's paper "On the postlarval development of some Cidarids". Mem. Ac. Sc. Copenhague. 8. Ser. XI. 1927). The unpaired interambulacral plate, with its primary spine, has been resorbed, but judging from the character of the proximalmost primaries these represent the Nos. 2 and 3; they have a sharply limited yellowish-brown band at the end of the collar, just as in the corresponding spines in *E. metularia*. The following primaries already have the long collar characteristic of *Acanthocidaris*, and the typical coloration on the aboral side of the collar is already distinct. These spines differ from those of the adult only in their smaller size and in the ridges on the shaft being rather distinctly serrate. The secondary spines on the oral side are still of embryonal character, though not of the youngest type (cf. *E. metularia*). On the peristome are two ambulacral plates in a series, including the buccal plate.

The discovery of the two large specimens proves that this species reaches a size corresponding to that of the two other species. The unfinished condition of the apical spines (the outer layer has not been formed) indicates that even these specimens have not yet reached full size.

One of the specimens examined by Koehler was infested by some parasitic Gastropods (*Mucronalia*?). — Otherwise the spines even of the largest specimens are almost free of foreign organisms, only a few barnacles being found on specimen 2.

Occurrence. The species was hitherto known only in the four young specimens taken by the "Siboga" in the Malay Archipelago, and the eight small specimens (without locality, but, no doubt, from the Indian Ocean) examined by Koehler (Op. cit.). I found it then (1922) in the Bay of Ambon in ca. 180—225 m, rock-bottom, (the specimen of 42 mm h.d.), and Dr. Sixten Bock found it at the Bonin Islands (1914) in depths of ca. 100—180 m, 15 specimens (no information about the character of the bottom). Further the collection of the Tokio Museum contains a single large specimen, labelled Yogashima, Sagami, 20 fathoms, VIII, 1897. It may thus be supposed to occur all over the region from the Sagami Sea, Japan, to the Malay Archipelago and the Indian Ocean. The bathymetrical distribution is thus ca. 40—225 m, as far as hitherto known. — The information available would seem to indicate that it prefers hard bottom (sand, shells, rocks).

Remarks. This species, which was originally referred by de Meijere to *Porocidaris*, on account of its serrate oral primaries, and afterwards to *Cidaris* s. str., on account of its globiferous pedicellariæ, was with full right transferred to *Acanthocidaris* by H. L. Clark. It is very easily distinguished from *A. hastigera* and *curvatispinis* by its strongly banded primary spines and the serially arranged red spots on the collar of the primary spines. Further it seems to be a good distinguishing character that all the oculars are insert, while in *hastigera* Oc. II is, apparently constantly, exsert. Also the tuberculation of the interporiferous zone of the ambulacra is different in the larger specimens. The globiferous pedicellariæ also appear to differ conspicuously, but

this is perhaps less reliable as the larger globiferous pedicellariæ of *curvatispinis* and *hastigera* may possibly not correspond to the large form of globiferous pedicellariæ in *maculicollis* (cf. p. 322).

In several regards this species recalls *Prionocidaris glandulosa* which latter has also upwards curved primaries, crenulate tubercles and subconjugate pores; the only essential difference between these two forms is, in fact, the structure of the primary spines, which is, however, important enough to make it necessary to refer them to two different genera. But it would seem clear that these two species afford the proof of a close connection between *Acanthocidaris* and *Prionocidaris*, the former being, on account of its strongly crenulate tubercles and subconjugate pores, evidently the more primitive.

As with *A. curvatispinis* Lambert & Thiéry (Op. cit.) have also changed the name *maculicollis*, because they think it a barbarism, and have given it the form "*maculocollis*". The two authors are no more fortunate in this case than in that of *curvatispinis*. The form maculicollis is (— I may again refer to the authority of Professor Holger Pedersen —) perfectly correct Latin, whereas the form maculocollis, introduced by Lambert & Thiéry as tip-top Latin, is an obvious barbarism.

Acanthocidaris sp.

In the collection of the British Museum there is a small Cidarid from off Ceylon (Coll. Herdman; no exact locality or depth), which has been thus designated by H. L. Clark on a label found in the jar: "very peculiar, may possibly be a young Acanthocidaris". (It is not mentioned in Clark's Catalogue Rec. Sea-Urch. Brit. Mus.). — There can be no doubt that it is really an *Acanthocidaris*, and, probably, a new species. As there is, however, only a single, very young specimen at hand, it would not seem reasonable to establish a new species on so insufficient material.

The main feature is the colour of the primaries. The collar is greyish-olive, the white tubercles forming three conspicuous series in nearly the whole length of the collar; the shaft is lighter olive, slightly reddish towards the point. The ridges, 5 on the upper side, are white and very conspicuous. The secondaries, which are rounded, scarcely tapering, have a greenish midline. (— Characters in the test it would be useless to try to find at this young stage —). On comparing the primaries of this specimen with those of young specimens of *maculicollis* and *hastigera* it seems quite evident that the Ceylon specimen cannot belong to any of these two species. Whether it is perhaps a young *curvatispinis* is, of course, impossible to say definitely; but it seems rather improbable. Thus we may rather confidently expect that a fourth species of *Acanthocidaris* will prove to exist in the Indian Ocean, at least in the vicinity of Ceylon.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
7.5 mm	4 mm	4 mm (54 % h.d.)	4 mm (54 % h.d.)	4—5	6—7	17 mm

Genus Stylocidaris Mrtsn.

Th. Mortensen. 1909. Echinoidea d. deutschen Südpolar Exp. p. 52, 54.
H. L. Clark. 1925. Catalogue Rec. Sea-Urchins Brit. Mus. p. 3, 22.

Pores not conjugate, the wall usually rising into a more or less prominent elevation; pores on peristome in single series. The tubercles may be crenulate in a greater or less degree. Madreporite not enlarged. Primary spines usually tapering to a simple point; hairs on the surface of the shaft usually simple, not anastomosing, sometimes totally lacking. Large globiferous pedicellariæ without end tooth, with a well developed limb on the stalk. Small globiferous pedicellariæ with a small end tooth; in some species a remarkably transformed, irregular form of small globiferous pedicellariæ occurs among the scrobicular spines on the upper side of test. Tridentate pedicellariæ slender, in one form only (except in *St. rufa*).

Genotype: *Cidaris affinis* Philippi.

This genus comprises a large number of species. Very probably, however, not all the species here referred to the genus do rightly belong there. This particularly holds good of *fusispina*. The primary spines of this species are so different from those of typical *Stylocidaris* that we can say almost with certainty that it cannot belong here; but as the few specimens known are small and probably not adult, it is impossible to characterize such genus satisfactorily (— large globiferous pedicellariæ are wanting —), and it may therefore be preferable to refer it provisionally to the genus *Stylocidaris*.

The species *badia* (H. L. Clark) differs from the other species in the hairs of the primaries forming a well developed, spongy coat, especially in the basal part. Still it seems evident that it should be referred to the genus *Stylocidaris*, not to *Prionocidaris*, to which it was originally referred by Clark; the non-conjugate pores forbid referring it to the latter genus, one of the main characters of which is that of the conjugate pores. It seems to be the nearest related to such species as *St. albidens*.

The three species, *panamensis*, *dubia* and *perplexa*, referred by Clark (Op. cit. 1925) to the genus *Stylocidaris* form a distinct group distinguished from typical *Stylocidaris* by the characters of their primary spines (cylindric, not tapering or even widening towards the end, and with a thick, spongy hair coat) and their large, globiferous pedicellariæ (no limb on the stalk). Though doubtless related to *Stylocidaris*, they are better made a separate genus, *Hesperocidaris* Mrtsn., leaving thus the genus *Stylocidaris* much more clearly circumscribed.

The rest of the species form two main groups, differing in the character of their primary spines. One group, the *affinis*-group, is characterized by having numerous low granules on the shaft, arranged in more or less distinct, longitudinal series, forming no sharp ridges, or at most so towards the end of the spine; in the other, the *bracteata*-group, the primaries are set with sharp, in greater or less degree serrate ridges, in the whole length of the shaft. The difference is very conspicuous when comparing typical examples of the two groups, so that one might rather be inclined to think that they represent different generic types. There are, however, transitional forms con-

necting the two groups (e. g. *albidens*, *brevicollis*), and they must, therefore, all be referred to the same genus.

It is a noteworthy fact that the great majority of the species of this genus are confined to the Indo-Pacific Ocean; only two species, *affinis* and *lineata* occur in the West Indies, the former also in the Mid-Atlantic and Mediterranean.

Whether any fossil species belong to this genus is impossible to decide with certainty. It would seem rather probable that the *Cidaris melitensis* Forbes belongs here, being perhaps the ancestor of the recent Mediterranean species, *affinis*; in any case, there is nothing in the characters of its test or spines to make this suggestion improbable. To the genus *Eucidaris*, to which Döderlein (Jap. Seeigel, p. 42) refers this species, it does not seem so nearly related, at least not to the Atlantic species, *tribuloides*.

Key to the species of Stylocidaris.[1]

1. Collar of primary spines spotted or striped ..... 2.
   Collar of primary spines not spotted or striped ..... 5.
2. Collar with brown, longitudinal stripes ..... 3.
   Collar with purple or reddish-brown spots, but no stripes ..... 4.
3. Secondary spines uniform reddish; interporiferous zone (on denuded test) red ..... *St. brevicollis.*[2]
   Secondary spines with a greenish-olive median stripe; interporiferous zone (on denuded test) olive-greenish ..... *St. albidens.*
4. Usually a single reddish-brown spot on the adapical side of the collar. Surface of the shaft (between the ridges) smooth, shining, without hairs ..... *St. maculosa.*
   Several small, red or purple spots on the collar; surface of shaft covered with low, simple hairs ..... *St. bracteata.*
5. Upper areoles somewhat adapically widened, more or less effluent ..... 6.
   Upper areoles not adapically widened ..... 7.
6. Ambital tubercles usually distinctly crenulate; longitudinal ridges of primary spines smooth ..... *St. tiara.*
   Ambital tubercles not crenulate; ridges of primary spines serrate ..... *St. effluens.*
7. Primary spines greenish-brown banded, with very small, low spinules arranged in numerous close, but distinct longitudinal series ..... *St. calacantha.*
   Primary spines not as above ..... 8.
8. Primary spines usually long and slender, almost cylindrical ..... 9.
   Primary spines rather short and thick, fusiform, not tapering to a fine point ..... 10.
   Primary spines tapering to a rather fine point ..... 11.
9. Primary spines with numerous narrow, rather well defined, red bands; the spinules arranged

[1] It should be emphasized that this key must not be regarded as more than a help in identifying the species of this genus with its many, partly not easily distinguishable species; it can only lead the way towards the species to which the specimens under examination belong. The identification arrived at by the use of the key should, therefore, always be tested by a careful comparison with the descriptions and figures — the more so as the characters used in the key are chosen not so much with regard to their real classificatory value as to their practical value as being the more easily observable.

[2] As the longitudinal stripes on the collar of *St. brevicollis* are not always distinct, this species is mentioned a second time in the key, under division 12.

in distinct longitudinal series. No dark spots at the median end of the horizontal interambulacral sutures ..... *St. annulosa.*
Primary spines, white, only a few of them mostly with 2—3 narrow, reddish bands; the spinules not arranged in distinct longitudinal series. A dark spot at the median end of the upper interambulacral sutures ..... *St. conferta.*

10. Primary spines closely set with low spinules arranged in fairly distinct longitudinal series, not forming smooth ridges in the distal part; whitish, with pinkish bands ..... *St. amboinæ.*
Primary spines in the basal part with 10—12 series of low, rounded tubercles, continuing into sharp, but perfectly smooth ridges in the distal part; brownish, with whitish bands *St. fusispina.*

11. Primary spines light brownish, with numerous low, white spinules, being thus finely spotted .... *St. rufa.*
Primary spines not thus coloured ..... 12.

12. Collar very short, ca. 0.5 mm. — The denuded test with the interporiferous zone of ambulacra conspicuously red ..... *St. brevicollis.*
Collar not very short, ca. 1 mm. Interporiferous zone of ambulacra white or greenish-brown or yellowish-brown ..... 13.

13. Primary spines very long, up to 3 h.d., brown, with whitish bands in the distal part; secondary spines a uniform dark redbrown ..... *St. badia.*
Primary spines scarcely more than 2 h.d., whitish, with faint brownish bands in the distal part. Secondary spines white, or with a dark midline, or quite pink ..... 14.

14. Interporiferous zone usually covered with small tubercles ..... *St. Reini.*
Interporiferous zone rather naked, each plate with only one or two tubercles adradially to the marginal plate ..... 15.

15. Ambulacra half as wide as the interambulacra ..... *St. Lorioli.*
Ambulacra only ca. $^1/_4$—$^1/_3$ as wide as the interambulacra ..... 16.

16. Primary spines with ca. 18 longitudinal series of spinules. Colour usually more or less reddish ..... *St. affinis.*[1]
Primary spines with ca. 12 longitudinal series of spinules. Colour white, only the median ambulacral and interambulacral lines brown ..... *St. lineata.*

Stylocidaris affinis (Phil.).

Pls. XXXVI. 1—7; LXXII. 15.

Cidaris affinis. Philippi. 1845. Beschreibung einiger neuen Echinodermen, nebst krit. Bem. über weniger bek. Arten. Arch. f. Naturgesch. 1845. I. p. 351—3.
Cidaris Stokesii. L. Agassiz & E. Desor. 1846. Cat. rais. Echinod. Ann. Sc. nat. 3. Sér. VI. 1846. p. 324.
Cidaris affinis. M. Sars. 1857. Middelhavets Littoral-Fauna, p. 110.
Leiocidaris affinis. Dujardin & Hupé. 1862. Hist. nat. Zoophytes Échinod. p. 485.
Leiocidaris Stokesii. Dujardin & Hupé. Ibidem.
Orthocidaris affinis. A. Agassiz. 1863. List of Echinod. p. 17.
Cidaris affinis. Heller. 1868. Zoophyten u. Echinod. d. Adriat. Meeres, p. 69—70.
Leiocidaris Stokesii. E. Perrier. 1869. Rech. s. les pédicell. p. 131. Pl. 3, 6 a—c.
Dorocidaris papillata (partim). A. Agassiz. 1872 Rev. of Ech. p. 105, 256.
Cidaris affinis. Wyv. Thomson. 1874. "Porcupine" Ech., p. 726, Pl. LX.
Dorocidaris papillata. H. Ludwig. 1879. Echinod. d. Mittelm. p. 554. (partim).
Dorocidaris papillata. R. Rathbun. 1885. Rep. Ech. Albatross. Gulf of Mexico, 1885. p. 611. (partim).
1886. Cat. Rec. Ech. U. S. Nat. Mus. p. 261.
Dorocidaris papillata. Carus. 1884. Prodr. Faunæ Mediterr. p. 98.

[1] The varieties *cladothrix* and *rubida*, see p. 346.

Cidaris affinis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 19, 35. Pl. **I. 1; VI. 9—10; VIII. 2; IX. 1, 8—9, 11—12, 17—19, 21—24; XI. 1, 22.** Part II. p. 14.
Cidarites affinis. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 95, 101, 104.
Dorocidaris affinis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 8. Pl. 12. b. 1—3.
Tretocidaris affinis. H. L. Clark. 1907. The Cidaridæ. p. 203.
Cidaris affinis. R. Koehler. 1909. Rés. Camp. Monaco. Fasc. XXXIV. p. 213.
Stylocidaris affinis. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 54.
Dorocidaris affinis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 148.
Cidaris affinis. Jackson. 1912. Phylogeny of Ech. p. 95, 96—97, 100.
Dorocidaris affinis. G. Stefanini. 1913. Echin. racc. nel. Mediterr. d. R. N. Ital. "Washington" Arch. Zool. VII. p. 10.
Stylocidaris affinis. Th. Mortensen. 1913. Die Echiniden d. Mittelm. p. 11.
Stylocidaris affinis. H. L. Clark. 1918. Rep. Crin. & Ech. coll. by the Bahama Exp. Univ. of Iowa Monogr. VII. p. 19.
Cidaris affinis. J. Grieg. 1921. Echinod. "Mich. Sars". p. 38.
Stylocidaris affinis. H. L. Clark. 1922. The Echinoderms of the Challenger Bank. Bermuda. Proc. Amer. Acad. Arts & Sci. LVII. p. 361.
Stylocidaris affinis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 23.
Dorocidaris affinis. G. Checchia-Rispoli. 1920. Sul Dorocidaris affinis Philippi. Boll. Soc. Zool. Ital. Ser. IV. Vol. I. p. 46. Tav. I.
Stylocidaris affinis. Koehler. 1921. Faune de France. I. Échinodermes. p. 110.
Stylocidaris affinis Koehler. 1927. Échinodermes des mers d'Europe. II. p. 17. Pl. XII. 18. a—b.
Stylocidaris affinis. Th. Mortensen. 1927. Sur les Échinides du "Travailleur" et du "Talisman". Arch. du Mus. d'Hist. Nat. 6. Sér. II. p. 24.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
43 mm	24 mm	20 mm (46.5 % h.d.)	19 mm (44.2 % h.d.)	7	15—16	48 mm
42 —	24 —	20 — (47.6 —)	16.5 — (39.3 —)	7	13—15	ca. 45 —
37 —	22 —	17.5 — (47.3 —)	16 — (43.2 —)	7	12—14	50 —
33 —	17 —	15 — (45.4 —)	14.5 — (44 —)	6—7	11—13	40 —
30 —	15 —	15 — (50 —)	13.5 — (45 —)	6	11—12	42 —
28 —	15 —	14 — (50 —)	12 — (43 —)	6	10—12	43 —
20 —	10 —	10.5 — (52.5 —)	9 — (45 —)	5—6	11—12	41 —
17 —	9 —	9.5 — (55.9 —)	8.5 — (50 —)	5	10—11	26 —
11 —	5.5 —	5.5 — (50 —)	5.5 — (50 —)	4—5	9—10	23 —
4 —	2 —	2 — (50 —)	2 — (50 —)	4	3—4	4 —
32 —	20 —	14 — (43.8 —)	14 — (43.8 —)	7	10—12	34 —
27 —	15 —	14 — (52 —)	12 — (43 —)	6—7	12—14	40 —
20 —	11 —	10 — (50 —)	9 — (45 —)	6—7	10—12	30 —
18 —	9 —	9.5 — (52.8 —)	7.5 — (41.8 —)	6	10—12	33 —
12 —	6 —	6 — (50 —)	5.5 — (45.8 —)	5	8—10	30 —

The five last specimens are from the West Indies, the rest all from the Mediterranean.

Test usually flattened above and below, sometimes, however, the aboral side is more vaulted, in direct continuation of the beautifully arched sides. Circumference round.

Ambulacra more or less distinctly sinuate. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles fairly large, distinctly mamelonate, nearly or, in the largest specimens, wholly contiguous. Inside the marginal tubercle

each plate carries, in younger specimens, a small tubercle at the lower edge and, in larger specimens, usually another slightly smaller, at the upper edge, nearer the median line, and sometimes a second one at the lower edge of the plate. When these latter tubercles are present, the regular vertical series, formed by the first of these secondary tubercles, is obscured. There is a distinct naked, but not sunk, median space (Pl. LXXII. 15; see also Th. Mortensen: West Ind. Ech. 1910. Pl. 14. 1). Also the secondary tubercles are generally distinctly mamelonate. The pores equal sized, not very distant; the wall is flat, rarely with an indistinct semilunar elevation at the upper side. The furrow separating the wall from the ridge usually very indistinct; the ridge fairly well marked, rounded. The pore zones scarcely sunk.

Interambulacra. Areoles fairly deep, rather small, well separated, usually only the two proximal ones confluent; the subambital ones slightly transverse-oval. The boss low; no trace of crenulation in adult specimens, while in the younger ones the uppermost tubercles are fairly distinctly crenulate. Scrobicular circle not very prominent, the tubercles scarcely larger than the marginal ambulacral ones. The rest of the plate closely covered with rather coarse secondary tubercles, slightly decreasing in size towards the middle of the area, leaving sometimes, not constantly, a narrow, naked, slightly sunk space along the vertical suture. Also on the adradial side of the areole there is usually a rather broad space, similarly closely covered by secondary tubercles, leaving no naked space along the edge. The median area varying considerably in width, from only half to as much as the whole width of an areole. In the largest specimens there is an indication of the secondary tubercles being arranged in horizontal lines, separated by very indistinct furrows.

Apical system about half h.d. (ca. 45—55 % h.d.), generally more or less elevated. The oculars, which are rather large, triangular, as a rule narrowly insert in the larger specimens. Genital pores small, rather distant from the edge. Periproctal plates fairly numerous. The whole apical system closely covered by small, uniformly sized tubercles, leaving scarcely a narrow, naked space along the edge. — Peristome distinctly smaller than apical system, except in the younger specimens. There are 13—14 ambulacral plates in a series in the larger specimens, 3—4 interradial plates, which do not quite reach the mouth edge; the ambulacra do not, however, quite join each other in the interradial midline, thus leaving a rather free passage to the interradial plates.

Primary spines generally not much exceeding h.d., but may, especially in younger specimens reach as much as 2 h.d., rarely more. They are, on the whole, slender, slightly widened in the lower part, tapering very gently towards the end, which is not widened. The shaft has numerous, usually about 18, rather coarsely serrate ridges. The surface otherwise covered by fine bush-shaped, rarely anastomosing hairs. The collar is about 2 mm long, distinctly increasing in thickness towards the milled ring; as a rule there is only a very short, naked part above the collar. The oral primaries are simple, finely longitudinally ridged, but hardly at all flattened or widened. The third is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 4 mm long, flattened, narrowing only

very slightly towards the rather straight cut end. There is hardly any trace of concavity at their end, not even on the oral side of the test. The marginal ambulacral spines of the same general shape, only shorter, ca. 2 mm, but increasing in length on the oral side, and somewhat more pointed. In well preserved specimens there is a conspicuous glandular ampulla at the base of all the secondary spines, even the scrobicular ones.

Pedicellariæ. Reference must be made to the description and figures of the pedicellariæ given in the "Ingolf" Ech., p. 36—37, and the "West Ind. Echini". 1910. p. 11. Pl. XVII. 14[1].

Spicules of the tubefeet of the usual form. The intestinal wall in the lower part with numerous three-radiate spicules, in the aboral part literally paved with small, round, calcareous bodies with a few small holes in the centre.

Colour. Ground colour of the not denuded test whitish, with a more or less pronounced tinge of greenish; the ambulacral midline and the vertical and horizontal sutures brownish; sometimes they may be more violet (Grieg. Op. cit.). The primary spines, when clean, are whitish with more or less distinct brown (more rarely greenish) bands, more pronounced in the distal part of the spine. The collar usually pink. The secondary spines red, or only with a reddish midline of various intensity. When the red colour is well developed, the specimen becomes strikingly beautiful. But the red colour may be so faint that hardly any trace of it is left, and the specimen looks nearly white. The denuded test is whitish, with a slight greenish-brownish tint on the aboral side and farther downwards along the ambulacra. The apical system is somewhat darker; there is generally a darker brownish line across the genital plates.

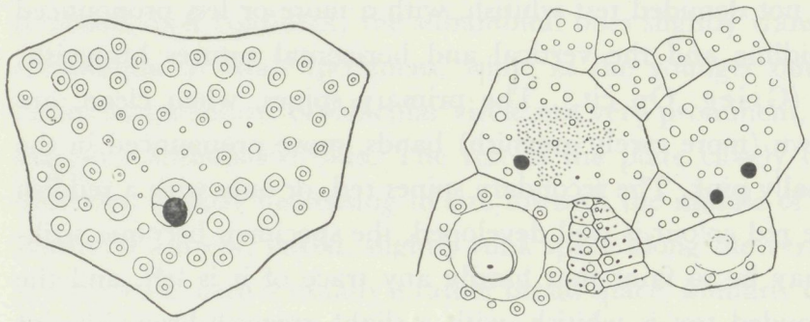
Biology. The alimentary canal has been found to contain bottom-material with fragments (— apparently crushed by the teeth —) of shells and Bryozoans. — The development is unknown, but the small size of eggs and genital openings indicate that it has a typical larva. As pointed out in the author's "Die Echiniden d. Mittelmeeres" (1913, p. 20) there is some probability that the larva figured in Joh. Müller's VII. "Abhandl. über die Echinodermenlarven" Taf. I. 2 is the larva of *Stylocidaris affinis*, but this is still only a conjecture. A young specimen of 4 mm h.d. from off Naples is interesting in its spines on the oral side recalling the embryonal spines, described in the young stages of *Eucidaris metularia*,[2] so that we may well suggest that its postembryonal development will prove to correspond with that of the said species. The madreporite not identifiable with certainty, as no pore is distinctly visible. Several plates on the periproct. The genital pores have, of course, not appeared as yet; they have appared in a specimen of 14 mm h.d. from the Mediterranean, but not yet in one of 11 mm h.d. On the

[1] It may be remarked that when Agassiz & H. L. Clark (Op. cit. p. 8) emphasize the diversity which may be found in the globiferous pedicellariæ, stating that occasionally the large globiferous "are scarcely distinguishable from those of *Dorocidaris* (Pl. 12. b, fig. 1), while not infrequently they are somewhat intermediate as the opening is not quite terminal (Pl. 12 b, fig. 2)", the former figures no doubt represent small globiferous pedicellariæ, and the latter seem to show what are undoubtedly large globiferous pedicellariæ without an end tooth, as they ought to be.

[2] Th. Mortensen. On the postlarval development of some Cidarids. Mem. R. Ac. Sci. Copenhague. 8. Sér. XI. 1927. p. 378.

other hand some young specimens from off the Canaries have the genital pores developed already at a size of 8 mm h.d. The small specimens offer the interesting feature that spines on the genital plates are developed only along the outer and inner margin, forming there a conspicuous fringe, while the rest of the plate is naked; this recalls the condition in the adult *Eucidaris metularia*. It appears that the species does not reach a very large size, the largest specimen on record being only 43 mm in horizontal diameter. According to the researches of Grieg (Op. cit.) adult specimens ca. 34—39 mm h.d.) must be at least two years old. — It appears to form hybrids with *Tretocidaris Bartletti* (A. Ag.). (See: Th. Mortensen. Echin. Deutsche Südpolar-Exp. p. 47 and H. L. Clark. Crin. & Ech. Bahama Exp. 1918. p. 20).

The spines of the adult specimens are as a rule not much overgrown by foreign organisms; Serpulids appear to be the more common of them, but small colonies of Bryozoans, calcareous sponges etc. may occur. In a specimen from the Westindies there is found a beautiful small coral, a *Turbinolia* (?) on one of the spines. Parasites are not known from this species.



1 2

Fig. 97. Genital plate of *Stylocidaris affinis*, showing anomalous development of plates in the genital pore (1); part of anomalous apical system of *Stylocidaris affinis* (2). × 6.

Anomalies. A large specimen, 41 mm h.d., presents the very curious anomaly that some small plates have developed within the genital pores (excepting the one in the madreporite) (Fig. 97. 1); it looks as if the genital pores had become too large and it was necessary partly to fill them up in order to make them smaller; one of the genital plates of this specimen also has two pores. A specimen from the West Indies, 18 mm h.d., has Ocular III partly coalesced with the madreporite, and the Ambulacrum III has given up its relation to the separate part of Oc. III, getting connection instead with the madreporite, in which there is an indication of an ocular pore; genital 3 has two pores (Fig. 97. 2). Another specimen from the West-Indies has the Interambulacrum 2 much disturbed, looks as if it had been crushed. By the reparation one of the plates has got two areoles and primary spines, and a secondary genital pore, besides the normal one, has appeared in the interambulacral midline, between plates 1 and 2 (Pl. XXXVI. Fig. 6).

Varieties. The main question here is this, whether the West-Indian specimens can be distinguished from the Mediterranean form as a separate variety. While in general they are so similar that it seems rather impossible to find in any way reliable distinguishing characters, it appears that there is a tendency to some difference in the apical system, Jackson (Op. cit. p. 96) having found that in the Westindian form 30 % of the specimens have all oculars insert, while in the Mediterranean form 53 % of the specimens examined had all oculars insert. This might indicate that the Westindian (or the Mediterranean form — whichever is to be regarded

as the original type —) is about to develop along a separate line. Also the colour is slightly different, the Westindian specimens being in general somewhat darker, the midline of the secondaries being of a more purplish tint, not bright red as in the Mediterranean form. (The fact mentioned in the "Ingolf" Ech. that tridentate pedicellariæ were not found by the author in the Mediterranean specimens, whereas they were found in numbers in Westindian specimens, does not mean any real difference between the two forms, since both Clark and Stefanini have found them in specimens from the Mediterranean, and on the other hand, they may also be lacking in specimens from the Westindies). But then it is a remarkable fact that the species has not been found at the Azores, where so much dredging has been done. If it should ultimately prove that the species does not occur in the Mid-Atlantic, but only in the vicinity of Africa (besides the Mediterranean) and in the Westindian Seas, we shall evidently have to recognize the Westindian form as representing a separate variety of *affinis*, in spite of the small differences observed between the two forms.

Occurrence. In the Mediterranean this species is known from off Tripolis to the West Coast of Italy and Sicily. In the Atlantic it has been found off Madeira and the Canaries down to Cape Verde, while it is not known North of Cape Sagras. In the West Indies it appears to occur all over, from Barbados to the Gulf of Mexico and off Florida and Bermuda (the Challenger Bank;) it is especially extremely numerous on the Pourtalès Plateau. Bathymetrical distribution ca. 30—1000 m.

It would seem rather probable that the fossil *Cidaris melitensis* (Forbes) Wright from the Miocene deposits of Malta and the West Indies is nearly related to *St. affinis*, perhaps the direct ancestor of it. It is very interesting to see that like the recent species it occurred both in the Mediterranean and the West Indies.

Remarks. For a long time this species was confused with *Cidaris cidaris* (= *Dorocidaris papillata*) on the authority of A. Agassiz who declared it identical with the latter (Rev. of Ech. p. 105); also Wyv. Thomson ("Porcupine" Ech., p. 726) remained in doubt as to its specific value. The present author restored it to specific rank ("Ingolf" Ech. I. 1903) and even maintained it to belong to another genus. While nobody now denies its claim to specific rank, its generic position has been much disputed, but in my opinion, with which also H. L. Clark has agreed, there can be no doubt that it must be referred to a separate genus, *Stylocidaris*, the genotype of which it represents.

The species is very closely related to the Pacific species *Stylocidaris Reini* (Döderlein) from which it differs mainly in the less closely tuberculated interporiferous zone of the ambulacra, in the not excavate secondary spines and in the general coloration.

Stylocidaris lineata Mrtsn.

Stylocidaris lineata. Th. Mortensen. 1910. W. Indian Echinoids. p. 10. Pls. **4—6; 7. 3—5; 14. 10; 16. 6, 9; 17. 4, 8.**
Stylocidaris affinis, var. *lineata.* H. L. Clark. 1918. Crin. & Echin. Bahama Exp. p. 20.

For description reference must be made to the author's work quoted.

This species differs from *St. affinis* mainly in its white colour, in its more naked interporiferous ambulacral zone and in its longer and coarser primary spines, which have as a rule only 12 series of spinules, while in *affinis* there are usually ca. 18 of them. Further there is generally a conspicuous smooth, shining neck above the collar, whereas in *affinis* this part is mostly very narrow and inconspicuous. On the other hand the difference in the tridentate pedicellariæ, pointed out in the original description, is scarcely reliable.

The species is known only from the West Indies, ca. 100—500 m.

According to H. L. Clark (Op. cit.) there are so many transitional specimens that he does not think it possible to accord *lineata* more than variety rank. Possibly he is right; however the fairly rich material available to me does not offer such transitions that there can be any doubt whether a specimen belongs to *affinis* or *lineata*; and it may also be suggested that the new character pointed out here, in the number of the series of spinules, perhaps the most valuable of all the characters, will help to identify with certainty the specimens regarded as intermediate. Anyhow, the typical form is so different from the true *affinis* that it must be kept distinct from the latter — whether as a species or only as a variety is of minor importance.

To Clark's suggestion (Op. cit.) that the white colour might perhaps be due to fading in alcohol and that "if there is more or less of a reddish tinge in life, the variety would be difficult to maintain" may be remarked that I did notice the white colour when dredging the type specimens (off Frederiksted, St. Cruz, in 1906), and that as the brown lines have kept very finely till now (1927), and as *St. affinis* otherwise keeps its colour excellently in alcohol, this suggestion of the white colour of *lineata* being due to fading is highly inprobable.

Stylocidaris Reini (Döderlein)

Pls. XXXV. 1—9; LXXII. 17—19; LXXXIV. 1—11.

Dorocidaris papillata. A. Agassiz. 1881. "Challenger" Ech. p. 38. (partim).
Cidaris (Dorocidaris) Reini. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ, p. 7. Taf. **IV. 1—7; VIII. 4. a—d.**
Phyllacanthus annulifera. Bell. 1898. Rep. Echinod. coll. Willey. Willey's Zool. Res. II. p. 134.
Cidaris Reini. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 19, 37.
Cidaris Reini. De Meijere. 1904. "Siboga" Ech. p. 5. Taf. **I. 2—3; XI. 103—108.**
Dorocidaris Reini. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. Albatross. 1906. Bull. Mus. C. Z. LI. p. 111 (partim).
Dorocidaris Reini. A. Agassiz & H. L. Clark. 1907. Hawaiian Echini. Cidaridæ. p. 10. Pl. **3. 1—14.**
Tretocidaris Reini. H. L. Clark. 1907. The Cidaridæ, p. 207.
Stylocidaris Reini. Th. Mortensen. 1909. Echinoidea d. deutsch. Südpolar Exp. p. 52, 54.
Dorocidaris Reini. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Stylocidaris Reini. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 25.
Stylocidaris Reini. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 292. Pl. **66. 2; 67. 2.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	49 mm	28 mm	24 mm (49 % h.d.)	21 mm (43 % h.d.)	7—8	16—17	63 mm
2	41 —	26 —	20.5 — (50 —)	18 — (44 —)	7	15—16	60 —
3	41 —	24 —	21 — (51 —)	18 — (44 —)	7	16—17	65 —
4	37 —	22 —	18 — (48.7 —)	15 — (40.5 —)	6—7	14—15	68 —
5	34 —	23 —	17 — (50 —)	16 — (47 —)	7	14—15	64 —
6	31 —	16 —	16 — (51.1 —)	14 — (46 —)	5—6	14—16	52 —
7	27 —	14 —	15 — (55.5 —)	11.5 — (42.6 —)	6	14—15	58 —
8	22 —	12 —	13 — (59 —)	10.5 — (48 —)	5	13—14	55 —
9	15 —	7 —	7.5 — (50 —)	7 — (46.6 —)	5	8—9	ca. 35 —
10	14 —	7 —	7 — (50 —)	6.5 — (46.4 —)	5	9—10	35 —
11	11 —	5.5 —	5.5 — (50 —)	5.5 — (50 —)	5	7—8	21 —
12	52 —	30 —	26 — (50 —)	21 — (40.4 —)	6—7	13—15 (16)	?
13	50 —	33 —	26 — (52 —)	22 — (44 —)	6—7	16—18	ca. 70 —
14	38 —	21 —	20 — (52.6 —)	17 — (47.4 —)	6—7	14—16	55 —
15	36 —	19 —	19.5 — (51.4 —)	16 — (44.7 —)	6 (7)	14—16	55 —
16	29 —	16 —	16 — (57 —)	12 — (41.4 —)	6	14—16	48 —

Specimens 1—11 are of the typical form, 12—16 of the var. *cladothrix*. Specimens 1—4 and 12—13 are from off Kiushiu, Japan; specimen 5 from the Sagami Sea, Japan; specimens 14—15 from off Mindanao and the rest from off the Kei Islands. All in the Copenhagen Museum.

Test rather low, flattened above and, sometimes somewhat less so, below. Sides strongly arched; circumference round or subpentagonal.

Ambulacra rather conspicuously sinuate; interporiferous zone about twice the width of a pore zone, sometimes, in larger specimens, not much more than the width of a pore zone, the latter being there comparatively broader. Marginal series of tubercles very regular, the tubercles rather small, not very distinctly mamelonate; they are contiguous in larger, scarcely so in younger specimens. The interporiferous zone otherwise closely covered by small tubercles, among which the one at the lower edge of each plate — the first to appear, and the only one present in young specimens and on the uppermost plates in the adult — is the largest and forms more or less distinct longitudinal series. Usually there is no naked vertical midline; sometimes, however, it may be quite distinct, as was the case in the type-specimen (Döderlein. Op. cit. p. 7). The whole interporiferous zone is flat and scarcely elevated above the pore zones. Pores equal-sized, or the outer one slightly the larger, separated by a fairly broad wall, which is in larger specimens almost flat, while in younger specimens, and on the oral side in the larger specimens there is a distinctly raised, semilunar elevation at the upper edge of the wall. The ridge very inconspicuous, scarcely differentiated from the wall (Pl. LXXII. 17—19).

Interambulacra. Areoles rather deep, well separated, except the 2—3 proximal ones, which are more or less distinctly confluent, especially in larger specimens; they are of medium size, the subambital ones somewhat transverse-oval; the boss rather low, the mamelon fairly small. In young specimens there may be a more or less distinct crenulation on the upper side of

the uppermost tubercles. Edge of areoles not distinctly elevated, but the scrobicular circle fairly conspicuous, the tubercles being about twice the size of the marginal ambulacral tubercles. Outside the scrobicular circle the plates are closely covered by smaller tubercles, gradually decreasing in size towards the median line, which is distinct enough, though scarcely sunk; generally there is no naked space along the median line (as was the case in the type specimen). On the adradial side there is in larger specimens quite a broad edge covered with small tubercles, in younger specimens there is generally room for only a few smaller tubercles between the scrobicular circle and the adradial edge of the plate. The median space is about half the width of an areole.

Apical system (Fig. 98) mostly about half h.d., varying from ca. 49—59 %. — It is usually quite flat, but may sometimes be slightly elevated. Its outline is as a rule nearly circular. Oculars generally narrowly insert; madreporite hardly enlarged. Genital pores small, rather distant from the edge. Periproctal plates fairly numerous. The whole apical system in the adult closely covered by small tubercles, those along the outer and inner edge of the genital plates sometimes slightly enlarged, more or less distinctly elongate. Usually there is a narrow bare edge along the inner side of the genital plates. In young specimens the genital and ocular plates are as a rule naked in a greater or less degree in the middle.

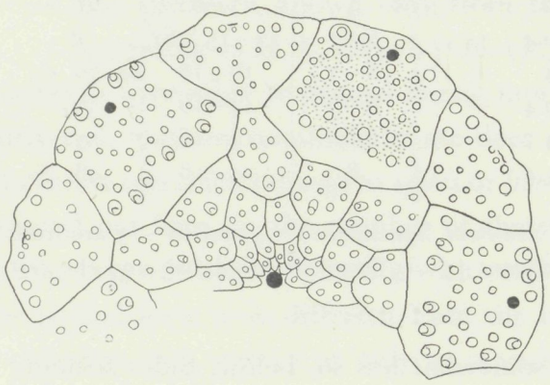


Fig. 98. Part of apical system of *Stylocidaris Reini*. × 4.

Peristome distinctly smaller than the apical system, ca. 40—50 % h.d., only in the youngest specimens it may be as large as the apical system. There are 16—18 ambulacral plates in a series in the largest specimens, ca. 8—10 interradial plates in a fairly regular series, which may reach almost to the mouth edge. The peristome is generally flat.

Primary spines. The upper ambital primaries reach a length of ca. 1.5—2 h.d. They taper very gently to a rounded, not widened point. They are closely covered with spinules of uniform size, arranged in usually very regular, longitudinal series to a number of ca. 12—15; towards the point they gradually become lower, and may here form simple ridges. Sometimes the spinules are rather sharp and quite erect or even downwards curved. The general surface between the ridges, and the ridges and the basal part of the spinules themselves are seen on fresh, well cleaned spines to be closely covered by low, fine and simple hairs. Just above the collar there is as a rule a rather conspicuous smooth, shining neck, about the length of the collar or even a little longer. The collar is about 2 mm long, generally markedly thickening towards the milled ring, which may be more or less prominent. Oral primaries simple, smooth, sometimes rather distinctly longitudinally ridged; the second or third only slightly flattened and widened in the outer part. The 3rd—4th already of the typical form, differing from the ambital spines only in their smaller size.

Secondary spines not strongly appressed. Scrobicular spines 4—5 mm long, usually somewhat concave, slightly tapering towards the rounded point. Marginal ambulacral spines of the same general shape as the scrobicular spines, but only about half the length of the latter; miliary spines simply pointed, in well preserved specimens with a glandular ampulla at the base.

Pedicellariæ. Large globiferous fairly common, of the usual type, with the valves somewhat varying in shape (Pl. LXXXIV. 1, 3—7); sometimes they may be finely spinous on the inside. Small globiferous (Pl. LXXXIV. 11) numerous, of various sizes, up to the same size as the large form[1]. A bivalve sample is represented in Pl. LXXXIV. 8. Abnormal, irregular, short-stalked pedicellariæ (Pl. LXXXIV. 9—10) may occur among the upper scrobicular spines. Tridentate pedicellariæ (Pl. LXXXIV. 2) with slender valves, joining only in the outer part; they reach a size of ca. 1.5 mm length of head. — Spicules of tubefeet of the usual form. The wall of the intestine (aboral part) studded — or rather paved — with small round plates with only few holes, like those of *Prionocidaris*. In the lower part only few, three-radiate spicules (Fig. 99).

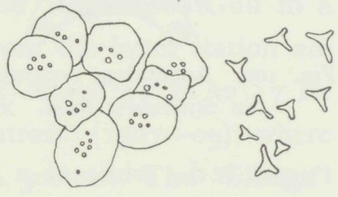


Fig. 99. Spicules from the intestinal wall of *Stylocidaris Reini*. × 125.

Colour. In general the colour is whitish, but as a rule the apical system is darker coloured, not rarely (— especially in specimens from off the Kei Islands —) of a very conspicuous dark purple. This darker colour may often be confined to the genital plates. Sometimes it continues over the upper part of the interambulacra. In young specimens the dark colour may be limited to small spots on the apical plates and the upper part of I. A. The primary spines are in general whitish with some indistinctly limited bands of a delicate pinkish colour; but they may be uniformly whitish or greenish. One of the "Siboga" specimens is stated to have vaguely limited broad dark-green bands ("Siboga" Ech. p. 6). The secondaries with a more or less conspicuous median stripe of reddish or green. In the "Albatross" Cidaridæ is mentioned and figured (p. 293, Pl. 66.2; 67.2) a nearly pink specimen; a similar specimen was found by the author off the Kei-Islands; contrary to the "Albatross"-specimen it has unusually short and slender spines, but otherwise it is a typical *Reini*. — The denuded test white, only the apical system, especially the genital plates, a more or less conspicuous reddish-brown or greenish.

Biology. In a specimen from Japan (var. *cladothrix*) the intestine was filled with bottom-material, containing pieces of shells and calcareous worm-tubes, also tubes of *Hyalinoecia* and parts of Hydroids. — Barnacles are often found attached to the spines, especially some specimens from off Tucuran (Mindanao) are quite overgrown with them (Pl. XXXV. 4). Also worm-tubes and sometimes Ophiurans or Actinians are found on the spines. Tufts of Hydroids are likewise often found attached to the end of the spines.

[1] According to Agassiz & Clark the end tooth may often be wanting in the small globiferous pedicellariæ. I have found this to be very rarely the case, and then only in a few samples, while in most of them it is well developed. May not the end tooth have been broken off in the many cases observed by Agassiz & Clark? That has, at least, very decidedly been the case in nearly all the samples without an end tooth, which I have observed.

The peculiar Synaptid *Tæniogyrus cidaridis* Ohshima was found on a few specimens from off the Kei-Islands, also a Lepidonotid worm has been found on a specimen. Parasites have not been observed in this species, but it would seem that it is not rarely attacked by other animals, most probably snails. In some cases small parts of the test are devoid of spines, covered by a brown skin — as if the skin and spines had been gnawed off and the wound was about to heal again. In a few cases there has, evidently, been a hole in the test, and it has healed up again, being closed by a quite irregular plating (Fig. 100). In one specimen there is a round hole in the test; no doubt this specimen was about to be eaten by a snail, when it was overhauled by the dredge to find a more noble death in the naturalist's jar.

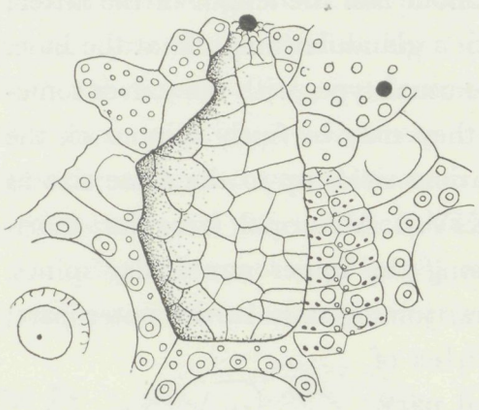


Fig. 100. Anomalous reparation of test in *Stylocidaris Reini*. × 8.

Genital pores are not yet developed in a specimen of 11 mm h.d., while at a size of 14 mm h.d. they have appeared. The large specimens of ca. 50 mm h.d. make the impression of having reached full size.

Var. **cladothrix** Mrtsn.

Stylocidaris Reini, var. *cladothrix*. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 293. Pls. **65.6—7; 66.1; 67.1; 75.4.**

This variety differs from the typical form only in the shape of the hairs on the primary spines, these being bushshaped and rather coarse, while in the typical form they are very small and simple. Other constant characters distinguishing it from the typical form do not seem to exist — and also specimens, showing the hairs rather intermediate, may occur. As, moreover, both forms occur together, from Japan to the Kei-Islands, it will be out of the question to regard this form with the coarser hairs as more than a variety — it might perhaps rather be more appropriate to designate it only as a forma.

Var. **rubida** Mrtsn.

Stylocidaris Reini, var. *rubida* Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 295. Pls. **63.2—3; 74.6—7.**

Differs from the type and the forma *cladothrix* in the red-banded primaries. The hairs of the primaries simple as in the typical form. Also between this variety and the typical form there are transitions so that it is hardly possible to assign to it at higher rank than that of variety. However, only few (4) young specimens are known, so that the final judgment of this form — which would seem to be more distinct than *cladothrix* — must be put off till more and better material becomes available.

One more variety should perhaps be distinguished. — From the Australian Museum, Sydney, I have had for examination a specimen from Bowen, Queensland (labelled *Phyllacanthus annulifera*) which is, at any rate, nearly related to *St. Reini* (Pl. XXXV. 3). It differs in having

only one tubercle on each ambulacral plate adradially to the marginal tubercle, in the primaries being more abruptly pointed and with rather distinct redbrown rings. Also the valves of the large globiferous pedicellariæ are more elongate and slender than I have seen them in *St. Reini* (Pl. LXXXIV. 4). Oculars all insert, rather broadly, except Oc. II, which is only narrowly insert. The apical system is not conspicuously darker coloured. Otherwise as the typical *St. Reini* (also in the hairs of the spines).

So long as only a single specimen of this form is known, it must be left undecided whether we have here a separate a variety of *St. Reini*, or perhaps even a separate species.

Occurrence. This species was originally found in the Sagami Sea (Döderlein), where it was taken again in 1902 by the "Albatross" (off Suno Saki, 160—285 m.) and again in 1914 by the author (700 m.). The "Albatross" further found it (1906) off Kagoshima Gulf in a depth of 273 m. (Station 4933, not St. 4936 — the two specimens from the latter station are *Stylocidaris fusispina*, cf. p. 383), and the present author dredged it (1914) at 128° 11′ E. 32° 17′ N. ca. 200 m. It was taken at the Philippines in 236—324 m. by the "Albatross" (1907—09), where also I took some specimens in 1914 (S.W. of Tucuran, Mindanao, ca. 500 m.). The "Siboga" took it in the vicinity of Timor (112 m.)[1] and off the Kei-Islands, in which latter place several specimens were taken by the present author in 1922. Further the specimens from Milne Bay, New Guinea, and from New Britain recorded as *Phyllacanthus annulifera* by Bell in his report on the Echinoderms of Willey's Zool. Results (II. p. 134) belong to *St. Reini* (the former of these I have examined in the Museum of Cambridge, the latter was reexamined by H. L. Clark. (Cat. Rec. Sea-Urch. Br. Mus. p. 24). Finally a specimen from Bowen, Queensland, is mentioned above. — The species may thus be supposed to be distributed from Southern Japan to the Molluccan Sea and to Queensland and New Britain; its centre of distribution, evidently, is the Malay region. The known bathymetrical distribution is ca. 100—700 m.

Remarks. This species was, as a matter of fact, first found by the "Challenger" (St. 204); but the specimen was erroneously identified by Agassiz as "*Dorocidaris papillata*", and Döderlein was the first to recognize the species. It is the Pacific representative of *Stylocidaris affinis* of the Atlantic region, these two species being evidently closely related. Among the other *Stylocidaris*-species *St. amboinæ* and *Lorioli* appear to be the nearest relatives. That it should be closely related to *St. bracteata*, as maintained by H. L. Clark (The Cidaridæ, p. 207) I cannot agree, and, therefore, I cannot join either in his astonishment that Döderlein "makes no reference whatever" to *bracteata*, when discussing the relations of his "*Dorocidaris*" *Reini* — the more so as

[1] H. L. Clark (The Cidaridæ, p. 207) states as his opinion that the "Siboga"-specimens "might just as naturally be called *bracteata*". This seems rather bold. As he has, apparently, not himself examined these specimens, it would seem that his only reason for this contention is the fact that the species was, at that time, otherwise only known from Japanese Seas. There is nothing in the description given by de Meijere which might lead to a suggestion of these specimens being in reality *bracteata*, and the two figures, Pl. I. 2—3, though not very clear, certainly show that the primary spines are not of the *bracteata*-type. I have examined the specimens in Amsterdam and find them correctly identified.

the species *bracteata* was at that time practically unknown, the description of the latter species in the "Challenger" Ech. conveying no idea of what it really looks like, and the only figures given of it representing — very poorly so — a primary spine and a small globiferous pedicellaria. H. L. Clark, who had access to the types or cotypes of the species established by Agassiz, evidently never realized what trouble the poor descriptions in Agassiz' works caused his fellow-workers abroad.

When Döderlein (Op. cit. p. 8) thinks *Reini* very similar to "*Dorocidaris papillata*", this is evidently due to the fact that at that time *Stylocidaris affinis* was taken to be identical with *D. papillata*. To the real *Dorocidaris papillata* (= *Cidaris cidaris*) it has no nearer relation, while it is, as already stated, closely related to *St. affinis*. Döderlein further thinks it related to (*Austrocidaris*) *canaliculata*, on account of the naked, sunken interambulacral median line in the type specimen, and he refers for this reason also *canaliculata* to *Dorocidaris*. This is, of course, out of the question, the more so as this naked, sunken median line is rather exceptional and by no means characteristic of *St. Reini*.

Stylocidaris amboinæ Mrtsn.

Pls. XXXVI. 8; XXXVII. 1—2; LXXII. 5—6; LXXXV. 21—23.

Phyllacanthus baculosa. A. Agassiz. 1881. "Chall." Ech. p. 39.
Stylocidaris amboinæ. Th. Mortensen. 1928. New Cidaridæ. p. 71.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	40 mm	20 mm	19.2 mm (48 % h.d.)	17 mm (42.5 % h.d.)	7	ca. 18	45 mm
2	31 —	15 —	15 — (48.4 —)	13 — (42 —)	6	13—15	40 —
3	24 —	13.5 —	12.5 — (52 —)	11 — (46 —)	6	12—14	35 —

Specimen 1 is in the British Museum ("Challenger", St. 201); spec. 2 is the type.

Test very flattened above and below; sides strongly arched, circumference round.

Ambulacra rather distinctly sinuate. Interporiferous zone about twice the width of a pore zone in the larger specimens, somewhat less so in the smaller one. Marginal series of tubercles very regular, the tubercles nearly contiguous; they are very distinctly mamelonate in the type, less so in the smaller specimen. Inside the marginal series the whole zone is closely covered by relatively large secondary tubercles which are, especially in the type specimen, of a uniform size (here also distinctly mamelonate), showing no arrangement in vertical series (Pl. LXXII. 5—6). Between the tubercles are found numerous miliary granules (carrying pedicellariæ). The whole interporiferous zone perfectly flat, with no naked midline. The pores are rather small, equal-sized, fairly distant; the wall nearly flat, the ridge low, but fairly distinct in the type specimen; in the smaller specimen the whole pore zone is perfectly flat, the ridge not separated off from

the wall by the usual furrow. — There is no trace of the semilunar elevation on the wall, so conspicuous a feature in younger *St. Reini*. The pore zones slightly sunk.

Interambulacra. Areoles not deep, well separated, only the 2—3 proximal ones confluent; the subambital ones transverse-oval. A slight crenulation is found on the uppermost ones. Scrobicular circle not very prominent, the tubercles about twice the size of the marginal ambulacral tubercles. Outside the scrobicular circle the plates closely covered by smaller tubercles, gradually decreasing in the size towards the median line, which is not sunk or naked, while the sutures are otherwise rather sharp and distinct. Also on the adradial side of the scrobicular circle there are some small secondary tubercles.

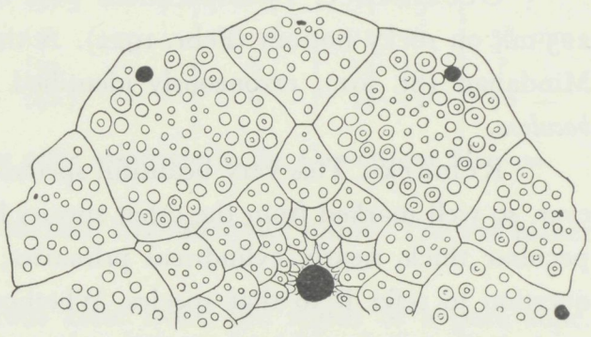


Fig. 101. Part of apical system of *Stylocidaris amboinæ*. × 6.

Apical system about half h.d. Ocular plates all insert, though rather narrowly. Genital pores near the edge, small, with a fairly large genital papilla. Periproct with comparatively few plates, not, or only slightly elevated. The whole apical system closely covered with tubercles, somewhat larger at the outer and inner edges of the genital plates and the outer edge of the oculars (Fig. 101). The peristome somewhat smaller than the apical system, flat. There are 11—12 ambulacral plates in a series (in the smaller specimen) and a regular series of 6 interradial plates, reaching almost to the mouth edge.

Primary spines. About 1—1.3 h.d., rather unusually thick, 4 mm in the type specimen, tapering only very slightly, ending rather abruptly, so as to be almost cylindric. The point is not widened, but more or less abruptly cut. The shaft is closely set with numerous small, uniformly sized spinules, which are in the smaller specimen distinctly arranged in longitudinal series, while in the two larger specimens they are mostly not arranged in distinct series. The hairs rather coarse, bushshaped, as in the f. *cladothrix* of *St. Reini*. The collar is scarcely more than 1 mm long, but there is a conspicuous, up to more than twice as long neck. Oral primaries quite simple, straight; the 3rd—4th transitional to the ambital spines.

The secondary spines are almost rectangular, flat or slightly concave; the scrobicular spines are 3—4 mm long. The marginal ambulacral and the miliary spines of the same general shape, only much smaller. The secondaries are not very closely appressed.

Pedicellariæ. Large globiferous pedicellariæ fairly numerous, of the typical form, the blade more or less thorny, partly with rather coarse holes (Pl. LXXXV. 21). The small globiferous rather characteristic, compressed, with the dorsal side very convex (Pl. LXXXV. 22—23); the smaller ones are exceedingly numerous. Tridentate pedicellariæ are not found on any of the specimens. — Spicules of the tubefeet slender rods of the usual type.

Colour. General colour of test whitish. The genital plates are dark-brown or greenish,

forming a very conspicuous star-shaped figure. In the type specimen also the upper horizontal sutures of I.A. of the same dark colour. Primary spines of a beautiful pinkish hue, in the type specimen with numerous white bands; in the two other specimens the bands are much less distinct. In the "Challenger" specimen the collar has a slight greenish tint. Also the primaries of the oral side distinctly banded, the general colour being here more reddish-brown. The secondaries with a redbrown, or, in the smaller specimen, greenish-brown median stripe. The naked test white, only the genital and periproctal plates greenish.

Occurrence. Two specimens were dredged by the author in the Amboina Bay, 180—225 m., on rocky bottom (Febr. 1922). A third specimen was dredged by the "Challenger" off Mindanao (St. 201), erroneously identified by Agassiz ("Chall." Ech. p. 39) as *Phyllacanthus baculosa*.

Remarks. This very beautiful species is, evidently, nearly related to *St. Reini*. It is, however, so well marked from the other species by various characters: the ambulacral structure, the peculiar thick, nearly cylindrical primaries, the pedicellariæ and the colour, that it is out of question to refer it to that species. Whether a larger material will show transitional forms to exist, so that it should perhaps rather be regarded only as a variety of *St. Reini*, it is impossible to say. Judging from the material available it seems the only rational course to regard it as a distinct species.

The specimen from the "Challenger" Stat. 201 (off Mindanao, 7° 3′ N. 121° 48′ E., 82—103 fms.) mentioned by Agassiz (Chall. Ech. p. 39) as a peculiar form of "*Phyllacanthus*" *baculosa*, evidently belongs here (examined by the author in the British Museum, June 1926). It appears that H. L. Clark has overlooked the specimen, as it is not mentioned in his Catalogue of the Recent Sea-Urchins of the British Museum.

Stylocidaris annulosa Mrtsn.

Stylocidaris annulosa. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 296, Pl. **63. 1; 64. 1—3; 65. 8; 75. 3; 80. 7—11.**

This species is very easily recognizable by its long, slender primary spines, banded with numerous narrow red bands, by its unusually slender secondary spines, and by its large, flat areoles.

For the full description and figures, see the work quoted.

Known only from the Philippine Seas, in depths of 186—194 m.

Stylocidaris conferta (H. L. Clark)

Pls. XXXVII. 3—7; LXXII. 14; LXXXV. 30—32.

Cidaris conferta. H. L. Clark. 1916. "Endeavour" Ech. p. 100. Pl. **XXXVIII. 1—4.**

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1. 43 mm	27 mm	20 mm (46.5 % h.d.)	16 mm (37.2 % h.d.)	7	16—17	?
2. 40 —	27 —	19.5 — (48.8 —)	15 — (37.5 —)	6—7	14—15	?
3. 35 —	20 —	17 — (48.6 —)	14 — (40 —)	5—6	15—16	58 mm
4. 32 —	20 —	17 — (53 —)	12.5 — (39 —)	6	14—15	?
5. 27 —	16 —	13 — (48.1 —)	11 — (40.7 —)	6	13—14	70 —

Specimen 3 in the Australian Museum, Sydney, the other specimens in the Copenhagen Museum.

Test rather flattened above and below; sides arched, circumference round. The test rather thin and fragile.

Ambulacra distinctly sinuate. Interporiferous zone twice the width of a pore zone. Marginal series of tubercles regular, the tubercles nearly contiguous (in larger specimens). Adradially to the marginal tubercle each plate carries one fairly large tubercle at the lower edge, and often also one at the upper edge, nearer the midline, the arrangement in vertical lines being thereby obscured. A fairly distinct, scarcely sunken, naked midline. Pores about equal-sized; wall rather narrow, in its upper part raised into a rounded tubercle, which slopes gently downwards into the low ridge; furrow scarcely distinct. The pore zone not sunken (Pl. LXXII. 14).

Interambulacra. Areoles not very deep; only the proximal ones transverse-oval. They are well separated, there being some small tubercles between the adjoining scrobicular rings of the upper ones; only the two (three) proximal ones confluent. The boss is remarkably low and the mamelon small. No trace of crenulation. The scrobicular ring fairly conspicuous, the tubercles about twice the size of the marginal ambulacral tubercles. Outside the scrobicular ring the plates are rather closely covered by smaller tubercles gradually decreasing in size towards the scarcely naked midline, which is rather distinctly sunken, especially at the median end of the horizontal sutures. Also on the adradial edge of the plates there are some secondary tubercles outside the scrobicular ring. Median area about half the width of an areole.

Apical system circular in outline, not raised. Oculars usually insert, more or less broadly, all of them or some of them; more rarely all of them exsert, as in Pl. XXXVII. 4. Genital pores near the outer edge, small, the female pores evidently not larger than the male pores — judging from the fact, that in all the (11) specimens examined the pores are of the same small size. The whole apical system rather closely covered by small tubercles of uniform size; some of those along the inner edge may be somewhat elongate; the inner edge may remain bare to a various extent (Fig. 102).

Peristome distinctly smaller than apical system, flat, not conically protruding; there are

ca. 10 ambulacral plates in a series in middle-sized specimens, about five[1] interradial plates, reaching nearly to the mouth edge, the ambulacra not joining at the proximal end.

Primary spines ca. 1.5—2.5 times the diameter of test, cylindrical, usually tapering rather abruptly at the end; the point simple, not crown-shaped. Often the ambital spines are somewhat compressed and widened near the point. The surface of the spines closely set with low, usually somewhat rounded knobs of perfectly uniform size, which as a rule do not show any distinct serial arrangement. The spine then, as a whole, makes the impression of being very smooth. The surface between and on the knobs, in fresh, but fully formed, spines, covered with a not very dense coat of low, rather coarse, simple hairs. The proximal part of the spine smooth and shining, forming a conspicuous neck, usually somewhat longer than the collar[2]. The latter is ca. 1 mm long, increasing in thickness towards the rather inconspicuous milled ring. The oral primaries are lancet-shaped, entirely smooth, not curved; the third is transitional to the ambital ones.

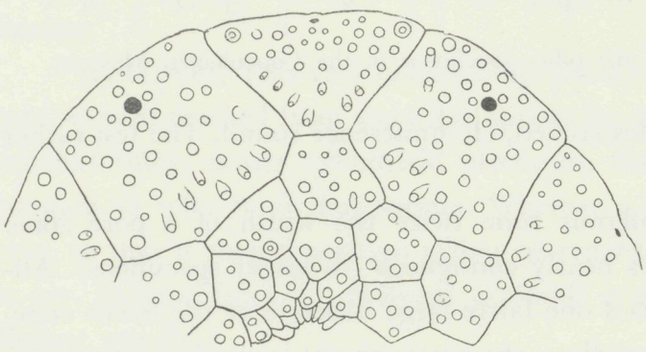


Fig. 102. Part of apical system of *Stylocidaris conferta*. × 6.

Secondary spines in general very slender, not strongly appressed. The scrobicular spines are ca. 5 mm long, flat, slightly concave, tapering gently towards the rounded point. The marginal ambulacral spines are much more slender, slightly flattened, pointed; they are almost as long as the scrobicular spines. The miliary spines simply spiniform, slender. There is no glandular ampulla at the base of these spines.

Pedicellariæ. The large globiferous form evidently very rare; I have found it only on one of the cotypes in the Museum of Comp. Zool. The valves (Pl. LXXXV. 30) are somewhat coarse and irregular, the opening rather small; otherwise they are of the typical form; the stalk with a not very conspicuous limb. The small form of globiferous pedicellariæ rather richly developed, partly very long-stalked (up to 3.5 mm length of stalk, by ca. 1 mm head). The valves slender, of the typical form, the end tooth small (Pl. LXXXV. 31). No samples found of the irregular form of globiferous pedicellariæ that occurs in several other *Stylocidaris*-species. Tridentate pedicellariæ very slender, usually small, but occasionally a sample of 2 mm length of head is found (Pl. LXXXV. 32). — Spicules of tubefeet of the usual type, those of the intestinal wall as in other *Stylocidaris*-species; a close pavement of small, rounded disks with few holes in the middle

[1] H. L. Clark (Op. cit.) states that there are 12—15 plates in each interambulacrum; this means that they have been subdivided in his specimens, as I have seen on one of the cotypes in the Museum Comp. Zool.

[2] H. L. Clark states that this "neck", as the spine gets older, comes to occupy more and more of the spine, so that in old spines only the distal half or two-thirds show the crowded granules clearly. This can, of course, be due only to wearing off of the granules in the lower part of the spines, no actual change of the surface structure of the spine being possible when it is once fully formed.

in the upper part of the intestine, irregular triradiate spicules in the rest of the intestine. Genital organs studded with irregular spicules, which partly assume the shape of large irregular plates, forming a complete pavement.

Colour. General colour white, both on test and spines[1]. But there is a fairly conspicuous brownish-olive spot on each genital plate and at the median end of each horizontal interambulacral suture, usually also at the adradial end of these sutures. Also along the midline of the ambulacra there is usually a series of more or less conspicuous spots of the same colour. The ambital primary spines usually with 2—3 narrow reddish bands, which stand out very conspicuously against the white ground colour of the primaries. The bands may, however, be very faint or even totally lacking, though rarely on all the primaries. The collar may be brownish. Secondary spines usually with a not very conspicuous midline of red-brown or olive; they may, however, be wholly white. Sometimes those of the oral side are slightly reddish at the tip. The denuded test white, with a greenish tint on the genital and periproctal plates and in the uppermost part of the interambulacra.

Biology. The small size of the genital openings indicates small eggs and, probably, a pelagic larval stage. The largest specimen recorded is 45 mm h.d. The spines are not much overgrown, a few Serpulids, a Scalpellum occurring here and there, but now and then a spine may be wholly invested by an arenaceous Zoanthid (Pl. XXXVII. 7). Sometimes there are traces of erodings on the test, evidently due to attacking Gastropods (e. g. Pl. XXXVII. 3). This specimen also shows the abnormality of the apical system being somewhat elongate. — In the intestine of one specimen was found bottom material with Foraminifera, Bryozoans, parts of Hydroids and sponges and what was probably a small Ascidian.

Occurrence. The species was first taken by the "Endeavour" on the Eastern slope of the Bass Strait and S. of Gabo Island, ca. 140—360 m. The present author found it in 1914 at 39° 10′ S. 149° 55′ E., and 38° 05′ S. 150° E., 360—470 m. Further I have seen some specimens from off Port Jackson, 450 m. It has not been recorded from other localities, and thus would seem to be confined to the S.E. Australian Sea.

Remarks. H. L. Clark has well recognized the affinity of this species with *Stylocidaris affinis*; but when he says, that no related species is known from the Indo-Pacific, and that *Styloc. bracteata* "is as near an ally as any" I cannot agree with him. The nearest ally evidently is *Stylocidaris Reini*, from which it is, however, distinguished very easily, especially by the characteristic shape and colour of the primary spines.

[1] H. L. Clark gives the general colour of test as yellowish-brown or dull-reddish, which does not hold good of the specimens examined by me. That this is not due to fading alone is evident from the fact that I find in my notebook the statement about one of the specimens that I took myself, that it was white with darkbrown spots (as above described), when it came up in the trawl.

Stylocidaris rufa Mrtsn.

Pls. LXXII. 10; LXXXIV. 20—25.

Phyllacanthus Thomasi. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ, p. 15. partim. **Pl. 26. 5—8; Pl. 30; Pl. 31. 1—4.** (Non: Pls. 27—29).

Phyllacanthus Thomasi. H. L. Clark. 1907. The Cidaridæ, p. 188. partim.

Stylocidaris rufa. Th. Mortensen. 1928. New Cidaridæ, p. 71.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	41 mm	24 mm	21 mm (51.2 % h.d.)	20 mm (48.8 % h.d.)	6—7	15—16	?
2	38 —	25 —	20 — (52.6 —)	20 — (52.6 —)	7	12—13	71 mm
3	38 —	25 —	18 — (47.4 —)	19 — (50 —)	7	14—15	75 —
4	35 —	22 —	17.5 — (50 —)	19 — (54.3 —)	6—7	12—14	75 —
5	35 —	19 —	17 — (50 —)	17 — (50 —)	6—7	14—15	?
6	31 —	18 —	16 — (51.6 —)	16 — (51.6 —)	6	14—15	70 —

Specimens 1—5 in the U. S. National Museum; No. 6, the type-specimen, in the Copenhagen Museum.

Test flattened above, somewhat less so below; sides strongly arched; circumference round.

Ambulacra rather distinctly sinuate; interporiferous zone about twice the width of a pore-zone. Marginal series of tubercles very regular, the tubercles very nearly contiguous, not very prominent. Adradially to the marginal tubercle each plate carries a single secondary tubercle at the lower edge of the plate, forming regular inner vertical series; median part of interporiferous zone otherwise bare, slightly sunken. Pores of equal size, separated by a fairly broad, slightly elevated, simply rounded wall; ridge fairly sharp, furrow hardly distinguishable (Pl. LXXII. 10).

Interambulacra. Areoles very shallow, the 2—3 proximal ones confluent; the subambital ones transverse-oval, the upper ones with fairly conspicuous radiating impressions. Scrobicular edge not raised, the tubercles somewhat more than twice the size of the marginal ambulacral tubercles. The median part of the I. A. plates rather closely covered with secondary tubercles, which decrease in size towards the bare, scarcely sunken, median line. A few secondaries on the adradial side of the scrobicular ring in the larger specimens. Median area about half the width of an areole.

Apical system about half h.d. (ca. 47—50 % h.d.), usually slightly elevated. Oculars usually all narrowly insert or nearly so; in the type specimen only Oc. I distinctly insert. Genital pores small, near the outer edge. Periproctal plates rather numerous. The whole apical system rather closely covered with tubercles of fairly uniform size, those along the inner and outer edge of the genital plates somewhat elongate (Fig. 103).

Peristome about the same size as the apical system, or even somewhat larger, usually slightly conical. Ca. 15 ambulacral plates in a series; 6—7 well developed interradial plates.

Primary spines fusiform, being somewhat thickened a little above the collar, then tapering very gradually to the rather fine, not widened point; sometimes they may be a little

compressed at the point. The shaft is set with very low spinules, connected into low, more or less distinct, sharp ridges, which become slightly more prominent towards the end of the spine. Just above the collar the spinules have more the character of low warts, which may be so broad as to be contiguous. Surface of shaft otherwise covered with very fine, short, simple hairs (Fig. 104. 3). The collar is short, ca. 1 mm long, scarcely thickening towards the inconspicuous milled ring; no distinct neck. — Oral primaries simple, longitudinally furrowed, not flattened or widened or curved; the 3rd—4th transitional.

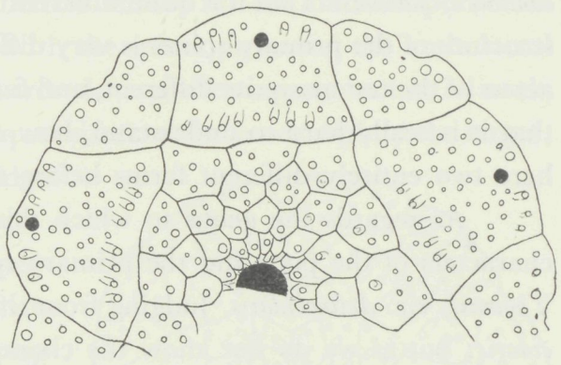
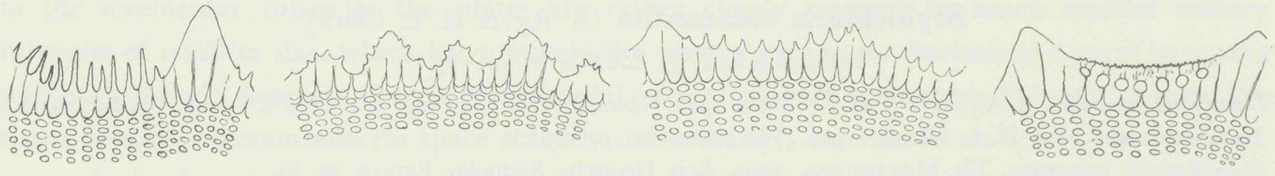


Fig. 103. Part of apical system of *Stylocidaris rufa*. × 6.5.

Secondary spines. The scrobicular spines ca. 4 mm long, flat, slightly widened in the basal part; point rounded. They fit rather closely around the base of the primary spines. Marginal ambulacral spines slender, flattened, slightly curved, ca. 2 mm long. Miliary spines flat and pointed, lancet-shaped, not appressed.

Pedicellariæ. Large globiferous form unknown; small globiferous slender, with a rather unusually small opening (Pl. LXXXIV. 20). Tridentate pedicellariæ of two sorts: the usual slender-valved form (Pl. LXXXIV. 22—23; a single sample was observed with more broad valves, Pl. LXXXIV. 21), and another form with shorter, more robust valves, with a coarse meshwork filling up the blade, except the end, where the valves join (Pl. LXXXIV. 24—25). The basal part of the coarse form narrower and more rounded than in the slender form. The latter form reaches a size of ca. 1.5 mm length



1. 2. 3. 4.

Fig. 104. Parts of transverse sections of primary spines of *Stylocidaris bracteata* (1), *St. calacantha* (2), *St. rufa* (3) and *St. fusispina* (4). 1. × 50; 2.—4. × 60.

of head, the coarser form of almost the same size. — Spicules of tubefeet of usual form.

Colour. Primary spines of a light redbrown ground colour, on which the white spinules come out very distinctly, the whole spine getting thus a beautiful mottled appearance. The collar also light redbrown. Scrobicular spines purplish-brown, as are also the miliary spines of the interambulacra and of the apical system, whereas the ambulacral spines are of a much lighter, yellowish colour, contrasting markedly against the darker interambulacral and apical spines and forming thus five conspicuous meridian stripes. On the naked test the apical system is dark redbrown, the oculars of a somewhat lighter colour. The test is of a light greenish-red, also in the

peripheral part of the areoles, which makes the radiating impressions more marked. The pore-zones are white.

Occurrence. Known only from the vicinity of the Hawaiian Islands, from the "Albatross" stations 3838, 3863, 4046, 4062, and 4096. Known bathymetrical distribution 128—515 m.

Remarks. This species was confounded by Agassiz and Clark with *Actinocidaris* (*"Phyllacanthus"*) *Thomasi*. That it is quite different from the latter species is beyond doubt. Above all the structure of the primary spines is very different from that of the true *Thomasi*; but also the characters of the test are quite different, and further the difference in the colour is so very conspicuous, that it is really hard to understand, how Agassiz and Clark could fail to notice that they had here two entirely different forms before them.

As regards the genus to which this species should be referred there is some doubt. The characters of the pore and the primary spines forbid referring it to the same genus as the true *Thomasi*, viz. *Actinocidaris*. Judging from these same characters it would belong to the genus *Stylocidaris*; but as we do not know the character of the large globiferous pedicellariæ, there is still some uncertainty whether it really belongs here; further the two very different types of tridentate pedicellariæ is a rather unique character, recalling the genus *Eucidaris*. In case the coarse form of these pedicellariæ should rather be regarded as a large globiferous pedicellaria, there would hardly be any doubt that this species should be made the type of a separate genus. But the said pedicellaria apparently does not represent anything but a tridentate form — there is no glandular cavity in the valves — and I therefore prefer for the present to leave the species in the genus *Stylocidaris*.

Stylocidaris calacantha (A. Ag. & H. L. Clark).

Pls. LXXII. 9; LXXXIV. 12—15.

Dorocidaris calacantha. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 11. Pls. **4. 1—12; 13; 14; 34; 35.**
Tretocidaris calacantha. H. L. Clark. 1907. The Cidaridæ, p. 205.
Stylocidaris (?) *calacantha.* Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 52, 54.
Dorocidaris calacantha. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	42 mm	28 mm	21 mm (50 % h.d.)	19 mm (45 % h.d.)	5—6	18—19	78 mm
2	40 —	24 —	20 — (50 —)	18 — (45 —)	5—6	19—20	62 —
3	31 —	18 —	17 — (54.8 —)	15 — (45 —)	5 (6)	18—19	ca. 60 —
4	30 —	18 —	17 — (56.6 —)	13 — (43.3 —)	5 (6)	18—19	82 —
5	24 —	15 —	13 — (54.5 —)	12 — (50 —)	5	17—18	68 —
6	21 —	12 —	11 — (52.4 —)	9 — (43 —)	5	14—15	ca. 50 —
7	11.5 —	6 —	6.5 — (59 —)	6 — (54.5 —)	4—5	10—11	27 —

No. 1 is the type-specimen (U. S. National Museum), the other specimens measured are in the Museum of Comp. Zoology. Excellent figures of this species are given by Agassiz & Clark (Op. cit.).

Test usually flattened above and below; sides beautifully arched, circumference round.

Ambulacra rather conspicuously sinuate; interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular; the tubercles nearly contiguous; they are low and not very prominent, but distinctly mamelonate. Adradially to the marginal tubercle each plate carries a smaller tubercle at the lower edge, these tubercles forming very regular longitudinal series. On the naked test these inner tubercles almost fill out the interporiferous zone, scarcely leaving a naked midline; on specimens with the spines preserved the ambulacral midline remains distinct, the small spines bending outwards. Interporiferous zone not at all sunk, rather somewhat elevated. Pores rather small, about equal-sized or the inner slightly the larger; the wall is moderately broad, distinctly raised; the ridge low, inconspicuous (Pl. LXXII. 9).

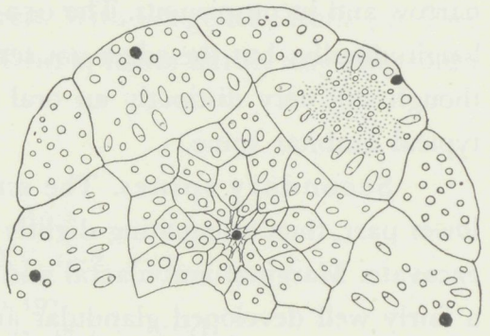


Fig. 105. Part of apical system of *Stylocidaris calacantha*. × 4.5.

Interambulacra. Areoles rather large, the uppermost fully formed one sometimes conspicuously larger than the following. They are not very deep, the boss filling up nearly the whole of the areole. Only the two proximal ones confluent, the upper ones distant enough from each other to give room for several small tubercles between the neighbouring scrobicular rings. The subambital areoles more or less distinctly transverse-oval. The uppermost tubercle (only one in each interambulacrum) may be fairly distinctly crenulate. The mamelon is rather large and conspicuous. Scrobicular tubercles fairly conspicuous, more than twice the size of the marginal ambulacral tubercles; the scrobicular edge, however, not raised. Admedially to the scrobicular tubercles the plates are rather closely covered by much smaller miliary tubercles of uniform size, which leave merely the vertical and upper horizontal sutures bare; the scrobicular circle comes so close to the adradial edge, that there is no room for smaller tubercles there. Median interambulacral space scarcely more than $^1/_3$ as wide as an areole, not sunken.

Apical system usually a little more than half h.d. Oculars usually all narrowly insert, may sometimes be partly exsert (thus in specimen 6. I and V insert, the others exsert). The genital pores are small, also in the female (Fig. 105), rather near the outer edge[1]. There may be a fairly conspicuous genital papilla. Periproctal plates fairly numerous, the periproct sometimes slightly raised. The whole apical system covered, more or less closely, by tubercles, those at the inner edge of the genital plates somewhat (sometimes very conspicuously) comma-shaped.

Peristome may be somewhat raised. There are in middle-sized specimens 12—14 ambulacral plates in a series, 5—6 interradial plates in a fairly regular series.

[1] As it is stated in the original description of this species by Agassiz & Clark (Op. cit. p. 12) that the "madreporic genital is riddled with the madreporitic openings", it may not be superfluous to state that this does not indicate any unusual character at all, the madreporic pores showing the normal distribution and arrangement (Fig. 105); on the other hand, the position of the genital pore of the madreporite in the outer edge in the specimen from which this figure was drawn is unusual.

Primary spines usually distinctly fusiform, thickened above the collar (ca. 5 mm in diameter in the larger ambital spines) and then tapering to a simple point; more rarely they are more slender, scarcely at all thickened in the basal part. They are set with small tubercles or granules, arranged in low, close-set ridges; there are up to ca. 35—40 of these ridges in the widest basal part, the whole shaft of the spine being thus very finely striated; the ridges are scarcely more prominent in the distal part of the spine. The surface of the shaft between the ridges with numerous low warts covered by low, simple hairs, or rather only short stumps (Fig. 104. 2; Pl. LXXXIV. 15). Just above the collar there is a conspicuous smooth, shining neck of ca. 2 mm length; the collar is ca. 1 mm long, rather distinctly the thickest in the middle; milled ring very narrow and inconspicuous. The oral primaries are simple, flattened, rather distinctly furrowed longitudinally, but the edges not serrate; the third is slightly transitional to the ambital spines, though still very distinctly an oral primary, while the fourth (rarely already the third) is a typical ambital spine.

Secondary spines. The scrobicular spines are ca. 4 mm long, a little widened in the lower part, then attenuating slightly towards the rounded end; they are simply flattened, scarcely excavate. Marginal ambulacral and miliary spines similar in shape, only smaller. There may be a fairly well developed glandular ampulla at the base of the smaller spines on the aboral side.

Pedicellariæ. The large globiferous form unknown. Small globiferous fairly numerous, reaching a size of ca. 1 mm length of head, the stalk 2—3 mm long; the valves are very slender, with a small opening and a well developed end tooth (Pl. LXXXIV. 12). Tridentate pedicellariæ with very slender valves, joining only in the outer part; the basal part of the blade with rather conspicuous, fairly regularly arranged crossbeams (Pl. LXXXIV. 13); they reach a size of ca. 1.5 mm length of head. — Spicules of tubefeet rather conspicuously spiny (Pl. LXXXIV. 14), lying very regularly. Intestinal wall studded with the usual small rounded plates with a few central holes. The walls of the genital organs likewise studded with larger, more or less irregular, fenestrated plates.

Colour. Very pale brown with a greenish cast, especially on the apical system. The primaries are creamy with narrow greenish-brown bands, at the base finely spotted with white. The secondaries have a broad green median stripe, sometimes dissolved into spots. The naked test is white, only the apical system conspicuously greenish, the oculars, however, of a lighter colour. The mamelon of the upper primary tubercles also greenish.

Biology. In a specimen opened the contents of the intestine was coarse bottom material with Foraminifera. — The small genital openings indicate small size of eggs and therefore probably a pelagic larva. Genital openings are not yet developed in the specimen of 11.5 mm h.d.; in the specimen of 21 mm h.d. the pores are present, but apparently recently formed. Whether it grows to a much larger size than ca. 40 mm h.d. is unknown. — The spines are on the whole rather clean; sometimes, however, they are more or less covered with the sandy tubes of a tubicolous Annelid. The specimens, on the whole, do not give the impression of being old and worn.

One specimen shows an abnormality in one of the ambulacra at the ambitus, the pore zones coming so close together in the midline that the interporiferous zone has been almost totally eliminated.

Occurrence. Known only from the Hawaiian Islands, where it is not rare in depths of ca. 225—355 m.

Remarks. The generic position of this species is still uncertain, as we do not know the structure of the large globiferous pedicellariæ; but it is very probable that it does really belong to the genus *Stylocidaris*. The very characteristic primary spines mark it very distinctly from all the other species of the genus, and it can hardly be said to show near relations to any of the other *Stylocidaris*-species; perhaps *St. conferta* may be the nearest. With the genus *Cidaris* (= *Dorocidaris*) or *Tretocidaris*, to which it was referred Agassiz & Clark, it has hardly anything to do.

Stylocidaris bracteata (A. Ag.)

Pls. XXXIX. 1—6; LXXII. 7—8; LXXXV. 1—2, 4—7.

Dorocidaris bracteata. A. Agassiz. 1879. Prel. Rep. "Challenger" Ech. p. 197.
Dorocidaris (Cidaris) bracteata. A. Agassiz. 1881. "Challenger" Ech. p. 37. Pl. I. 1; XLII. 1.
Dorocidaris bracteata. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ; p. 42.
Stephanocidaris bracteata. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 28, 173. Pl. **X. 18.**
Cidaris (Cidaris) baculosa, var. *brevicollis.* De Meijere. 1904. "Siboga" Ech. p. 11. Taf. II. 7 (non Taf. II. 8).
Cidarites bracteata. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 94, 101.
Tretocidaris bracteata. H. L. Clark. 1907. The Cidaridæ, p. 202, 206. Pl. **10, 1—2.**
Stylocidaris (?) bracteata. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 52, 54.
Dorocidaris bracteata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Tretocidaris bracteata. H. L. Clark. 1914. Echinod. W. Austral. Mus. p. 161.
Stylocidaris bracteata. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 23.
NON: *Dorocidaris bracteata.* A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 9. Pl. 3. 15—28. (*Stylocidaris maculosa* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	33 mm	20 mm	16 mm (48.4 % h.d.)	14 mm (42.4 % h.d.)	(6) 7	14—15	68 mm
2	30 —	17 —	15.5 — (51.7 —)	14.5 — (48 —)	6—7	12—14	50 —
3	30 —	17 —	15 — (50 —)	14 — (47 —)	6 (7)	12—14	40 —
4	30 —	15 —	15 — (50 —)	13.5 — (45 —)	6	12—14	63 —
5	27 —	15 —	13 — (48 —)	12 — (44.4 —)	6 (7)	11—12	48 —
6	24 —	13.5 —	12 — (50 —)	11 — (45.8 —)	6	12—13	59 —
7	21 —	12 —	10 — (47.6 —)	10 — (47.6 —)	5—6	10—11	50 —
8	17 —	8.5 —	9 — (53 —)	8 — (47 —)	5 (6)	10—12	37 —
9	11 —	5.5 —	5.5 — (50 —)	5 — (45.4 —)	(4) 5	8—9	23 —
10	7.5 —	4 —	4 — (53.3 —)	4 — (53.3 —)	5	6—7	14 —

The specimens measured all in the Copenhagen Museum.

Test flattened above, less so below, as it is sloping very gently from the ambitus downwards; circumference round.

Ambulacra rather distinctly sinuate, ca. 27—28 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles rather small, but distinctly mamelonate; they are very nearly contiguous, but usually separated by some very minute tubercles (carrying pedicellariæ). Adradially to the marginal tubercle each plate carries a fairly large secondary tubercle at the lower edge; in larger specimens there is further a second, slightly smaller tubercle at the upper edge, nearer the median line, and there may even be a third one, placed in the midline of the area. While in the younger specimens the single secondary tubercles form very regular vertical series, these series are obscured in the larger specimens. Where the tubercle in the midline has appeared the whole interporiferous zone is covered with tubercles, otherwise there is a fairly conspicuous naked, not sunken, median area (Pl. LXXII. 7—8). The pores small, equal-sized; the wall fairly broad, flat, only its upper part forms a small semilunar elevation. Furrow inconspicuous, ridge low, rounded. The whole pore zone scarcely sunk.

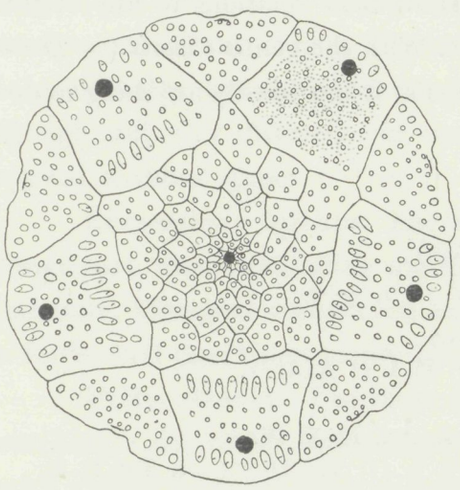


Fig. 106. Apical system of *Stylocidaris bracteata*. × 4.5.

Interambulacra. Areoles of medium size, not very deep; only the two—three proximal ones confluent, the upper ones usually so widely separated that there is room for some small tubercles between the two adjoining scrobicular circles. The subambital areoles transverse-oval, in the largest specimens this may also hold good of the ambital ones. Rather distinct radiating impressions sometimes found in the upper areoles. The boss and the mamelon rather large[1]; the upper tubercles may be faintly crenulate. The scrobicular circle is not very prominent or conspicuous, the tubercles not much larger than the marginal ambulacral tubercles. Outside the scrobicular circle the plates are closely covered by secondary tubercles, gradually decreasing in size towards the median line, which latter is slightly sunk, but with no naked space along it. In larger specimens there are also some small tubercles outside the scrobicular circle on the adradial side. At the median end of the horizontal sutures there is a more or less distinct, small groove, recalling that of Goniocidarids. The median area about half, more rarely as much as $^2/_3$ the width of an areole.

Apical system (Fig. 106) ca. 47—53 % h.d. Oculars triangular, usually all narrowly

[1] In the original description ("Challenger" Ech.) "the small size of the mammary boss of the primary tubercles" is pointed out as one of the characters of this species. Even when compared with specimens of corresponding size of *Cidaris cidaris* (*Dorocidaris papillata*) — the species with which Agassiz especially compares *bracteata* — the mamelon can by no means be said to be smaller in the present species.

insert; the outline of the whole system circular. Genital pores rather small, not very close to the edge. Periproct usually somewhat elevated, periproctal plates rather numerous. The whole apical system closely covered with tubercles, those along the outer edge of the oculars and the outer and inner edge of the genital plates somewhat larger, those of the genitals being usually very markedly elongate.

Peristome distinctly smaller than the apical system, ca. 42—48 % h.d.; only in the youngest specimens it may be as large as the apical system (53.3 % h.d. in a specimen 7.5 mm h.d.). There are 12—14 ambulacral plates in a series in the largest specimens, and a usually very regular series of 7—8 interradial plates, which almost reach the mouth edge. The peristome is usually slightly elevated.

Primary spines. The larger ambital spines usually about twice the h.d., but may reach about 2.5 h.d. or, on the other hand, sometimes be less than 1.5 h.d. They are, as a rule, somewhat widened in the basal part, tapering then very gradually towards the not or only very slightly widened point. There are usually 10, in the lower part of the shaft very sharply serrate, longitudinal ridges, those of the aboral surface as a rule conspicuously more developed than those of the adoral surface, which gives the spines a somewhat flattened appearance. The surface of the shaft, between the ridges, in well preserved spines covered with very fine, simple hairs (Fig. 104. 1). A smooth, shining, ca. 2 mm long neck above the collar, which latter is very low, only ca. 1 mm, scarcely thickening towards the inconspicuous milled ring. The oral primaries not much specialized, short and straight, not widened, but with fairly distinct longitudinal ridges, which may form a small end crown in the 2nd—3rd spine; the 3rd—4th is transitional to the ambital spines.

Secondary spines. The scrobicular spines are 3—4 mm long, very nearly rectangular, flat, those on the oral side more or less distinctly excavate (Pl. LXXXV. 7). The ambulacral and smaller secondary spines of the same general shape, only smaller. No glandular ampulla at the base of these spines. The spines of the apical system rather short and fine, mostly erect, excepting those around the anal opening and along the edge of the genital and ocular plates, which latter form a fairly conspicuous fringe.

Pedicellariæ. The large globiferous pedicellariæ rather scarce, often wanting; they are usually found at the adradial end of the upper horizontal interambulacral sutures, and at the grooves along the median interambulacral suture. The shape and structure is that typical of *Stylocidaris* (Pl. LXXXV. 1—2); the irregular shape shown in Pl. 3. 15 of A. Agassiz & H. L. Clark's Hawaiian Ech., Cidaridæ is, evidently, abnormal. The limb of the stalk is very finely developed. Small globiferous pedicellariæ of the typical form, with a fairly well developed end-tooth; ("Ingolf" Ech. Pl. X. 18; erroneously designated there as a large globiferous pedicellaria); the larger samples may reach the same size as the large globiferous. Among the scrobicular spines of the upper side is not rarely found some short-stalked pedicellariæ with very irregular valves (Pl. LXXXV. 4—5), such as are known from several other species of the genus *Stylocidaris*. The

tridentate pedicellariæ, which have very slender valves (Pl. LXXXV. 6), may reach a considerable size, up to ca. 1.5 mm length of head. — Spicules of tubefeet of the usual type; the intestinal wall with very few, irregular, triradiate spicules in the lower part, while the upper part is paved with small round plates with a few small holes in the centre.

Colour. General colour creamy, with a faint tinge of pink. As a rule the median line of the ambulacra is somewhat darker; generally a rather conspicuous brownish spot is found at the median end of the interambulacral horizontal sutures, and also at the outer corner of the ocular plates; sometimes the whole of the sutures between the oculars and genitals is thus brownish coloured, as may also be the case with the inner edge of the genitals. The apical system otherwise usually not darker coloured. The primary spines greenish-yellow, with more or less conspicuous red-brown bands, which continue over the neck and the collar as series of round spots — a very characteristic feature of this species. The secondary spines have a slight pinkish tint, the tip of a faint yellowish or olive colour. There is no longitudinal median stripe[1]. The denuded test of a creamy colour, the interporiferous ambulacral zones dark olive, forming five conspicuous dark radiating lines. The apical system of a more or less conspicuous olive-purplish tint; this colour may, however, be confined to a spot on the middle of the genital plates, a spot just above the pore on the ocular plates and one in the middle of the outer periproctal plates. The peristome of a fairly conspicuous greenish tint.

Biology. A specimen opened was found to have its alimentary canal filled with rather coarse sand with a few Foraminifera, especially *Polytrema*. — The species does not appear to reach a larger size than ca. 35 mm h.d. The genital pores do not appear until rather late; they have not yet appeared in 2 specimens of 11 mm h.d., but in the next size represented, 17 mm h.d. they are well developed. The small size of the genital pores (and eggs) would indicate development through a pelagic larval stage. The primary spines of the larger specimens are especially covered by Serpulid tubes, but also Barnacles, Bryozoans, Sponges, and small Hydroids are not rarely found on them. A parasitic Gastropod, *Mucronalia* sp., was found on one of the specimens. No anomalies observed.

Varieties. The specimen figured by de Meijere in the "Siboga" Ech. Taf. II, 7 and regarded by him as a variety of *Prionocidaris baculosa*, the var. *brevicollis*, has nothing with *baculosa* to do, as I can ascertain having had the opportunity of studying this specimen more closely; it belongs to *St. bracteata*, though probably it ought to be regarded as a separate variety of this species. It differs from the typical form in lacking the brown spots on the shaft of the primaries, while the red spots in the basal part of the spines are conspicuous. Also the dark spots at the median end of the horizontal interambulacral sutures are lacking. The interporiferous zone of the ambulacra is of a light pink colour, not dark olive as in the typical form; also the apical system is

[1] In the original description ("Chall." Ech. p. 37) the secondary spines are stated to be "light reddish-brown". This colour is not found in any of the specimens in hand. Clark's statement (The Cidaridæ, p. 206) that they may have a longitudinal rosy stripe may perhaps refer to hybrids (see below).

scarcely darker, and the comma-shape of the tubercles along the inner edge of the genitals scarcely observable. The secondaries of a uniform light pinkish tint. — As only a single specimen is at hand, it is impossible to judge of the constancy of these differences, and the question whether it represents a local variety (perhaps even a separate species) or merely an individual variation cannot be decided at present. With the true *brevicollis* it has nothing to do (see under that species, p. 381).

The specimens from the Japanese Seas referred by A. Agassiz & H. L. Clark (Hawaiian Ech., Cidaridæ, p. 9) to *St. bracteata* belong to the nearly related, but quite distinct species *St. maculosa* Mrtsn.

Hybrids. A specimen from the Bay of Ambon makes very much the impression of being a hybrid between *St. bracteata* and *Reini*. It has its primaries banded as in *bracteata*, but without the red spots on the collar. The apical system is dark coloured and the secondaries have a reddish median stripe as in *Reini*, as also the general shape of the primaries is more as in *Reini*. Perhaps the specimen mentioned by Clark as having a dark apical system and the secondaries with a longitudinal rosy stripe also corresponds to this specimen and should be regarded as a hybrid.

Occurrence. The type locality is the Bay of Ambon, where the species was discovered by the "Challenger" in ca. 40—180 m. I found it there again in good numbers in 1922 (ca. 100—200 m.), as also at Banda, ca. 100 m., and at the Kei Islands (St. 25, off Great Kei, 85 m.). It was also taken by the "Siboga" at St. 49. a (8° 23′ S. 119° 4′ E., 69 m.), one specimen erroneously recorded by de Meijere as "*Cidaris* (*Cidaris*) *baculosa*, var. *brevicollis*" ("Siboga" Ech. p. 11, Taf. II. Fig. 7) (cf. p. 381, under *St. brevicollis*). The species is further recorded from the Parry Shoal (Arafura Sea), the Holothuria Bank, from between Fremantle and Geraldton, 100—180 m., from the Amirantes, the Macclesfield Bank and Japan. The specimens from between Fremantle and Geraldton I have seen but not examined very closely; they may, however, well belong to this species. On the other hand the rest of the specimens do not really belong to *bracteata*. As regards the locality Parry Shoal, Arafura Sea, there is no specimen in the British Museum from that locality labelled *Stylocidaris bracteata*, but there is a specimen labelled in Clark's hand "Prionocidaris bispinosa (Lamk); most atypical". This appears to be the specimen mentioned in the Catalogue as *St. bracteata*. It is neither *bracteata* nor *bispinosa*, but *Prionocidaris baculosa*, var. *annulifera* — as are also the specimens from the Holothuria Bank referred by Clark to *Stylocidaris bracteata*. Clark has repeatedly called attention to the difficulty of distinguishing young *Prionocidaris baculosa* (viz. the var. *annulifera*) from *Stylocidaris bracteata* (Cat. Rec. Sea-Urch. Br. Mus. p. 14, 16, 23); however he has not succeded in distinguishing them properly, evidently because he was not sufficiently acquainted with the characters of *St. bracteata*. As a matter of fact the primary spines of *bracteata* with their sharp, prominent ridges allow distinguishing with certainty this species from *baculosa*, var. *annulifera*, even in quite young stages — in spite of both species having red spots on the collar. (That these spots are, in general, more purple in *baculosa*, more crimson in *bracteata*, as Clark points out, is quite true; but Clark has himself given ample proof that it is not possible to distinguish the two species by this character alone).

The specimen from the Amirantes is *Prionocidaris baculosa*, var. *longicollis* (Mrtsn.), and the specimens from Macclesfield Bank and Japan are *Stylocidaris maculosa* Mrtsn. (see under those two species). Thus the true *Stylocidaris bracteata* is till now known with certainty only from Ambon, Banda, Sumbava and the Kei Islands, and probably also from off W. Australia, in depths of ca. 40—200 m.

Remarks. The original description of this species in the "Challenger" Ech. was very poor, giving mainly the character of the primary spines (— without mentioning the very characteristic crimson spots on the collar —) and otherwise emphasizing only some points in which this species differs from the Atlantic *Dorocidaris papillata* (= *Cidaris cidaris*). Only a very poor figure of a primary spine, and a much worse of what is probably a small globiferous pedicellaria accompany the description. In the "Ingolf" Ech. Pl. X. 18 I gave a figure of a pedicellaria (from a specimen in the British Museum) erroneously regarded as a large globiferous, in reality the small form. H. L. Clark in his work "The Cidaridæ" 1907 at length gave figures of the species (Pl. X. 1—2) and pointed out some of the more important characteristics of the species.

Regarding its generic place there can be no doubt that it belongs to the genus *Stylocidaris*, being the nearest related to such species as *maculosa*, *brevicollis* and *albidens*. The statement by H. L. Clark (The Cidaridæ, p. 206) that it is apparently the East Indian representative of *Tretocidaris bartletti* is a consequence of his conception of the genus *Tretocidaris* in that work, a conception which he has now given up as untenable. The fact that it was referred in the "Ingolf" Ech. to the genus *Stephanocidaris* was due to insufficient knowledge of the globiferous pedicellariæ and to the then reigning confusion with regard to the genus *Stephanocidaris*.

Stylocidaris maculosa Mrtsn.

Pls. XXXIX. 7—12; LXXII. 3; LXXXV. 8—15.

Dorocidaris bracteata. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 9. Pl. III. 15—28.
Stylocidaris maculosa. Th. Mortensen. 1928. New Cidaridæ, p. 72.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	15 mm	8 mm	9.5 mm (63.3 % h.d.)	7 mm (46.6 % h.d.)	(5) 6	9	28 mm
2	13 —	7 —	8 — (61.5 —)	6 — (46 —)	5—6	8—9	25 —
3	11 —	6 —	6 — (54.5 —)	5.5 — (50 —)	5 (6)	7—8	11 —
4	9.5 —	4.5 —	5 — (52.6 —)	4.5 — (47.4 —)	5	6—8	23 —
5	8 —	4 —	4.5 — (56.2 —)	4 — (50 —)	4—5	5—6	15 —
6	15.5 —	7.5 —	8 — (51.6 —)	7.5 — (48.4 —)	6	8—9	30 —

Specimens 1—5 in the Copenhagen Museum; specimen 6 in the British Museum.

Test usually much flattened above, somewhat less so below; sides arched, circumference round.

Ambulacra slightly sinuate. Interporiferous zone about twice the width of a pore zone,

or a little more. Marginal series of tubercles very regular, the tubercles fairly conspicuous, distinctly mamelonate, very nearly contiguous. Adradially to the marginal tubercle each plate (at the ambitus) carries a single, very small tubercle at the lower edge, the whole interporiferous zone otherwise remaining naked, but not sunk. The pores small, equal-sized; the wall not very broad, its upper part rather distinctly elevated; ridge low, inconspicuous. The pore zone not sunken (Pl. LXXII. 3).

Interambulacra. Areoles fairly well-sized, not sunken; they are well separated, at most the two lowermost ones confluent; the subambital ones very slightly transverse-oval. The boss is rather large, so to say filling up the whole areole; the mamelon of medium size; rather distinct traces of crenulation on the upper primary tubercles. The scrobicular circle not very conspicuous, the tubercles not much larger than the marginal ambulacral tubercles. Outside the scrobicular tubercles the plates rather closely covered by smaller tubercles which gradually decrease in size towards the median line, which is scarcely sunk, but may be more or less bare. On the adradial side of the scrobicular circle there is hardly room for any secondary tubercles. The median end of the horizontal sutures may be more or less conspicuously bare and sunk, so as to form an indistinct groove. The median area about half the width of an areole.

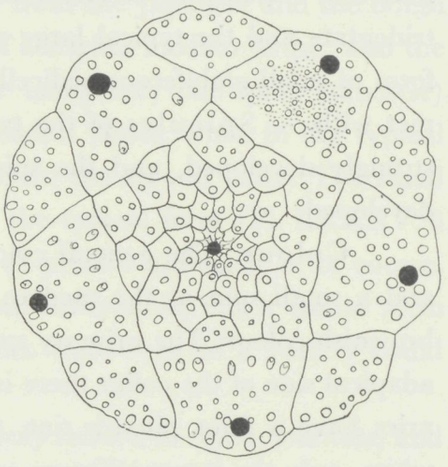


Fig. 107. Apical system of *Stylocidaris maculosa*. × 8.

Apical system rather large, ca. 53—63 % h.d. Oculars usually exsert, or one or two of them (I and V) narrowly insert; ocular pores usually not to be seen directly from above, being covered by the tubercles. Genital pores small, rather distant from the edge. Periproct usually somewhat elevated, covered with fairly numerous plates. All the plates of the apical system uniformly covered with tubercles, those along the inner edge of the genital plates slightly elongate (Fig. 107).

Peristome distinctly smaller than the apical system, ca. 46—50 % h.d., slightly conically elevated. There are 7—8 plates in each series of ambulacral plates in the largest specimens, and 3—5 interradial plates in a more or less regular series, which may almost reach the mouth edge.

Primary spines varying in length from ca. 1—2 h.d. They are rather conspicuously widened in the basal part, then tapering gradually. The point may be slightly widened. There are usually 10 sharp longitudinal ridges, which are strongly serrate in the basal part, especially the two lateral ones, while those of the adoral side are somewhat lower and less coarsely serrate; this gives the spine a somewhat flattened appearance. The surface of the shaft between the ridges smooth and shining, without hairs. Collar very short, and the neck usually very short. Oral primaries sometimes rather distinctly curved; they are longitudinally ridged, and may be somewhat widened at the point. The 2nd—3rd transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 2 mm long; the upper ones slightly tapering, those of the oral side more rectangular; they are flattened, not excavate at the point. The marginal ambulacral spines of the same shape, only slightly smaller. The spines of the apical system small and delicate, erect, only those along the outer edge of the genital and ocular plates somewhat larger, forming a not very conspicuous fringe; also those around the anal opening somewhat larger, as usual.

Pedicellariæ. Large and small globiferous (Pl. LXXXV. 11, 15) and tridentate pedicellariæ in the main like those of *St. bracteata*. But besides the usual form of large globiferous pedicellariæ there is sometimes found another, larger form, with more elongate valves, which may to a various degree recall tridentate pedicellariæ, forming, as it were "hybrids" between the tridentate and the typical large globiferous pedicellariæ (Pl. LXXXV. 9—10, 12). The irregular form of small globiferous pedicellariæ, known from several other *Stylocidaris*-species, has not been met with. — Spicules of the typical form. The spicules of the intestinal wall of the usual type, strongly developed, and the spicules of the genital organs especially are exceedingly strongly developed.

Colour. The general colour is creamy-yellowish; usually the edges of the genital plates and a small spot at the median end of the horizontal interambulacral sutures is of a darker, brownish colour. The primary spines are very conspicuously banded with reddish-brown; on the adapical side of the collar there is a conspicuous patch of this reddish-brown colour. The secondaries have a faint pinkish tint, the point may be slightly olive-coloured. The denuded test is white, only the interporiferous zone of the ambulacra faintly brownish-pink. The apical system is somewhat darker, brownish-olive, especially the inner part of the genital plates. The oculars are white, except the inner point which is pinkish. There may be a slight tint of greenish on the peristome.

Biology. In a specimen opened the alimentary canal was found to contain pieces of Bryozoans and Sponges, and some grains of coarse sand. — It appears that the species does not grow to a larger size than ca. 15 mm h.d. (— I have seen in all 20 specimens —), specimens of this size partly looking rather old and worn, with the spines partly overgrown by foreign organisms: Bryozoans, tubicolous Annelids, Sponges, Polytrema. A young specimen of 4 mm h.d. (from the Bonin Islands), which I have hardly any doubt belongs to this species, shows the oral primaries still of the embryonal type (cf. the author's paper "On the postlarval development of some Cidarids". 1927). Evidently the species is very liable to be attacked by foreign organisms, probably Gastropods. On several of them parts of the test have been eaten (eroded) away and the holes closed with an irregular mass of small plates, or the plates have been more or less regularly restored; in the denuded specimen represented in Pl. XXXIX. 11—12 only one of the ambulacra is intact, the four others with more or less irregular, regenerated parts. — True parasites have not been observed.

A specimen in the Museum of Comp. Zoology shows the abnormality of having two pores in four of the genital plates.

Occurrence. Some specimens of this species were taken by the author in 1914 on the bank Okinose in the Sagami Sea, in depths of ca. 100—200 m., also one at a depth of ca. 700 m. near the same place. Also Dr. Sixten Bock got a specimen there in a depth of ca. 350 m.; further Dr. Bock took some specimens at the Bonin Islands in a depth of ca. 150 m. Three specimens were taken by the "Albatross", St. 3746, 1900, off Suno Saki, Sagami Bay, in ca. 90 m.

To this species I refer also the specimen from the Macclesfield Bank which H. L. Clark (Cat. Rec. Sea-Urch. Brit. Mus. p. 23) records under the name of *Stylocidaris bracteata* (the specimen was lent me for examination from the British Museum). It is the specimen of 15.5 mm h.d. in the above measurements (Pl. XXXIX. 7). It differs slightly from the Japanese and the Bonin Isl. specimens in the secondary spines having an indication of a darker median stripe; also the peristomial ambulacral plates are a little more naked, there being only one spine (tubercle) adradially to the tubefoot on the outer three pairs of ambulacral plates, while in the typical specimens there are two adradial spines (tubercles) already from the second plate. The small globiferous pedicellariæ are somewhat more slender than in the typical form (Pl. LXXXV. 8 to compare with Pl. LXXXV. 15). From the single specimen at present known it is, of course, impossible to judge with certainty of the value of these small differences, but it would seem that, even if they should prove to be constant, a higher rank than that of a variety could hardly be assigned to this form from the Maccelsfield Bank.

Remarks. There is no doubt that this species is very closely related to *Styloc. bracteata*, and it may be a matter of personal judgment, whether it should be regarded as only a variety of that species or rather as a separate species. In the structure of the test there is no quite reliable character to distinguish it from *bracteata*, when specimens of corresponding sizes are compared. But the colour affords a very easy means of distinguishing the two species, the Japanese species always having a conspicuous brown patch on the collar, while *bracteata* always has some series of small red spots. Then there are no hairs on the surface of the primaries in *maculosa*, such being very distinct in *bracteata*. The existence of a second, larger form of globiferous pedicellariæ in *maculosa* also appears to be a specific character of value — although not found in all specimens. Further it is evident that the Japanese species is a much smaller form than *bracteata*, apparently not exceeding a size of ca. 15 mm h.d., while *bracteata* grows to more than the double size, at east to 35 mm h.d. It is in accordance herewith that the genital pores usually appear at a much smaller size in the Japanese species (at 7—8 mm h.d.), than in *bracteata* (at ca. 11—12 mm h.d.). It is worth point in out that of all the 23 specimens of *maculosa* known till now, not one is intermediate so that one could be in doubt, whether it should be reckoned to *maculosa* or *bracteata*. Thus I, at least, cannot doubt that we must regard the Japanese form as a distinct species.

That the specimens from the "Albatross" St. 3746, mentioned by Agassiz & Clark (Hawaiian Ech. Cidaridæ, p. 9) as *Dorocidaris bracteata* belong to the present species I can ascertain, having had the opportunity of examining them in the Museum of Comp. Zoology and in the U. S. National Museum.

A. Agassiz & Clark (Op. cit.), in treating this species under the erroneous name "*Dorocidaris bracteata*", somewhat exultantly point out that the structure of the large globiferous pedicellariæ, according to my scheme in the "Ingolf" Ech., assigns to this species (and herewith, of course, to the true *bracteata*) a place within the genus *Cidaris*, not in the genus *Stephanocidaris* in which I had erroneously placed *bracteata*; furthermore they find that a form like that represented in their Pl. III. 16 would seem to show that it is nearer to *Stereocidaris*, and then add the ironic remark: "what are we to do with such disorderly pedicellariæ?" — The figure 16, Pl. III undoubtedly represents one of the peculiar forms intermediate between the large globiferous and the tridentate type, as described above (cf. Pl. LXXXV. 9—10, 12); there is nothing "disorderly" or *Stereocidaris*-like in it.

Stylocidaris effluens Mrtsn.

Stylocidaris effluens. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 285. Pls. **59. 3; 62. 1—2; 65. 1—4; 75. 1—2; 80. 1—6.**

This species has much resemblance to and is, evidently, nearly related to *Stylocidaris tiara* (Anderson), from which it differs mainly in its primary tubercles being non-crenulate and in the character of its primary spines which have 9—10 rather coarsely serrate, sharp, longitudinal ridges, while in *St. tiara* there are 7—8 entire ridges. Both species agree in the more or less rudimentary character of the upper primary tubercles, the areoles being produced adapically.

For full description and figures of this species see the work quoted.

Known only from the Philippine Sea, in depths of 161—704 m.

Stylocidaris tiara (Anderson)

Pls. XXXVII. 8—10; LXXII. 12; LXXXV. 24—26.

Dorocidaris tiara. A. R. S. Anderson. 1894. Natural History Notes from H.M.S. "Investigator". Ser. II. 16. On the Echinoidea coll. during the season 1893—94. J. Asiatic Soc. Bengal. Vol. LXIII. p. 188.
Dorocidaris tiara. Alcock & Anderson. 1895. Illustrations of the Zoology of the "Investigator" Pl. **V. 2, 2 a.**
Dorocidaris tiara. Döderlein. 1901. Diagn. einiger v. d. Valdivia-Exp. ges. Seeigel-Arten. Zool. Anz. XXIV. p. 20.
Dorocidaris tiara. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 23, 30, 173.
Tretocidaris tiara. H. L. Clark. 1907. The Cidaridæ, p. 202.
Stylocidaris (?) *tiara.* Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 52, 54.
Dorocidaris tiara. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Dorocidaris tiara. Koehler. 1924. Anomalies des Échinides, p. 460, Pl. XXXI. 22, XXXII. 16—21.
Dorocidaris tiara. Koehler. 1927. "Investigator" Ech. III. p. 15. **Pls. I. 4—5; II. 2; III. 1, 6; IV. 1—2, 4—9; VI. 1, 5—6; XXIII. 2.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	42 mm	33.5 mm	17 mm (40.5 % h.d.)	14.7 mm (35.4 % h.d.)	8	?	?
2	31 —	24 —	13 — (41.9 —)	12 — (38.7 —)	7	?	42 mm
3	29 —	18 —	12 — (41.4 —)	11.5 — (39.7 —)	6—7	12—14	?
4	27 —	15 —	11 — (40.7 —)	10 — (37 —)	6	10—12	ca. 35 —
5	23 —	14 —	10.5 — (45.7 —)	10 — (43.5 —)	6	10—12	31 —

Nos. 1—2 after Anderson (Op. cit.).

Test varying a good deal in shape; it is usually flattened below, more rounded above; in the larger specimens it may be rather high, somewhat conical, (though with the apex truncated), the oral side remaining flattened. Sides generally beautifully arched; circumference round or subpentagonal.

Ambulacra nearly straight. Interporiferous zone rather unusually narrow, scarcely broader than a pore zone. Marginal series of tubercles regular, the tubercles rather small, not contiguous. Adradially to the marginal tubercle each plate carries only one secondary tubercle at the lower edge, forming regular vertical series; besides there are some few miliary tubercles, sometimes a regular series between the adjoining marginal tubercles. The rest of the plate bare; midline slightly sunken. The pores are somewhat unusually large, the outer may be rather distinctly the larger; the wall is fairly broad, almost quite flat; the ridge rounded, not prominent (Pl. LXXII. 12).

Interambulacra. Areoles at ambitus circular, fairly deep; the uppermost ones are usually conspicuously drawn out towards the apical system (as in *St. effluens*) and almost quite flat. The proximal ones are slightly transverse-oval. At most the two proximalmost areoles confluent (? in the largest specimens); those on the aboral side rather widely separated, several miliaries being found between the neighbouring scrobicular rings. On the upper plates the boss and mamelon are quite rudimentary; at the ambitus the boss is fairly conspicuous, occupying nearly the whole of the areole; the mamelon is, on the whole, small and inconspicuous. As a rule there is a rather distinct crenulation on the ambital tubercles. The scrobicular tubercles are fairly conspicuous, about twice the size of the marginal ambulacral tubercles; edge of areoles not raised. On the aboral side the scrobicular ring is drawn out apicalwards, and on the uppermost plate the ring is incomplete. Outside the scrobicular ring the plates are rather closely covered with small secondary and miliary tubercles, leaving no bare median space. On the adradial side scarcely room for any secondary tubercles outside the scrobicular tubercles. Median line not sunken. Median space rather narrow, about $^1/_3$ the width of an areole.

Apical system ca. 40—45 % h.d.[1], distinctly pentagonal in outline; the genital and ocular plates together form a flattened, slightly sunken area, within which the periproctal area

[1] Koehler's statement (Op. cit. 1927, p. 16) that the apical system reaches about $^2/_3$ of the h.d. is, evidently, erroneous; also the measurements given by himself (p. 18) show the apical system to be less than half h.d.

arises as a gently rounded eminence. Oculars rather large, usually narrowly insert, sometimes exsert all of them; genital plates somewhat unusually narrow; genital pores small[1], near the outer edge. The whole apical system rather sparsely covered with tubercles of fairly uniform size, some few of them a little elongate (Fig. 108). — Peristome flat, distinctly smaller than apical system. There are 12—13 ambulacral plates in a series in middle-sized specimens. 4—5 interradial plates in a series, which does not reach the mouth, though the ambulacra do not join at the mouth edge.

Primary spines ca. 1.2—1.5 h.d., very slender, ca. 2 mm in diameter, tapering gently towards the simple point. They are provided with usually 8 (sometimes 7) sharp, non-serrate ridges; only in the distal part the ridges are more or less distinctly serrate. The surface of the spines otherwise covered with a not very dense coat of low simple or slightly anastomosing hairs. The ridges stop at about 1—1.5 mm distance from the collar, leaving a perfectly smooth and shining neck. The collar which is likewise ca. 1—1.5 mm long, increases distinctly in thickness towards the rather conspicuous milled ring. The oral primaries are smooth, lancet-shaped, at most slightly serrate along the edges; the second and third with more or less distinct ridges in the distal part, the third being transitional to the ambital primaries. — The primary spines are very brittle, undamaged specimens of this species being therefore somewhat rare.

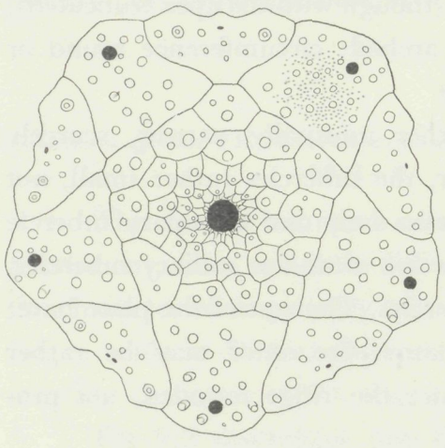


Fig. 108. Apical system of *Stylocidaris tiara*. × 5.

Secondary spines on the whole slender and delicate, not closely appressed. The scrobicular spines are ca. 4 mm long, slightly concave, narrowing very slightly towards the rounded point. The marginal ambulacral spines of the same general shape, only more slender and a little shorter, ca. 3 mm long. Miliary spines also of the same general shape, only smaller. Evidently no glandular ampulla at base of these spines.

Pedicellariæ. Only the small form of the globiferous pedicellariæ has been observed[2]; they are rather copiously developed, reaching a size of ca. 1 mm length of head, the stalk up to 2 mm long. The valves are of the usual shape, with a fairly conspicuous end tooth (Pl. LXXXV. 26). The irregular form of globiferous pedicellariæ has not been observed. Tri-

[1] According to Anderson (Op. cit. p. 189) the genital pores "are large, circular, situated in the outer third of the plates, and partly occluded by a delicate membrane". But "large" does not mean anything definite in the absence of exact measures, and the figure Pl. V. 2. a, of the "Illustr. Zool. Investigator" shows the pores of the same size as in my specimens; it is therefore not to be doubted that the genital pores are really small, as shown in fig. 108, and of about the same size in both sexes. — Koehler (Op. cit. 1927, p. 16) also states the genital pores to be large, but this is again a mistake, as appears from his own statement a few pages later (p. 20): "sur tous les échantillons ces orifices restent toujours très fins, contrairement à l'affirmation d'Anderson".

[2] This statement is in contradiction to Koehler, who (Op. cit. 1927, p. 19) describes and figures "large globiferous pedicellariæ". There is, however, not the slightest doubt that what Koehler regards as large globiferous pedicellariæ are only larger samples of the small form.

dentate pedicellariæ also well developed, with head up to 1.5 mm long; the valves are rather coarse, not widely apart in the proximal half (Pl. LXXXV. 24—25). — Spicules of tubefeet of the usual type, those of the intestinal wall as in the other *Stylocidaris*-species.

Colour. General colour chestnut brown, with a green shade on the aboral side, especially on the apical system. The primaries pale pink, changing towards the extremity into a pale olive-green. The secondaries olive-green, with a darker longitudinal median band, which may be dissolved into a series of spots. The denuded and cleaned test is white, only the apical system more or less conspicuously greenish, especially the genital plates which may thus form a conspicuous star-shaped figure.

Biology. A specimen opened was found to contain in its intestinal canal only bottom material with Foraminifera, especially Globigerina. — An interesting case of a parasitic Gastropod (*Mucronalia*) infesting the primary spines and transforming them into curious galls was described by Koehler ("Anomalies", loc. cit.). On one of the specimens examined by the author a Polynoid worm is found on one of the ambulacra. — The small size of the genital pores indicates small eggs and perhaps a pelagic larval stage.

Occurrence. Known only from the Indian Ocean, from off Ceylon, and the Andamans, in depths of ca. 215—720 m.

Remarks. Döderlein (1901. Op. cit.) expressed the opinion that this species might be nothing but a local form of *Stereocidaris indica*, the rudimentary condition of the upper areoles quite naturally leading to the suggestion that it might be a *Stereocidaris*. That this was not the case was shown by the present author, who had the opportunity in 1902 of examining a specimen in the collection of de Loriol; the resemblance of its pedicellariæ and its primary spines to those of *Stylocidaris bracteata* led me to the suggestion that it was identical with *bracteata* ("Ingolf"-Ech. I. p. 173). H. L. Clark (The Cidaridæ, p. 202) very justly objects to this idea, which was, however, very excusable at the then state of our knowledge of the species *bracteata*. That it is not so very nearly related to *St. bracteata* is easily seen on comparing the two species, especially the redspotted collar of *bracteata* distinguishing it at a glance from *tiara*.

That Koehler refers this species to the genus "*Dorocidaris*" is due to his mistaking the larger samples of the small globiferous pedicellariæ as the true large form. The discovery of the true large globiferous pedicellariæ in *Stylocidaris effluens* (Th. Mortensen. 1927. Albatross Cidaridæ, p. 289, Pl. 80,4) leaves no doubt of the interpretation of the pedicellariæ observed by Koehler in *St. tiara*. Also in *St. effluens* (as in so many another species of Cidarids) the large form of the globiferous pedicellariæ is very rarely met with; it is, therefore, not so extraordinary a fact that it has not yet been observed in *St. tiara*.

The nearest relation of *St. tiara* is, no doubt, *St. effluens* Mrtsn., with which it agrees especially in the effluent character of the uppermost areoles. It differs from *St. effluens* mainly in the ridges of the primary spines being entire, distinctly serrate in *effluens*; further in its crenulate

ambital primary tubercles (non-crenulate in *St. effluens*). Also in the test, especially the ambulacral structure, there are fairly obvious differences. There can, therefore, be no question but that we have here two perfectly different species.

Stylocidaris Lorioli (Koehler)

Pls. LXVII. 4; LXXII. 13; LXXXIV. 31—32.

Dorocidaris Lorioli. Koehler. 1927. "Investigator" Ech. III. p. 21. Pl. **III. 2—5.**

To the description of this species given by Koehler may be added some supplementary remarks, based on a specimen, cotype, which was kindly placed at my disposal.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
24 mm	15 mm	13 mm (54.2 % h.d.)	11.5 mm (48 % h.d.)	5—6	11—12	37 mm

The general shape of the test is very much as in *St. tiara*, but the proportion of the apical system and peristome would seem to be somewhat larger, ca. half h. d., against ca. 40—45 % in *tiara*. (Koehler does not give the dimensions of his specimens, but in the specimen represented in Pl. III. 2 it would seem that the apical system is ca. 48 % h. d.). The ambulacra are broader than in *tiara*, ca. 45 % of I. A., against ca. 35 % in *tiara*, and especially the interporiferous zone is conspicuously broader than in *tiara*; there are two inner tubercles on each plate, only one in *tiara* (Pl. LXXII. 13 to comp. with Pl. LXXII. 12). The upper areoles have not the effluent character as in *tiara*, but are well formed, fairly deep. There is no trace of crenulation on the primary tubercles. The ocular plates are all rather broadly insert in the specimen at hand and with almost straight inner sides (broadly triangular); this appears to be the case also in the specimen represented by Koehler in his Pl. III. 3, whereas in the specimen Pl. III. 2 the shape of the oculars appears to be quite different, with semicircular inner side; also it seems that they are exsert in this specimen. The primary spines have only ca. 12 series of spinules against 15—17 in Koehler's specimens. The hairs are simple or bush-shaped. The tridentate pedicellariæ have the valves more slender and more widely apart than in *tiara* (Pl. LXXXIV. 31—32 to comp. with Pl. LXXXV. 24—25). The colour of the apical system is dark green or rather olive, this colour continuing on to the upper interambulacral plates; there is an indication of red bands on the primary spines.

The species is known only from the Indian Ocean, off the Andaman Islands, ca. 200 m.

Koehler at first regarded this form as a variety of *St. tiara*, but finally decided to establish a separate species for it, yielding to the opinion expressed by me in letters to him. There is certainly no doubt that in general resemblance it comes very close to *St. tiara*; but the differences pointed out by Koehler and in the additional remarks given here, especially in the character of the primary spines, of the ambulacra and interambulacra, seem to preclude the idea of regarding

this form simply as a variety of *tiara*. The character of the primary spines, indeed, approaches it more to *Stylocidaris Reini* — though I would not say I think it so very nearly related to that species.

Regarding Koehler's referring of this species to *Dorocidaris* the same holds good as for *St. tiara* (cf. above, p. 371).

Stylocidaris albidens H. L. Clark

Pls. XXXVI. 9; XXXVIII. 1—3; LXXII. 11; LXXXIV. 16—18.

Stylocidaris bracteata, var. *albidens*. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 23.
Stylocidaris bracteata, var. *albidens*. Koehler. 1927. "Investigator" Ech. III. p. 33.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	40 mm	25 mm	16.5 mm (41 % h.d.)	14 mm (35 % h.d.)	7—8	ca. 12	50 mm
2	37 —	22 —	16 — (43.2 —)	13.5 — (36.5 —)	7—8	13—14	ca. 40 —
3	34 —	22 —	15 — (44.2 —)	14 — (41 —)	7—8	11—13	50 —
4	32 —	20 —	15 — (47 —)	12 — (37.5 —)	6—7	12—13	45 —
5	20 —				5—6	11	40 —

The specimen 5 is the type-specimen (British Museum).

Test flattened above and below, sides arched or slightly subvertical; circumference round.

Ambulacra slightly sinuate. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles distinctly mamelonate, sometimes distinctly transverse-oval or rather with a more or less distinct areole, contiguous, only separated by a more or less complete series of miliary tubercles. Adradially to the marginal tubercle each plate carries usually two secondary tubercles, situated one above the other. There is also often one tubercle at the median corner of the plate, as also there may be some irregularities with the other secondary tubercles. When only the two first mentioned tubercles are developed (in younger specimens and in the upper part of the ambulacra of older specimens) these form a rather regular vertical series adradially to each marginal series, the median part remaining naked. When all the tubercles are developed, there is no naked median space, and no distinct inner vertical series. The pores are equal-sized, not very distant, the wall forming a distinct semilunar, rather high prominence; the ridge is very low and inconspicuous (Pl. LXXII. 11).

Interambulacra. Areoles not very deep, well separated, only the 2—3 proximal ones confluent. The subambital ones distinctly transverse-oval. Boss rather low; there may be a fairly distinct trace of crenulation on the uppermost tubercles. Scrobicular ring not very prominent, not elevated; the scrobicular tubercles, of which there are 18—20, scarcely larger than the marginal ambulacral ones. Outside the scrobicular ring the plates are closely covered by smaller tubercles gradually decreasing in size towards the scarcely sunk median line. Also on the adradial side secondary tubercles are more or less numerous. The median interambulacral space about half the width of an areole.

Apical system 41—47 % h.d., usually slightly raised. Oculars usually all insert, but sometimes very narrowly so or even one or two of them exsert (the specimen 32 mm h.d.). Genital pores small, near outer edge. The whole apical system closely covered by small tubercles of uniform size. Periproctal plates fairly numerous (Fig. 109). Peristome distinctly smaller than apical system, ca. 35—41 % h.d. There are 10—11 ambulacral plates in a series. Interradial plates in a regular series of 4—5, not reaching the mouth edge.

Primary spines on the whole resembling those of *St. bracteata*. They are slightly fusiform, being a little widened above the base, then tapering gently; the point may be slightly crown-shaped. There are 10—12 series of sharp thorns, which unite into fairly distinct ridges in the distal part, while in the basal part they remain more or less distinctly separate, especially on the adapical side. The lateral ridges are usually somewhat more prominent, and those of the adoral side lower than those of the aboral side, the spines thus looking more or less flattened. The general surface of the shaft is covered by a close coat of low simple hairs. The basal part (neck), of ca. 1 mm length, is smooth, shining, like a continuation of the collar, which is likewise ca. 1 mm long, slightly widening towards the inconspicuous milled ring. The oral primaries simple, scarcely widened, slightly furrowed on the aboral side. The 3rd—4th is transitional to the ambital spines.

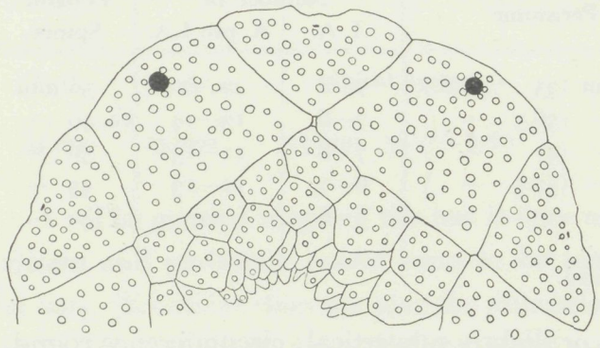


Fig. 109. Part of apical system of *Stylocidaris albidens*. × 6.

Secondary spines. The scrobicular spines are ca. 4 mm long, flattened, very slightly tapering towards the rounded point. They may be slightly excavate at the point, especially those of the oral side. Marginal ambulacral spines slender, slightly flattened, those of the oral side more or less distinctly curved. Apparently no glandular ampulla at the base of the secondary spines.

Pedicellariæ. Large globiferous form observed only in the type specimen; it is of the typical form (Pl. LXXXIV. 16), with a limb on the stalk; the small globiferous and tridentate pedicellariæ of the usual form, both very slender (Pl. LXXXIV 17—18). The irregular form of the small globiferous type has not been observed. — Spicules of tubefeet of the usual form.

Colour. The general colour is a dirty creamy-yellowish. The primaries, when well cleaned, are generally more or less pinkish in the lower half, the colour disappearing in the outer part. In the type specimen the colour of the primaries is more brownish, and they are somewhat banded in the distal part. The white thorns stand out rather conspicuously on the ground colour. Towards the base the colour continues over the collar as conspicuous reddish-brown longitudinal lines. The secondaries have a conspicuous greenish-olive median stripe, which changes into a more or less pink colour towards the base of the spine. The ambulacral spines do not differ markedly in colour from the other secondaries. The naked test in general white.

The interporiferous zone of the ambulacra of an olive colour, sometimes with a tinge of pink on the marginal tubercles; the ambulacra thus form five conspicuous dark meridian stripes. The apical system is of a more or less dark greenish-olive colour, which may continue a little on to the upper interambulacral plates. At the median end of the horizontal interambulacral sutures there is a small, more or less conspicuous, dark spot. The peristomial plates with a slight greenish tint.

Biology. The species appears to have reached its full size at a horizontal diameter of ca. 40 mm. The spines of these larger specimens are not very much overgrown by foreign organisms, though several of them may be covered by Bryozoa, Serpulid tubes and barnacles.

Occurrence. The type specimen was found off Ceylon (Herdman); several specimens were taken off Port Blair on the Andamans by the "Investigator".

Varieties. A specimen 20 mm h.d. from off the Andaman Islands, 90 m., differs from the usual form in its colour; the secondaries are of a more uniform reddish, the primaries brownish as in the type specimen. The apical system is nearly white, except the oculars which are conspicuously red. Also the interporiferous zone, particularly the marginal tubercles, is reddish. This colour, especially that of the apical system, gives so marked a difference from the usual form that it is hardly justifiable simply to regard this specimen as identical with the other specimens. But so long as there is only one young specimen available, and as there seem to be no other differences from the usual form than the colour, it may be the better course for the present to regard it only as a colour variety of *albidens*.

Remarks. It must be conceded that the identification of the "Investigator"-specimens with Clark's *Stylocid. bracteata*, var. *albidens*, is not wholly beyond doubt. In the type-specimen, which I have seen in the British Museum, the primary spines are darker and rather distinctly banded, and the spinules are distinctly united into ridges. Further the type-specimen has only a single secondary tubercle adradially to the marginal ambulacral tubercle. But as the type-specimen is only 20 mm in diameter, and no specimens of a size smaller than 32 mm h.d. of the Port Blair-form have been examined, it is impossible to say whether the differences, especially that of the ambulacra, is only due to age or not. — For the present I have thought it justifiable to designate the "Investigator"-specimens as *albidens*; but if it should ultimately be found that adult specimens of the Ceylon-form differ in the same and, eventually, other characters from the "Investigator"-form as does the type-specimen of "*albidens*", then the "Investigator" specimens represent a new species and will have to be renamed.

That it is not justifiable to refer the specimens here described under the name of *Stylocidaris albidens* — be they now identical with the type of *albidens* or not — to *Stylocidaris bracteata* as a variety only of that latter species, as is done by Clark, seems to me beyond doubt. Above all the colour of the spines affords a very conspicuous difference — and there is no indication at all that *bracteata* should be so variable in regard to this character that the present form, with the longitudinal stripes on the collar, could be included. The case is a strict parallel to that of

Prionocidaris baculosa—pistillaris, where also the form with the longitudinal stripes on the collar (*pistillaris*) was unjustly regarded as only a variety of the form with the purple spots on the collar (*baculosa*).

To the "variety" *albidens* H. L. Clark (Op. cit.) refers also a second specimen from the Macclesfield Bank, although it is "more olive than the one from Ceylon and the abactinal system, ambulacral secondaries and primary spines are much lighter". In my opinion this specimen, which I have seen in the British Museum, cannot be identical with the Ceylonese form — which is the type of *albidens*. It is a very young specimen, only 8.5 mm h.d. In the ambulacra only the marginal series of tubercles is present. The oculars are all widely exsert. The primaries are in general like those of the type — the reason why Clark united them under the same name — but the secondaries are very different, short and broad, the scrobicular ones of a uniform dark olive colour, the others white. Also in the shape of the large globiferous pedicellariæ there is a fairly conspicuous difference (Pl. LXXXIV. 19 to comp. with Pl. LXXXIV. 16). That these differences should be due alone to age seems highly improbable, and there is every reason to expect that the specimen from the Macclesfield bank will prove to belong to another, undescribed species.

Stylocidaris badia H. L. Clark

Pls. XL; LXXII. 16; LXXXV. 27—29.

Rhabdocidaris baculosa. De Loriol. 1883. Cat. rais. Ech. de l'île Maurice. p. 4—7. Pl. **I. 1. a—g.**
Cidaris (Cidaris) baculosa, var. De Meijere. 1904. "Siboga" Ech. p. 12.
Prionocidaris badia. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus., p. 14. Pl. **II. 2.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	38 mm	24 mm	20 mm (52.6 % h.d.)	19 mm (50 % h.d.)	(6) 7	13—14	88 mm
2	34 —	22 —	17 — (50 —)	19 — (56 —)	(6) 7	13—14	103 —
3	31 —	18 —	15 — (48.4 —)	15 — (48.4 —)	(6) 7	12—14	65 —
4	27 —	17 —	12.5 — (46.3 —)	13 — (48.1 —)	6—7	13—14	90 —
5	25 —	15 —	12.5 — (50 —)	14 — (56 —)	6—7	12—14	86 —

Specimen 4 is the type-specimen; no. 1 is in the Museum of Munich, nos. 2—3 in the Museum of Genève, 4 and 5 in the British Museum.

Test somewhat flattened above, less so below; sides arched; circumference round. Ambulacra ca. 25—30 % of width of I.A. Interporiferous zone rather broad, a little more than twice the width of a pore zone. Marginal series of tubercles not very prominent, tubercles contiguous. Space inside the marginal series in the larger specimens filled up with a number of small tubercles, which are not distinctly arranged in longitudinal series (Pl. LXXII. 16). In the specimens 4—5 there is a fairly regular inner series of tubercles, distinctly smaller than the marginal tubercles; in specimen 5 there is now and then a small tubercle near the median line, which makes the serial arrangement less distinct. No naked, sunk median line. Pores equal sized, not

very distant; the wall rises in its upper part into a fairly distinct, broad prominence; ridge low and indistinct in its inner part.

Interambulacra. Areoles not deepened, well separated, only the 2 (3) proximal ones confluent. At least some of the upper tubercles distinctly crenulate. Median interambulacral space narrow, about half the width of an areole. Scrobicular circle of tubercles not very prominent; median space only with very small tubercles, leaving a naked, but scarcely sunk median line. At the adradial side of areoles there is hardly room for a few small tubercles outside the scrobicular circle.

The apical system (see: De Loriol. Pl. I. 1. c) ca. 48—56 % h.d., uniformly, though not very closely, covered by small, low tubercles, only those along the outer edge being somewhat larger (Fig. 110). Ocular plates all insert, more or less broadly. Genital pores in all the specimens examined — perhaps all males — rather small, not far from the edge. Madreporite hardly larger than the other genital plates. Periproct somewhat elevated, with fairly numerous small plates, the inner ones carrying spines somewhat larger than the outer ones, forming a raised tuft around the anal opening. — The peristome, which appears to be usually (not in specimens 1 and 3) larger than the apical system (ca. 48—56 % against 46—52 % h.d.), has 12—13 ambulacral plates in a series and a regular series of 7—8 interradial plates which reaches to near the mouth edge, the inner 4—5 ambulacral plates, however, joining with those of the neighbouring radius.

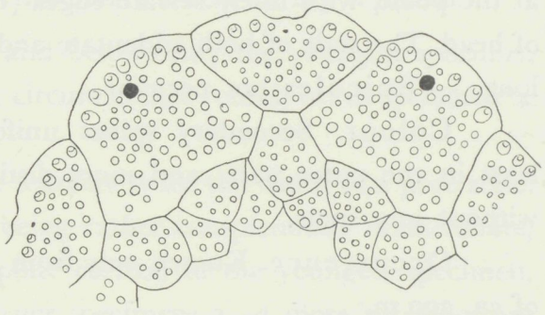


Fig. 110. Part of apical system of *Stylocidaris badia*. × 6.

Primary spines. The upper ambital spines usually very long, up to 3 times h.d., somewhat swollen in the basal part (ca. 5 mm in diameter), then gradually tapering, the point sometimes flaring very inconsiderably. They are rather closely set with thorns of uniform size, ca. 1.5 mm long, arranged in ca. 10 regular longitudinal series. The thorns are lancet-shaped, somewhat transparent, sometimes bifurcating in the tip; they are rather erect, obliquely outwards directed, each rising separately, directly from the surface of the spine, not from a longitudinal ridge (cf. de Loriol, Pl. I. 1. f). Those on the under surface of the spine somewhat smaller. In the outer half of the spine they gradually diminish in size, at the same time uniting so as to form distinct ridges, which continue to the point. The surface of the spine otherwise covered with a spongy coat of low, anastomosing hairs. The collar is short, scarcely exceeding 1 mm, hardly widening towards the milled ring, which is not prominent.[1] The oral primaries are only little specialized. The first is somewhat flattened, scarcely widened, the side edges not serrate; the

[1] The finely longitudinally striped spines without thorns, which de Loriol describes as occurring near the apical system, are only young spines in which the outer layer has not yet been formed. Such spines are found also in one of the specimens in the British Museum.

second, in places also the third, rather deeply fluted, somewhat flaring at the tip. From the third (fourth) they assume the shape of the ambital spines, only much shorter than these. — The secondary spines appressed, those surrounding the base of the primaries ca. 4.5 mm long, flat, not pointed; the marginal ambulacral spines similar in shape, but much smaller, only ca. 2.5 mm long. The small spines simply pointed, probably with a glandular coat of skin at the base.

Pedicellariæ. Large globiferous pedicellariæ of the typical form (LXXXV. 28); the stalk with a limb of rather short, outstanding prominences (only one sample seen, in specimen 5). The small globiferous of the typical form (Pl. LXXXV. 29), with a very small end tooth; they scarcely exceed 0.5 mm length of head. The tridentate pedicellariæ are the best developed, especially found on the peristome and the oral side of the test. The valves are very slender, joining only at the point, with finely serrate edges (Pl. LXXXV. 27); they reach a size of ca. 1.5 mm length of head. The stalk of both tridentate and globiferous forms rather long and slender, up to 2 mm long. — Spicules not peculiar.

Colour. Secondary spines uniformly brown; primaries banded brown and white, at least in the outer part, and more distinctly on the under side. The collar uniformly brown, without any spots.

Occurrence. Known only from Mauritius, taken on fishing lines, probably at the depth of ca. 200 m.

Some of the larger spines in the specimen 2 are overgrown by worm-tubes, Bryozoa and *Polytrema*.

The above description is mainly based on the specimens mentioned by de Loriol (Op. cit.) which were lent me for examination. Further I have had an opportunity of examining the two specimens in the British Museum and one in the Museum of Munich.

De Loriol regarded this form only as a variety of the polymorphous *Prionocidaris* ("*Rhabdocidaris*") *baculosa*, in spite of the fact that it lacks the purple spots on the collar, that very conspicuous character of *baculosa*. A. R. S. Anderson[1] meant to recognize it as a separate species, though without naming it; probably, however, it was rather *S. albidens* which Anderson had before him, since this species was well represented in the "Investigator" collections, while *St. badia* was not represented. Only in 1925 H. L. Clark established the species under the name of *Prionocidaris badia*, expressing the opinion that it is the nearest related to *Pr. bispinosa*. With this opinion I cannot agree; it is even beyond doubt that this species was not rightly referred to the genus *Prionocidaris*, as its pores are not conjugate. It must be referred to the genus *Stylocidaris*, with which the character of its pores agrees. Within this genus it seems to be the nearest related to *St. albidens* H. L. Clark.

[1] Report of the Surgeon-Naturalist 1898—99. Rep. Marine Survey of India 1898—99. p. 5.

Stylocidaris brevicollis (de Meijere)

Pls. XXXVIII. 4—6; LXXII. 1—2; LXXXV. 3, 16—20.

Cidaris (Cidaris) baculosa, var. *brevicollis*. De Meijere. 1904. "Siboga" Ech. p. 11, Taf. **II. 8, 13** (non 7); Taf. XI. 110.
?Prionocidaris brevicollis. Koehler. 1927. "Investigator" Ech. III. p. 33. Pl. V. 1, 4—5; XXIII. 3.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	40 mm	26 mm	17.5 mm (43.8 % h.d.)	17.5 mm (43.8 % h.d.)	8	12—13	ca. 45 mm
2	32 —	19 —	15.5 — (48.4 —)	15.5 — (48.4 —)	7	12—13	50 —
3	13 —	7 —	6 — (46 —)	6 — (46 —)	6	8—10	29 —

Specimen 1 and 3 are the type-specimens ("Siboga", St. 49. a). The measurements given by de Meijere of these two specimens, 43 mm and 14 mm h.d., are incorrect. — Specimen 2 is from the Bay of Ambon.

Test rather high, not distinctly flattened above and below, only the youngest specimen somewhat more flattened above. Sides beautifully arched; circumference round, or, in specimen 2, slightly subpentagonal.

Ambulacra slightly sinuate; interporiferous zone scarcely twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles being rather conspicuously mamelonate, contiguous. Adradially to the marginal tubercle each plate carries, in the youngest specimen, a single secondary tubercle at the lower edge; in the larger specimens 2—3 more tubercles are developed, more or less regularly, obscuring the original distinct vertical series of the first formed inner tubercles, and covering almost the whole of the interporiferous zone. The pores are, in the larger specimens, rather distant, of about equal size. The upper part of the wall forms a rather sharply limited, semilunar elevation; the ridge is narrow and distinctly lower than the semilunar elevation of the wall (Pl. LXXII. 1—2). This structure is more distinct in specimen 2 than in the larger specimen 1. In the small specimen the pores are, of course, much more close together, and the elevation of the wall is not so elegantly shaped.

Interambulacra. Areoles rather small, scarcely deepened; they are well separated, only the two proximal ones confluent. They are very markedly transverse-oval, except the 1—2 upper ones. Edge of areoles not elevated, the scrobicular tubercles rather conspicuous in the largest specimen, less so in the specimen 2, though also in the latter about twice the size of the marginal ambulacral tubercles. Outside the scrobicular ring the plates closely covered by secondary tubercles, gradually decreasing in size towards the middle line of the area, which is not at all naked, and hardly sunken. Also on the adradial side of the scrobicular ring there are several small tubercles. Median area about $^2/_3$ the width of an areole.

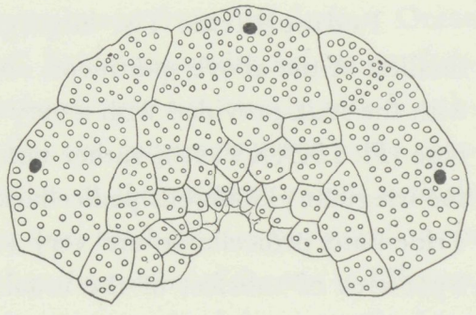


Fig. 111. Part of apical system of *Stylocidaris brevicollis*. × 4.

Apical system (Fig. 111) nearly half h.d. (43.8—48.4 % in the examined specimens), somewhat raised.

Ocular plates broadly insert in the largest specimen, narrowly so in the two other specimens, (as also in the two specimens from the "Siboga" St. 51). Genital pores rather small, not very close to the edge. Periproctal plates fairly numerous. All the plates of the apical system closely covered by small tubercles of nearly uniform size, only those along the outer edge of the genital plates slightly larger; there may be a more or less conspicuous bare inner edge on the genital plates. In the young specimen the genital and ocular plates are less closely tuberculated. — Peristome of the same size as the apical system, somewhat elevated. There are 16—18 peristomial ambulacral plates in a series in the larger specimens, 6—7 interradial plates, not reaching the mouth edge.

Primary spines ca. 1.5—2 h.d. or, in the youngest specimen, even a little more than 2 h.d. (In the largest specimen the primaries are all very much overgrown and scarcely quite intact). They are slightly fusiform, tapering gently towards the rather fine, not widened point. The shaft of the spine is set with rather conspicuous thorns arranged in distinct longitudinal series to the number of ca. 12—14. The thorns are as a rule not united into ridges, except in the outer, more slender part of the spines; they are conspicuously larger on the aboral than on the adoral side of the spine, which gives the spine a somewhat flattened appearance. The surface of the shaft otherwise covered by a close coat of very fine, low, unbranched hairs. The basal part of the shaft is smooth, passing gradually into the collar, which is very short, scarcely more than 0.5 mm. Milled ring very inconspicuous. — The oral primaries are short, simple, usually with distinct longitudinal ridges on the aboral side. The third is transitional to the ambital spines.

Secondary spines. The scrobicular spines are ca. 3—3.5 mm long; they are very nearly rectangular, flattened or slightly convex on the outer side and with bevelled end, like a chisel (Pl. LXXXV. 16); this shape is more distinct on the oral than on the aboral side, and much more so in the largest specimen; in the latter the secondary spines are, on the whole, thicker, with outer side convex. Many of these spines in this specimen evidently have the outer part regenerated. — The marginal ambulacral spines of the oral side have a similar shape, only narrower and more or less curved; on the aboral side they are more simple, spiniform. The miliary spines simple, flattened, lancet-shaped. No glandular ampulla to be observed. The secondary spines on the whole rather erect, especially on the oral side, and more so in the largest specimen.

Pedicellariæ. The large globiferous pedicellariæ, which have been found only in the smallest of the above specimens, and in a specimen from "Siboga" St. 51, are of the usual type, with the stalk provided with a very fine limb (Pl. LXXXV. 17—18). The small form of the usual type (Pl. LXXXV. 20), rather numerous; besides I have found in specimen 2 several samples of the irregular globiferous pedicellariæ, known from several species of *Stylocidaris* (Pl. LXXXV. 3). Tridentate pedicellariæ are very scarce, small, with slender, simple valves (Pl. LXXXV. 19). Spicules of tubefeet of the usual type; in well extended tubefeet arranged in beautiful half-rings (Fig. 21, p. 35).

Colour. Secondaries light reddish or pinkish, those of the ambulacra darker. The primaries

are of a reddish-purplish tint, on which the white thorns stand out very conspicuously. The dark colour continues as longitudinal stripes down to the milled ring. The naked test is white on the interambulacra; the interporiferous zone of the ambulacra red, even to the peristome, forming thus very conspicuous meridian stripes. Apical system reddish-brown, only the oculars white.

Biology. The largest specimen (Pl. XXXVIII. 6) has its spines almost totally covered by barnacles and makes the impression of being an old one. Its spines are for the greater part broken, which seems to be due to old age, not to rough handling by the capture. A Polynoid worm was found among the spines on the specimen from Amboina.

Occurrence. The species was taken by the "Siboga" at Station 49. a (8° 23′ S. 119° 4′ E., Sapeh Strait, 69 m., 2 specimens), and at Station 51 (Molo Strait, 69—91 m., 2 specimens); further the author dredged a specimen in the Bay of Ambon in 1922 (ca. 90 m.).

Remarks. That this species has no nearer relation to *Prionocidaris baculosa*, to which it was referred by de Meijere as representing only a variety of that species, is evident — above all on account of its pore structure. The reason why de Meijere thought it should be referred to *baculosa*, was this that together with the two specimens from St. 49. a (the above no.s 1 and 3) there was a third specimen with isolated red spots on the collar, that very prominent character of *baculosa* (figured in his Taf. II. 7). In spite of the red spots on the collar this specimen does, however, not belong to *baculosa*, but to *Stylocidaris bracteata*, which has likewise red spots on the collar — a fact naturally unknown to de Meijere, as there was at that time no description of *bracteata* from which it could be gathered that this was one of its chief characters. (Regarding this specimen, see otherwise under *St. bracteata*, p. 363).

As regards the affinities of the species *brevicollis* it seems to be the nearest related to *St. albidens* from which it differs, however, conspicuously e. g. in its ambulacral structure, and in the uniform colour of its secondaries (striped in *albidens*). Also to *St. bracteata* it is rather nearly related, but at once distinguished from it by the lacking of the red spots on the collar. As pointed out by de Meijere (Op. cit., p. 12—13) the Mauritius form, recently designated by H. L. Clark as *Prionocidaris badia*, also is related to *brevicollis* and certainly belongs like the latter to the genus *Stylocidaris*, not to *Prionocidaris*, where it was placed by Clark.

It must be regarded as very doubtful whether the specimens from the Indian Ocean mentioned by Koehler in his Report on the "Investigator" Echinoids really belong to *Stylocidaris brevicollis*. A specimen from the Seychelles, ca. 70 m., at hand agrees so closely with Koehler's figures (Pl. V) that I cannot doubt they are identical. But this specimen shows some characters which do not fit with *St. brevicollis*. Above all, the collar of the primary spines is fairly long, ca. 1 mm, not the characteristic short one of *brevicollis*; then the hairs are not simple as in *brevicollis*, but anastomose and form a thick, spongy coat; further the colour of the test is different, greenish-olive, and the interporiferous zone is not red. This specimen is, I have no doubt, a young *Prionocidaris pistillaris*, and I rather think Koehler's specimens likewise belong to the said

species. It must be remarked, though, that I have not observed the peculiar form of pedicellariæ represented by Koehler in his Pl. XXIII. d., either in the said young specimen from the Seychelles or in any of the other specimens of *Pr. pistillaris* which I have examined.

Stylocidaris (?) fusispina Mrtsn

Pls. XXXVII. 11—12; LXXII. 4; LXXXIV. 26—30.

Dorocidaris Reini. A. Agassiz & H. L. Clark. 1907. Prel. Rep. Ech. Albatross, 1906. p. 111. (partim).
Stylocidaris (?) fusispina. Th. Mortensen. 1928. New Cidaridæ, p. 72.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	11 mm	6 mm	6.5 mm (59 % h.d.)	5.5mm (50 % h.d.)	5	6—7	12 mm
2	9 —	5 —	5 — (55.5 —)	4.5 mm (50 —)	4—5	6	8 —

Specimen no. 1 is the type; no. 2 is in the Museum of Comp. Zoology. (A third specimen, 13 mm h.d., is in the U. S. National Museum; no detailed measurements were taken of this specimen).

Test flattened above and below; sides arched, circumference round.

Ambulacra slightly sinuate; interporiferous zone twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles rather unusually large, distinctly mamelonate, contiguous. Only a very small miliary, pedicellaria-bearing tubercle at the lower edge of the plate adradially to the marginal tubercle, otherwise the interporiferous zone quite naked. Median line not sunken. The pores are small, equal sized, rather unusually oblique; the wall is somewhat narrow, rather conspicuously elevated; the ridge low, rounded (Pl. LXXII. 4).

Interambulacra. The areoles are very low wholly occupied by the rather large boss; the two—three proximal ones confluent. Mamelon rather large. A fairly distinct crenulation on the adapical side of the upper tubercles. Edge of the areoles not at all elevated, the scrobicular tubercles inconspicuous, not larger than the marginal ambulacral ones; there are only 10 of them in each scrobicular ring. There is only a single series of secondary, not much smaller, tubercles outside the scrobicular ones, and alternating with these latter, none on the adradial side. No naked or sunken median part. The median area about half the width of an areole.

Apical system (Fig. 112) large, ca. 55—59 % h.d. Oculars all exsert. Genital pores small, near the outer edge. Only a series of fairly large tubercles along the outer and inner edge of the genitals and the outer edge of the oculars, the spines attached thereto forming a fairly conspicuous fringe, the rest of these plates almost wholly naked; the madreporite with some more tubercles. Pore area small, a little elevated. Periproct with fairly numerous small plates, slightly raised. — Peristome smaller than the apical system, but still as much as half h.d.; it is slightly raised. There are 6—7 ambulacral plates in a series, three interradial plates, widely separated from the mouth edge by the joining of the ambulacra.

The primary spines are very characteristic: distinctly fusiform, provided with 10—12

sharp, but perfectly smooth longitudinal ridges, which are in the basal part transformed into series of low, rounded tubercles (Pl. LXXXIV. 30). The surface of the spine, between the ridges, is covered by a low, spongy texture of anastomosing hairs (Fig. 104. 4). The point of the primaries simple, not crown-shaped widened. The collar ca. 0.5 mm long, increasing in thickness towards the very inconspicuous milled ring. The oral primaries simple, scarcely widened or curved, distinctly longitudinally ridged on the aboral side. The third is transitional to the ambital spines.

Secondary spines simply flattened, slightly narrowing towards the rounded point. The scrobicular spines are ca. 2.5 mm long, the marginal ambulacral spines slightly shorter and narrower; none of the secondaries very closely appressed.

Pedicellariæ. Large globiferous pedicellariæ unknown. The small globiferous pedicellariæ rather strongly developed; they reach a size of ca. 0.5 mm length of head, the stalk being ca. 1 mm long. The valves are rather robust, with a short opening and a distinct end tooth (Pl. LXXXIV. 28—29). The tridentate pedicellariæ (Pl. LXXXIV. 26—27) of the usual type, up to 1 mm length of head; the stalk much shorter. A four-valved sample was found in the type specimen. — The spicules of the tubefeet of the usual type.

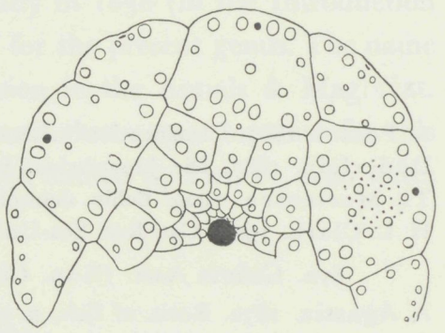


Fig. 112. Part of apical system of *Stylocidaris fusispina*. × 9.

Colour. The type specimen is in general reddish-yellow. The primaries with two—three conspicuous brownish or reddish-yellow bands; the secondaries with a conspicuous median stripe of the same reddish-yellow colour. The naked test in general white, but the tubercles, both primaries and secondaries with a pinkish tint. The apical system light reddish-yellow.

Biology. The species apparently does not reach a much larger size than that of the type, which has the appearance of being nearly adult; it is in accordance herewith that the genital pores have appeared already in the specimen of 9 mm. — The primary spines are very clean, only a small Bryozoan colony is found on a few of the spines.

The type specimen shows sign of an attack by a Gastropod in the middle of one of its ambulacra. The hole caused thereby is closed up by a mosaic of small plates.

Occurrence. The species is known only from the Japanese Seas. The type-specimen was taken by the author on the Okinose Bank, Sagami Sea, ca. 100 m., VI. 1914. Two specimens were taken by the "Albatross" in 1906 off Kagoshima Gulf, 185 m.

Remarks. The two specimens from the "Albatross" St. 4936, were recorded (Op. cit.) under the name of *Dorocidaris Reini*; but the authors duly point out that the spines are very peculiar and state that "it is possible that the two specimens are really the young of an hitherto undescribed species". I have had the opportunity of examining these two specimens, one in the Museum of Comp. Zoology, the other in the U. S. National Museum, and find them identical with the fine specimen which I collected in the Sagami Sea. That they have nothing with *Stylocidaris Reini*

to do, but represent a distinct species, is beyond any doubt. The only questionable thing is, whether this species really belongs to the genus *Stylocidaris*. The structure of the pores is rather different from that usually found in *Stylocidaris*, and rather indicates that it ought to be made the type of a separate genus. Also the primary spines are rather unique for a *Stylocidaris*; the surface of the shaft much more recalls *Acanthocidaris*, but the very short collar is a conspicuous difference from that genus, with which there is otherwise no likeness either. Still, so long as we know only the three small specimens mentioned, and as, moreover, the large globiferous pedicellariæ are still unknown, it seems the better course for the present to refer it to the genus *Stylocidaris*. Evidently, it has no near relation to any of the other *Stylocidaris*-species known till now.

Genus **Eucidaris** Pomel.

A. Pomel. 1883. Classification méthodique. p. 109.
Döderlein. 1887. Die Japanischen Seeigel. I. p. 42.
Th. Mortensen. 1909. Echin. deutsche Südpolar-Exp. p. 39, 54.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 3, 20.

Syn. *Cidaris* Auct. (Non. *Cidaris* Leske, p. 286).

A. Agassiz. 1872. Revis. of Ech. p. 384.
A. Agassiz. 1881. "Challenger" Ech. p. 33.
H. L. Clark. 1907. The Cidaridæ, p. 183.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 141.

Syn. *Gymnocidaris* A. Agassiz (1863), non: *Gymnocidaris* L. Agassiz (1838).

A. Agassiz. 1863. List of Echin. p. 17.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 101.

Pores not conjugate, wall rising into a rounded prominence; pores on peristome in larger specimens more or less distinctly biseriate (not in *metularia*). Madreporite slightly enlarged. Primary spines typically cylindric, terminating in a small crown with a central prominence; the shaft with low, rounded warts arranged in rather distinct longitudinal series. General surface of shaft usually covered with a thick, spongy coat of anastomosing hairs. Sometimes the primaries may be fusiform, tapering to a simple point, sometimes they are very thick, clubshaped. Secondary spines rather appressed. Large globiferous pedicellariæ without an end tooth, with or without a limb on the stalk. Small globiferous pedicellariæ with a small, but distinct end tooth. Tridentate pedicellariæ may occur in two distinct forms, both with long, slender valves.

Genotype: *Cidarites metularia* Lamarck.

The species referred to this genus have been recognized by all recent authors as forming a natural group, although the characters given by the various authors are mostly of a rather slight value. The main character of the genus, evidently, is that of the primary spines, which, when typically developed, are cylindrical with a small but distinct end-crown, in the middle of which rises a small, indented prominence. Also the biseriate condition of the ambulacral pores on the peristome is a very noteworthy character, though usually not found in young specimens

and, correspondingly, not in the species *metularia*, which does not grow to any large size. The existence of two sorts of tridentate pedicellariæ also appears to be a valuable generic character, though as yet only the common form has been observed in *tribuloides* and *clavata*.

A very interesting feature is the tendency to develop thick spines, recalling the numerous fossil forms of thick, club-shaped Cidarid-spines. This is the case in the two species *Thouarsii* and *tribuloides*, the two varieties, or species, *galapagensis* and *clavata* representing the climax of a parallel development in this direction in the two former species.

The genus can be traced back to the Miocene in West Indian and North American deposits.

The name *Gymnocidaris* proposed by A. Agassiz, 1863 (List of Echinod.) for *metularia* was proposed by L. Agassiz for a Hemicidarid (*G. diademata*) already in 1838 (in the Introduction to "Monogr. d'Échinod. I. Salénides") and thus cannot be used for the present genus. The name *Cidaris* must be used for the former *Dorocidaris* (cf. the discussion in the Annals & Mag. Nat. Hist., quoted under the genus *Cidaris*). The name *Eucidaris* Pomel thus comes into use for this genus, as first made out by Döderlein, no genotype having been named by Pomel, who states only "trois espèces vivantes".

Key to the species of Eucidaris.

1. Primary spines cylindrical (more rarely tapering), not very thick, club-shaped ..... 2.
   Primary spines very thick, club-shaped ..... 4.
2. Apical system almost wholly naked; interporiferous zone of ambulacra almost naked. Small form ..... *E. metularia.*
   Apical system distinctly tuberculated[1]; interporiferous zone of ambulacra closely covered with tubercles. Larger forms ..... 3.
3. Interporiferous zone ca. twice the width of a pore zone; apical system about the same size as the peristome, no conspicuous naked margin of apical plates. Secondary spines light coloured. Large globiferous pedicellariæ without a limb on the stalk ..... *E. tribuloides.*
   Interporiferous zone scarcely wider than a pore zone; apical system distinctly smaller than peristome; apical plates with a conspicuous naked margin. Secondary spines dark coloured. Large globiferous pedicellariæ (always?) with a limb on the stalk ..... *E. Thouarsii.*
4. Secondary spines uniformly dark, nearly black ..... *E. galapagensis.*
   Secondary spines yellowish-white ..... *E. clavata.*

[1] In young specimens of *E. tribuloides* and *Thouarsii* the apical sytem is almost as naked as in *metularia*; but they are easily distinguished from *metularia* by the character of the interporiferous zone of the ambulacra.

Eucidaris metularia (Lamk.)

Pls. XLI. 1—8; LXXIII. 6; LXXXVI. 11—14.

Cidarites metularia. Lamarck. 1816. Hist. nat. anim. s. vert. III. p. 56. II. Ed. 1840. III. p. 381.
Cidarites metularia. Deslongchamps. 1825. Encycl. méth. II. p. 195. Pl. 134. 8[1].
Cidarites metularia. Blainville. 1834. Manual d'Actinologie. p. 232.
Cidarites metularia. Desmoulins. 1837. Mém. s. les Éch. III. Synon. génér. p. 324.
Cidaris metularia. L. Agassiz & Desor. 1846. Cat. rais. p. 22, (324).
Cidaris metularia. Dujardin & Hupé. 1862. Hist. nat. Zooph. Éch. p. 470.
Gymnocidaris metularia. A. Agassiz. 1863. List of Echinod. p. 17.
Gymnocidaris minor. A. Agassiz. Ibid.
Cidaris metularia. Martens. 1866. Ostasiat. Echinod. p. 142.
Cidaris metularia. R. Perrier. 1869. Rech. s. l. pédicellaires, p. 125. Pl. 3. 2.
Cidaris metularia. A. Agassiz. 1872. Rev. of Ech. p. 98, 254, 385. Pl. I. c. 23—24; **I. g. 1**; XXXV. 3.
Cidaris metularia. Quenstedt. 1872—75. Petrefactenkunde Deutschlands. Tab. **73. 21—22.**
Cidaris metularia. H. W. Mackintosh. 1878. Acanthology of Desmosticha. I. p. 480. Pl. IX. 8.
Cidaris metularia. Studer. 1880. Ech. Gazelle, p. 861.
Cidaris metularia. Möbius. 1880. Beitr. z. Meeresfauna d. Ins. Mauritius u. d. Seychellen. p. 48.
Cidaris metularia. P. de Loriol. 1883. Cat. Rais. Ech. Maurice. p. 4.
Cidaris metularia. Döderlein. 1885. Seeigel v. Japan u. den Liu-Kiu Inseln, p. 3.
Eucidaris metularia. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ, p. 42. Taf. **IX. 1.**
Cidaris metularia. Sluiter. 1888. Evertebr. a. d. Samml. k. Naturw. Vereins Nederl. Indien, Batavia. Echinodermen II. Echinoidea. p. 287.
Cidaris metularia. Martens. 1889. Echinod. aus New Guinea. Sitz. ber. Ges. Naturf. Fr. Berlin. p. 184.
Cidaris metularia. P. de Loriol. 1893. Échinod. de la baie d'Amboine. p. 360.
Cidaris metularia. Sluiter. 1895. Echiniden Samml. Mus. Amsterdam. p. 67.
Cidaris metularia. Pfeffer. 1896. Ostafr. Echiniden . . . . ges. v. Dr. Stuhlmann. p. 45.
Cidaris metularia. Bell. 1898. Actinogonid. Echinod. Funafuti and Rotuma. P. Z. S. 1898. p. 849.
Cidaris metularia. Bell. 1899. Echinod. Willey's Zool. Res. II. p. 134.
Cidaris (Eucidaris) metularia. H. Ludwig. 1899. Echinod. d. Sansibargebietes. p. 550.
Cidaris metularia. Bell. 1902. Actinogon. Echinod. Maldive & Laccadive Isl. p. 230 (in Stanley Gardiner. Fauna & Geogr. Maldive & Lacc. Isl. I.).
Cidaris metularia. Bell. 1903. Echinod. Zanzibar; p. 246.
Cidaris metularia. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 15, 17, 19, 29. II. 1907. p. 14.
Cidaris metularia. De Meijere. 1904. "Siboga" Ech. p. 7.
Cidaris metularia. Bell. 1904. Echinoderma. Pearl Oyster Fisheries. II. p. 138.
Cidarites (Gymnocidaris) metularia. Döderlein. 1906. Ech. Deutsch. Tiefsee-Exp. p. 101.
Cidaris (Dorocidaris) metularia. Yoshiwara. 1906. Japanese Echini. Pl. I. 1.
Cidaris metularia. A. Agassiz & Clark. 1907. Hawaiian Ech. Cidaridæ. p. 5. Pl. **1. 3—7.**
Cidaris metularia. H. L. Clark. 1907. The Cidaridæ. p. 184.
Cidaris metularia. H. L. Clark. 1908. Some Japanese and East Ind. Ech. p. 301.
Cidaris metularia. Bell. 1909. Rep. Ech. coll. Stanley Gardiner, p. 19. Trans. Linn. Soc. 2. Ser. XIII.
Eucidaris metularia. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 54.
Eucidaris metularia. Th. Mortensen. 1910. Ech. Swedish S. Polar Exp. p. 19. Note.
Cidaris Mauri. Lambert & Thiéry. 1910. Ess. nom. rais. p. 141.
Eucidaris metularia. Döderlein. 1911. Echinoidea v. d. Aru Inseln. p. 239.
Eucidaris metularia. Jackson. 1912. Phylogeny of Echini, p. 97, 100.

[1] The figure is a reproduction from Seba. Thesaurus locupletissimus, III. Pl. XIII. 11; the same figure is reproduced in Leske's "Additamenta", Pl. XXXIX. 4. Although a rather crude figure, it seems beyond doubt that it really represents the species *metularia.*

Eucidaris metularia. H. L. Clark. 1923. Echinod. fauna S. Africa. p. 370.
Eucidaris metularia. H. L. Clark. 1925. Cat. Rec. Sea-Urchins Brit. Mus. p. 20.
Eucidaris metularia. H. L. Clark. 1926. Echinod. trop. central Pacific. p. 94.
Eucidaris metularia. Th. Mortensen. 1927. Postlarval development of some Cidarids. p. 369—38.
Eucidaris metularia. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 260.
Eucidaris metularia. Koehler. 1927. "Investigator" Ech. III. p. 9.
NON: *Cidaris metularia.* Lütken. 1864. Bidr. til Kundskab om Echiniderne. p. 79. (= *Eucid. tribuloides*).
Cidaris metularia. Bell. 1881. Rep. on a coll. made by Mr. T. Conry in Ascension Isl. Ann. Mag. N. Hist. V. Ser. VIII. p. 436 (= *Eucid. tribuloides*).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	24 mm	14 mm	11.5 mm (48 % h.d.)	12.5 mm (50.2 % h.d.)	6—7	9—10	
2	24 —	15 —	11 — (46 —)	12 — (50 —)	6 (7)	9 (10)	20 mm
3	21 —	13 —	10 — (47.6 —)	10.5 — (50 —)	6—7	9—10	19 —
4[1]	20 —	12 —	(10) 9 — ((50) 45 —)	10.5 — (50.2 —)	5—6	10—11	19 —
5[1]	19.5 —	13 —	(8.5) 9 — ((43.6) 46 —)	11 — (56 —)	6	9—10	18 —
6	18 —	10 —	8.5 — (47.2 —)	10 — (55.5 —)	5—6	9—10	13 —
7	16 —	9 —	8 — (50 —)	9.5 — (59.2 —)	5—6	9	14 —
8	14 —	8 —	7 — (50 —)	8 — (57 —)	5 (6)	8—9	16 —
9	11 —	6 —	5.8 — (52.7 —)	6 — (54.5 —)	5—6	8 (9)	13 —
10	9 —	5 —	5 — (55.5 —)	5 — (55.5 —)	4—5	6—7	9.5 —
11	7 —	3.5 —	4 — (57 —)	4.2 — (60 —)	4—5	5—6	7 —

[1] In specimens 4 and 5 the apical system is irregular, elongate.

Test flattened above, somewhat less so below. Sides rather strongly arched; circumference circular or somewhat subpentagonal.

Ambulacra rather distinctly sinuate, ca. 25 % of width of the interambulacra; interporiferous zone scarcely twice the width of a pore zone. Marginal series of tubercles perfectly regular, the tubercles fairly prominent, contiguous, very distinctly mamelonate. It is a peculiar feature that the admedian side of the boss, and partly also of the mamelon, is set with small, round, shining, glassy knobs, which make the tubercles more conspicuous, especially when dark coloured like the mamelon. Adradially to the marginal tubercle there is a single, very small tubercle at the lower edge of the plate, forming, in the larger specimens, regular, vertical series; the interporiferous zone otherwise is bare, slightly sunken. Pores of about equal size, separated by a fairly broad wall which is in the larger specimens raised into a more or less distinct rounded knob. Ridge low and inconspicuous, furrow indistinct (Pl. LXXIII. 6).

Interambulacra. Areoles fairly large, not sunken; the 2—3 proximal ones confluent; the subambital ones somewhat transverse-oval. Boss not very high, the adapical side of it usually somewhat sunken on the upper ones; mamelon of moderate size. No traces of crenulation. Scrobicular ring not at all prominent, the tubercles being very low, but of a rather unusual form: the boss is flat, its outline semi-elliptical; the mamelon is somewhat prolonged towards the areole;

also the outline of the boss is often seen rather distinctly continuing over the periferal part of the areole. The secondary tubercles, which fill up the whole plate outside the scrobicular ring, are flat, of somewhat irregular outline, so as to fit in closely among each other (Fig. 113. a); the admedian side of their bosses is more or less conspicuously formed by similar rounded glassy knobs as on the marginal ambulacral tubercles. Median line scarcely distinct, not sunken. Median area ca. $^1/_2$—$^2/_3$ the width of an areole.

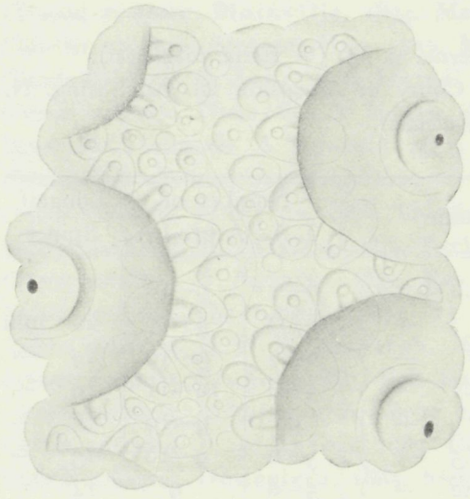


Fig. 113. a. Part of interambulacrum of *Eucidaris metularia*, showing the continuation of the scrobicular tubercles over the areole. × 8.

Apical system about half h.d. (ca. 46—57 %), relatively the larger in the younger specimens, as usually. It is as a rule entirely flat, or even slightly sunken, more rarely the periproct slightly elevated. Oculars normally all exsert, even in the largest specimens. Two specimens in the material available have Oculars I, IV and V insert, as was also found by Jackson (Op. cit.) in a couple of specimens. One specimen from the Bonin Islands has Oculars III and IV insert. The oculars have the shape of a nearly regular triangle, the inner sides usually almost straight, the outer side slightly convex, the whole apical system being thus almost regularly circular in outline. Genital pores small, rather distant from the edge. A single series of larger tubercles along the outer edge of both genital and ocular plates, the whole apical system being otherwise almost entirely naked, excepting the periproctal plates, which carry each one or a few tubercles. On a closer examination the apical plates are seen to be closely covered with small, shining, glassy warts, like those of the marginal ambulacral tubercles (Fig. 113. b); the minute, real spine-bearing tubercles which are found scattered on the apical plates are scarcely distinguishable between these warts[1]. The ocular pore is almost quite concealed under the fringe of tubercles on the outer margin. The madreporite may be slightly larger than the other genital plates, the pores usually (in the larger specimens) occupying the whole plate; here are no glassy warts, and the fairly numerous small tubercles therefore are seen quite distinctly scattered among the pores. — Peristome usually distinctly larger than the apical system (50—60 % h.d.), generally somewhat conically elevated. There are 13—15 ambu-

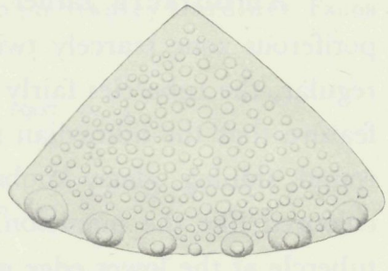
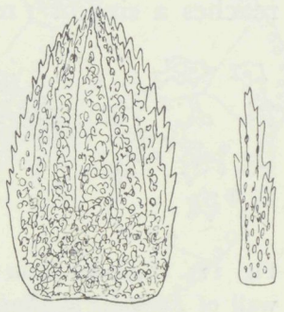


Fig. 113. b. Ocular plate of *Eucidaris metularia*. × 20.

[1] In the description of this species in the "Revision of the Echini" (p. 385) it is stated that the small spines and pedicellariæ on the apical system are "mounted upon brilliant glassy tubercles". This is only partly correct. The spine-bearing tubercles are partly glassy like the glassy warts and hardly distinguishable from these latter (only on the madreporite they are quite distinct); but the main part of these "brilliant glassy tubercles" have neither spines nor pedicellariæ attached to them; they are seen as small, shining dots on the intact plates, between the spines and pedicellariæ.

lacral plates in a very regular series in the larger specimens and a fairly regular series of 5—6 interradial plates, which do not reach the mouth edge.

Primary spines usually less than h.d., rather thick and robust (more so in the littoral specimens), cylindric or slightly thickened in the basal part, and in the latter case slightly tapering[1]. The point is not widened, but usually distinctly crown-shaped, with the central part forming a more or less prominent knob[2]. The shaft is closely set with low spinules arranged in ca. 12—18 distinct longitudinal series which assume the shape of ridges at the point of the spine, thus forming the end-crown; the apparent great variation in the number of the longitudinal series of spinules is due to the fact that it increases with age, so that the number is greater on the uppermost spines in fully adult specimens, than on the uppermost spines in younger specimens. The surface of the shaft, between the spinules, is covered by a spongy coat of anastomosing hairs, with numerous fine, erect spinules on the outer surface. Also between the large hairs small erect spinules (Fig. 118. 3. p. 396)[3]. Collar very short, only ca. 0.5 mm, slightly thickening towards the inconspicuous milled ring. There may be a smooth neck, somewhat longer than the collar, but as a rule it is not very shining and therefore not very conspicuous. — The oral primaries simple, short, scarcely flattened or curved. The collar on the proximalmost ones a little longer than on the other spines, especially it may be somewhat produced on the adoral side. The 2nd already is transitional to the ambital spines.



1 2

Fig. 114. Miliary spines from the test (1) and from the apical system (2) of *Eucidaris metularia*. × 100.

Secondary spines on the whole rather strongly appressed. The scrobicular spines are ca. 2—2.5 mm long, broad, flat, may be slightly convex in the basal part, narrowing very slightly towards the square-rounded point, which may or may not be slightly concave on the outer side. They fit very well together, forming thus a close mail round the base of the primaries. The marginal ambulacral spines more slender, with perfectly straight sides, ca. 1.5—2 mm long. Miliary spines of test broad, scale-like (Fig. 114. 1), those of the upper side sometimes with a glandular ampulla at the base. The spines of the apical system usually are very fine, thorny stumps (Fig. 114. 2); only in a specimen from the Bonin Islands they are broader, more scale-like, as those of the test. The spines along the margin of the apical system are broad and flat like the other secondaries and form a very conspicuous fringe all round the apical system.

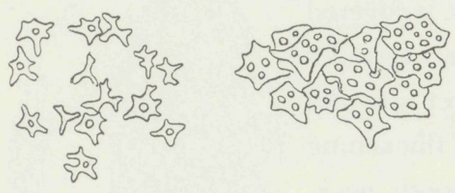
Pedicellariæ. The large globiferous form fairly common, usually at the adradial end of the upper horizontal sutures of the interambulacra, apparently never on the apical system, except between the marginal fringe of spines, or in the ambulacra. The limb of the stalk is usually grace-

[1] A specimen from Mauritius in the collection of the British Museum has the primaries so much tapering as to be distinctly fusiform.

[2] This crown is exellently represented in Pl. I. c. 23—24 of the "Revision of the Echini".

[3] This structure of the spines was described and figured already by Mackintosh (Op. cit.).

fully curved (Pl. LXXXVI. 13); valves of usual form. The small globiferous common all over, varying a good deal in size, but scarcely exceeding 0.35 mm length of head; valves of usual form, with a fairly large opening and a small end tooth. Tridentate pedicellariæ fairly common, i. e. in specimens from deeper water, whereas they do not occur in any of the numerous littoral specimens examined by the author. They occur in two forms, one with straight, the other with curved valves; the former may vary somewhat in shape, being sometimes restricted above the base, sometimes not (Pl. LXXXVI. 11—12, 14). The form with the curved valves is much more rare than that with the straight valves; both forms may be found on one and the same specimen. In both the valves are very slender and wide apart, joining only in the point. The form with the straight valves reaches a size of 1 mm length of head, the other scarcely so much. — Spicules of tubefeet of the usual type, not very numerous. In the intestinal wall spicules are found only in the upper part, in the shape of small, irregular plates (Fig. 115. 1), the main part of the intestine is entirely devoid of spicules. The genital organs with few, small, mainly triradiate spicules.



1 2

Fig. 115. Spicules from the intestinal wall of *Eucidaris metularia* (1) and *E. Thouarsii* (2). × 125.

Colour. Primary spines brownish, generally with 3—4 narrow, more or less distinct, whitish bands. Secondary spines purplish-brown; often the scrobicular spines on the admedian side of the primaries are whitish, as is the whole median interambulacral space. Interporiferous zone generally white. Apical system often somewhat light coloured, or the lines between the plates may be white, coming out very beautifully on the darker, reddish or brownish ground colour. Usually there is a more or less conspicuous brownish spot at the median end of each interambulacral horizontal suture. As a rule the specimens from deeper water are more bright coloured than the littoral specimens, often reddish; these latter may sometimes be dark purplish all over. Young specimens are usually brighter coloured than the adult. The denuded test is white except the marginal ambulacral tubercles, which are more or less dark purplish throughout unto the peristome, and thus make the ambulacra show off as five conspicuous meridian stripes. The apical system is more or less dark, the ocular plates usually marked off by their edges being lighter coloured.

Biology. It is in the main a littoral form, found especially among corals on the reefs. In the alimentary canal were found fragments of algæ (*Corallina* — in littoral specimens), Bryozoa, sponges and bottom material in general. The author found that in rock ponds near Hilo, Hawaii, where the species was quite common, the specimens concealed themselves during day time under rocks and stones, coming out to feed by night time[1]. Development. The very small and per-

[1] Döderlein (Op. cit. 1885, p. 3) has observed that specimens living among Millepores at Amami-Oshima, Japan, so closely resembled ("so täuschend nachahmen") the Millepores as to be hardly distinguishable. That this can hardly be a case of real mimicry was pointed out in my "Observations on protective adaptions and habits, mainly in marine animals". (Papers from Dr. Th. Mortensen's Pacific Exped. 1914—16. I. Vid. Medd. Bd. 69. 1917. p. 80).

fectly clear eggs almost certainly develop into a pelagic larva (cf. the author's "Studies of the development and larval forms of Echinoderms", 1921, p. 24). The newly metamorphosed sea-urchin has been described in the author's paper "On the postlarval development of some Cidarids", 1927, p. 369—383. The genital pores appear at a size of ca. 8 mm h.d. The species does not reach a larger size than ca. 30 mm h.d. (according to H. L. Clark, The Cidaridæ, p. 184; I have not seen larger specimens than 27 mm h.d.). Even the largest specimens have their spines not much overgrown with foreign organisms, especially incrusting calcareous algæ. Rarely a Crepidula may be found attached to the spines. — Parasitic or commensal molluscs or worms otherwise not known to occur on this species. A curious case of parasitism occurs in specimens from Hawaii; the tubefeet on the oral side are somewhat swollen and generally protruding between the marginal ambulacral spines, being evidently not retractile. On a microscopical examination the skin of such tubefeet is found to be studded with small fusiform bodies, pointed in both ends, recalling Diatoms like e. g. *Navicula* in shape; but they are not Diatoms, as they are dissolved in hypochlorite of sodium. Probably it is some sort of plant-organism, which infests the tubefeet and makes them swell — a sort of elephantiasis! I have observed it only in younger specimens, which may probably mean that the infested sea-urchins are killed by the parasite.

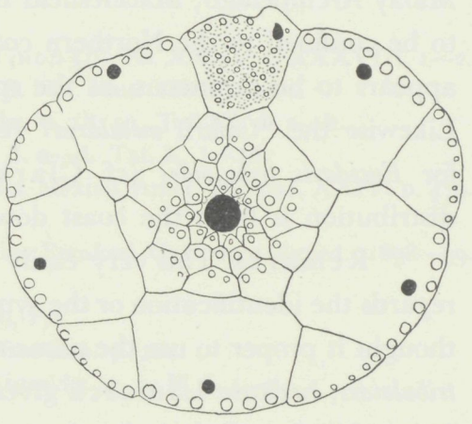


Fig. 116. Anomalous apical system of *Eucidaris metularia*. × 6.

Anomalies are rare, mainly consisting in the apical system being transversely elongate; in one such case the madreporite has been transplaced to the ocular III, which has also got a genital pore, but no ocular pore (Fig. 116). A case of two primary tubercles and spines on one plate (at the peristomial margin) has been observed (a specimen from Hawaii) (Pl. XLI. 4).

Variation. In spite of the wide range of this species very little variation occurs so that separate varieties can scarcely be distinguished. As a rule the specimens from deeper water have more slender primaries and are more bright coloured than the littoral specimens; but there is otherwise no differences and there is no reason for regarding them as separate forms.

v. Martens (Op. cit. p. 142) has established a variety *spuria*, distinguished from the typical form by the primaries attenuating a little towards the point, the end crown being therefore smaller and less distinct than in the typical form, in which the spines do not attenuate towards the end. There is, however, no reason at all for this distinction; spines of both forms may be found even on one and the same specimen.

In this connection should be mentioned a specimen from the Bonin Islands, collected by Dr. Sixten Bock, 1914; it is remarkable by the spines on the apical system being more numerous, broader and coarser than otherwise in this species, and further by the Oculars III and IV being insert. Since, however, another specimen from the same locality is in every respect of the typical

form, the above mentioned specimen is, evidently, only an individual variation. It is important to notice in this connection that the two specimens from Amami-Ohshima, Japan, mentioned by Döderlein, Op. cit. 1885, are of the typical form, with almost naked apical system and all oculars exsert. I am greatly obliged to Prof. Döderlein for lending me these specimens for examination.

Occurrence. The species is distributed all over the Indo-Pacific, from Mozambique and the Red Sea to the Fiji, Rotuma, Marshall, Gilbert and Hawaiian Islands, Guam, all over the Malay Archipelago; Macclesfield Bank, Bonin Islands, Japan (Ohshima). At Australia it appears to be confined to the Northern coasts. The record of its occurrence at the Cape of Good Hope appears to be erroneous, as the species has not been found S. of Mozambique in recent times. Likewise the "*Cidaris metularia*" recorded by Bell (Op. cit. 1881) from Ascension is a mistake for *Eucidaris tribuloides* (cf. Clark. Cat. Rec. Sea-Urch. Br. Mus. p. 22).[1] The bathymetrical distribution is from the coast down to ca. 570 m.

Remarks. This very easily recognizable species has not given rise to confusion, either as regards the identification or the synonymy. Only two cases are to be mentioned. Lütken (Op. cit.) thought it proper to use the name *metularia* for the common West Indian littoral Cidarid, *Eucidaris tribuloides*, because Lamarck gives, besides the Indian Ocean, St. Domingo as locality for *metularia*, while for *tribuloides* he gives only the "Indian Ocean". Nobody has followed Lütken herein, and there is certainly not sufficient reason for this most undesirable interchange of the two names against the unanimous use in the whole echinological literature.

Recently Lambert & Thiéry have maintained that the name *metularia* should be changed into *Mauri* Rumphius. The figure, Pl. XIII. 4 of Rumphius' "D'amboinsche Rariteitkamer" (1705) on which Lambert & Thiéry are founding this change is an exceedingly poor one, which is decidedly not recognizable as the species *metularia*, and there is nothing in the description that shows it definitely to be this species. It may, at most, be said that on account of the locality it is possible that it really is *metularia*. To maintain on such ground this change of a name, used unanimously (with the sole exception of Lütken) in the whole of the echinological literature since Lamarck, is simply ridiculous. That the name *Cidaris Mauri* is prelinnean also precludes the use of it according to the rules of nomenclature.

That the *Gymnocidaris minor* of Agassiz (1863) is simply identical with *metularia* is beyond doubt, as is evident alone from the locality Sandwich Islands (and Kingsmill Islands), where *metularia* is the only littoral Cidarid. The identity with *metularia* was also recognized by Agassiz himself (Revis. of the Echini, p. 254). — A var. *minor* was otherwise already established by Deslongchamps in the "Encyclopédie méthodique" (p. 195), based on the figure Tab. XIII, 11 in Seba's "Thesaurus", which is unanimously regarded as representing the typical *metularia*.

[1] It would appear, on the other hand, that the *Prinocidaris baculosa* of Roxas' Philippine Littoral Echinoidea (Philipp. J. Sci. 36. 1928. p. 250, Pl. I. 1) is *Eucidaris metularia*, although his statement that the primary spines have "purple lines on the collar" is rather enigmatical. These specimens need reexamination.

Eucidaris Thouarsii (Val.)

Pls. XLII. 5—12; LVII. 1—2; LXXIII. 3—5; LXXXVI. 1—7.

Cidaris Thouarsii. L. Agassiz & Desor. 1846. Cat. Rais. p. 326 (22).
Cidaris Danae. L. Agassiz & Desor. Ibidem.
Leiocidaris Thouarsii. Dujardin & Hupé. 1862. Hist. nat. Zooph. Éch. p. 485.
Leiocidaris Danae. Dujardin & Hupé. Ibidem.
Cidaris Thouarsii. A. Agassiz. 1863. List of Echin. p. 17.
Cidaris Thouarsii. Verrill. 1867. Notes on Radiata, p. 294. 1871. p. 579.
Leiocidaris Thouarsii. Perrier. 1869. Rech. s. l. pédicell. p. 130, Pl. III. 10.
Cidaris Callao. Perrier. Ibidem. p. 129. Pl. III. 8.
Cidaris Thouarsii. A. Agassiz. 1872. Rev. of Ech. p. 98, 385, Pl. **I. c. 1—5 a** (non 5 b). Pls. XXXV. 2, XXXVIII. 1—2.
Cidaris Thouarsii. Rathbun. 1886. Cat. Ech. U. S. Nat. Mus. Proc. U. S. Nat. Mus. 1886. p. 260.
Cidaris (Eucidaris) Thouarsii. Döderlein. 1887. Jap. Seeigel. I. Cidaridæ. p. 18, 50. Taf. **IX. 4. a—h.**
Cidaris (Eucidaris) galapagensis. Döderlein. Ibidem. p. 20, 50, Taf. **IX. 3. a—d.** Taf. **X. 1—14.**
Cidaris Thouarsii. I. W. Fewkes. 1890. Sea-Urchin excavations at Guaymas, Mexico. Amer. Natural. XXIV. p. 479.
Cidaris Thouarsii. Lovén. 1892. Echinologica, p. 21—22.
Cidaris Thouarsii. H. L. Clark. 1902. Echinoderma. Papers from Hopkins Stanford Galapagos Exped. 1898—99. Proc. Wash. Ac. IV. p. 526.
Cidaris Thouarsii. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 19, 29, 172.
Cidarites (Gymnocidaris) Thouarsii. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 101.
Cidaris Thouarsii. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 4. Pl. I. 1—2.
Cidaris Thouarsii. H. L. Clark. 1907. The Cidaridæ, p. 185.
Eucidaris Thouarsii. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 54.
Cidaris Thouarsii. Lambert & Thiéry. 1910. Ess. nom. rais. p. 145.
Eucidaris Thouarsii. Jackson. 1912. Phylogeny of Echini, p. 97, 100.
Eucidaris Thouarsii. H. L. Clark. 1913. Echinod. Lower California. ("Albatross" 1911). Bull. Amer. Mus. Nat. Hist. XXXII. p. 220. 1923. Suppl. Report. Ibid. Vol. XLVIII. p. 157.
Cidaris Thouarsii (?). Clark & Twitchell. 1915. Mesozoic & Cenoz. Ech. U. S. Geol. Surv. Monogr. 54. p. 179.
Cidaris Thouarsii (?). W. S. W. Kew. 1920. Cretaceous & Cenozoic Echinoidea Pac. Coast N. America. Univ. Calif. Publ. Geol. XII. p. 54.
Eucidaris Thouarsii. Th. Mortensen. 1921. Studies devel. & larval forms of Echinoderms. p. 22. Pl. V. 1—2.
Eucidaris Thouarsii. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 21.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	42 mm	26 mm	14.5 mm (34.5 % h.d.)	18.5 mm (44 % h.d.)	8—9	10—11	
2	35 —	20 —	12 — (34.3 —)	16 — (45.7 —)	7—8	9—11	36 mm
3	35 —	19 —	13 — (37.1 —)	16 — (45.7 —)	8	9—11	36 —
4	30 —	17 —	11 — (36.6 —)	14 — (46.6 —)	7	9—11	28 —
5	28 —	14 —	10 — (35.7 —)	13 — (46.4 —)	7	9—10	28 —
6	23 —	13 —	9 — (39 —)	11.5 — (50 —)	6—7	9—11	20 —
7	20 —	10.5 —	8.5 — (42.5 —)	10 — (50 —)	6	9—10	18 —
8	16 —	8 —	7 — (43.8 —)	9 — (56.3 —)	5—6	9—10	20 —
9	14 —	6.5 —	6 — (42.9 —)	7 — (50 —)	5—6	8—9	14 —
10	10 —	5 —	4 — (40 —)	5 — (50 —)	5	7—8	11 —
11	7 —	3.5 —	3 — (42.9 —)	3.5 — (50 —)	4—5	6—8	9 —
12	41 —	23 —	13 — (31.7 —)	21 — (51.2 —)	7—8	12—14	35 —

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
13	40 mm	25 mm	14 mm (35 % h.d.)	20 mm (50 % h.d.)	8	10—12	30 mm
14	27.5 —	15 —	9.5 — (34.5 —)	14 — (50.9 —)	6—7	11—12	28 —
15	21 —	11.5 —	8.5 — (40.5 —)	10 — (47.6 —)	6	10—12	21 —

Specimens 1—11 from Panama, 12—13 from Lower California, 14—15 from Galapagos (var. *galapagensis*).

Test usually low, flattened above and below, sometimes even slightly sunken towards the apical system. Sides beautifully arched; circumference circular, more rarely subpentagonal.

Ambulacra rather distinctly sinuate, ca. 20—25 % the width of the interambulacra. Interporiferous zone narrow, only little more than the width of a pore zone. Marginal series of tubercles quite regular, the tubercles contiguous, in larger specimens more or less transverse-oval. Adradially to the marginal tubercle each plate carries a secondary tubercle at the lower edge, forming usually regular inner series. In larger specimens there may be, at the ambitus, another, smaller secondary tubercle near the median corner, tending to obscure the serial arrangement. The area between the marginal tubercles on the whole very narrow, and wholly covered with these tubercles (Pl. LXXIII. 3—5). The pores equal-sized, or sometimes the outer rather distinctly the larger; the wall rather broad, raised into a low, rounded elevation; ridge low, almost flat.

Interambulacra[1]. Areoles rather large, as a rule very shallow; they are very distinctly confluent, usually only the 2—3 upper ones in each series being well separated, and sometimes also these are confluent. Corresponding herewith only the uppermost areoles are round, the ambital and subambital ones conspicuously transverse-oval. The mamelon is fairly large (distinctly larger than in *tribuloides*); a more or less distinct crenulation is usually found on the adapical side of the upper primary tubercles in younger specimens. In correspondance with the confluence of the areoles the scrobicular circles are incomplete, except the uppermost ones. The tubercles are fairly conspicuous, not so low as in *metularia*, and the outline of the boss is semicircular, not semi-elliptical; but the mamelon is prolonged towards the areole as in *metularia*. The median area closely covered by small secondaries, which are not irregular in outline as in *metularia*; they diminish gradually in size towards the median line which is, as a rule, not naked or sunken. In larger specimens there may be fairly distinct, fine transverse lines across the median area. The width of the median area is scarcely half that of an areole.

Apical system ca. 32—44 % h.d., as usual relatively the larger in the younger specimens; it is always distinctly smaller than the peristome. Ocular plates in adult specimens usually insert,

[1] H. L. Clark (Op. cit. 1923, p. 158) records a number of interambulacral, coronal plates of 9—10, "a very large number for *Thouarsii*". As he does not give the size of this specimen, it is impossible to see whether this number is in any way unusual; larger specimens than the largest here recorded must be expected to have 9—10 coronal plates, as seen by the gradual increase of their number corresponding to the gradual increase in size of the specimens. Döderlein (Op. cit. 1887, p. 50) also states a specimen of 51 mm h.d. to have 10 coronal interambulacral plates. The species is known to grow to a size of 65 mm (var. *galapagensis*(?); Clark. Cat. Rec. Sea-Urchins Br. Mus., p. 21).

except II and III (the two at the madreporite); but in larger specimens also these latter may be insert; inversely, in younger specimens all may be exsert. The oculars, on the whole, are rather broad, and the genitals correspondingly narrow in the outer part. Genital pores of medium size, rather near the outer edge. Periproct usually flat, the periproctal plates fairly numerous. The whole apical system fairly closely covered with tubercles, those along the outer and inner edge of the genitals distinctly the larger. Glassy warts may be fairly distinct, but they are never so conspicuous as in *metularia*. A fairly broad, bare, white edge along the sides of the genital and ocular plates makes a very conspicuous polygonal-starshaped figure on the apical system.

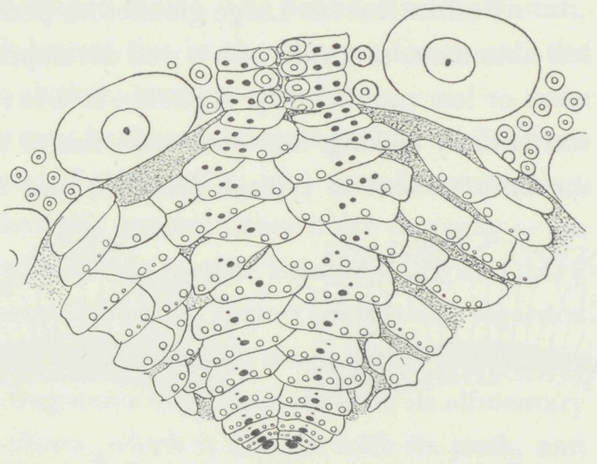


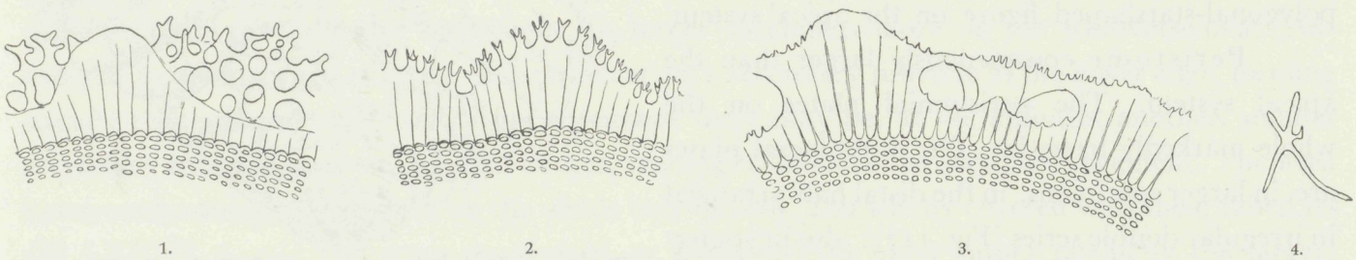
Fig. 117. Part of peristome of *Eucidaris Thouarsii*, showing diploporite condition of pores. × 3.5.

Peristome conspicuously larger than the apical system. The peristomial plates on the whole markedly irregular. The ambulacral plates are, in larger specimens, in the distal half arranged in irregular double series (Fig. 117); also in younger specimens such arrangement is indicated, more or less distinctly, particularly it is a conspicuous feature that the outermost 3—5 pores form an oblique, outward directed series. Sometimes the adradial part of some plate in the distal part of the series is separated off so as to form a separate plate in the ambulacral midline. There are in the larger specimens ca. 20—25 ambulacral plates in each series; in a specimen of 23 mm h.d. there are 16—17 in a series. The interradial plates may form a single regular series of 6—7, nearly reaching the mouth edge, or they may be irregularly split up in 2—3 smaller plates each.

Primary spines scarcely exceeding h.d. They are rather robust, cylindric, or slightly tapering, the point having, in well preserved spines, the shape of a crown which is not widened; in the centre a small round prominence (much as in *metularia*). Often the spines are somewhat thickened in the basal part, being thus more or less distinctly fusiform. (In the variety *galapagensis* they are scarcely at all tapering, may even be the thickest at the point). Generally the primaries are ca. 3—4 mm in diameter in the thickest part, but they may be as thick as 5 mm or more, up to 8 mm (in var. *galapagensis*). The shaft is set with low, rounded spinules or warts, which are distinctly arranged in ca. 18 close longitudinal series; at the end of the spine the warts unite into distinct ridges or lamellæ, which form the end crown. The general surface of the shaft otherwise covered by a thick spongy coat of anastomosing hairs; in well preserved spines the hair-coat even almost conceals the warts (Fig. 118. 1). The collar is only ca. 1 mm long, increasing slightly in thickness towards the inconspicuous milled ring. There is only a very short neck above the collar. The oral primaries are very simple, not at all specialized, only much smaller than the upper primaries, and with the collar somewhat longer; they pass quite gradually into the ambital spines.

Secondary spines. The scrobicular spines are ca. 3—4 mm long, rather broad, flat, almost rectangular; they are usually more or less conspicuously excavate towards the rounded point, particularly those on the oral side. The miliary spines simply pointed. Marginal ambulacral spines also flattened and excavate towards the point, only much more slender than the scrobicular spines. No distinct fringe around the edge of the apical system.

Pedicellariæ. Large globiferous pedicellariæ (Pl. LXXXVI. 1—2, 7), which are more or less abundant, as a rule with a well developed limb, like that of *E. metularia*; it may, however, be more or less rudimentary. Agassiz & Clark (Op. cit.) have found samples on which the limb was entirely lacking, and even state this to be the more common condition. I have always found the limb present in typical *Thouarsii*, and always absent in *galapagensis*; the said statement of



1. 2. 3. 4.

Fig. 118. Part of transverse sections of primary spines of *Eucidaris Thouarsii* (1), *E. Thouarsii*, var. (Clarion Isl.) (2), and *E. metularia* (3). Spicule from sensory cushion of tridentate pedicellaria of *E. Thouarsii*. 1—3. × 35; 4. × 125.

Agassiz & Clark, therefore, is probably due to the fact that they have not treated *Thouarsii* and *galapagensis* separately. The small globiferous of the usual form, with a small end tooth; sometimes the stalk is very long, up to 3 mm by a length of head of ca. 0.5 mm. The tridentate pedicellariæ occur in two different forms, as in *metularia*[1]; one (Pl. LXXXVI. 6) has a very elongate, slender head, up to 1.5 mm long, with the valves only slightly apart; the other (which Döderlein designates as the form "mit löffelförmigen Klappen") (Pl. LXXXVI. 4), scarcely surpasses a size of ca. 1 mm length of head, and has a much broader head, with the valves wide apart; there is a conspicuous elevation, evidently of sensory character, in the base, with the rather unique feature of isolated spicules occurring in this sensory cushion (Fig. 118. 4). The valves of the first form are quite simple (Pl. LXXXVI. 5), those of the second with one or two serrate longitudinal crests (Pl. LXXXVI. 3). Tridentate pedicellariæ are stated to be absent in specimens from the Galapagos (Agassiz & Clark, Op. cit.). — Spicules of tubefeet of the usual type; the spicules of the intestinal wall are much more numerous than in *metularia*, small fenestrated, more or less irregular plates (Fig. 115. 2).

Colour. General colour of both primaries and secondaries dark purplish. Usually the tip of the primaries is whitish and one or two narrow whitish bands may occur below the tip. These bands are particularly distinct on the primaries of the oral side, and, on the whole, in younger specimens (Pl. XLII. 5—6). Quite young specimens have the primaries more white, with

[1] Döderlein (Op. cit. 1887) has observed and figured both forms of tridentate pedicellariæ, while Agassiz & Clark have only observed the more common, slender form.

three to four narrow, dark, purplish bands. The base of the secondary and the miliary spines may be whitish to a greater or lesser extent and thus form a conspicuous white stripe in the ambulacral and interambulacral midlines. This appears to be especially the case in specimens from Lower California, while specimens from Panama are as a rule without such white stripes. The spines on the apical system are dark, contrasting markedly to the broad white margins of the apical plates, which, as stated above, form a conspicuous white star-shaped figure. The denuded test is whitish, with a more or less conspicuous greenish or greenish-brown tint in the interporiferous and the median interambulacral areas. The apical system is darker, greenish-purplish.

Biology. This is mainly a littoral form, which may be found concealed under rocks (from which it probably comes out to feed during night time). Fewkes (Op. cit.) records some observations by F. W. Cragin from which it appears that this species bores holes in rocks — the only Cidarid recorded among the fairly numerous rock-boring regular Echinoids. H. L. Clark (Op. cit. 1923) mentions that at Espiritu Santo, Lower California, these Cidarids are regarded as "enemies of pearl oyster at propagating plant", Clark adding that "it seems highly improbable that this can be a fact". As I have found it to contain fragments of Mollusc-shells in its alimentary canal, it would appear that this species feeds on Molluscs, which it crushes with its teeth, and it is thus by no means improbable that it could do harm to the young pearl oysters. — On the other hand, it would appear that the Cidarid is sometimes attacked by fishes; a specimen found by the author at Taboga, Panama, has nearly all its primary spines bitten off, several of them to the very base. There can hardly be any doubt that it is some tetrodont fish which has been the attacker. Several primaries are beginning to regenerate; it appears that the remnant of the spines is thrown off, before regeneration starts, at least, several of the primary tubercles are entirely naked (Pl. XLII. 12).

Development. That it has a pelagic larva is certain (cf. the author's "Studies of the Development and larval forms of Echinoderms", p. 22, Pl. V. 1—2); the larva would seem to have a shape like that of *Echinopluteus transversus*; still, this is uncertain, as the larva was only reared unto the beginning *Pluteus*-stage. In a specimen of 3 mm h.d. there are three ambulacral plates in a series on the peristome and one interradial plate, the first unpaired coronal interambulacral plate having already been dissolved, and probably a pair of the following interambulacral plates. The primaries of the proximalmost plates appear to correspond with those of plates 5—6 of *E. metularia*. There are 4 coronal interambulacral plates and 3—4 ambulacral plates corresponding to each of the upper interambulacrals. The apical system is naked, except for a few spines at the outer edge; in the young specimens these outer spines form a fairly conspicuous fringe round the apical system; only at a size of ca. 5 mm spines begin to appear on the middle of the genital plates. The genital pores appear at a size of about 8 mm h.d. — The largest size recorded is 65 mm h.d. Old specimens may have their spines much overgrown by foreign organisms — sponges, worm-tubes, Bryozoa, and, especially, incrusting algæ. — No anomalies have been observed, and no parasitic Molluscs. What would appear to be a sort of microscopic plant-

organism, attacks the scrobicular spines and produces a sort of galls on them (observed in a couple of specimens from Panama). A gall-like swelling on some of the primary spines in the var. *galapagensis* has been figured by Döderlein. It is unknown what is the cause of these swellings — which recall similar galls produced by parasitic Gastropods in some species of Cidarids (e. g. *Stylocidaris tiara* and *effluens*).

Variation. See below, under var. *galapagensis*.

Occurrence. Distributed along the West Coast of America, from Lower California to Panama and Galapagos. Bathymetrical distribution from the coast to 45 m (dredged by the author at that depth at Islas Perlas, I. 1916).

Remarks. This species is the nearest related to the common West Indian *Eucidaris tribuloides*, from which it is, however, very well distinguished, especially by its much narrower interporiferous and median interambulacral areas[1] as also by its darker colour.

The figure Pl. I. c. 5. b of the "Revision of the Echini", stated in the explanation of the plate to represent "Part of test of older specimen (of *Thouarsii*), showing the broad bare median interambulacral space" is almost certainly of *tribuloides*, not of *Thouarsii*; the paragraph (p. 386) referring to such specimens, therefore, in reality refers to *tribuloides*. The statement (ibidem) that "these large specimens of *Thouarsii* are mentioned by Dr. Lütken and by Prof. Verrill in his Notes on Radiata as a new species of Cidaris from the Gulf of California" I have been unable to verify; at least, the two authors do not say so in the places quoted. But this does not matter so much, as there can hardly be any doubt that these specimens with the broad median interambulacral area are only *tribuloides* which have been erroneously labelled as coming from the West Coast of America.

It appears that this species can be traced as fossil back to the Middle Miocene. R. Arnold, in his "Descriptions of new Cretaceous and Tertiary Fossils from the Santa Cruz Mountains, California" (Proc. U. S. Nat. Mus. XXXIV. 1908, p. 351; 359) mentions a *Cidaris* species a. about which H. L. Clark has informed him that it (viz. the spine on which it is based) is "very much like many spines of some individuals of the species of *Cidaris* common on the west coast of Lower California, Mexico, and Central America, *C. thouarsii*. I do not think it shows a single feature by which it can be distinguished from *thouarsii*. If it is not *thouarsii*, it is certainly from the ancestor of that species". As no figure is given, it is impossible to form a judgement of the value of this statement, which is repeated, without any additional information, by Clark & Twitchell (Op. cit. 1915) and Kew (Op. cit. 1920).

[1] Verrill's statement (Op. cit. 1867, p. 254) that it differs from the West Indian *Cidaris annulata* Gray (= *E. tribuloides*) "in the wider and more closely granulated median area of the interambulacra" is, evidently, only a slip of the pen; it is the inverse that is the case.

Var. **galapagensis** Döderlein.

Pls. XLII. 13; LXXXVI. 8—10.

Cidaris (Eucidaris) galapagensis. Döderlein. 1887. Jap. Seeigel, I. Cidaridæ, p. 20, Taf. **IX. 3. a—d; X. 1—14.**

According to Döderlein this form differs from the typical *Thouarsii*, besides in its thick, club-shaped primary spines, in lacking the naked margin on the apical plates, and in the much narrower interporiferous zone, in which the secondary tubercles are arranged in a single, median series; further the large globiferous pedicellariæ are stated to be conspicuously different.

Döderlein points out that the relations between this form and typical *thouarsii* are so close that, although he describes it as a separate species, it is perhaps doubtful whether it can rank higher than a variety of *thouarsii*, and H. L. Clark after having examined a large series of specimens comes to the result that he can even hardly recognize it as a valid variety (Cat. Rec. Sea-Urch. Brit. Mus. p. 21).

Though having not had the opportunity of examining in detail more than a few specimens of the form with the club-shaped spines I would still think it desirable to maintain this form as a separate variety. To the characters pointed out by Döderlein I would add that the collar of the primaries is somewhat longer in *galapagensis* than in typical *Thouarsii*. As for the difference in the globiferous pedicellariæ pointed out by Döderlein (Op. cit. 1887, Taf. IX. 3. a, c, compared with Taf. IX. 4. b, e) it is true, there is some slight difference in the shape of the valves, especially in the shape of the opening (Pl. LXXXVI. 9—10 to compare with Pl. LXXXVI. 2, 7); but it is a much more conspicuous difference that while in typical *Thouarsii* there is, so far as my experience goes, always a distinct limb on the stalk, this limb appears to be constantly absent in *galapagensis* or at most there is the merest trace of it (Pl. LXXXVI. 8). (This leads to the suggestion that Agassiz & Clark's statement of the limb being "more commonly lacking" in *Thouarsii* is probably based on specimens of *galapagensis*).

From the study of the material available, therefore, I cannot agree with H. L. Clark that *galapagensis* cannot be maintained even as a separate variety. I am rather inclined to think it a valid species, but, at least, must maintain it as a separate variety. It is true, specimens with slender spines like the typical *Thouarsii* also occur at the Galapagos. This, however, is no proof against the validity of *galapagensis*, as it is quite well possible that both the typical *Thouarsii* and the true *galapagensis* may occur there. It is not done with examining the primary spines of these specimens; they should also be carefully examined for the other *galapagensis*-characters. Only in case all these characters are found intergrading, the *galapagensis*-form must lose its rank as a separate variety (or species).

H. L. Clark states that *galapagensis*-specimens occur also at Mexico and Lower California, which, indeed, would seem very probable. However, this may perhaps still deserve renewed investigation. I have before me a specimen from Clarion Isl., Lower California (Pl. LVII. 1—2), which, in general, much resembles *galapagensis*, with which it agrees in the character of the ambulacra (Pl. LXXIII. 4), in the absence of the naked margin on the apical plates and in the

absence of the limb on the stalk of the globiferous pedicellariæ, as also in the shape of their valves. But it differs from *galapagensis* in the collar of the primaries being of olive-green colour, and in the hairs on the surface of the shaft being low, bush-shaped, not anastomosing — a very conspicuous difference from the thick spongy coat of anastomosing hairs in *galapagensis* and typical *Thouarsii* (Fig. 118. 2 to compare with Fig. 118. 1); also the primaries are somewhat tapering, not so distinctly club-shaped as in *galapagensis*. Further the marginal ambulacral spines are more slender than in *galapagensis* and in typical *Thouarsii*, indeed, simply spiniform. These differences rather preclude the possibility of regarding this form as identical with *galapagensis* or *Thouarsii* and tend to indicate that we have in the Lower Californian region, besides the typical *Thouarsii* still another variety of *Thouarsii* or perhaps even a separate species of *Eucidaris*. But this problem can only be settled through the study of a much larger material than what has been available to the author.

Eucidaris tribuloides (Lamarck.)

Pls. XLI. 9—16; XLVIII. 1; LXXIII. 1; LXXXVI. 16.

Cidarites tribuloides. Lamarck. 1816. An. s. vert. III. p. 56. II. Ed. 1840, p. 380.
Cidarites tribuloides. Deslongchamps. 1824. Encycl. Méth. II. p. 195. (With var. *major*).
Cidarites tribuloides. Desmoulins. 1837. Mém. s. les Éch. III. p. 322.
Cidaris tribuloides. Agassiz & Desor. 1846. Cat. rais. Éch. p. 326 (22).
Cidaris tribuloides. Joh. Müller. 1854. Über den Bau d. Echinodermen. Taf. II. 7.
Cidaris annulata. Gray. 1855. Arr. fam. Ech. P. Z. S. p. 37.
Cidaris tribuloides. Dujardin & Hupé. 1862. Hist. nat. Zooph. Éch. p. 470.
Cidaris metularia. Lütken. 1864. Bidr. til Kundsk. om Echiniderne. Vid. Medd. p. 79.
Cidaris tribuloides. Stewart. 1865. On the Spicula of the Regular Echinoidea. Trans. Linn. Soc. XXV. p. 366. Pl. XLVII. 10; XLVIII. 3, 5—7, 11.
Cidaris tribuloides. Martens. 1866. Über ostasiatische Echinodermen, p. 143. ("Indisches Ocean").
Cidaris annulata. A. Agassiz. 1867. Prel. Rep. Ech. deep water betw. Cuba and Florida Reef. Bull. M. C. Z. II. p. 253.
Cidaris annulata. Stewart. 1871. On the minute structure of certain hard parts of the genus Cidaris. Qu. J. Micr. Sc. XI. p. 51. Pl. IV.
Cidaris tribuloides. A. Agassiz. 1872. Rev. of Ech. p. 99, 253. Pl. **I. d; II. 1—3; II. c. 13.**
Cidaris tribuloides. Stewart. 1877. On certain organs of the Cidaridæ. Trans. Linn. Soc. 2. Ser. I. p. 571. Pl. 70. 6.
Cidaris tribuloides. Studer. 1880. "Gazelle" Ech. p. 862. (Monatsber. Akad. Berlin).
Cidaris tribuloides. R. Rathbun. 1880. List of Brasilian Echinod. Trans. Conn. Acad. V. p. 143.
Cidaris tribuloides. A. Agassiz. 1881. "Challenger" Ech. p. 36. Pl. I. 2. 3. 5. 6.
Cidaris tribuloides. R. Greeff. 1882. Echinodermen, beobachtet auf einer Reise nach der Guinea-Insel São Thomé. Zool. Anz. 1882. p. 137, 157.
Cidaris tribuloides. A. Agassiz. 1883. "Blake" Ech. p. 9.
Cidaris tribuloides. Ramsay. 1885. Cat. Ech. Austral. Mus. p. 1. (II. Ed. 1891).
Cidaris tribuloides. R. Rathbun. 1885. Rep. Ech. "Albatross" Gulf of Mexico. 1885. Proc. U. S. Nat. Mus. p. 609.
Cidaris tribuloides. R. Rathbun. 1886. Catalogue Echini U. S. Nat. Museum. Proc. U. S. Nat. Mus. p. 260.
Eucidaris tribuloides. Döderlein. 1887. Jap. Seeigel. I. p. 42, 51. Taf. **IX. 2.**
Cidaris tribuloides. Ridley. 1888. Zoology of Fernando Noranha. J. Linn. Soc. XX. p. 559.
Cidaris tribuloides. I. E. Ives. 1891. Echinoderms from the Bahama Islands. Proc. Ac. Nat. Sc. Philadelphia. p. 337.
?*Cidaris tribuloides*. Cotteau. 1893. Éch. nouveaux on peu connues. Mém. Soc. Zool. Fr. V. p. 736. Pl. XI. 11—14.
Cidaris tribuloides. Sluiter. 1895. Ech. Samml. Mus. Amsterdam. p. 67.
Cidaris tribuloides. Jackson. 1896. Studies of Palæechinoidea. Bull. Geol. Soc. America. VII. p. 218. Pl. VIII. 48.

Cidaris tribuloides. Koehler. 1898. Éch. et Oph. Rés. Camp. Monaco. XII. p. 8.
Cidaris tribuloides. H. L. Clark. 1898. Notes on Bermuda Echinoderms. Ann. New York Acad. Sc. XI. p. 412. Further Notes .... Ibid. XII. 1899. p. 131.
Cidaris tribuloides. H. L. Clark. 1901. Bermudan Echinoderms. Proc. Boston Soc. Nat. Hist. 29. p. 344.
Cidaris tribuloides. H. L. Clark. 1901. Echinoderms of Porto Rico. Bull. U. S. Fish Comm. 1900. II. p. 252.
Cidaris tribuloides. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 14, 17, 18, 19, 29.
Cidarites (*Gymnocidaris*) *tribuloides*. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 101.
Cidaris tribuloides. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 3. Pl. **2. 1—4.**
Cidaris tribuloides. H. L. Clark. 1907. The Cidaridæ. p. 185.
Cidaris minor. Koehler. 1908. Ast., Oph. et Éch. Rep. "Scotia". V. p. 302. Pl. XV. 136—138.
Cidaris tribuloides. Koehler. 1909. Échinodermes. Rés. Camp. Monaco. XXXIV. p. 214.
Cidaris tribuloides. A. Gruvel. 1909. Dispersion de quelques espèces appart. à la faune marine des côtes de Mauritanie. C. R. 149. p. 1018.
Eucidaris tribuloides, var. *africana*. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 40. Taf. **VI. 1, 3, 10, 13; X. 1, 4; XIII. 17; XIV. 11—13, 19; XV. 1, 15, 18—19; XVI. 19.**
(?) *Cidaris tribuloides*. Lambert. 1910. Description des Echinides des Terrains néogènes du bassin du Rhone. Mém. Soc. Paléontol. Suisse. XXXVII. p. 9. Pl. I. 41—43.
Cidaris tribuloides. Lambert & Thiéry. 1910. Ess. nom. rais. p. 145.
Cidaris tribuloides. Jackson. 1912. Phylogeny of Ech. Pl. II. 5—16, and numerous figures in the text, esp. p. 98. figs. 62—71.
Eucidaris tribuloides, var. *africana*. Koehler. 1914. Echinoderma. Beitr. z. Kenntnis d. Meeresfauna Westafrikas. p. 216. Pl. **XI. 11, 23.**
Cidaris minor. Ibidem. p. 217. Pl. **XI. 16, 17; XII. 10.**
Eucidaris tribuloides. Jackson. 1914. Studies of Jamaica Echini. Publ. Carnegie Inst. Washington. 182. p. 141.
Eucidaris tribuloides. H. L. Clark. 1918. Rep. Crin. & Ech. Bahama Exp. Bull. Lab. Nat. Hist. Univ. Iowa. VII, p. 17.
Eucidaris tribuloides. H. L. Clark. 1921. Rep. Crin. .... Echinoidea of the Barbados-Antigua Exped. Univ. Iowa. Studies in Nat. Hist. IX. 1921. p. 105.
Cidaris tribuloides. Jackson. 1922. Fossil Echini of the West Indies. (Carn. Inst. Publ. No. 306), p. 23. Pl. 1. 18—20.
Cidaris tribuloides. Tennent. 1922. Studies in the Hybridization of Echinoids. Cidaris tribuloides. Publ. 312. Carnegie Inst. (p. 12. Fig. 5).
Eucidaris tribuloides. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 21.
Cidaris tribuloides. M. S. Roig. 1926. Los Equinodermos Fosiles de Cuba. Bol. de Minas. 10. Habana. p. 32.
Eucidaris tribuloides. H. Engel. 1927. Echinoidea (v. Curaçao). Bijdr. tot de dierk. XXV. p. 163.
Eucidaris tribuloides. Th. Mortensen. 1927. Éch. Travailleur & Talisman. p. 24.
NON: *Cidaris tribuloides*. Russo. 1894. Echinod. raccolti nel Mar Rosso degli Uffic. d. R. Marina Italiana. Bol. Soc. Natural. Napoli. VII. p. 160. (probably either *Prionocidaris baculosa* or *Eucidaris metularia*.)
— *Cidaris tribuloides*. Koehler. 1908. Ast. Oph. et Ech. "Scotia". V. p. 304 (= *Eucidaris clavata* Mrtsn.).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A pro A.I.	Longest Spines
1	57 mm	31 mm	21 mm (37 % h.d.)	21 mm (37 % h.d.)	9—10[1]	11—12	62 mm
2	50 —	27 —	18.5 — (37 —)	18 — (36 —)	9—10	11—12	50 —
3	47 —	29 —	18 — (38.3 —)	17 — (36 —)	9—10	11—13	53 —
4	35 —	18 —	13.5 — (38.6 —)	12 — (34.3 —)	8—9	10—11	42 —
5	31 —	16 —	12.5 — (40 —)	12 — (38.7 —)	7—8	10—11	36 —
6	26 —	13 —	11 — (42.3 —)	10 — (39 —)	7—8	9—10	38 —
7	44 —	25 —	17 — (38.4 —)	17 — (38.4 —)	8—9	10—11	38 —
8	43 —	27 —	16 — (37 —)	15 — (35 —)	9—10	10—11	35 —
9	32 —	17 —	13 — (40.6 —)	12.5 — (39.4 —)	8	10 (11)	26 —
10	27 —	14 —	11 — (40.7 —)	11 — (40.7 —)	7—8	9—10	22 —
11	25 —	14 —	10 — (40 —)	11 — (44 —)	7—8	8—9	22 —
12	21 —	11 —	8 — (38 —)	9 — (43 —)	6—7	8—9	20 —
13	17 —	9 —	7 — (41.2 —)	8 — (47 —)	6	7—8	17 —
14	10 —	5 —	4.5 — (45 —)	5 — (50 —)	5—6	6—8	9 —
15	53 —	40 —	15.5 — (30 —)	21 — (40 —)	11—12	8—9	26 —

Specimens 1—6 slender-spined forms, from deeper water; specimens 7—10 littoral specimens, St. Jan; specimens 11—14 littoral forms, with strongly annulate spines, from the coral reef at Tobago, B.W.I.; specimen 15 from Loango (Mus. Paris).

Test usually conspicuously flattened above and below, sides beautifully arched; circumference circular, rarely subpentagonal.

Ambulacra very slightly sinuate, ca. 25 % of width of interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles perfectly regular, the tubercles rather prominent, contiguous, in larger specimens more or less distinctly transverse-oval. Adradially to the marginal tubercle each plate carries, in younger specimens, one secondary tubercle at the lower edge of the plate, forming regular vertical series. In larger specimens there are usually one or two more secondary tubercles, thus filling up the whole interporiferous zone. Usually there is no distinct naked midline, but sometimes it may be fairly distinct, even in large specimens. Pores usually rather small, equal-sized; the wall, which is moderately broad, forms a rounded elevation; the ridge very low and inconspicuous. The pore zone on the whole somewhat sunken (Pl. LXXIII. 1).

Interambulacra. Areoles rather small, scarcely sunken. Usually only the 2—4 proximal areoles confluent, and only the subambital ones transverse-oval. The mamelon relatively small. In young specimens the upper ones may be distinctly crenulate. Scrobicular tubercles fairly conspicuous, of the same shape as in *Thouarsii*, not semi-elliptical in outline as in *metularia*. The

[1] Jackson. (Phylogeny of Echini, p. 248) states to have found fourteen (interambulacral) plates in a column in this species. Unfortunately he does not give the size of the specimen in which he found this extraordinary number of coronal plates; but as the species has not been recorded to grow to a larger size than ca. 60 mm h.d., it is not very probable that he could have had a specimen before him of so much larger size as the number of coronal plates would seem to indicate. I cannot help suggesting, therefore, that either the specimen with these many coronal plates was abnormal, or that the statement is due to some mistake.

median area uniformly covered by small secondaries arranged, in larger specimens, in more or less distinct transverse series separated by fine horizontal lines. The median area up to twice as broad as an areole. The median vertical suture is sometimes distinctly sunken. Also at the adradial side of the scrobicular ring there is a rather conspicuous space, covered with small secondary tubercles. In younger specimens the median area is relatively much narrower, not as wide as an areole.

Apical system ca. 37—45 % h. d., flat, or the periproct slightly raised. Usually oculars I, IV and V insert, the two others, adjoining the madreporite, exsert; but also these two latter may be narrowly insert. (A number of variants are figured by Jackson (Phylog. of Ech. p. 98, figs. 62—71)). The madreporite slightly enlarged. Genital pores small, usually nearer the outer edge, but sometimes almost in the middle. The whole apical system rather closely covered with uniform, small tubercles, those along the outer edge of oculars and genitals somewhat larger. In younger specimens there is a more conspicuous difference in the size of the outer and inner tubercles, corresponding to the fact that in younger specimens the spines along the margin form a very conspicuous fringe, as in *metularia*, while in the adult specimens there is no distinct marginal fringe, all the apical spines being about of the same size. There is not so conspicuous a bare margin on the apical plates as in *Thouarsii*. Glassy granules may be fairly conspicuous in younger specimens. Periproctal plates fairly numerous.

Peristome about the same size as the apical system (in *Thouarsii* usually distinctly larger), only in younger specimens it is usually somewhat larger than the apical system. The ambulacral pores may show, in larger specimens, a tendency to a biserial arrangement; this is, however, less pronounced than in *Thouarsii*. There are ca. 16—18 ambulacral plates in a series in adult specimens. Interradial plates ca. 6—8 in a generally regular series, almost reaching the mouth edge.

Primary spines typically rather stout, cylindric, or very slightly tapering, ending abruptly in a small, but distinct crown, with a small central prominence. But they may be more slender, tapering to a rather fine, scarcely at all crown-shaped point, and often also widened in the basal part, so as to be very distinctly fusiform; or they may be more or less conspicuously thickening towards the point, recalling to some extent the species *clavata*. The shaft is set with low, rounded warts, arranged in ca. 18 longitudinal series, which assume at the end of the spine the shape of low ridges or lamellæ, which form the end crown of the spine. Usually the warts are of uniform size, but sometimes part of them become larger, especially towards the end of the spine, or arranged in more or less distinct whorls, the spine thereby assuming a somewhat verticillate appearance. The general surface of the shaft is covered by a rather thick spongy coat of anastomosing hairs. The collar is ca. 1 mm long, slightly thickening towards the milled ring, which is not very conspicuous. There is scarcely an indication of a smooth neck above the collar. The oral primaries are quite simple, passing very gradually into the ambital spines.

Secondary spines. The scrobicular spines usually with straight sides and somewhat

rounded point; they are flattened, or slightly convex on the outer side, the point being usually sharper, chisel-like; sometimes the scrobicular spines on the oral side are rather conspicuously widened towards the point. Marginal ambulacral spines much narrower than the scrobicular spines, generally distinctly flattened, but sometimes they are more simply spiniform. Spines of marginal fringe of apical system very like the marginal ambulacral spines. Miliary spines lancet-shaped. There may be a very conspicuous glandular swelling of the skin at the base of the miliary spines. The secondaries as a rule rather strongly appressed.

Pedicellariæ. Large globiferous pedicellariæ without a limb on the stalk. (For figures of the valves see the author's Ech. Deutsch. Südpolar Exp. Taf. XIV. 11, 19). Small globiferous of the usual form, with a small end tooth. Only one sort of tridentate pedicellariæ observed, the form with the slender head; they are on the whole scarce, often wanting. They were found especially well developed along the margin of the apical system in some young specimens, reaching a size of 1 mm length of head. — Spicules of tubefeet of the usual form. In the upper part of the intestine the spicules have the shape of rounded plates, with a few holes in the middle.

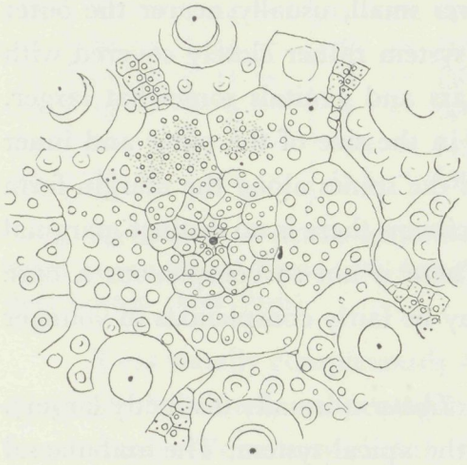


Fig. 119. Apical system and upper part of test of an abnormal *Eucidaris tribuloides*. × 5.

Colour. The primaries in younger specimens usually very conspicuously ringed with whitish and purplish-brown. In larger specimens the primaries are usually of a uniform brownish-purplish colour, while the oral primaries here as a rule retain the ringed character. The collar is whitish, sometimes of an olive-greenish tint. The secondaries white or whitish, generally tipped with brown (in younger specimens). The denuded test has a fairly conspicuous greenish tint, the apical system usually not darker than the corona.

Biology. In the intestinal canal of littoral specimens I have found pieces of algæ and Bryozoa. — The development has been shown by Tennent (Op. cit.) to be through a pelagic larva, very probably like *Echinopluteus transversus*; only the younger stage known. Young specimens have very conspicuously banded primary spines; the youngest specimen available to the author, 4 mm h. d., has 3 peristomial ambulacral plates in each series; the proximal primaries appear to correspond to the spines nos. 4—5 in *metularia*. The genital pores appear at a size of 9—10 mm h.d. The largest size recorded for the species is 58 mm h.d. The older specimens may have the spines rather much overgrown by Barnacles, Bryozoans and Serpulids. The littoral specimens generally have their primaries covered by small, fine algæ. Some specimens which I found on the reef at Bucco Bay, Tobago, B.W.I., living concealed under a thick carpet of Corallina, were remarkably fine, having their spines perfectly clean, their whitish and purplish rings showing very beautifully (Pl. XLI. 10—11) — Parasites appear to be common in places. Rathbun

(Op. cit. 1885) states that at the "Albatross" Station 2407 "fully one half of the specimens were infested with a species of *Stylifer*, which was generally found boring into the spines", producing a sort of galls. A similar case was described by the present author in the var. *africana* (Ech. Deutsch. Südpolar Exp. p. 42, Taf. XVI. 19). — Anomalies are not very rare. Jackson (Op. cit.) has described a couple of cases (fig. 64, p. 98 and fig. 185, p. 167). A specimen from the coral reef at Bucco Bay, Tobago, B.W.I. is remarkable by the rudimentary condition of the oculars, there being, in fact, only one real ocular plate; one of the ambulacra does not reach the apical system at all; there are two madreporites and several other irregularities (Fig. 119).

Variation. The species is very variable. Looking at the various more characteristic types, without the intermediate forms, one would hardly believe they could all be one and the same species, but rather two-three distinct species. But intermediate forms prove that it is all one and the same species; at most we can distinguish one or two varieties.

As the typical form may be regarded such specimens as have rather stout, nearly cylindric spines, ending in a distinct crown, as is, on the whole, characteristic of the genus *Eucidaris*. To this type belong mainly littoral forms from the West Indies, particularly the specimens from the reef at Tobago with the beautifully annulated spines (Pl. XLI. 10—11). Specimens from somewhat deeper water have as a rule more slender, often fusiform spines, which taper to a rather fine point (Pl. XLVIII. 1). They have generally the spines of a uniform brownish colour, but specimens occur which have the spines as finely annulated as those from Tobago. Some specimens have more or less verticillate spines, recalling to some degree *Plococidaris verticillata*; this is particularly the case with young specimens from more southern localities. Such specimens were especially mentioned and figured by Agassiz in the "Challenger" Echinoidea, p. 36. Pl. I. 2, 3, 5, 6, and later on again by Koehler in his report on the "Scotia" Echinoderms (1909), p. 302, Pl. XV. 136—138, and in his West-African Echinoderms (Op. cit. 1914) p. 217, Pls. XI. 16, 17; XII. 10. Koehler designates this form as *Cidaris minor*, in the first place as "sp. aut var. nov.", in the latter he definitely regards it as a distinct species. The only characters especially pointed out as characteristic of this supposed species are, indeed, — besides the verticillate character of the primaries — that the marginal ambulacral spines are more or less distinctly banded with red and white, and that the genital pores are developed already at a size of 9.5 mm h.d., which indicates it to be a species of small size.

Having had the opportunity of comparing one of the "Challenger" specimens from Bahia, further the type of Koehler's *Cidaris minor*, as also some specimens of this form from Anno Bon, in the Gulf of Guinea, belonging to the Paris Museum, with young specimens of *tribuloides* from off St. Jan, West Indies, I cannot have the slightest doubt that Koehler's *Cidaris minor* is nothing but the young *tribuloides*. The young specimens, on the whole, have more or less verticillate primaries, and young specimens from the West Indies may be as distinctly verticillate as those from the African coast, though, I agree, these latter are in general a little more verticillate. The banded character of the marginal ambulacral spines also is somewhat more distinct in the African

specimens, and particularly in specimens from Ascension. But these differences are so slight that they cannot justify distinguishing the African specimens as a separate variety or even species. They are simply the young specimens of the African *tribuloides*. As regards the genital pores, they appear, as it has been stated above, at a size of ca. 9—10 mm h.d. also in West Indian specimens. It may finally be remarked that the name *minor* could not well be used, were this form to be regarded as a separate species or variety; the name has been used twice already within the genus *Eucidaris*, first by Deslongchamps (Encycl. méth. p. 195) for a variety *minor*, then by A. Agassiz 1863 for "*Gymnocidaris minor*", both being nothing but young specimens of *Eucidaris metularia*.

In the report on the Echinoidea of the German S. Polar Expedition I established the variety *africana* for some specimens of *tribuloides* from Cape Verde, this variety being distinguished from the typical, West Indian form particularly by the more narrow median area of the interambulacra, and the correspondingly broader areoles; also the valves of the globiferous pedicellariæ are usually broader than in the West Indian form (cf. Ech. Deutsch. Südpolar Exp. Taf. XIV. 12—13, comp. with 11, 19)[1].

H. L. Clark (Op. cit. 1925) finds after the study of the rich material in the British Museum that the form found in the Eastern Atlantic is not "uniformly recognizable different" from the West Indian and Brazilian form. I agree, the differences are not quite constant. But in general the African form is characterized by the features pointed out in the original description, as also stated by Koehler after the examination of a rather large African material (Op. cit. 1914); it is, evidently, a form in the course of specialization, which it is both justifiable and practical to designate as the variety *africana*.

A very remarkable specimen in the Paris Museum, from Loango (M. Nobre 1890) may perhaps represent another separate variety (Pl. XLI. 9). As seen from the measurements of this specimen (No. 15 in the above table of measurements) it differs from the typical *tribuloides* in the unusual height of the test, the great number of interambulacral and small number of ambulacral plates, the large size of the peristome, and the short primary spines. Also the secondary spines on the oral side are unusual in being strongly excavate towards the end. The median interambulacral space is as broad as in the typical *tribuloides*; the interporiferous zone is somewhat unusually narrow, with only one secondary tubercle adradially to the marginal tubercle. Large globiferous pedicellariæ as in var. *africana* (tridentate not observed). Primary spines brownish, the collar, which is ca. 3 mm long, olive-green.

With only the single specimen available it is, of course, impossible to judge of the value of these characters; but if they prove to be constant, we have here a very distinct form which should rather be regarded as a separate species of the genus *Eucidaris* than as a variety of *tribuloides*. But it is quite possible that it is only an individual aberration.

Occurrence. Very common all over the West Indies, from S. Carolina and the Bermuda

[1] Judging from the figure of a valve of a large globiferous pedicellaria given by Stewart (Op. cit. 1871. Pl. IV. 3) his "*Cidaris annulata*" was the variety *africana* of *tribuloides*.

Isl. to Bahia[1] and Fernando Noronha. The form occurring at the African Coasts, especially at the Cape Verdes and in the Gulf of Guinea, belongs to the variety *africana* Mrtsn. Whether the specimens recorded from the Azores and Ascension belong to the typical form or rather to the var. *africana* is uncertain. The specimens from St. Helena recorded as *E. tribuloides* are *Eucid. clavata* Mrtsn. (these specimens were lent me for examination from the R. Scottish Museum, Edinburgh). It is also unknown how far South on the African coast the species occurs; a specimen from Loango may possibly represent a separate species (cf. above).

It is mainly a littoral form, occurring under stones at the shore and among corals, but is common also in somewhat deeper water down to 450 m. — As fossil it is recorded from the Miocene of Cuba (Jackson, 1922). The species has also been recorded as fossil from the Pliocene of the Pyrenees by Cotteau (Op. cit. 1893) and from the Pliocene of the Rhone Bassin by Lambert (Op. cit. 1910). As the species does not now occur in the Mediterranean or farther North in the Eastern Atlantic than the Maroccan Coast[2] (Gruvel Op. cit., exact locality not given), it would be of very considerable interest to have proof of its occurring there in Pliocene times. I cannot, however, regard this as definitely proven. Only spines have been found in these deposits; those described by Cotteau are quite small, not more than 12 mm long, and could then only be compared with the oral primaries of *tribuloides*, as is also done by Cotteau; but they do not, by any means, so closely resemble the oral primaries of *tribuloides*, that the identification can be considered as certain; on the contrary, I find them so different, judging from Cotteau's figures — thus e. g. the collar is usually a good deal longer in the oral primaries of *tribuloides* — that I cannot at all accept that identification. It would also be rather funny if only the oral primaries should be found. — As for the spines identified by Lambert as *tribuloides* I do not think it any more certain that they are really this species; they resemble much more some of the spines of *Cidaris margaritifera* Meneghini figured by Checchia-Rispoli in "Gli Echinidi viventi e fossili della Sicilia". IV. Palæontogr. Italica. XXII. 1916. Tav. XXVI. 1—27.

Remarks. This common and well known species, one of the oldest known Cidarids, is the nearest related to *E. Thouarsii*, the common West American species. The two species are, however, very well distinguished by various characters, e. g. the much broader median interambulacral space and smaller areoles of *tribuloides*, the larger size of the peristome in *Thouarsii*, the existence of a limb on the stalk of the large globiferous pedicellariæ in *Thouarsii*, not in *tribuloides*, the much lighter colour of the secondaries in *tribuloides;* thus they are not merely to be

[1] The specimen from 51°26′ S. 68°5′ W. 57 fms. mentioned by H. L. Clark (The Cidaridæ, p. 185) as collected by the "Hassler" is not sufficient proof of the species occurring so far South, both because the specimen is very young (5 mm h.d.) and because there may have been made a mistake with the label, as hinted at by Clark.

[2] Ramsay, in his Catalogue of the Echinoidea of the Australian Museum, mentions a specimen "dredged off Coast of Spain". On this single testimony (without other informations) we cannot accept its occurrence here as a fact. It may perhaps be suggested that it is the locality "St. Vincent" which has caused the statement, as there is a Cape St. Vincent at the Spanish coast and a St. Vincent at the Cape Verdes; at the latter locality many *tribuloides*-specimens have been dredged.

regarded as local races of one and the same species, separated through the upheaval of the Central-American land-bridge, such as is the case with several other forms — in Echinoderms as well as in other animal groups — represented on both sides of the isthmus.

The confusion of the names *metularia* and *tribuloides* due to the original statement by Lamarck that the species *tribuloides* "habite l'Ocean Indien" was sufficiently cleared up by Agassiz (Rev. of Ech. p. 253) as also some mistakes with regard to Gray's *Cidaris annulata* (— not *annellata*, as Agassiz has it —). This need not to be repeated here. The more recent record of the occurrence in the Red Sea of *tribuloides* (Russo, Op. cit.) no doubt rests on a misidentification, either of *metularia* or (more probably) *Prionocidaris baculosa*.

Eucidaris clavata Mrtsn.

Pls. XLII. 1—4; LXVII. 10—11; LXXIII. 2; LXXXVI. 15.

Eucidaris tribuloides Koehler. 1908. Ast. Oph. et Ech. "Scotia" V. p. 304.
Eucidaris tribuloides. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 22 (partim).
Eucidaris clavata. Th. Mortensen. 1928. New Cidaridæ. p. 73.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	39 mm	24 mm	15 mm (38.5 % h.d.)	19 mm (48.7 % h.d.)	7—8	10—11	30 mm
2	36 —	22 —	14 — (38.9 —)	18 — (50 —)	7—8	10—11	28 —
3	35 —	21 —	12.5 — (35.7 —)	15 — (42.9 —)	7—8	9—10	33 —
4	34 —	21 —	13 — (38.2 —)	18 — (52.6 —)	7—8	9—10	28 —
5	32 —	19 —	12.5 — (39 —)	15 — (46.9 —)	7	9—10	30 —
6	25 —	13 —	10.5 — (42 —)	11 — (44 —)	6	9—10	24 —
7	25 —	13 —	10 — (40 —)	12 — (48 —)	7	9—10	22 —
8	24 —	18 —	11 — (45.8 —)	12 — (50 —)	6—7	8—9	22 —
9	23 —	13 —	10 — (43.5 —)	10 — (43.5 —)	6—7	10	30 —
10	16 —	8 —	7 — (43.8 —)	8 — (50 —)	5—6	8—9	15 —
11	9.5 —	5 —	4 — (42.1 —)	5 — (52.6 —)	5	6—7	8 —

Specimens 1—5 and 8 from the "Scotia" collection (R. Scottish Museum, Edinburgh), specimens 6—7 and 9—10 from the Paris Museum, specimen 11 from the British Museum; specimen 7 is the type.

Test low, flattened above and below; sides arched, circumference circular.

Ambulacra rather distinctly sinuate, ca. 25 % of width of the interambulacra. Interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles rather prominent, contiguous. Adradially to the marginal tubercle each plate carries a secondary tubercle at the lower edge; these inner tubercles form regular, longitudinal series, leaving no naked median line; in the larger specimens, or at the ambitus in specimens of middle size, there may be another secondary tubercle on the middle of the plate; when these secondary tubercles are well developed the serial arrangement of the inner tubercles becomes indistinct.

The pores are rather small, equal-sized; the wall is moderately broad, slightly raised, rounded; ridge low and inconspicuous (Pl. LXXIII. 2).

Interambulacra. The areoles are confluent, except the 2—4 upper ones, not at all deepened. The ambital and subambital areoles are distinctly transverse-oval. Edge of areoles not raised. The scrobicular tubercles rather conspicuous. The median space usually narrow, scarcely half the width of an areole, there being thus room for only few secondary tubercles outside the scrobicular circle; it may, however, be somewhat broader, ca. $^3/_4$ the width of an areole, in which case the median space is closely covered by small tubercles of very uniform size, arranged in fairly distinct, horizontal rows, separated by fine furrows (Pl. LXVII. 11). The median space on the whole very flat, no naked or sunk median line. On the adradial side of the scrobicular circle there is no room for secondary tubercles.

Apical system. Oculars all rather widely insert. Genital plates somewhat low, the genital pores rather distant from the edge. Periproct with fairly numerous plates, much as in *tribuloides*. The whole apical system somewhat more sparsely tuberculated than in *tribuloides* (Fig. 120); glassy warts not distinct.

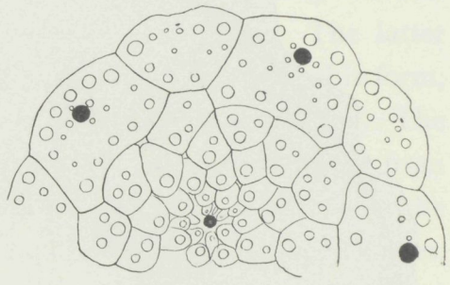


Fig. 120. Part of apical system of *Eucidaris clavata*. × 6

Peristome usually conspicuously larger than the apical system. There are 15—17 ambulacral plates in a series in the larger specimens, 6—7 in the smallest specimen; a biserial arrangement of the pores very conspicuous in the larger specimens. 6 interradial plates in a regular series, in the larger specimens, which may reach almost to the mouth edge. In the larger specimens the peristomial plates, particularly the interradials, are surrounded by a rather broad border of naked, white skin and give much the impression of being half dissolved.

Primary spines, The ambital and upper primaries are more or less, sometimes very conspicuously, club-shaped; they increase in thickness rather abruptly above the collar and then very gradually towards the end, where they are the widest, unto as much as 8—9 mm in diameter, against ca. 4 mm at the base. Sometimes they are slightly restricted in the distal third, then widening again rather abruptly in the point. As a rule they are less than the diameter of the test, but sometimes they are longer, ca. 1.3 h.d., and then much more slender, though still very distinctly club-shaped; both forms may occur on one and the same specimen (Pl. XLII. 2). The surface of the spines is set with low granules, arranged in ca. 18 fairly distinct, longitudinal rows, which at the end of the spine may assume the shape of small lamellæ, forming an inconspicuous end-crown. Typically the end of the spine is straight cut, but sometimes it is more or less gradually rounded. The general surface of the shaft covered with a close, spongy coat of anastomosing hairs. The collar is ca. 0.5—1 mm long, scarcely thickening towards the very inconspicuous milled ring. There is only an indication of a smooth neck above the collar.

The oral primaries very short, simple, not club-shaped; the 3rd—4th is transitional to the ambital spines.

Transverse sections through the thick spines show the very interesting fact that the new radial septa, which must, of course, be intercalated between the original ones as the spine grows thicker, originate in fan-shaped bundles; centres of formation of the new septa are found scattered all over between the axial part and the outer layer. Also the axial part is somewhat irregular (Fig. 121). The structure of these thick spines, in fact, recalls that of "*Cidaris*" *Hausmanni*, as represented by Bather (Triassic Echinoderms of Bakony, Pl. XVI. Fig. 448). It is interesting to notice that the "nuclei of fan-systems" are darker coloured, as Bather finds them to be also in *Cid. Hausmanni*. Bather thinks the dark colour to be due to the "carbonized stroma" — which is, at least, not the cause of the darker colour of these nuclei in the recent species.



Fig. 121. Part of transverse section of primary spine of *Eucidaris clavata*, showing the centres of formation of the new radiating septa. (The smaller irregular black spots are impurities in the section). The hairs on the surface of the outer layer left out by the reproduction. (After a photographic figure). × 15.

Secondary spines. The scrobicular spines ca. 4 mm long, flat, rectangular, with rounded end; on the oral side they are more or less conspicuously widened towards the end. Marginal ambulacral spines of the same general shape, only much narrower. The smaller spines are lancet-shaped. A glandular ampulla at the base of the smaller, apical spines apparently does not exist.

Pedicellariæ. The large globiferous with slender valves (Pl. LXXXVI. 15) and without a limb on the stalk. The small form well developed, reaching a size of ca. 0.5 mm length of head; both forms rather long-stalked, ca. 2 mm length of stalk. Tridentate pedicellariæ not found on any of the specimens examined. Spicules of tubefeet of the usual type.

Colour. Primary spines brown, not banded, even in the smallest specimen; in the latter the warts of the primaries are white and thus fairly conspicuous. Secondary spines whitish, with the end more or less conspicuously brownish. Test white with a faint olive tint, particularly on the genital and ocular plates.

Biology. Probably this species does not grow to a notably larger size than the larger of the specimens available, as appears from the fact that the upper spines in these specimens are on the whole fully developed. Also the fact that the spines of these specimens are in general very much overgrown by foreign organisms: Hydroids, Bryozoans and incrusting algæ, indicates that

they are rather old. Genital openings have not yet begun to form in the young specimen of 9.5 mm h.d. — No parasites have been observed, but on one of the "Scotia" specimens a Polynoid worm is found on an ambulacrum.

Occurrence. Known with certainty only from St. Helena and Ascension. The specimens from the Paris Museum are labelled Magellan Strait (Admiral Serres 1879); but this locality is almost certainly incorrect. Bathymetrical distribution from the shore down to ca. 100 m ("Scotia").

Remarks. This form is a very interesting parallel to the var. *galapagensis* of *E. Thouarsii*, which latter may perhaps equally well deserve to rank as a separate species. That the present species is closely related to *E. tribuloides* cannot be doubted, the question being only whether it should be regarded as a distinct species or merely as a variety of *tribuloides*. The latter course was taken by H. L. Clark (Op. cit. 1925) who did not even give a name to this form, although he states it to be a "much more conspicuous variety" (viz. than the var. *africana*). The reason why he did not name it, evidently, was this that he found not all the specimens from St. Helena to possess such thick spines. This may well be the case — though I have seen in the British Museum only a couple of very young specimens, which had not such club-shaped spines. Certainly there is much difference in the thickness of the spines; but in the specimens examined by me at least some of the spines are very distinctly club-shaped and conspicuously different from the spines of *E. tribuloides*. Also in the characters of the test there are noteworthy differences. The interporiferous zone of the ambulacra is in general narrower and less tuberculated than in *tribuloides*; the apical system less tuberculated; the peristome is usually conspicuously larger than the apical system, whereas in *tribuloides* it is about the same size as the apical system. Also the colour of test and primary spines is different. All these differences, I think, make it not only justifiable, but rather necessary to regard this thick-spined form as a separate species.

From *galapagensis* it is distinguished at a glance by the light colour of its secondary spines, these being nearly black in *galapagensis*.

This species like *galapagensis* recalls the numerous fossil forms with club-shaped spines.

Genus **Actinocidaris** Mrtsn.

Th. Mortensen. 1928. New Cidaridæ, p. 73.

Apical system about half h.d. Oculars usually exsert; madreporite not enlarged. Tubercles non-crenulate. Pores subconjugate. Peristomial ambulacral plates in a single line. Primary spines thick, cylindrical or somewhat fusiform, finely tuberculated, the surface covered by a coarse, reticulate outer layer, formed by the thick, anastomosing hairs. Secondary spines not scale-like, not closely appressed. Large globiferous pedicellariæ unknown; small globiferous with a distinct end tooth; tridentate pedicellariæ with long and slender valves.

Genotype: *Phyllacanthus Thomasi* A. Ag. & H. L. Clark.

This genus is probably the nearest related to *Prionocidaris*. The character of the pores forbid uniting it with *Prionocidaris* which must be confined to the forms with typical conjugate pores; also the remarkable, coarse, spongy outer covering of the spines is very different from the coat of fine, anastomosing hairs of the *Prionocidaris*-species. The secondary tubercles recall to some degree those of *Chondrocidaris* (as observed by Agassiz & Clark in their description of "*Phyllacanthus*" *Thomasi*), the mamelon being very distinctly eccentric, the spines thus being attached halfway on the side of the tubercles, which shows the way how the peculiar attachment at the side of the tubercles in *Chondrocidaris* may have originated. Also to the genus *Stylocidaris*, as also to *Eucidaris*, it shows some relation, but both the character of the pores and of the primary spines are different. From the genus *Phyllacanthus*; to which the species *Thomasi* was originally referred, it differs essentially in having the ambulacral pores on the peristome in a single series. Also the structure of the spines peculiar to *Phyllacanthus* is not found here. Whether the remarkable character of alternating red and white radiating stripes seen on transverse section of the spines is of generic value is impossible to say as long as only a single species is known. The name *Actinocidaris* refers to this feature.

Actinocidaris Thomasi (A. Agass. & H. L. Clark)

Pls. LXXIV. 1; LXXXIII. 22.

Phyllacanthus Thomasi. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 15. (partim). Pl. 5, 1—17; Pls. **27; 28; 29.** (Non: Pl. 26, 5—8; Pl. 30; Pl. 31, 1—4. = *Stylocidaris rufa* Mrtsn.).

Phyllacanthus Thomasi. H. L. Clark. 1907. The Cidaridæ, p. 188 (partim).

Phyllacanthus(?) *Thomasi*. Th. Mortensen. 1909. Ech. d. Deutschen Südpolar Exp. p. 50, 53.

Leiocidaris Thomasi. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.

Phyllacanthus Thomasi. Jackson. 1912. Phylogeny of the Ech. p. 100, 102.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	74 mm	50 mm	34 mm (46 % h.d.)	29 mm (39.2 % h.d.)	8—9	15—16	100 mm
2	72 —	52 —	34 — (47.2 —)	28 — (39 —)	8—9	14—15	95 —
3	37 —	25 —	20 — (54 —)	18 — (48.7 —)	7	13—14	72 —
4	35 —	23 —	19 — (54.3 —)	18 — (51 —)	7	13—14	55 —
5	34 —	20 —	17 — (50 —)	17 — (50 —)	6	13—14	65 —

No. 2 is the type-specimen, in the U. S. National Museum; the other specimens are in the Museum Comp. Zool.

Test rather high, flattened above, more rounded below, passing gently into the somewhat raised peristome. Sides arched, circumference round.

Ambulacra distinctly sinuate; interporiferous zone ca. twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles contiguous, even rather conspicuously transverse-oval, distinctly mamelonate. Adradially to the marginal tubercle each plate carries

one rather large secondary tubercle almost as large as the marginal, and sometimes a little higher than the latter; in the larger specimens there may be, more or less regularly, two or even three inner tubercles on each plate; but even where only one inner tubercle is found, the whole interporiferous zone is filled up, so that there is no naked midline. A few miliary tubercles are scattered among the secondaries. The interporiferous zone is not sunken, whereas the pore zones are rather distinctly sunken. The pores are of about equal size, distant, subconjugate (Pl. LXXIV. 1); ridge not very prominent.

Interambulacra. Areoles very shallow; only the two proximal ones (sometimes none) confluent; the subambital ones slightly transverse-oval. Tubercles non crenulate. Edge of areoles not raised, scrobicular tubercles inconspicuous, not much larger than the marginal ambulacral ones. Booth admedian and adradial part of the plates covered with rather large secondary tubercles, with distinct, but very eccentric mamelon; they scarcely decrease in size towards the midline, which is neither naked nor sunken. There is a more less distinct arrangement of these secondary tubercles in horizontal lines. The median area is somewhat broader than an areole.

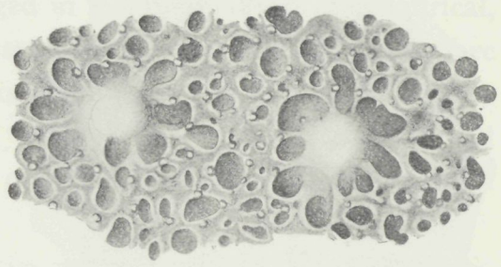


Fig. 122. Part of primary spine of *Actinocidaris Thomasi*, showing the spongy hair-coat. × 25.

Apical system ca. 46—55 % h.d., relatively smaller in the larger specimens; the oculars as a rule all exsert, more rarely one insert (Hawaiian Ech. Pl. 28). In the type specimen Oc. V is narrowly insert, Oc. I and IV nearly so. Madreporite not enlarged. Genital pores small, near outer edge. Periproct with fairly numerous small plates. The whole apical system closely covered with tubercles of uniform size. — Peristome slightly conically raised; ca. 20 ambulacral plates, the pores in single series, 6—7 interradial plates in irregular double series, not reaching the mouth edge (Hawaiian Ech. Pl. 27).

Primary spines rather thick and robust, a little widened above the collar, then tapering very gently; they are not pointed and not widened in the end. They are finely tuberculated in fairly regular longitudinal series, which form more or less conspicuous ridges towards the point. The surface of the shaft covered by a thick, spongy coat, with fine, round pores, formed by coarse, anastomosing hairs (Fig. 122). In well preserved, fully formed spines this coat almost covers the tubercles, and the spine rather gives the impression of being covered by some incrusting, sponge-like organism[1]. In transverse section the spines show a very beautiful radiating arrangement of alternating red and white stripes, the white corresponding to the tubercle-series, the red to the interspaces between the tubercle series (Fig. 123). The collar is 3—4 mm long, scarcely thickening downwards. No shining neck above the collar on the larger spines, but on the smaller subambital

[1] Very probably H. L. Clark's statement (The Cidaridæ, p. 188) that in old specimens the spines are "more or less incrusted with foreign material which conceals the true colour" is due to a misconception of this reticulate "hair"-covering.

ones and the oral primaries it is very conspicuous. The oral primaries not specialized, only conspicuously fluted at the point. The 3rd—4th is transitional.

Secondary spines. The scrobicular spines are ca. 6 mm long, slender, flat, slightly tapering towards the rounded point; they are not very closely appressed, and do not fit as a close mail around the base of the primaries, as they do in *Phyllacanthus*. The ambulacral spines ca. 4 mm long, simply spiniform. Miliary spines more pointed, lancet-shaped.

Pedicellariæ. Large globiferous pedicellariæ unknown. The small globiferous with a well developed end tooth and a rather small opening (Haw. Ech. Pl. 5, 3—4). The tridentate pedicellariæ with very slender valves, which join only in the outer part (Pl. LXXXIII. 22); they reach a size of ca. 1.5 mm length of head. — Spicules of the tubefeet spiny rods of the usual Cidarid type.

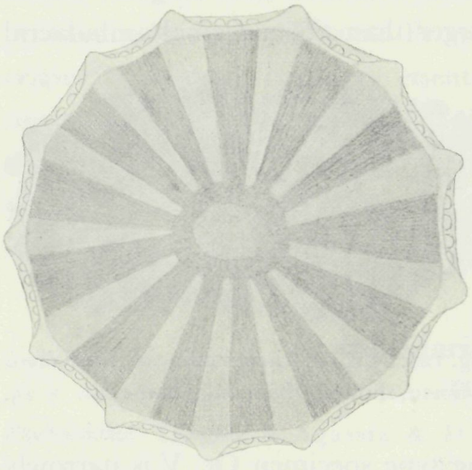


Fig. 123. Transverse section of primary spine of *Actinocidaris Thomasi*. × 10.

Colour. The primary spines of a greyish-white or greyish-pink ground colour, on which the numerous whitish tubercles come out rather distinctly; they are banded with rather narrow transverse bands of a somewhat darker, more redbrown colour. The collar is dark chocolate-brown. Regarding the peculiar colour seen in transverse sections, see above (Fig. 123). The secondaries are dark purplish; the ambulacral spines are of the same colour as the interambulacral (— contrary to *Stylocidaris rufa*, which was confounded with the present species). The naked test creamy white. Apical system apparently not conspicuously darker than the test (cf. Hawaiian Ech. Cidaridæ. Pl. 28 — contrary to *Stylocidaris rufa*).

Occurrence. Known only from the vicinity of the Hawaiian Islands. As Agassiz & Clark's "*Phyllacanthus thomasi*" comprises another species, *Stylocidaris rufa* Mrtsn., besides the true *Thomasi*, it is to be pointed out that among the "Albatross" stations named under "*Thomasi*", the stations 3838 and 4096 apply only to *Stylocidaris rufa*, St. 3823 alone to *Thomasi*, the rest of the stations to both species together. Known bathymetrical range: 128—400 m.

Remarks. That this species does not belong to the genus *Phyllacanthus* is definitely proved by the fact that the ambulacral pores of the peristome form single series; also the characters of the spines, both primaries and secondaries, distinguish it from *Phyllacanthus*. In my report on the Echinoidea of the German South Polar Exped. I expressed (loc. cit.) some doubt as to the true generic position of *Thomasi* for the reason that the large globiferous pedicellariæ are unknown; I had by that time not had the opportunity of examining this species myself, and both the description of the species given by Agassiz & Clark and the then knowledge of the characters of the genus *Phyllacanthus* were far too insufficient for recognizing the true affinities of the species *Thomasi*. Whatever the character of the large globiferous pedicellariæ will prove to be, this species

must form the type of a separate genus. The present description is based on the examination of the specimens preserved in the Museum of Comp. Zoology and in the U. S. National Museum. This study also revealed the fact that two different species were comprised by Agassiz & Clark under the name "*Phyllacanthus Thomasi*"; as for the differences between the true *Thomasi* and the other species, *Stylocidaris rufa* Mrtsn., confounded with it, see under the latter.

Genus **Hesperocidaris** Mrtsn.

Th. Mortensen. 1928. New Cidaridæ; p. 73.

Pores not conjugate, wall nearly flat; pores on peristome in single series. Madreporite not enlarged. Primary spines slender, with low granules arranged in longitudinal series; cylindrical, not tapering, but sometimes conspicuously widened and flattened towards the end, the surface covered with a thick, spongy coat of anastomosing hairs. Secondary spines not strongly appressed. Large globiferous pedicellariæ without an end tooth and without a limb on the stalk. Small globiferous with a small end tooth. Tridentate pedicellariæ of one form only, with slender valves.

Genotype: "*Dorocidaris*" *panamensis* A. Agassiz.

This genus comprises the three West-American species referred by Clark to *Stylocidaris*, viz. *panamensis*, *dubia*, and *perplexa*. No doubt the genus is nearly related to *Stylocidaris* — as there is also a rather conspicuous general resemblance, especially between *panamensis* and the West-Indian form of *Stylocidaris affinis*. However, the differences in the primary spines and the large globiferous pedicellariæ mark this group of species so well off from the typical *Stylocidaris*, that it seems better to regard them as forming a separate genus. Also the zoogeographical separation of this group from the mainly Indo-Pacific *Stylocidaris*-species is a noteworthy feature. The species *perplexa* differs conspicuously from the two other species, and ought perhaps rather to form a separate genus. But not having any specimens of this species at disposal, I have not had the opportunity of studying it very closely, and therefore prefer to leave it for the present in the same genus as the two other species.

Key to the species of Hesperocidaris.

1. Interporiferous zone completely covered with small tubercles. Ambital primary spines generally flattened and conspicuously widened towards the end ..... *H. perplexa*
   Interporiferous zone rather naked; ambital primary spines not flattened and widened towards the end ..... 2.
2. Primary spines usually with 16—18 longitudinal series of tubercles; secondary spines dark brownish ..... *H. panamensis*
   Primary spines with 12—13 longitudinal series of tubercles; secondary spines greenish or whitish, with a reddish-purple median stripe ..... *H. dubia*

Hesperocidaris panamensis (A. Agassiz)

Pls. XVIII. 8; LXXIII. 8; LXXXII. 23—29.

Dorocidaris panamensis. A. Agassiz. 1898. Prel. Rep. Ech. "Albatross" 1891. p. 73. Pl. **I**; Pl. **II. 1.**
Dorocidaris panamensis. A. Agassiz. 1904. Panamic Deep Sea Ech. p. 20. Pls. **1—4.**
Dorocidaris (?) *panamensis*. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 30; II. p. 5, 15.
Dorocidaris (?) *panamensis*. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 103.
Dorocidaris panamensis. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 9. Pl. 2. 5—8.
Tretocidaris panamensis. H. L. Clark. 1907. The Cidaridæ; p. 204.
Stylocidaris panamensis. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 52, 54.
Dorocidaris panamensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.
Stylocidaris panamensis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 24.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	34 mm	17 mm	16 mm (47 % h.d.)	14 mm (41 % h.d.)	7	13—14	50 mm
2	30 —	14 —	14 — (47 —)	13 — (43.3 —)	6—7	12—13	30 —
3	23 —	11 —	11 — (48 —)	10 — (43.5 —)	5—6	10—11	23 —
4	20 —	10 —	10 — (50 —)	9.5 — (47.5 —)	5—6	11—12	24 —
5	18 —	8 —	9 — (50 —)	8 — (44.4 —)	5—6	10	
6	10 —	5 —	5 — (50 —)	4.5 — (45 —)	(4)—5	8—9	

All the specimens, measured in the Museum Comp. Zool., are from the Cocos Islands; nos. 2 and 4 from 160 m., the rest from 120 m.

Test very flattened, both above and below, more or less distinctly incurved at the edge of the peristome. Sides very arched; circumference circular.

Ambulacra rather unusually broad, ca. 40 % of Interambulacra, slightly sinuate; interporiferous zone about twice the width of a pore-zone. Marginal series of tubercles very regular, the tubercles not contiguous. Adradially to the marginal tubercle a single secondary tubercle at the lower edge, forming regular vertical series. At the ambitus there may be another secondary tubercle near the inner edge on a few of the plates; also a few miliary tubercles are found, especially below the marginal tubercle. Interporiferous zone otherwise naked, scarcely sunken. Pores rather large, equal-sized; the wall fairly broad, quite flat; ridge low, rounded (Pl. LXXIII. 8). The pore-zone slightly sunken.

Interambulacra. Areoles low, the subambital ones transverse-oval; the two—three proximal ones confluent, the upper ones may be so widely separate as to give room for several secondary tubercles between the adjoining scrobicular rings. Boss not very prominent, mamelon rather small; traces of crenulation may sometimes be found, cf. Pl. III. 6 and Pl. IV. 8 of the Panamic Deep-Sea Echini. (I have not seen any specimen with all the tubercles crenulate, as represented in Pl. III. 6. Op. cit.). Edge of areoles not raised, the scrobicular tubercles scarcely larger than the marginal ambulacral tubercles. The admedian part of the plates rather closely covered with secondary tubercles, gradually decreasing in size towards the fairly conspicuous, naked, slightly

sunken median line. Also on the adradial side of the scrobicular ring there may be some secondary tubercles on the uppermost plates. Median area about half to two thirds the width of an areole.

Apical system 47—50 % h.d., not raised. Oculars all rather widely exsert. Genital pores small, nearly in the middle of the plate. Periproctal plates not numerous. The whole apical system rather closely covered with tubercles of uniform size, which may leave a fairly conspicuous bare space along the edges of the genital plates (Fig. 124).

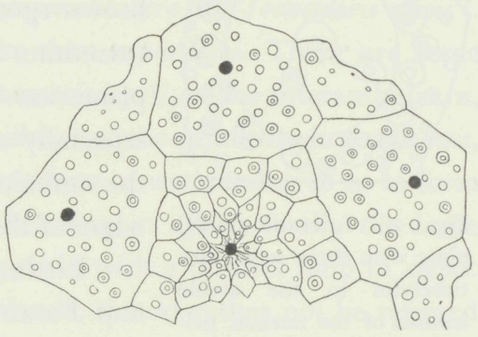


Fig. 124. Part of apical system of *Hesperocidaris panamensis*. × 6.

Peristome usually flat, somewhat smaller than the apical system; ca. 12 ambulacral plates in a series in the larger specimens, 4—5 interradial plates in a regular series[1].

Primary spines about 1—1.5 h. d., fairly slender, cylindrical, not tapering, partly rather widening towards the point, which may be slightly flaring. The shaft, in well-preserved, fully formed spines, is closely set with low, rounded granules, arranged in ca. 16—18 distinct, but close, longitudinal series, not in the shape of ridges, except in the outer part in those spines where the end is somewhat flaring. The surface of the shaft, between the granules, covered by a low, spongy texture formed by rather coarse, anastomosing hairs (Fig. 125). There is a fairly conspicuous, smooth, somewhat shining neck; the collar is about 1 mm long, increasing distinctly in thickness towards the fairly conspicuous milled ring. The oral primaries are simple, nearly smooth, the long collar making more than half the length of the proximalmost ones. The third is transitional to the ambital spines.

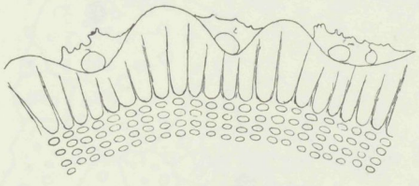


Fig. 125. Part of transverse section of primary spine of *Hesperocidaris panamensis*. × 65.

Secondary spines slender, flattened. The scrobicular spines ca. 3 mm long, not at all tapering, the point slightly thickened; they do not fit close together round the base of the primaries. The marginal ambulacral spines of the same shape, only more slender. Miliary spines lancet-shaped. There may be a rather conspicuous glandular ampulla at the base of the spines, mainly on the underside of the spine.

Pedicellariæ. Large globiferous with a rather broad subterminal opening; no limb on the stalk (Pl. LXXXII. 23, 25); they are comparatively rare. Small globiferous numerous, varying greatly in size, from only ca. 0.1 mm to ca. 0.5 mm length of head. The end-tooth is very small and inconspicuous, the opening rather broad (Pl. LXXXII. 24, 26—27). Tridentate pedicellariæ occur only very rarely; they have slender valves, joining only with their point (Pl. LXXXII. 28—29); they are rather small, not much exceeding 0.5 mm

[1] Agassiz states (Pan. Deep-Sea Ech. p. 20) that "the secondary tubercles and miliaries are crowded on the actinal side of the older buccal plates (Pl. III. 4). The tubercles on the peristomial plates are by no means unusually numerous, rather somewhat more scarce than usual, and that they are placed on the "actinal" (= adoral) edge of the plates is common to all Cidaridæ.

length of head. — Spicules of tubefeet not strongly thorny and rather scarce. The tubefeet somewhat unusually large, specially on the oral side. The spicules of the intestinal wall as in *Stylocidaris*, round plates with a few holes in the middle in the upper part of the intestine, small, three-radiate spicules in the lower part.

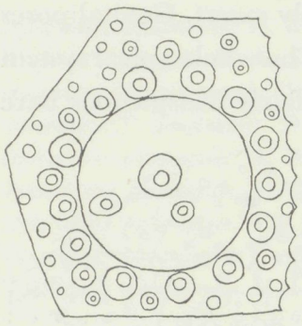


Fig. 126. Interambulacral plate with three secondary tubercles in the areole instead of the normal primary one, of *Hesperocidaris panamensis*. × 8.

Colour. Test creamy-white with small, more or less conspicuous, brown spots. Spines, primary and secondary, dark-brownish; there is sometimes a rather indistinct whitish band near the end of the ambital primaries. The naked test has a faint greenish or reddish-brown tint, especially on the upper areoles and along the interporiferous zone of the ambulacra. The apical system is more conspicuously redbrown, the edges of the genital and ocular plates being of a lighter, whitish colour.

Biology. In a specimen opened I have found fragments of shells and Foraminifera in the alimentary canal. — The small size of the genital openings indicate small eggs and, probably, pelagic larvæ. In the specimen of 10 mm h.d. the genital openings have not yet appeared; at the size of 15 mm h.d. they have just appeared, and by the size of 18 mm they are fully formed. The largest specimen known is 36 mm h.d. Whether it grows to a much larger size is unknown. The spines of the larger specimens are not much overgrown by foreign organisms. A curious anomaly is that of a genital plate with several pores covered by small scales (Pan. Deep-Sea Ech. Pl. IV. 6); Agassiz regards these pores as genital pores which does not seem very probable, both on account of their irregular form and plate covering, and because the specimen is a young one, only 14 mm h.d. I have not seen the specimen and shall therefore refrain from giving any suggestion as to the true explanation of the case.

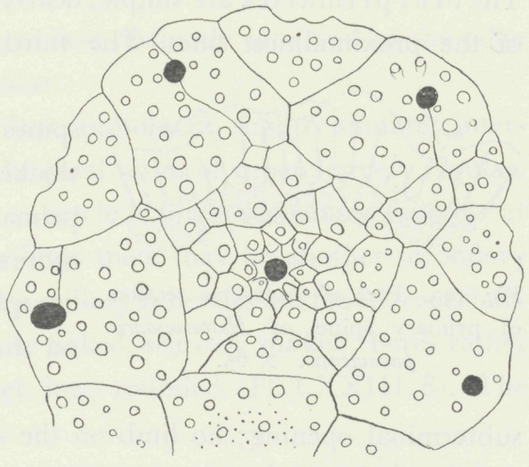


Fig. 127. Abnormal apical system of *Hesperocidaris panamensis*. × 6.

One specimen is peculiar in some of the upper primary interambulacral tubercles, one or two in each interambulacrum, except 1. a, being quite small and rudimentary (Pl. XVIII. 8); one or two secondary tubercles (spines) have developed in the areole, besides the original one in the centre; the areole is otherwise of the normal size, only shallower (Fig. 126). The spine attached to the primary (central) tubercle in these areoles has the character of a secondary, not of a primary spine. Also in another specimen the same curious abnormality is found, though not in so many of the upper areoles. Another specimen has some of the genital plates subdivided in two or more smaller plates (Fig. 127).

Occurrence. Known only from off Cocos Island and off Galera point, Ecuador, ca. 120—200 m.

Remarks. The statement of Agassiz that this species is the Pacific representative of "*Dorocidaris papillata*" evidently is due to his confounding of *Stylocidaris affinis* with *D. papillata* (= *Cidaris cidaris*). While there is no nearer relation between *panamensis* and the real *D. papillata* it is true enough that there is a considerable general resemblance between *panamensis* and the common West Indian *Stylocidaris affinis*, as also Clark (The Cidaridæ, p. 204) has corrected Agassiz' statement into that of *panamensis* being the Pacific representative of "*Tretocidaris affinis*". Still the resemblance between the two species is hardly more than superficial. There are some essential differences: the great width of the ambulacra in *panamensis* (40 % of the interambulacra, against only ca. 25 % in *affinis*); the more or less distinct club-shape of the primaries in *panamensis*, slightly pointed in *affinis*; the different character of the hairs: coarse, anastomosing so as to form a spongy coat in *panamensis*, fine, bushshaped, rarely anastomosing in *affinis*; finally the large globiferous pedicellariæ, without a limb on the stalk in *panamensis*, with a distinct limb in *affinis*. These two species, therefore, in spite of their general resemblance, should rather not be referred to the same genus.

Hesperocidaris dubia (H. L. Clark).

Pls. LXXIII. 9; LXXXII. 19—22.

Tretocidaris dubia. H. L. Clark. 1907. The Cidaridæ, p. 204. Pl. **6. 3—4.**
Stylocidaris dubia. Th. Mortensen. 1909. Ech. Deutsche Südp. Exp. p. 52, 54.
Dorocidaris dubia. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	25 mm	13 mm	11.5 mm (46 % h.d.)	10 mm (40 % h.d.)	6	11—12	25 mm
2	21 —	10 —	11 — (52.4 —)	10 — (47.6 —)	5—6	10—12	25 —
3	21 —	11 —	11 — (52.4 —)	10 — (47.6 —)	5—6	10—11	21 —
4	13 —	6 —	7 — (54 —)	7 — (54 —)	5	8—9	20 —

No. 1 is the type specimen, in the U. S. Nat. Museum; nos. 2—4 in the Museum Comp. Zool.

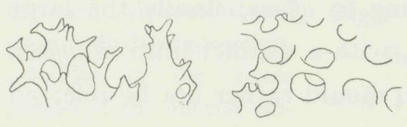
Test flattened, as in *panamensis*, but less so on the apical side, the apical system rising gently. Sides strongly arched, circumference round.

Ambulacra wide, ca. 40 % of interambulacra, slightly sinuate; interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles contiguous or nearly so, fairly prominent. A small tubercle at the lower edge of the plates, adradially to the marginal tubercle, making regular, vertical series. Interporiferous zone otherwise naked and rather sunken. Pores equal-sized, separated by a fairly broad, flat wall; ridge low, rounded (Pl. LXXIII. 9). Pore-zone only slightly sunken[1].

[1] A comparison of the figures of the ambulacra of *panamensis* and *dubia* (Pl. LXXIII. 8 and 9) shows a conspicuous difference in the horizontal sutures, due to the fact that the inner tubercle is placed at a lower level in *panamensis* than in *dubia*. This is perhaps not a reliable difference. The figure of *dubia* was drawn in the Museum of Comp. Zoology, in August 1926, that of *panamensis* in Copenhagen, July 1927. No specimen of *dubia* being available to the author, a direct comparison could not be made after the said difference was noticed, and there is then a possibility that the figure of *dubia* is not sufficiently exact in this regard.

Interambulacra. Areoles fairly large, rather shallow; the two—three proximal ones confluent, the subambital ones transverse-oval. Scrobicular ring not elevated, not very conspicuous. Outside the scrobicular tubercles only a single series of secondaries, close to the former, leaving a rather conspicuous bare median and adradial part. The median area not sunken, only about half the width of an areole.

Apical system about half h.d. (46—54%), somewhat elevated; oculars to a various degree insert, in the type specimen Oc. III—IV, in one of the specimens of 21 mm h.d. the four of the oculars insert, in the others all of them exsert. Genital pores small, near the edge; they are not yet developed in the specimen of 13 mm h.d. A series of somewhat larger tubercles along outer and inner edge of genital plates, those in the middle of the plates smaller; almost none in the youngest specimen. Peristome somewhat smaller than apical system, except in young specimens. There are 11 ambulacral plates in each series in the larger specimens, 7—8 in the younger, and 3—4 interradial plates.



1. 2.

Fig. 128. Hairs from primary spines of *Hesperocidaris perplexa* (1) and *H. dubia* (2). × 95.

Primary spines scarcely more than h.d. They are cylindrical, with the tip not, or only slightly flaring. The shaft with low, rounded granules arranged in 12—13 distinct longitudinal series, which assume the shape of ridges only at the point of the spine. Sometimes the granules of the adapical side are distinctly larger than those on the adoral side. The surface of the spine between the series of granules covered with a spongy coat of coarse, anastomosing hairs (Fig. 128. 2). The collar is about 1.5 mm long, slightly thickening towards the fairly conspicuous milled ring; the smooth neck of about the same length as the collar, more or less distinct. Oral primaries simple, the collar making not so conspicuous a part of them as in *panamensis*.

Secondary spines. The scrobicular spines ca. 3 mm long, flat, usually widened at the tip (Pl. LXXXII. 22); the marginal ambulacral spines about the same length, more slender, somewhat thickened at the point. Miliaries simply tapering. The larger secondaries often show distinct signs of the outer part being regenerated.

Pedicellariæ. Large globiferous like those of *panamensis*, without a limb on the stalk; the valves are more slender than in that species (Pl. LXXXII. 21 to comp. with Pl. LXXXII. 25). Small globiferous less abundantly developed than in *panamensis*, otherwise like those of the latter species, as are also the tridentate pedicellariæ. — Spicules of tubefeet of the usual spiny type, not characteristic, but rather numerous.

Colour. Primary spines greenish-brown, sometimes indistinctly banded; the tip whitish; secondaries whitish with a conspicuous median stripe of reddish-purple, widening at the point in conformity with the shape of the spine. The test greenish, the pore-zones, the median part of the ambulacra and interambulacra white; apical system, especially the periproct, reddish brown.

Occurrence. Known only from off the coast of Ecuador, ca. 150—200 m.

Remarks. As pointed out by Clark (Op. cit.) this species is closely related to *panamensis*. That it is a distinct species seems beyond doubt, the much more naked character of the test, the fewer longitudinal series of granules on the primary spines, the much broader scrobicular spines, the more slender valves of the large globiferous pedicellariæ and finally the colour affording excellent distinguishing characters.

Hesperocidaris perplexa (H. L. Clark)

Pls. XLII. 14; LXXIII. 7; LXXXII. 30—31.

Tretocidaris perplexa. H. L. Clark. 1907. The Cidaridæ, p. 205, Pl. **6. 1—2**; Pl. **7. 1—4.**
Stylocidaris (?) *perplexa.* Th. Mortensen. 1909. Echin. Deutsche Südpolar-Exp. p. 52, 54.
Dorocidaris perplexa. Lambert & Thiéry. 1910. Ess. nom. rais. p. 149.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	51 mm	32 mm	19 mm (37.3 % h.d.)	18 mm (35.3 % h.d.)	8	14—15	47 mm
2	50 —	27 —	20 — (40 —)	17 — (34 —)	7—8	15—16	42 —
3	49 —	26 —	20 — (40.8 —)	16 — (32.7 —)	8	12—14	?
4	49 —	27 —	22 — (45 —)	17 — (34.7 —)	7—8	13—15	47 mm

Nos. 1 and 4 in the U. S. National Museum; nos. 2—3 in the Museum of Comp. Zool.; no. 3 is the holotype, the specimen figured in Pl. 7. 1—4 of H. L. Clark's "Cidaridæ".

Test flattened above and below, in specimens 1—2 less so above. Sides strongly arched, circumference round.

Ambulacra rather broad, ca. 33 % of the width of the interambulacra. Interporiferous zone twice the width of a pore-zone. Marginal series of tubercles perfectly regular, the tubercles contiguous or very nearly so. The space inside the marginal series completely filled up with small tubercles, the outer of which may form a rather distinct vertical series. Median line sometimes fairly distinct, — not in the type-specimen; in this latter the interporiferous zone is somewhat elevated, while it is flat in the other specimens. Pores rather large (the outer may be slightly the larger), separated by a moderately broad wall; this is scarcely raised, may even be lower than the ridge. The pores must rather be designated as semi-conjugate (Pl. LXXIII. 7).

Interambulacra. Areoles small, very slightly sunken; the 3—4 upper ones are so widely separated that there is room for several secondary tubercles between the adjoining scrobicular rings (cf. The Cidaridæ, Pl. 7. 1—4). The 2—3 proximal ones confluent; the subambital ones slightly transverse-oval. In the holotype one of the upper tubercles is fairly distinctly crenulate; otherwise no trace of crenulation. Scrobicular tubercles very inconspicuous, scarcely larger than the secondaries outside the scrobicular ring; these latter cover the whole median part, diminishing gradually in size towards the midline which remains distinct, though not sunken. Also on the adradial side of the areoles there is quite a broad part covered with secondary tubercles. The median area is ca. $^2/_3$ the width of an areole.

Apical system (see The Cidaridæ, Pl. 7. 1) rather small, ca. 37—45 % h. d. Oculars may be all exsert or some of them insert. Genital pores small, near outer edge. The whole apical system, except a more or less conspicuous bare margin on genital plates, closely covered with small tubercles of uniform size. — Peristome distinctly smaller than apical system, with 4 interradial plates and 10—11 plates in the ambulacral series, the plates being rather high and stout, the tubercles at their inner edge small.

Primary spines scarcely as long as the h.d., the ambital ones generally conspicuously widened and flattened in the outer part, being the broadest at the tip, which may be slightly crown-shaped (Pl. XLII. 14). The shaft is covered with uniform low, more or less sharp granules, arranged in ca. 18 distinct longitudinal series; in the broad outer part the number of these series becomes larger, new series being intercalated as the spine widens; they do not take the shape of ridges except at the very end. The surface of the spines otherwise covered by bush-shaped, anastomosing hairs, which form in the basal part of the spine a spongy covering, not as coarse though as in *panamensis* and *dubia* (Fig. 128. 1). Above the collar there is a conspicuous smooth, shining neck of ca. 3 mm length; the collar is distinctly shorter, ca. 2 mm long, conspicuously thickening towards the fairly prominent milled ring. — Oral primaries simple, slightly curved; the third is transitional.

Secondary spines. The scrobicular spines ca. 4 mm long, narrow, but rather thick, more or less widening towards the point, which is somewhat concave on the outer side, especially on the spines of the oral side.

Pedicellariæ. The large globiferous form (observed only on one of the specimens in the U. S. National Museum, a fine specimen in alcohol) like those of *panamensis* (Pl. LXXXII. 30) and, as in *panamensis* and *dubia*, without a limb on the stalk. The small globiferous as in *panamensis*, abundantly developed, reaching a size of ca. 0.8 mm length of head, with the stalk up to 2.5 mm long. Tridentate pedicellariæ well developed, like those of *panamensis*, but reaching a larger size, nearly 1 mm length of head (Pl. LXXXII. 31); the stalk usually about the length of the head. — Spicules of tubefeet of the usual type.

Colour. General colour of test greenish, especially on the aboral side. Primary spines light grayish in the basal part, darker in the outer part, with a faint indication of brownish bands. The collar and neck of a conspicuous bright olive-green colour. Secondaries greenish, with a rather broad longitudinal stripe of deep reddish-purple (which makes the concavity of the end of the scrobicular spines the more conspicuous). Miliary spines greenish.

Biology. The primaries may be strongly overgrown by an arenaceous Zoanthid. — Otherwise nothing known of its biology. — The holotype has the apical system somewhat irregular, oblong, 20 mm by 18 mm in diameter.

Occurrence. Gulf of California, 65—70 m.; Clarion Island (the latter locality perhaps not quite reliable).

Remarks. As pointed out by H. L. Clark (Op. cit.) this species is much like *dubia*, and

these two species (together with *panamensis*) are evidently nearly related. Among the several characteristic features of the present species (e. g. the small size of the apical system and peristome, close tuberculation of interporiferous zone, compressed primary spines —) the semi-conjugate character of the pores may be especially mentioned as showing that we must not lay too much stress on a little difference in the character of the pores, any more than on any of the other characters. In spite of the fact that in *panamensis* and *dubia* the wall between the pores is perfectly flat, in *perplexa* somewhat concave, there cannot be the slightest doubt that these three species are closely related all of them. In this case the character of the large globiferous pedicellariæ lacking the limb on the stalk accordingly is decidedly of greater classificatory value than the said character of the pores.

Ralph Arnold, in his paper "Descriptions of new Cretaceous and Tertiary fossils from the Santa Cruz mountains, California" (Proc. U. S. Nat. Mus. XXXIV. 1908, p. 359) quotes H. L. Clark as writing to him concerning the new fossil species *Cidaris Merriami* described by Arnold in the said paper (p. 359, Pl. XXXII. 8): "I am very glad to see this material of *merriami*, for it satifies me that the species must have been allied to, if not identical with *Tretocidaris perplexa* Clark, the only other living littoral Cidarid known from north of Panama (other, I mean, than *thouarsii*). So your material shows that the ancestors of both *thouarsii* (— of which is spoken above in the same letter —) and *perplexa* lived in the Tertiary, in California". — Although it is very probable that Clark may be right in this statement I would say that the figure (Pl.XXXII.8) of a spine of *Cid. Merriami* certainly is much too poor for convincing one of the close relation to *St. perplexa*; the material itself, I hope, has been better.

Genus **Centrocidaris** A. Agassiz.

A. Agassiz. 1904. Panamic Deep Sea Echini, p. 32.
H. L. Clark. 1907. The Cidaridæ, p. 214.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 5, 30.

Test very flat. Ambulacra unusually broad, about half as broad as the interambulacra. Median ambulacral and interambulacral areas bare, somewhat sunken, but not as sharply limited furrows. Apical system about half h.d., genital plates unusually high and narrow; peristome somewhat smaller than apical system. Primary spines slender, the hairs forming a smooth, shining outer layer, so that the whole spine appears very smooth. Secondaries slender, not much appressed. Large globiferous pedicellariæ may have a small end tooth derived from the coalescing outer lateral teeth; no distinct limb on the stalk. Small globiferous pedicellariæ with a small end tooth. Tridentate pedicellariæ simple.

Genotype and only known species: *Goniocidaris Döderleini* A. Agassiz.

The relations of this genus are not very clear. The structure of the primary spines recall *Schizocidaris*, but there is otherwise nothing recalling that genus or the Goniocidarids, so that it must be assumed that the peculiar structure of the primary spines has developed independently

in these two genera. To *Austrocidaris*, with which it was thought very nearly related by Agassiz it has scarcely any nearer connection. The end tooth of the large globiferous pedicellariæ is scarcely of much importance as it is evidently only a secondary, not constant character being due to the coalescence of the two outermost lateral teeth. The statement (H. L. Clark) that there are two sorts of large globiferous pedicellariæ is a mistake. — Perhaps it is the nearest related to the other West American species, *Hesperocidaris panamensis*, *dubia*, and *perplexa*, with which it agrees in the main in the ambulacral structure and in the large globiferous pedicellariæ.

Centrocidaris Döderleini (A. Agassiz).

Pls. XVIII. 7; LXXIII. 10; LXXXIII. 1—10.

Goniocidaris Döderleini. A. Agassiz. 1898. Prel. Rep. Ech. "Albatross". p. 73. Pl. **III. 1.**
Goniocidaris (?) *Döderleini*. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 28, 30. II. p. 16.
Centrocidaris Döderleini. A. Agassiz. 1904. Panamic Deep Sea Echini, p. 33. Pls. **5; 14. 1—2.**
Centrocidaris Döderleini. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 103.
Centrocidaris Döderleini. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech., Cidaridæ, p. 29. Pl. **10. 1—9; 12. b. 7—9.**
Centrocidaris Döderleini. H. L. Clark. 1907. The Cidaridæ, p. 214.
Centrocidaris Döderleini. Th. Mortensen. 1909. Ech. Deutsche Südpol. Exp., p. 54.
Centrocidaris Döderleini. Lambert & Thiéry. 1910. Ess. nom. rais., p. 149.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	27 mm	13 mm	13.5[1]mm (50 % h.d.)	10.5[1]mm (39 % h.d.)	7—8	8—9	33 mm
2	18 —	8.5 —	10 — (55.5 —)	9 — (50 —)	7	7—8	
3	14 —	6.5 —	7 — (50 —)	6 — (42.9 —)	6—7	7	23 —
4	14 —	7 —	7 — (50 —)	6.5 — (46.4 —)	6—7	7—8	23 —
5	12 —	6 —	6 — (50 —)	5.5 — (46 —)	6—7	6—7	19 —
6	12 —	5.5 —	6 — (50 —)	5.5 — (46 —)	6 (7)	6—7	18 —
7	9 —	4 —	5 — (55.5 —)	5 — (55.5 —)	5—6	5—6	12 —

No. 1 is the type-specimen, in the U. S. National Museum; nos. 2—7 in the Museum of Comp. Zoology.

Test very low, flattened above and below; sides arched, circumference circular, in the larger specimens slightly subpentagonal.

Ambulacra straight or with the merest indication of a sinuation in the upper part. They are rather unusually wide, ca. 40—52 % of the width of the interambulacra[2]. The interporiferous zone about twice the width of a pore zone. Marginal series of tubercles quite regular, the tubercles almost contiguous. Adradially to the marginal tubercle each plate carries one smaller tubercle at the lower edge, forming regular inner series; the rest of the interporiferous zone naked, rather

[1] Agassiz (Pan. Deep-Sea Ech.) gives for this specimen the diameter of the "abactinal" system as 8.5 mm, of the peristome 9 mm. I cannot explain this divergence in the measurements. The photographic figures Pl. 10. 1—2 of the same specimen (natural size) show the measures to be as given above.

[2] H. L. Clark (The Cidaridæ, loc. cit.) gives 55—60 % of the width of the interambulacra; according to my measurements it scarcely exceeds 52 %, in the type specimen, in the others it does not exceed 50 %.

distinctly sunken. In the largest specimen, the type, there are two such inner tubercles at the lower edge, forming thus four vertical series inside the marginal series, and the interporiferous zone is thus almost wholly occupied by these tubercles (cf. Panamic Deep Sea Echini, Pl. 5. 3). In the specimens with the spines preserved the interporiferous zone, as well as the median interambulacral zone, make the impression of being much more naked, because the spines attached to these smaller tubercles are bending outwards and fitting in between the marginal ambulacral, resp. the scrobicular spines. The pores are rather large, of about equal size; the wall is not very broad, simple, flat, at a level with the ridge; the furrow is very inconspicuous (Pl. LXXIII. 10)[1]. In the larger specimens the pores are somewhat larger, but the wall is not broader than in the younger specimens.

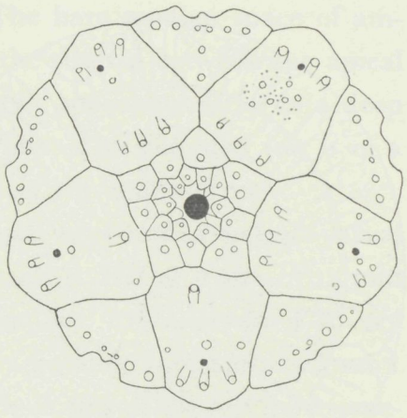


Fig. 129. Apical system of *Centrocidaris Döderleini*. × 8.

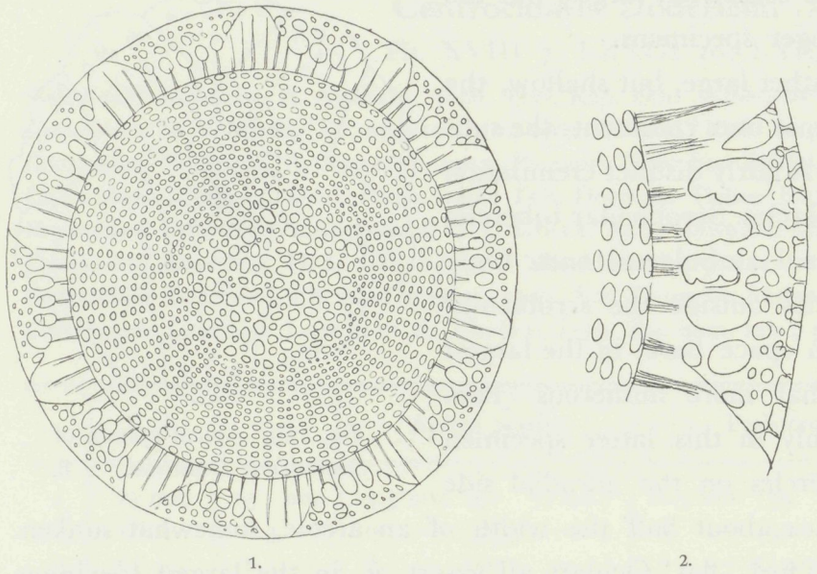
Interambulacra. Areoles rather large, but shallow, the boss filling it all up; the 2—3 proximal ones confluent; the subambital ones slightly transverse-oval. A fairly distinct crenulation may be found on the uppermost tubercles. Scrobicular tubercles only slightly larger than the marginal ambulacral ones. Only a single series of secondary tubercles outside the scrobicular ring, leaving a rather broad median space bare; in the largest specimen the tubercles are somewhat more numerous (Pan. Deep-Sea Echini. Pl. 5. 4), and only in this latter specimen there are also some secondary tubercles on the adradial side of the scrobicular ring. Median space about half the width of an areole, somewhat sunken.

Apical system ca. 50—55 % h.d., flat. Oculars all exsert or, in the largest specimen, Oc. III and IV barely insert; genital plates unusually high and narrow. Genital pores small, somewhat distant from the outer edge. Periproct small, with rather few plates. The whole apical system very sparsely tuberculated; only some few tubercles along the outer edge of the oculars and the outer and inner edge of the genitals, the latter being usually rather distinctly elongate; there may also be a single tubercle in the middle of the plate. The madreporite usually has some more tubercles in the middle, among the pores. The periproctal plates only with a single tubercle

[1] According to Agassiz (Pan. Deep Sea Ech. p. 33) "the poriferous zone is characterised by its great width (Pl. 5. 3); it is as broad as the median ambulacral space between the vertical rows of primary ambulacral tubercles, and by the depth of grooves connecting the ambulacral pores". Clark (The Cidaridæ, p. 214) states that the distance between each two pores is about equal to the diameter of the pore, the "surface of interval" being slightly elevated. — The width of the pore-zone is not so large as to be especially characteristic, even in the type-specimen, and it seems rather certain that this statement by Agassiz is based not on the specimen, but on the said figure, Pl. 5. 3 — which is not altogether too exact. Also the deep grooves connecting the pores are evidently due to the said figure, which represents the pores in a much too diagrammatic way, surrounded by an oval ring, which they are not in reality. On the whole the descriptions in the "Panamic Deep Sea Echini" are rather much influenced by the drawings (which were made, apparently somewhat too independently, by Lovén's old and excellent draughtsman, Mr. Westergren). H. L. Clark's statement that the distance between the pores of a pair is about equal to the diameter of the pore holds good, if the diameter of the pore means the vertical diameter, not the horizontal.

each, excepting the largest, which may have two—three tubercles (Fig. 129; cf. also Pan. Deep-Sea Ech. Pl. 5. 2). — Peristome usually distinctly smaller than apical system (in the largest specimen more so, in the youngest as large as the apical system). There are in the largest specimen 10—11 ambulacral plates in a series, 4 well developed interradial plates in a regular series, usually with 1—2 tubercles along the inner edge. The small specimen has 7 ambulacral plates in a series and 2 interradial plates.

Primary spines ca. 1—1.5 h.d., slender, cylindrical slightly tapering; the point not widened. The surface of the larger ambital spines perfectly smooth, only with an indication of ca. 10 entirely smooth, longitudinal ridges, which are very low, not rising over the general surface, except towards the point of the spine. In fact it is only by the colour that these ridges are visible, they being of a translucent character, whereas the surface otherwise is milky white. In reality the structure is quite different: the ridges are fairly high and sharp, but the hairs from the surface between the ridges grow up to form a close, spongy structure, quite smooth on the outside, resting on the basal part of the hairs as upon columns (Fig. 130), recalling the condition in *Schizocidaris*. The collar is fairly conspicuous, ca. 1 mm long, somewhat thickening downwards. Milled ring not very prominent. The subambital spines with more distinctly serrate ridges and somewhat shorter collar. Oral primaries simple, but again with a comparatively long collar, as long as the shaft. The 2nd—3rd is transitional.



1. 2.

Fig. 130. Transverse section of primary spine of *Centrocidaris Döderleini* (1), and part of the same more magnified (2). 1. × 70; 2. × 175.

Secondary spines very slender, flattened, slightly widened in the basal part and slightly thickened at the point (Pl. LXXXIII. 8). The scrobicular spines, which do not fit very closely round the base of the primary spines, are ca. 3 mm long, the marginal ambulacral spines nearly of the same size. The miliary spines more simply lancet-shaped. There may be a fairly distinct, glandular "ampulla" at the base of the apical spines. The secondary spines are, on the whole, somewhat more coarsely thorny than usual in Cidarids (Pl. LXXXIII. 9).

Pedicellariæ. The large globiferous form has rather slender valves, sometimes with a rudimentary end tooth[1], formed evidently by the coalescing of the two outermost lateral teeth

[1] The statement by Agassiz & Clark (loc. cit.) that they have a "powerful" end tooth is rather exaggerate, as shown by their own figure, Pl. 12. b. 7.

(Pl. LXXXIII. 2—3). There is only a faint indication of a limb on the stalk (Pl. LXXXIII. 1). The small globiferous pedicellariæ of the usual form, with a small end tooth; those from the peristome, and also the smaller samples in general, have relatively broader and more flat valves with a rather broad opening and a small end tooth[1] (Pl. LXXXIII. 4—7). The tridentate pedicellariæ with slender valves, joining only in the outer part (Pl. LXXXIII. 10) (See "Hawaiian Echini. Cidaridæ"; Pl. 10. 1—2; Pl. 12. 7—9). — Spicules of tubefeet not peculiar.

Colour. Primary spines white, the collar yellowish; Agassiz states the primaries to be reddish in the living specimen. The secondaries greenish, with an indication of a darker brownish midline; they may be tipped with dark yellow (H. L. Clark). The bare median space of ambulacra and interambulacra deep brownish violet in life, as also the sutures between the apical plates are "marked by a sharp violet" which colour in the alcoholic specimens fades into deep purplish or dull red or brownish. The apical system otherwise white. The denuded test is of a greenish-olive tint, more pronounced in the interporiferous zone of the ambulacra.

Biology. The small size of the genital pores indicates small eggs and a pelagic larval stage. Genitals pores have not appeared in the specimens of 12 mm h.d. but at a size of 14 mm h.d. they are developed. — The type specimen is somewhat anomalous. Ambulacrum I is very irregular at the ambitus (but normal above and below); in the adjoining Interambulacrum 1 there is a small separate plate in the midline at the ambitus; the whole side of the test here somewhat sunken. Finally genital 5 has two genital pores (Pl. XVIII. 7). (These anomalies were not mentioned by Agassiz).

Occurrence. The type specimen was found off Cocos Island 94 m., later on some specimens were taken ("Albatross") near Hood Island, Galapagos, in depths of 180—540 m. Not known from any other localities.

Remarks. The affinity of this species to *Austrocidaris canaliculata* emphasized by Agassiz, who even places the latter species in the genus *Centrocidaris* together with *C. Döderleini*, was based only upon the naked median line of the ambulacra and interambulacra. The sunken median line of *Austrocidaris canaliculata* is, however, quite different from that of *C. Döderleini*, being sharply

[1] The globiferous pedicellariæ from the peristome were by Agassiz & Clark (Op. cit.) regarded as a second form of large globiferous pedicellariæ, this Cidarid thus being unusual in having "at least four very distinct sorts of pedicellariæ"; the statement that these peristomial pedicellariæ have no end tooth and no lip does not agree with my observations, as I find both a very distinct lip and a usually rather distinct, but small end tooth. At least I have never seen any of these peristomial pedicellariæ that would quite suit to the description and the figure (Pl. 12. b. 8) given by Agassiz & Clark. The said figure also shows some spines on the inside of the valve of this pedicellaria; such I have not observed either on any of the samples seen by me. The fig. 4. Pl. LXXXIII otherwise so closely resembles the figure given by Agassiz & Clark in regard to the general shape, that it can hardly be doubted that it represents the same type as that of Agassiz & Clark and with a good will, it may well be said to have no end tooth; (unfortunately it is a broken valve, the only one I have seen; but as it is the outer part, the blade, that matters, it is so far sufficient). It is therefore not very likely that there should still exist another type of pedicellariæ here, and I think it not too rash to suggest that the pedicellaria figured by Agassiz & Clark was abnormal in being without lip. — To regard this form as a large globiferous I do not see any reason.

limited in the former, not at all so in the latter; further the structure of the primary spines of *C. Döderleini* is so entirely different from that of *Austrocidaris*, that this character alone would suffice for showing that there is no nearer relation between the two forms.

Genus Plococidaris Mrtsn.

Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 51.

Differs from the genus *Prionocidaris* in the pores being not distinctly conjugate, the peri-proct with fewer plates, not conically raised, in its verticillate primary spines and in the test being conspicuously mottled with green.

Genotype: *Cidarites verticillata* Lamarck.

The genus *Plococidaris* was established by the author (Op. cit.) for the two species *bispinosa* and *verticillata*, the former being designated as the genotype; otherwise no diagnosis of the genus was given. It seems, however, more natural to refer *bispinosa* to *Prionocidaris*, this genus being confined to the species with distinctly conjugate pores (as for *Pr. glandulosa*, see below, p. 435), the principal character distinguishing *bispinosa* from the other *Prionocidaris*-species being the non-spotted collar of the primaries. This leaves *verticillata* alone in the genus *Plococidaris*, which may then be diagnosed in accordance therewith. To drop the name *Plococidaris* as a simple synonym of *Prionocidaris* and create a new name instead seems unnecessary, especially since no diagnosis was given of it when first established.

In the report on the Echinoidea of N.W. Australia (Mjöberg) 1918, p. 8, I expressed the opinion, in accordance with Döderlein, that both *bispinosa* and *verticillata* might enter in the genus *Prionocidaris*, though as a separate group. As set forth below (p. 435) the genus *Prionocidaris* becomes a much more natural group, when the species *verticillata* is removed from it. Also the very peculiar character of the primary spines would seem to justify making *verticillata* the type of a separate genus.

Plococidaris verticillata (Lamarck).

Pls. LI. 3—7; LXXIV. 5; LXXXIII. 19—21.

Cidarites verticillata. Lamarck. 1816. Hist. nat. anim. s. vertèbres. III. p. 56. II. Ed. 1840, III. p. 381.
Cidarites verticillata. Deslongchamps. 1824. Encycl. méth. Pl. 136. 2—3.
Cidaris verticillata. L. Agassiz & E. Desor. 1847. Cat. Rais. Échinod. p. 23.
Cidaris verticillata. Peters. 1854. Seeigel. Mossambique. p. 118.
Cidaris verticillata. Gray. 1855. Arr. fam. Echinida. p. 37.
Cidaris verticillata. Dujardin & Hupé. 1862. Hist. nat. Zoophytes Échinod. p. 472.
Cidaris verticillata. Martens. 1866. Ostasiat. Echinod. p. 141.
Cidaris verticillata. Perrier. 1869. Rech. s. l. pédicellaires. p. 128. Pl. **III. 7. a—b.**
Phyllacanthus verticillata. A. Agassiz. 1872—73. Rev. of Ech. p. 151, 392, Pl. **I. c. 40—42; I. f. 3.**
Cidaris verticillata. Hoffmann. 1874. Echinod. Madagascar. p. 49, 54.
Phyllacanthus verticillata. Tenison Woods. 1878. On Australian Echini. Proc. Linn. Soc. N.S.Wales. II. p. 151.
Phyllacanthus verticillatus. Giebel. 1878. Seeigeln d. Gattung Phyllacanthus. Z. Ges. Naturw. 51. p. 864.

Phyllacanthus verticillata. A. Agassiz. 1881. "Challenger" Ech. p. 40.
Rhabdocidaris verticillata. De Loriol. 1882. Eocäne Echiniden aus Aegypten u. d. libyschen Wüste. p. 6.
Rhabdocidaris verticillata. De Loriol. 1883. Cat. rais. Ech. île Maurice, p. 10.
Phyllacanthus verticillata. Ramsay. 1885. Cat. Ech. Austral. Mus. p. 3. (II. Ed. 1891).
Phyllacanthus verticillatus. Döderlein. 1885. Seeigel v. Japan u. d. Liu-Kiu Ins. p. 7.
Leiocidaris verticillata. Döderlein. 1887. Jap. Seeigel. Cidaridæ. p. 22. Taf. **IX. 8, a—i.**
Phyllacanthus verticillatus. Bell. 1887. Echinod. Andaman Isl. p. 140.
Phyllacanthus verticillata. Sluiter. 1889. Nachträgl. Ech. fauna d. Java Meeres, p. 110.
Lhyllacanthus verticillata. Sluiter. 1895. Ech. Samml. Mus. Amsterd. p. 68.
Lhyllacanthus verticillata. Pfeffer. 1896. Ostafr. Ech. p. 45. — 1900. Echinod. Ternate, p. 83.
Leiocidaris verticillata. Ludwig. 1899. Echinod. d. Sansibargeb. p. 551.
Peiocidaris verticillata. Döderlein. 1902. Ech. Amboina u. Thursday Isl. (Semon) p. 690.
Peiocidaris verticillata. Bell. 1903. Echinod. Zanzibar. p. 246.
Cidaris verticillata. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 15, 19, 29; II. (1907) p. 14.
Cidaris (Cidaris) verticillata. De Meijere. 1904. "Siboga" Ech. p. 8.
Cidarites (Stephanocidaris) verticillata. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 101.
Cidaris (Leiocidaris) verticillata. Yoshiwara. 1906. Japanese Echini. Pl. II. 6.
Phyllacanthus verticillata. H. L. Clark. 1907. The Cidaridæ, p. 187.
Plococidaris verticillata. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 50, 53.
Phyllacanthus verticulata (sic!). Rudmose Brown. 1910. Echin. from the Kerimba Archipelago, Portugueze E. Africa (Mozambique). Pr. R. Phys. Soc. Edinb. XVIII. p. 37.
Leiocidaris verticillata. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris verticillata. Döderlein. 1911. Ech. Aru Ins. p. 242, 243.
Prionocidaris verticillata. Th. Mortensen. 1918. Ech. W. Australia (Mjöberg) p. 8.
Prionocidaris verticillata. H. L. Clark. 1921. Ech. Fauna Torres Str. p. 145.
Leiocidaris verticillata. Lambert. 1922. Ech. Madagascar. p. 22.
Prionocidaris verticillata. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 17.
Plococidaris verticillata. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 260.
Prionocidaris verticillata. Roxas. 1928. Philipp. litt. Ech. Philipp. J. of Sci. 36. p. 249. Pl. I. 2.
NON. *Cidaris verticillata.* Gray. 1855. Arr. fam. Ech. P. Z. S. p. 37. (probably = *Prionocidaris bispinosa).*

Under the literature referring to this species A. Agassiz (Rev. of Ech.) records Griffith, in Cuvier's "Animal Kingdom". Pl. XIII. 1. 1827. I have not seen this edition of Cuvier's "Règne animal"; in the French edition (Échinodermes 1837). Pl. XIII. 1 is "*Echinus*" (viz. *Heterocentrotus*) *mamillatus*, while the only recent Cidarid figured is *Cidaris tribuloides* (Pl. XII. 1).

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
37 mm	20 mm	18 mm (48.6 % h.d.)	17 mm (46 % h.d.)	6—7	13—14	25 mm
33 —	18 —	15 — (45.5 —)	14 — (42.4 —)	6—7	11—12	29 —
23 —	12.5 —	11.5 — (50 —)	11.5 — (50 —)	6	10—11	22 —
14 —	6.5 —	7 — (50 —)	6.5 — (46.4 —)	5	8	13 —

Test low, flattened above and below, sides arched; the circumference may be rather distinctly pentagonal in larger specimens. Ambulacra (Pl. LXXIV. 5) ca. 30—38 % of width of I.A. The interporiferous zone twice the width of a pore zone. Marginal tubercle series prominent, very regular, contiguous. Inside the marginal series there is, in the larger specimens, a fairly regular series of smaller tubercles, and in the largest specimen in hand there is on some of the

plates at the ambitus another small tubercle near the inner corner of the plate; it occurs, however, not so regularly as to form a distinct longitudinal series (it may well be expected to do so in still larger specimens); in the medium sized specimens the tubercles inside the marginal series do not yet form regular longitudinal series, occurring on some plates after one another alternatingly on the two sides. The part inside the marginal series otherwise is quite bare and somewhat sunk. Pores not very distant, in the largest specimen fairly distinctly conjugate, not yet so in the smaller specimens. In the largest specimen also they are unequal sized, the outer pore distinctly the larger (Pl. LXXIV. 5), while in the smaller specimens they are of equal size.

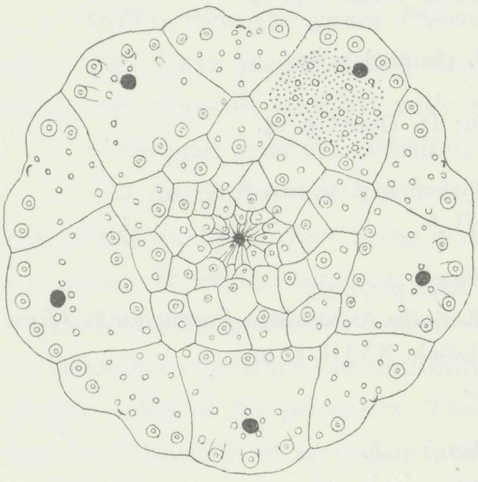


Fig. 131. Apical system of *Plococidaris verticillata*. × 6.

Interambulacra. Tubercles not crenulate. Areoles not sunk, distinctly separated, at most the 2—3 lowermost ones confluent. Only the subambital areoles somewhat elliptic. Scrobicular circle of tubercles fairly prominent, the tubercles about twice the size of the ambulacral marginal tubercles. Outside the scrobicular circle there is an alternating circle of smaller tubercles and, in the largest specimen, still a few smaller tubercles outside these; but a distinct, naked, rather sunken median space remains. The whole median space about half the width of an areole. No naked adradial space left.

Apical system ca. 45—50 % h.d. (Fig. 131). Oculars triangular, in larger specimens all insert, though not broadly so. Genital pores small, rather distant from the edge. Both ocular and genital plates very bare, mainly with a series of tubercles along the outer and inner edge; in the largest specimen those of the inner edge very small and inconspicuous. Periproct with fairly numerous small plates, also rather sparsely covered with tubercles. In younger specimens the oculars are partly exsert; at a size of 14 mm h.d. Ocular V becomes insert, and then gradually also I and IV, the two oculars adjoining the madreporite (II and III) being the last to become insert. At a size of 20 mm h.d. they may all be insert. The genital pores appear at a size of ca. 14 mm h.d. In a small specimen of 4 mm h.d. all the oculars are widely exsert.

Peristome in the larger specimens with 9—10 ambulacral and 4—5 interradial plates, which do not reach the mouth edge. The outer interradial plates may be double. At a size of 14 mm h.d. there are 6—7 ambulacral and 3 interradial plates. The peristomial plates upon the whole rather high.

Primary spines eminently characteristic through having three—four successive whorls of prominent, sharp ridges, like crowns placed one above the other (Pl. LI. 3—4). Also the point of the spine has generally the shape of such a crown, though much smaller than those on the shaft. Between the whorls smaller, obtuse thorns are found, generally not arranged in longitudinal

series. The surface of the shaft between the thorns otherwise covered by a spongy texture formed by anastomosing hairs, or rather irregular lamellæ (Fig. 132). Also between the ridges of the "crowns" this spongy outer layer is well developed. The collar is very short, only ca. 1 mm long; there is hardly an indication of a basal milled ring, the collar not widening downwards. Not considering the whorls, the shaft is slightly fusiform, tapering to a short, blunt point. The primaries are, upon the whole, short, scarcely as long as the h.d.; the specimen of 33 mm recorded by H. L. Clark as having the primaries 35—38 mm long is exceptional. The oral primaries are very simple, cylindrical, at most the proximal one slightly flattened on the adoral side, and slightly curved. The second oral spine is distinctly longitudinally furrowed in its outer part, the ridges gradually passing into the small thorns, which are here distinctly arranged in longitudinal series, an arrangement which disappears already on the third spine. The whorls begin to appear already on the second or third oral spine.



Fig. 132. Part of "hair"-coat of primary spine of *Plococidaris verticillata*. × 70.

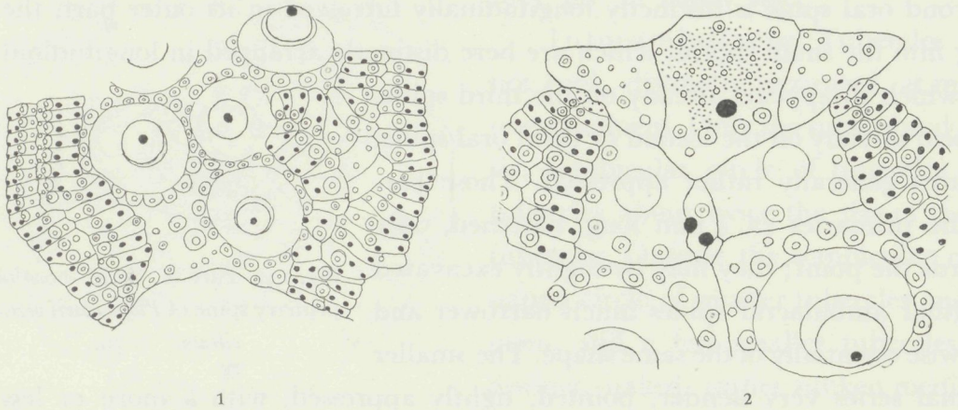
Secondary spines generally rather appressed. Those surrounding the base of the primaries ca. 4 mm long, flattened, only slightly narrowing towards the point; they may be slightly excavated in the outer part. Marginal ambulacral spines much narrower and more slender, but otherwise essentially of the same shape. The smaller spines inside the marginal series very slender, pointed, tightly appressed, with a more or less expanded, probably glandular, coat of skin at the base. The small spines of the apical system more leaf-shaped, pointed, distinctly excavate (Pl. LXXXIII. 21) and often with a thick, probably glandular, skin coat. They are, as a rule, strongly appressed. Peristomial spines of the usual form.

Pedicellariæ. The large globiferous form (Pl. LXXXIII. 20), already well described by Perrier, generally occurs in great numbers, especially on the naked median interambulacral area. They are usually rather long stalked, ca. 1.5 mm length of stalk. This also holds good of the small form of globiferous pedicellariæ, which are of the usual type, with a well developed end tooth. Sometimes the limb on the stalk of the large globiferous pedicellariæ is only indistinctly developed. Tridentate pedicellariæ very rare. They were found only in two younger specimens, a few samples, close to the apical system. The valves are very slender, wide apart below, joining only with the point; length of head scarcely 1 mm, stalk short, also scarcely 1 mm long (Pl. LXXXIII. 19)[1]. Spicules of the tubefeet of the usual form and arrangement. The walls of the intestine with the usual pavement of small, round, glassy bodies with only a few small holes in the middle. The internal organs otherwise with the usual sorts of spicules.

The general colour is green. The primary spines more or less distinctly banded, the whorls being whitish, the intervening spaces darker, sometimes brownish. The secondaries are

[1] Döderlein (Jap. Seeigel, p. 23) describes a fourth form of pedicellariæ: "winzig korbartig, unbewaffnet, mit auffallend weit geöffnetes Centralkammer" (Taf. IX, Fig. 8, g). This is nothing but a developmental stage of a globiferous pedicellaria.

whitish, usually with a greenish tint in the outer part, the tip again being white. The ambulacral spines somewhat darker. The small spines inside the marginal ambulacral spines with dark base, very conspicuous on the otherwise white interporiferous area. On some (larger) specimens this dark base is extended, the dark colour arranged in radiating lines, recalling chromatophores in the skin of some fishes. The spines on the apical system dark greenish[1]. The naked test has a very unusual colour for a Cidarid, being conspicuously mottled with dark green on a white ground colour[2]. The pore zones and the naked median part of the interambulacra as also the adradial corners of the interambulacral plates dark green; the tubercular boss grayish green. The apical system excepting the ocular plates dark green. There may be a whitish band across the genital plates.



1 2

Fig. 133. Parts of test of an abnormal specimen of *Plococidaris verticillata*; oral (1) and aboral side (2). 1. × 4; 2. × 6.

Biology. This species is mainly found on coral reefs. At a small Island (Huisman Isl.) in the Sunda Strait the author found it way down among the old branches of the Madreporas. Döderlein has found it living in the same way among the colonies of Millepora at the Liu-Kiu Islands. This habit may account for its being not so very commonly met with. It has, however, also repeatedly been taken by dredging, but always on coral sand. It feeds on all sorts of organisms as are found on the coral branches, Bryozoa, Hydroids, Foraminifera etc., especially the red Polytremas make a conspicuous part of the contents of its intestine.

Apparently the species does not grow to any considerable size. The largest size recorded is 40 mm h.d. The primary spines of the adult specimens are usually overgrown by foreign organisms, like Bryozoa, *Polytrema*, small Sponges etc. In the young specimen of 4mm h.d. (— which I have hardly any doubt in referring to this species —) the primary spines are not yet distinctly verticillate, but otherwise not of embryonal character. Development unknown. I did not find ripe sexual products in the specimens taken at Huisman Isl., Sunda Strait, in the beginning of August.

[1] V. Martens (Op. cit. p. 141) gives the following description of the colour: "auch während des Lebens trüb röthlichgrau, die grossen Stacheln mehr grau, erdfarbig, selten mit Spuren von hellern und dunklern Ringbändern, ihr Hals blass amaranthroth; die ihre Basis umgebenden kleinen platten Stacheln regelmässig an der Spitze heller". This description apparently was drawn up from the living specimens; however, the present author has a rather vivid impression that the colour of the specimens collected by himself at the Huisman Isl., Sunda Strait, was just the same in life as it is now on the preserved specimens.

[2] In *Schizocidaris assimilis* a similar coloration sometimes occurs.

A very remarkable case of abnormity was observed in one of the specimens from Huisman Isl. In Interamb. 2 and the adjoining ambulacra II and III there is a considerable deformity on the oral side, Ambulacr. III even branching in a peculiar way (Fig. 133. 1). At the ambitus normal condition has been established, but then again an irregularity comes in close to the apical system, a plate with two pores appearing in the midline of the interambulacrum (Fig. 133. 2).

Occurrence. Distributed all over the Indo-Pacific region, from Zanzibar, Mozambique and Mauritius to Fiji and Samoa (also recorded from Hawaii), and from Japan (Oshima, Liu-Kiu Islands) to the Australian East coast (exact localities unknown). It is a strictly littoral form, known with certainty only from the ebb-zone to 54 m. In the "Siboga" Ech. it is recorded from 984 m. but, as suggested by de Meijere, this may probably be a mistake due to an erroneous labelling of the specimen. Werth (Zur Kenntnis d. jüngeren Ablagerungen in tropisch Ost-Afrika. Z. deutsch. Geol. Ges. LIII. p. 290) records it as subfossil from quaternary deposits of East Africa. Further J. Cottreau (Echinides de Madagascar, Ann. de Paléontologie. III. 1908. p. 182. Pl. V. 9, 9. a) records it from deposits of Miocene age (Aquitanian) from Madagascar, and Duncan & Sladen (Monogr. Fossil Ech. of Sind. Part V. The Gaj or Miocene Series. Pal. Indica. XIV. 1885 p. 283) record spines "which recall in the most vivid manner the facies of spines of the type of the recent *Phyllacanthus verticillata* Lamk.". Whether these fossils actually belong to the same species as the recent *verticillata* is impossible to say definitely. But that it is a very closely related form, perhaps the ancestor of our recent species, seems certain enough.

Remarks. This species may well claim to be the easiest recognizable of all species of Cidarids, and therefore never has been the object of misidentifications, such as is the case with most other Cidarids known from older times. Alone the *Cidaris verticillata* of Gray probably is something quite different (?*bispinosa* Lamk.), as pointed out by de Loriol (Descr. trois espèces d'Echinides 1873, p. 32); but this is not because of erroneous determination, but because Gray had forgotten that there was a *Cid. verticillata* Lamarck and so established what he thought a new species under that same name.

Another thing is that there has been much dissence about its generic position, as appears from the list of literary references given above. Generally it has been referred to *Phyllacanthus*, as done first by A. Agassiz. The present author established (1909) the genus *Plococidaris*, comprising the species *bispinosa* Lamk. and *verticillata* Lamk. Döderlein (1911) referred both to the genus *Prionocidaris*, which I accepted (1918). As explained above, p. 428, it seems, however, the better course to separate *verticillata* from the genus *Prionocidaris* and make it the type of a separate genus.

Genus **Prionocidaris** A. Agassiz.

A. Agassiz. 1863. List of Echini, p. 18.
Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 50.
L. Döderlein. 1911. Ech. d. Aru-Inseln, p. 242.
Th. Mortensen. 1918. Ech. N.W. Australia (Mjöberg), p. 7—8.
H. L. Clark. 1916. Ech. "Endeavour", p. 99.
H. L. Clark. 1925. Cat. Rec. Ech. Brit. Mus. p. 2, 12.

Syn. *Stephanocidaris*. A. Agassiz.

A. Agassiz. 1872—73. Rev. of Ech. p. 160, 393. (non: A. Agassiz. 1863. List of Echini, p. 18).
Pomel. 1883. Class. méth. p. 111.
Duncan. 1889. Revis. gen. Ech. p 31.
Th. Mortensen. 1903. "Ingolf" Ech. p. 28.
A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. I. Cidaridæ. p. 17.
H. L. Clark. 1907. The Cidaridæ, p. 192.

Syn. *Schleinitzia*.

Th. Studer. 1880. Ech. "Gazelle", p. 862.

Apical system usually ca. 40—50 % of h.d. Oculars nearly always all broadly insert. Periproct generally with numerous small plates, often conically raised. Madreporite not noticeably larger than the other genitals. The whole apical system more or less closely covered by small tubercles. Test rather thin and fragile. Primary tubercles non-crenulate, or at most with an indication of crenulation on the uppermost tubercles. Pores usually distinctly conjugate. Peristome generally slightly smaller than the apical system. Primary spines rather slender, mostly tapering, often widened in the point, more rarely simply cylindrical; they are as a rule rather coarsely thorny, the thorns forming more or less distinct longitudinal series, sometimes arranged in more or less distinct whorls. The surface of the spines otherwise covered by a spongy coat of more or less anastomosing, fine, hairs. The collar as a rule not very long, usually provided with very characteristic purplish or white spots. The oral primaries more or less distinctly "capped". The secondaries flattened, not tightly appressed, the smaller ones spiniform, not scale-like. Large globiferous pedicellariæ, which are often very scarce or even totally lacking, without an end tooth and with a beautiful limb on the stalk. Small globiferous pedicellariæ with an end tooth, often very numerous. Tridentate pedicellariæ with very slender, simple valves. Spicules of intestinal wall small, round bodies with few holes, lying so close as to be more or less imbricated.

Genotype: *Cidarites pistillaris* Lamark.

This genus is very well characterized through the combination of the above characters, especially the conjugate pores and the characters of the pedicellariæ. It stands undoubtedly near to the genus *Acanthocidaris*, the species *Prionoc. glandulosa* bearing so great resemblance to *Acanthocidaris maculicollis* that, were it not for the different character of the primary spines, one would certainly regard them as congeneric. But on the other hand, *Pr. glandulosa* is so closely connected with *Prionocidaris australis*, a perfectly typical *Prionocidaris*, that it is even a question, whether they should not rather be regarded as identical. Thus, the two genera *Acanthocidaris* and *Prionocidaris*

are bound very closely together, though in their typical form appearing so conspicuously different. Also to the genus *Stylocidaris* the present genus is closely related (see under that genus).

As for the species here referred to the genus *Prionocidaris*, viz. *baculosa* (including *annulifera* Lamk.), *pistillaris*, *bispinosa*, *hawaiiensis*, *australis* and *glandulosa*, it is evident that they form a very natural group. It is true, the pores of *glandulosa* are not distinctly conjugate; but as it is evidently very closely related to *Pr. australis*, possibly only the young of the latter (— only small specimens of *glandulosa* are known, and only large specimens of *australis* —), there is no doubt that it really belongs to this genus.

Two more species, *verticillata* Lamk. and *badia* H. L. Clark, have lately been referred to *Prionocidaris*. Regarding the latter, it is certainly no true *Prionocidaris*, as shown by the fact that its pores are not conjugate. It belongs to the genus *Stylocidaris* and is rather closely related to another *Stylocidaris*-species from the Indian Ocean, *St. albidens* H. L. Clark.

The species *verticillata* decidedly stands quite apart from the true *Prionocidaris*-species. It is characteristic through its peculiar verticillate primaries and the green colour of its spines and test, the latter being even mottled, a feature otherwise unknown in the genus, and very rare in Cidarids. Also the apical system is characteristic in the periproct having fewer plates and not being elevated, as is so often (though not constantly) the case in the *Prionocidaris*-species; finally the pores are not distinctly conjugate. These various characters mark this species so well off from the other species of the genus *Prionocidaris* that it seems more proper to make it the type of a separate genus. — In 1909 I established the genus *Plococidaris* for the two species *bispinosa* and *verticillata* (Ech. Deutsche Südpolar Exp. p. 51), laying special stress on the non-spotted character of the collar in these two species. This character, however, is evidently of less importance and hardly sufficient for removing *bispinosa* from *Prionocidaris*. But replacing *bispinosa* in the genus *Prionocidaris* leaves the name *Plococidaris* free to be used for *verticillata*. The fact that the primaries of *Pr. baculosa* may sometimes be as verticillate as in *verticillata* (cf. H. L. Clark. Cat. Rec. Ech. Br. Mus. p. 13) might be in favour of regarding it

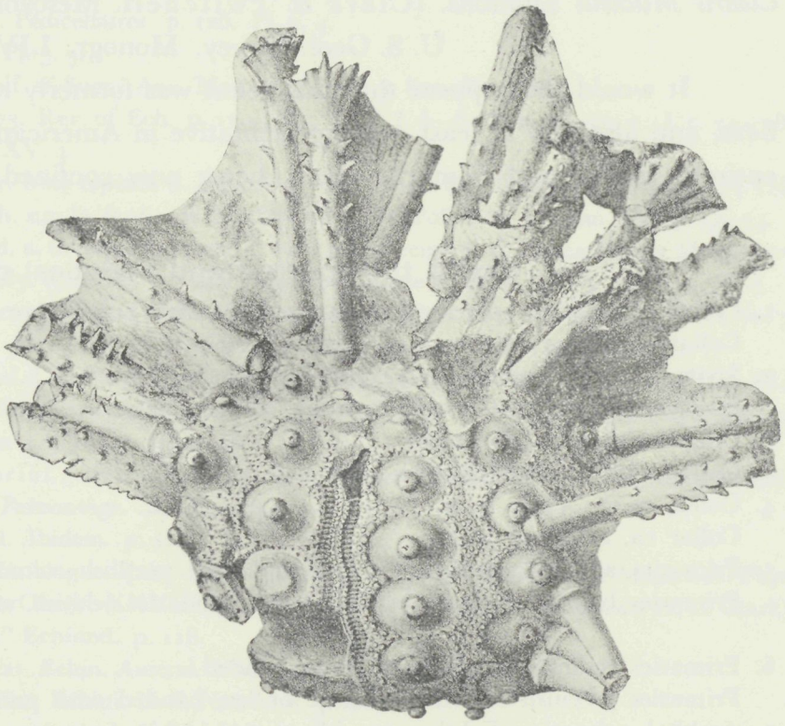


Fig. 134. *Prionocidaris* (?) *Sismondai* (K. Mayer). After Lambert. Descr. Éch. foss. Terr. Mioc. de la Sardaigne. Mém. Soc. Pal. Suisse. XXXIV. 1907. Pl. I. 1. Slightly reduced.

only as a subgenus, but I think it, after all, preferable to make *verticillata* the type of a separate genus, by which course also the genus *Prionocidaris* becomes a much more natural and well circumscribed genus.

The intricate history of the names *Prionocidaris—Stephanocidaris* has been given in detail by Döderlein (Ech. d. Aru-Inseln, p. 242), and by the present author (Ech. N.W. Australia (Mjöberg), p. 7—8) and need not be repeated here (see also under the species *baculosa*, *bispinosa* and *australis*). — The name *Schleinitzia* of Studer simply is a synonym of *Prionocidaris*, the species upon which it was established, *Schl. crenularis* Studer, being identical with *Prionoc. bispinosa* (and also including *Pr. baculosa* var. *annulifera*).

It seems very probable that various fossil species belong to this genus. As such I would mention:

Rhabdocidaris venulosa Cotteau. (Pal. Franç. Terr. Crétacé. Pl. 1084) ..... Cretaceous.
Leiocidaris canaliculata Duncan & Sladen. (Foss. Ech. Sind. 1884. Pl. XXI. 1—9) . Eocene.
Cidaris itala Laube (Dames. Die Echiniden d. Vicentinischen Tertiärgebietes. Palæontographica XXV. 1877. Taf. I. 7)..... Eocene.
Cidaris Adamsi Wright. (Fossil Ech. Malta. Qu. J. Geol. Soc. London. XX. 1864. Pl. XXI. 5) ..... Miocene.
Rhabdocidaris Sismondai Mayer. (Fig. 134) ..... Miocene.
Cidaris Mitchelli Emmons. (Clark & Twitchell. Mesozoic & Cenozoic Echinod. U. S. Geol. Survey. Monogr. LIV. 1915. Pl. 55. 1)..... Eocene.

It would thus appear that this genus was formerly rather richly represented in European Seas, and also had at least one representative in American Seas, whereas in recent times it has entirely disappeared from these seas, being now confined to the Indo-Pacific.

Key to the species (and varieties) of Prionocidaris.

1. Collar of primary spines spotted or striped with purplish or white..... 2.
   Collar of primary spines not spotted or striped..... *Pr. bispinosa.*
2. Spots or stripes on the collar purplish..... 3.
   Spots or stripes on the collar white..... 6.
3. Collar with purplish stripes..... *Pr. pistillaris.*
   Collar with isolated purplish spots..... 4.
4. Collar ca. 3—5 mm long..... *Pr. baculosa*, var. *longicollis.*
   Collar ca. 1—3 mm long..... 5.
5. Primaries and secondaries of a uniform dark, purplish colour..... *Pr. baculosa.*
   Primaries banded with red and white; secondaries whitish with a brown median stripe *Pr. baculosa*, var. *annulifera.*
6. Primaries reddish or yellowish-white banded..... *Pr. hawaiiensis.*
   Primaries greenish or whitish, more or less banded with purple..... 7.
7. Ambital primaries slightly upwards curved; white spots on the collar more prominent on the adapical side..... *Pr. glandulosa.*
   Ambital primaries not upwards curved; white spots on the collar equally conspicuous all round..... *Pr. australis.*

Prionocidaris baculosa (Lamark).

Pls. XLV; XLVI; XLVII. 2—3; XLVIII. 2; LI. 2; LIII. 4—11; LV. 2; LXVII. 6—7; LXXIII. 13—16; LXXXVII. 1—5, 10—11.

Savigny. 1809. Planches d'Echinod. d'Egypte. Pl. VII. 1.

Cidarites baculosa. Lamarck. 1816. Hist. nat. anim. s. vertèbres. III. p. 55. (II. Ed. 1840. III. p. 380).

Cidarites annulifera. Lamarck. 1816. Ibidem, p. 57. (II. Ed. 1840, p. 382).

Cidarites pistillaris. Deslongchamps. 1824. Encycl. méth. Hist. nat. des Zoophytes II. Pl. 137 (non: p. 194).

Cidarites baculosa. Andouin. 1825. Expl. sommaire des Planches d'Echinod. de l'Egypte, publ. par Savigny 1809. Descr. de l'Egypte I. 4. p. 210.

Cidarites baculosa. Michelin. 1845. Essai d'une faune de l'île Maurice. Zoophytes, Echinodermes et Stellérides. Magaz. de Zool. 2. Sér. VII. p. 16. Pl. VIII.

Cidaris baculosa. Agassiz & Desor. 1847. Cat. Rais. des Échinod. p. 23.

Cidaris Krohnii. Agassiz & Desor. 1847. Ibidem, p. 23.

?*Cidaris annulifera.* Agassiz & Desor. 1847. Ibidem, p. 23.

Cidaris pistillaris. Agassiz & Desor. 1847. Ibidem, p. 23.

?*Cidaris lima.* Valenciennes. 1847. (In Agassiz & Desor. Cat. Rais. des Échinod. p. 23).

?*Cidaris pistillaris.* Peters. 1854. Seeigel v. Mossambique. p. 118.

Cidaris ornata. Gray. 1855. Arr. fam. Echinida. P. Z. S. p. 37.

Cidaris baculosa. Dujardin & Hupé. 1862. Hist. nat. Zoophytes Échinod. p. 471. (Here also *Cidaris annulifera, Krohnii* & *lima*; diagnoses from Lamarck and Agassiz & Desor repeated).

Cidaris baculosa. A. Agassiz. 1863. List of Echinod. p. 17.

Cidaris baculosa. v. Martens. 1866. Ostasiatische Echinod. Arch. f. Naturgesch. XXXII, 1, p. 144.

?*Cidaris circinnata* (M. S.) v. Martens. Ibid. p. 147. (teste A. Agassiz).

Cidaris baculosa. Perrier. 1869. Rech. s. l. Pédicellaires. p. 126. Pl. 3, 4.

Cidaris Krohnii. Perrier. Ibidem. p. 127. Pl. 3. 3.

Cidaris baculosa. Gray. 1872. Echinod. Gulf of Suez. Ann. Mag. Nat. Hist. 4. Ser. X. p. 119.

Phyllacanthus baculosa. A. Agassiz. 1872—73. Rev. of Ech. p. 150, 388; Pls. **I. f. 4—5**; I. e. 11—20. a; I. c. 34—38; XXIV. 9; XXV. 4.

Cidaris annulifera. De Loriol. 1873. Descr. trois espèces d. Échinides. Mém. Soc. Sc. Neuchatel V. p. 25. Pl. III.

?*Cidaris pistillaris.* Hoffmann. 1874. Rech. sur la faune de Madagascar. (Fr. Pollen & v. Dam.) V. p. 50, 54.

Schleinitzia crenularis. Studer. 1876. Echinod. a. d. antarkt. Meere u. zwei neue Seeigel a. d. Papua Inseln. Monatsber. Ak. Berlin p. 463. (partim) — 1880. Ech. Corv. Gazelle. Ibid. p. 865. Taf. I, 1, d—f.

Phyllacanthus baculosa. Stewart. 1877. On certain organs of the Cidaridæ. Trans. Linn. Soc. 2. Ser. I. p. 571. Pl. 70. 7.

Phyllacanthus annulifera. Tenison Woods. 1878. Echini of Australia. Pr. Linn. Soc. N.S.W. II. p. 151.

Phyllacanthus baculosa. Giebel. 1878. Seeigel d. Gattung Phyllacanthus. Zeitschr. d. ges. Naturw. 3. Ser. III. p. 864.

?*Phyllacanthus baculosa.* K. Martin. 1880. Die Tertiärschichten auf Java. Anhang: Revision d. v. Herklots herausgeg. fossilen Echiniden Javas. p. 1.

Cidaris (*Rhabdocidaris*) *annulifera.* De Loriol. 1882. Eocaene Echin. aus Ägypten u. d. Libyschen Wüste. Palæontogr. XXX. p. 4.

Cidaris (*Rhabdocidaris*) *baculosa.* De Loriol. Ibidem. p. 4.

Rhabdocidaris baculosa. De Loriol. 1883. Catalogue Rais. des Echinod. île Maurice (Robillard). Mém. Soc. Phys. & d'hist. nat. Genève XXVIII. p. 4. Pl. II. 2. (non: Pl. I, 1 = *Pr. badia* H. L. Clark).

Phyllacanthus annulifera. Bell. 1884. "Alert" Echinod. p. 118.

Phyllacanthus annulifera. Ramsay. 1885. Cat. Echin. Austral. Mus. p. 2. (II. Ed. 1891).

Phyllacanthus annulifera. Rathbun. 1886. Cat. Echini. U. S. Nat. Mus. p. 262.

Leiocidaris baculosa. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ u. Salenidæ. p. 23, Taf. IX. 10, a—g.

Leiocidaris annulifera. Döderlein. Ibidem. p. 24. Taf. IX. 10, h—i.

Cidaris baculosa. Lovén. 1887. Echinoidea descr. by Linnæus p. 144. Taf. **5.**

Phyllacanthus annulifera. Sluiter. 1889. Evertebr. Samml. Batavia. Natuurk. Tijdschr. Nederl. Indie XLVIII. p. 286.

Phyllacanthus annulifera. Sluiter. 1890. Nachträgliches Echinod. Fauna d. Java-Meeres. Ibidem. 49. p. 109.
Phyllacanthus baculosa. L. Boutan. 1892. Voyage dans la Mer Rouge. p. 89—90.
Dorocidaris papillata. Russo. 1893. Ech. Mar Rosso. p. 160 (vide Th. Mortensen "Ingolf" Ech. I. p. 35).
Rhabdocidaris annulifera. De Loriol. 1893. Echinod. Baie d'Amboine. Rev. Suisse de Zool. p. 360.
Phyllacanthus annulifer. Bell. 1894. Echinod. Macclesfield Bank. p. 395.
Cidaris baculosa. Bell. Ibidem. p. 395, 397.
Rhabdocidaris baculosa. Mazzetti. 1894. Ech. Mar Rosso. p. 225.
Phyllacanthus annulifera. A. R. S. Anderson. 1894. Nat. Hist. Notes . . . "Investigator". Echinoidea coll. 1893—94. J. As. Soc. Bengal. LXIII. p. 188.
Phyllacanthus annulifera. Koehler. 1895. Cat. rais. Ech. îles de la Sonde. Mém. Soc. Zool. Fr. p. 408.
Phyllacanthus annulifera. Sluiter. 1895. Echiniden Samml. Mus. Amsterdam. Bijdr. tot de dierk. Afl. 17, p. 68.
Leiocidaris baculosa. Ludwig. 1899. Echinod. Sansibar. Abh. Senckenb. Naturf. Ges. XXI. p. 551.
Rhabdocidaris baculosa. Anderson. 1899. Rep. Mar. Survey of India, 1898—99, p. 5.
Leiocidaris pistillaris. Döderlein. 1902. Echinoidea v. Amboina u. Thursday Isl. (Semon) p. 692. Taf. **LIX. 1—5.**
Leiocidaris baculosa. Bell. 1903. Echinod. Zanzibar. p. 246.
Cidaris baculosa. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 19—20, 29, 35, 172.
Cidaris annulifera. Th. Mortensen. Ibidem, p. 19—20, 172.
Cidaris (Cidaris) baculosa. De Meijere. 1904. "Siboga" Ech. p. 9. Taf. **II. 9—12** (non: 7, 8, 13); XI, 109—110.
Phyllacanthus baculosa. Bell. 1904. Echinoderma; in Herdman. Rep. Pearl Oyster Fish. II. p. 138.
Rhabdocidaris baculosa. Fourtau. 1904. Contr. à l'Ét. des Éch. du Golfe de Suez. Bull. Inst. Egypte. 4. Sér. IV. p. 410.
Cidaris (Leiocidaris) baculosa. Yoshiwara. 1906. Japanese Echini. Pl. I. 11; Pl. II. 1.
Cidarites cidaris. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 96, 101.
Phyllacanthus baculosa. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. I. Cidaridæ. p. 15. Pl. 12, b. 16—17.
Phyllacanthus baculosa. H. L. Clark. 1907. The Cidaridæ. p. 189.
Phyllacanthus baculosa. H. L. Clark. 1908. Some Japanese and E. Indian Echinoderms. p. 301.
Prionocidaris baculosa. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 50, 53.
(?) *Phyllacanthus baculosus.* Rudmose Brown. 1910. Echin. from the Kerimba Archipelago, Portug. E. Africa (Mozambique). Pr. R. Phys. Soc. Edinb. XVIII. p. 37.
Phyllacanthus baculosus. Rudmose Brown. 1910. Echin. & Ast. from the Mergui Archip. and Moskos Isl., Lower Burma. Ibidem, p. 22.
Prionocidaris baculosa. H. L. Clark. 1910. Echin. Ceylon. p. 90, 98.
Leiocidaris cidaris. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris baculosa. Döderlein. 1911. Echin. v. d. Aru-Inseln. Abh. Senckenb. Naturf. Ges. XXXIV. p. 243.
Phyllacanthus baculosa. Jackson. 1912. Phylogeny of Echini. p. 99, 101—2, 152—53, 192, 194. Textfigs. 169 (p. 149), 223 (p. 193); Pl. 3, 3—4.
?*Leiocidaris pistillaris.* Lambert. 1922. Ech. vivants et foss. Madagascar, p. 20.
Prionocidaris baculosa, var. *annulifera.* H. L. Clark. 1923. Ech. W. Australia, p. 248.
Leiocidaris baculosa. Koehler. 1924. Anomalies irrég. & déformations du test chez les Éch. p. 263, 375. Pl. XII. 17.
Prionocidaris baculosa. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 12.
Prionocidaris baculosa, var. *annulifera.* Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 257. Pl. **53; 54.**
Prionocidaris baculosa. Koehler. 1927. "Investigator" Ech. III. p. 30.
Prionocidaris baculosa, var. *annulifera.* Koehler. 1927. Ibidem, p. 31.
Stylocidaris (?) longicollis. Th. Mortensen. 1928. New Cidaridæ, p. 72.
NON: *Phyllacanthus annulifera.* A. Agassiz. Rev. of Ech. p. 387 (= *Prionocidaris bispinosa* (Lamarck)).
— *Phyllacanthus baculosa.* A. Agassiz. 1881. "Chall." Ech. p. 39 (= *Stylocidaris amboinæ* Mrtsn.).
— *Phyllacanthus annulifera.* Bell. 1899. Rep. Ech. coll. Willey. Willey's Zool. Res. II. p. 134 (*Stylocidaris Reini* (Död.)).
— *Prionocidaris annulifera.* H. L. Clark. 1923. Ech. S. Afr. p. 370. 1924. S. Afr. Fish. & Mar. Biol. Survey I. Echinoidea p. 1 (= *Prionocidaris pistillaris* (Lamarck)).
— *Prionocidaris baculosa.* Roxas. 1928. Philipp. litt. Ech. Philipp. J. Sci. 36. p. 250. Pl. I. 1. (Probably *Eucidaris metularia).*

See further under *Prionocidaris bispinosa.*

Forma **typica** (including var. **erythræa** Döderlein).

Pls. XLVII. 2—3; XLVIII. 2; LIII. 9—11; LV. 2; LXXIII. 13; LXXXVII. 1—4.

Savigny. Descr. de l'Égypte. Tab. 7.
A. Agassiz. Rev. of Echini. p. 388. Pl. I. f. 4—5.
Döderlein. Japan. Seeigel. I. Cidaridæ. (*Leiocid. baculosa*) p. 23. Taf. IX. 10 a—g.
Döderlein. Ech. Amboina & Thursday Isl. (Semon) p. 694, Taf. LIX. 4—5.
Loriol. Ech. île Maurice. p. 4. Pl. II. 2.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	82 mm	42 mm	33 mm (40.2 % h.d.)	30 mm (36,6 % h.d.)	9—10	10—11	45 mm
2	68 —	44 —	30 — (44.1 —)	28 — (41.2 —)	9—10	10—11	55 —
3	60 —	39 —	25 — (41.7 —)	24 — (40 —)	9—10	10—11	53 —
4	50 —	29 —	19 — (38 —)	21 — (42 —)	8—9	9—10	31 —
5	44 —	26 —	18 — (40.9 —)	18 — (40.9 —)	7—8	9—11	28 —
6	38 —	23 —	17 — (44.7 —)	18 — (50 —)	7—8	10—11 (12)	28 —
7	30 —	16 —	13 — (43.3 —)	13 — (43.3 —)	7	9—11	41 —
8	19 —	10 —	9 — (47.1 —)	10 — (52.6 —)	5—6	10—11	27 —
9	16 —	8 —	7 — (43.7 —)	7 — (43.7 —)	5	8—9	30 —

The specimens 2—5, 7 and 9 in the Museum of Comp. Zoology

Test much rounded, somewhat flattened above and below; circumference circular or slightly subpentagonal, the I.A. being sometimes slightly swollen.

Ambulacra ca. 29.5—33 % of width of I.A. Interporiferous zone about twice the width of the pore zone. Marginal series of tubercles very regular, the tubercles small, but contiguous. Inside the marginal series as a rule two double series of much smaller tubercles, each plate bearing along its lower edge two small tubercles, the one at the inner corner the smaller. Sometimes there is also a small tubercle at the upper side of the plate, causing irregularities in the inner series; in the largest specimens there are some more irregularly placed miliary tubercles. The interporiferous zone, in general, makes the impression of being rather naked, scarcely sunk towards the median line. The pores are of equal size, wide apart, distinctly conjugate, the outer pore as a rule close to the outer edge[1] (Pl. LXXIII. 13).

Interambulacra. Primary tubercles smooth, not crenulate. Areoles not deepened, rather transversely elongate (oval), not confluent, except the two—three proximal ones[2]. Median area rather varying in width, from distinctly less than half to as much as or (in the largest specimen) even more than the width of an areole. Scrobicular circle of tubercles fairly prominent, the

[1] In younger specimens the pores are more close together, more or less oblique, and not distinctly conjugate.

[2] According to Döderlein (Jap. Seeigel I. Cidaridæ, p. 23) the areoles in larger specimens are confluent to a much larger extent; this is probably only due to a difference in the terminology. In the present work the areoles are designated as confluent only when the tubercles between them actually disappear. In this species the wall between the areoles may be rather narrow and low, and the tubercles on it small and arranged more or less in a single series, even towards the ambitus; but the tubercles have actually disappeared only between the 2—3 proximal areoles.

tubercles being distinctly larger than the marginal ambulacral series. Outside the scrobicular circle a few tubercles about half that size, alternating with the former; the rest of the median space closely covered with very small tubercles leaving at most a slight indication of a naked median line, which may be indistinctly sunk.

Apical system (Fig. 135) ca. (38) 40—47 % of h.d. Ocular plates usually all insert in the adult; in the largest specimen, however, Oc. II is exsert, and III only just insert; in the specimen of 19 mm Oc. IV is widely exsert. Genital pores small, well separated from the edge. Anal system not elevated. All the plates of the apical system rather densely covered with small tubercles; those along the inner and outer edge of genital plates and outer edge of ocular plates may be somewhat the larger and rather distinctly elongate, but this is no constant feature. — Peristome ca. 36—43 % h.d.; in younger specimens it may be more than half h.d., and distinctly larger than the apical system. 16—18 (19) ambulacral plates in each series on peristome in adult specimens, not very broad, leaving a rather broad interradial space, covered with a fairly regular series of 6—7 interradial plates, distinctly higher than the ambulacral ones. The interradial plates do not reach the mouth edge, usually only to the 5th—6th proximal ambulacral plate; in the largest specimen they very nearly reach the mouth edge.

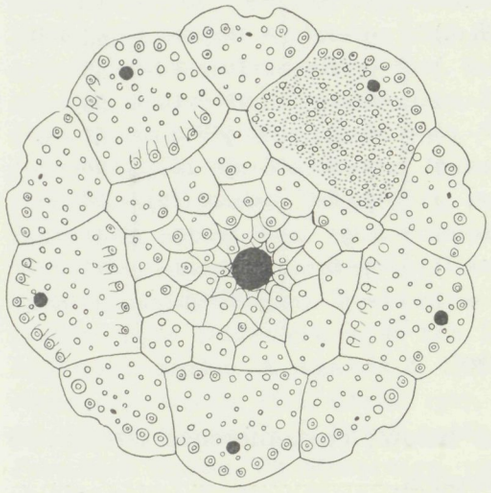


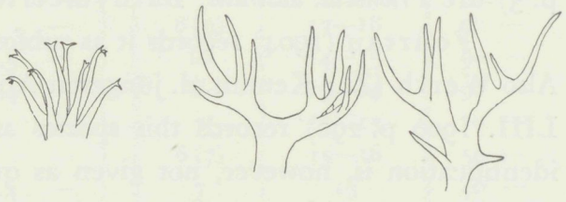
Fig. 135. Apical system of *Prionocidaris baculosa*. × 4.5.

Primary spines from less than h.d. to about 1.7 h.d., varying greatly in shape, from almost cylindrical to fusiform, tapering, with the point more or less flower-like widened. The shaft very closely set with thorns which do not generally show any distinct serial arrangement, except in the outer third part of the spines. The thorns are generally quite low, more or less rounded, uniform in size; this especially holds good for the specimens with nearly cylindric spines (var. "*erythræa*"). But often some of the thorns become enlarged, mainly on the upper surface of the spine, forming whorls[1] of greater or lesser distinctness, especially in the specimens with fusiform, tapering spines. The point is usually somewhat widened into the shape of a crown, particularly on the subambital spines; it is often oblique, more or less worn, as a consequence of their serving for walking on. The surface of the shaft, in well preserved spines, covered with a dense fur of slender hairs slightly branching at the point (Fig. 136. 1). The collar is generally short, rarely exceeding 2 mm in length, but often much less, only about 1 mm. It is set with purple spots which sometimes show a tendency to merge into one another so as to form longitudinal streaks. The oral primaries not much specialized; the first one slightly flattened and, sometimes, slightly curved; there may be a faint

[1] H. L. Clark (1925) records an extreme case of a specimen having the primaries as verticillate as are the primaries in *Plococidaris verticillata*.

indication of lateral serrations. The second and third only through their smaller size and the terminal crown (which is especially developed in the third) characterized as oral primaries. — The secondary spines generally appressed, rather broad, flattened, not pointed; more or less distinctly excavated at the point, especially those on the oral side; those around the base of the primary spines 5—6 mm long; in the specimen 82 mm h.d. as much as 8 mm long. The ambulacral spines somewhat shorter, much narrower.

Pedicellariæ. The large globiferous pedicellariæ, which are rather scarce, have slender valves, the blade being narrow with the edge slightly reenteringly curved (Pl. LXXXVII. 2—3); the stalk has a beautiful limb (cf. Döderlein. Japan. Seeigel. Taf. IX. 10. a). Small globiferous more numerous, of the usual type, with a distinct, though small end tooth (Pl. LXXXVII. 4). The tridentate pedicellariæ reach a size of ca. 1.5 mm length of head. The valves are very slender, joining to a varying extent in the outer part (Pl. LXXXVII.1).



1 2

Fig. 136. Hairs from primary spines of *Prionocidaris baculosa* (1) and *Pr. pistillaris* (2). × 80.

Spicules of the tubefeet of the usual type. The intestinal wall studded with small, rounded, glassy spicules, with only a few, small holes in the middle; they may lie so close as to be overlapping. (See under var. *annulifera*).

Colour. The denuded, well cleaned test has a distinct greenish tint, the apical system and the ambulacra being somewhat darker, though with a lighter median line in the ambulacra. The primary spines are of a uniform purplish-violet colour[1], usually not banded; the collar with purplish spots on a yellowish-greenish ground-colour — a coloration eminently characteristic of this species. (— This character was already pointed out by Lamarck as a main character of this species, "collo guttatis" —). Secondaries of a uniform dark, purplish colour.

Biology. This species appears to be common on the coral reefs. Boutan (Op. cit.) records having found it thrown up on the beach. The primary spines in specimens from the reefs or very shallow water are generally very strongly overgrown by algæ, especially incrusting forms.

Occurrence. This form is common in the Western part of the Indian Ocean, the African coast, from the Red Sea down to Zululand, Mauritius (the type locality), Seychelles, Madagascar; a specimen from the Chagos Archipelago is found in the British Museum. It is recorded also from the Philippine Sea (near Zamboanga, "Challenger") and from the Moluccan Sea (Gisser,

[1] The claret colour shown in two of the spines figured by Michelin (Op. cit. 1845) is evidently more unusual, one is inclined to think due to the artist more than to nature itself. According to A. Agassiz (1863) this species figured by Michelin is very different from the *Cidaris baculosa* of Lamarck, as figured by Savigny (Op. cit. 1809). The fact that Michelin's figures show the purple spots on the collar of the spines proves that this is the true *baculosa* which he figures, not the var. *pistillaris* as Agassiz suggests; otherwise the figure is so poor that it ought hardly to be taken seriously into consideration. — In this connection it may be pointed out (as done also by Martens, Op. cit.) that the form figured in the "Encyclopédie méthodique" Pl. 137 under the name of *Cidarites pistillaris* likewise is seen from the detail figure of a primary spine to have the collar red-spotted. Thus also this figure represents the true *baculosa*, not *pistillaris*.

near Ambon, Molo Strait; "Siboga"). The specimen from the "Challenger" St. 201 is not this species but *Stylocidaris amboinæ* (see under that species). The "Siboga" specimens I have not examined, but it may perhaps not be too rash to suggest that they will rather prove to belong to the var. *annulifera* which I found so common at Amboina and Banda (the few descriptive notes given by de Meijere of these specimens decidedly confirm this suggestion). The typical *baculosa*, therefore, is not known with certainty to occur outside the Indian Ocean. Some specimens from Lord Howe Island, sent me for examination by the Australian Museum, Sydney, labelled *Phyllacanthus baculosa* (probably identical with those mentioned by Ramsay Op. cit. p. 3) are *Prionocid. australis*. Bathymetrical distribution: from the shore to ca. 200 m.

Fourtau (1904) records it as subfossil from *Ostrea cucullata*-deposits near the Suez Canal. Also Werth (Zur Kenntn. d. jüngeren Ablagerungen in trop. Ost-Afrika; Z. deutsch. Geol. Ges. LIII. 1900 p. 290) records this species as fossil from quaternary deposits of East Africa; the identification is, however, not given as quite certain ("wahrscheinlich"). (Also "*Cidaris*" *verticillata* is recorded from the same deposits, the designation not being indicated as doubtful). The statement of the occurrence in the Tertiary deposits of Java of "*Phyllacanthus*" *baculosa* (Martin. Op. cit. 1880) is doubtful. The material, which was lent me for examination from the Palæontological collection of Leiden, is very poorly preserved and does not allow a definite identification with the recent species.

Remarks. Döderlein (1902. Echinoidea v. Amboina u. Thursday Isl. (Semon), p. 694) has established a variety *erythræa* for the specimens from the Red Sea, characteristic in having short spines, not surpassing the h.d. in length, the spines being cylindric, hardly tapering at all, and without prominent thorns. There are, however, all possible transitions between this variety and the typical form, and, as, moreover, both forms occur together: the typical form also in the Red Sea, and, on the other hand, the variety also at Mauritius, there is, evidently no reason, or rather no possibility for maintaining the form with short cylindric spines as a separate variety, and the name *erythræa* becomes a simple synonym of *baculosa*.

Var. **annulifera** (Lamarck).

Pls. XLV. 1—2; XLVI; LI. 2; LIII. 4—8; LXXIII. 14—15; LXXXVII. 5.

De Loriol. 1873. Descr. trois espèces d. Echinides; p. 25, Pl. III.
Döderlein. 1902. Echin. v. Amboina u. Thursday Isl. (Semon); p. 695. Taf. LIX, 1—3.
De Meijere. 1904. "Siboga" Ech. p. 11, 13; Taf. II, 9—12.
Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 257. Pl. **53**; **54**.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
80 mm	50 mm	33 mm (41.3 % h.d.)	27 mm (33.7 % h.d.)	10—11	16—18	95 mm
57 —	35 —	24 — (42 —)	20 — (35 —)	8 (9)	17—18	90 —
55 —	40 —	21 — (36.4 —)	19 — (34.5 —)	10	14—15	90 —
47 —	31 —	21.5 — (45.7 —)	19 — (40.4 —)	8	13—14	90 —
33 —	21 —	16 — (48.4 —)	15.5 — (47 —)	7	12—13	70 —
35 —	19 —	16.5 — (47.1 —)	16 — (46 —)	6 (7)	15—16	59 —
27 —	16 —	12 — (44.4 —)	12 — (44.4 —)	7	13	40 —
20 —	10 —	8.5 — (42 —)	8 — (40 —)	6	10—12	45 —
15 —	8 —	7 — (46.6 —)	6.5 — (43.3 —)	5—6	9—10	29 —

Shape of test rather variable, especially varying very considerably in height. It is in general not so regularly arched as the typical form, but this is no constant feature. It may be subpentagonal, the interambulacra being more or less swollen.

Ambulacra (Pl. LXXIII. 14—15) rather varying in width, ca. 26—33 % of I.A. Interporiferous zone from slightly broader than to about twice the width of the pore zone. Marginal series of tubercles very regular, tubercles small, contiguous. Inside the marginal series each plate carries two smaller tubercles at the lower edge, there being thus in all four series of small tubercles inside the marginal series. In larger specimens there may be a tubercle also at the upper edge of the plate, which tends to obscure the regular serial arrangement of the other tubercles. No distinct naked or sunk median line. Pores widely separated, distinctly conjugate[1].

Interambulacra. Primary tubercles smooth, sometimes a few of the upper ones rather distinctly crenulate on the upper (aboral) edge. Areoles not sunk, not confluent, except at most the two lowermost ones. They are more or less distinctly transverse-oval. Scrobicular circle of tubercles fairly conspicuous, the tubercles being considerably larger than the marginal ambulacral ones. Outside the scrobicular tubercles some tubercles about half that size alternate with the former and then the rest of the median space is covered with small tubercles, which may show, in the larger specimens, an indication of an arrangement in transverse series. The median space in the larger specimens about $^2/_3$, in medium sized specimens about half the width of an areole. There is no naked median line or outer, adradial space.

[1] The statement of De Loriol (1873) that the pores of this form are "nullement conjugués par un sillon" was corrected later on by himself. (Eocæne Echinoideen aus Aegypten u. d. Libyschen Wüste. Palæontogr. XXX. 1882. p. 4).

Apical system (Pl. LIII. 5) generally ca. 42—48 % of h.d., more exceptionally so small as ca. 36 %; it is somewhat larger than or as large as the peristome, not smaller than the latter, as is generally the case in the typical form. All oculars broadly insert. Genital pores small, rather close to the edge. Both genital and ocular plates closely set with small tubercles, those along the inner edge of the genital plates sometimes distinctly elongate, comma-shaped. Anal system with a varying number of plates, more or less elevated. Peristome with ca. 16—17 ambulacral plates in medium sized specimens and a series of 5—7 interradial plates, which do not reach the mouth edge.

Primary spines varying in length from little more than h.d. to a little more than 2 h.d. In regard to shape they vary very considerably. Typically they are cylindric, tapering very gently towards the point which is simple or slightly widened. Not rarely they are flattened in the outer half, in the larger specimens. The surface of the shaft is closely set with short thorns arranged in close, longitudinal series. The surface between the thorns is covered with bush-shaped outgrowths slightly coarser than the hairs in the typical form; they may form a so complete general covering that the whole spine appears quite smooth. But often some of the thorns are more prominent, especially in the basal third of the shaft; in the same time the basal part of the spine may be more or less distinctly swollen, flattened, the thorns along the sides being then generally large, forming a pair of very conspicuous, serrate lateral keels (cf. Th. Mortensen. Albatross Cidaridæ, Pl. 53—54). Also the median series of thorns on the upper side may be considerably larger, or there may be three prominent series of thorns on the upper side, while the flattened under side remains smooth. In other specimens again there is a tendency to a whorl-like arrangement of the larger thorns. The collar is generally ca. 3 mm long, thus distinctly longer than in the typical form. The oral primaries are, in the larger specimens (Pl. XLVI), broad, flattened, more or less paddle-shaped; in smaller specimens they are more slender, less transformed. The point, especially of the third and fourth spine, sometimes also of the fifth, may be conspicuously widened, trumpet-shaped.

Secondary spines. The scrobicular spines are ca. 8—9 mm long, in the larger specimens, ca. 5 mm in middle-sized specimens. They are flattened, rather narrow, rounded pointed; the ambulacral spines are scarcely half so long, slightly flattened. The secondary spines, upon the whole, not much appressed.

Pedicellariæ like those of the typical form. Large globiferous pedicellariæ generally very scarce. Tridentate pedicellariæ mostly with the valves joining only in the point (Pl. LXXXVII. 5). — Spicules of the tubefeet of the usual type; small glassy plates with only a few holes in the middle fill up the wall of the intestine (the upper loop) as in the typical form; irregular triradiate spicules in the walls of the genital and Stewart organs. From the line of attachment of the mesentery to the intestine long, slender spines issue, projecting free into the body cavity (Fig. 137).

Colour of denuded, well cleaned tests white, the apical system and the ambulacra generally more or less dark brownish; more rarely there is a slight greenish tint. The primary spines

are usually very conspicuously ringed with red and white. In the basal part the red rings are often dissolved into smaller spots, which form the continuation of the red spots on the collar, these latter being generally arranged so as to form longitudinal series, but not confluent. Often the primary spines are rather dark, so as partly to conceal the annular coloration; this appears to be the case mainly in specimens from the littoral region. On the other hand the spines may be so light coloured as to be nearly white ("Siboga" Ech. p. 10, Taf. II. Fig. 9). The secondary spines are whitish, with a brown median stripe. The ambulacral spines are of a uniform brown colour; the tubefeet also being brown, the ambulacra, upon the whole, form conspicuous dark stripes.

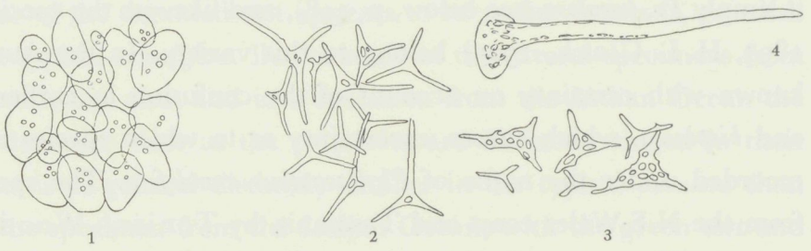


Fig. 137. Spicules from the intestinal wall (1), the Stewart's organs (2), the genital organs (3), and a spicular spine from the mesentery (4) of *Prionocidaris baculosa*, var. *annulifera*. 1. × 125; 2.—4. × 65.

Biology. At Banda I found specimens of this variety lying dry at low tide. Old specimens (Pl. XLVI) generally have the spines very much overgrown with foreign organisms, especially barnacles and sponges, to such a degree that hardly anything of the spine proper is seen, excepting the collar which always remains naked; also the oral primaries remain naked, evidently on account of the wearing off of what might settle on them of foreign organisms. On one specimen ("Albatross" St. 5151) was found a parasitic Gastropod (*Mucronalia* sp.?); on another specimen, from Banda, a Crepidulid, *Hipponyx* sp., was found on one of the spines. — Some young stages (from the Java Sea, Danish Expedition to the Kei Islands 1922) give some interesting information about the development of various important features: The genital pores are just about to form in a specimen of 11 mm h.d.; the two oculars adjoining the madreporite are here still exsert, the three others distinctly insert. In a specimen 8 mm h.d. all the oculars are exsert, while in another specimen, 7 mm h.d. Oculars IV and V are distinctly in contact with the periproct, and in one of 6.5 mm h.d. Oc. V is just about to reach the periproct. In this latter specimen the number of I.A. plates is 4—5; the upper primary tubercles distinctly crenulate. 6 ambulacral plates correspond to one of the upper I.A. plates. A series of small tubercles may just be discerned adradially to the marginal series of ambulacral tubercles. The pores markedly oblique, not yet conjugate. On the peristome there are 5—6 ambulacral plates in a series; 2 interradial plates have appeared. The longest primaries are 14 mm, thus scarcely exceeding 3 h.d. They have already the typical coloration, banded redbrown and whitish, and with the typical red spots on the collar; also the secondary spines have the characteristic dark median stripe. The apical system is dark brownish, especially the genital plates, while the oculars are white; thus the apical system, on the denuded test, forms a very conspicuous star. The ambulacra are brownish, thus forming 5 very conspicuous stripes on the otherwise white test.

Occurrence. This variety evidently has its centre of distribution in the Java, Philippine and Moluccan Seas, where it appears to occur all over, from the littoral region down to ca. 250 m. It further occurs so far North as the Bonin Islands (a specimen collected by Dr. Sixten Bock, 1914, also recorded from there by Rathbun, 1886, and by Yoshiwara). Also from Japan it is known, viz. Misaki (Yoshiwara's Jap. Echini) and off Kaimondake, the South-end of Kiushiu (a specimen in the Copenhagen Museum, collected 1926 by D. Langford); it is also this variety which H. L. Clark has recorded from the Uraga Channel Japan (naming it simply *Pr. baculosa* (see below, p. 448), and likewise the specimens from Macclesfield Bank (Bell 1894, H. L. Clark, 1925) belong to this variety. In the Australian Seas its distribution is not known with certainty on account of the confusion in earlier literature of the names *annulifera* and *bispinosa*, which causes uncertainty as to which species is really meant with the specimens recorded under the name of *Phyllacanthus annulifera*. The specimens recorded under this name from the N.S.Wales coast and Tasmania by Tenison Woods (1878) are probably not *baculosa* var. *annulifera*; some specimens from Port Denison, sent me for examination by the Australian Museum, labelled *Phyllacanthus annulifera*, are *Prionocidaris bispinosa*, mainly of the var. *Ramsayi* Döderlein. It is recorded by Studer (1880) from West New Guinea (under the name of *Schleinitzia crenularis*)[1]. On the West Coast of Australia it is recorded from the Abrolhos (H. L. Clark, 1923). In the Indian Ocean it is known to occur at Ceylon (De Loriol, 1873, Bell's Pearl Oyster Report, 1904, H. L. Clark, 1915); it is not known from Mauritius or the Red Sea, whereas a specimen from Mozambique in the Paris Museum is a rather distinct *annulifera*.

Its known bathymetrical distribution is from the shore down to ca. 250 m., the greatest depth on record being 247 m. ("Siboga" Ech. St. 306).

Remarks. The question whether this form ought to be regarded as a separate species or only as a variety of *baculosa* has been much discussed. Thus while de Loriol decidedly maintains that it should be regarded as a separate species, Döderlein maintains that in reality there is no constant difference, so that it cannot be conceded the rank of more than a colour variety of *baculosa*, in which opinion he is joined by Koehler (Op. cit. 1927), and H. L. Clark (The Cidaridæ, p. 189) reaches the result that "it seems useless in the present state of our knowledge to attempt to recognize varieties", and in his last work (1925) does not name this variety at all.

As will appear from the descriptions of both the typical form and the *annulifera*-form given here the only differences that can be pointed out are: the length of the collar and the colour of the primary and secondary spines and of the test, further the length of the spines and, especially, the number of ambulacral plates corresponding to an interambulacral plate. On comparing typical specimens of *baculosa* and *annulifera* the possibility of their belonging to one and the same species would seem to be out of question. The relatively short, uniformly dark coloured primary spines of the typical *baculosa* are so markedly different from the long, ringed spines of typical

[1] The "*Phyllacanthus annulifera*" recorded by Bell (Willey's Zool. Res.) from New Guinea and New Britain is *Stylocidaris Reini* (Döderlein); see under that species.

annulifera as could be desired. But then all intermediates occur — very dark spines with only a few rings near the tip, less dark spines with about the outer half ringed and, even in the same specimen, spines ringed in their whole length, but somewhat darker than normally in *annulifera*. I have collected such specimens in good number at Banda and Amboina; on the whole, it would appear that specimens living in the littoral region are darker than those living in deeper water. The form and colour of the secondary spines would seem to be more constant, but specimens may occur in which the longitudinal stripe widens so as to occupy the whole spine which then becomes uniformly dark. The colour of the denuded test appears to be rather constant, greenish in the typical *baculosa*, white in the typical *annulifera*. But in some of the littoral specimens from Banda I find a rather distinct greenish tint also, and in a specimen from the Indian Ocean the test is very distinctly greenish, at the same time as the primaries are distinctly ringed in their outer part. The length of the collar is in general distinctly smaller in the typical *baculosa* than in the typical *annulifera*; but the same specimen from the Indian Ocean, with the green test and annulated spines has the collar as long as in the typical *annulifera*. The length of the primaries is generally distinctly greater in *annulifera* than in *baculosa*; but the littoral specimens from Banda have them as short as in typical *baculosa*. According to de Loriol (Echinod. Baie d'Amboine, p. 361) the apical system of *baculosa* (typica) is much wider than in *annulifera*. The measurements of the two forms given here show definitely that this is no reliable character, its range of variation being about the same in both (not even counting the extreme of 36.4 of h.d. in *annulifera*). The width of the ambulacra, which is also pointed out by de Loriol as affording a distinctive character in the two forms, likewise is variable and much too uncertain for founding any distinction thereupon. This has all already been very carefully shown and definitely established by Döderlein (Ech. Semon. p. 693).

This review of the characters of the two forms would seem to give the result that, while hardly any character may be relied upon as a good specific character, there is too much difference for simply uniting them all together. We must, therefore, maintain *annulifera* as a variety of *baculosa*, as a rule fairly well distinguishable, though the range of variation of both the variety and the typical form is exceedingly great. The typical *baculosa* is mainly found in the Western part of the Indian Ocean, the var. *annulifera* has its centre of distribution in the Malay Archipelago.

The conclusion must then be that the various forms: *baculosa* (*typica—erythræa*) and *annulifera*, can only be regarded as more or less distinct varieties of one polymorphous species. Agreement has also been reached about the names, viz. that the name *baculosa* should be used as the name of the typical form. — Döderlein (Op. cit. 1902, p. 692) maintained that the name *pistillaris* Lamarck had to be substituted for *baculosa*, being the first-named of the two in Lamarck's "Histoire naturelle des animaux sans vertèbres" (1816, p. 55). He has since then again dropped *pistillaris* for the more usual name of *baculosa*. However, the question *pistillaris* versus *baculosa* now loses all foundation through the demonstration given here that *pistillaris* and *baculosa* so far from being synonyms are two perfectly distinguishable species; in reality then there is no such question

at all, both names having to be used, each for its own species. — Lambert & Thiéry (Ess. nom. rais. p. 155) maintain that *baculosa* is to be regarded as the "*Echinus cidaris*" of Linnæus. There is no reason to repeat here the whole history of these names, it must suffice to refer to the discussion in the Annals & Mag. Nat. Hist. 8. Ser. I—III, 1908 between F. A. Bather and H. L. Clark[1], giving the result, with which I entirely agree, that it is the North Atlantic "*Dorocidaris papillata*" which is to be regarded as the "*Echinus cidaris*" of Linnæus (cf. under Cidaris, p. 287).

As regards the name *annulifera* Lamarck perfect agreement has also been reached at length, after H. L. Clark has felt obliged to give in that A. Agassiz' use of this name (for *Prionocidaris bispinosa* Lamarck) was a mistake. It must be regarded as definitely settled that the *annulifera* of Lamarck is merely a variety of *baculosa*. Another thing is that *annulifera* rather represents the main form of this highly polymorphous and widely distributed species, *baculosa* being only a variety, mainly confined to the Western part of the Indian Ocean. But this cannot now be altered — it is a result of the historical development of Echinological science, analogous to that of *Ophiocomina nigra* and its var. *Raschi*, where also the "variety" is in reality the main form, the "typical" form merely a fjord- or inwater variety.

H. L. Clark (The Cidaridæ, p. 190) mentions a specimen from the Bonin Islands peculiar through the secondaries being very long, with a deep brown longitudinal stripe, and the collar of the primaries having some indistinct white spots as well as the characteristic deep purplish-red dots; he suggests the possibility of its being an undescribed species. A very fine specimen (30 mm h.d.) of evidently this same form was collected by Dr. Sixten Bock (1914) at the Bonin Islands, at a depth of 80 fathoms (Pl. XLV. 1). In my opinion it belongs decidedly to the var. *annulifera*. The only difference from typical *annulifera* would seem to be that the median ambulacral series of spines (tubercles) is later in its development, the present specimen having only two median series, while e. g. in a specimen of 27 mm h.d. from Banda the four usual series have already appeared. (In a specimen of 25 mm h.d. from Banda there are still only two median series). The indistinct white spots on the collar mentioned by Clark are the continuation of the series of larger thorns of the shaft, which are here more than usually conspicuous on account of their colour: white against the brownish ground colour of the spine; they may be found as well in specimens from the Moluccan Sea. The secondaries do not in any way differ from those of typical *annulifera*, except in being more appressed, which appears to be due to the unusually fine preservation. Possibly the specimens from the Bonin Islands will ultimately prove to form a rather well differentiated local form of the var. *annulifera*; the material available does, however, not justify definitely designating it thus — and still less as a separate species. For the present it must be designated as *Prionocidaris baculosa*, var. *annulifera*. The specimen from the Uraga

[1] F. A. Bather. The Echinoid name Cidaris and its modern application. Ann. Mag. Nat. Hist. 8. Ser. I. p. 284. — The Genotype of Cidaris. Ibid. 8. Ser. II. p. 134.
H. L. Clark. The type of Cidaris. Ibid. 8. Ser. I. p. 532.
H. L. Clark & F. A. Bather. The type of Cidaris. Ibid. 8. Ser. III. p. 88.

Channel, mentioned by H. L. Clark (1925 p. 13) belongs to the same form as the Bonin Island specimens, as I can state after having examined it in the British Museum. That the Japanese specimens of *baculosa* var. *annulifera* do not all belong to this form is proven by the fact that the above mentioned specimen from off Kaimondake is quite different, in fact not to be distinguished from the specimens from Amboina and Banda.

Two more varieties of the species *baculosa* have been distinguished, viz. the var. *australis* Ramsay (Döderlein. Ech. Thursday Isl. u. Amboina, p. 695) and var. *brevicollis* de Meijere ("Siboga" Ech. p. 11, Taf. II. 7, 8 u. 13). The former, which is now generally recognized as a separate species, *Prionocidaris australis* (Ramsay), is the species which has caused so much trouble through being so tenaciously, but wrongly, maintained by A. Agassiz and H. L. Clark to be the true *Cidaris bispinosa* of Lamarck. The var. *brevicollis* of de Meijere does not at all belong to the *baculosa*-group, not even to the same genus as *baculosa*. It is nearly related to *bracteata* and must together with that species, be referred to the genus *Stylocidaris*.

Still one more Cidarid has erroneously been referred to *baculosa*, viz. the form described and figured by de Loriol (1883) in his "Catalogue raisonnée des Echinodermes de l'île Maurice" (Echinoidea, p. 6. Pl. I. 1). Already A. R. S. Anderson (Rep. Marine Survey of India. 1898—99, p. 5) maintained it as a separate species, and quite recently H. L. Clark (Cat. Rec. Ech. Brit. Mus. 1925, p. 14) has established it as a separate species under the name *Prionocidaris badia* (here transferred to the genus *Stylocidaris*). For the sake of completeness it may be mentioned that Clark found it designated in the British Museum collection as "*Phyllacanthus baculosa*, var. *longispina*" — a M.S. name which it might have been better not to trouble literature with[1].

Var. **longicollis** (Mrtsn.)

Pls. XXXIX. 13—14; LXVII. 6—7; LXXIII. 16; LXXXVII. 10—11.

Stylocidaris bracteata. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 23. partim.
Stylocidaris (?) *longicollis.* Th. Mortensen. 1928. New Cidaridæ. p. 72.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	27 mm	14 mm	11 mm (40.7 % h.d.)	11.5 mm (42.6 % h.d.)	7	11—12	38 mm
2	17 —	8.5 —	7 — (41.2 —)	7 — (41.2 —)	6	9—10	15 —
3	13 —	6.5 —	5 — (38.5 —)	5.5 — (42.3 —)	5	8—9	27 —
4	10 —	5 —	4.5 — (45 —)	4.5 — (45 —)	4—5	7—8	15 —

Specimens 1—3 in the Museum of Cambridge, spec. 4, the type-specimen, in the British Museum.

[1] A curious mistake is made by Koehler ("Investigator" Ech. III. p. 32), who states that it is the form represented by De Loriol in the Mém. Soc. Sc. nat. Neuchatel. V. Pl. III. 1873 (the paper "Description de trois espèces d'Échinides app. à la Famille des Cidaridées") which Clark has made a new species, *Prionocidaris badia*, whereas I maintain this form to be the true *annulifera*, as it was designated by de Loriol. It is the species represented by de Loriol in his "Catalogue rais. des Échinod. île Maurice", Mem. Soc. Phys. & Hist. nat. Genève, XXVIII, Pl. I. 1 (1883) which was made a new species, *Prionocidaris badia*, by H. L. Clark, and there is no disagreement between Clark and me concerning the specific value of this form.

Test low, flattened above and below, slightly incurved at the peristomial edge. Sides strongly arched; circumference circular.

Ambulacra slightly sinuate; interporiferous zone scarcely twice the width of a pore zone. Marginal series of tubercles very regular, the tubercles contiguous or very nearly so, distinctly mamelonate. Adradially to the marginal tubercle each plate carries, in the larger specimens, a single, much smaller, but still distinctly mamelonate tubercle at the lower edge, these inner tubercles forming very regular longitudinal series. Otherwise the interporiferous zone is bare, except for one or two miliary tubercles at the base of the marginal tubercle. The median line is not at all sunk. Pores equal-sized, in the larger specimens distinctly conjugate, though still not very distant from each other. The upper furrow very conspicuous; ridge very well marked, rounded (Pl. LXXIII. 16).

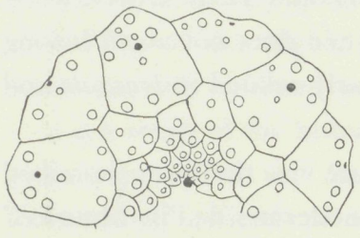


Fig. 138. Part of apical system of a young *Prionocidaris baculosa*, var. *longicollis* (the type specimen). × 10.

Interambulacra. Areoles not at all sunken, the boss rising from the very edge; the 2—3 proximal ones confluent. They are rather distinctly transverse-oval, except the uppermost ones. The boss rather prominent, the mamelon small; the upper ones are distinctly crenulate. Edge of areoles not at all elevated, the scrobicular circle inconspicuous. Outside the scrobicular tubercles some sparse smaller tubercles decreasing in size towards the median line, which is slightly sunk. Adradially to the scrobicular circle there is only room for a single series of small tubercles. Median space about half the width of an areole.

Apical system. Oculars broadly insert, even already in the specimen of 10 mm (Fig. 138). Tubercles rather sparse, though in the larger specimens somewhat more numerous than in the younger, the middle of the plates being here not naked, as is the case in the young; two—three of the tubercles along the inner edge of the genital plates somewhat larger, but scarcely elongate. Genital pores small, more or less near the outer edge. Periproct not raised, periproctal plates fairly numerous. — Peristome of the same size as or slightly larger than the apical system. There are 11—12 ambulacral plates in a series in the largest specimen, and a regular series of 5—6 interradial plates, not reaching the mouth edge.

Primary spines rather varying in length, ca. 1—2 h.d. They are in the largest specimen of a very characteristic shape, somewhat club-shaped, the distal part being thickened and slightly flattened. There are on the adapical side of the spine 5 rather regular series of thorns, which increase conspicuously in size in the distal part, though not uniting into ridges. Between these thorns there are numerous small stumps, not regularly arranged. On the adoral side of the spine these thorns and stumps are of about equal size and form fairly regular, close series. The surface of the shaft otherwise covered with simple or slightly bush-shaped hairs, covering likewise the base of the thorns and the stumps. They do not appear to anastomose so as to form a spongy coat. The collar is very conspicuous, ca. 5 mm long, slightly increasing in thickness towards the very inconspicuous milled ring. There is no indication of a neck. — The oral primaries are

flattened, slightly curved; in the largest specimen they are fairly broad, with edges somewhat serrate. On account of the long collar the oral primaries may have a distinctly "capped" appearance (Pl. LXXXVII. 10). The second—third is transitional to the ambital primaries.

Secondary spines. The scrobicular spines ca. 5 mm long, slender, flattened, tapering to the rounded point; the marginal ambulacral spines of the same general shape, only more slender. In the younger specimens the secondary spines are relatively shorter and broader. No distinct, glandular ampulla on the spines of the upper side. The spines on the periproct form a more or less conspicuous tuft round the anal opening.

Pedicellariæ. Large globiferous pedicellariæ not observed. The small globiferous of the usual form, with a small opening and a rather large end tooth (Pl. LXXXVII. 11); they reach a size of ca. 0.5 mm length of head. Tridentate pedicellariæ with slender valves, not different from those of the typical *baculosa*. Spicules of tubefeet of the usual type.

Colour. In the larger specimens the primary spines are uniformly dark brownish, in the younger specimens they are very conspicuously banded red-brown and white. The collar whitish, with numerous purplish spots, not arranged in distinct series. The scrobicular spines a uniform light brown, the marginal and apical spines slightly darker. The naked test white, only the pore-zones and the marginal tubercles, but not the interporiferous zone, light brownish. Also the apical system light brownish, the ocular plates being somewhat lighter coloured, sometimes quite white.

Biology. It is evident that the largest specimen is still far from full grown, as the upper primaries are in an unfinished condition. The spines of all the specimens examined are quite free of foreign organisms. — One of the specimens carries two parasitic Gastropods (*Mucronalia*) on the peristome.

Occurrence. Amirante Islands, Saya de Malha Bank, and the Seychelles; ca. 60—100 m.

Remarks. The single, small specimen found in the British Museum, spec. 4 of the above measurements, was identified by Clark (Op. cit.) as *Stylocidaris bracteata*. On seeing this specimen by a visit to the British Museum in 1926 I realized that it could not belong to *St. bracteata*. The specimen was sent me to Copenhagen for closer examination, and I came to the result that it represented a new species; but on account of its young age it could not be decided to which genus it should be referred. It was referred with doubt to *Stylocidaris*, but the probability that it might ultimately turn out to be a *Prionocidaris* was hinted at ("New Cidaridæ", p. 72). During a visit to Cambridge, England, in April 1928, I found in the Museum there some more specimens of the same form, which were likewise sent to me to Copenhagen for study. The largest of these specimens is, although not nearly full grown, sufficiently advanced for showing that the pores are conjugate, and therewith the doubt as to its generic position is done away with — it is a *Prionocidaris*. On the other hand doubt arose as to its specific value. It is quite evident that it belongs to the *baculosa*-group, and apparently more nearly to the var. *annulifera* than the typical *baculosa*. For the present it would seem the best course to retain it as a separate variety, character-

ized by its primary spines, so markedly different from those of var. *annulifera*. But the definite settling of its classificatory value — species or variety, or perhaps only a synonym of the var. *annulifera*, must wait until adult specimens are available.

Prionocidaris pistillaris (Lamk.).

Pls. XLIX; L; LI. 1; LXXIII. 18; LXXXVI. 20—21.

Cidarites pistillaris. Lamarck. 1816. Hist. nat. anim. s. vertèbres. III. p. 55. (II. Ed. 1840. III. p. 379).
Cidarites pistillaris. Deslongchamps. 1824. Encycl. méth. Hist. nat. des Zoophytes. II. p. 194. (non Pl. 137).
Cidarites papillaris. Michelin. 1845. Essai d'une faune de l'île Maurice. Zoophytes, Echinodermes et Stellérides. Mag. de Zool. 2. Sér. VII. p. 16. (misspelling for *pistillaris*).
Cidaris pistillaris. L. Agassiz & E. Desor. 1846. Catalogue Rais. Echinod. p. 327.
?*Cidaris pistillaris*. Peters. 1854. Seeigel von Mossambique, p. 118.
Cidaris pistillaris. Dujardin & Hupé. Hist. nat. Zoophytes Echinodermes. p. 471.
Prionocidaris pistillaris. A. Agassiz. 1863. List of Echinod. p. 18.
?*Cidaris pistillaris*. Hoffmann. 1874. Rech. s. la faune de Madagascar. (Fr. Pollen & v. Dam) V. p. 50, 54.
Cidaris pistillaris. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 172.
Cidaris baculosa, var. *pistillaris*. Döderlein. 1906. Ech. Deutsche Tiefsee-Exped. p. 96.
?*Leiocidaris pistillaris*. Lambert. 1922. Ech. vivants et foss. Madagascar, p. 20.
Prionocidaris baculosa. H. L. Clark. 1923. The Echinoderm Fauna of South Africa. Ann. S. Afr. Mus. XIII. p. 370.
Prionocidaris baculosa. H. L. Clark. 1924. Echinoderms of S. African Fisheries and Marine Biol. Survey. I. Sea-Urchins. Union of S. Africa. Fisheries & Mar. Biol. Survey. No. 4. p. 1.
?*Leiocidaris pistillaris*. Lambert & Thiéry. 1925. Ess. nom. rais. p. 561.
Prionocidaris baculosa, var. *lineata*. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 14.
NON: *Leiocidaris pistillaris*. Döderlein. 1902. Echinoidea v. Amboina u. Thursday Isl. (Semon). p. 692. Taf. LIX. 1—5. (*Pr. baculosa*, var. *annulifera*).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	50 mm	31 mm	20 mm (40 % h.d.)	19 mm (38 % h.d.)	7—8	13—15	79 mm
2	50 —	34 —	21 — (42 —)	10 — (38 —)	10	11—12	39 —
3	40 —	23 —	15 — (37.5 —)	15 — (37.5 —)	8	12—13	52 —
4	31 —	16 —	14 — (45.2 —)	13.5 — (43.5 —)	7	11—12	44 —
5	23 —	12 —	9.5 — (41.3 —)	9.5 — (41.3 —)	6—7	10—11	30 —
6	12 —	5.5 —	5.5 — (45.8 —)	5 — (41.7 —)	5—6	9—10	18 —

Specimen No. 1 is in the Museum of Comparative Zoology; specimens 3 and 4 in the Paris Museum, the rest of them in the Copenhagen Museum. The specimen 3 is the neotype of the species.

Test flattened above and below, sides beautifully arched. Circumference round. — Ambulacra nearly straight. Interporiferous zone ca. 1.5 the width of a pore zone. Marginal series of tubercles quite regular, the tubercles small and low, but contiguous. Inside the marginal series the whole interporiferous zone is closely covered by smaller tubercles, the outer ones (which are fairly distinctly mamelonate) forming a nearly regular series inside the marginal series (Pl. LXXIII. 18). As a rule there are two tubercles along the lower edge of the plates, so disposed as to form an oblique, downwards directed line, which produces the impression that the inner part

of the plates is downwards directed. This arrangement is, however, not so conspicuous in the specimen from which the figure was drawn. There is no distinct naked median line; when such a median line is observed on specimens with their spines intact, this is due to the spines bending outwards, thus leaving the middle bare. The whole interporiferous zone quite flat. Pores very distinctly conjugate, as in *baculosa*; the ridge is not high, but, on account of the rather deep furrow between the plates, fairly conspicuous.

Interambulacra. Areoles not deepened, well separated, except the 2—3 proximal ones. Scrobicular ring not at all thickened or elevated, the tubercles inconspicuous, about twice the size of the marginal ambulacral tubercles. Outside the scrobicular circle the plates closely covered, on both the median and adradial side, with small tubercles gradually decreasing in size towards the median line and the adradial edge. The median line scarcely sunk, not naked, but — as in the ambulacra — distinct in specimens with the spines intact. The median part from little more than half the width of an areole to about as wide as an areole (in the specimen with the short primaries; see below).

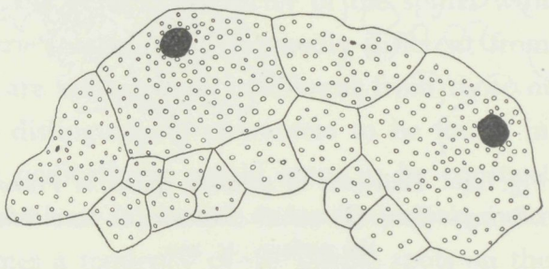


Fig. 139. Part of apical system of *Prionocidaris pistillaris*. × 4.

Apicalsystem (Fig. 139). Oculars all broadly insert, madreporite not distinctly enlarged. Genital pores rather small, near outer edge. Periproct flat or elevated, the number of periproctal plates apparently not large. The whole apical system closely covered with small tubercles; those along the inner edge of the genital plates may be somewhat larger, their spines forming a sort of fringe. — Peristome in adult specimens with 12—13 ambulacral plates in a series, 6—7 well developed interradial plates in a regular series not quite reaching the mouth edge.

Primary spines usually only slightly exceeding h.d., the specimen 2 is quite exceptional, having the upper spines much less than h.d. (Pl. XLIX. 2). They are gently tapering, often somewhat flattened, especially towards the point, which is usually somewhat widened, sometimes rather conspicuously so. They are fairly closely set with small thorns of uniform size, arranged in fairly distinct longitudinal series. The thorns of the upper (aboral) surface of the shaft usually somewhat larger than those on the lower (adoral) surface; when the spines are flattened, the lateral thorns may be somewhat enlarged, forming a more or less conspicuous lateral edge. Towards the end of the shaft the thorns gradually become somewhat smaller, and may be replaced by more or less conspicuous ridges. The surface of the shaft otherwise covered by a close coat of bush-shaped hairs, coarser than in *baculosa* (Fig. 136. 2); in the basal part of the spine they anastomose, so as to form like a spongy structure (Fig. 140. 1) (only to be observed on fresh spines or, sometimes, in the basal part in the older spines). Collar ca. 4 mm long, scarcely widening towards the very inconspicuous milled ring. Oral primaries flattened, slightly curved, with edges more or less distinctly serrate; they cannot well be designated as "capped". The 3rd—4th transitional to the ambital spines.

Secondary spines. The scrobicular spines ca. 5 mm long, flat, sides straight or very nearly so; the point rounded. Marginal ambulacral spines ca. 3 mm long, much narrower than the scrobicular spines. Miliary spines more pointed, rather appressed.

Pedicellariæ. Large globiferous pedicellariæ rather conspicuously different from those of *baculosa* (Pl. LXXXVI. 20—21 to compare with Pl. LXXXVII. 2—3); the blade has usually broad sides, also the whole valve is more curved than in *baculosa*. They are rather scarce, in fact in most specimens entirely absent. Small globiferous pedicellariæ like those of *baculosa*, only apparently in general somewhat more slender. Tridentate pedicellariæ in the main as in *baculosa* (only one sample seen, in which the calcareous substance was partly dissolved). — Spicules not peculiar.

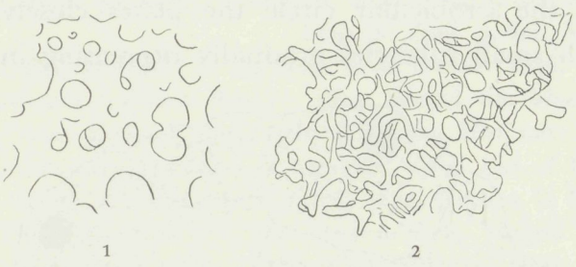


Fig. 140. Hair-coat of primary spines of *Prionocidaris pistillaris* (1) and *Pr. australis* (2), seen from the surface. × 100.

Colour. Primary spines of a uniform dark-brownish colour, not banded. The thorns are generally whitish and therefore fairly conspicuous. The collar with very conspicuous alternating longitudinal stripes of purple and whitish; the stripes may continue a little beyond the collar. Secondary spines purplish-brown or dark brown, often with the tip lighter. Those on the apical system may be darker, and the marginal ambulacral and miliary spines more olive-greenish. The denuded test with a greenish tint on the apical system, the upper part of interambulacra and on the interporiferous zone of ambulacra; the pore zones somewhat darker.

Biology. Two specimens in the Strasbourg Museum, collected by Ortmann 1891, were labelled "im Seegrass" which gives at least some information of the habitat of this species. That it is also to be found on the coral reefs can scarcely be doubted. — The young specimen of 12 mm h.d. has not yet the genital pores developed.

Occurrence. The species is known with certainty to occur at Mauritius, the Seychelles, Madagascar (Nossi-Bé) and the East African coast from Dar es Salaam to Natal. Bathymetrical distribution: littoral to 60 m. In the Leiden Museum I have seen a specimen stated on the label to be from Larantoeka, Flores; as there was, however, also a specimen of *Psammechinus miliaris* labelled as coming from this same locality, it is evident that no reliance at all can be put on this old label.

Remarks. For a long time there has been a fairly unanimous agreement that Lamarck's two species *Cidaris baculosa* and *Cid. pistillaris* were identical, and on this assumption Döderlein (1902. Ech. Amboina & Thursday Isl.) took the step of substituting the name *pistillaris* for the name *baculosa*, which latter has otherwise been in constant use in echinological literature, the change being based on the fact that *pistillaris* in Lamarck's work precedes the name *baculosa* by a few lines. Fortunately this application of the rule is out of question in the present case, because it appears that the assumption that *pistillaris* and *baculosa* are identical is erroneous.

Already in 1903, in my work on the "Ingolf" Echinoidea I. p. 172, I expressed the opinion, after having examined a specimen in the Paris Museum, that it was not identical with *baculosa*, but should at least be regarded as a separate variety, if not as a separate species. In his Echinoidea d. deutschen Tiefsee-Expedition p. 96, Döderlein agrees that *pistillaris* should be regarded as a separate variety, and that accordingly the name *baculosa* must be kept for the form thus designated by Lamarck, in accordance with general use in echinological literature.

After now having examined quite a considerable number of specimens (more than 20) in the various Museums of Europe and in the Museum of Comparative Zoology, Cambridge Mass., I cannot hesitate any longer in regarding *pistillaris* as a separate species. All these specimens show that very conspicuous feature of the collar of the primaries being longitudinally striped by alternating purple-bluish and whitish streaks; also the general character of the spines with their uniform thorns in close longitudinal series, is very constant and markedly different from *baculosa*, and finally the large globiferous pedicellariæ are conspicuously different from those of *baculosa*. It is true that there are hardly any reliable distinguishing characters to be found in the test, but the characters of the primaries and the pedicellariæ would seem to be constant enough for maintaining *pistillaris* as a distinct species. At least it is much more distinct than the variety *annulifera*. In *baculosa* there is, no doubt, sometimes a tendency of the purple spots on the collar to fuse into longitudinal streaks; but, in my experience, this never extends to more than a few of the spines of a specimen, and there is then no such regular striation as in *pistillaris*, where the stripes on the collar are found on all the primary spines.

Recently (1925) H. L. Clark (in his Cat. Rec. Sea-Urch. Brit. Museum, p. 14) has also come to the conclusion that this form with the striped collar should be recognized as at least a separate variety of *baculosa*, while in his South African reports, 1923 and 1924, he designates this form simply as *baculosa*. But he thinks it "quite improbable" that the word "collo-sulcatis" in Lamarck's diagnosis of his *Cidaris pistillaris* refers to these stripes of the collar, and as the type-specimen of *pistillaris* does not exist, he thinks the name *pistillaris* should be ignored, and therefore gives the variety the new name *lineata*. It is rather curious that H. L. Clark is here afraid of an old name, because the type does not exist, when in other cases he adopts old dug up names with very much less right than can be claimed by the name *pistillaris*, neither the type specimens existing nor anything in the original diagnoses giving proof that the species, for which the name is adopted, was really meant by the old author — e. g. *Ophiura ophiura* (Linnæus) for *Ophiura texturata* Lamarck, or *Ophiacantha sphærulata* (Pennant) for *Ophiocomina nigra* (O. F. Müller) or *Echinocyamus minutus* Pallas for *Echinocyamus pusillus* (O. F. Müller) (cf. Th. Mortensen. Notes on some Scandinavian Echinoderms, with descriptions of two new Ophiurids. Vid. Medd. Dansk Naturh. Foren. Bd. 72. 1920. p. 53, 65).

It is true that the type specimen of Lamarck's *pistillaris* does not exist any longer, (while that of *baculosa* — a naked test — is found in the Paris Museum). But there are in the Paris Museum splendid specimens from the Seychelles, collected by Rousseau, 1841. These specimens

are cited by L. Agassiz & Desor in their "Catalogue Raisonnée" 1846, who may well be supposed to have had access to compare them with the type specimen. In any case they correspond very well with Lamarck's original diagnosis, especially with the expression "collo-sulcatis" which, contrary to H. L. Clark, I must think almost beyond doubt refers to the conspicuous, striped collar, and which gives so excellently the difference from *baculosa*, equally well characterized by the word "collo-guttatis". Be that as it may, I herewith declare, as I am entitled to do, the said specimens in the Paris Museum to be the neotypes of the species *Prionocidaris pistillaris* (Lamarck).

One of the reasons for the confusion, which has been reigning with regard to *pistillaris*, is the fact that the Cidarid figured under the name *Cidaris pistillaris* in the Encyclopédie méthodique, Pl. 137 is not the true *pistillaris*, but, as shown unmistakably by the figure A, representing a primary spine, *baculosa*, with the isolated spots on the collar.

Lambert, in his paper on the Echinoids of Madagascar (1922) and in the supplement to the Essai de nom. rais. (1925, p. 561) appears also to have come to the result that *pistillaris* is to be regarded as a separate species, besides *baculosa* (which latter he erroneously identifies with the *Echinus cidaris* of Linnæus and then designates as *Leiocidaris cidaris* (L.)). It is, however, not at all clear whether his conception of the species *pistillaris* is correct, partly because his remarks on the species that it is characterized by its primary spines being "fusiformi-subulatis" against "subteretibus apice truncatis" in *baculosa*, show that he has not at all grasped the real difference between the two species, partly because he refers to Döderlein, 1902, as having shown that *pistillaris* is a distinct species besides *baculosa*, whereas what Döderlein did in his work of 1902 was only to substitute the name *pistillaris* for the commonly used name *baculosa*.

Prionocidaris australis (Ramsay).

Pls. LII; LIII. 12; LXXIII. 17; LXXXVI. 17—19; LXXXVII. 6—8.

Stephanocidaris bispinosa. A. Agassiz. 1872—73. Rev. of Ech.; p. 160, 393. Pl. **I. c. 43**; **I. f. 1.** (Non: *Cid. bispinosa* Lamk.).
Phyllacanthus australis. Ramsay. 1885. (1891). Cat. Ech. Austral. Mus. p. 3, 46. Pl. **I. I. a—b.**
Leiocidaris pistillaris, var. *australis*. Döderlein. 1902. Ech. Amboina & Thursday Isl. (Semon) p. 695.
Phyllacanthus (?) *australis*. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 28.
Cidarites (*Stephanocidaris*) *cidaris*, var. *australis*. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 101.
Stephanocidaris bispinosa. A. Agassiz & H. L. Clark. 1907. Hawaiian. Ech. Cidaridæ. p. 18. Pl. 12. b. 10—11.
Stephanocidaris bispinosa. H. L. Clark. 1907. The Cidaridæ. p. 194.
Stephanocidaris bispinosa. H. L. Clark. 1909. "Thetis". Ech. p. 552. Pl. **LIV. 1.**
Leiocidaris bispinosa. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris Agassizi. Döderlein. 1911. Ech. Aru-Inseln. p. 241—243.
Prionocidaris Agassizi. Döderlein. 1914. Echinoidea. Fauna Südw. Australiens. IV. p. 452.
Prionocidaris australis. H. L. Clark. 1916. "Endeavour" Ech. p. 97.
Prionocidaris australis. Th. Mortensen. 1918. Ech. N.W. Australia (Mjöberg); p. 8.
NON: *Prionocidaris australis*. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 12 (= *Pr. glandulosa*).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	70 mm	43 mm	29 mm (41.4 % h.d.)	25 mm (35.7 % h.d.)	10—11	12—14	60 mm
2	68 —	42 —	31 — (45.6 —)	23.5 — (34.6 —)	8—9	13—14	49 —
3	62 —	37 —	31 — (50 —)	24 — (39 —)	8—9	11—13	42 —
4	56 —	36 —	25 — (44.6 —)	20 — (36 —)	8—9	11—13	77 —
5	54 —	34 —	23.5 — (43.4 —)	20 — (37 —)	8—9	13—14	80 —
6	48 —	29.5 —	ca. 18 — (ca. 38 —)	18 — (38 —)	9	12—13	93 —
7	45 —	25 —	21.5 — (48 —)	18 — (40 —)	7		60 —
8	42 —	24 —	17 — (40.5 —)	17 — (40.5 —)	8—9	12—13	87 —
9	39 —	22.5 —	17 — (43.6 —)	15 — (38.5 —)	7—8	11—13	84 —
10	27 —		12 — (44 —)	8 — (30 —)			67 —

Measurements of specimen 7 after H. L. Clark's "Thetis" Echinoderms, of spec. 10 after his "Endeavour" Ech. Specimens 1—2, 5—6 and 8—9 in the collection of the Museum of Comp. Zoology (specimens 6 and 8 with redbrown secondaries). The specimen 10 apparently has been lost, not being found in the Museum of Comp. Zoology and, as I am informed, not in the Australian Museum, Sydney, either.

Test somewhat flattened above, rather strongly incurved at the edge of the peristome. Sides arched, circumference round. — Ambulacra ca. 16 % of width of I.A., slightly sunk, scarcely sinuate. Interporiferous area ca. 1.5 the width of a pore zone. Marginal series of tubercles very regular, though usually not very prominent; the tubercles generally contiguous. Close inside the marginal tubercles, at the lower edge of the plates, a much smaller tubercle is found, forming a more or less regular inner series to each side; one or more small tubercles on each plate nearer the median line, forming no regular longitudinal series at all. The interporiferous zone, according to the number of these inner tubercles, now rather bare, now more crowded with tubercles. The limits between the plates rather indistinct; median line not at all sunk. The pores usually equal-sized and distinctly conjugate, the furrow between the pores, however, not very deep (Pl. LXXIII. 17).

Interambulacra. (7)8—10(11) coronal plates; the areoles are distinctly separate all of them, even the proximal ones scarcely confluent. But the separating wall is very low and narrow, and the tubercles on it small, and, on the subambital ones, in a single line; the areoles thus appear more or less distinctly confluent, but in reality are not so. A very slight trace of crenulation may be found on the adapical side of the uppermost tubercle. Mamelon rather small. Areoles scarcely deepened, the ambital and subambital ones distinctly transverse-oval. Scrobicular circle of tubercles inconspicuous, scarcely exceeding the marginal ambulacral tubercles. Outside the scrobicular tubercles one or two tubercles of similar size, not regularly arranged; the rest of the plate, both the admedian and the adradial part, otherwise very closely covered with very small tubercles, leaving no naked space. Median line scarcely sunk. The median area about as broad as the areoles (Pl. LIII. 12).

Apical system ca. 45—50 % h.d. (Fig. 141). Ocular plates all widely insert. Madreporite usually somewhat enlarged. Periproctal plates fairly numerous. All the plates of the apical

system closely covered with small tubercles, those along the margins of the plates slightly the larger. Genital pores small, near the outer edge of plates, sometimes on a small elevation. Two of the genital plates (I and V) of the specimen figured in the "Revision of Echini" have two genital pores.

Peristome 36—40 % of h.d., in the youngest specimen only 30 % h.d. There are in specimen 2 ca. 20 ambulacral plates in a series; they are rather narrow, not joining those of the neighbouring radius, thus leaving an open space for the interradial plates unto the mouth edge, which they do not, however, quite reach. The interradial plates fairly numerous, in a rather irregular double series. The outline of the peristome rather distinctly pentagonal, the corners of the pentagon being off the ambulacra.

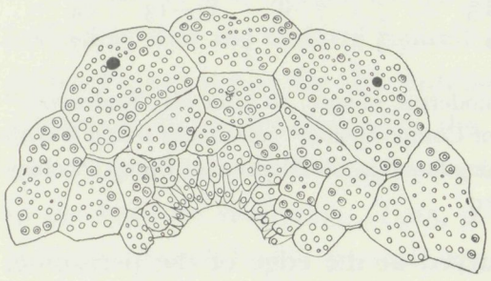


Fig. 141. Part of apical system of *Prionocidaris australis*. × 2.5.

Primary spines varying considerably in length, from ca. $^1/_2$—$^2/_3$ of h.d. to as much as 2 h.d., or even, in young specimens 2.5 h.d. (H. L. Clark "Endeavour" Ech. p. 98). The shaft is more or less widened and flattened in the lower part, generally with a rather prominent series of larger thorns along the edges; the upper side generally with some irregularly arranged larger thorns, sometimes forming a median series; the aboral side upon the whole tending to become carinate, the spine being thus almost or quite triangular, where widest. They are gently tapering, but often with the point more or less widened into an irregular crown. Surface of shaft otherwise, in well preserved, fully formed samples, with a close coat of finely branching and anastomosing hairs (Fig. 140. 2). The collar is usually ca. 4—5 mm, sometimes only 2 mm long, slightly widening towards the not very prominent milled ring. The oral primaries somewhat flattened, curved; the collar is here about of the same length as on the ambital spines, while the shaft is very short, in the innermost ones even shorter than the collar; this produces the impression of the cortex layer forming a small cap on the spines (cf. A. Agassiz & H. L. Clark. Op. cit. Pl. 12.b. 10—11). The third (and fourth) transitional to the ambital spines; in larger specimens sometimes even the fifth primary has partly the character of an oral spine, not at all tapering, but with a conspicuous terminal crown, which is oblique, as if used for walking on.

The secondary spines surrounding the base of the primaries ca. 8—10 mm long, slender, pointed, slightly curved; they may be slightly excavate in the basal part. The marginal ambulacral spines about half that length, much more slender, almost setaceous; also the other secondary spines slender, not scale-like. The secondary spines upon the whole not appressed. Those of the peristome scarcely widening in the outer part.

Pedicellariæ. The large globiferous pedicellariæ (Pl. LXXXVI. 17—18), which may be exceedingly numerous or scarce, or even totally lacking, have rather slender valves, the opening surrounded by a collar of rather large teeth; the outer part of the opening as a rule bridged over

by a narrow cross-beam, which is generally provided with a long, downwards directed tooth (Pl. LXXXVII. 8). The head is ca. 1 mm, the stalk ca. 3—4 mm long, with a beautiful limb (Pl. LXXXVII. 7). The small globiferous form (Pl. LXXXVII. 6) is also fairly numerous and reaches a fair size; they are of the typical form, with very slender valves provided with a well developed end tooth. The tridentate pedicellariæ (Pl. LXXXVI. 19) have long, narrow valves which may be joining partly or in their whole length; the blade is compressed, but with the edge bent outwards, very irregular, thorny. Also inside the blade there are some irregular crests and thorns. These pedicellariæ reach a size of ca. 2 mm length of head. — Spicules of tubefeet of the usual form.

Colour. The young, not fully formed primaries are dark purple; the fully formed primaries are more light-greenish, more or less distinctly banded with purplish. The collar is spotted all over with whitish, polygonal spots, separated by purplish lines; more rarely the spots merge into more or less distinct longitudinal lines. Sometimes the spots continue beyond the collar a little way on to the shaft. The secondary spines show a remarkable diversity of colour, from bright red to greenish with a longitudinal stripe of red; the marginal ambulacral spines generally of a uniform greenish colour. The naked test is whitish, with a purplish tint on the median part of the interambulacra on the upper side and with the ambulacra rather conspicuously purple. — The species upon the whole would appear to be strikingly beautiful, when well preserved, judging from the enthusiastic description of "a superb specimen of this lovely species, one of the handsomest of the Cidaridæ" given by H. L. Clark ("Thetis" Echinoderms, p. 552); it may, however, well be said that the figure given of the specimen thus mentioned (Op. cit. Pl. LIV. 1) does not give the impression of anything extraordinarily beautiful. The specimen figured by Ramsay (Op. cit.) would appear easily to exceed it in regard to beauty.

Biology. The older primaries are as a rule very much overgrown by various organisms, especially barnacles, but also sponges, Bryozoa, Brachiopods, mussels, worm-tubes, among which small Ophiurids and Crustaceans may be found sheltering. — The largest specimen on record measures 73 mm h.d. — About the younger stages nothing is known beyond the measurements of a specimen 27 h.d. given above, from H. L. Clark's "Endeavour" Ech. — The small size of the genital pores indicates that the eggs are small, which again leads to the suggestion that it may have a true pelagic larva.

Occurrence. Recorded only from East Australia, from Port Jackson and off the Queensland coast, from depths of ca. 10—85 m. In the U. S. National Museum there is, however, a fine, large specimen from the Bass Strait, between Victoria and Tasmania (F. H. Baker). It also occurs at Lord Howe Island, some specimens from there having been sent me for examination from the Australian Museum, Sydney (they were labelled *Phyllacanthus baculosa*). It has further been recorded from the Macclesfield Bank (H. L. Clark. Cat. Rec. Sea-Urch. Br. Mus.), but this is due to Clark's making *Priocid. glandulosa* a synonym of *australis*, which, at least for the present, does not seem acceptable. The species has not otherwise been found outside Australia. It is true,

the locality Malacca is also given in the "Revision of Echini", but this is certainly not reliable, as both the identification and the label may well be subjected to doubt. (I have not found the specimen in the Paris Museum).

Remarks. The erroneous identification of this species with the "*Cidarites*" *bispinosa* Lamarck made by Agassiz in the "Revision of Echini" and continued by H. L. Clark until 1916 ("Endeavour" Echinoderms) has been a source of very great confusion; (cf. Döderlein. Echin. v. d. Aru Inseln, 1911, p. 241—242, and the author's Echin. of N.W.Australia (Mjöberg), 1918, p.7—8, where details are given). As regards the structure of the apical system, — which is especially emphasized by Agassiz as distinguishing this species from all other Cidarids, being "thin, movable, resembling, in fact, far more the flexible anal system of Echinidæ proper than the massive abactinal system of Cidaridæ", and again emphasized in Agassiz & Clark's Hawaiian Echini. I. Cidaridæ p. 18 and in Clark's "Cidaridæ" p. 193, — I would point out that neither from the inspection of the figure in the "Revision of Echini", nor from the actual examination of several specimens, including the specimen figured by Agassiz, can I see any noteworthy difference between the apical system of this species and that of other Cidarids. It is just as typical Cidarid in structure as that of any other Cidarid and in no way Echinoid; in fact, the apical system of an old and well known species as *Prionocidaris baculosa* might with more right be said to resemble an Echinoid apical system, in as much as the periproctal plates of that species may be much smaller and more numerous than otherwise usual in Cidarids. (Cf. e. g. Pl. LIII. 7 with Pl. I. f. 1 of the "Revision of Echini"). The same holds good of *Prionocid. bispinosa* (Lamarck — non Agassiz).

The species is beyond doubt very closely related to *Prionocid. glandulosa* (de Meijere), so closely, indeed, that it may well be questioned whether they are not really the same species. The differences to be observed at a direct comparison of the two forms may, for the greater part at least, well be due to age — e. g. the ambulacral structure (cf. Pl. LXXIII. 17 and 11), the much closer tuberculation of the apical system in *australis* (cf. Fig. 141 and 142), and the more distinct crenulation of the primary tubercles in *glandulosa*. That the difference in the coloration of the ambulacral spines, used in the key to the "*Stephanocidaris*"-species in H. L. Clark's "Cidaridæ", p. 194, is of no value, was recognized by Clark himself ("Endeavour" Echinod. p. 99). More importance may be ascribed to the differences in the primary spines. These are, upon the whole, longer in *glandulosa*, 2—3 h.d., against ca. 0.5—1.5 h.d. in *australis*; still H. L. Clark records them as 2.5 h.d. in the young specimen of 27 mm h.d. But the shape appears to be different, more slender, not flattened in *glandulosa*, and then the characteristic upwards curving of the ambital spines in *glandulosa* does not appear to exist in *australis*; further the coloration of the collar offers an apparently constant difference: in *glandulosa* the upper side is much more strongly coloured than the under side, the white spots being especially conspicuous in the basal part through the purplish ground-colour; in *australis* the collar has the same coloration all round, the purplish ground-colour not being confined to the basal part of the upper side. — The pedicellariæ do

not offer very noteworthy differences, only I have not observed the outer median tooth in the globiferous pedicellariæ of *glandulosa*; but this is not quite constant in *australis* either; neither would the difference in size of these pedicellariæ (ca. 1 mm length of head in *australis*, against ca. 0.5—0.8 mm in *glandulosa*) appear to be very reliable. Finally, the fact that all the specimens of *glandulosa* hitherto recorded are small, not exceeding 27 mm h.d. would seem to indicate that this form does not reach any such large size as does *australis*. Thus there are some differences to be observed between the two forms which seem to forbid simply regarding the two forms as identical, at least until, on a direct comparison of young specimens of undoubted *australis* with specimens of *glandulosa* of a corresponding size, — or, inversely, of larger specimens of undoubted *glandulosa* with *australis* — it is proved that none of these characters really hold good. In such case the name *glandulosa* must be dropped as a synonym of *australis*.

Prionocidaris glandulosa (de Meijere).

Pls. LIV. 7—8; LXXIII. 11; LXXXVII. 9.

Cidaris (Cidaris) glandulosa. De Meijere. 1904. "Siboga" Ech. p. 13. Taf. **I. 5—6.**
Stephanocidaris glandulosa. H. L. Clark. 1907. The Cidaridæ, p. 194.
Prionocidaris glandulosa. Th. Mortensen. 1909. Ech. Deutsche Südpolar-Exp. p. 51, 53.
Prionocidaris glandulosa. Döderlein. 1911. Ech. v. d. Aru-Inseln. p. 243.
Leiocidaris glandulosa. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris australis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 12.
Prionocidaris glandulosa. Th. Mortensen. 1927. "Albatross" Cidaridæ. p. 256.

	h. d.	v. d.	Apical system	Peristome	Number of I.A.	Number of A. pro I. A.	Longest Spines
1	27 mm	14.5 mm	12 mm (44.4 % h.d.)	11 mm (40.7 % h.d.)	6	10—12	55 mm
2	25 —	13[1] —	10 — (40 —)	9.5 — (38 —)	5—6	12—13	65 —
3	18 —	9 —	8.5 — (47 —)	8 — (44.4 —)	5 (6)	12—13	38 —
4	18 —	10 —	9 — (50 —)	8 — (44.4 —)	5	12—13	45 —
5	24 —	12.5 —	12 — (50 —)	10.5 — (43.7 —)	6	12	47 —
6	14 —	7 —	6 — (42.8 —)	5.5 — (39.3 —)	5	11—12	31 —
7	11 —	5.5 —	5.5 — (50 —)	5 — (45.5 —)	5	10—11	28 —
8	12 —	5.5 —	5 — (41.7 —)	5 — (41.7 —)	4—5	10—11	35 —

Specimens 1—2 are from the "Siboga"; specimen 3 from the "Albatross" 5442; spec. 4—5 from the "Albatross" Stat. 5140; spec. 6—8 from off Elat, Great Kei (Danish Exped. to the Kei Isl. 1922).

Shape of test low, sides strongly arched, upper and lower side flattened excepting for the more or less elevate anal system. Ambulacra ca. 26—36 % of width of I.A. Interporiferous

[1] The height of this specimen is given by de Meijere as 16 mm. He evidently measures to the top of the anal system, which makes a considerable difference.

zone about twice as broad as the pore zone. Marginal series of tubercles very regular, the tubercles small, not contiguous, except in the larger specimens. Inside the marginal tubercle each plate carries a smaller tubercle at the lower inner corner, there being thus two regular double inner series of small tubercles. In the specimen of 24 mm h.d. another small tubercle occurs at the inner corner of the plate, but not regularly; de Meijere also mentions such inner tubercle occurring at the ambitus in his largest specimen. The median part otherwise bare, but not sunk. Pores equal-sized, separated by a rather broad, not elevated wall; they may well be termed subconjugate. The outer pore very close to the edge of the plate (Pl. LXXIII. 11).

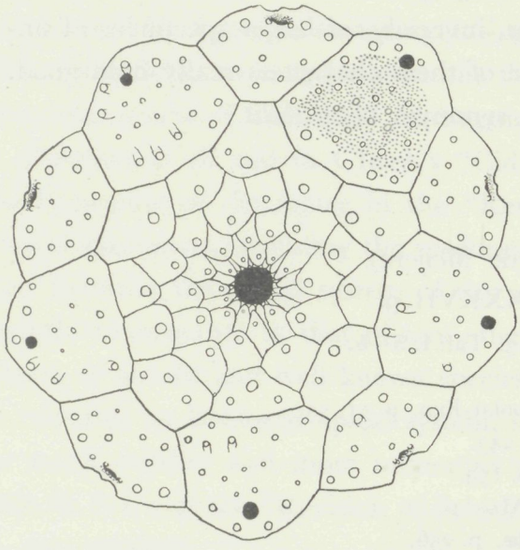


Fig. 142. Apical system of *Prionocidaris glandulosa*. × 8.

Interambulacra. A fairly distinct crenulation on the upper side of the 2—3 uppermost tubercles. Areoles not at all deepened, sometimes with indistinct radiating impressions near the edge; they are well separated, at most the two lowermost ones being confluent. Median part of I.A. narrow, scarcely half the width of an areole. The scrobicular circle of tubercles in the smaller specimens very inconspicuous, the tubercles hardly larger than the marginal ambulacral tubercles; in the specimen of 24 mm h.d. they are more conspicuous, distinctly larger than the ambulacral tubercles. Outside the scrobicular ring an alternating circle of slightly smaller tubercles, the rest of the plate covered with small tubercles leaving no naked, sunk median line; no naked adradial space. In smaller specimens there is a distinct bare median space; this was also found fairly distinct in a specimen of 20 mm h. d. in the Museum of Comp. Zoology.

Apical system (Fig. 142), ca. 40—50 % of h.d. Ocular plates broadly triangular, with inner angle truncate, all insert, the contact with the anal plates usually very wide; in the younger specimens the oculars adjoining the madreporite only narrowly insert. Genital pores small, well separated from the edge; they have appeared already in the specimen 11 mm h.d. Both genital and ocular plates rather closely covered with tubercles, the outer and inner being the largest, though not distinctly comma-shaped, and the spines attached to them forming a more or less distinct fringe. Anal system more or less elevated (in the specimen 24 mm h.d. not at all so)[1], arched (not conical), covered with rather numerous plates gradually decreasing in size inwards, each generally with a larger tubercle at the inner edge. The spines on the periproct rather large, forming a dense brush that covers the anal opening. — Peristome ca. 38—45 %

[1] This is probably due to preservation, the specimen having perhaps been lying some time before being preserved. This will generally have the effect of the anal system sinking in.

of h.d.[1]. There are 10—11 ambulacral plates in a series in the larger specimens, 4—5 interradial plates in a series, not reaching the mouth edge. In a specimen 18 mm h.d. there are only 6—7 ambulacral plates in a series on the peristome.

Primary spines ca. 2—3 h.d., slender, tapering very gently to a simple point. In the larger specimens some of the larger spines curve slightly upwards, recalling *Acanthocidaris*, but they are not flattened as in that genus. The collar is rather long, 3—5 mm; the limit between collar and shaft usually regular, but sometimes it is oblique. The collar has longitudinal series of low, somewhat elongated, white tubercles; those of the upper side are made very conspicuous through the colour of the interspaces between them, which is purple in the lower part, green in the upper part of the collar; (in the specimens of 27 and 24 mm the green colour not distinct on the upper spines); those on the lower side of the collar usually (not always) much more indistinct, though there are traces of the same colour as on the upper side. Shaft of the spine rather coarsely thorny, generally 4—5 longitudinal series on both upper and lower side, besides a pair of lateral series the thorns of which are often distinctly larger. Also the median upper series of thorns may be enlarged. The surface of the spines otherwise covered with a fine hairy coat, formed by scattered elevations which branch at the top like a bush and anastomose. The oral primaries not very specialized, slender, slightly curved, only with inconspicuous lateral serrations, but the point more or less flower-like expanded, especially on the second spine. The third spine not transformed. On account of the rather long collar they may have a very distinct "capped" appearance.

Secondary spines only slightly appressed, simply pointed, flattened, those surrounding the base of the primary spines somewhat curved; they reach a length of 4—5 mm. The ambulacral spines somewhat shorter, but otherwise of the same shape. A more or less distinct bag of glandular skin surrounds the base of the secondary spines.

Pedicellariæ of the usual three types. The large globiferous are long-stalked, with a large, beautiful limb at the upper end of the stalk. The valves with a well marked, triangular, terminal opening, the edge of which is set with fine teeth (Pl. LXXXVII. 9). The head of these pedicellariæ ca. 0.5 mm long, the stalk ca. 1.5 mm. The small globiferous pedicellariæ may reach the same size, but are much more slender and have no limb on the stalk and a well developed end tooth on the valves. The tridentate pedicellariæ have very slender and narrow valves, with irregularly serrate edges, joining only in the outer half. They reach a size of 1.8 mm head and about the same length of the stalk. The pedicellariæ, on the whole, very closely resemble those of *Pr. australis*.

The large globiferous pedicellariæ were found to be very numerous in the "Siboga"-

[1] The statement in the key to the species of *Stephanocidaris* in H. L. Clark's "Cidaridæ" p. 194 that in *St. glandulosa* the "abactinal system is smaller than the actinostome" does not hold good. It is founded on the statement by de Meijere, that in his specimen of 25 mm h.d. the peristome is 11 mm, the apical system 10 mm. In reality the peristome of this specimen is only 9,5 mm. (I have reexamined this specimen in the Amsterdam Museum).

specimens, the species name "glandulosa" referring to this fact. This is, however, no constant feature. In the specimens from the "Albatross" not a single large globiferous pedicellaria is found; on the whole pedicellariæ are scarce in these specimens (which fact cannot be due alone to poor state of preservation), on the other hand the tridentate and small globiferous pedicellariæ reach a larger size than in a specimen with numerous large globiferous pedicellariæ. Of the three specimens from off Elat, Great Kei (St. 25 of the Danish Exped. to the Kei Islands) one has a fair number of large globiferous pedicellariæ, though not specially numerous, the two others none; in one of these latter the small globiferous pedicellariæ are numerous and well developed. — Spicules of tubefeet well developed, arranged regularly, of the usual thorny shape. The wall of the intestine studded with small, rounded calcareous plates with few holes.

Colour of denuded test white, with spots of purple in the median part of I.A. (in a specimen of 24 mm h.d.; a specimen of 18 mm h.d. only shows a trace of greenish colour). Ambulacra purplish, in the smaller specimens with median line white; the pore zone more greenish-brown. Apical system purple-greenish; the genital plates are much darker, the white ocular plates showing very conspicuously off against them, making thus a star-shaped figure. Primary spines in the outer half conspicuously banded with purplish-red and white. Secondary spines whitish, with a more or less distinct greenish-purplish median line.

Biology. The fact that of the 29 specimens (including the 10 specimens from the Macclesfield Bank) recorded till now none exceeds a size of 27 mm h.d., would seem to indicate that this species does not grow to any large size. The fact that the primary spines of the specimen 24 mm h.d. are partly covered with foreign organisms (Serpulids, barnacles) seems to point in the same direction. Still, it is to be noted that in the largest specimens the uppermost primaries are not yet fully formed; this means that these specimens have not yet attained full size. In one of the specimens of 18 mm h.d. the genital organs are full of very small, evidently nearly ripe eggs, which leads to the suggestion that it has pelagic larvæ.

The specimen of 24 mm h.d. shows the abnormality of having two genital pores in genital 3.

Occurrence. The species was found by the "Siboga" in the Molo-strait and at Sumbawa. By the "Albatross" it was found off Luzon, 139 m and off Jolo, 82 m. 3 specimens were dredged off Elat, Great Kei, in a depth of 85 m, by the author (Danish Exped. to the Kei Islands, 1922, St. 25). Further the specimens from Macclesfield Bank, 50—83 m, recorded by H. L. Clark (Cat. Rec. Sea-Urch. Brit. Mus. p. 12) under the name of *Pr. australis* should also be referred to *glandulosa*. (Reexamined by the present author in the British Museum). Evidently then the species will be found to be widely distributed over the Moluccan and Philippine Seas. The range of depth, as far as hitherto known, is ca. 50—140 m, thus very limited. But it may well be expected to occur also in somewhat deeper water.

Remarks. Regarding the affinities of this species one cannot help being struck with its resemblance to *Acanthocidaris maculicollis*, the more emphasized through the slight upwards curving of the primary spines in larger specimens; were it not for the entirely different surface structure

of the primaries, one might be strongly tempted to regard these two forms as belonging to the same genus. The character of the primary spines, however, forbids that. — As to its relations to other species of the genus *Prionocidaris*, it is evidently most nearly related to *Prionocid. australis* (Ramsay) (= *Stephanocidaris bispinosa* A. Agass., non Lamarck). H. L. Clark and de Meijere (The Cidaridæ p. 195, — "Siboga" Echin. p. 5) even suggest that it may be only the young of that species, and in the Cat. Rec. Sea-Urch. Brit. Mus. Clark definitely regards *glandulosa* as identical with *australis*. So long as typical, adult specimens of *australis* have not been met with in the Moluccan Seas (— the specimens of "*australis*" i. e. *glandulosa*, recorded from the Macclesfield Bank are all small, the largest 17 mm h.d.), I would not think this probable, or at least, not proven. But it would appear that the only essential difference between the two forms is in the primary spines (see under *Pr. australis*); the other differences may well be due to age.

Prionocidaris hawaiiensis (A. Agassiz & H. L. Clark.)

Pl. LXXIII. 12.

Stephanocidaris hawaiiensis. A. Agassiz & H. L. Clark. 1907. Hawaiian Echini. I. Cidaridæ. p. 18. Pls. **4. 20—23; 12 b. 12—13; 24; 25; 26. 1—4.**
Stephanocidaris hawaiiensis. H. L. Clark. 1907. The Cidaridæ. p. 195.
Prionocidaris hawaiiensis. Th. Mortensen. 1909. Ech. Deutsch. Südpolar-Exp. p. 51, 53.
Leiocidaris hawaiiensis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris hawaiiensis. Döderlein. 1911. Ech. Aru-Inseln. p. 243.
Prionocidaris hawaiiensis. Th. Mortensen. 1918. Ech. N.W. Australia (Mjöberg) p. 8.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	41 mm	25 mm	20 mm (49 % h.d.)	19 mm (46.3 % h.d.)	8	13—15	87mm(?)
2	36 —	22 —	15 — (41.7 —)	14 — (39 —)	7	11—13	85 —
3	35 —	22 —	15 — (43 —)	15 — (43 —)	7	11—13	?
4	33 —	20.5 —	15 — (45.4 —)	15 — (45.4 —)	6—7	12—13	91 —
5	33 —	21 —	15 — (45.4 —)	14 — (42.4 —)	7	12—13	ca.80 —
6	31 —	18 —	13.5 — (43.5 —)	13.5 — (43.5 —)	7	11—12	65 —
7	29 —	17 —	12 — (41.4 —)	13 — (45 —)	6—7	11—12	75 —
8	17 —	9 —	7 — (41.2 —)	7.5 — (44.1 —)	5—6	8—9	26 —
9	16 —	8.5 —	6.5 — (40.6 —)	7 — (43.8 —)	5—6	8—9	25 —
10	12 —	6 —	5.5 — (46 —)	6 — (50 —)	5	8—9	30 —
11	9 —	4 —	4 — (44 —)	4 — (44 —)	5—(4)	7	16 —

The specimens 1, 4—11 examined in the Museum of Comparative Zoology, Cambridge, Mass.

Test rather low, flattened above and below; sides arched, circumference round, sometimes subpentagonal, the I.A. bulging out quite conspicuously (specimen 1). Ambulacra ca. 23 % of width of I.A. The interporiferous zone about twice as broad as the pore zone. The marginal series of tubercles very regular, the tubercles being rather large, contiguous. Inside the marginal series there is a regular series of much smaller tubercles situated at the lower edge of each plate; besides there is, in adult specimens, another slightly smaller tubercle at the inner or upper corner

of the plate, though not always developed regularly on all the plates. These latter tubercles tend to obscure the regularity of the inner series of tubercles. Median space not sunk; where all the inner tubercles are developed scarcely any naked space remains, where only the outer series is developed the interporiferous zone is rather naked. Pores equal-sized, not very distant, fairly distinctly conjugate (Pl. LXXIII. 12).

Interambulacra. Areoles not sunk, markedly transverse-oval; they are not confluent, though nearly so, being separated by a series of very small tubercles, distinctly smaller than those of the lateral parts of the scrobicular circle. Tubercles rather prominent; some of the uppermost ones may show a fairly distinct crenulation on the upper side, especially in younger specimens. The boss rather small. Scrobicular circle not very prominent, the tubercles (of the lateral parts) not much larger than the marginal ambulacral tubercles. Both the median and adradial part of the plates otherwise closely covered by smaller tubercles, gradually decreasing in size towards the median and the adradial edge. There is thus no naked median space left.

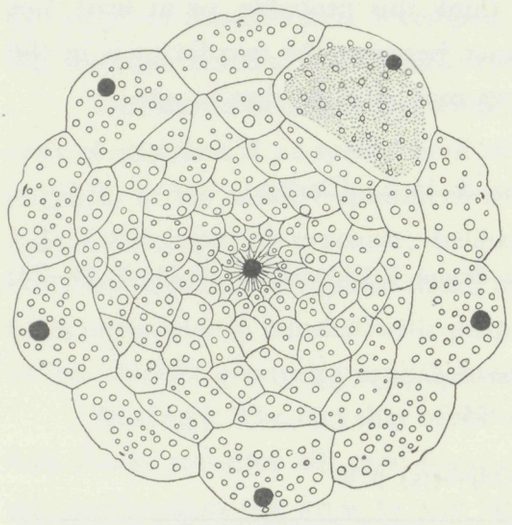


Fig. 143. Apical system of *Prionocidaris hawaiiensis*. × 4.

Apical system ca. 42—49 % of h.d. Ocular plates very broadly insert, both genital and ocular plates rather unusually low, forming a narrow outer ring. Also the shape of the ocular plates is somewhat unusual, the outer edge being convex, the inner, truncated, edge somewhat concave. The periproct is somewhat raised, covered with numerous, nearly equal-sized, small plates. Apical system, upon the whole, covered with numerous, very small tubercles, those on the periproctal plates slightly the larger. Genital pores small, near the edge of the plates (Fig. 143).

Peristome rather distinctly pentagonal, about the same size as the apical system (39—46(50) % h.d.); in the younger specimens it is rather a little larger. There are ca. 12—14 ambulacral plates in a series in the larger specimens, and 5—6 interradial plates in a single, more or less regular series, not quite reaching the mouth edge, while, however, the ambulacral plates of each two neighbouring series do not join so as definitely to exclude the interradial series from the mouth edge. In the specimen of 12 mm h.d. there are 7—8 ambulacral plates in a series, 4—5 interradial plates.

Primary spines ca. 2—2.5 h.d., gently tapering to a blunt, usually not widened point, somewhat flattened on the oral side. Sometimes the ambital primaries may be gently curved downwards. They are rather densely covered with thorns, which are not very prominent, excepting the two lateral series; also a series along the middle of the upper side may be more prominent. The thorns of the upper (aboral) side upon the whole larger than those of the under (adoral) side of the spines. Between the larger thorns, which are rather distinctly serially arranged,

smaller thorns may occur without any order whatever. The surface of the shaft otherwise, in fully developed spines, covered with a coat of fine, bush-shaped hairs, which in the lower part of the shaft (or more?) may anastomose so as to form a spongy coat. The collar is ca. 4 mm long, distinctly increasing in thickness downwards towards the not very prominent milled ring. It is provided with low, whitish tubercles more or less distinctly serially arranged; they are rather conspicuous, in spite of being so low as hardly to be termed tubercles, on account of their colour, whitish, against a darker, greenish-yellow ground colour, (which is somewhat darker towards the shaft). The oral primaries are peculiar in having a very long collar, the cortex-layer being confined to the point of the spines, which may thus be characterized as being "capped". Otherwise they are flattened, but not widened, and with a mere indication of serrations in the outer part. The second primary is essentially of the same character, only somewhat longer and sometimes with the point a little widened. The third is transitional to the ambital primaries.

The secondary spines at base of the primaries are rather unusually long, ca. 7 mm, very slender, pointed, flattened, slightly curved, not excavate. They are not appressed. The ambulacral spines are nearly of the same length, but more slender and scarcely flattened. The spines of the ocular and genital plates short, flattened, pointed, not appressed; apparently there is in the younger specimens a rather thick glandular skin at their base.

Pedicellariæ. Large globiferous pedicellariæ have not been found. Small globiferous pedicellariæ of the usual type with a rather prominent end tooth; they reach a considerable size, up to 1 mm length of head and are rather long-stalked. This kind of pedicellariæ is rather common, especially on the apical system in young specimens and in the interambulacra of the adults. The tridentate pedicellariæ reach a length of 1.5 mm (head). The valves are narrow, joining in nearly their whole length (cf. A. Agassiz & H. L. Clark. Op. cit. Pl. 4. 20—23). Spicules of tubefeet of the usual type. In the intestinal wall the round glassy disks, with few holes in the middle, are found numerously as in the other species.

Colour. The primary spines are generally banded with brick-red and yellowish or white; sometimes they are only banded near the tip, the shaft being otherwise of a uniform brick-red colour. The larger serrations along the sides of the primary spines usually white. The collar has whitish spots on a darker, greenish-yellow ground colour, becoming darker towards the shaft. In some young specimens the prevailing colour of the primaries is stated to be yellowish-green, in place of red. The spines of the upper side are stated to be sometimes darker ("a uniform dark-violet colour"). This, however, holds good only of such spines as are not yet fully developed. The secondary spines are of a uniform dirty greenish-brown colour; the ambulacral spines somewhat darker, more reddish-brown. The test, when well cleaned, is whitish, with a more or less distinct reddish tint on the upper interambulacral plates, especially in the median part; the tubercles remain white. The ambulacra are more or less intensely reddish in the interporiferous zone, this colour passing also more or less on to the pore zone. The ambulacra thus form, through their colour, five conspicuous radiating lines on the test. The apical system is slightly darker than the test.

Biology. The intestine of one of the specimens before me contains a great number of Foraminifera of various bottom-species (not arenaceous); it would appear, then, that this species picks up such forms from the bottom. It contains, however, also such forms as *Polytrema* and incrusting Bryozoa.

Growth. In young specimens up to 8—9 mm h.d. the oculars are still exsert. By a size of ca. 10 mm h.d. they may all be narrowly insert. The genital openings appear at a size of ca. 16 mm h.d. The small size of the openings indicates that this species has small eggs and, perhaps, pelagic larvæ.

Parasites. On one of the specimens in the Museum of Comp. Zoology is found a parasitic Gastropod (*Mucronalia*?) in a sort of gall in the test, close to the peristome. There is a small pore on the top of the gall, but also a large, triangular opening on the side of it.

Occurrence. The species is known only from the Hawaiian Islands, where it appears to be common enough. Known bathymetrical range: 32—510 m.

Remarks. It is evident that this species is the nearest related to *Pr. australis*, with which it agrees in the coloration of the collar of the primaries — a character of primary importance within this genus — while the colour of the shaft of the primaries is conspicuously different in the two species; it also differs from *australis* in its much more confluent areoles, narrower median interambulacral area, and the red colour of the ambulacra on the denuded test. (The differences in the tuberculation of the interporiferous zone of the ambulacra are perhaps less reliable, depending so much on size). The near relation of the two species also found expression in the fact that Agassiz & Clark referred *hawaiiensis* as the second species (besides their "*Stephanocidaris bispinosa*" = *Prionocidaris australis*) to the genus *Stephanocidaris*, as understood by them at that time.

Prionocidaris bispinosa (Lamarck).

Pls. XLIV. 2; XLVII. 1; LIII. 1—3; LXXIII. 19; LXXXVII. 12.

Cidarites bispinosa. Lamarck. 1816. Hist. nat. anim. sans vertèbres. III. p. 57. II. Ed. 1840, III. p. 382.
Cidarites bispinosa. Deslongchamps. 1824. Encyclopédie méthod. II. p. 196.
?*Cidaris annulata.* Gray. 1855. Arr. fam. Echinida. P. Z. S. p. 37 (teste A. Agassiz. Rev. of Ech. p. 150) (If the locality West Indies given by Gray is correct, this species is not *Pr. bispinosa*).
?*Cidaris circinnata* (M. S.) Martens. 1866. Ostas. Echinod. p. 150 (teste A. Agassiz. Rev. of Ech. p. 150).
?*Cidaris rosaceus* Rousseau. In Perrier 1869. Rech. s. l. Pédic. p. 129 (teste A. Agassiz. Rev. of Ech. p. 150).
Cidaris Lütkeni. De Loriol. 1873. Descr. trois espèces d. Échinides. p. 29. Pl. 4.
Rhabdocidaris bispinosa. De Loriol. 1873. Ibidem. p. 38. Pl. 5.
Phyllacanthus annulifera. A. Agassiz. 1873. Rev. of Ech. p. 387. Pl. I. e, 21—26 a (non = *Cid. annulifera* Lamk.).
Schleinitzia crenularis (partim). Studer. 1876. Echinod. a. d. antarkt. Meere u. zwei neue Seeigel a. d. Papua Inseln. Monatsber. Ak. Berlin. p. 463. 1880. Echin. d. Corv. "Gazelle" Ibid. p. 865. Taf. I. 1—1c (non Taf. I. 1d—g = *Pr. baculosa*, var. *annulifera*).
Rhabdocidaris recens. Troschel. 1877. Archiv f. Naturgesch. 43. p. 127; Tab. VIII. Nachträgliche Bemerkung. Ibid. p. 260. (Sitz.ber. Niederrhein. Gesellsch. Phys. Section. Sitz. 10. Decbr. 1877).
?*Phyllacanthus annulifera.* A. Agassiz. 1881. "Challenger" Ech. p. 39.
?*Phyllacanthus annulifera.* Bell. 1884. Echinod. "Alert". p. 118.

Phyllacanthus annulifera. Ramsay. 1885. Catal. Ech. Austr. Mus. p. 2, 45. (II. Ed. 1891).
Stephanocidaris bispinosa. Koehler. 1895. Catal. rais. Echinod. îles de la Sonde, p. 409.
Phyllacanthus annulifera. Pfeffer. 1896. Ostafr. Echinod. p. 45.
Leiocidaris annulifera. Ludwig. 1899. Ech. Sansibar. p. 551.
Rhabdocidaris annulifera. Bedford. 1900. Echinod. Singapore & Malacca; p. 275, Pl. XXI. 1. a—d.
Leiocidaris bispinosa. Döderlein. 1902. Ech. Amboina & Thursday Isl. (Semon) p. 695, Taf. **LVIII. 5—11.**
Stephanocidaris bispinosa. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 17, 20, 28, 172. Pl. X. 17.
Stephanocidaris bispinosa. Th. Mortensen. 1904. Siam Ech. p. 6. Pl. **II. 3, 17, 18; IV. 30; V. 20, 25.**
Stephanocidaris bispinosa. Bell. 1904. Echinod. Pearl Oyster Rep. p. 138.
Cidaris (Stephanocidaris) bispinosa. De Meijere. 1904. "Siboga" Ech. p. 4. Taf. **I. 4; II. 14.**
Cidarites (Stephanocidaris) bispinosa. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 92. Taf. **44 (36) 4. a—i.**
Phyllacanthus annulifera. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 15. Pl. 12b. 14—15.
Phyllacanthus annulifera. H. L. Clark. 1907. The Cidaridæ. p. 188.
Plococidaris bispinosa. Th. Mortensen. 1909. Ech. Deutsche Südpol. Exped. p. 50.
Leiocidaris annulifera. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Prionocidaris bispinosa, var. *aruana.* Döderlein. 1911. Ech. v. d. Aru-Inseln. p. 240. Taf. **IX 1—2.**
Phyllacanthus annulifera. Jackson. 1912. Phylogeny of Echini. p. 101, 102, 152, 153.
Prionocidaris bispinosa. Döderlein. 1914. Ech. S.W. Australiens. p. 451.
Phyllacanthus annulifera. H. L. Clark. 1914. Ech. W. Austral. Mus. p. 161.
Prionocidaris bispinosa. H. L. Clark. 1915. Ech. Ceylon. p. 98.
Prionocidaris bispinosa. Th. Mortensen. 1918. Ech. Australia (Mjöberg). p. 6. Pl. **III. 1**; Pl. **IV. 3.**
Prionocidaris bispinosa. H. L. Clark. 1921. Echinod. Torres Strait. p. 144.
Prionocidaris bispinosa, var. *chinensis.* H. L. Clark. 1923. Echinod. West Australia. p. 248.
Leiocidaris recens. Lambert & Thiéry. 1925. Ess. nom. rais. p. 561.
Prionocidaris bispinosa. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 15.
Prionocidaris bispinosa. H. L. Clark. 1926. A coll. of Echinod. from the Austral. Mus. Rec. Austr. Mus. XV. p. 188.
Prionocidaris bispinosa. Th. Mortensen. 1927. "Albatross" Cidaridæ, p. 258. Pl. 52.3.
Prionocidaris bispinosa, var. *nigro-brunnea.* Th. Mortensen. 1928. New Cidaridæ, p. 74.
NON: *Stephanocidaris bispinosa.* A. Agassiz. 1872—73. Rev. of Ech. p. 160, 393. Pl. I. c. 43. I. f. 1.
— *Stephanocidaris bispinosa.* A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 18, Pl. 12b. 10—11.
— *Stephanocidaris bispinosa.* H. L. Clark. 1907. The Cidaridæ. p. 194.
— *Stephanocidaris bispinosa.* H. L. Clark. 1909. Echinod. "Thetis", p. 552. Pl. LIV. 1.

The species named *Stephanocidaris bispinosa* in these works is not *Prionocidaris bispinosa* (Lamarck), but *Prionocidaris australis* (Ramsay).

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
78 mm	47 mm	29 mm (37.1 % h.d.)	ca. 22 mm (28.2 % h.d.)	10	15—16	76 mm
77 —	46 —	29 — (37.7 —)	22.5 — (29.2 —)	10—11	15—16	90 —
56 —	33 —	24 — (42.9 —)	ca. 19 — (ca. 34 —)	8 (9)	16—17	58 —
44 —	23 —	20.5 — (46.5 —)	16.5 — (37.5 —)	8	14—15	55 —
37 —	20 —	17 — (46 —)	15 — (40.5 —)	7—8	15—16	50 —
33 —	17 —	16.5 — (50 —)	15 — (45.5 —)	6 (7)	15—16	
22 —	11 —	9.5 — (43.2 —)	9 — (40.9 —)	6	12—13	30 —
16 —	8 —	7 — (50 —)	6.5 — (40.6 —)	6	9—10	21 —

Test generally rather low, flattened above and below, in the larger specimens somewhat incurved at the peristome; sides beautifully arched. Ambulacra ca. $^1/_3$ the width of the I.A. Interporiferous zone about twice the width of the pore zone. Marginal series of tubercles very regular, the tubercles contiguous. Inside the marginal tubercle each ambulacral plate carries, in medium-sized specimens, two tubercles, disposed in an oblique series downwards, the outer one about half the size of the marginal tubercle, the inner much smaller. These tubercles form four longitudinal series in the interporiferous zone; but then a third inner tubercle may occur nearer the upper edge of the plate, obscuring the inner longitudinal series ("Siam" Ech. Pl. II. 3), and in the very large specimens the space inside the secondary series is wholly covered by numerous small, crowded tubercles, leaving no bare median line. Pores small, equal-sized, conjugate, in large specimens very distant (Pl. LXXIII. 19).

Interambulacra. Areoles scarcely sunk, in the large specimens markedly transverse-oval, excepting the uppermost ones; they are not confluent, excepting, at most, the two proximal ones. A few of the uppermost tubercles may be distinctly crenulate on the aboral side. Scrobicular circle of tubercles fairly conspicuous, the tubercles about twice the size of the marginal ambulacral tubercles. Some tubercles about half the size of the scrobicular ones are alternating with these latter, the rest of the plate being rather closely covered with smaller tubercles decreasing gradually in size towards the median line and the adradial edge, leaving no naked space. In the large specimens the smaller tubercles show a fairly distinct arrangement in transverse series. The median interambulacral space is in the large specimens ca. $^2/_3$, in the medium-sized specimens only ca. $^1/_2$ the width of an areole.

Apical system (Pl. LIII. 2; Siam Ech. Pl. II. 18) ca. 43—50 % of the h. d. in medium-sized specimens, in very large ones only ca. 37 % h.d.[1]. Mostly all the oculars are insert, but not very rarely II. and III. may be exsert, even in the large specimen of 77 mm h.d. these two oculars scarcely reach the periproct. The oculars are about heart-shaped, with truncate inner apex, not outwards produced. Genital pores rather small, not very close to the edge. Both ocular and genital plates closely covered with tubercles, which are somewhat larger at the outer and inner edge, sometimes even comma-shaped. The spines are, of course, correspondingly larger at the outer and inner edge than in the middle, and bent respectively outwards and inwards, a transverse line across the middle of the genital plates marking the different directions; on the naked plates no such transverse line is observable. The anal plates fairly numerous, with somewhat larger, not very crowded tubercles. — Peristome somewhat smaller than the apical system, ca. 34—45 % h.d. in medium-sized specimens, in large specimens only ca. 28—29 % h.d. There are in the largest specimens ca. 16 ambulacral plates in each series and 7—8 interradials in a more or less regular series which does not reach the mouth edge, the ambulacral series joining for about the inner third or fourth of the distance from the mouth edge to the peristomial edge. In medium-

[1] De Meijere (Op. cit.) even records a specimen of 44 mm h.d. with the apical system only 15 mm, viz. 34 % h.d. This, however, would seem to be an exceptional case.

sized specimens there are ca. 12—14 ambulacral and 5—7 interradial peristomial plates, thus, the number of these plates scarcely increases in the later growth stages, in conformity with the fact that the peristome is relatively smaller in the large specimens[1].

The primary spines are cylindrical or slightly tapering, sometimes ("*Cidaris Lütkeni*") nearly fusiform; as a rule they do not exceed the h.d., only a few of the longest reaching about 1.5 h.d. They are set with coarse thorns, but the development of these thorns varies to the utmost, from nearly or even wholly smooth to excessively thorny spines occurring even in specimens from one and the same locality. In the less thorny spines the thorns show a tendency to an arrangement in two lateral series; in more thorny spines the thorns are developed mainly on the upper side and often arranged in more or less distinct whorls. Generally the spines are slightly tapering, but the point is often more or less widened, sometimes ending in a large crown of long thorns (Pl. XLIV. 2). In older specimens some of the upper spines may be more or less flattened towards the point ("Albatross" Cidaridæ, Pl. 52. 3). The fully formed spines in general set with numerous small thorns or knobs showing only indistinctly an arrangement in longitudinal series, the surface otherwise being covered with fine bush-shaped, more or less anastomosing hairs. The collar is ca. 2 mm long, generally distinctly widening downwards, towards the prominent milled ring. — The oral primaries are short, the proximal ones flattened, slightly widened, slightly serrate along the edges; the second and, especially the third with widened, more or less crown-shaped point; all of them distinctly knobbed on the aboral side. In large specimens also the fourth or even the fifth primaries are modified as oral spines.

The secondary spines surrounding the base of the primaries are flattened, scarcely narrowing towards the point; on the oral side they are more or less excavate towards the point. The ambulacral spines are much narrower, pointed. The secondaries upon the whole fairly appressed, less so in less well preserved specimens. The smallest spines are pointed, not scale-like, without glandular ampulla.

Pedicellariæ. Large globiferous pedicellariæ only very rarely found; they have like those of *Prionocidaris baculosa* a limb on the stalk but no end tooth on the valves (Pl. LXXXVII. 12, var. *elegans*; cf. Döderlein, Ech. Deutsche Tiefsee Exp. p. 93. Taf. XLIV, 4 g—h). On the peristome similar pedicellariæ may occur, which have, however, no limb on the stalk. The small form of globiferous pedicellariæ is richly developed; they reach a considerable size, 1.5 mm length of head, the stalk up to 4 mm long. The valves are narrow, elongate, with a fairly large opening provided with a well developed end tooth ("Ingolf" Ech. Pl. X. 17, erroneously designated as a large globiferous pedicellaria). The tridentate pedicellariæ of the usual simple shape; length of head up to 1.5 mm. Spicules of the usual form, mainly arranged in two series in the tubefeet. In the walls of the intestine numerous small rounded plates with few holes and in the other inner organs more irregular spicules (Siam Ech. Pl. V. 20, 25).

[1] Bedford (Op. cit.) maintains that the peristomial plates do not increase in number after the animal has reached a diameter of 22 mm. This statement does not quite agree with my observations.

Colour. The primary spines generally banded with purplish-red on a white-yellowish or greenish ground colour. The collar uniformly pink or brown. Secondary spines surrounding the base of the primaries pink in the basal part, passing into a yellowish or greenish colour towards the point. In some specimens these spines are nearly white, perhaps having faded; sometimes the spines have a darker median stripe; in some specimens from Sharks Bay, S.W.Australia (var. *nigro-brunnea*; see below) the secondaries are of a uniform, very dark colour. The ambulacral spines are darker, the ambulacra thus forming five dark radiating lines on the animal. Also the smaller interambulacral spines are darker. The denuded test is grayish-white, the tubercular boss bright pink[1]. Sometimes the test may be dark violet, especially ambulacra and apical system (cf. Th. Mortensen. Ech. N.W. Australia).

Varieties. The great variability in the character of the primary spines has caused the establishing of several varieties within this species. As the typical form is regarded that described by de Loriol (1873, Pl. V.) with strongly thorny primary spines, rarely exceeding h.d.

Var. *Ramsayi* Döderlein (1902. Ech. Semon. Taf. LVIII. 11) has the primaries distinctly more than h.d., rather slender, not tapering, with thorns only near the point, which is generally crown-shaped widened. Locality: Queensland.

Var. *chinensis* Döderlein (Ibidem, Taf. LVIII, 10). Primary spines long, tapering, not thorny, a few of the upper ones with some long thorns. Locality: China Sea. Also recorded from W. Australia (H. L. Clark. 1923).

Var. *aruana* Döderlein (1911. Ech. Aru Inseln Taf. IX. 1—2). Primary spines long, up to nearly 3 h.d., without larger thorns; the point rarely widened into a small crown. Locality: Aru Islands. (Singapore).

Var. *elegans* Mrtsn. (Th. Mortensen. 1918. Ech. N.W.Australia. Mjöberg p. 7. Pl. IV. 3). Primaries very short, not more than $^2/_3$ h.d. Secondary spines white, with a sharply limited red-brown midline. Ocular plates almost naked. A rather broad, naked ambulacral midline. Locality: N.W.Australia.

Some specimens from Sharks Bay, S.W.Australia, may well deserve being designated as a separate variety, rather more so, indeed, than some of the above varieties, although Döderlein, in his report on the Echinoidea of the Hamburg S.W.Australian Expedition (Die Fauna S.W.Australians IV. 1914. p. 45) states that they belong to the typical form. These specimens I have had an opportunity of studying partly in Munich, partly in Berlin, while four other specimens from the same locality, belonging to the Hamburg Museum, were sent me to Copenhagen for study. They are characteristic through the uniform dark colour of the secondary spines, so dark sometimes as to be almost black (Pl. XLVII. 1); one of the specimens, however, has only the scrobicular spines dark-brown, all the rest of the secondaries and the test being of a creamy

[1] This appears to be a valuable, practical character for distinguishing naked tests of this species from those of *Prionoc. baculosa*, var. *annulifera*, in which the tubercle boss is white, or at least not distinctly pink, naked tests of these species being otherwise not easily distinguishable, as pointed out by Döderlein.

white. The primaries, which are also more or less dark violet, are generally somewhat less than the h.d. (only in the younger specimens slightly exceeding h.d.), rather coarsely thorny and ending in a fairly conspicuous crown. In fact, these specimens through the character of their primaries recall *Goniocidaris tubaria*. Further the apical system is somewhat smaller than usual in *bispinosa*, ca. 32—40 % h.d., against ca. 43—50 % h.d. in typical *bispinosa* of corresponding size; also the ambulacral plates are somewhat less numerous, ca. 10—13 to an I.A. against ca. 14—16 in typical *bispinosa* of a corresponding size. — These differences certainly seem important enough for distinguishing this form as a separate variety, which I have named var. *nigro-brunnea* (New Cidaridæ, p. 74)[1].

To this variety may be referred the specimens from off Cape Jaubert, N.W.Australia, mentioned in my report on the Mjöberg-Collection (1918. p. 6. Pl. III. 1).

All these varieties, perhaps with exception of the two last ones, are very poorly characterized and, evidently, of very little real value. As local forms they can hardly be regarded, being widely distributed. Thus I have specimens of both the typical form and the var. *aruana* from Singapore, the typical form and the var. *chinensis* from off Jolo, this variety also being recorded from West Australia by H. L. Clark, while Döderlein records both the typical form and the var. *Ramsayi* from the Queensland Coast. In his "Cat. Rec. Sea-Urch. Brit. Mus." 1925 p. 16, H. L. Clark comes to the same result regarding these varieties. A series of specimens from Holothuria Bank, examined by him in the British Museum, exhibit nearly all the various forms of spines characterizing the different varieties.

Growth. At a size of 5 mm h.d. there are only 3—4 ambulacral plates in each series on the peristome, and the first interradial plate has just appeared. All the oculars are exsert. At a size of 10—11 mm h.d. Oculars II and III are still exsert; in a specimen af 14 mm h.d. all oculars are widely insert. In the latter specimen the genital pores have been formed, while in another specimen, 16 mm h.d., they have not yet been formed. The specimens of 77—78 mm h.d. mentioned above, evidently, have reached full size. In these large specimens the primaries are very much overgrown by foreign organisms, especially barnacles. Even on the oral primaries they are found, but, as usual, never on the collar of the spines. Upon the whole the fully formed primaries of this species are very liable to be covered with foreign organisms, and clean adult specimens are rarely found.

Biology. It prefers a hard bottom, sand, shells, corals, but has been recorded also from muddy bottom. The contents of the digestive canal are as a rule broken shells — apparently from Molluscs which it has crushed with its teeth. — Development unknown. — H. L. Clark (Cat. Rec. Sea-Urh. Brit. Mus. p. 16) records some specimens from Holothuria Bank with a few irregular, crimson spots on the collar (the spines smooth). He is inclined to think these specimens

[1] A specimen (31 mm h.d.) recently received from Queensland (Mr. Rainford, Bowen) is, however, again somewhat intermediate, its secondary spines being dark as in the var. *nigro-brunnea*, while otherwise the specimen rather belongs to the typical form.

to be hybrids between *Pr. bispinosa* and *Stylocidaris bracteata*), which latter species also occurs here. This suggestion seems very reasonable.

Parasites. Two specimens from the Gulf of Siam are infested on the apical system by a group of parasitic Gastropods (*Mucronalia* sp. — not *Stylifer* as is stated in the author's "Siam" Echinoidea, p. 8). Also the brittlestar *Ophiothela* may occur on the spines of this species.

Abnormalities. A case of two genital pores in the madreporite has been figured in the author's "Siam" Echinoidea, Pl. II, 18. The specimen described by Troschel as *Rhabdocidaris recens* has the posterior genital plate rudimentary, without genital pore, while the ocular V is fused with genital 4 (Op. cit. Taf. VIII. 1). Also the posterior interambulacrum is abnormal in this specimen, having in the upper part three single plates, one above another, occupying the whole width of the interambulacrum; above these the plates appear to assume again the normal shape (cf. description, Op. cit. p. 132; Pl. VIII. fig. 2).

Occurrence. The species has its centre of distribution in the Java-Philippine and Moluccan Seas, but ranges so far as Ceylon and to S.W.Australia (Abrolhos and Sharks Bay) in the Indian Ocean. On the East Coast of Australia it is known from the Queensland Coast (Port Denison); recently (1926) H. L. Clark has recorded it from the Gulf of Carpentaria. The species recorded as *Phyllacanthus annulifera* from New Britain by Bell (Ech. coll. Willey p. 134) is *Stylocidaris Reini*; as for the *Phyllacanthus annulifera* recorded by Pfeffer (and after him by Ludwig) from East Africa it may well be supposed that it is the true *annulifera* Lamk.; it was without definite locality. The bathymetrical distribution appears to be very limited, only from ca. 4—50 m, the deepest record being 54 m. ("Siboga" St. 79).

Remarks. Great confusion has been reigning in literature as regards this species, because of the mistake made by A. Agassiz in the "Revision of Echini", who reports as *Stephanocidaris bispinosa* (Lamarck) quite another species, *Prionocidaris australis* (Ramsay), while the true "*Cidarites*" *bispinosa* of Lamarck is erroneously named in that work *Phyllacanthus annulifera* (Lamarck), the true "*Cidarites*" *annulifera* of Lamarck being unknown to A. Agassiz. H. L. Clark continued the mistake of A. Agassiz, until 1916 ("Endeavour" Echinod. p. 97—98), when he recognized that the species regarded by Agassiz and himself as the *Cid. bispinosa* of Lamarck is in reality quite a different species, viz. the one described by Ramsay as *Phyllacanthus australis*. To repeat here the whole of this intricate synonymic history would seem superfluous, it may suffice to refer to Döderlein's Echinoidea v. d. Aru-Inseln 1911, p. 241—242, and to the author's Echinoidea of N.W.Australia (Mjöberg) 1918, p. 7—8, where the details are given. It may be pointed out that the description of "*Phyllacanthus annulifera*" given in the "Revision of Echini" suits rather badly to *Prionocidaris bispinosa*; perhaps it was based on more than one species (the figures may well represent the true *bispinosa*). This can, however, scarcely be ascertained any more, and, as it has now only historic interest, is hardly worth bothering.

Regarding *Schleinitzia crenularis* Studer and *Rhabdocidaris recens* Troschel their specific identity with *bispinosa* is beyond doubt; the former, however, also includes *Prionocid. baculosa*, var.

annulifera[1]. Whether Gray's *Cidaris annulata* is really *Prionoc. bispinosa*, may well be doubted. Gray gives the locality "West Indies" without any question mark. If this be correct, this species can, of course, not be identical with the Indo-Pacific *Prionocid. bispinosa*, but must be *Eucidaris tribuloides*; however, as the type does not appear to exist any longer, the question cannot be decided. Whether *Cidaris rosaceus* Rousseau and *Cid. circinnata* (Martens) are really synonyms of *bispinosa* must likewise remain uncertain, but both being nomina nuda this is quite unimportant.

That *Cidaris Lütkeni* de Loriol is identical with *Prionocidaris bispinosa* seems beyond doubt, as generally agreed upon. The statement in the original description of this species "Pores assez rapprochés l'un de l'autre dans chaque paire et séparés par une sorte de bourrelet non par une granule. On ne voit pas de trace de sillon" (Op. cit. p. 30) would seem to make this identification impossible. De Loriol has, however, himself corrected this statement; it has, indeed conjugate pores (Eocäne Echiniden aus Aegypten u. d. libyschen Wüste. 1882. p. 6) and later on he himself agrees that it cannot be maintained as a separate species and refers it as a synonym to "*Rhabdocidaris annulifera*" (Échinodermes de la baie d'Amboine, 1893; p. 360), being misled by Agassiz's wrong use of the name *annulifera*. Of course, de Loriol could not really mean his *Cidaris Lütkeni* to be a synonym of *annulifera* Lamarck, which he was himself the first to clear up.

The placing of the following genera of fossil Cidarids here in continuation of the recent genera of the group *Stylocidarina* is due to practical reasons and does not eo ipso imply that they all really belong to this group (cf. above p. 320). The author's opinion of the affinities of these fossils is given under each genus separately.

Genus **Plegiocidaris** Pomel.

Pomel. 1883. Classif. méth. p. 109.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 40.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 129.

Ambulacra simple, but on the peristome the ambulacral plates are pluriseriate; pores not conjugate. Primary tubercles perforate, crenulate. Primary spines with a rather long collar, forming like a handle to the club-shaped, not much longer shaft; the limit between collar and shaft often oblique, and the spine somewhat unsymmetrical.

Genotype: *Echinus coronatus* Schlotheim. Jurassic. (Fig. 144).

The species *coronatus* having by Lambert & Thiéry been designated the type of the genus, leads to the above diagnosis, which marks the genus very well off from the other fossil

[1] Lambert & Thiéry (1925. Ess. nom. rais. p. 561) express the opinion that "si le type est normal et ne représente pas un cas tératologique .... il devrait constituer un genre particulier". The suggestion is quite superfluous. The description and figures given by Troschel leave no doubt whatever that it is an abnormal specimen.

or recent forms. It would appear that Lambert & Thiéry overlooked the figures of an unusually well preserved specimen given by Quenstedt (Petrefactenkunde Deutschlands, 1872—75. Tab.62. 100—102), which shows beyond any doubt that this species had pluriseriate ambulacral plates on the peristome, a character otherwise known only in the recent genera *Phyllacanthus* and *Eucidaris*, though much less developed in these latter. *Plegiocidaris* then, in this regard, represents a markedly specialized type, in spite of its old age. It is not known, whether any of the other species of true *Plegiocidaris* really had the same arrangement of the peristomial ambulacral plates.

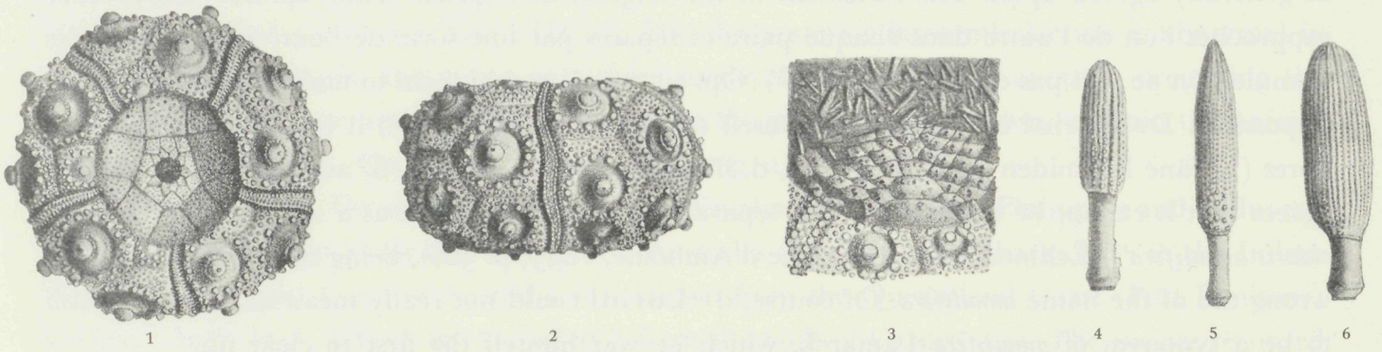


Fig. 144. *Plegiocidaris coronata*. Test seen from above (1) and in side view (2); part of peristome, showing pluriserial arrangement of ambulacral plates (3); primary spines (4—6). Fig. 3 magnified. (After Quenstedt. Petrefactenkunde Deutschlands. 1874. Taf. 62. Fig. 32, 34, 36, 38, 100.)

But judging from the parallel offered by *Phyllacanthus* and, to a somewhat less degree, by *Eucidaris*, it may well seem justifiable to conclude that such was the case.

As for the other species referred to the genus *Plegiocidaris* it seems unjustifiable to accept other than such with the same very characteristic form of primary spines as in *coronata* as really belonging to the genus. As such species may be mentioned the following:
Plegiocidaris cervicalis (Agassiz). Jura. (Paléont. Franç. Jurass. Pls. 178—180, 193. (Fig. 14, 5. p. 25).
Plegiocidaris perlata (Quenstedt). Jura. (Quenstedt. Petrefactenkunde Deutschl. Pl. 63, 2—18).
Plegiocidaris guinchoensis (De Loriol). Jura. (Loriol. Faune Jurass. du Portugal. Pl. IV, 5—8).

No doubt several other species will prove to belong to the genus as here limited. Thus, I think it quite probable that e. g. *Cid. valfinensis* Cotteau (Pal. Fr. Terr. Jurass. Pl. 195, 1—6), *Cid. Davousti* Cotteau (Ibid. Pl. 164, 1—8), *Cid. Sæmanni* Cotteau (Ibid. Pl. 151), *Cid. Falsani* Dumortier (Ibid. Pl. 144, 1—3), *Cid. langrunensis* Cotteau (Ibid. Pl. 162, 1—5) are really congeneric with *Plegiocidaris coronata*. But they are not sufficiently known for definitely assigning them a place within that genus. The fact alone that the tubercles are perforate and crenulate and the pores non-conjugate, or that the spines are like those of *Pl. coronata* is not sufficient — though I rather think a shape of the spines like those of *coronata* may be a definite proof. It is also quite possible that other species with somewhat similar spines may rightly belong to the genus, e. g. *Cidaris Dumortieri* Cotteau (Pal. Franç. Jurass. Pl. 155, 1—5), *Cid. bathonica* Cotteau (Ibid. Pl.157). But when Lambert & Thiéry refer to the genus *Plegiocidaris* also forms with long and slender,

perfectly smooth spines, like *Cid. Chantrei* Cotteau (Ibid. Pl. 155, 8—10) or with long and slender, coarsely thorny spines, like *Cid. armata* Cotteau (Ibid. Pl. 145, 16—18) I certainly must protest and express my astonishment that the authors who a few pages later in the same work use the shape of the primary spines as the only really distinguishing character for such genera (or subgenera) as *Balanocidaris* and *Sardocidaris* can, in the case of the genus *Plegiocidaris*, think such striking differences in the shape of the spines entirely valueless for a generic distinction.

As diagnosed here the genus *Plegiocidaris* is very well limited, and apparently confined to the Jurassic period. In the wide sense given it by Lambert & Thiéry *Plegiocidaris* is, as stated above, nothing but a lumber-room into which are thrown all forms with perforate, crenulate tubercles and non-conjugate pores, from the Trias to the recent days, regardless of other characters.

Whether the genus has any nearer relation to any of the recent forms is very hard to say. The character of the spines might indicate a relation to *Eucidaris*, and it may therefore seem the best course to place *Plegiocidaris* in the group of the *Stylocidarina*, where we have also, in *Acanthocidaris*, a recent form with crenulate tubercles. But I would not at all think it to represent the ancestral stock from which the *Stylocidarina* developed. The polyseriate condition of the ambulacra on the peristome indicate it to be an early highly specialized branch on the great Cidarid stem, which did, probably, not leave descendants among the recent forms. That it has no relation to *Histocidaris* which Lambert & Thiéry are bold enough to regard as a synonym of *Plegiocidaris* is perfectly clear and need not be discussed. Possibly a form like *Cid. Chantrei* Cotteau, with slender, perfectly smooth spines, may represent an ancestral Histocidarid.

Subgenus: **Paracidaris** Pomel.

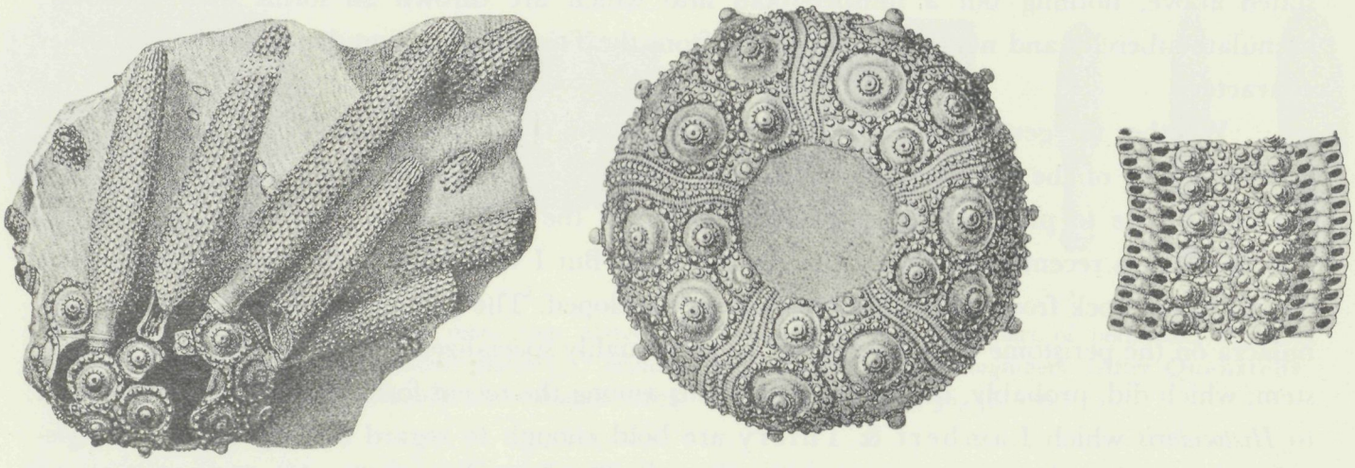
Pomel. 1883. Classif. méth. p. 109.
Döderlein. 1887. Jap. Seeigel. Cidaridæ. p. 40.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 135.

Ambulacra simple, but there is a tendency to forming compound plates, some of the marginal tubercles increasing in size, others becoming correspondingly smaller or totally disappearing, so that there may in places, especially adorally, be only one marginal tubercle corresponding to two pore pairs. Pores not conjugate. Primary tubercles perforate, crenulate. Primary spines thick, claviform, with short collar.

Genotype: *Cid. florigemma* Phillips. Jura. (Fig. 145).

To this subgenus may possibly be referred such species as *Cidaris Toucasi* Cotteau (Pal. Franç. Jurass. Pl. 143, 1—4) *Cid. bajocensis* Cotteau (Ibid. Pl. 154, 1—6), *Cid. Caumonti* Cotteau (Ibid. Pl. 153, 5—12), *Cid. Babeaui* Cotteau (Ibid. Pl. 155, 11—12; 156), *Cid. sublævis* Cotteau (Ibid. Pl. 158, 1—5), *Cid. Poucheti* Desor (Ibid. Pl. 199; 200, 1—4). In the absence of the spines it is not safe to ascertain definitely that they do belong together with the type, *Cid. florigemma*.

The only character really distinctive of *Paracidaris* in the diagnoses given by the authors quoted above is the tendency to form compound plates. This, however, is to be observed in several widely different forms of recent Cidarids, e. g. *Histocidaris Cobosi*, *Stereocidaris grandis*, *Phyllacanthus irregularis*. There is not the slightest doubt that this irregularity in the ambulacra has developed independently in these various forms of recent Cidarids, and we must infer from this fact that the same will be the case among fossils, and accordingly this feature cannot have the value of a generic character in itself alone. Also, Döderlein (Op. cit.) points out that we have the same tendency towards forming compound plates in other fossil Cidarids, as for instance in *Rhabdocidaris*. And even in *Cid. florigemma* the character is subject to much variation, as seen by the figures given in the Paléont. Française. Terr. Jurassique. Pl. 182—184.



1 2 3

Fig. 145. *Paracidaris florigemma.* Specimen with the primary spines partly in situ (1); test, from above (2); part of ambulacrum, magnified (3). (After Paléontologie Française. Terr. Jurassique. Pl. 181. 1; 182. 1 and 4).

It is thus necessary to take also other characters into consideration and here again, as in *Plegiocidaris*, the very peculiar shape of the primary spines of the type must be regarded as one of the main characters of the genus, or subgenus, and it must be a condition for referring other species to it, that their spines should be of the same main character. I must therefore emphatically protest against the referring (by all the authors quoted above) of such species as *Cid. spinulosa* Roemer (Pal. Franç. Jurass. Pl. 148, 11—12; 149), *Cid. spinosa* Agassiz (Ibid. Pl. 194) or *Cid. Legayi* Sauvage & Rigaux (Ibid. Pl. 201, 5—7; 202, 1—9) all with slender, thorny spines, to *Paracidaris*. Possibly *Cid. Zschokkei* Desor (Ibid. Pl. 150) may rightly belong there — and very probably some of the species having glandular spines of a similar form as in *florigemma*, as e. g. *Cid. cucumifera* Agass. (Ibid. Pl. 148, 1—10), *Cid. Roysi* Desor (Ibid. Pl. 154, 7—12), *Cid. filograna* Agass. (Ibid. Pl. 170) also belong here[1].

[1] I have not made a point of searching the literature on fossil Echinoids in order to find whether these species have been made more completely known, my object being — as stated above — only to deal with generic types of fossil Cidarids, not with all the various species referred to them.

It seems evident that *Paracidaris florigemma* must be nearly related to *Plegiocidaris*. Unfortunately we do not know, whether it had a similar arrangement of the ambulacral plates on the peristome as in *Plegiocidaris coronata*. But the great general resemblance between these forms leads to the suggestion that *Paracidaris* represents only a slightly more specialized branch from the latter and, in view of the small value to be attached to the irregularity of the ambulacra as a generic character, I cannot regard *Paracidaris* as more than a subgenus of *Plegiocidaris* (as is also the view held by Lambert & Thiéry).

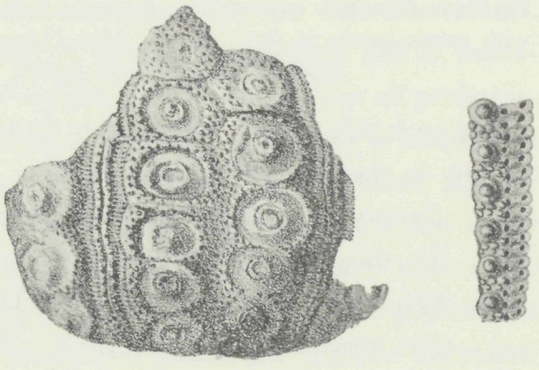
Genus **Alpicidaris** Lambert.

Lambert. 1910. Sur trois genres d'Échinides nouveaux. Ann. Soc. Linn. Lyon. LVII. p. 4.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 150.

Pores non-conjugate; on the oral side the ambulacra show a marked tendency towards forming compound plates, one larger tubercle corresponding to three ambulacral plates. Primary tubercles perforate, non-crenulate. Spines unknown.

Genotype: *Alpicidaris Cureti* Lambert. Cretaceous. (Fig. 146). No other species known.

As pointed out by Lambert this genus seems to be very closely related to *Paracidaris*, from which it differs — so far as known — only in the non-crenulate condition of the tubercles, and, accordingly, it is a quite obvious suggestion that it has derived from *Paracidaris*, since, as must be maintained against Lambert, it cannot be doubted that the forms with smooth tubercles (— apart from such old types as for instance *Triadocidaris*, where the matter is questionable —) have developed from forms with crenulate tubercles. It may rather be doubtful whether there is any reason for separating this species from *Paracidaris*. It is a curious case of inconsistency, when Lambert, who separates this species from *Paracidaris* as a distinct genus because of one having smooth, the other crenulate tubercles, makes the genus *Sinæcidaris*, established by Fourtau for a *Typocidaris*-like form which differs from *Typocidaris* (= *Stereocidaris*) only in having crenulate tubercles, a synonym of *Typocidaris*. If *Alpicidaris* is to be regarded as a separate genus, certainly *Sinæcidaris* must have the same claim to be held a separate genus.



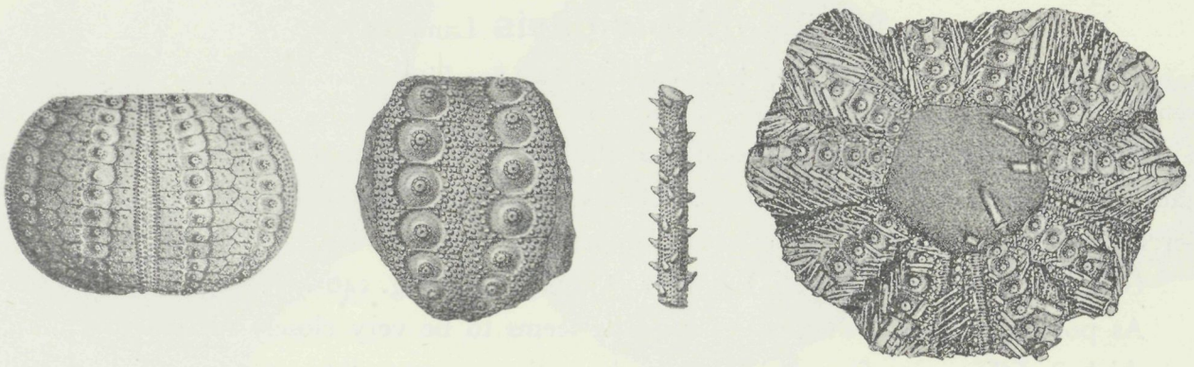
1 2

Fig. 146. *Alpicidaris cureti*. Fragment of test (1) and part of ambulacrum, magnified (2). (After Lambert & Thiéry. Essai de nomenclature raisonnée des Échinides. Pl. V. 1—2.)

Genus **Polycidaris** Quenstedt.

Quenstedt. 1858. Der Jura, p. 644; 1872—75. Petrefactenkunde Deutschlands, p. 215.
Pomel. 1883. Classif. méth. p. 109.
Döderlein. 1887. Jap. Seeigel; Cidaridæ, p. 41.
Duncan. 1889. Revis. Genera Ech. p. 34.
H. L. Clark. 1907. The Cidaridæ, p. 199.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 135.
NON: *Polycidaris* Bettoni.
Bettoni. 1900. Fossili Domeriani d. prov. Brescia. Mem. Soc. Pal. Suisse. XXVII. p. 11. (A. Pedinid).

Ambulacra straight; pores non-conjugate. Interambulacral plates rather numerous, up to about 15; all the areoles confluent, the scrobicular rings being reduced to an undulating line



1 2 3 4

Fig. 147. *Polycidaris multiceps* (1); *P. Legayi*, part of test (2) and of primary spine (3); *P. spinulosa*, oral part of test, with spines partly in situ (4). (1. After Quenstedt. Petrefactenkunde Deutschlands, Tab. 69. 10; 2—3. after Paléontol. Franç. Terr. Jurass. Pl. 202. 1, 5; 4. after the same work Pl. 148. 11).

along each side of the areole series. Tubercles perforate, crenulate. There may be small grooves or pits in the interambulacral midline. Primary spines (probably) slender, thorny.

Genotype: *Cidarites multiceps* Quenstedt. Jura. (Fig. 147. 1).

To this genus may, more or less probably, further belong:

Cid. nonarius Quenstedt (Petref. Deutschl. Tab. 69, 14) Jura.

Cid. trouvillensis Cotteau. Jura. (Pal. Franç. Jurass. Pl. 187).

Cid. Legayi Sauvage. Jura[1]. (Fig. 147. 2—3).

Cid. spinulosa Roemer. Jura. (Fig. 147. 4).

Cid. moraldina Desor. Jura. (Pal. Franç. Jurass. Pl. 205, 1—8).

Rhabdocidaris Rhodani Cotteau. Jura. (Ibid. Pl. 210, 8—9).

The species *Cidaris Blainvillei* Desmarest (Pal. Franç. Jurass. Pl. 161) and *Rhabdocid. Gauthieri* Cotteau, referred to *Polycidaris* by Pomel, Döderlein and Lambert & Thiéry could scarcely belong there, since they have conjugate, or at least subconjugate pores[2]. On the whole,

[1] The species *Cidaris Legayi* Cotteau is referred by Pomel (Op. cit.) first to *Paracidaris* and immediately thereafter to *Polycidaris*.

[2] The figure of the test, Pl. 211, represents *Rhabdocidaris Gauthieri* as having conjugate pores, the detail figure of the ambulacrum, fig. 2, same plate shows them non-conjugate.

it is clear that the confluent areoles alone do not suffice for a generic character, as this condition occurs in other forms which certainly cannot be referred to the genus *Polycidaris*, as in some triassic forms, like e. g. *Triadocidaris Suessi* Laube or *Miocidaris Keyserlingi* (Geinitz)[1]. On the other hand it should be a matter of course that only such species as have really confluent areoles can rightly belong in the genus *Polycidaris*. I cannot understand, therefore, how Lambert & Thiéry can refer *Cidaris Collenoti* Cotteau (Pal. Franç. Jurass. Pl. 153, 1—4), with not confluent areoles, to this genus.

The primary spines of *Polycidaris multiceps*, unfortunately, are unknown. But if we are right in referring such species as *Legayi* and *spinosa* to the genus *Polycidaris*, the slender, cylindric, more or less thorny spines will be a character of the genus.

As mentioned under *Procidaris*, there is a very considerable likeness between that genus and *Polycidaris*; were it not for the perforate ambulacral tubercles of the former, it would seem quite natural to make *Procidaris* a synonym only of *Polycidaris*, as is also done by Lambert & Thiéry who refer *Cid. Edwardsi*, the only genuine *Procidaris*-species of those originally referred to that genus, to *Polycidaris*.

Quenstedt (Petrefactenkunde Deutschlands p. 216) calls attention to the fact that the small grooves of the test of *Polycidaris* (*nonarius*) to some degree recall those of *Goniocidaris*, and after him Döderlein (Jap. Seeigel, p. 45) and H. L. Clark (The Cidaridæ, p. 199) have made the same observation, suggesting that there may be some genetic relation between these forms; H. L. Clark even definitely states that "it is clear that its relationships are with *Goniocidaris*. Except for the narrow ambulacra and the merged areolæ, *P. nonarius* is strikingly like *G. umbraculum*". I do not think a direct genetic relation between *Polycidaris* and *Goniocidaris* at all probable. The naked, sunk vertical line and the pits may well recall *Goniocidaris*, and there is nothing in the character of the pores which would forbid assuming a closer relation between them. But the fusion of the areoles in *Polycidaris* would seem to be a rather specialized character, not easily transformed to the type of areoles found in Goniocidarids. But above all: if *Polycidaris* were really the ancestor of *Goniocidaris*, how could we explain the fact that all the innumerable generations and all the transitional forms which must then have existed and linked the Jurassic *Polycidaris* with the recent *Goniocidaris* have totally disappeared, without leaving any trace in the geological history? Further I would point out that such grooves are by no means confined to *Polycidaris* (— where they are, at least, rather indistinct —) and *Goniocidaris*, but are found in several other forms, e. g. *Stereocidaris*, *Austrocidaris*, *Ctenocidaris* or even in the young *Cidaris cidaris*. I therefore think the suggestion of a genetic relation between *Polycidaris* and *Goniocidaris* entirely unjustified.

[1] Döderlein (Op. cit.) suggests that these triassic forms may be the ancestors of *Polycidaris*.

Genus **Procidaris** Pomel.

Pomel. 1883. Classif. méth. p. 109.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 41.

Ambulacra simple, but with marginal tubercles perforate. Pores not conjugate. Primary tubercles perforate, crenulate. Areoles confluent. Primary spines slender, cylindrical, smooth.

Genotype: *Cidaris Edwardsi* Wright. Jura. (Fig. 148).

To this genus, unique among Cidarids by its perforate ambulacral tubercles, Pomel referred, besides the above named species, *Cid. Toucasi* Cotteau, *Cid. Crossei* Cotteau and *Cid. spinosa* Agass. It is true that these species are represented in the Paléont. Française, Terr. Jurass. Pl. 143 and Pl. 194 as having perforate ambulacral tubercles, but, according to a kind information received from Lambert, *Cid. Toucasi* and *Cid. Crossei* have in reality imperforate ambulacral tubercles, the figures being erroneous in this regard, and as for *Cid. spinosa* the figs. 1—2, Pl. 194 which show this character, do not belong to *Cid. spinosa*, are not even of a Cidarid but of a Pedinid, related to *Orthocidaris*. As for the last of the species included by Pomel in his genus *Procidaris*, *Cid. Edwardsi* Wright, I have had the opportunity of examining the type specimen in the British Museum and can only affirm that the ambulacral marginal tubercles are really perforate, as also Dr. Bather had ascertained in a letter to me. Thus this species, by the elimination of the three other species, becomes the type of the genus, this perforation of the ambulacral tubercles being evidently a character of generic value.

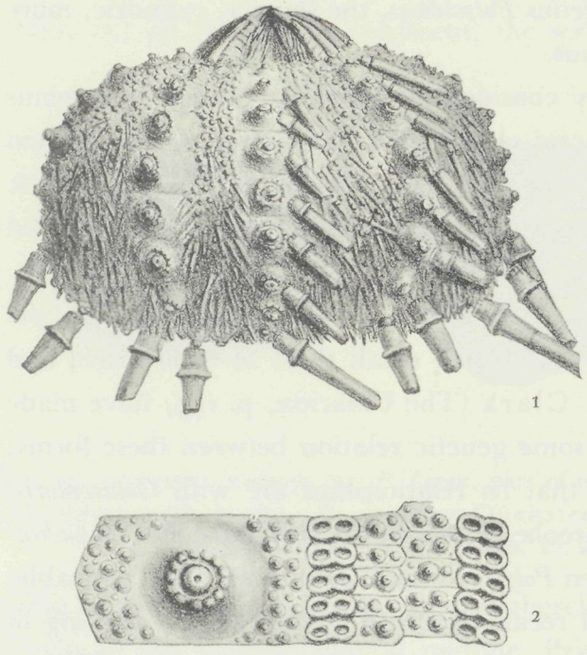


Fig. 148. *Procidaris Edwardsi*. Type-specimen, with the spines partly preserved in situ (1); part of test magnified (2). The specimen is represented upside down. (After Wright. Monogr. Brit. Fossil Echinod. Oolitic Formations. Pl. I. 1.a, 1.b).

It may be added that the statement of Pomel in his diagnosis of *Procidaris* that the pores are bigeminate on the oral side, thus approaching *Diplocidaris*, is erroneous as far as *Procid. Edwardsi* is concerned. There is some irregularity in the ambulacra towards the peristome, a tendency towards the formation of compound plates, but there is no diploporous condition.

The smooth, cylindrical primary spines of *Procidaris Edwardsi* recall the recent *Histocidaris*. But whether there is any real genetical relation between these two genera remains very doubtful, as, upon the whole, the affinities of *Procidaris* to recent Cidarids are quite uncertain. The character of the areoles and the ambulacral tubercles in *Procidaris* rather mark it as a very specialized, by no means as a primitive form, as the name "Procidaris" might suggest; it also appears that the oral primaries in *Procidaris* are simple, cylindrical and smooth, not strongly serrate as is usual

in *Histocidaris*. The confluent areoles recall *Polycidaris*, to which genus it is referred by Lambert & Thiéry.

Döderlein (Op. cit.) suggests that the Triassic Cidarid of which a fragment of an ambulacrum, showing the marginal tubercles partly perforate, is represented in his Taf. X, 20, may be an ancestor of *Procidaris*. This might not be improbable — if it be really a Cidarid which is represented in the said figure. This is, however, not at all certain; the ambulacrum rather belongs to an early Diadematoid form. Döderlein (Op. cit. p. 37) himself also suggests that it may perhaps belong to a *Hemicidaris*.

Genus **Balanocidaris** Lambert.

Lambert. 1910. Les Échinides fossiles des îles Snow-Hill et de Seymour. Wiss. Ergebn. Schwed. Südp. Exp. III. p. 4. Lambert & Thiéry. Ess. nom. rais. p. 146.

Pores non-conjugate. Primary tubercles perforate, non-crenulate. Primary spines very thickened, glandiform, with rather coarse spinules, serially arranged.

Genotype: *Cidaris glandifera* Münster. Jurass. (Fig. 14. 4, p. 25; Fig. 149. 4).

Other species: *Balanocidaris cucumifera* (Agass.) Jura. (Fig. 149. 1—2).

— *Roysii* (Desor.) Jura. (Fig. 149. 3).

— *meandrina* (Agass.) Jura. (Pal. Franç. Jurass. Pl. 163. 1—10).

— *icaunensis* (Cotteau) Jura. (Ibid. Pl. 190. 1—5).

Among the several other species referred by Lambert & Thiéry to this genus (or subgenus) I would think it very doubtful whether such as *Cid. Haussmanni* Wissman. (Bather. Triassic Ech. Bakony, Pl. XII) or *Cid. dorsata* Braun (Ibid. Pl. XI) really belong here; further such species as *Cid. Michaleti* Cotteau (Pal. Fr. Jurass. Pl. 487, 9—10), *Cid. pilum* Michelin (Ibid. Cretac. Pl. 1046, 1—11), *Cid. gibberula* Agass. (Ibid. Pl. 1051, 15—18) and *Cid. pleracantha* Agass. (Fig. 14. 6—7, p. 25) can only with uncertainty be regarded as belonging together with the typical *Balanocidaris*-species. There is no definite proof that all forms with more or less distinctly glandiform primary spines are nearly related; on the contrary, we know, that they are not, as we have very similar forms of spines in e. g. *Tylocidaris*, or in *Paracidaris* — or in the recent *Eucidaris galapagensis* and *clavata*.

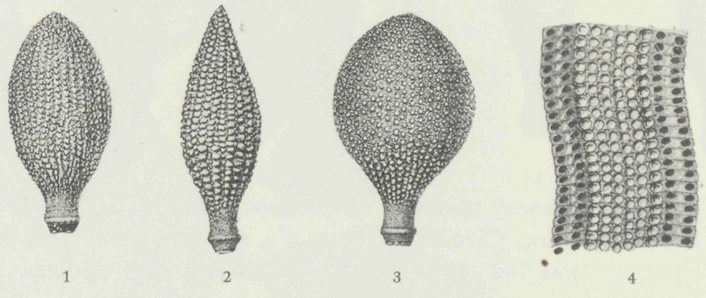


Fig. 149. Primary spines of *Balanocidaris cucumifera* (1—2), and *B. Roysii* (3); part of ambulacrum of *B. glandifera* (4). (After Paléontol. Franç. Jurass. Pl. 148. 4, 6; 154, 7 and 195, 12.)

This genus — or subgenus — may well be supposed to be related to *Eucidaris*, as is also the place assigned to it by Lambert & Thiéry.

Genus **Cyathocidaris** Lambert.

Lambert. 1910. Les Échinides fossiles des îles Snow-Hill et de Seymour. Wiss. Ergebn. Schwed. Südp. Exp. III. p. 1. Lambert & Thiéry. 1910. Ess. nom. rais. p. 145.

Pores non-conjugate. Primary tubercles perforate, non-crenulate. Primary spines of the aboral side cup-shaped, sometimes with a conspicuous central prominence; the widening may be confined to one side (*C. erebus*).

Genotype: *Cidaris cyathifera* Agassiz. Cretaceous. (Fig. 150. 1—3).

Other species: *Cyathocid. erebus* Lambert. Cretaceous. (Fig. 14. 8, p. 29).
Cyathocid. patera Lambert. Cretaceous. (Op. cit. Pl. I, 19—22).
Cyathocid. Nordenskiöldi Lambert. Cretaceous. (Fig. 150. 5—7).
Cidaris crateriformis Gümbel. Eocene. (Fig. 150. 4).

Quite probably also the other species referred by Lambert to this genus really belong there (*Cid. pistillum* Quenst., *C. Ortmanni* de Loriol, *C. avenionensis* Desm.); but in the absence of any knowledge of the test the fact that the spines of these forms are much less specialized must make us hesitate in simply referring them to this genus; perhaps also *C. Nordenskiöldi* should be regarded as doubtfully belonging to *Cyathocidaris*.

The spines of these forms, as pointed out by Lambert, recall those of *Goniocidaris*, but the absence of grooves in the test in the type species, the only one of which the test is known,

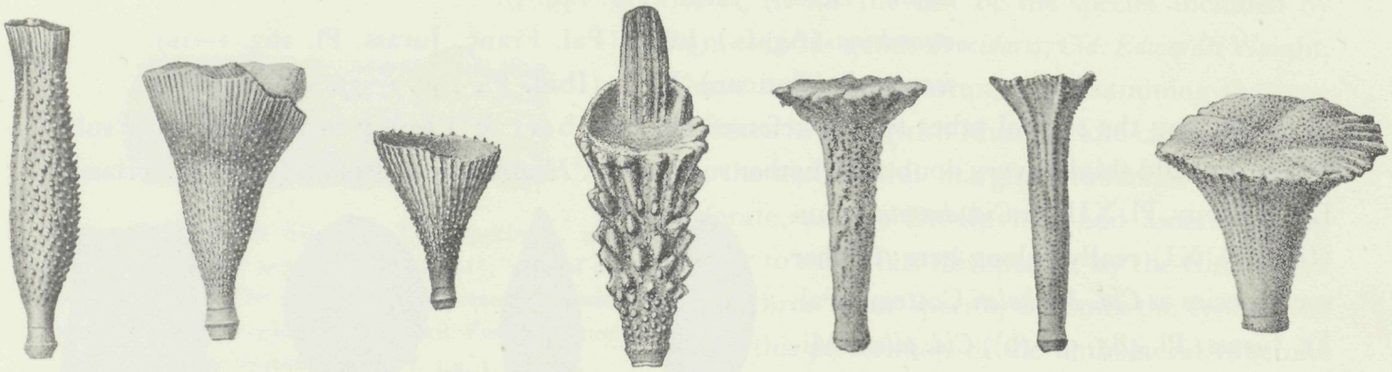


Fig. 150. Primary spines of *Cyathocidaris cyathifera* (1—3), *C. crateriformis* (4) and *C. Nordenskjöldi* (5—7). (After Paléontol. Franç. Crétacé. Pl. 1072. 1, 4, 10 (1—3); Pal. Franç. Eocène. Pl. 301. 11 (4), and after Lambert. Ech. foss. îles Snow-Hill & Seymour, Schwed. Südpolar Exp. III. 1910. Pl. I. 13, 15, 16 (5—7).

makes it very doubtful whether they have any relation to *Goniocidaris*, and it would rather seem probable that they are related to *Eucidaris* of which Lambert makes *Cyathocidaris* only a subgenus; whether it should rather be made a separate genus is a question of minor importance. The only thing that is quite safely said is that it is practical and appears natural to unite these forms into a separate group. But it must be remembered that there is no definite proof that the various forms with this type of spines are really related to one another. It is quite possible that such spines may have developed along different lines, as we know with certainty is the case with the broad, fan-shaped spines of *Rhabdocidaris*, *Cidaris Blakei* and *Notocidaris platyacantha*.

Genus **Tylocidaris** Pomel.

Pomel. 1883. Classif. méth. p. 109.
Döderlein. 1887. Jap. Seeigel, Cidaridæ, p. 41.
H. L. Clark. 1907. The Cidaridæ, p. 183.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 156.

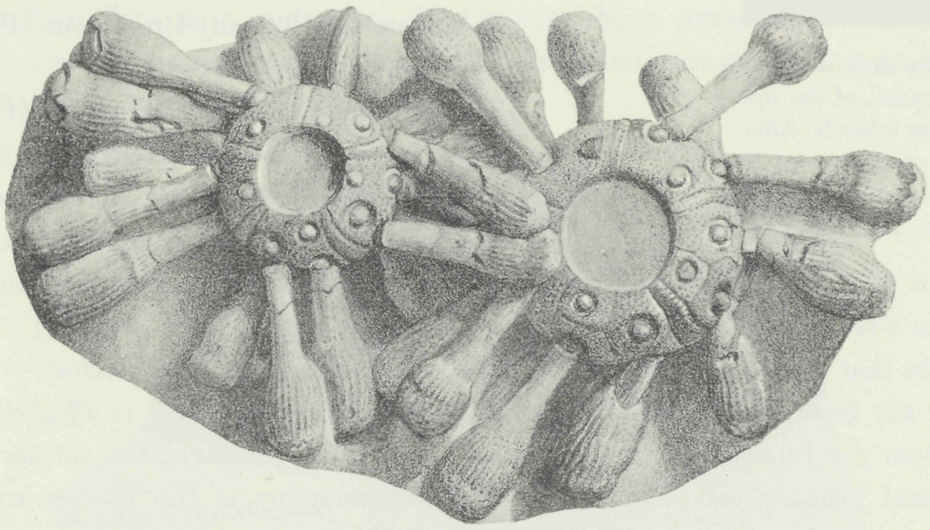


Fig. 151. *Tylocidaris clavigera.* Two specimens with the primary spines in situ. Natural size. (After Wright. Monogr. British fossil Echinod. Cretaceous Formations. Pl. IV. 1. a.)

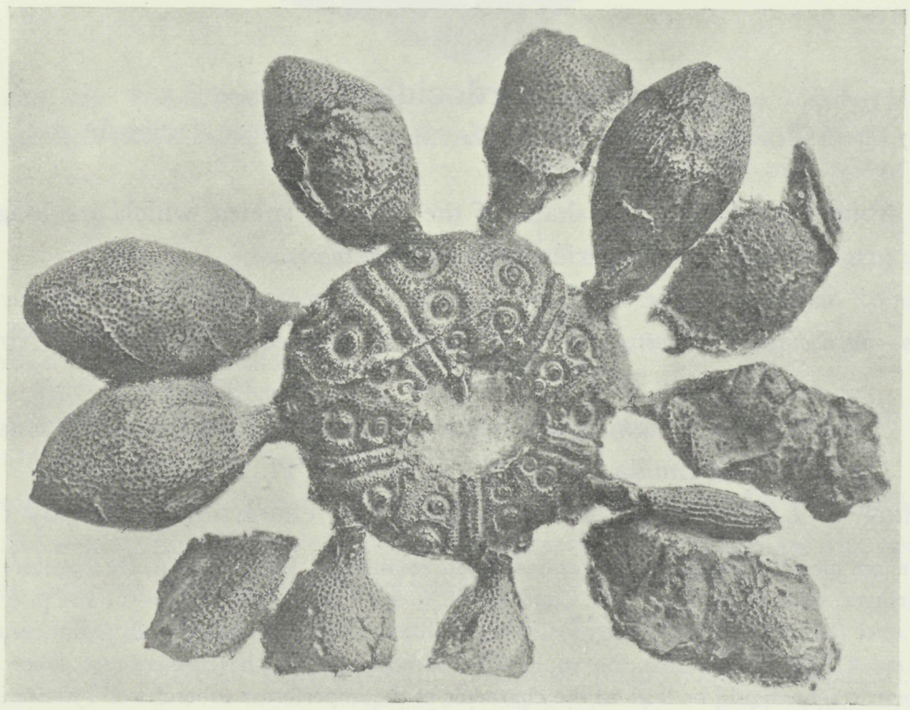


Fig. 152. *Tylocidaris baltica.* From a galvanoplastic cast of a specimen, or rather the empty impression of a specimen, in an erratic flint-block, found at Næstved, Seeland, in the Palæontological collection of Copenhagen. Nat. size. NB. The tubercles have come out rather indistinctly in the cast; in reality they are smooth, imperforate, as typical of *Tylocidaris.*

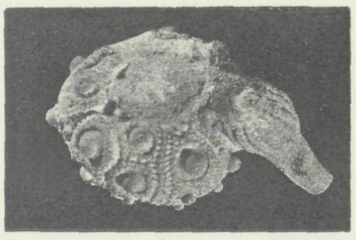


Fig. 153. *Tylocidaris clavigera*; showing perforation of the uppermost primary tubercle. After a photograph of a specimen in the palæontological collection Karlsruhe. Nat. size.

Pores non-conjugate. Primary tubercles imperforate, non-crenulate. Primary spines thick, club-shaped.

Genotype: *Cidaris clavigera* König. Cretaceous. (Fig. 151).

Other species: *Tyloc. Bowerbanki* (Forbes). Cretaceous. (Wright. Brit. Fossil Ech. Cretaceous. Pl. II. 1).

Tyloc. Ramondi (Cotteau). Cretaceous. (Pal. Fr. Cretac. Pl. 1076).

Tyloc. vexillifera Schlüter. Cretaceous. (Fig. 26, p. 41)[1].

Tyloc. baltica (Schlüter). Cretaceous. (Fig. 152)[1].

Tyloc. Walcotti (W. B. Clark). Cretaceous. (Clark & Twitchell. Mesozoic & Cenozoic Ech. U. S. Pl. IX. 3).

It is a very interesting fact that specimens of *T. clavigera* usually, but not constantly, show more or less distinct traces of perforation of the upper tubercles (Fig. 153), which proves beyond doubt that they have derived from Cidarids with perforate tubercles[2] — and we may again safely say from forms with crenulate tubercles. Döderlein sees in *Plegiocidaris propinqua* (Münster) from the Jurassic (Malm) the direct ancestor of *Tylocidaris*, this species having some of its proximal primary tubercles imperforate. As the spines of this species are also of the claviform type, the suggestion of Döderlein seems very probable. The genus has left no descendants among recent Cidarids.

Subgenus **Sardocidaris** Lambert.

Lambert. 1907. Descr. Éch. foss. Terr. Mioc. Sardaigne. Mém. Soc. Pal. Suisse. XXXIV. p. 22.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 156.

Differs from *Tylocidaris* in the shape of the primary spines, which are long, cylindric or fusiform. The primary tubercles imperforate as in *Tylocidaris*.

Genotype: *Sardocidaris Piæ* Lambert. Miocene. (Fig. 154).

Other species: *Sardocidaris Schweinfurthi* (Gauthier). Cretaceous. (Fourtau. Notes Éch. foss. Égypte. Bull. Inst. Égypt. 4 Sér. II. 1901. Pl. I. 1—3).

Sardocidaris Scarabellii (Stefanini). Miocene. (Stefanini. Ech. foss. mioc. medio dell'Emilia. Pal. Ital. XIV. 1908. Pl. I. 1—2).

According to Lambert the genus *Sardocidaris* is characterized also by the high ridge

[1] For the two species *Tylocidaris baltica* and *vexillifera* see further: J. P. J. Ravn. De Regulære Echinider i Danmarks Kridtaflejringer. 1928. Mém. Ac. R. Sci. Copenhague. 9. Sér. I. p. 29. Tav. III. 7—11 and p. 32. Tav. IV. 1—35.

[2] Stefanini (Echinidi del Miocene medio dell'Emilia. I. Pal. Ital. XIV. 1908, p. 67) recalls the statement by Agassiz (Rev. of Ech. p. 257) that the young "*Dorocidaris papillata*" has imperforate tubercles which would show that no great weight should be laid on the character of the imperforate tubercles of *Tylocidaris*. As shown here (p. 297) Agassiz's statement is beyond doubt erroneous, resting on an inaccurate figure, and the exceptional character of *Tylocidaris* is not shaken thereby.

separating the pore-pairs. As this ridge otherwise has not proved to afford characters of generic value it is rather certain that it is the same here — the more so as Stefanini (Op. cit. p. 68) states that in the species *Scarabellii*, which is very closely related to *S. Piæ*, if not, indeed, identical with it, this ridge is not at all specially prominent. Neither in the third species, *S. Schweinfurthi* is it represented as in any way unusually prominent. There is thus only the shape of the spines to separate it from *Tylocidaris*, and as the type species shows some rather transitional forms (see Fig. 154), I would not regard this genus as very valid, but rather as a subgenus of *Tylocidaris* — as it is done by Lambert & Thiéry (Op. cit.).

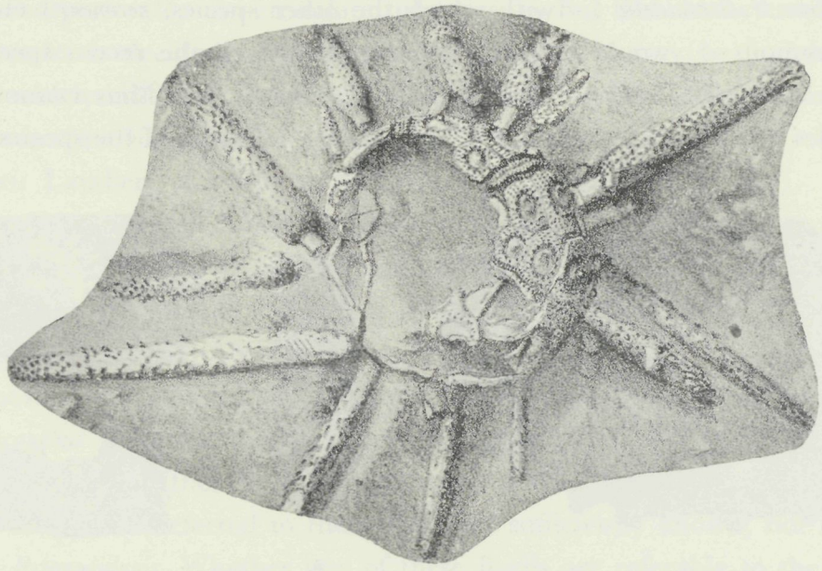


Fig. 154. *Sardocidaris Piæ*. Broken test with primary spines in situ. Nat. size. (After Lambert. Descr. Éch. foss. Terr. Mioc. de la Sardaigne. Mém. Soc. Pal. Suisse. XXXIV. 1907. Pl. II. 1.)

Genus **Porocidaris** Desor.

Desor. 1855. Synopsis des Éch. foss. p. 46.
Pomel. 1883. Classif. méthod. p. 112.
Duncan & Sladen. 1884. Fossil Echinod. Western Sind. III. p. 112.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 44.
Cotteau. 1889. Échinides Éocènes. Pal. Franç. Terr. Tertiaire. II. p. 465.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 138.

Pores conjugate. Primary tubercles perforate, crenulate; the areoles confluent, with a circle of deep, pore-like depressions. Primary spines, at least the oral ones, flattened and coarsely serrate, with the collar more or less coarsely tuberculate.

Genotype: *Cidarites Schmidelii* Münster. Eocene. (Fig. 155).

Other species: *Porocidaris ruinæ*. Oppenheim (Rev. d. tertiären Echiniden Venetiens u. d. Trentino. Zeitschr. deutsch. Geol. Ges. 1902. p. 173. Pl. VIII. 7). Eocene. (Only spines known).

Of the two other species referred by Lambert & Thiéry to *Porocidaris* one, *P. tuberculosa* Michelin is described only from a small fragment of a spine which is certainly too insufficient a base for stating this species with certainty to belong to this genus. The other, *P. anomala* Duncan & Sladen has the pores of the areoles only slightly developed, and Duncan & Sladen point out that it does not agree well with the original diagnosis of the genus in the very character upon which the genus was established. When, however, the authors do refer it to *Porocidaris*, they do so because the supposed discovery by Wyv. Thomson of a recent species, *Porocidaris purpurata*, seemingly proved the pores in the areoles to be not so essential a character as the only known fossil species *P. Schmidelii* (— with which the other species, *veronensis* etc. mentioned by Desor are synonymous —) would seem to indicate. However, the recent species described by Wyv. Thomson or Agassiz have no relation to *Porocidaris*, and thus cannot prove that the pores in the areoles are no valid character. Therefore the referring of the species *anomala* to *Poro-*

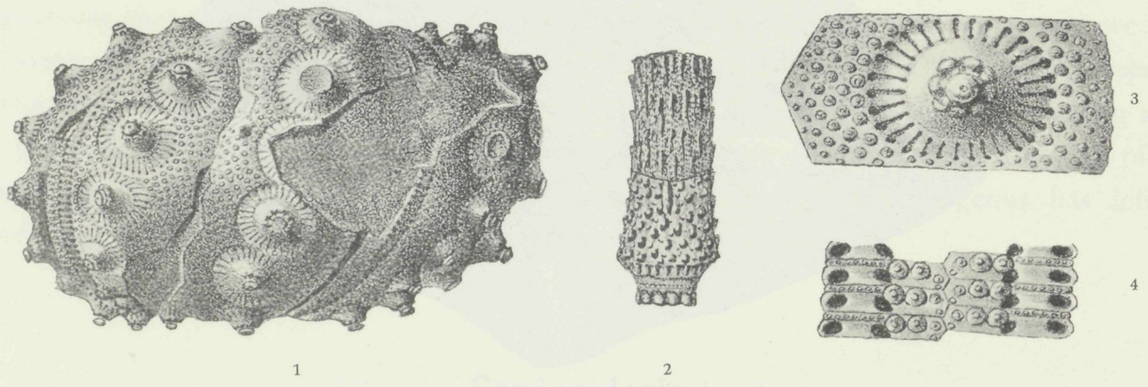


Fig. 155. *Porocidaris Schmidelii*. A partly crushed test, natural size (1); basal part of a primary spine (2); interambulacral plate (3) and part of ambulacrum (4), enlarged. (After De Loriol. Monogr. Éch. Couches Nummulitiques de l'Égypte. Mém. Soc. Phys. & Hist. nat. Genève. XXVII. 1880. Pl. I. 1, 1e, 1f. (1, 3—4), and Paléont. Franç. Eocène. Pl. 310. 17 (2).)

cidaris must remain doubtful, the more so as its spines are unknown, but for a small fragment of a slender (?aboral) spine; also the pores seem to be not typically conjugate as they are in *P. Schmidelii*.

The peculiar "pores" in the areoles, so very characteristic of this genus probably had no special function beyond serving for attachment of the spine-muscles. It appears that normally they did not perforate the test in life. In recent forms nothing quite similar occurs, but it is rather probable that the indistinct radiating impressions occurring in the areoles of several recent Cidarids are homologous with the pores in the areoles of *Porocidaris*.

The numerous recent forms which have at various times, from Wyv. Thomson to Agassiz & H. L. Clark, been referred to the genus *Porocidaris*, have, as already said, in reality nothing therewith to do, differing from it in having non-conjugate pores, and in having no circle of pores (or deep depressions) in the areoles. The reason for referring them to *Porocidaris* was the strongly

serrated oral primaries. But this is quite evidently a character which has developed in quite a number of forms not more nearly related e. g. *Histocidaris*, *Aporocidaris*, *Ctenocidaris*.

The genus *Porocidaris* may perhaps be the nearest related to *Rhabdocidaris*.

Pleurocidaris Pomel (Class. méth. p. 111).

It seems to me exceedingly doubtful whether this genus can justly be maintained. The character distinctive of *Pleurocidaris* is the arrangement of the miliary granules of the broad interambulacral median space in distinct horizontal series, separated by narrow lines; otherwise it agrees with *Phyllacanthus* and *Prionocidaris* (the *Leiocidaris* of Lambert & Thiéry) in having conjugate pores and perforate, non-crenulate tubercles. — But this character of the interambulacral miliary tubercles is decidedly not of generic value, as it may be found in all degrees of development in widely different forms (e. g. *Prionocidaris baculosa*, *Chondrocidaris gigantea*, *Calocidaris micans*, *Goniocidaris biserialis*).

Aulacocidaris Lambert (Lambert & Thiéry. Ess. nom. rais. p. 155).

The genus *Aulacocidaris* of Lambert likewise agrees with *Phyllacanthus* and *Prionocidaris* (or Lambert & Thiéry's *Leiocidaris*) in the characters of the pores and the primary tubercles, but is stated to differ from them in the ambulacra having a tendency to form compound plates adorally, the marginal ambulacral tubercles being here alternately large and small. This, however, has also been shown by a closer study of the recent forms to be no reliable generic character, especially *Phyllacanthus irregularis* affording a striking proof thereof.

In my opinion then neither *Pleurocidaris* nor *Aulacocidaris* are valid genera, and very probably at least some of the species referred to them might, if sufficiently known, not be distinguishable from the recent *Prionocidaris*. Whether any of these fossils are referable to the true *Phyllacanthus* seems more doubtful.

Group *Rhabdocidarina.*

Pores conjugate; they may be arranged in double series on the peristome. Tubercles crenulate or non-crenulate. Primary spines on the whole large and coarse, cylindrical, smooth, or with more or less coarse thorns, sometimes very conspicuously widened. Large globiferous pedicellariæ with a rather large subterminal opening, without an end tooth; stalk without a distinct limb; small globiferous pedicellariæ with or without an end tooth. Large forms.

The group is not very well limited, and perhaps the genus *Phyllacanthus* does not rightly belong here but should rather form a group of its own or perhaps be referred to the *Stylocidarina*. The fossil genus *Rhabdocidaris* may well be regarded as the main genus of the group, and to this the recent genus *Chondrocidaris* would seem to be related. The fossil genus *Porocidaris* is perhaps also related to *Rhabdocidaris*.

Key to the recent genera of the group Rhabdocidarina.

Primary spines rather coarsely thorny; pores on the peristome in a single series..... *Chondrocidaris.*
Primary spines smooth; pores on the peristome in double series..... *Phyllacanthus.*

Genus **Rhabdocidaris** Desor.

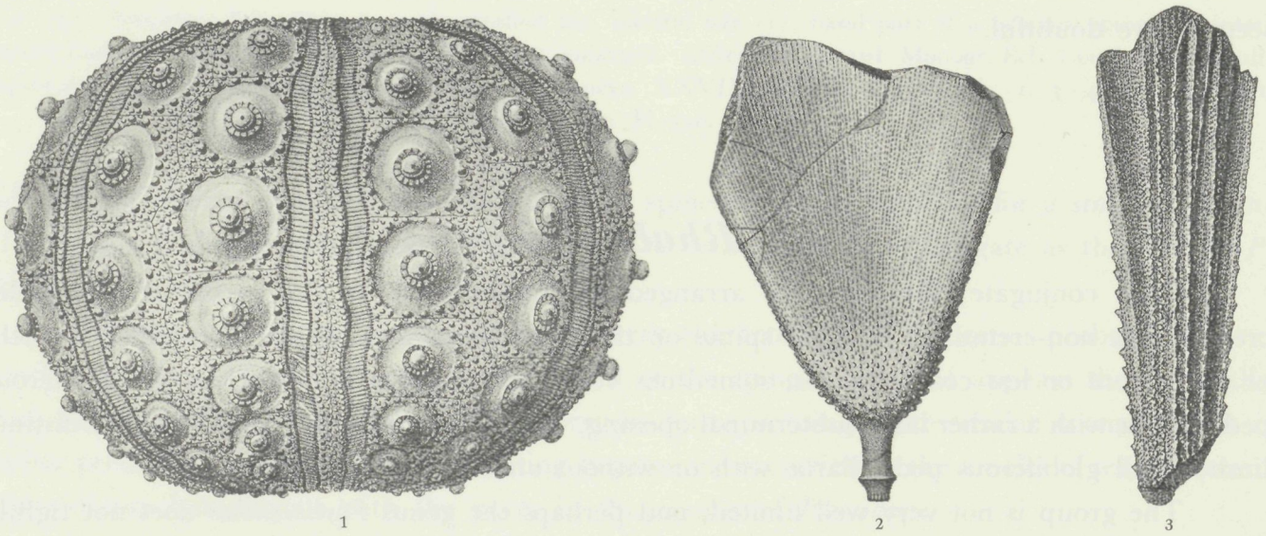
Desor. 1855. Synopsis des Éch. foss. p. 39[1].
Pomel. 1883. Classif. méth. p. 111.
Döderlein. 1887. Jap. Seeigel. Cidaridæ. p. 42.
Duncan. 1889. Revis. gen. Ech. p. 31.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 136.

Ambulacra more or less strongly sinuate, pores conjugate. Primary tubercles perforate, strongly crenulate. Primary spines very long, slender, thorny, or widened into broad plates. Mainly forms of very large size.

Genotype: *Cidaris orbignyana* Agass. Jura. (Fig. 156. 1, 3).

Other species: *Rhabdocidaris major* Cotteau. Jura. (Pal. Franç. Jurass. Pl. 206, 8—10; 207; 208).
Rhabdocidaris horrida de Loriol. Jura. (Ibid. Pl. 209; 210, 1—7).
Rhabdocidaris sarthacensis Cotteau. Jura. (Ibid. Pl. 218, 1—4).
Rhabdocidaris copeoides Desor. Jura. (Fig. 14, p. 25; Fig. 156. 2).
Rhabdocidaris trispinata (Quenstedt). Jura. (Quenstedt. Petref.k. Deutschl. Tab. 65, 37).

Probably a good many of the other fossil species referred to this genus in Lambert & Thiéry's "Essai nom. rais." really belong here, but certainly not all of them. Especially I do



1 2 3

Fig. 156. *Rhabdocidaris orbignyana*, test in side view, slightly reduced (1); primary spines (broken) of *Rh. copeoides* (2) and *Rh. orbignyana* (3); natural size. (After Pal. Fr. Jurass. Pl. 225. 1 (1), 216. 1 (2) and 226. 3 (3)).

[1] Desor spells the name *Rabdocidaris*; but as in other places, e. g. p. 2, 48, he writes it *Rhabdocidaris*, it is evident that the spelling without an h in the place quoted is due to a misprint.

not think that such forms as have long and slender spines with coarse, outstanding thorns can really belong to this genus, as e. g. the pliocene *Cid. rosaria* Bronn[1] or the miocene *Rhabdoc. Sanchezi* Lambert (Ess. nom. rais. Pl. XIV, 1—3), or *Cid. prænobilis* Quenstedt (Petref.k. Deutschl. Tab. 65), which has also been referred to *Rhabdocidaris* (— Lambert & Thiéry refer this species to *Plegiocidaris*, which is equally unacceptable —). That some of the numerous cretaceous and eocene species are true *Rhabdocidaris* may be quite possible, but at least there is no indication that the genus survived the Eocene. Its flourishing age was the Jurassic Period.

Genus **Chondrocidaris** A. Agassiz.

A. Agassiz. 1863. List of Echinod. p. 18.
Th. Mortensen. 1903. "Ingolf" Ech. I. p. 29.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 102.
H. L. Clark. 1907. The Cidaridæ. p. 190; 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 2, 10.

Apical system ca. 36—45 % of h.d., very compact and closely covered with tubercles of uniform size. Oculars widely exsert; madreporite scarcely larger than the other genital plates. Test thick, with a wide median interambulacral space closely covered with small tubercles of uniform size, of the shape of elevated, glassy, more or less spiny warts, without a mamelon; they carry very small, conical, appressed spines, which are attached to the side, not to the top of the tubercle. Same sort of spines on apical system and in the median ambulacral area. Primary tubercles smooth, non-crenulate, the areoles not much sunken, not confluent; primary spines thick, with very coarse thorns, arranged without any distinct order. Surface of shaft otherwise with delicate, not branched hairs. Collar fairly long, indistinctly or not at all striate. Pores conjugate. The peristome is about the size of, or even distinctly exceeding the apical system; peristomial ambulacral pores in single series. Large globiferous pedicellariæ without, small globiferous pedicellariæ with an end tooth; no limb on the stalk. Tridentate pedicellariæ simple.

Genotype: *Chondrocidaris gigantea* A. Agassiz.

The characters of the small secondary spines and tubercles distinguish this genus from all other recent Cidarids. Also the primary spines are rather unique. These characters, together with the others, mentioned in the diagnosis, raise the generic value of this form beyond any doubt, and since both Agassiz and Clark have acknowledged the correctness of recognizing it as a distinct genus, against the former mixing it up with *Phyllacanthus*, there is no need for a further discussion of this matter. — To unite it with the fossil *Rhabdocidaris*, as done by de Loriol, is evidently out of question, the strongly crenulate tubercles of the latter being too marked a difference, and there being no proof at all that the other features, characteristic of the recent form, were found also in the fossils.

[1] Cf. Lambert. Description des Échinides fossiles des terrains miocéniques de la Sardaigne (Mém. Soc. Palæont. Suisse. XXXIV. 1907. Pl. II, 13).

Until quite recently only one species of this genus was known, the *Chondrocidaris gigantea*, recorded from Hawaii, the Loyalty Islands and Mauritius. But in 1925 the form from the Loyalty Islands was shown by H. L. Clark to represent a distinct species. Thus we know at present two species of this genus, both confined to the Indo-Pacific.

Very probably also a fossil form should be referred to this genus. J. Cottreau (Echinides de Madagascar, Ann. de Paléontol. III. 1908. p. 39) describes and figures (Pl. V. 7, 7 a.) some primary spines of a "*Phyllacanthus*" which so strikingly recall *Chondrocidaris* that it would seem fairly justifiable to see herein a form closely related to the one now living at Mauritius (the thorns appear to be confined to one side of the spines as in some specimens of the Mauritius-form); very likely it is the direct ancestor of this recent form. The fossil spines were found in deposits of probably Miocene Age.

Further the spines described as "*Phyllacanthus*" *sundaica* by K. Martin (Palæontol. Ergebnisse von Tiefbohrungen auf Java. Samml. Geol. Rijks Mus. Leiden. Bd. III. 1883—87. p. 287. Tab. XV. 293. a—f) have partly a considerable resemblance to the spines of *Chondrocidaris* and may not unlikely belong to that genus, as also Martin himself has pointed out this resemblance and the probable relation of this tertiary fossil to the recent Hawaiian "*Phyllacanthus*" *gigantea*.

Whether the spines figured by Duncan & Sladen (Monogr. Fossil Ech. of the Makrán series. Pal. Indica. XIV. 1886. Pl. LVII. 1, 2, 14) belong to a related form, as suggests Cottreau, seems more doubtful.

Key to the species of Chondrocidaris.

Spines more or less fusiform, collar widened outwards, vase-shaped, ca. 7—15 mm..... *Ch. brevispina.*
Spines cylindrical, collar not widening outwards, scarcely exceeding 5 mm..... *Ch. gigantea.*

Chondrocidaris gigantea (A. Agassiz).

Pls. LXIV. 1—2; LXV; LXVI; LXXIV. 3—4.

Chondrocidaris gigantea. A. Agassiz. 1863. List of Ech. p. 18.
Phyllacanthus gigantea. A. Agassiz. 1872. Rev. of Ech. p. 150, 390. Pl. **I. a; I. e. 27—31.**
Phyllacanthus gigantea. A. Agassiz. 1881. "Challenger" Ech. p. 40.
Rhabdocidaris gigantea. De Loriol. 1882. Eocæne Ech. a. Ægypten u. d. Lib. Wüste. p. 6.
Rhabdocidaris gigantea. De Loriol. 1883. Cat. Rais. Ech. Maurice. p. 8. Pl. **II. 1.**
Phyllacanthus gigantea. Rathbun. 1886. Cat. Ech. U.S. Nat. Mus. p. 262.
Leiocidaris gigantea. Döderlein. 1902. Ech. Amboina & Thursday Isl. (Semon). p. 690.
Chondrocidaris gigantea. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 20, 29. (non Pl. X. 15, 19, 26 = *brevispina*).
Chondrocidaris gigantea. Döderlein. 1906. Ech. Deutsche Tiefsee Exp. p. 96, 102.
Chondrocidaris gigantea. A. Agassiz & H. L. Clark. 1907. Hawaiian Ech. Cidaridæ. p. 14. Pl. 4. 13—19.
Chondrocidaris gigantea. H. L. Clark. 1907. The Cidaridæ, p. 191.
Chondrocidaris gigantea. Th. Mortensen. 1909. Ech. Deutsche Südpolar Exp. p. 53.
Leiocidaris gigantea. Lambert & Thiéry. 1910. Ess. nom. rais. p. 155.
Chondrocidaris gigantea. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 11.
NON: *Phyllacanthus gigantea.* Sluiter. 1895. Echiniden Samml. Mus. Amsterdam. p. 68 (= *Prionocidaris bispinosa*).
— *Phyllacanthus gigantea.* Bell. 1899. Rep. Ech. coll. by Dr. Willey. p. 135 (= *Chondrocidaris brevispina*).

	h. d.	v. d.	Apical system	Peristome	Width of I. A.	Width of A.	Number of I. A.	Number of A.pro I.A.	Longest Spines
1	100 mm	68 mm	41 mm (41 % h.d.)	35 mm (35 % h.d.)			10	14—15	155 mm
2	97 —	55 —	35 — (36 —)	33 — (34 —)	49 mm	9 mm	10	14—15	102 —
3	93 —	55 —	35 — (37.3 —)	34 — (36.6 —)			9 (10)	13—15	96 —
4	84 —	48 —	29 — (34.5 —)	32 — (38 —)			8—9	15—16	83 —
5	78 —	45 —	33 — (42.3 —)	30 — (38.5 —)	40 —	9 —	8	14—15	83 —
6	73 —	45 —	29 — (39.7 —)	32 — (44 —)	37 —	7.5 —	8—9	15—16	
7	36 —	21 —	16 — (44.4 —)	18 — (50 —)	19.5 —	4 —	5	15—17	58 —

Specimen 1 in the Paris Museum, 2 in the Copenhagen Museum, 3, 4 and 6 in the Museum of Comparative Zoology, 5 in the U. S. National Museum and 7 in the Genève Museum. The specimen 6 is the naked test, Pl. LXIV. 1—2.

Test rather low, the height not much more than half h.d., flattened above, scarcely so below, the sides very beautifully arched. Circumference round. — Ambulacra 18—20 % of width of I.A., almost straight. Interporiferous zone ca. 1.3 the width of a pore area. Marginal series of tubercles very regular, but rather inconspicuous, the tubercles being somewhat unusually low, but contiguous. The space inside the marginal series wholly filled up by secondary tubercles, almost as large as the marginal ones and, in larger specimens, of somewhat irregular shape. Those nearest the marginal tubercle form a distinct longitudinal series, the rest may be more irregularly placed so as not to form distinct longitudinal series. The horizontal sutures are deep and may continue almost directly across the area, the vertical, median sutures being partly indistinguishable. The whole interporiferous zone flat, without indication of a sunk midline, somewhat elevated above the pore zone. Pores rather distant, very distinctly conjugate. The outer pore apparently somewhat larger than the inner (Pl. LXXIV. 3—4), which is, however, due to the rising of the interporiferous zone above the pores, the inner pore being thereby partly covered.

Interambulacra. Tubercles non-crenulate. Areoles all very distinctly separated, the upper ones even so much as to give room for several small tubercles (spines) between the two neighbouring scrobicular circles. They are only little sunk. Those at and especially below the ambitus distinctly transverse-oval. The median space very broad, as broad as, or even distinctly broader than an areole; it is closely and uniformly covered with small tubercles, which leave no naked or sunk median line. Also on the adradial side of the scrobicular ring there is, especially in the largest specimens, a rather broad space covered with the same uniform tuberculation. The scrobicular tubercles semicircular, not very prominent, though conspicuously larger than those outside and than the marginal ambulacral tubercles. The small tubercles rather high, somewhat glassy warts, without any mamelon; (this also holds good of the secondary ambulacral tubercles). Numerous rather sharp horizontal lines on the interambulacral plates, passing directly across the midline from one plate to the other.

Apical system ca. 35—41 % h. d. in the larger specimens, evidently relatively larger in

the younger specimens. Oculars all exsert, triangular. Madreporite not conspicuously larger than the other genital plates. Genital pores rather small, more or less distant from the outer edge of the plate. Periproct rather small, not elevated; the periproctal plates not very numerous, the outer ones rather large. The whole of the apical system closely covered with small tubercles (spines) like those of the median interambulacral space, those along the edge of the plates scarcely larger than the rest, while those on the inner periproctal plates are somewhat larger.

Peristome about the same size as, or even distinctly larger than the apical system[1]. There are ca. 20 ambulacral plates in a series, each with 2—3 fairly large tubercles on each side of the pore. Interradial plates 8—10 in a series, not reaching to the edge of the mouth.

Primary spines at ambitus as a rule scarcely exceeding h.d. in length, but may be as much as 1.5 h.d.; the upper ones considerably shorter. They are cylindrical, slightly tapering in the outer part, ca. 6—7 mm thick at base, set with very coarse thorns arranged without any order. Towards the end of the spine these thorns gradually develop into high ridges, and at the point may form a rather large, flaring, irregular crown. Surface of spines otherwise apparently smooth, but covered with fine hairs, which do not branch or anastomose. On a spine from the large specimen in the Paris Museum the hairs in places form a very dense, velvety coat, especially on the basal part. The hairs are shorter and less close set in the distal part of the spine. Evidently the hairs break off very easily, so that it is difficult to find a spine quite intact. The collar is ca. 5—7 mm long, scarcely widening towards the milled ring which is not at all prominent. There is no distinct neck. The collar does not — or at most very indistinctly — show the fine striping otherwise usually seen, and neither do the young spines show the usual fine stripes, a fact which is due to the structure of the calcareous tissue of the spine being rather less regular than usual. Also the cortex layer of the primaries is somewhat unusually feebly developed (Fig. 157). The oral primaries are very simple, not widened or flattened, only simply fluted, and pass very gradually through the second and third to the ambital spines.

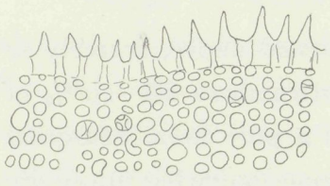


Fig. 157. Part of transverse section of primary spine of *Chondrocidaris gigantea*. × 65.

Secondary spines. Scrobicular spines ca. 10 mm long, flat, not pointed, sometimes slightly excavated near the end, which is straight cut. The marginal ambulacral spines 5 mm long, slender, scarcely flattened near the point. The rest of the secondary spines small cones, scarcely 1 mm long, only those close to the scrobicular circle slightly larger. They are appressed and attached to the sides of the tubercles, not to the top — in accordance with the unusual shape of the small tubercles. On the peristome the spines of the interradii are ca. 1—1.5 mm long, those of the ambulacra 3—4 mm long, excepting the one nearest the midline of the radius, which is again shorter, ca. 2 mm long. The whole inner part of the peristome closely covered with spines of

[1] Agassiz & Clark 1907 (Op. cit. p. 14) give the diameter of the peristome of a specimen 83 mm h.d. (very probably the above specimen 4) as only 18 mm (23 % h.d.). This, evidently, is an error.

uniform length, 3—4 mm long, flattened, spatulate, as is the usual shape of the peristomial spines in Cidarids.

Pedicellariæ. Large globiferous pedicellariæ unknown; a single sample was found on one of the specimens in the British Museum, but, unfortunately the calcareous substance was completely dissolved[1]. The small globiferous pedicellariæ are very numerous, occurring all over the test among the small spines, also on the peristome. They have the characteristic form shown in Pl. X. 26 of the "Ingolf" Ech. I. and in Pl. 4. 15—16 of "Hawaiian Ech. Cidaridæ", the opening elongate, triangular, with a distinct, though as a rule rather small end tooth. They reach scarcely a size of 0.5 mm length of head, the stalk being somewhat shorter. The tridentate pedicellariæ, which are rather scarce, reach a size of nearly 2 mm length of head, the stalk being of about the same length. The valves are narrow, simple, joining in their whole length and very much resemble those of *Ch. brevispina* (cf. Pl. LXXXVII. 18—19). Spicules of tubefeet not peculiar. The intestinal wall studded with small, irregular, fenestrated plates; in the upper part of the intestine they are much larger and form a continuous pavement. The genital organs contain a number of more or less regular, large, anchor-shaped spicules (Fig. 158).

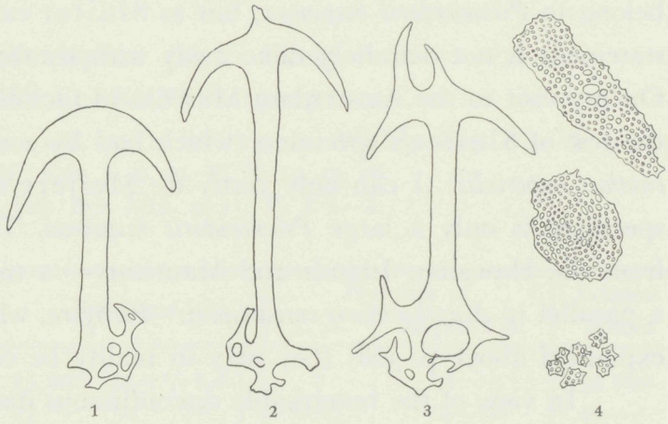


Fig. 158. Spicules from the genital organs (1—3) and from the intestinal wall (4) of *Chondrocidaris gigantea*. × 36.

Colour. Primary spines of a dark chocolate colour (according to Agassiz & Clark) or more reddish, more or less spotted or mottled. Larger secondary spines dark brown at tip, lighter in the basal part; the small spines greyish-yellow. The naked test of a slight greenish tint, with a touch of brownish towards the interambulacral midline.

Biology. Lives on a sandy bottom outside the reefs. Its spines may be very much overgrown by various organisms — algæ, sponges, Bryozoans, Foraminifera, Molluscs (Oysters, Calyptræa) and worms[2]. — Development unknown. The fact that a very young, just metamorphosed Cidarid was found on the peristome of the specimen in hand is no proof that it is viviparous or protects its brood, as there is no certainty at all that it is a young of this species; in fact this young specimen very closely resembles the young specimens of *Eucidaris metularia* which I have collected at Banda, and as the latter species also occurs at the Hawaiian Islands,

[1] The large form figured in the "Ingolf" Ech. I. Pl. X. 15, 19 was found on the specimen from the Loyalty Isl. in the British Museum, collected by Willey, and thus belongs to the species *brevispina* H. L. Clark.

[2] In some of the spines on the peristome some parasitic organism appears to live; these spines are considerably broader than the others, more or less corroded at the point, and also darker coloured than the others. From the dried specimen, on which this observation was made, nothing definite can, of course, be said about the reason for this transformation of the spines, but appearance is decidedly for its being due to some kind of parasitic organism.

it may well be a young *Eucidaris metularia* which has happened to settle down on this specimen of *Chondrocidaris gigantea*.

Occurrence. Hitherto known with certainty only from the Hawaiian Islands, from depths of ca. 25—385 m., and from Mauritius. — It has been recorded also from the Loyalty Islands and the Java Sea. The specimen from the Loyalty Islands (Coll. Willey) was made the type of the new species *Ch. brevispina* H. L. Clark (1925). The record of its occurrence in the Java Sea is due to Sluiter, who mentions (Op. cit.) a specimen from the Lipar Islands, at Banka. De Meijere ("Siboga"-Ech. p. 204) asserts that the spines, on which Sluiter's statement rests, belong to *Prionocidaris bispinosa*; but as Sluiter expressly says: "ein getrocknetes Exemplar" his statement is not definitely done away with by de Meijere's examination of the spines alone. On my visit to the Amsterdam Museum in October 1926 I succeeded, however, in finding also the test of Sluiter's specimen (which had by a mistake been laid among some tests of *Phyllacanthus imperialis*). I can only verify de Meijere's statement: there is no doubt that Sluiter's specimen is only a large *Prionocidaris bispinosa*. Thus *Chondrocidaris gigantea* is still known only from the Hawaiian Islands and Mauritius — a most remarkable distribution; it has, however, a parallel in *Acanthocidaris curvatispinis—hastigera*, which two species are so closely related that (as explained above p. 328) they may in reality be one and the same species.

In view of the remarkable discontinuous distribution the question, whether the specimens from Mauritius could perhaps be distinguished as a separate species, deserves very careful consideration.

Through the kindness of the late Professor M. Bedot, Director of the Natural History Museum of Genève, I have been able to examine in detail the specimen described and figured by de Loriol (1883, Op. cit.); the measurements are given above (specimen 7). From a study of this specimen I was inclined to regard this form as, at least, a separate variety, on account of the ambulacral structure and the spines. The ambulacra (Pl. LXXIV. 3) have only a single tubercle inside the marginal one, forming a very regular series, whereas in the Hawaiian form there are, even at the edge of the peristome, four inner series of tubercles. The primary spines have the large thorns or outgrowths very unequally developed, the adoral side of the spine being nearly smooth. The marginal ambulacral spines are broad and flat, while in the Hawaiian form they are slender and narrow, only slightly flattened towards the point. Also in regard to colour the primary spines differ from those of the Hawaiian form, being irregularly spotted with red on a lighter ground colour.

These differences would seem to be important enough for regarding the Mauritius form as a separate species, and certainly would be so, if they were constant. But they are not constant. Other specimens from Mauritius are so like the Hawaiian form that it seems impossible to distinguish them. Therefore I cannot but join H. L. Clark who states (Cat. Rec. Sea-Urch. Brit. Mus.) that on a closer inspection he did not find sufficient reason to distinguish the Mauritius from the Hawaiian form, even though his first impression was to the contrary.

If, as the facts available tend to show, the species *Chondrocidaris gigantea* really lives only at Hawaii and Mauritius, the only natural explanation of this discontinuous distribution would seem to be that these two populations are the last remnants of a species formerly widely distributed over the Indo-Pacific area. This would then also lead to the suggestion that it cannot have a typical pelagic larva, as it would otherwise be very difficult to understand, why the larva should not be transported by the currents so as to give rise to new colonies in other localities, at least in the Indian Ocean.

Chondrocidaris brevispina (H. L. Clark).

Pls. LIV. 1—3; LXXIV. 2; LXXXVII. 13—19.

Phyllacanthus gigantea. Bell. Report on the Echinoderms coll. by Dr. Willey. In: Willey. Zool. Res. II. p. 135.
Chondrocidaris gigantea. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 20. Pl. X, 15, 19, 26.
Chondrocidaris brevispina. H. L. Clark. 1925. Cat. Rec. Ech. Brit. Mus. p. 11. Pl. **I. 1—2.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I. A.	Longest Spines
1	55 mm	34 mm	21 mm (38 % h.d.)	25 mm (45.5 % h.d.)	7	13—15	39 mm
2	54 —	33 —	22 — (40.7 —)	27 — (50 —)	6—7	14—16	40 —
3	24 —	14 —	10.5 — (43.8 —)	13 — (54.2 —)	5	11—12	20 —

Specimen 1 is in the Museum of Leiden, specimen 2 is the type specimen (British Museum), and specimen 3 is in the Hamburg Museum.

Test flattened above; sides arched, circumference round. — Ambulacra ca. 27 % of width of I.A., rather sinuate. Interporiferous zone twice the width of a pore zone; it is only slightly elevated above the pore zone. Marginal series of tubercles very regular, the tubercles contiguous, not very prominent. Inside the marginal series the whole interporiferous zone is, in the larger specimens, filled up with finely rugose glassy warts, usually three to each plate, not forming distinct vertical series. The outer ones are about as large as the marginal tubercles. In the small specimen the inner tubercles are less numerous, those nearest the marginal tubercles forming fairly distinct vertical series (Pl. LXXIV. 2); above and below the ambitus there is only the regular double series inside the marginal series. No naked horizontal sutures to be observed and no naked sunk median line. The pores are distinctly conjugate, but rather close together, small, about equal-sized.

Interambulacra. Tubercles non-crenulate. Areoles very little sunk, all distinctly separated; as in *gigantea* there are even some smaller tubercles between the scrobicular circles of each two adjoining areoles in the upper part of the test. The median interambulacral space about as broad as an areole in the larger specimens, only about half as broad as an areole in the young specimen; it is closely covered with secondary tubercles of a uniform size, leaving no naked

median and no horizontal lines. The scrobicular tubercles very little prominent, with semicircular base.

Apical system ca. 38—44 % h.d. Oculars all exsert, triangular. Madreporite scarcely larger than the other genital plates. Genital pores fairly large, rather near the outer edge of the plates. Anal area small, flat, with an outer circle of larger plates and apparently very few inside these. The whole apical system closely covered with small tubercles of the same character — warty, glassy — as those of the test. Those along the outer edge of the genital and ocular plates are somewhat larger, slightly elongate (Fig. 159).

Peristome ca. 45—54 % h.d., thus distinctly larger than the apical system; it is rather conically protruding (Pl. LIV. 2—3). There are in the small specimen 10 ambulacral plates in a series and 6 interradial plates, not reaching the mouth edge; in the type specimen ca. 14 ambulacral, 7 interradial plates in a series.

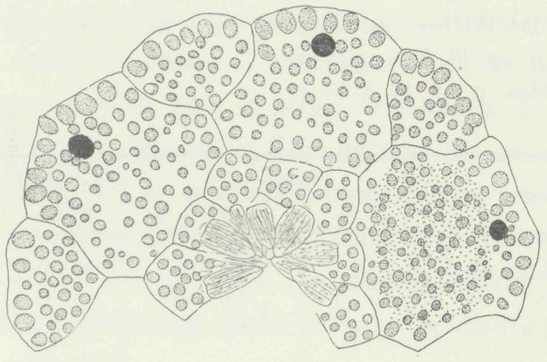


Fig. 159. Part of apical system of *Chondrocidaris brevispina*. × 6.

The primary spines are somewhat less than h.d., but give the impression of being much shorter on account of the strong development of the collar, which may reach a length of 15 mm; in the small specimen the collar does not surpass a length of 7 mm. It widens rather abruptly a little above the base, being thus of a peculiar vase-shape. It appears that the spine is liable to break at the limit between the collar and the shaft, the latter then regenerating from the middle of the surface of the fracture; a very characteristic appearance is thereby produced (comp. Pl. LIV. 3). No longitudinal lines are seen on the collar; the milled ring is very inconspicuous. The shaft of the spine is in the small specimen less attenuating than in the large ones, in the best developed spine of the young specimen even almost cylindrical. It is set with coarse thorns, transforming into longitudinal ridges towards the point, rather equally developed both on the upper and lower side of the spine. Surface of the shaft as in *gigantea*, without longitudinal striæ. The hair cover appears to be exceedingly developed, forming a thick coat of outstanding hairs, gradually decreasing in size distalwards. The coat stops very abruptly at the collar. — This hair cover very strongly recalls a growth of sponges, and, as a matter of fact, both Clark and I myself have taken it to be a sponge; but having afterwards seen how strongly developed the hair coat may be on the basal part of well preserved spines of *Ch. gigantea*, I have little doubt that the "sponge" on the *brevispina* spines is nothing but the hairs of the spine. The oral primaries are very simple, with the shaft more or less distinctly fluted, passing very gradually into the ambital spines, as in *gigantea*.

The secondary spines are, as pointed out by Clark, rather rough, "markedly papillose", differing thus conspicuously from the smooth spines of *gigantea*. The scrobicular spines are

ca. 3 mm long, the marginal ambulacral spines about half that length, somewhat thickened at the point and curved (Pl. LXXXVII. 15—17). They are simply rounded at the point, convex on the upper side, not flattened or even excavate as are those of *gigantea*, but may curve somewhat outwards (concave in profile); on the underside they are somewhat hollowed, smooth. The anal opening is surrounded by a tuft of similar larger spines, contrasting markedly against the exceedingly small spines attached to the sides of the small glassy warts covering the test and apical system. Also around the genital opening and along the outer edge of the apical system there is a series of distinct spines. On the peristome there is a regular double series of larger spines following each series of tubefeet, the spines of the interradii and a double series along the midline of each radius being distinctly smaller. Also the peristomial spines are of the same form as the scrobicular and marginal ambulacral spines, not distinctly spatulate as are otherwise usually the peristomial spines in Cidarids.

Pedicellariæ. While Clark states that in the type specimen no tridentate or large globiferous pedicellariæ were found, I have found both sorts in this very specimen, which I examined in the British Museum during a visit 25 years ago (in 1901). The large globiferous form, which was figured in my "Ingolf" Echinoidea I. Pl. X. 15 and 19 (under the name of *Chondrocidaris gigantea*) is characteristic through its large, somewhat cordate opening, with its lower edge protruding like a lip. In the specimen 3 the large globiferous pedicellariæ, which are fairly numerous, have a more simple, rounded opening, the lower edge not forming a protruding lip (Pl. LXXXVII. 13—14). It is more probable that this is the normal form, seeing that they are all so in this specimen, while the form figured in the "Ingolf" Ech. was found in only a single sample. The small globiferous pedicellariæ are of the same shape as in *Ch. gigantea*. Of tridentate pedicellariæ I found a couple of samples in the type-specimen. They are rather large, 1.5 mm length of head, the valves very narrow, compressed, joining in their whole length; the edges are finely serrate. The stalk very short (Pl. LXXXVII. 18—19). Spicules of usual type.

Colour of the small specimen olive-greenish on test and collar of primary spines, the shaft of these latter reddish, especially towards the point; in the type-specimen the colour is somewhat more differentiated, e. g. the milled ring olive-yellow, the collar dark olive. In the largest specimen the collar is more reddish. But, on the whole, it seems that the typical colour of this species is olive-green, only the shaft of the primaries being a more or less pronounced coral-red.

Occurrence. The type specimen came from the Loyalty Islands (Lifu); the small specimen in the Hamburg Museum is labelled Apia (Samoa). The largest specimen is labelled Padang, Sumatra (Müller). There is no doubt that it is a shallow-water species, probably a coral reef species.

Remarks. This species is very well distinguished from *Ch. gigantea*, especially through the remarkable development of the collar of its primary spines; but also the secondary spines are markedly different.

Many years ago — in 1903 — I had an opportunity of seeing in the Hamburg Museum a specimen of a *Chondrocidaris*, which was identified as *Phyllacanthus gigantea*, an identification that I accepted, although noticing its rather different aspect from that usual in *Ch. gigantea*. On seeing H. L. Clark's description and figures of *Ch. brevispina* (1925) I was reminded of this specimen and, thinking that it might probably belong to Clark's species, begged to have it sent to Copenhagen for a closer examination, which was very kindly granted me. In fact it proved to be *brevispina*, the second specimen known of this remarkable species. — On a visit to Holland in October 1926 I found in the Museum of Leiden one more specimen, likewise identified as *Phyllacanthus gigantea*. This, the third specimen known, is the largest of them all, and in very fine condition (Pl. LIV. 1—2). Although it is from about the middle of the last century there seems to be no doubt of the correctness of the label, which gives as locality: Padang, on the South coast of Sumatra. It may thus be concluded that the species will prove to be widely distributed over the Malay region. Probably it lives concealed in the deeper parts of the coral reefs, since so few specimens have been found. I am greatly indebted to Dr. E. D. van Oort, Director of the Leiden Museum, for the very fine photographs of this splendid specimen.

Genus **Phyllacanthus** Brandt.

I. F. Brandt. 1835. Prodromus descriptionis anim. p. 67.
Pomel. 1883. Class. méth. p. 111.
Duncan. 1889. Revis. gen. Ech. p. 32.
Th. Mortensen. 1903. "Ingolf" Ech. I. p. 30.
Döderlein. 1906. Ech. Deutsche Tiefsee-Exped. p. 103.
H. L. Clark. 1925. Cat. Rec. Sea-Urch. Brit. Mus. p. 9.

Syn. *Leiocidaris* Desor.

Desor. 1855. Synopsis des Éch. foss. p. 48.
Pomel. 1883. Class. méth. p. 111.
Duncan. 1889. Revis. gen. Ech. p. 31.
Lambert & Thiéry. Ess. nom. rais. p. 153.

Apical system small, rarely exceeding 40% h.d., very compact and closely covered with tubercles (spines); oculars generally widely exsert. Madreporite conspicuously larger than the other genital plates, encroaching upon the small anal area. Test thick, with prominent, non-crenulate primary tubercles. Scrobicular tubercles conspicuous, usually with a well limited elevation on the side towards the areole. Ambulacra sinuate; the space inside the marginal tubercles usually very narrow, filled up by small tubercles. Pores conjugate, but the upper part of the wall somewhat raised. Peristome generally conspicuously larger than the apical system, usually ca. 40—50% h.d. Ambulacral series on peristome biseriate or even pluriseriate. Primary spines thick and stout, cylindrical or fusiform, with fine granules more or less distinctly serially arranged, the surface otherwise covered by a spongy structure of branching outgrowths. The spines upon the whole smooth, never with prominent thorns. Secondary spines broad, flat, closely appressed, the

minor ones more or less scale-like; at most some larger spines along the inner edge of the genital plates and around the anal and genital openings, forming prominent tufts. Both large and small pedicellariæ without an end tooth[1]; no limb on the stalk. Tridentate pedicellariæ with serrate, longitudinal crests in the blade, the basal part often thorny on the outer side.

Genotype: *Cidarites (Phyllacanthus) dubia* Brandt.

As diagnosed above this genus is exceedingly well limited and comprises a perfectly natural group of species, distinguished at a glance as belonging here. The peculiar character of the scrobicular tubercles, which are semilunar in shape and have a well limited elevated area on the side towards the areole and another, not sharply limited elevation on the outer side (Fig. 160) is, evidently, a special adaptation serving for strongly appressing the spines around the base of the primary spine; it is rather unique among recent Cidarids. Among the fossil forms a somewhat similar structure is found in *Cidaris lacrymula* Duncan & Sladen (Monogr. Fossil Echinoidea of Sind. I. Pl. V. 5—7).

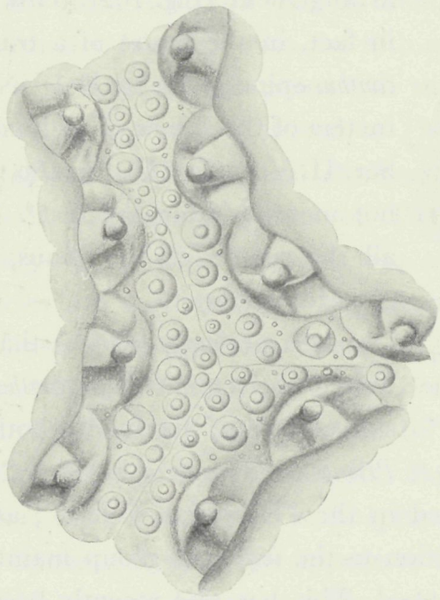


Fig. 160. Scrobicular tubercles of *Phyllacanthus imperialis*. × 8.

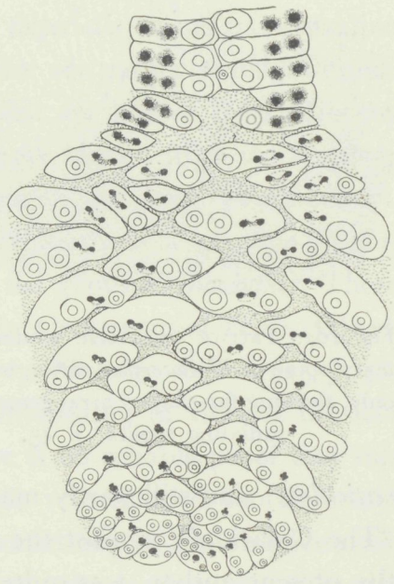


Fig. 161. Peristomial ambulacrum of *Phyllacanthus parvispinus*, showing diploporous arrangement. × 6.

More conspicuous, however, is the biserial arrangement of the ambulacral pores on the peristome (Fig. 161; cf. also Fig. 11, p. 22), and one cannot help wondering that it has been overlooked hitherto[2]. A similar, though less pronounced, biserial arrangement of the pores is found only in *Eucidaris* of recent Cidarids. Among the fossils a biserial or rather pluriserial arrangement of the peristomial pores is found in *Plegiocidaris coronatus* (Schloth.) (cf. above, p. 476, Fig. 144.3). In *Diplocidaris* and *Tetracidaris*, the ambulacra themselves present a biserial arrangement of the pores (peristome

[1] In the diagnosis of the genus *Phyllacanthus* given in the "Ingolf" Echin. I. p. 30 is said "small pedicellariæ with and endtooth"; this is, of course, a — very regrettable — misprint for "without", as evident both from description (p. 18) and the figure (Pl. IX. 6). In the Danish edition the diagnosis has it correct.

[2] Pomel, it is true, says in his diagnosis of the genus *Leiocidaris* "les pores du bas sont bigéminés, avec les granules mamelonnés grossis en conséquence". This, however, does not apply to the true *Phyllacanthus*-forms, but, evidently, to some fossil species erroneously referred here; he does not name any such species under *Leiocidaris*, but only the recent species *baculosa*.

unknown), while in *Phyllacanthus* the ambulacra themselves are simple as in all other recent Cidarids. Alone in the species *irregularis* there is an indication of a diploporous arrangement also in the ambulacra.

The inner structure of the primary spines also has a character rather unique among Cidarids. The central core sends out more or less distinct rays into the surrounding radiating layer. While the holes in this layer are otherwise arranged in series radiating very regularly from the inner part towards the surface, in *Phyllacanthus* they show a characteristic fan-like arrangement around the rays of the central part, then gradually assuming the usual regular radiating arrangement (Fig. 162). This structure may be observed, in fact, in the figure of a transverse section of a *Phyllacanthus*-spine given by Bell (Notes on the structural characters of the spines of Echinoidea. Journ. R. Micr. Soc. Ser. II. Vol. IV. 1884. p. 486, Pl. XIII. 3), while he does not mention it in the text[1]. This character is found in all the species of the genus, and it is thus a valuable generic character.

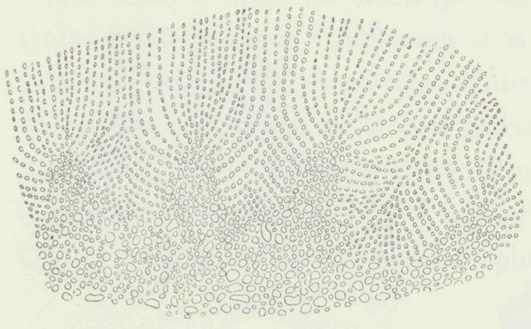


Fig. 162. Part of transverse section of primary spine of *Phyllacanthus dubius*, inner part only, showing fan-shaped arrangement of the radiating spokes. × 45.

It is perfectly evident that the assemblage of species united in the genus *Phyllacanthus* by Agassiz in the "Revision of Echini" (including both *Chondrocidaris gigantea* and *Prionocidaris baculosa*, *bispinosa* ("*annulifera*") and *Plococidaris verticillata*) and still partly maintained in the "Hawaiian Echini", as well as in H. L. Clark's "The Cidaridæ", against the restriction to the *imperialis*-group maintained by Döderlein and the present author, was quite unnatural. This has also recently been acknowledged by H. L. Clark (1916, 1925). No further discussion of this is needed[2].

As regards the name *Phyllacanthus* there is not the slightest doubt that even on the strictest application of the rules of nomenclature this name is perfectly valid[3]. It is equally clear that

[1] Also Hesse (Die Mikrostruktur der fossilen Echinoideenstacheln. 1900, p. 235) has observed this characteristic structure of the *Phyllacanthus*-spines. The same structure he has found in the spines of *Cidaris farringdonensis* Wright and *Cidaris punctata* Römer. Whether this indicates any genetic relation between the recent *Phyllacanthus* and the fossil forms (the test of which is unknown) is hard to say. The general shape of the spines of the two fossil forms, both characteristic by their long collar, does not to any striking degree recall *Phyllacanthus*.

[2] The following papers deal with the characters and the limitation of the genus *Phyllacanthus* (*Leiocidaris*): Duncan. Revision Genera & groups of Echinoidea p. 32; Döderlein: Japan. Seeigel, p. 43; Echinoidea v. Thursday Isl. u. Amboina (Semon) p. 689; Echinoidea Deutsche Tiefsee-Exped. p. 98; Echinoidea v. d. Aru-Inseln, p. 243. De Loriol: Eocäne Echiniden a. Aegypten u. d. Libyschen Wüste. 1881. p. 5—6 (*Rhabdocidaris*); Th. Mortensen: "Ingolf" Echinoidea I. p. 18, 30; Echinoidea Deutsche Südpolar-Exped. p. 50; Echinoidea N.W.Australia (Mjöberg) p. 7—8; H. L. Clark: The Cidaridæ, p. 136; "Endeavour" Echinoderms, p. 96.

[3] Lambert & Thiéry (Sur les Genres d'Échinides proposés par Brandt en 1835. Bull. Soc. Sci. Nat. Haute-Marne 1909, p. 62) maintain this name to be simply a synonym of *Cidarites*. The reasons adduced for this assertion seem to me quite futile and rather sophistical, and I fully agree with H. L. Clark (1916, p. 96) that *Phyllacanthus*, as well as the other subgenera proposed by Brandt are perfectly valid, "certainly as much so as any genera of Echini that were proposed prior to 1846".

the name *Leiocidaris* Desor is a simple synonym thereof. To retain both *Leiocidaris* and *Phyllacanthus* as two distinct genera, as do Pomel and Duncan is absolutely not permissible on the rules.

Six species of this genus, viz. *imperialis*, *dubius*, *parvispinus*, *longispinus*, *irregularis* and *magnificus* are known till now. That *dubius* should be regarded as a separate species, not only as a variety of *imperialis* is shown below (p. 510). The species *Thomasi* A. Ag. and H. L. Clark (Hawaii) certainly does not belong to *Phyllacanthus*, it must form a genus of its own, *Actinocidaris*, and is more nearly related to *Stylocidaris* or *Prionocidaris*.

It is a very noteworthy fact that four of the six species, viz. *parvispinus*, *longispinus*, *irregularis* and *magnificus* are known only from Australia (one of them, *parvispinus*, apparently also at Tasmania and possibly the Kermadec Islands). Also the fifth species *imperialis* occurs in Australian seas. Australia thus is the true home of this genus. All the species are rather strictly littoral.

Spines which are probably correctly referred to *Phyllacanthus* are known from Miocene deposits of India and Madagascar. Also the fossil *Phyllacanthus javana* Martin from the Tertiary deposits of Java (K. Martin. Palæontol. Ergebn. von Tiefbohrungen auf Java. Samml. Geol. Rijks.Mus. Leiden. III. 1883—87. p. 289. Tab. XV. 294. a—e) evidently is a genuine *Phyllacanthus*. No other fossil species can with certainty be referred to the genus *Phyllacanthus*. There is some possibility that the *Leiocidaris hemigranosus* (Shumard) from the Cretaceous of Texas (Clark & Twitchell. Mesozoic and Cenozoic Echinod. U. S. Geol. Survey. Monogr. LIV. 1915 p. 48. Pls. X—XI) may be a true *Phyllacanthus*, which would be very interesting in view of the fact that otherwise the genus is confined to the Indo-Pacific. But there is no reliable proof that this species is a real *Phyllacanthus*; the test structure is, in spite of much resemblance, too uncertain for giving such proof; the scrobicular tubercles appear to have something of the characteristic structure, but the peristome is scarcely larger than the apical system; the madreporite is hardly enlarged, and finally the spines are unknown. Thus this species was, at least, not very nearly related to any of the recent species; but being a Cretaceous form it could not be expected either to be so very closely alike the recent forms, and the possibility cannot be denied that we have here an ancestor of the recent *Phyllacanthus*-forms.

Key to the species of Phyllacanthus.

1. Coronal plates of adult specimens (ca. 50—70 mm h.d.) 6—7 ..... 2.
   Coronal plates of adult specimens (ca. 50—70 mm h.d.) 8—10 ..... 4.
2. Primary spines rarely surpassing h.d., oral primaries slender; colour of primaries dark, often with white bands ..... 3.
   Primary spines generally ca. 1.3 h.d.; oral primaries club-shaped. Colour of primaries whitish-greenish ..... *Ph. longispinus.*
3. Primary spines with numerous, close, indistinct series of granules; denuded test white .. *Ph. imperialis.*
   Primary spines with ca. 16—20, distinct, well spaced series of granules; denuded test of a pinkish tint ..... *Ph. dubius.*
4. Oral primaries flaring at tip ..... *Ph. magnificus.*
   Oral primaries not flaring at tip ..... 5.

5. A series of larger spines (tubercles) along the inner edge of the genital plates. Spines on apical system pointed, not scale-like. Marginal series of ambulacral tubercles more or less irregular, the tubercles and spines of varying size..... *Ph. irregularis.*
No larger spines (tubercles) along the inner edge of the genital plates. Spines on apical system broad, scale-like. Marginal series of ambulacral tubercles (spines) very regular, of uniform size..... *Ph. parvispinus.*

Phyllacanthus imperialis (Lamarck).

Pls. LIV. 4; LVII. 3; LXXIV. 6; LXXXVIII. 4—10.

Cidarites imperialis. Lamarck. 1816. Animaux s. vertèbres III. p. 54. II. Ed. 1840 III. p. 378.
Cidarites imperialis. Deslongchamps. 1825. Encyclopéd. méth. p. 194. Pl. 136. 8.
Cidarites imperialis. Desmoulins. 1837. Mém. s. les Ech. III. p 164.
Cidaris imperialis. Agassiz & Desor. 1847. Cat. Rais. p. 22.
Leiocidaris imperialis. Desor. 1855. Synopsis Ech. foss. p. 48.
Leiocidaris imperialis. Dujardin & Hupé. 1862. Hist. nat. Zooph. Ech. p. 484.
Phyllacanthus imperialis. A. Agassiz. 1863. List of Ech. p. 17.
Phyllacanthus fustigerus. A. Agassiz. 1863. Ibidem. p. 17.
Phyllacanthus fustigera. A. Agassiz. 1863. Synopsis Ech. Stimpson. p. 353.
Cidaris (imperialis Lam.?) *fustigera.* Martens. 1866. Ostasiat. Ech. p. 147.
Phyllacanthus imperialis. A. Agassiz. 1872—73. Rev. of Ech. p. 151, 391. Pl. I. e. 1—6; **I. f. 2.**
Cidaris fustigera. Hoffmann. 1874. Rech. faune Madagascar. Echinod. p. 50.
?*Phyllacanthus dubius.* Giebel. 1878. Seeigel d. Gattung Phyllacanthus. p. 864.
Phyllacanthus imperialis. Tenison Woods. 1878. Echini of Australia. p. 151.
Rhabdocidaris dubia. De Loriol. 1881. Eocäne Ech. Aegypten u. Libysche Wüste. p. 6.
Rhabdocidaris imperialis. De Loriol. 1883. Cat. Rais. Ech. Maurice. p. 11. Pl. **I. 2.**
Rhabdocidaris dubia. De Loriol. Ibidem. p. 12.
Rhabdocidaris imperialis. Bell. 1884. Notes on the structural characters of the spines of Echinoidea (Cidaridæ). J. R. Microsc. Soc. 2. Ser. IV. p. 849. Pl. XIII. 3.
Rhabdocidaris imperialis. Duncan. 1885. Perignathic girdle of Echinoidea. p. 186. Pl. XXX. 5—7.
Phyllacanthus imperialis. Ramsay. 1885. Cat. Ech. Austral. Mus. p. 2.
Phyllacanthus dubia. Ramsay. Ibidem. II. Ed. 1891. p. 3, 45.
Phyllacanthus imperialis. Rathbun. 1886. Cat. Ech. U. S. Nat. Mus. p. 262.
Cidaris imperialis. Lovén. 1887. Ech. descr. by Linnæus. p. 147.
Leiocidaris imperialis. Döderlein. 1887. Japan. Seeigel. I. Cidaridæ. p. 25. Taf. IX. 7. a—f.
Leiocidaris imperialis. Döderlein. 1888. Echinod. v. Ceylon. Zool. Jahrb. III. Syst. p. 842.
Phyllacanthus imperialis. Sluiter. 1889. Evertebr. Samml. Batavia. p. 287.
Rhabdocidaris imperialis. De Loriol. 1893. Ech. d'Amboine. p. 361.
Phyllacanthus imperialis. Sluiter. 1895. Ech. Mus. Amsterdam. p. 67.
Leiocidaris imperialis. Ludwig. 1899. Ech. Sansibar. p. 552.
Phyllacanthus imperialis. Bell. 1899. Rep. Ech. Coll. Willey. p. 135.
Phyllacanthus imperialis. Hesse. 1900. Mikrostruktur d. foss. Ech.stacheln. p. 235, fig. 3.
Phyllacanthus dubia. Hesse. Ibidem.
Leiocidaris imperialis. Döderlein. 1902. Ech. Amboina u. Thursday Isl. (Semon) p. 690. Taf. **LVIII. 1—4.**
Phyllacanthus imperialis. Th. Mortensen. 1903. "Ingolf" Ech. I. p. 18, 30. Pl. IX. 6; X. 8.
Cidaris (Phyllacanthus) imperialis. De Meijere. 1904. "Siboga" Ech. p. 22.
Phyllacanthus imperialis. Bell. 1904. Ech. Pearl-Oyster Report. p. 139.
Rhabdocidaris imperialis. Fourtau. 1904. Ech. Golfe de Suez. p. 411.
Phyllacanthus imperialis. Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 98. Taf. XL. 5. a—e.

Phyllacanthus imperialis. H. L. Clark. 1907. The Cidaridæ. p. 188.
Leiocidaris imperialis. Lambert & Thiéry. 1910. Ess. nom. rais. p. 153.
Phyllacanthus imperialis. Döderlein. 1911. Ech. Aru Inseln. p. 243.
Phyllacanthus imperialis. Jackson. 1912. Phylogeny of Echini. p. 100, 102.
Phyllacanthus imperialis. H. L. Clark. 1915. Ech. Ceylon. p. 90.
Phyllacanthus imperialis. Th. Mortensen. 1918. Ech. Australia (Mjöberg); p. 8.
Phyllacanthus imperialis. H. L. Clark. 1921. Ech. Fauna Torres Str. p. 145.
Leiocidaris imperialis. Lambert. 1922. Ech. Madagascar. p. 19.
Phyllacanthus imperialis. H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 10.
NON: *Cidaris imperialis*. Lamk.? Philippi. 1845. Beschr. neuer Echin. p. 353 (unidentifiable, but not *imperialis* Lamk.).
— *Phyllacanthus imperialis* (Lamk.) H. L. Clark. 1916. "Endeavour" Ech. p. 97 (= *Ph. parvispinus*).
— *Phyllacanthus imperialis*. H. L. Clark. 1909. Ech. "Thétis". p. 552 (= *Ph. parvispinus*).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	81 mm	56 mm	29 mm (35.8 % h.d.)	31 mm (38.3 % h.d.)	7—8	21—22	
2	75 —	49 —	26 — (34.7 —)	35.5 — (46.7 —)	6—7	23—25	
3	65 —	46 —	19 — (29 —)	32 — (49 —)	6	25—26	74 mm
4	65 —	40 —	20.5 — (32.3 —)	30 — (46.2 —)	6—7	21—22	68 —
5	36 —	20.5 —	13.5 — (37.5 —)	19 — (52.8 —)	5	19—21	55 —

Specimen 1 in the Leiden Museum, specimen 2 in the British Museum. 1.—2. from the Red Sea, 3. from Tongatabu, 4.—5. from Mauritius.

Test somewhat varying in height, but on the whole rather low, flattened above and somewhat less so below. Circumference round; sides regularly arched.

Ambulacra conspicuously sinuate, narrow, ca. 16—20 % of interambulacra. Interporiferous zone about the width of a pore zone, rather elevated. The marginal series of tubercles rather prominent, the tubercles being contiguous. Adradially to the marginal tubercle each plate carries a single, much smaller tubercle, situated in the middle of the plate. In the larger specimens some of the ambulacral plates at the ambitus may carry two inner tubercles, the serial arrangement of the inner tubercles being thereby obscured (LXXIV. 6). By the narrowness of the interporiferous zone there is no indication of a naked median line. The pores, though not wide apart, are distinctly connected by a furrow, the upper part of the wall being, however, elevated. They may thus well be termed conjugate, though differing conspicuously from *Prionocidaris* in this respect.

Interambulacra. Tubercles perfectly smooth, rather prominent; the boss is large. The areoles, which are scarcely sunk, are usually well separated, even the lowermost ones. Below the ambitus they are distinctly transverse-oval. The scrobicular circle is conspicuous, the tubercles being distinctly larger than both those outside the circle and the marginal ambulacral tubercles. The median area is very narrow, only about $^1/_3$ of an areole, closely covered by small tubercles, leaving no naked median line. On the adradial edge there is scarcely room for a single small tubercle outside the scrobicular circle.

The apical system (Fig. 163) is remarkably small, only ca. 29—37 % of h.d. The oculars appear to be constantly and widely exsert; they are small, the outer edge rounded, the inner edge sometimes with a slight peak. The genital plates about twice as broad as long, the madreporite conspicuously the largest. Genital pores rather small, usually fairly distant from the edge. Both genital and ocular plates closely covered with tubercles of rather uniform size, — at most those along the outer and inner edge slightly the larger — leaving only the edges bare, thereby somehow giving the impression that the sutures between the plates are deepened. Periproct small, with only few plates, likewise covered with tubercles.

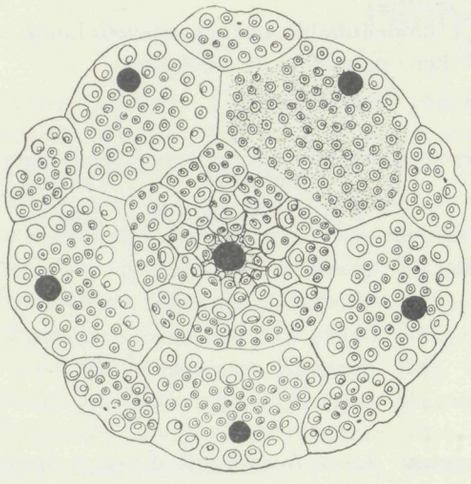


Fig. 163. Apical system of *Phyllacanthus imperialis*. × 5·5.

The peristome is conspicuously larger than the apical system, ca. 46—53 % of h. d. It is, as a rule, strongly projecting, in connection with the fact that the dental apparatus is unusually high. The ambulacral plates are very distinctly 4-seriate; in one of the larger specimens (Tongatabu) this arrangement is less regular in the outer part, but very distinct nearer the mouth. The plates are rather unusually narrow, in accordance with the alternation, their number in a series is ca. 20. The interradial plates do not reach the mouth edge. They may be more or less distinctly biseriate.

The primary spines relatively short, generally only as much as h.d., only exceptionally as much as 1.25 h.d. They are thick and robust, slightly fusiform, the thickest, ca. 8—9 mm, a little above the collar; at the point they are still ca. 5 mm wide, the end rather abruptly cut. The surface of the shaft is finely longitudinally striated with numerous low ridges set with small rounded, not at all prominent granules. Sometimes the ridges have a more irregular sinuate course. The space between the ridges is filled up with branching hairs which form a close spongy structure, at a level with the ridges, the surface of the spine being thus upon the whole quite even and smooth. In the outer part of the spine the ridges become somewhat higher and the interspaces narrower, leaving no room for the spongy hair-structure; thus this part of the spine is deeper furrowed, especially at the point, the ridges passing on to the end surface, forming there a more or less regular star-shaped figure. This structure of the spines is distinct only in the more fresh spines, the older spines being as a rule more or less worn and overgrown with incrusting organisms. The collar is ca. 6 mm long, slightly increasing in thickness downwards, towards the not very prominent milled ring[1]. There is scarcely an indication of a neck. The oral primaries are simply club-shaped, not widened, flattened or curved,

[1] A. Agassiz ("Rev. of Ech." p. 391) states that "the bare space of spine above milled ring (i. e. the collar) is not rigidly defined, striation of base passing gradually into granulation of shaft". This statement does not at all hold good; the limit between collar and shaft is so sharp and well defined here as in any Cidarid, except — as everywhere — in young spines in which the cortex-layer has not yet been formed. Perhaps Agassiz happened to look at such young spines, when he wrote the above statement.

but they are rather strongly furrowed in nearly their whole length. The second is similar to the first, only longer, and the third again is longer, forming the transition to the ambital spines. Spines in various stages of regeneration are not rarely met with.

Secondary spines. The scrobicular spines strongly appressed, slightly narrowing towards the end, which is straight cut. They are ca. 10 mm long, thick and robust, slightly convex on the outer side, slightly concave on the inner side, the sides being straight cut, so that they fit very closely together and form a very close mail round the base of the primaries. The smaller spines outside those of the scrobicular circle likewise very tightly appressed and so shaped as to fit exactly into the interstices left at the base of the larger spines; those of the median interambulacral space quite small and scale-like. The marginal ambulacral spines scarcely 4 mm long, likewise strongly appressed. They are flattened and do not narrow at all towards the end, which is simply rounded; the spines of the interporiferous zone are very small, appearing as grains only, one at the base of each marginal spine. The apical system closely covered by similar small, scale-like spines, strongly appressed; only those immediately round the anal opening somewhat longer. None of the secondary spines with a thick, glandular skin. The spines of the peristome curved, as usual, but very little widened in the outer part.

Pedicellariæ. The large globiferous very scarce, mainly on the peristome. The valves (Pl. LXXXVIII. 4) fairly slender (comp. also Taf. IX. 7d of Döderlein. Japan. Seeigel. Cidaridae); in the forma *unicolor* (Pl. LXXXVIII. 5) they are somewhat shorter and broader; the opening surrounded by more or less prominent teeth. The stalk (Pl. LXXXVIII. 9) is scarcely as long as the head; there may be some irregular thorns at the upper end slightly indicating a limb. The small globiferous pedicellariæ not very numerous, and upon the whole small and simple, though varying considerably in size (Pl. LXXXVIII. 6, 10). The tridentate pedicellariæ well developed, reaching a size of ca. 1.5 mm length of head or even (a specimen from Elat, Great Kei, "Siboga") as much as 2.5 mm; stalk short. The valves (Pl. LXXXVIII. 7, 8) are narrow, the blade with more or less regular longitudinal, finely serrate crests; they join in their whole length. They are more or less coarsely spiny on the outer side in the basal part. Only in the forma *unicolor* I have found them smooth, but this is hardly a constant character. — Spicules of tubefeet of the usual type.

Colour of secondary spines dark purple or violet; the primaries may be somewhat lighter coloured, often with a number of yellowish-white bands. In the specimen from Great Kei the primaries have a faintly greenish tint, without bands; in another specimen (Saleyer, "Siboga" St. 213) the oral primaries are faintly greenish at the point, this specimen having also the usual white bands on the spines.

Varieties. Döderlein (Op. cit. 1902) distinguishes, besides the typical form, the variety *fustigerus* (besides *parvispinus* and *dubius* which are here recognized as separate species). This variety is distinguished merely by having two narrow, sharply limited, yellowish-white bands near the tip of the primaries, while in the typical form there are usually 3, more rarely 2 or 4 bands

(or only one) evenly distributed over the whole spine. As there are otherwise no differences, it does not seem very necessary to maintain this variety; but the character distinguishing it being a very definite one, it cannot do any harm to keep it, though rather as a "forma" not as a variety, which latter rank it scarcely can claim.

The two bands on the spines of the *fustigerus*-form arise in the following way. There is originally a single, rather broad, white band, sharply limited. In the middle of this band the colour gradually disappears, the ground colour of the spine thus forming a dark band separating the two ends of the white band. The two white bands of the forma *fustigerus* thus really represent only the proximal and the distal ends of the originally single white band.

If we keep this two-banded form separate, we may also distinguish the specimens without any bands on the spines under a separate name, as a forma *unicolor*. To this form belongs the above mentioned specimen from Elat, Great Kei ("Siboga"), as also the fine specimen from Tongatabu figured in Pl. LVII. 3. But judging from the scanty material at present available this form with the unbanded spines cannot any more than *fustigera* claim the rank of a variety.

Thus we may distinguish the following forms of *Phyllacanthus imperialis*:

1. Forma *typicus*. Primary spines with 1—4, mostly 3, rather diffuse whitish bands, distributed evenly over the spine.
2. Forma *fustigerus*. Primary spines with 2 narrow, sharply limited whitish bands near the end.
3. Forma *unicolor*. Primary spines unbanded, of a uniform dark violet colour, or with a faintly greenish tint.

Biology. Sluiter (Op. cit. 1889) has observed that it will hide day over under coral blocks, whereas by night it moves around; there is no reason to doubt that this observation, which was made on a specimen in an aquarium, will hold good to the species in general. Of its food nothing is known, but no doubt it feeds on incrusting organisms like *Ph. dubius*. — Development unknown; likewise the younger stages are unknown. Regenerating spines are not uncommon; the remarkable spines of another shape and colour than the normal spines mentioned by Sluiter (Op. cit.) are such regenerating spines.

Parasites are evidently rare in this species. Hupé has, as long ago as in 1860, recorded a case of a parasitic Gastropod, *Stylifer orbignyanus*, causing galls in its spines[1]. But there is no certainty that it was really this species; the figure which he gives of a normal spine does not resemble the spines of *imperialis* to a very striking degree, but, at least, it would seem to be a *Phyllacanthus* (the locality is said to be "Nouvelle Hollande"). — The old primaries are generally incrusted with foreign organisms: Foraminifera, calcareous algæ, etc. A species of *Crepidula* is not rarely found on the spines.

Occurrence. The species is distributed all over the Indo-Pacific, from the Red Sea, Zanzibar and Madagascar to Queensland and the Tonga Islands, and to the Liu-Kiu Islands.

[1] Observation d'un mode particulier de parasitisme offert par un Mollusque gastéropode du genre Stylifer. Revue et Magasin de Zoologie. 2. Sér. XII. p. 118. Pl. X.

From the latter locality, in which the species was not hitherto known to occur, I have a specimen from the Museum of Leningrad. The specimens recorded by H. L. Clark in his reports on the "Thetis" and the "Endeavour" Echinoderms are *Ph. parvispinus* (these specimens were sent me for examination from the Australian Museum, Sydney); it would therefore seem that the species occurs in the Australian Seas only in the Torres Strait region. — The locality "Mediterranean" mentioned by H. L. Clark in his Cat. Rec. Sea-Urch. Brit. Mus. is not only "highly improbable", as he says, but quite evidently wrong.

The bathymetrical distribution of this species appears to be limited to the littoral region, where it occurs especially on the coral reefs. The greatest depth from which it is recorded is 73 m ;"Siboga", St. 310).

The species has been recorded as fossil from the Quaternary deposits near Suez (Fourtau, 1904); further it is recorded from deposits of Miocene Age (Aquitanian) on Madagascar, by J. Cottreau (Échinides de Madagascar. Ann. de Paléontologie. III. 1908. p. 183. Pl. V. 10). Spines "of the character of the recent *Phyllacanthus imperialis* and *P. dubia*" are recorded from the deposits of the Gaj or Miocene Series, India, by Duncan & Sladen (A Monograph of the Fossil Echinoidea of Sind. V. Palæontologia Indica. Ser. XIV. 1885. Pl. XLV. Fig. 13). While it seems quite probable that these spines really belong to some species of *Phyllacanthus* there is no certainty that they belong to the recent species *Ph. imperialis*, as is not maintained either by Duncan & Sladen, while Cottreau gives this identification without any question mark. The *Phyllacanthus javana* Martin from the Tertiary deposits of Java (cf. above p. 497) would rather seem to be a near relation of *Ph. imperialis*.

Remarks. This species is well distinguished from the other species of the genus, especially by its characteristic primary spines with the very numerous, close series of granules. It is particularly well distinguished from the genuine *Ph. dubius* by this character. The uncertainty which has been reigning with regard to the specific difference of these two forms is due to the fact that the authors (de Loriol, de Meijere, Döderlein) did not know the true *Ph. dubius*; what they took for *Ph. dubius* was in reality *Ph. imperialis*. It was therefore quite natural that they did not find any reliable characters by which to distinguish the supposed *dubius* from *imperialis*.

Phyllacanthus dubius Brandt.

Pls. LV. 1; LVI. 1—2; LXIII. 4—6; LXXIV. 7; LXXXVIII. 13—17.

Cidarites (Phyllacanthus) dubia. I. F. Brandt. 1835. Prodromus descriptionis anim. ab H. Mertensio in orbis terrarum circumnavigatione observatorum. I. p. 68. (Also in Recueil des Act. Acad. imp. St. Pétersbourg. 1835. p. 268).

Phyllacanthus dubia. A. Agassiz. 1863. Synopsis Ech. coll. by Dr. W. Stimpson. North Pacif. Exploring Exped. Proc. Ac. Nat. Sc. Philadelphia. 1863. p. 353.

Phyllacanthus dubia. A. Agassiz. 1872—73. Rev. of Ech. p. 150, 389. Pl. I. c. 39; I. e. 7—10; **I. f. 6—7.**

Phyllacanthus dubia. Rathbun. 1886. Cat. Ech. U. S. Nat. Mus. p. 262.

Cidaris (Leiocidaris) dubia. Yoshiwara. 1906. Jap. Echini. Pl. II. 2—5.

NON: *Rhabdocidaris dubia.* De Loriol. 1883. Cat. Rais. Ech. Maurice. p. 12 (= *Ph. imperialis*).

— *Phyllacanthus dubia.* Ramsay. 1885. Cat. Ech. Austral. Mus. (II. Ed. 1891) p. 3, 45 (= *Ph. imperialis*).

— *Phyllacanthus dubia.* Farquhar. 1906. Notes on New Zealand Echinod. Trans. N. Z. Inst. 39. p. 130 (probably *Ph. parvispinus*).

— *Phyllacanthus dubia.* Benham. 1911. Stellerids and Echinids from the Kermadec Islands. Trans. N. Z. Inst. 43. p. 159 (probably *Ph. parvispinus*).

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	60 mm	36 mm	21 mm (35 % h.d.)	29 mm (48.3 % h.d.)	6 (7)	19—20	73 mm
2	58 —	37 —	22 — (38 —)	28 — (48.3 —)	6	20—21	57 —
3	51 —	30 —	20.5 — (40.2 —)	28.5 — (55.9 —)	5	20—21	64 —
4	49 —	34 —	19 — (39 —)	27.5 — (56 —)	5—6	20—21	54 —
5	48 —	30 —	16 — (33.3 —)	23.5 — (48.9 —)	5—6	20—21	56 —
6	44 —	28 —	16 — (36.4 —)	25 — (56.8 —)	5—6	19—20	42 —
7	40 —	23 —	15.5 — (38.8 —)	22 — (55 —)	5	20—21	51 —
8	22 —	12 —	8 — (36.3 —)	11 — (50 —)	4—5	12—16	36 —
9	12 —	7 —	5 — (41.7 —)	7 — (58.3 —)	4—5	10—11	19 —

Specimen 1 in the Tokio Museum, the rest in the Uppsala and Copenhagen Museums.

Test flattened above, scarcely so below, where it passes gradually into the raised peristome. Sides very beautifully arched. Circumference round.

Ambulacra conspicuously sinuate. Interporiferous zone not much wider than a pore zone. Marginal series of tubercles perfectly regular, the tubercles rather small, distinctly mamelonate, contiguous. Adradially to the marginal tubercle each plate at the ambitus carries a single small tubercle, there being here a fairly regular double series of inner tubercles. The interporiferous space is so narrow that an alternation must take place, so that when one is found at the lower edge of the plate, that on the opposite side is at the upper edge of the plate. Farther up the interporiferous space is so narrow that there is only a single median series, and in the uppermost part there is no room at all for inner tubercles. The pore zones rather conspicuously sunk. The pores about equal-sized, not very distant; upper part of wall raised, somewhat higher than the ridge (Pl. LXXIV. 7).

Interambulacra. Areoles shallow, well separated even unto the peristome, the sub-

ambital ones distinctly transverse-oval. The boss is large and prominent, the mamelon large and conspicuous. Edge of areoles not at all raised. The median space very narrow, ca. $^1/_3$ the width of an areole, quite filled up with small, secondary tubercles; on the adradial side of the scrobicular circle there is room only for a very few small tubercles. Median line not sunk.

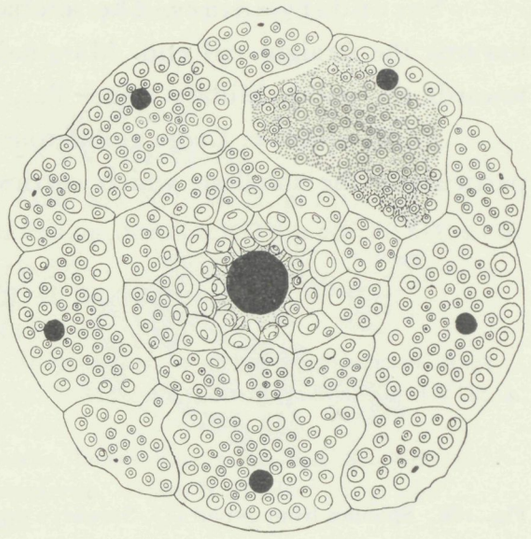
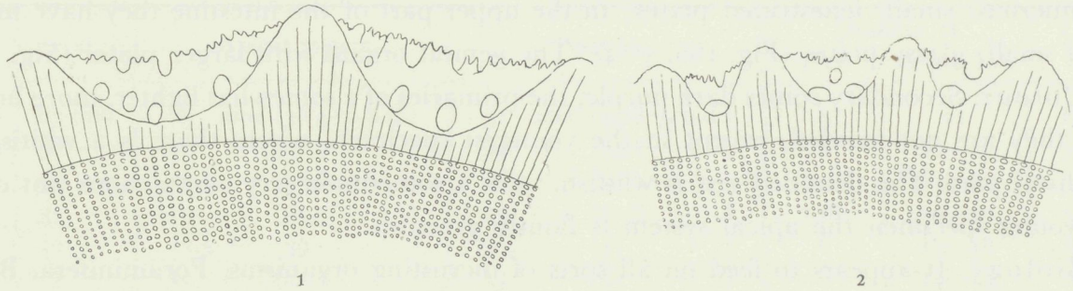


Fig. 164. Apical system of *Phyllacanthus dubius*. × 4.5.

Apical system scarcely exceeding 40 % h.d. The ocular plates may have an inward prolongation so as to join the periproct, this prolongation being even sometimes severed off from the ocular as a small separate plate. Madreporite not much enlarged. Genital pores rather small, the female pores somewhat nearer the outer edge than the male pores. Periproct small with a moderate number of plates; the statement in the "Rev. of Ech." that these plates are larger and less numerous than in *imperialis* does not hold good. The whole apical system closely covered with small tubercles which leave a fairly conspicuous, bare edge to the genital plates, giving the impression that the sutures are somewhat sunk. The tubercles along the inner edge of the genital plates and especially those on the inner periproctal plates somewhat larger (Fig. 164).

Peristome conspicuously raised. The pores are arranged in very regular, double series, excepting only the proximalmost 6—8 pores; there are ca. 22—24 pores in each ambulacral



1 2

Fig. 165. Part of transverse sections of primary spines of *Phyllacanthus dubius* (1) and *Ph. parvispinus* (2). × 35.

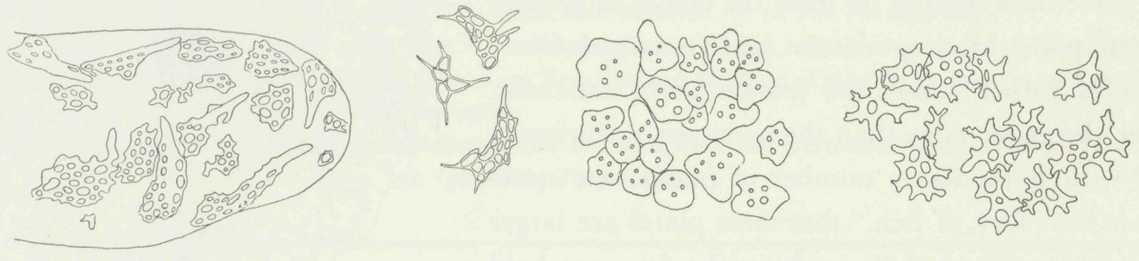
half. Interradial plates 6—7, sometimes in a regular, single series, sometimes in irregular, double series; they do not reach the mouth edge.

Primary spines usually only about as long as h.d., rather slender, cylindrical, usually slightly thicker in the basal part. There are some 18—20 distinct, regular longitudinal series of granules, forming at the end of the spine more or less prominent ridges, the point of the spine being thus somewhat fluted. The surface of the shaft between the series of granules covered by a close, spongy coat of anastomosing hairs (Fig. 165. 1). The collar is 3—4 mm long, slightly

increasing in thickness towards the inconspicuous milled ring. There is hardly an indication of a neck. Oral primaries simple, slender, not club-shaped, distinctly longitudinally ridged in their whole length; they pass very gradually into the ambital spines.

Secondary spines. The scrobicular spines are 5—7 mm long, flat, slightly narrowing towards the straight cut end. Marginal ambulacral spines 2—3 mm long, flat, not narrowing towards the point. Miliary spines flat, scale-like.

Pedicellariæ. Large globiferous pedicellariæ observed only in the two young specimens, particularly the smallest, which carries one at the apex of each ocular plate besides several



1 2 3 4

Fig. 166. Spicules from gonad (1), Stewart's organ (2), intestinal wall, upper (3) and lower part (4) of *Phyllacanthus dubius*. 1.—2. × 50; 3.—4. × 125.

scattered on the test. They are of the typical form, without an end-tooth and without a limb on the stalk. The valves are rather low and coarse (Pl. LXXXVIII. 17). The small globiferous very richly developed, from the typical small, delicate form to large, coarse forms resembling tridentate pedicellariæ; there are all transitional forms, so that it is impossible to distinguish between these two types (Pl. LXXXVIII. 13—16). — Spicules of tubefeet of the usual form. In the intestinal wall numerous, small, fenestrated plates; in the upper part of the intestine they have more the shape of small, glassy plates (Fig. 166. 3—4). The genital organs with larger plates (Fig. 166. 1).

Colour. Secondary spines dark purple, the primaries of a somewhat lighter, more brownish colour; they are not banded, except in the youngest specimen, where there is a whitish band in the distal part. The denuded test is whitish, with a sometimes very conspicuous tint of pink; in the young specimen the apical system is faintly greenish.

Biology. It appears to feed on all sorts of incrusting organisms, Foraminifera, Bryozoa, calcareous Algæ, etc., which it gnaws off the branches of the corals among which it lives. — The spines may be rather much overgrown by incrusting Algæ or Foraminifera. Genital pores have appeared in the specimen of 22 mm h.d., but, of course, not in the one of 12 mm h.d. — No parasites have been observed.

Occurrence. Known only from the Bonin Islands, where it occurs in the littoral region, among corals. It is interesting to notice that the *Phyllacanthus* occurring at the Liu-Kiu Islands is the typical *imperialis*, not *dubius*.

Remarks. It seems perfectly evident that this must be recognized as a distinct species, well distinguished from *imperialis*, especially by the character of the primary spines. When doubt

has repeatedly been expressed as to its distinctness from *imperialis* (de Loriol, Döderlein, de Meijere), this is, evidently, due to the fact that these authors did not have the true *dubius* before them; what has been identified as *Ph. dubius* from Mauritius is in reality *imperialis*. The figures given in the "Revision of Echini" Pl. I. f. 6—7 represent the species very well.

Phyllacanthus parvispinus Tenison Woods.

Pls. LXIII. 1—3; LXIV. 3; LXXIV. 8; LXXXVIII. 18—24.

Phyllacanthus dubia. Tenison Woods. 1878. Echini of Australia. Pr. Linn. Soc. N. S. W. II. p. 151.
Phyllacanthus parvispina. Tenison Woods. 1880. Some new Austral. Ech. Pr. Linn. Soc. N.S.W. IV. p. 286. Pl. **XIV. a—b.**
Phyllacanthus tenuispinus. Bell. 1884. A coll. of Ech. from Australia. p. 503.
Phyllacanthus parvispina. Ramsay. 1885. Cat. Ech. Austral. Mus. p. 3, II. Ed. 1891. p. 3, 45.
Cidaris parvispinis. Lovén. 1887. Ech. descr. by Linnæus p. 148—149.
Phyllacanthus parvispinus. Whitelegge. 1889. Marine & Freshwater Invertebrate Fauna of Port Jackson. p. 41.
Leiocidaris imperialis, var. *parvispina.* Döderlein. 1902. Ech. Thursday Isl. & Amboina (Semon) p. 690. Taf. LVIII. 4.
Phyllacanthus parvispina. Th. Mortensen. 1903. "Ingolf" Ech. p. 18, 30.
Phyllacanthus imperialis, var. *parvispina.* Döderlein. 1906. Ech. Deutsche Tiefsee-Exp. p. 98. Taf. XL. 5. a—c.
Phyllacanthus dubia. Farquhar. 1906. Notes on New Zealand Echinoderms. Trans. N. Z. Inst. 39. p. 130.
Phyllacanthus imperialis. H. L. Clark. 1909. Echinod. "Thetis". p. 552.
Phyllacanthus dubia. Benham. 1909. Stellerids and Echinids from the Kermadec Isl. Trans. N. Z. Inst. 43. p. 159.
Leiocidaris parvispina. Lambert & Thiéry. 1910. Ess. nom. rais. p. 561.
Phyllacanthus imperialis. H. L. Clark. 1916. "Endeavour" Echinod. p. 97.
Phyllacanthus parvispinus. Th. Mortensen. 1918. Ech. W.Australia (Mjöberg) p. 5. Pl. V. 21.
Phyllacanthus tenuispinus[1]. Th. Mortensen. Ibidem. p. 8, 22. (Misprint for *parvispinus*).
Phyllacanthus imperialis, var. *parvispina* H. L. Clark. 1925. Cat. Rec. Sea-Urch. Br. Mus. p. 10.
NON: *Phyllacanthus imperialis parvispina.* Döderlein. 1914. Echinoidea Fauna S.W.Australiens. IV. p. 452 (= *Phyllacanthus irregularis* Mrtsn.).

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
92 mm	63 mm	28 mm (30.4 % h.d.)	32 mm (34.8 % h.d.)	9	21	66 mm
82 —	58 —	26 — (31.7 —)	29 — (35.6 —)	8	20—21	52 —
70 —	50 —	23.5 — (33.6 —)	28.5 — (40.7 —)	7—8	21—22	58 —
55 —	33 —	19 — (34.5 —)	23 — (41.8 —)	7 (8)	19—20	39 —
32 —	20 —	12.5 — (39 —)	15 — (47 —)	6	17—18	35 —
24 —	13 —	10 — (41.7 —)	12 — (50 —)	6	14—15	27 —
16 —	9 —	7.5 — (47 —)	8 — (50 —)	5—6	12—13	16 —

Test rather low[2], flattened above and below; sides beautifully arched; circumference round.

Ambulacra ca. 16—18 % of I. A. in adult specimens, somewhat more in younger specimens. The interporiferous zone distinctly broader than a pore zone, somewhat elevated above

[1] Ramsay (Op. cit. p. 45) has under the name *Phyllacanthus parvispina* as synonym *P. tenuispina* Tenison Wood M.S.S.

[2] In Tenison Woods' description the test is stated to be higher (100 mm) than its horizontal diameter (90 mm). Bell (Op. cit.) suggests that the "numbers of millimetres of height and diameter have been reversed". This, however, appears not to be so. The type-specimen, which has been sent me from the Australian Museum,

the pore zones. Marginal tubercles contiguous; the space inside the marginal series very narrow, completely filled up by smaller tubercles, leaving no bare median line, the tubercles being so close set as to be more or less irregular in shape (Pl. LXXIV. 8). Each plate carries one tubercle on the middle of the plate, about half the size of the marginal one; these tubercles form a fairly distinct inner double series; even in the largest specimens there is no distinct third longitudinal series. The pores are very much like those of *Ph. imperialis*, equal-sized, not very distant, connected by a furrow, but with a prominent knob, formed by the upper part of the wall. The limits between the plates unusually deep and broad, generally passing straight across the interporiferous zone; the median separating line is indistinct, so that it has the appearance of each two opposite plates having fused into one, except in places where the ambulacral area curves more strongly; in such places the inner part of the plates is wedge-shaped, fitting between those of the opposite side.

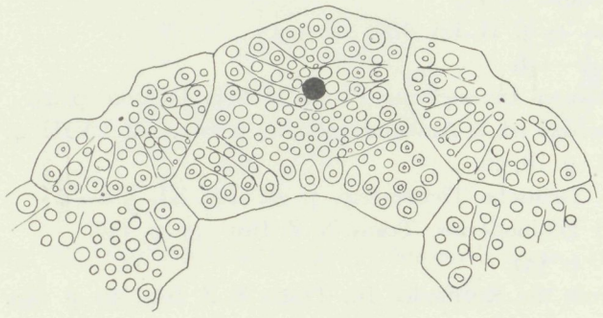


Fig. 167. Part of apical system of *Phyllacanthus parvispinus*. × 4.

Interambulacra. Areoles rather sunk, transverse-oval, except the uppermost ones, all of them distinctly separated. The tubercles somewhat less prominent, and the boss slightly smaller than in *imperialis*. No trace of crenulation. Tubercles of scrobicular circle of the same structure as in *imperialis*, rather conspicuous. The median interambulacral space densely covered with small tubercles of uniform size. In the larger specimens the median space is rather broad, though not so much as half the width of an areole, flat, with fairly conspicuous horizontal lines separating the tubercles. In younger specimens the median line may be distinctly sunk. At the adradial edge there is only a single series of small tubercles, the scrobicular circle reaching close to the edge.

Apical system in larger specimens ca. 30—35 % h. d., in young specimens relatively larger, ca. 39—47 % h. d. The ocular plates are widely exsert; madreporite conspicuously larger than the other genital plates. Genital pores small, fairly distant from the outer edge; it appears that the male genital openings are nearer the middle of the plate than are the female openings. Periproct small, with few plates. The whole of the apical system closely covered with tubercles of uniform size, those along the edge only slightly the larger. Horizontal lines may be rather distinct on the genital plates, radiating lines on the ocular plates, giving the impression of an arrangement of the tubercles in transverse or radiating series (Fig. 167). These horizontal lines are also seen on some of the upper interambulacral plates, in larger specimens.

Peristome distinctly larger than apical system, ca. 35—42 % h. d. in larger specimens,

measures 90 mm h. d., but 58 mm v. d. The height 100 mm thus appears to be due to some error — if this be really the type-specimen, which is perhaps not quite certain, since I am informed that "the type" of Tenison Woods' *Ph. parvispinus* is in the National Museum of Victoria, Melbourne. The matter is, however, very unimportant, since there is not the slightest doubt about which species is meant with Tenison Woods' *Phyllacanthus parvispinus*.

ca. 47—50 % in younger specimens, ca. 25 ambulacral plates in a series in a specimen of 70 mm h.d., ca. 20 in a specimen of 55 mm h.d. They are arranged very distinctly biserially even unto the mouth edge (Fig. 161, p. 501), sometimes even triserially, the plates being correspondingly very narrow. The interradial plates may be arranged in a single or an irregular double series; they do not reach the mouth edge. The peristome is usually quite flat, not prominent, as is generally so conspicuously the case in *imperialis* and especially in *dubius*.

Primary spines in larger specimens as a rule only ca. $^2/_3$ h. d., in younger specimens at most slightly exceeding h.d. They are fairly slender, 5—6 mm thick at base in large specimens, slightly tapering, but not pointed; sometimes they are slightly fusiform. The surface of the shaft is finely and uniformly granulated, the granules being, as a rule, not arranged in longitudinal series, except in the outer part, where the series then gradually pass into elevated ridges, that make the end of the spines conspicuously fluted. Surface of shaft otherwise covered with a spongy structure of anastomosing hairs (Fig. 165. 2; 168. 3). The collar is ca. 5 mm long, increasing conspicuously in thickness towards the milled ring, which latter is not very prominent. The lower end of the shaft, just above the collar, is smooth, forming a 1—3 mm broad, somewhat shining neck. The oral primaries like those of *imperialis*, only the fluting confined to the outer third of the spines, while in *imperialis* and *dubius* it extends nearly to the collar. The third is transitional to the ambital spines.

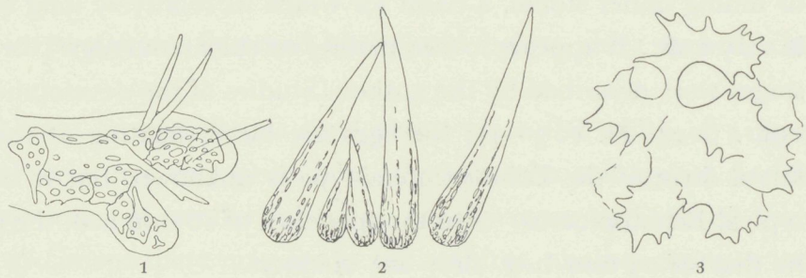


Fig. 168. *Phyllacanthus parvispinus*. Spicules of gonads (1); thorns from the mesentery (2); "hair" from primary spine (3). 1.—2. × 50; 3. × 80.

The secondary spines like those of *imperialis* and *dubius*. The marginal ambulacral spines flattened, not pointed (Fig. 170. 2). The scale-like character of the spines on the apical system is a conspicuous difference from *Ph. irregularis*.

Pedicellariæ. The large globiferous form usually quite numerous, both on test and peristome. Valves with a large opening and large glandular cavity (cf. Döderlein, 1906, Pl. XL. 5. a —c; Th. Mortensen, 1918, Pl. V. 21), sometimes the blade is rather widened in the upper part (Pl. LXXXVIII. 20—21); stalk short, only half the length of the head. Small globiferous pedicellariæ not peculiar, of the form typical of the genus. Tridentate pedicellariæ well developed, up to 2 mm length of head. The valves with the blade filled up by a meshwork, forming more or less distinct serrate longitudinal ridges. Transitional forms between the tridentate and the small globiferous type are found as in *Ph. dubius* (Pl. LXXXVIII. 19, 22—24). Spicules like those of *Ph. dubius*. In the genital organs some of the spicules are prolonged into very prominent thorns (Fig. 168. 1). Where the mesentery is attached to the intestine, strong, prominent thorns

are developed, forming a conspicuous fringe (Fig. 168. 2). A similar structure is found also in *dubius*, but much less developed.

Colour. Spines purple-brownish, the primaries slightly darker; no light rings on the primaries, only in small specimens, 8—20 mm h.d., there is a faint indication of light bands in some of the primaries. The denuded, well cleaned test has a, sometimes very conspicuous, greenish tint, the boss of the primary tubercles of a creamy colour.

Biology. This is a shallow water species, to be found in rock crevices or under stones at low water. It is stated to retire into somewhat deeper water in cold weather. The end of the spines may be rather much worn off, doubtless on account of this habit of creeping into crevices or hiding under stones, a habit for which its relatively long and stout spines would seem to make it very unfit. It appears to feed mainly on calcareous algæ (*Corallina*). — The early development stages were described by the author (Studies of the development and larval forms of Echinoderms 1921. p. 24. Pl. V. 3—4); the eggs are large, floating at the surface. Whether it has a pelagic larval form of the Echinopluteus-type is unknown, but it may well be expected not to have a typical Echinopluteus. — In the specimen of 16 mm h.d. the genital pores have not yet appeared; in that of 24 mm h.d. they are distinct.

Occurrence. Known from the East Coast of Australia, from Shoalhaven Bight, N.S.Wales to Moreton Bay. The greatest depth from which it is recorded is 27—29 m. ("Endeavour").

The record of its occurrence on the West Coast of Australia, at Fremantle (Döderlein, op. cit.), is erroneous, resting on a misidentification of *Phyllac. irregularis* Mrtsn.

The statement of its occurrence at the Kermadec Islands (Farquhar, op. cit., Benham, op. cit.) appears to be correct. The specimen in question (which is in the Otago Museum) was sent me for examination by Prof. Benham. It is a naked test, 42 mm h.d., partly broken, with 7 coronal plates. Test of a greenish tint. The ambulacra and the apical system have the character of typical *parvispinus*, as have also the few loose primary spines. There is thus scarcely any doubt that this is really *parvispinus*, and the species may then be expected to be rather widely distributed in the South Sea.

The *Phyllacanthus dubia* recorded by Tenison Woods as common in Tasmania (On Echini of Australia. Proc. Linn. Soc. N.S.Wales. II. 1878) may well be this species, as supposed by Ramsay (Op. cit.). The *Phyllacanthus dubia* recorded from Lord Howe Island (Benham, Op. cit.) may probably likewise be *Ph. parvispinus*.

Remarks. That *parvispinus* is very well distinguished from *imperialis* can no longer be doubted. The number of interambulacral plates is greater, 7—8(9) in adult specimens, against only 6(7) in *imperialis*; the primary spines are conspicuously different, as also the pedicellariæ show some differences. Finally the colour is different. That it is likewise different from *longispinus*, *irregularis* and *magnificus* is evident enough, as appears from the descriptions.

Phyllacanthus longispinus Mrtsn.

Pls. LXIII. 7—8; LXXIV. 9.

Phyllacanthus longispinus. Th. Mortensen. 1918. Ech. N.W.Australia (Mjöberg); p. 4. Pls. **I—II; III. 2; V. 15.**

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	83 mm	51 mm	26.5 mm (31.9 % h.d.)	38 mm (45.8 % h.d.)	7	24—26	
2	68 —	42 —	23 — (33.8 —)	30 — (44 —)	6—7	23—26	ca. 80 mm
3	52 —	32 —	17 — (32.7 —)	23 — (44.3 —)	6 (7)	18—20	ca. 70 —

These specimens are in the Australian Museum, Sydney.

Test of the same shape as in *parvispinus*, flattened above and below, sides arched, circumference rounded.

Ambulacra 15.5—18 % of I.A.; interporiferous zone about twice the width of a pore zone, rather elevated. The marginal series not very prominent, the tubercles contiguous. Inside the marginal series a distinct, double series of smaller tubercles, usually more well spaced than in the former species. In the larger specimens there may be, at the ambitus, another more or less regular, inner double series of tubercles. The median space not at all sunk and there is no distinct median line. Pores as in the other species (Pl. LXXIV. 9).

Interambulacra. The plates and the areoles comparatively larger than in *parvispinus*, and the number of ambulacral plates corresponding to an interambulacral plate also correspondingly larger. Also the mamelon is larger than in *parvispinus*, specimens of a corresponding size compared, thus 4 mm in diameter in a specimen 83 mm h.d. of *longispinus*, against 3.5 mm in a specimen 81 mm h.d. of *parvispinus*. This different size of the mamelon in the two species is also easily observed on comparing the figures of the test of the two species (Pl. LXIII. 7—8 and 1—3). The boss is relatively small, not occupying more than half the areole. Median area only about $^1/_3$ the width of an areole.

Apical system ca. 35—40 % h. d. Ocular plates all widely exsert. Madreporite conspicuously larger than the other genitals; the genital pore on the top of a usually very conspicuous conical elevation. Tubercles along the edge of the plates slightly the larger. Periproct slightly larger than in the other species, though not constantly so (cf. paper quoted, Pl. III. 2). — Peristome ca. 45 % h. d., thus, as in the two former species, conspicuously larger than the apical system; it is rather conical. The oral ambulacral plates are arranged biserially (or even triserially) as in the two former species.

The primary spines are as a rule ca. 1.3 h.d. They are comparatively slender, 6—7 mm thick at the base, not fusiform, tapering very gently towards the end, which may be slightly flaring, and is, otherwise, fluted for a short distance. The surface of the shaft is distinctly granulated, the granules showing a distinct serial arrangement, especially in the outer part of the spines; there are ca. 20 of these longitudinal series. The surface otherwise with the usual spongy structure.

The collar is ca. 5 mm long, gently increasing in thickness downwards. There is a fairly distinct smooth neck above the collar, but it is not nearly as conspicuous as in *parvispinus*. The oral primaries are club-shaped, differing conspicuously from the slender oral primaries of the two former species. They are fluted in almost the whole length of the shaft. The third spine forms the transition to the ambital spines.

The secondary spines surrounding the base of the primaries, as well as the small spines of the median interambulacral space and the apical system, like those of the two former species; the ambulacral marginal spines on the other hand differ in being more slender, cylindrical, with hardly an indication of a flattening at the tip.

Pedicellariæ. Mainly as in *imperialis*, but the large globiferous form differs in having the edges of the valves more serrate, and in the glandular cavity being small (cf. Op. cit. Pl. V.15). They appear to be numerous on the peristome.

Colour of secondary spines dark violet; the primaries are unbanded, uniformly greyish white, with a slight greenish or light brownish tint. The naked test pinkish on the aboral side, otherwise of a more olive-greenish tint, whereas the areoles are white, with a more or less pronounced pink tint, the boss white and the mamelon cream coloured.

Biology unknown.

Occurrence. Known only from the coast of N.W.Australia (Cape Jaubert) and Port Darwin (Australian Museum, Sydney).

Remarks. This species differs conspicuously from the other species of the genus *Phyllacanthus* through its long, slender spines, the clubshaped oral primaries, the slender ambulacral spines, the colour of the primaries, as also through the character of the ambulacra, and the genital pores being placed on an elevation. The difference in the pedicellariæ, though less conspicuous, also contributes to distinguish this magnificent species from its congeners.

Phyllacanthus magnificus H. L. Clark.

Pls. LXI. 2; LXII. 1—2; LXXXVIII. 1—3.

Phyllacanthus magnificus. H. L. Clark. 1914. Echinod. West-Austral. Museum. Rec. W. A. Mus. I. p. 158. Pl. XXVI.

h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
72 mm	48 mm	26 mm (36.1 % h.d.)	26 mm (36.1 % h.d.)	8—9	18—19	58 mm

The specimen measured is the cotype, in the Museum Comp. Zoology. The measurements given by Clark, 75 mm h.d., 51 mm v.d. are not quite exact.

Test nearly spherical. Ambulacra ca. 30 % of I. A. Interporiferous zone about twice the width of a pore zone. Marginal series regular, the tubercles contiguous. Adradially to the marginal tubercle each plate carries one tubercle about half that size in the middle of the plate,

forming regular longitudinal series; at the ambitus there is another small tubercle at the midline, there being thus here a single median irregular series. Pores as usual in the genus *Phyllacanthus*.

Interambulacra with 8—10 plates in a series (in specimens of 72—92 mm h.d.). Only the two lowermost areoles slightly confluent; the subambital ones distinctly transverse-oval. Median area about $^2/_3$ the width of an areole, densely covered with small tubercles of uniform size, rather distinctly arranged in horizontal series with fairly distinct furrows between them.

Apical system 30—36 % h. d. In the type specimen (92 mm h. d.) Ocular V insert and I nearly so; in the second specimen (72 mm h.d.) Oc. V nearly insert, the others exsert. Madreporite much enlarged, so as to give the impression of the apical system being quite oblique, this being the more emphasized by the oculars opposite the madreporite being nearly insert, those adjoining the madreporite widely exsert. Genital pores large, near centre of plate, surrounded by a circle of about a dozen broad, flat spinelets larger than the others on the plate; as these spines are closed over the pores, they form a conspicuous conical elevation, but apparently there is no elevation on the plate itself, as it is the case in *longispinus*. — Peristome rather prominent, of the same size as the apical system, of the typical *Phyllacanthus*-structure. Interradial plates 5—6.

Primary spines less than h.d., the longest 75 mm in the specimen of 92 mm h.d.; they measure 10 mm in thickness at the base, tapering gently to a diameter of 5 mm at the tip. They are rough with small, rounded, not in regular series arranged granules, "which soon become more or less completely concealed by a spongy alteration in the outer layer of the spine", viz. the usual spongy coat of branching, anastomosing hairs. At the tip the granules are more regularly arranged in series, which pass into ridges that surround the blunt end of the spine. There are 24—36 of these longitudinal ridges. Collar low, rarely exceeding 3 mm in height. There is a fairly distinct, smooth neck above the collar. The oral primaries are stout, more or less flaring at the tip, not longitudinally ridged.

Secondary spines. The scrobicular spines with a usually rather conspicuous keel on the outer side, decreasing towards the end, which is flattened. At the base of the spine the keel often ends abruptly, forming a conspicuous hump (Pl. LXXXVIII. 2). Marginal ambulacral spines flattened, not pointed. Small spines on test and apical system scale-like, appressed.

Pedicellariæ. The large globiferous stated to be particularly common on the ambulacra, viz. in the type-specimen, as they are not found in the cotype. The head nearly 1 mm long, the stalk only half that length, without a limb. The opening of the valves surrounded by coarse, curved teeth; it is very variable in size and form, sometimes divided vertically into two openings (Pl. LXXXVIII. 3; the figure drawn from a sample placed at my disposal by H. L. Clark; the opening was partly damaged, and the teeth around the opening are probably somewhat larger than shown in the figure). The small globiferous pedicellariæ like those of *imperialis*. The tridentate pedicellariæ up to ca. 2 mm length of head, the valves slender, meeting only at or near the tip. According to Clark there is a single, rather prominent, sharply serrate ridge in the

middle of the blade. This does not hold good of the samples seen by me, these having sometimes 2—3 ridges in the basal part, only one in the distal part (Pl. LXXXVIII. 1), sometimes no ridges at all. (All the samples seen are more or less broken; the figured valve had the blade complete, the basal part being reconstructed from another sample). — Spicules of tubefeet of the usual type.

Colour deep red-brown; primaries purplish-red, the collar yellowish-brown. The test and the primary tubercles apparently of a slight pinkish colour.

Occurrence. The only two specimens known were found between Fremantle and Geraldtown, West Australia. Depth not recorded (probably littoral).

Remarks. This species appears to be the nearest related to *parvispinus*, from which it differs, however, conspicuously in the characters of the ambulacra, the oral primaries and the keeled scrobicular spines.

The figure accompanying the original description of this species is very poor, much reduced in size (and turned upside down) and does not at all give impression of the species name *magnificus* being very appropiate. It was therefore a great satisfaction to me that H. L. Clark sent me the cotype preserved in the Museum of Conparative Zoology (where I had had an opportunity of examining it in 1926) in order that I might be able to give new figures of it. The figures of the specimen given here in Pls. LXII will, I think, give a better impression of the species, though perhaps not quite justify the species name; at least, I cannot see that this species exceeds any of the other *Phyllacanthus*-species in size (except, probably, *Ph. dubius*) or in beauty.

Phyllacanthus irregularis Mrtsn.

Pls. LVIII; LIX; LX; LXI. 1; LXXIV. 10—11; LXXXVIII. 11—12.

Phyllacanthus imperialis parvispinus. Döderlein. 1914. Echinoidea. Fauna Südwest Australiens IV. p. 452.
Phyllacanthus irregularis. Th. Mortensen. 1928. New Cidaridæ. p. 74.

	h. d.	v. d.	Apical system	Peristome	Number of I. A.	Number of A. pro I.A.	Longest Spines
1	110 mm	73 mm	33 mm (30 % h.d.)	33 mm (30 % h.d.)	10	18—19	58 mm
2	100 —	63 —	32 — (32 —)	34 — (34 —)	10	16—18	42 —
3	89 —	57 —	28 — (31.5 —)	28 — (31.5 —)	10	19—20	58 —
4	85 —	55 —	23 — (27 —)	30 — (35.3 —)	8—9	20	55 —
5	77 —	47 —	22 — (29 —)	25 — (32.5 —)	8	19—21	43 —
6	73 —	44 —	22 — (30.1 —)	25 — (34.2 —)	8	18—20	ca. 40 —
7	70 —	42 —	21 — (30 —)	24 — (34.3 —)	7—8	19—20	60 —
8	70 —	43 —	19 — (27.1 —)	23 — (32.9 —)	7—8	18—19	60 —
9	59 —	35 —	18 — (30.5 —)	18 — (30.5 —)	7—8	19—20	40 —

Specimens 1, 3, 6—8 in the West Australian Museum, Perth; specimen 2 in the Museum of Adelaide; specimen 4, cotype, in the Berlin Museum; specimen 5, the type-specimen, in the Hamburg Museum; specimen 9 in the Australian Museum, Sydney.

Test rather low, flattened above and below; sides arched. Circumference round.

Ambulacra ca. 17—20 % of I.A. The interporiferous zone a little broader than a pore zone, somewhat elevated above the pore zones. The marginal series of tubercles usually very irregular (Pl. LXXIV. 10—11), the tubercles varying very considerably in size, even totally wanting on some of the plates. This irregularity may be more distinct on the oral side. Sometimes it is less pronounced, only rarely there is no irregularity at all. The space inside the marginal series filled out by smaller tubercles; in the type-specimen they do not form very distinct longitudinal series, while in other specimens they show a fairly distinct arrangement in a double longitudinal series; small tubercles usually entirely fill up the middle part, and there is no naked or sunk median line. The pores are generally somewhat irregularly disposed, some few of them being pushed some distance away from the outer edge; there is thus, in fact, an indication of a diploporous condition of the pores. The character of the pores otherwise as in *parvispinus*.

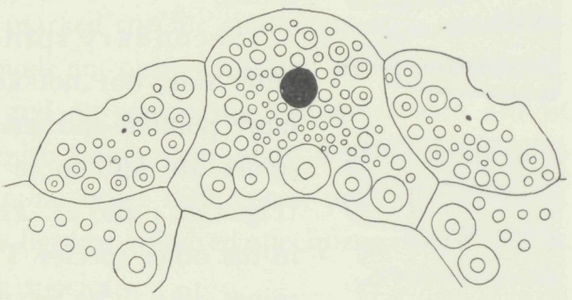


Fig. 169. Part of apical system of *Phyllacanthus irregularis*. × 4.

Interambulacra. Areoles deep, well separated, at most the two proximalmost ones confluent, the ambital and subambital ones distinctly transverse-oval. Edge of areoles not raised; scrobicular tubercles rather conspicuous, but the peculiar *Phyllacanthus*-structure (cf. Fig. 160, p. 501) not very distinct. The median space, which is about half the width of an areole, is quite filled with small tubercles, more or less distinctly arranged in horizontal rows, separated by short, sometimes very distinct furrows, passing directly across the midline, which may be quite distinct and a little sunk. On the adradial side of the areoles there may be a fairly broad space filled with smaller tubercles, which may even be separated by horizontal furrows.

Apical system ca. 27—31 % h. d. The ocular plates all widely exsert; madreporite distinctly larger than the other genital plates. Genital pores fairly large, not close to the edge. The tubercles along the inner edge of the genital plates very conspicuously larger than the others (Fig. 169). No larger tubercles and no elevation round the genital pores. Usually horizontal radiating lines are distinct on genital or ocular plates. The periproct small, with few periproctal plates, irregularly pentagonal on account of the encroaching madreporite, as usual in the genus *Phyllacanthus*. The whole apical system flat, or even somewhat sunken.

Peristome not conspicuously larger than the apical system, ca. 32—35 % h. d., ca. 24 plates in each half of radius, arranged very distinctly biserially unto the very mouth edge; the interradial plates in an irregular double series, not reaching the mouth edge. It is more or less raised, sometimes almost flat.

Primary spines short, only ca. $^1/_2$—$^2/_3$ h. d., usually distinctly fusiform, tapering to a rounded, not widened point. They may be as much as 9 mm diameter in the thickest part; more

rarely they are nearly cylindrical. The surface of the shaft is finely and uniformly granulated, the granules not arranged in distinct and regular longitudinal series, except in the outer part, where they gradually pass into elevated ridges, much as in *parvispinus*. The surface between the granules covered with the usual spongy coat of anastomosing hairs. The collar is ca. 4—5 mm long, increasing in thickness towards the milled ring, which is not very prominent. In well preserved spines the lower part of the shaft is smooth, forming a ca. 2—3 mm broad, shining neck, just as in *parvispinus*. The oral primaries are very smooth, the proximal ones cylindrical or slightly flattened and curved, scarcely with an indication of a fluting at the point. The 2nd and 3rd more distinctly fluted, and forming a very gradual transition to the ambital spines.

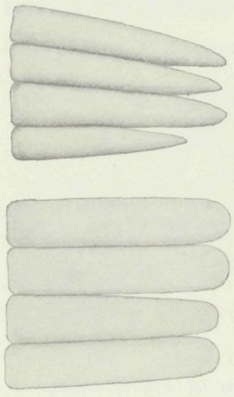


Fig. 170. Marginal ambulacral spines of *Phyllacanthus irregularis* (1) and *Ph. parvispinus* (2). × 8.

Secondary spines. The scrobicular spines more or less convex on the outer side, but not keeled, the smaller ones outside the scrobicular circle more pointed and less flattened than in the other species. The ambulacral spines are also more pointed and less flattened than in the other species (Fig. 170. 1 and 2). The spines of the apical system slender, not scale-like as in the other species. The inner edge of the genital plates carries some larger spines, like those usually found on the periproctal plates — a conspicuous difference from the other species, where only the periproctal plates carry such longer spines. On the peristome the spines of the interradii are somewhat smaller than those of the radii.

Pedicellariæ. The large globiferous pedicellariæ may be very common, particularly in the ambulacra, where they may form a continuous series in the midline; they are rather characteristic, the upper part of the blade being somewhat widened, with rather strongly serrate edges (Pl. LXXXVIII. 11). However, this is not a quite constant character, the edges being sometimes less widened (Pl. LXXXVIII. 12); also in *parvispinus* the globiferous pedicellariæ may sometimes have a similar widening (Pl. LXXXVIII. 20—21). The small globiferous may be very numerous and form like a white fluff among the secondary spines, both on the test and on the apical system. The tridentate pedicellariæ as in *parvispinus*, rather numerous, reaching a size of ca. 3 mm length of head. The stalk of both tridentate and large globiferous pedicellariæ rather short, while the small globiferous are fairly long-stalked, the stalk 2—3 times as long as the head.

Colour. Primary spines usually dark purplish-violet, with a whitish band in the outer part (this is seen only on fairly well preserved spines which are not too overgrown with foreign organisms). Collar dark chocolate. In the largest specimen the spines are lighter coloured, more brownish, and the neck (not the collar) of a greenish tint. The secondary spines from almost black to dark purplish-violet or even brown. The test whitish, with a slight brownish or violet tint, not greenish as in *parvispinus*.

Biology unknown. The specimen 1., of 110 mm h.d., is the largest of all known recent Cidarids.

Occurrence. Known only from the West and South coast of Australia, from the Fremantle region to Bremer Bay on the S. coast. It is evidently a littoral form, like the other species. One specimen was labelled "dredged off Fremantle", but the depth is not stated.

Remarks. This species has much general resemblance to *Ph. parvispinus*, to which the first two specimens known were, indeed, referred by Döderlein (Op. cit.). A closer study reveals, however, so important differences from *parvispinus* that it must be out of question to regard them as identical. The main character is the irregularity in the marginal ambulacral tubercles and in the pores, which latter show, in fact, a beginning diploporous arrangement wholly unique among recent Cidarids. As stated above this character is, however, not quite constant. Further the large tubercles (spines) on the inner edge of the genital plates as well as the fusiform primaries, the pointed ambulacral and miliary spines form very marked specific characters; also the differences shown by the large globiferous pedicellariæ, though not quite constant, are of importance.

The great difference in colour is remarkable, and on comparing specimens with almost black secondary spines with such as have light, brownish spines, one might well be tempted to regard them as different species. There are, however, no other differences, and as, moreover, all transitions are found between the darkest and the lightest coloured specimens, there can be no question but that they are all one and the same species.

3. Subfamily **Diplocidarinæ** I. W. Gregory.

Coronal plates with rigid sutures. Pore-pairs arranged in double series, the pores conjugate or non-conjugate. Primary spines cylindrical, the tubercles crenulate. (Pedicellariæ unknown).

Large forms, ranging from the Jurassic to the Lower Cretaceous. Only two genera known, *Diplocidaris* and *Tetracidaris*.

Key to the genera of the Diplocidarinæ.

Interambulacrals in two series only ..... *Diplocidaris.*
Interambulacrals in four series, except adorally and aborally ..... *Tetracidaris.*

Genus **Diplocidaris** Desor.

Desor. 1855. Synopsis des Éch. fossiles. p. 44.
Pomel. 1883. Class. méth. p. 112.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 43
Duncan. 1889. Rev. gen. Ech. p. 35.
H. L. Clark. 1907. The Cidaridæ, p. 191.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 138.

Syn. *Alternocidaris* Quenstedt.
Quenstedt. 1873. Petrefactenk. Deutschl. p. 219.

Pores conjugate or subconjugate. Interambulacra with only two series of plates throughout. Tubercles perforate, crenulate, the upper ones more or less rudimentary. Primary spines cylindrical but rather short, more or less coarsely granulated. Apical system distinctly smaller than peristome. Oculars exsert.

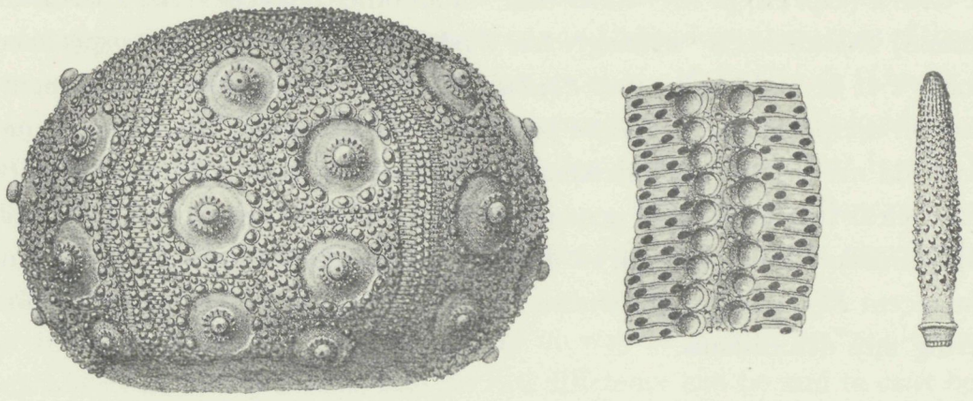
Mainly large forms. All from the Jurassic Period.

Genotype: *Cidaris gigantea* Agassiz. (Fig. 171).

Other species: *Diplocidaris Dumortieri* (Cotteau). (Pal. Fr. Jurass. Pl. 227).
Diplocidaris Gauthieri (Cotteau). (Ibidem, Pl. 228).
Diplocidaris alternans (Quenstedt). (Petref.k. Deutschl. Pl. LXIX. 15).
Diplocidaris Etalloni de Loriol. (Fig. 172. 1).
Diplocidaris miranda (Agass.). (Fig. 172. 2).
Diplocidaris Jacquemeti Lambert. (Ess. nom. rais. Pl. I. 19—22).
Diplocidaris Choffati Lambert. (Ech. Calloviens du Plateau Césareda. Comm. Serv. Geol. Portugal. IX. 1913. Pl. I. 1—3).

The species *D. Jacquemeti* is computed by Lambert (Ess. nom. rais. p. 139) to have reached a horizontal diameter of 130 mm, and thus to be the largest of all known Cidarids. As however only isolated plates are known, the calculation of its size is rather uncertain for awarding this species the prize of the record size among Cidarids.

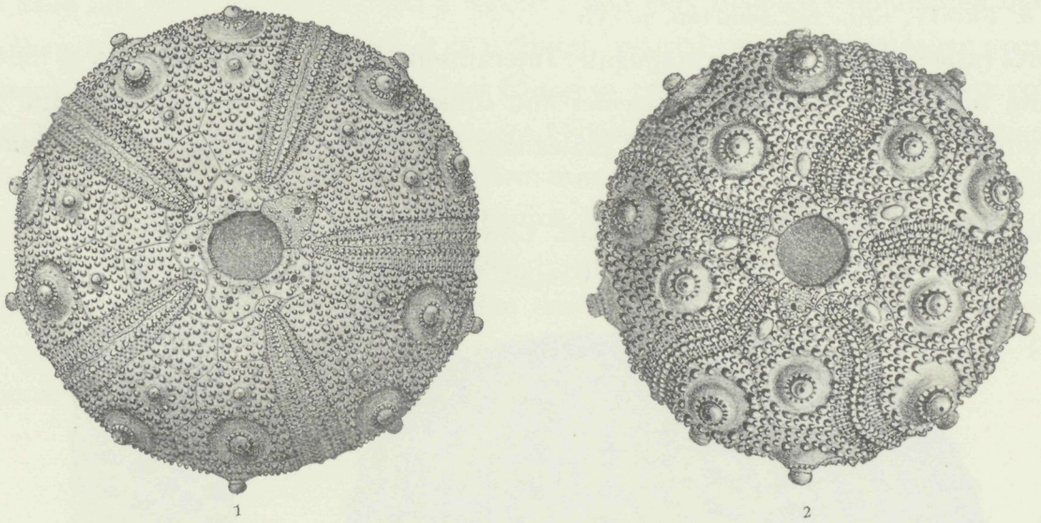
It is a noteworthy fact that the species of *Diplocidaris* may be divided into two groups, those with the ambulacra conspicuously sinuate and those with straight ambulacra. To the former



1 2 3

Fig. 171. *Diplocidaris gigantea*; test in side view (1), natural size; part of ambulacrum, magnified (2); primary spine (3). (After Paléont. Franç. Jurass. Pl. 229. 1, 3; 232. 2.)

group belong *gigantea* and *miranda*, to the latter *Etalloni*, *Dumortieri*, *Gauthieri* and *Choffati*. Perhaps, if completely known in all their characters, the two groups would be found to represent two different generic types. But, as I have not had the opportunity of studying these forms except



1 2

Fig. 172. *Diplocidaris Etalloni* (1) and *Diplocid. miranda* (2). Tests seen from above; Fig. 1 slightly reduced. (After Paléont. Franç. Jurass. Pl. 233. 2 (1); 236. 2 (2).)

from literature, I shall not insist on separating them into two genera. On the other hand it is quite safe to say that the *Diplocidaris desipiens* described by de Loriol (Faune Jurassique de Portugal. Échinodermes. 1890—91, p. 48, Pl. IX. 3) is no *Diplocidaris*, and not even a Cidarid. The pores are close together, separated by a conspicuous granule, and they seem to be arranged in arcs of three. Further the scrobicular tubercles are perforate, a character entirely unknown

in Cidarids. I think the single coronal plate known, with some adhering ambulacrals, is rather a compound ambulacral plate of a Hemicidarid.

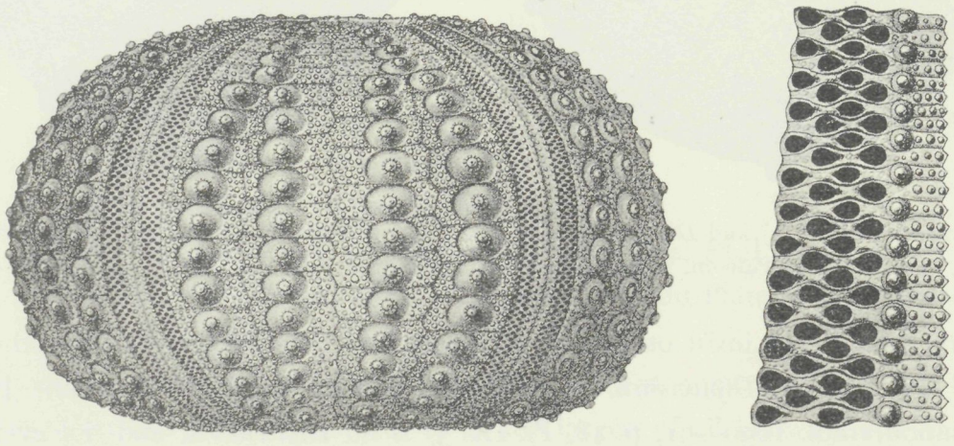
H. L. Clark (Op. cit. p. 191) states that "in all other respects" (viz. apart from the diploporous condition) *Diplocidaris* is "strikingly like *Phyllacanthus*, especially some specimens of *Phyllacanthus imperialis*". If he had known that *Phyllacanthus* has a diploporous arrangement of the ambulacral pores on the peristome, he would probably have found the likeness much more striking. I, for my part, do not see any very striking resemblance between *Diplocidaris* and *Phyllacanthus*; at any rate it is clear that there is no genetic connection between them, since *Diplocidaris*, known only from the Jurassic Period, through its diploporous condition shows itself much more specialized than the recent *Phyllacanthus*. *Diplocidaris* evidently died out at the end of the Jurassic Period without leaving any descendants.

Genus **Tetracidaris** Cotteau.

Cotteau. 1872. Échinides nouveaux ou peu connues. I. Série. p. 163.
Cotteau. 1873. Sur le genre Tetracidaris. Bull. Soc. Géol. Fr. 3. Sér. I. p. 258.
Pomel. 1883. Classif. méth. p. 110.
Döderlein. 1887. Jap. Seeigel. Cidaridæ, p. 43.
Duncan. 1889. Rev. gen. Ech. p. 35.
H. L. Clark. 1907. The Cidaridæ, p. 192.
Lambert & Thiéry. 1910. Ess. nom. rais. p. 157.

Pores rather distant, but not conjugate. Interambulacral plates in four series at the ambitus, there being thus four series of large areoles and tubercles in each interambulacrum. Adorally and aborally there are only two series of plates and two series of large tubercles. Primary spines slender, cylindrical.

Genotype: *Tetrocidaris Reynesi* Cotteau. Lower Cretaceous (Neocom). (Fig. 173).
Other species (?) *T. Kiliani* Savin. Lower Cretac. (Valangien). Ess. nom. rais. Pl. II. 6.



1 2

Fig. 173. *Tetracidaris Reynesi*; test in side view, slightly reduced (1); part of ambulacrum, magnified (2). (After Cotteau. Sur le genre Tetracidaris. Bull. Soc. géol. Fr. 3. Sér. I. Pl. III. 1, 3.)

As already recognized by Cotteau (Op. cit.) this remarkable form is related to *Diplocidaris*, and it would seem beyond doubt that it represents a specialized offshoot from the *Diplocidaris* type. It also bears a considerable likeness to *Heterocidaris*, and Duncan (Op. cit.) finds it to resemble *Astropyga*, this resemblance and "the very non-Cidaridean characters of the ambulacra" rendering its position among the Cidarids problematical. — H. L. Clark (Op. cit.) states that "in the arrangement of the pores this species is intermediate between Diplocidaris and Phyllacanthus, but it is not in any sense a connecting link between these genera. It may be regarded as a specialized offshoot of the Diplocidaris branch". — Referring to Duncan's opinion of its relation to *Astropyga* he says "there is some reason for thinking it is not genetically connected with the Cidaridæ at all".

As for the ambulacra their structure can in no way be said to be "non-Cidarean", it is, indeed, so very like that of *Diplocidaris*, that no real difference can be said to exist between these two genera in the ambulacral structure. On the other hand the ambulacral structure of *Heterocidaris* (— not to mention *Astropyga* —) is very different, the ambulacral plates there being compound, of the Diadematoid type. Also the absence of gill-slits in the peristomial edge indicates the true Cidarid character of *Tetracidaris*. The only feature which might speak against *Tetracidaris* being a true Cidarid is the structure of the primary spines. Judging from Cotteau's figures it would appear that there is no special cortex layer, as is otherwise typical of the Cidarids. In order to have this definitely ascertained a renewed and very detailed examination of the spines of *Tetracidaris* would be needed. Until it is definitely proved that a cortex layer does not exist here, I must suppose it to exist as in typical Cidarids, the more so as the carinate condition of the spines is a character found in several recent Cidarids, but not in the Diadematoids. I must therefore join Cotteau in regarding *Tetracidaris* as a true Cidarid, a highly specialized offshoot from *Diplocidaris*. That it has no nearer relation to the Archæocidarids, in spite of its four columns of interambulacrals, is beyond doubt. — It is rather difficult to understand how this extraordinary type originated — the suggestion that it arose as a sudden mutation lies at hand. It died out very soon — it appears to be confined to the Lower Cretaceous — leaving no descendants.

Geographical Distribution.

It may be practical to begin this chapter with a tabellaric view of the distribution of all the known species, with the more important varieties, of Cidarids.

	Pacific Deep-Sea	South Sea Islands	Hawaii	Japan	Malay Archipelago	Australia	New Zealand	Indian Ocean	S. Africa	Antarktis	Magellanic Region	W. America	W. Indies	W. Atlantic	E. Atlantic	S. Atlantic	Mediterranean	Arktis	Depth in metres
Histocidaris Mrtsn.																			
elegans (A. Ag.)	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	200—1440
crassispina Mrtsn.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	740
misakiensis (Yosh.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?
variabilis (A. Ag. & H. L. Cl.)	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	320—555
Cobosi (A. Ag.)	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	615
Sharreri (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	570
carinata Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	360
australiæ Mrtsn.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	145—550
magnifica Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	283
formosa Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	245—304
recurvata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	984
Nuttingi Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	225
acutispina Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	1785
denticulata Koehler	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	400—1362
Poriocidaris Mrtsn.																			
purpurata (W. Th.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	750—1804
Aporocidaris A. Ag. & H. L. Cl.																			
Milleri (A. Ag.)	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3610—3385
fragilis A. Ag. & H. L. Cl.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2800—3550
antarctica Mrtsn.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	2450—3486
incerta (Koehler)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	100—300
Ctenocidaris Mrtsn.																			
speciosa Mrtsn.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	75—400
Perrieri Koehler	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	180—550
spinosa (Koehler)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	200
Geliberti (Koehler)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	200
rugosa (Koehler)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	272—585
nutrix (W. Th.)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	0—225
var. longispina Mrtsn.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	270

	Pacific Deep-Sea	South Sea Islands	Hawaii	Japan	Malay Archipelago	Australia	New Zealand	Indian Ocean	S. Africa	Antarktis	Magellanic Region	W. America	W. Indies	W. Atlantic	E. Atlantic	S. Atlantic	Mediterranean	Arktis	Depth in metres
Notocidaris Mrtsn.																			
Mortenseni (Koehler)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	100—600 (?2540)
gaussensis Mrtsn.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	350—385
hastata Mrtsn.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	2450—2725
platycantha (H. L. Cl.)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	180—640
var. contracta Koehler	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	200—570
Homalocidaris Mrtsn.																			
gigantea (H. L. Cl.)	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	180
Rhynchocidaris Mrtsn.																			
triplopora Mrtsn.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	200—385
Austrocidaris H. L. Cl.																			
canaliculata (A Ag.)	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	0—270
var. Lorioli (Mrtsn.)	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	1080
spinulosa Mrtsn.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	197
Ogmocidaris Mrtsn.																			
Benhami Mrtsn.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	100—190
Goniocidaris Ag. & Des.																			
tubaria (Lamk.)	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	0—145
var. impressa Koehler	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	0—115
umbraculum (Hutton)	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	20—100
florigera A. Ag.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	232—290
spinosa Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	200
biserialis (Död.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	70—500
mikado (Död.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	115—700
peltata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	235—245
clypeata Död.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100—700
fimbriata (de Meij.)	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	370—567
alba Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	400
crassa Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	450
sibogæ Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	450
australiæ Mrtsn.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	35—470
tenuispina Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	685—1411
var. tuberculata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	969
var. major Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	570
Schizocidaris Mrtsn.																			
assimilis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	180—300
serrata (Mrtsn.)	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	160—185
fasciata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	283
Psilocidaris Mrtsn.																			
echinulata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	1400—1751
Rhopalocidaris Mrtsn.																			
hirsutispina (de Meij.)	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	385—469
var. viridis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	296
gracilis (Död.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	180—720

	Pacific Deep-Sea	South Sea Islands	Hawaii	Japan	Malay Archipelago	Australia	New Zealand	Indian Ocean	S. Africa	Antarktis	Magellanic Region	W. America	W. Indies	W. Atlantic	E. Atlantic	S. Atlantic	Mediterranean	Arktis	Depth in metres
rosea Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	170—720
var. tenuis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	300
Stereocidaris Pomel.																			
grandis (Död.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	70—200
var. hyatorina Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	120—400
hawaiiensis Mrtsn.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	285—455
granularis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	360—510
var. rubra Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	294
squamosa Mrtsn.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	270
stylifera Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	247
purpurascens Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	204—414
sulcatispinis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	231—385
microtuberculata (Yosh.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	140—700
tubifera Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	351—400
var. impressa Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	245
indica Död.	.	.	.	×	×	.	.	×	.	.	.	.	.	.	.	.	.	.	400—1289
var. philippinensis Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	410—745
var. sumatrana Död.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	1024
var. carinata Död.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	1019—1134
var. africana Död.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	1289
Alcocki (Anderson)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	235—1145
ingolfiana Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	300—1745
capensis Död.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	500
leucacantha A. Ag. & H. L. Cl.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	300—950
sceptriferoides Död.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	360—700
var. lanceolata Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	700
var. lamellata Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	(?)370—1040
japonica (Död.)	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	70—700
Cidaris Leske.																			
cidaris (L.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	.	50—2000
var. meridionalis Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	850—1000
abyssicola (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	(32) 200—400
var. teretispina Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	60—445
rugosa (H. L. Cl.)	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	260—540
Blakei (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	315—420
nuda (Mrtsn.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	70—450
Calocidaris H. L. Cl.																			
micans (Mrtsn.)	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	200—330
Tretocidaris Mrtsn.																			
Bartletti (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	140—635
spinosa Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	ca. 70. St. Helena, Ascension
Acanthocidaris Mrtsn.																			
curvatispinis (Bell.)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	200. Mauritius

	Pacific Deep-Sea	South Sea Islands	Hawaii	Japan	Malay Archipelago	Australia	New Zealand	Indian Ocean	S. Africa	Antarktis	Magellanic Region	W. America	W. Indies	W. Atlantic	E. Atlantic	S. Atlantic	Mediterranean	Arktis	Depth in metres
hastigera A. Ag. & H. L. Cl.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37—355
maculicollis (de Meij.)	.	.	.	×	×	.	.	×	.	.	.	.	.	.	.	.	.	.	40—225
Stylocidaris Mrtsn.																			
affinis (Phil.)	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	.	×	.	30—1000
lineata Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	100—500
Reini (Död.)	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	100—500
var. cladothrix Mrtsn.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	197—247
var. rubida Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	208
amboinæ Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	180—225
annulosa Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	186—194
conferta (H. L. Cl.)	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	145—470. S. E. Australia
rufa Mrtsn.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	128—515
calacantha (A. Ag. & H. L. Cl.)	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	225—355
bracteata (A. Ag.)	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	69—200. W. Australia
maculosa Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	90—700. Also Macclesfield Bank
effluens Mrtsn.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	161—704
tiara (Anderson)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	215—720
Lorioli (Koehler)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	200
albidens H. L. Cl.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	108—135
badia (H. L. Cl.)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	200. Mauritius only.
brevicollis (de Meij.)	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	69—91
fusispina Mrtsn.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100—185
Eucidaris Pomel.																			
metularia (Lamk.)	.	×	×	×	×	×	.	×	.	.	.	.	.	.	.	.	.	.	0—570. N. Australia
Thouarsii (Val.)	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	0—45
var. galapagensis Död.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	Littoral, Galapagos only.
tribuloides (Lamk.)	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	0—450
var. africana Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	0—40
clavata Mrtsn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	0—100. St. Helena only.
Actinocidaris Mrtsn.																			
Thomasi (Ag. Ag. & H. L. Cl.)	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	120—400
Hesperocidaris Mrtsn.																			
panamensis (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	120—200
dubia (H. L. Cl.)	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	150—200
perplexa (H. L. Cl.)	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	65—70
Centrocidaris A. Ag.																			
Döderleini (A. Ag.)	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	180—540
Plococidaris Mrtsn.																			
verticillata (Lamk.)	.	×	×	×	×	×	.	×	.	.	.	.	.	.	.	.	.	.	0—54.
Prionocidaris A. Ag.																			
baculosa (Lamk.)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	0—200
var. annulifera (Lamk.)	.	.	.	×	×	×	.	×	.	.	.	.	.	.	.	.	.	.	0—250

	Pacific Deep-Sea	South Sea Islands	Hawaii	Japan	Malay Archipelago	Australia	New Zealand	Indian Ocean	S. Africa	Antarktis	Magellanic Region	W. America	W. Indies	W. Atlantic	E. Atlantic	S. Atlantic	Mediterranean	Arktis	Depth in metres
var. longicollis Mrtsn.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	60—100
pistillaris (Lamk.)	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	0—60
australis (Ramsay)	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	10—85. E. Australia
glandulosa (de Meij.)	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	50—140
hawaiiensis (A. Ag. & H. L. Cl.)	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	32—510
bispinosa (Lamk.)	.	.	.	.	×	×	.	×	.	.	.	.	.	.	.	.	.	.	4—54
Chondrocidaris A. Ag.																			
gigantea A. Ag.	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	25—385. Mauritius
brevispina H. L. Cl.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	Littoral. Sumatra.
Phyllacanthus Brandt																			
imperialis (Lamk.)	.	.	.	×	×	×	.	×	.	.	.	.	.	.	.	.	.	.	0—73
dubius Brandt	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Littoral. Bonin Isl.
parvispinus Ten. Woods	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	0—28. Kermadec Isl.
longispinus Mrtsn.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	Littoral
magnificus H. L. Cl.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	Littoral
irregularis Mrtsn.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	Littoral
Total...	3	3	11	26	48	18	2	21	2	16	4	6	13	6	10	1	2	0	

The first fact to impress itself upon us when studying this list is the remarkable poverty in Cidarids of the Atlantic in comparison with the Indo-Pacific. Whereas the richest part of the Atlantic region, the West Indian Sea, has in all 13 species of Cidarids, the East Atlantic having only 10 species, and the Mediterranean no more than 2, we know from the Malay Archipelago no less than 48 species (and varieties), from Japan 26, from Australia 18 and from the Indian Ocean 21 species.

This contrast becomes the more remarkable, when we take also the fossil forms into consideration.

In the following list is given the approximate numbers of species of the various genera of Cidarids recorded from the Mesozoic and Tertiary deposits of Europe and N. Africa, from Lambert & Thiéry's "Essai de nomenclature raisonnée". For simplicity's sake I take here the generic names as they are used in the said work. That I cannot accept such genera as *Plegiocidaris*, *Cidaris*, *Dorocidaris*, *Rhabdocidaris*, etc. in the same sense or extent as they are used by Lambert & Thiéry appears sufficiently from the systematic part of the present work. But for the purpose here: to give a general idea of the number of species known from the various epochs it does not matter that the "genera" are partly taken in another sense than in the systematic part of the work.

	Trias	Lower Jurassic	Middle Jurassic	Upper Jurassic	Lower Cretaceous	Middle Cretaceous	Upper Cretaceous	Eocene	Oligocene	Miocene	Pliocene
Miocidaris	5	5	.	.	.	.	.	.	.	.	.
Triadocidaris	8	.	.	.	.	.	.	.	.	.	.
Mikrocidaris	4	.	.	.	.	.	.	.	.	.	.
Aplocidaris	1	.	.	.	.	.	.	.	.	.	.
Plegiocidaris	8	18	44	40	13	6	5	6	.	1	1
Paracidaris	.	2	6	6	4	.	.	.	.	.	.
Polycidaris	.	.	7	.	.	.	.	.	.	.	.
Rhabdocidaris	.	4	18	28	17	3	2	14	.	1	1
Porocidaris	.	.	.	.	.	.	.	2	.	.	.
Diplocidaris	.	2	4	6	1	.	.	.	.	.	.
Cidaris	11	13	19	19	20	20	33	33	3	12	1
Cyathocidaris	.	.	.	.	.	.	2	1	.	1	.
Balanocidaris	5	3	4	2	1	3	2	.	.	.	.
Dorocidaris	.	.	.	.	2	6	18	3	.	5	.
Stereocidaris	.	.	.	.	.	9	7	1	.	.	.
Typocidaris	.	.	.	.	4	7	13	.	.	.	.
Leiocidaris	.	.	1	.	1	4	5	13	.	5	.
Aulacocidaris	.	.	.	.	3	3	.	.	.	.	.
Temnocidaris	.	.	.	.	.	.	3	.	.	.	.
Tylocidaris	.	.	.	.	.	2	5	.	.	.	.
Sardocidaris	.	.	.	.	.	2	.	.	.	1	.
Tetracidaris	.	.	.	.	2	.	.	.	.	.	.
Total...	42	47	103	101	68	65	95	73	3	26	3

Roughly speaking no less than about 600 different species of Cidarids are known from European deposits, mainly the mesozoic formations. Particularly in the Jurassic period the seas then occupying the main part of what is now Europe "swarmed" with Cidarids, the order reaching its maximum development during that period, such forms as *Rhabdocidaris* and *Diplocidaris* forming the climax. Also in the Cretaceous period Cidarids were exceedingly numerous here, comprising such striking forms as *Temnocidaris*, *Tylocidaris*, *Balanocidaris* and *Tetracidaris*, the three latter again representing extreme points of development in the Cidarid type. Then in the course of the Tertiary epoch the number of Cidarids gradually decreases[1], until in the present European seas, viz. the Mediterranean and the adjacent part of the Atlantic we have only two species, or, if we include also the deep-water species of the Eastern Atlantic, in all four species!

Such striking facts naturally must induce us to speculation about the reasons for this

[1] The fact that only 3 species are known from the Oligocene, against 73 from the Eocene and 76 from the Miocene is, I am informed by my friend J. P. J. Ravn, in the main due to the oligocene deposits being much less accessible than the eocene and miocene deposits and therefore much less known. It does not mean, therefore, that here was a sudden, very great decline in the number of species and then a conspicuous rise again in the Miocene. Were the oligocene fauna as well known as that of the other periods it would rather surely be found to be intermediate between the Eocene and the Miocene in regard to the number of its species.

remarkable development. The family of the Cidarids is still in a flourishing condition; we know at present ca. 150 species and varieties of recent Cidarids, and as many of these are known only in single specimens we may safely say that there is still a fair number of forms to be discovered, so that the total number of recent Cidarid-species will amount to ca. 200. It is accordingly not the declining of the vitality of the type itself that is the reason for the disappearance of the Cidarids from the recent European Seas. It is true, such types as *Rhabdocidaris*, *Diplocidaris*, *Tylocidaris* and *Balanocidaris* have no recent representatives; but then *Stereocidaris*, so richly represented in the European Cretaceous formations, is in recent times equally richly represented in the Indo-Pacific (— whereas there is only one species in the whole Atlantic, none in the Mediterranean —); and in the Goniocidarids we have evidently a new climax of the Cidarid type, as also other types — *Histocidaris*, *Stylocidaris*, *Prionocidaris*, *Phyllacanthus* — are in a flourishing condition.

It would therefore seem that we have to seek the reasons for the disappearance of the Cidarids from the European Seas (— and the other orders of Echinoids evidently will afford parallel cases —) in changes in the physical conditions. I shall not go deeper into this matter, but would merely point at one fact: the lowering of the temperature. The gradual change from the tropical conditions of mesozoic times to the temperate conditions of recent days — and even the subarctic or boreal conditions during the glacial epoch — necessarily must lead to a corresponding change of the marine fauna. But this cannot explain why also the tropical parts of the Atlantic are so remarkably poor in Cidarids — and in Echinoderms on the whole — in comparison with the Indo-Pacific. No doubt we must seek the main reasons for this poverty of the Atlantic fauna in the geological history of this region, be it now the Wegener-theory, or Ihering's Archhelenis-theory that is the truth. On both these theories the tropical part of the Atlantic is of comparatively recent origin, and we can thus herein see some reason for the poverty of its fauna.

No doubt the impression of the richness in Cidarids (— and Echinoids in general —) of the European mesozoic deposits is to some degree exaggerated through the fact that these deposits have been so much more intensely studied than those of other parts of the world. But evidences are not for equally rich faunas to be found in extra-European mesozoic deposits. The mesozoic deposits of N. America have been very intensely studied, but as far as the Echinoids are concerned they can in no way compete with the European deposits (— whereas the N. American palæozoic deposits perhaps exceed, or at least equal, the European deposits of palæozoic age in their richness of Echinoderms —). Also the meagre knowledge available of the mesozoic Echinodermfauna of the Indo-Pacific region decidedly indicates that it was not nearly as rich as that of the mesozoic seas of the European region. It seems to be an established fact, therefore, that in mesozoic times the European Seas were the paradise of Cidarids — and of Echinoids in general — just as the Malay Archipelago is it today.

A more detailed comparison of the Atlantic Cidarid-fauna with that of the Indo-Pacific and of the Antarctic seas leads to some interesting results.

Genus	Atlantic	Indo-Pacific	Antarctic
Histocidaris	2 species	12 species	0 species
Poriocidaris	1 —	0 —	0 —
Aporocidaris	0 —	(2 —)	2 —
Ctenocidaris	0 —	0 —	6 —
Notocidaris	0 —	0 —	4 —
Homalocidaris	0 —	0 —	1 —
Rhynchocidaris	0 —	0 —	1 —
Austrocidaris	0 —	0 —	2 —
Ogmocidaris	0 —	(1 —)	0 —
Goniocidaris	0 —	14 —	0 —
Schizocidaris	0 —	3 —	0 —
Psilocidaris	0 —	1 —	0 —
Rhopalocidaris	0 —	3 —	0 —
Stereocidaris	1 —	15 —	0 —
Cidaris	5 —	0 —	0 —
Calocidaris	1 —	0 —	0 —
Tretocidaris	2 —	0 —	0 —
Acanthocidaris	0 —	3 —	0 —
Stylocidaris	2 —	15 —	0 —
Eucidaris	2 —	1 —	0 —
Actinocidaris	0 —	1 —	0 —
Plococidaris	0 —	1 —	0 —
Prionocidaris	0 —	6 —	0 —
Chondrocidaris	0 —	2 —	0 —
Phyllacanthus	0 —	6 —	0 —
Total...	16 —	86 —	16 —

(Varieties not considered in this list).

The most striking result (— besides the already mentioned poverty of the Atlantic Cidarid fauna —) is this that the whole group of the Cidarina, viz. the genera *Cidaris*, *Calocidaris* and *Tretocidaris*, is entirely confined to the Atlantic region. Also the genus *Poriocidaris* appears to be confined to the Atlantic (the record of its occurrence in the Indian Ocean is very doubtful). It is further of importance that not a single species is common to the Atlantic and the Indo-Pacific (there are no cosmopolitan species of Cidarids).

Of the 16 Atlantic species 7 are confined to the West Indies and the Western Atlantic, 3 (*Cidaris cidaris*, *Poriocidaris purpurata*, and *Cidaris nuda*) to the Eastern Atlantic, while 2 (*Tretocidaris spinosa* and *Eucidaris clavata*) are known only from St. Helena and Ascension. The main interest here connects with the fact that the East and West Atlantic faunas are so conspicuously different, a difference hardly to be explained by the present day physical conditions.

The Cidarid fauna of the Pacific coasts of America, the Panamic region, is like the Atlantic fauna very poor in comparison with that of the Indo-Pacific region. It comprises in all only 7 species, viz.

Histocidaris Cobosi	Centrocidaris Döderleini
Hesperocidaris panamensis	Eucidaris Thouarsi
— dubia	— galapagensis
— perplexa	

Of these the genera *Hesperocidaris* and *Centrocidaris* are peculiar to the region, and also the deep-sea form *Histocidaris cobosi* stands rather isolated, whereas the two *Eucidaris*-species are related to the Atlantic *Euc. tribuloides* and *clavata;* they may have been derived from a common stock living in the Central-American region before the upheaval of the land-bridge now separating the West Indian from the Panamic region.

The Magellanic region also is very poor in Cidarids, with only 3 species, viz. *Austrocidaris canaliculata*, *A. spinulosa*, and *Ctenocidaris speciosa*. The two former are peculiar to the region, as is the genus *Austrocidaris* on the whole, whereas *Ctenocidaris speciosa* is more properly a member of the Antarctic fauna. On the whole the Magellanic Cidarid-fauna is closely related with the genuine Antarctic fauna.

The Antarctic region, on the other hand, has a remarkably rich Cidarid-fauna, 6 genera, with 14 species[1]), all belonging to the group *Ctenocidarina*, and all of them, with the exception of the genus *Aporocidaris*, confined to the Antarctic Seas. Of this latter genus two species, *A. Milleri* and *A. fragilis*, are found in the Pacific deep-sea; but it is very questionable whether these two species are really different from the Antarctic species *A. antarctica*, so that it would seem that this species alone has spread over the Pacific, all the other species being confined to the Antarctic. The fact that the whole group of the *Ctenocidarina* through the characters of the pores and secondary spines appears as a rather primitive group tends to indicate that it has had its home here in the Antarctic Seas from very old times and thus has had time to develop into a great number of species — apparently an analogous case to that of the Marsupials in Australia.

It is a very striking fact that contrary to this richness in Cidarids of the Antarctic Seas not one single Cidarid has its home in the Arctic Seas. Even in the Bering Sea, so close to the rich Japanese region, not one Cidarid is known to occur. It is true the Atlantic species *Cidaris cidaris* occurs as far North as ca. 67° N. at the Norwegian coast, thus within the Arctic circle; but this does not make it an arctic species, the physical conditions along the Norwegian coast being so strongly influenced by the warm Atlantic currents that the arctic region is here pushed far to the North of the arctic circle.

The Indo-Pacific Cidarid fauna has its centre in the Malay Archipelago, the Ambonese region, as it has been named with a very well chosen name by Döderlein.[2]) No less than 48 species and varieties, belonging to 13 genera are represented here, against 26 species in the Japanese Seas, 21 in the Indian Ocean and 18 in the Australian seas. Above all the *Goniocidarina*

[1] In the above list the Magellanic region is comprised under the Antarctic, thus including also the genus *Austrocidaris* w th its two species in the number of Antarctic Cidarids.

[2] L. Döderlein. Indopacifische Euryalæ. Abh. Bayr. Akad. d. Wiss. XXXI. 1927.

have had an extraordinary development here, as also the genera *Histocidaris*, *Stereocidaris* and *Stylocidaris* evidently have their centre of distribution in this region.

	Ambonese region	Japan	Australia	Indian Ocean
Histocidaris elegans	×	×	×	×
— crassispina	.	.	×	.
— misakiensis	.	×	.	.
— carinata	.	×	.	.
— australiæ	.	.	×	.
— magnifica	×	.	.	.
— formosa	×	.	.	.
— recurvata	×	.	.	.
— acutispina	×	.	.	.
— denticulata	.	.	.	×
Goniocidaris tubaria	.	.	×	.
— florigera	×	.	.	.
— spinosa	×	.	.	.
— biserialis	.	×	.	.
— mikado	.	×	.	.
— peltata	×	.	.	.
— clypeata	.	×	.	.
— fimbriata	×	.	.	.
— alba	.	×	.	.
— crassa	×	.	.	.
— sibogæ	×	.	.	.
— australiæ	.	.	×	.
— tenuispina	×	.	.	.
Schizocidaris assimilis	×	.	.	.
— serrata	×	.	.	.
— fasciata	×	.	.	.
Psilocidaris echinulata	×	.	.	.
Rhopalocidaris rosea	×	×	.	.
— gracilis	.	×	.	.
— hirsutispina	×	.	.	.
Stereocidaris grandis	.	×	.	.
— granularis	×	.	.	.
— squamosa	.	.	.	×
— stylifera	×	.	.	.
— purpurascens	×	.	.	.
— sulcatispinis	×	.	.	.

	Ambonese region	Japan	Australia	Indian Ocean
Stereocidaris tubifera	×	.	.	.
— microtuberculata	.	×	.	.
— indica	×	×	.	×
— Alcocki	.	.	.	×
— sceptiferoides	(×)	×	.	.
— japonica	.	×	.	.
Acanthocidaris curvatispinis	.	.	.	×
— maculicollis	×	×	.	×
Stylocidaris Reini	×	×	×	.
— amboinæ	×	.	.	.
— annulosa	×	.	.	.
— conferta	.	.	×	.
— bracteata	×	.	.	.
— maculosa	.	×	.	.
— effluens	×	.	.	.
— tiara	.	.	.	×
— albidens	.	.	.	?
— badia	.	.	.	?
— brevicollis	×	.	.	(?)
— fusispina	.	×	.	.
Eucidaris metularia	×	×	×	×
Plococidaris verticillata	×	×	×	×
Prionocidaris baculosa	×	×	×	×
— pistillaris	.	.	.	×
— australis	.	.	×	.
— glandulosa	×	.	.	.
— bispinosa	×	.	×	×
Chondrocidaris gigantea	.	.	.	×
— brevispina	×	.	.	.
Phyllacanthus imperialis	×	×	×	×
— dubius	.	×	.	.
— parvispinus	.	.	×	.
— longispinus	.	.	×	.
— magnificus	.	.	×	.
— irregularis	.	.	×	.

Only very few species are distributed all over the Indo-Pacific, viz. the littoral species *Eucidaris metularia*, *Plococidaris verticillata*, *Prionocidaris baculosa* and the deep-sea species *Histocidaris elegans*. A few more have also a wide distribution over the Indo-Pacific, as *Stereocidaris indica*,

Acanthocidaris maculicollis (not at Australia), *Stylocidaris Reini* (not in the Indian Ocean), and *Prionocidaris bispinosa* (not at Japan). Only two species, *Rhopalocidaris rosea* and *Stereocidaris sceptiferoides* are apparently common to the Japanese and the Ambonese region, but there is much probability that the Ambonese forms of these two species will prove be distinct species (for the present they are distinguished as separate varieties, *Stereoc. sceptiferoides*, var. *lamellata*, and *Rhopaloc. rosea*, var. *tenuis*). A good deal more species have previously been recorded as common to the Ambonese and the Japanese region, but the closer study has shown this to be due to misidentifications.

In spite of the relatively few forms common to these regions it is quite evident that their faunas are closely related, and it appears that partly, at least, the faunas of the Japanese, Australian and Indian region are radiations from the central Ambonese region. Thus the two Australian *Goniocidaris*-species (+ the single New Zealand species, *G. umbraculum*), make very much the impression of being offshoots from the great central stock of in all 13 species of Goniocidarids (four genera) in the Ambonese region. This is particularly evident of the species *G. australiæ*, so very closely related to, perhaps identical with, the Ambonese *G. sibogæ*, and also for the New Zealand species *G. umbraculum*, whereas *Goniocidaris tubaria*, with its variety *impressa*, stands more apart from the Ambonese Goniocidarids and forms one of the more prominent characteristics of the Australian region. Of the four *Goniocidaris*-species of the Japanese region the species *clypeata* and *alba* are very closely related to the Ambonese forms *fimbriata* and *crassa*, whereas the species *biserialis* and *mikado* have no very close relatives in the Ambonese region. Also *Rhopalocidaris gracilis* is characteristic of Japan, whereas the species *Rh. rosea* has at least a very close relative in the Ambonese region, if they are not identical. Quite peculiar to the Ambonese region are the genera *Psilocidaris* and *Schizocidaris*, as also the subgenus *Cyrtocidaris* of *Goniocidaris*.

Similar relations between the Japanese and the Ambonese regions obtain with regard to the genus *Stereocidaris*, though here the predominance of the Ambonese region is less evident, the number of species represented in both areas being nearly the same (5 in the Japanese, 7 in the Ambonese region); on the other hand this genus is, as far as hitherto known, not at all represented in Australian Seas. Of the genus *Stylocidaris* 6 species are known from the Ambonese region, 3 from Japan, 2 from Australia, and 3 (?4) from the Indian Ocean.

A very characteristic feature of the Australian region is the rich development of the genus *Phyllacanthus*. Of the 6 species known of this genus three, *longispinus*, *magnificus* and *irregularis* are confined to Australia; one, *parvispinus*, appears to be more widely distributed over the South-Sea Islands, another, *imperialis*, being distributed all over the Indo-Pacific, while one, *dubius*, is known only from the Bonin Islands.

The fact that the Bonin Islands have a Cidarid peculiar to them, besides another very conspicuous Echinoid, *Colobocentrotus Mertensii*, shows that this little group of islands must have been isolated for a very long period. The same holds good to a still greater extent of the Hawaiian Islands. 11 Cidarids are known from there, a very considerable number for so small a locality;

no less than 8 of these species are peculiar to this area, one of them representing a separate genus, *Actinocidaris*. Two of the species occurring there are the widely distributed *Eucidaris metularia* and *Plococidaris verticillata*. One more, *Chondrocidaris gigantea* is extraordinary in occurring also at Mauritius, but known from nowhere else. It would seem that this extraordinary distribution must be thus explained that this species was formerly widely distributed all over the Indo-Pacific, but has died out except in these two remote localities. The fact that spines of what is at least a very closely related, perhaps even the same species, the "*Phyllacanthus*" *sundaicus* of Martin, are known from Tertiary deposits of Java (cf. p. 492), makes this explanation very probable.

Our knowledge of the Cidarid fauna of the South Sea Islands is very insufficient, so that it is not possible to form an adequate opinion of its zoogeographical relations. But it would appear to be a poor fauna, consisting mainly of the more widely distributed Indo-Pacific forms (*Eucidaris metularia*, *Phyllacanthus imperialis*), probably also of some Australian types (*Phyllacanthus parvispinus*, *Prionocidaris australis*). The most noteworthy of the Cidarids occurring there is *Chondrocidaris brevispina;* the record of this species occurring also on the coast of Sumatra shows however, (— if the locality be not a mistake, which does not seem to be the case, cf. p. 500 —) that it is not a form peculiar to the South Sea Islands.

New Zealand is very poor in Cidarids, only two species being known from there, viz. *Goniocidaris umbraculum* and *Ogmocidaris Benhami*, both endemic. While *G. umbraculum* is related to the Australian-Ambonese Goniocidarids, *O. Benhami* has its nearest relation in the S. American *Austrocidaris canaliculata*. Thus the relations of the New Zealand region to both Australia and Antarktis is well shown by its Cidarids, in good accordance with its geographical position.

The Indian Ocean, as already said, shows through its Cidarid fauna close relation to the Ambonese region. Of its 21 Cidarid species 8 are peculiar, viz. *Histocidaris denticulata*, *Stereocidaris squamosa*, *St. Alcocki*, *Acanthocidaris curvatispinis*, *Stylocidaris tiara*, *St. albidens*, *St. badia*, and *Prionocidaris pistillaris*. Further the typical form of *Prionocidaris baculosa* is very characteristic of the Western part of the Indian Ocean, as also the variety *longicollis* appears to be peculiar to this region. Not one genus is peculiar to the Indian Ocean, whereas the total absence of the Goniocidarids is a very marked feature. On the whole the Indian Ocean in regard to its Cidarid fauna is far behind the Ambonese region, though still much richer than the Atlantic region.

The South African Seas again are very poor in Cidarids, only one being known with certainty from there, viz. *Stereocidaris capensis*. There is, however, no doubt that at least two more species will prove to occur there, viz. a *Stereocidaris*-species (cf. p. 270) and a *Goniocidaris*-species (cf. p. 154). The relations of these forms are decidedly with the Indo-Pacific Cidarids.

Truly abyssal forms are remarkably scarce among Cidarids. The whole of the Pacific (or still less the Atlantic) Deep-sea has scarcely one Cidarid peculiar to it. Only two species are confined to the immense Deep-sea area of the Pacific, viz. *Aporocidaris Milleri* and *A. fragilis*, but

these two species are evidently offshoots from the Antarctic Cidarid-fauna, and even very probably both identical with the Antarctic species *Aporocidaris antarctica*.

Whereas thus the abyssal parts of the oceans are on the whole very poor in Cidarids, the archibenthal areas, depths of ca. 200—1000 m., are exceedingly rich, much richer than the littoral region; and whereas the littoral fauna of Cidarids is no doubt fairly completely known, we may safely expect the archibenthal regions, particularly of the Indo-Pacific, to contain a good many interesting Cidarids still awaiting discovery.

List of Abbreviations.

As explained in the Introduction (p. 4) a list of literature is not to be given in this first part of the Monograph of the Echinoidea. The references to literature are given in full under each species, only in a more or less abbreviated form. For every reference the year of publication is given, and for those less commonly quoted or of minor importance also the periodical in which they appeared is quoted. Those works which are of primary importance and thus to be taken as familiar to every student of Echinoids, are quoted in a much abbreviated form — as e. g. "Rev. of Ech." for "Revision of the Echini", "Chall. Ech." for the Report on the Echinoidea of the "Challenger" Expedition, "Ét. s. l. Éch." for Lovén's "Études sur les Échinoidées", "Rech. s. l. pédic." for Perrier's "Recherches sur les pédicellaires et les ambulacres des Asteries et des Oursins" — this needs no further explanation. Likewise the abbreviations for the reports on the Echinoids of the larger Deep-sea Expeditions, the "Siboga", the "Ingolf", the "Blake" etc. need not be specially explained. There are, however, a few of the abbreviations constantly used of which an explanation may be desirable; but for the rest reference must be given to the lists of literature found in the previous main works e. g. in the "Revision of the Echini", in my work on the "Ingolf" Echinoidea, and in Lambert & Thiéry's "Essai de nomenclature raisonnée des Echinides".

Agassiz. 1863. "List of Ech." — List of Echinoderms sent to different Institutions in Exchange for other specimens, with Annotations. Bull. Mus. Comp. Zool. No. 2.

Agassiz & H. L. Clark. 1906. "Prel. Rep. Ech. Albatross". — Preliminary report on the Echini collected in 1906, among the Aleutian Islands, in Bering Sea, and along the coasts of Kamtchatka, Sakhalin, Korea, and Japan, by the U. S. Fish Comm. Steamer "Albatross". Bull. Mus. Comp. Zool. LI. 5.

Agassiz & H. L. Clark. 1907. "Hawaiian Ech." Cidaridæ. — Hawaiian and other Pacific Echini. The Cidaridæ. Mem. Mus. Comp. Zool. XXXIV. 1.

Agassiz & Desor. 1847. "Cat. Rais. des Ech." — Catalogue raisonné des familles, des genres et des espèces de la Classe des Échinodermes. Ann. d. Sciences. 3. Sér. VI—VIII.

H. L. Clark. 1909. "Thetis" Ech. — Scientific Results of the trawling expedition of H. M. C. S. "Thetis" off the coast of N. S. Wales, 1898. Echinodermata. Mem. Austral. Mus. IV.

H. L. Clark. 1916. "Endeavour" Ech. — Report on the Sea-Lilies, Starfishes, Brittle-Stars and Sea-Urchins obtained by the F. I. S. "Endeavour" on the coasts of Queensland, N. S. Wales, Tasmania, Victoria, S. Australia, and Western Australia. Biol. Res. Fishing Exper. F. I. S. "Endeavour" 1909—14. IV. 1.

H. L. Clark. 1925. "Cat. Rec. Sea-Urch. Br. Mus." — A Catalogue of the recent Sea-Urchins (Echinoidea) in the collection of the British Museum.

Deslongchamps. 1824. "Encycl. méth." — Encyclopédic méthodique. Histoire naturelle des Zoophytes. II. Texte & Planches.

Desmoulins. 1837. "Mém. s. l. Ech." — Mémoires sur les Échinides. I—III. Actes Soc. Linn. Bordeaux. 1835—37.

Döderlein. 1911. "Ech. Aru Ins." — Über Echinoidea von den Aru-Inseln. Abh. Senckenb. Naturf. Gesellsch. XXXIV. (H. Merton. Ergebn. einer Zool. Forschungsreise in den sudöstlichen Molukken. Bd. II).

Duncan. 1889. "Revis. gen. Ech." — A Revision of the genera and great groups of the Echinoidea. Journ. Linn. Soc. Zoology. XXIII.

Gray. 1855. "Arr. fam. Ech." — An Arrangement of the families of Echinida, with descriptions of some new Genera and species. P. Z. S. 1855. p. 35.

Koehler. 1898. "Rés. Camp. Monaco." XII. — 1909. "Rés. Camp. Monaco" XXXIV. — Résultats des Campagnes scientifiques accomplies sur son Yacht par Albert Ier, Prince de Monaco. Fasc. XII. Échinides et Ophiures, provenant des campagnes du yacht l'Hirondelle. Fasc. XXXIV. Échinodermes provenant des campagnes du yacht Princesse-Alice.

Lambert & Thiéry. 1910. (1925) "Ess. nom. rais." — Essai de nomenclature raisonnée des Échinides. 1910—1925.

Mortensen. 1918. "Ech. N. W. Australia (Mjöberg)." — Results of Dr. E. Mjöbergs Swedish Scientific Expeditions to Australia 1910—13. XXI. Echinoidea. K. Sv. Vet. Ak. Handl. 58. 9.

Mortensen. 1927. "Albatross" Cidaridæ. — Report on the Echinoidea coll. by the U. S. F. Steamer "Albatross" during the Philippine Expedition 1907—10. I. The Cidaridæ. U. S. Nat. Mus. Bulletin 100. (Vol. 6. 4).

Mortensen. 1928. "New Cidaridæ". — Papers from Dr. Th. Mortensen's Pacific Exped. 1914—16. XLIV. New Cidaridæ. Preliminary Notice. Vid. Medd. Dansk Nat. Foren. 85. p. 65.

Pomel. 1883. "Class. méth." — Classification méthodique et genera des Échinides vivants et fossiles.

Yoshiwara. 1906. "Japan. Echini." — A Japanese work published in the Zoological Magazine, Tokyo. 1898—1906. — Only the plates quoted.

Echinoderm names composed of -cidaris, which do not mean Cidarids.

Acrocidaris Agassiz — a Pseudodiadematid.
Asterocidaris Cotteau — a Hemicidarid.
Bothriocidaris Eichwald — a Cystoid.
Cidarella Desmoulins — a Salenid.
Cidaropsis Cotteau — a Pedinid.
Cystocidaris Zittel = *Echinocystis* Wyv. Thomson, fam. Echinocystidæ.
Devonocidaris Thomas — a Lepidocentrid.
Dialithocidaris A. Agassiz — an Arbaciid.
Echinocidaris Desmoulins = *Arbacia*, fam. Arbaciidæ.
Genocidaris A. Agassiz — a Temnopleurid.
Glyptocidaris A. Agassiz — a Phymosomatid.
Gymnocidaris Agassiz — a Hemicidarid.
Habrocidaris A. Agassiz & H. L. Clark — an Arbaciid.
Heliocidaris Desmoulins — an Echinometrid.
Hemicidaris Agassiz — a Hemicidarid.
Heterocidaris Cotteau — a Diadematid.
Idiocidaris de Loriol — a Salenid.
Koninckocidaris Dollo & Buisseret = *Lepidechinus* Hall, a Lepidocentrid.
Leptocidaris Queenstedt — a Pedinid.
Orthocidaris Cotteau — a Pedinid.
Palæocidaris Quenstedt (non Desor) = *Lepidocentrus* Müller, fam. Lepidocentridæ.
Perischocidaris Neumayr — a Lepidesthid.
Pholidocidaris Meek & Worthen — a Lepidesthid.
Plesiocidaris Pomel — a Hemicidarid.
Plesiocidaroida Duncan — *Tiarechinus* Neumayr.
Podocidaris A. Agassiz — an Arbaciid.
Polycidaris Bettoni (non Quenstedt) — a Pedinid.
Proterocidaris de Koninck = *Oligoporus* Meek & Worthen, a Melonechinid.
Protocidaris Whidborne = *Pholidocidaris* Meek & Worthen, a Lepidesthid.
Pseudocidaris Etallon — a Hemicidarid.
Pygmæocidaris Döderlein — an Arbaciid.
Salenocidaris A. Agassiz — a Salenid.
Timorocidaris Wanner — a Crinoid.
Toxocidaris A. Agassiz — an Echinometrid.
Trigonocidaris A. Agassiz — a Temnopleurid.

Appendix.

After the whole of the text of the present work had been printed I received a small paper by P. Thiéry "Considérations phylogéniques sur les Cidaridæ", published after the death of Dr. Thiéry by Cuénot and Lambert (Archives de Zool. expér. & génér. 67. 1928. Notes et Revue, 4. p. 179—181). There is no possibility of entering now on a detailed discussion of the views set forth in this paper; but the new genera established by Thiéry must be briefly mentioned. In general his phylogenetic considerations, taking *Miocidaris* as the ancestral form from which various types have evolved along diverging lines, are in fair agreement with the views I have expressed in the chapter on the classification of the Cidarids (cf. p. 43—56).

The new genera established by Thiéry are:

Pachycidaris Thiéry. A Streptocidarid with the marginal ambulacral tubercles irregularly developed. Pores non-conjugate. Primary spines strongly thorny.

Genotype: *Pachycidaris Thiéryi* Collignon & Lambert (= *Cidaris spinosa* Cotteau, non Agassiz; partim). Pal. Fr. Jurass. Pl. 194. 3—15.

The following three genera have passed the Streptocidarid stage, the imbrication of the plates having disappeared.

Merocidaris Thiéry. Primary tubercles on aboral side crenulate and perforate, on oral side non-crenulate and imperforate. Marginal ambulacral tubercles regular. Pores non-conjugate.

Genotype: *Cidaris honorinæ* Cotteau. Pal. Fr. Jurass. Pl. 257. 44—10; 258. 1—4.

(The fact that *Tylocidaris clavigera* (König) may have the upper primary tubercles perforate should be recalled here, cf. p. 486).

Cænocidaris Thiéry. Differs from *Merocidaris* in having the marginal ambulacral tubercles irregularly developed, the ambulacral plates at the peristomial border being to some degree compound, like in *Paracidaris*.

Genotype: *Cidaris cucumifera* Agassiz. Pal. Fr. Jurass. Pl. 147; 148. 1—10.

Anisocidaris Thiéry. Differs from *Cænocidaris* in the pore-zone being widened, the pores, however, remaining non-conjugate. Marginal ambulacral tubercles irregular.

Genotype: *Cidaris bajocensis* Cotteau. Pal. Fr. Jurass. Pl. 154. 1—6.

Megacidaris Thiéry. The sutures are oblique, recalling to some degree *Miocidaris* (though not really imbricating as in that genus). Pores conjugate; marginal ambulacral tubercles regular.

Genotype: *Rhabdocidaris horrida* (Merian). Pal. Fr. Jurass, Pl. 209; 210. 1—7.

Parrhabdocidaris[1] Thiéry. A *Rhabdocidaris* with compound ambulacral plates.

Genotype: *Rhabdocidaris varusencis* Cotteau. Pal. Fr. Jurass. Pl. 211. 4.

[1] The original spelling *Parhabdocidaris* evidently is incorrect.

To the list of names composed of -cidaris, which do not mean Cidarids, should be added

Anthocidaris Lütken — an Echinometrid.

Index.

Synonyms in Italics.

Page

abyssicola (Cidaris) 301
Acanthocidaris 321
Acanthostraca 25
Actinocidaris 411
acutispina (Histocidaris) 100
Adamsi (Cidaris) 436
affinis (Goniocidaris) 145
affinis (Stylocidaris) 40, 336
africana (Eucidaris) 406
africana (Stereocidaris) 265
Agassizi (Prionocidaris) 456
alba (Goniocidaris) 193
albidens (Stylocidaris) 373
Alcocki (Stereocidaris) 266
Alpicidaris 479
alternans (Diplocidaris) 524
Alternocidaris 524
amboinæ (Stylocidaris) 348
Anaulocidaris 37, 58, 66, 189
Anisocidaris 545
annulata (Cidaris) 400, 468, 475
annulata (Tretocidaris) 316
annulifera (Prionocidaris) 443
annulosa (Stylocidaris) 350
anomala (Porocidaris) 488
Anomocidaris 225, 228, 283
antarctica (Aporocidaris) 116
Aplocidaris 65
Aporocidaris 109
Archæocidaridæ 57
Archæocidaris 59
arduennensis (Typocidaris) 19, 146
armata (Cidaris) 477
aruana (Prionocidaris) 472
Aspidocidaris 150, 153
assimilis (Schizocidaris) 206
Aulacocidaris 489

Page

australiæ (Goniocidaris) 201
australiæ (Histocidaris) 91
australis (Prionocidaris) 456
Austrocidaris 140
avenionensis (Cidaris) 484
Babeaui (Cidaris) 477
baculosa (Prionocidaris) 437
badia (Stylocidaris) 376
bajocensis (Anisocidaris) 545
bajocensis (Cidaris) 477
Balanocidaris 483
baltica (Tylocidaris) 486
Bartletti (Tretocidaris) 315
bathonica (Cidaris) 476
Baylei (Temnocidaris) 285
Benhami (Ogmocidaris) 144
biserialis (Goniocidaris) 173
bispinosa (Prionocidaris) 468
Blainvillei (Cidaris) 480
Blakei (Cidaris) 307
borealis (Cidaris) 289
Bothriocidaris 6, 57
Bowerbanki (Tylocidaris) 486
bracteata (Stylocidaris) 359
brevicollis (Stylocidaris) 379
brevispina (Chondrocidaris) 497
Buchi (Anaulocidaris) 67
Caenocidaris 545
calacantha (Stylocidaris) 356
callao (Cidaris) 393
Calocidaris 312
canaliculata (Austrocidaris) 141
canaliculata (Leiocidaris) 436
canaliculata (Pleurocidaris) 177
Cannoni (Miocidaris) 62
capensis (Stereocidaris) 269
carinata (Histocidaris) 89

	Page
carinata (Stereocidaris)	265
Carteri (Stereocidaris)	227
cassiani (Miocidaris)	62
Caumonti (Cidaris)	477
Centrocidaris	423
cervicalis (Plegiocidaris)	476
Challengeri (Plegiocidaris)	72
Chantrei (Cidaris)	69, 477
chinensis (Prionocidaris)	472
Choffati (Diplocidaris)	524
Chondrocidaris	491
Cidaridæ	61
Cidarina	286
Cidaris	286
cidaris (Cidaris)	289
Cidaris (*Leiocidaris*)	438
Cidarotropus	58
circinnata (Cidaris)	437, 468
cladothrix (Stylocidaris)	346
clavata (Eucidaris)	408
clavigera (Tylocidaris)	486, 545
clavigera (Xenocidaris)	60
clypeata (Goniocidaris)	186
Cobosi (Histocidaris)	84
Collenoti (Cidaris)	481
conferta (Stylocidaris)	351
contracta (Notocidaris)	136
copeoides (Rhabdocidaris)	490
coronata (Plegiocidaris)	476
crassa (Goniocidaris)	195
crassispina (Histocidaris)	77
crateriformis (Cyathocidaris)	484
crenularis (*Schleinitzia*)	437, 468
cretosa (Stereocidaris)	226
Crossei (Cidaris)	482
cucumifera (Balanocidaris)	483
cucumifera (Caenocidaris)	545
cucumifera (Cidaris)	478
Cureti (Alpicidaris)	479
curvatispinis (Acanthocidaris)	323
Ctenocidarina	108
Ctenocidaris	120
Cyathocidaris	484
cyathifera (Cyathocidaris)	484
Cyrtocidaris	150, 153
Danæ (Cidaris)	393
danica (Temnocidaris)	285
Davousti (Cidaris)	476
denticulata (Histocidaris)	100
depressa (Cidaris)	145
desipiens (Diplocidaris)	525
Diplocidarinæ	524
Diplocidaris	524
Discocidaris	149, 153
di Stefanii (Stereocidaris)	230
Döderleini (Centrocidaris)	424
Dorocidaris	286
dorsata (Cidaris)	483
dubia (Hesperocidaris)	419
dubius (Phyllacanthus)	510
Dumortieri (Cidaris)	476
Dumortieri (Diplocidaris)	524
Echinocrinus	59
echinulata (Psilocidaris)	212
Edwardsi (Procidaris)	12, 482
elegans (Histocidaris)	72
elegans (Prionocidaris)	472
effluens (Stylocidaris)	368
Eocidaris	58
Eotiaris	61, 62
erebus (Cyathocidaris)	484
erythræa (Prionocidaris)	439
Etalloni (Diplocidaris)	524
Eucidaris	384
Eurocidaris	120
Falsani (Cidaris)	476
farringdonensis (Cidaris)	146, 502
fasciata (Schizocidaris)	211
Faurai (Anaulocidaris)	67
filograna (Cidaris)	478
fimbriata (Goniocidaris)	190
florigemma (Paracidaris)	478
florigera (Goniocidaris)	167
forbesiana (Cidaris)	58
formosa (Histocidaris)	94
foveata (Cidaris)	146
fragilis (Aporocidaris)	114
fusispina (Stylocidaris)	382
fustigerus (Phyllacanthus)	504, 508
galapagensis (Eucidaris)	399
gaussensis (Notocidaris)	134
Gauthieri (Diplocidaris)	524
Gauthieri (Rhabdocidaris)	480
Gauthieri (Sinæcidaris)	284
Gauthieri (Stereocidaris)	230
Geliberti (Ctenocidaris)	126
gerana (Mikrocidaris)	64
geranioides (Goniocidaris)	156, 161, 163

	Page
gibberula (Cidaris)	483
gigantea (Chondrocidaris)	492
gigantea (Diplocidaris)	524
gigantea (Homalocidaris)	137
glandifera (Balanocidaris)	483
glandulosa (Prionocidaris)	461
Goniocidaridæ	61
Goniocidarina	144
Goniocidaris	149, 153
gracilis (Porocidaris)	104
gracilis (Rhopalocidaris)	216
grandis (Stereocidaris)	233
granularis (Stereocidaris)	242
granulata (Cidaris)	145
guinchoensis (Plegiocidaris)	476
Gymnocidaris	384
gymnozona (Cidaris)	34
halaensis (Cidaris)	145
hannoverana (Stereocidaris)	227
hastata (Notocidaris)	135
hastigera (Acanthocidaris)	325
Haussmanni (Cidaris)	410, 483
hawaiiensis (Prionocidaris)	465
hawaiiensis (Stereocidaris)	239
Helenæ (Aplocidaris)	65
hemigranosus (Leiocidaris)	503
Hesperocidaris	415
hirsutispina (Rhopalocidaris)	214
Histocidarina	69
Histocidaris	70
Homalocidaris	137
honorinæ (Merocidaris)	545
horrida (Megacidaris)	546
horrida (Rhabdocidaris)	490
hyatorina (Stereocidaris)	235
hystrix (Cidaris)	289
icaunensis (Balanocidaris)	483
immunita (Triadocidaris)	63
imperialis (Phyllacanthus)	504
impressa (Goniocidaris)	163
impressa (Stereocidaris)	263
incerta (Aporocidaris)	118
indica (Stereocidaris)	263
ingolfiana (Stereocidaris)	267
integra (Stereocidaris)	265
irregularis (Phyllacanthus)	518
itala (Cidaris)	436
Jacquemeti (Diplocidaris)	524
japonica (*Anomocidaris*)	280
japonica (Stereocidaris)	279, 280
javana (Phyllacanthus)	503
jorgensis (Goniocidaris)	141, 146
julianensis (Cidaris)	121
Keyserlingi (Miocidaris)	62, 63
Kiliani (Tetracidaris)	526
Krohnii (Cidaris)	437
lacrymula (Cidaris)	501
lævispina (Eocidaris)	58
Lallieri (Stereocidaris)	227
lamellata (Stereocidaris)	278
lanceolata (Stereocidaris)	277
langrunensis (Cidaris)	476
Legayi (Cidaris)	478, 480
Leiocidaris	500, 503
Lepidocidaris	58
leucacantha (Stereocidaris)	271
liagora (Triadocidaris)	63
lima (Cidaris)	437
lineata (Prionocidaris)	455
lineata (Stylocidaris)	342
longicollis (Prionocidaris)	449
longispina (Ctenocidaris)	129
longispinus (Phyllacanthus)	517
Lorioli (Austrocidaris)	142
Lorioli (Miocidaris)	62, 63
Lorioli (Stylocidaris)	372
Lütkeni (Cidaris)	468, 475
maculicollis (Acanthocidaris)	329
maculosa (Stylocidaris)	364
magnifica (Histocidaris)	94
magnificus (Phyllacanthus)	518
magnifica (Temnocidaris)	19, 285
major (Goniocidaris)	204
major (Rhabdocidaris)	490
malum (Stereocidaris)	226
margaritifera (Cidaris)	407
mauri (Cidaris)	386, 392
meandrina (Balanocidaris)	483
Megacidaris	546
melitensis (Cidaris)	335, 341
membranipora (*Goniocidaris*)	128
Merceyi (Stereocidaris)	18, 226
meridionalis (Cidaris)	298
Merocidaris	545
Merriami (Cidaris)	423
metularia (Eucidaris)	386
micans (Calocidaris)	312
Michaleti (Cidaris)	483

	Page
microtuberculata (Stereocidaris)	257
mikado (Goniocidaris)	178
Mikrocidaris	64
Milleri (Aporocidaris)	110
minor (Cidaris)	401, 405
minor (*Gymnocidaris*)	386, 392
Miocidaris	62, 545
miranda (Diplocidaris)	524
misakiensis (Histocidaris)	79
Mitchelli (Cidaris)	436
moraldina (Cidaris)	480
Mortenseni (Notocidaris)	131, 228
multiceps (Polycidaris)	480
nigro-brunnea (Prionocidaris)	473
nonarius (Polycidaris)	147, 480
Nordenskjöldi (Cyathocidaris)	484
Nortonechinus	60
Notocidaris	130
nuda (Cidaris)	311
nutrix (Ctenocidaris)	128
nutrix (Eurocidaris)	128
Nuttingi (Histocidaris)	98
Ogmocidaris	143
orbignyana (Rhabdocidaris)	490
ornata (Cidaris)	437
Orthocidaris	286
Ortmanni (Cidaris)	484
oxyrine (Cidaris)	310
Palæocidaris	59
Pachycidaris	545
panamensis (Hesperocidaris)	416
papillata (*Cidaris*, *Dorocidaris*)	289
Paracidaris	477
Parrhabdocidaris	545
parvispinus (Phyllacanthus)	513
patera (Cyathocidaris)	484
peltata (Goniocidaris)	183
pentagona (Mikrocidaris)	64
Perischocidaris	58
perlata (Plegiocidaris)	476
Permocidaris	58
perplexa (Hesperocidaris)	421
Perrieri (Ctenocidaris)	123
persimilis (Triadocidaris)	63, 64
Petalocidaris	149, 153
Phalacrocidaris	225, 228, 283
philippinensis (Stereocidaris)	265
Phyllacanthus	500
Piæ (Sardocidaris)	486
pilum (Cidaris)	483
pistillaris (Prionocidaris)	452
pistillum (Cidaris)	484
plana (Miocidaris)	62
platyacantha (Notocidaris)	135
Plegiocidaris	475
pleracantha (Cidaris)	483
Pleurocidaris	147, 489
Plococidaris	428
Polycidaris	147, 480
Poriocidaris	102
Porocidaris	17, 487
Poucheti (Cidaris)	477
prænobilis (Cidaris)	491
præternobilis (Triadocidaris)	63
Prionocidaris	434
Procidaris	12, 482
propinqua (Plegiocidaris)	486
Psilocidaris	211
punctata (Cidaris)	502
purpurascens (Stereocidaris)	251
purpurata (Poriocidaris)	104
Quoyi (Goniocidaris)	156
Ramondi (Tylocidaris)	486
Ramsayi (Prionocidaris)	472
recens (Rhabdocidaris)	468
recurvata (Histocidaris)	97
Reini (Stylocidaris)	342
remus (Rhabdocidaris)	310
Reynesi (Tetracidaris)	526
Rhabdocidarina	489
Rhabdocidaris	490
Rhodani (Rhabdocidaris)	17, 480
Rhopalocidaris	212
Rhynchocidaris	139
rosaceus (Cidaris)	468
rosaria (Cidaris)	491
Rosavendai (Rhabdocidaris)	310
rosea (Rhopalocidaris)	220
rossica (Archæocidaris)	59
Roysii (Balanocidaris)	483
rubida (Stylocidaris)	346
rubra (Stereocidaris)	245
rufa (Stylocidaris)	354
rugosa (Cidaris)	305
rugosa (Ctenocidaris)	126
ruinæ (Porocidaris)	487
Sæmanni (Cidaris)	476
Sanchezi (Rhabdocidaris)	491

	Page
Sardocidaris	486
sarthacensis (Rhabdocidaris)	490
Scarabellii (Sardocidaris)	486
sceptrifera (Stereocidaris)	226
sceptriferoides (Stereocidaris)	274
Schizocidaris	204
Schleinitzia	434
Schmidelii (Porocidaris)	487
Schweinfurthi (Sardocidaris)	486
scrobiculata (Eocidaris)	58
serrata (Schizocidaris)	211
Sharreri (Histocidaris)	86
sibogæ (Goniocidaris)	198
Sinæcidaris	284
Sismondai (Prionocidaris)	435, 436
speciosa (Ctenocidaris)	122
spinosa (Cidaris)	478, 482, 545
spinosa (Ctenocidaris)	124
spinosa (Goniocidaris)	171
spinosa (Tretocidaris)	317
spinulosa (Austrocidaris)	143
spinulosa (Cidaris)	156
spinulosa (Cidaris)	478, 480
spuria (Eucidaris)	391
squamosus (Lepidocidaris)	58
squamosa (Stereocidaris)	245
Stephanocidaris	21, 149, 153, 434
Stereocidarina	225
Stereocidarinæ	68
Stereocidaris	225
Stokesii (Cidaris)	336
Streptocidarinæ	61
Stromatocystis	7, 57
stylifera (Stereocidaris)	248
Stylocidarina	320
Stylocidaris	334
subcoronata (Miocidaris)	62
sublævis (Cidaris)	477
subpentagona (Mikrocidaris)	64
subsimilis (Triadocidaris)	63, 64
sulcatispinis (Stereocidaris)	254
sumatrana (Stereocidaris)	265
sundaica (Phyllacanthus)	492
talismani (Poriocidaris)	104
Temnocidaris	140, 284
tenuis (Rhopalocidaris)	223
tenuispina (*Anomocidaris*)	280
tenuispina (Goniocidaris)	204
tenuispinus (Phyllacanthus)	513
tenuispinus (Stereocidaris)	280
teretispina (Cidaris)	304
teretispina (Stereocidaris)	267
testiplana (Cidaris)	146
testudo (Anaulocidaris)	67
Tetracidaris	52, 526
texanus (Cidaris)	230
Thiéryi (Pachycidaris)	545
Thomasi (Actinocidaris)	412
Thouarsii (Eucidaris)	393
tiara (Stylocidaris)	368
Tiarechinus	7
Toucasi (Cidaris)	12, 477, 482
Tretocidaris	314
Triadocidaris	63
tribuloides (Eucidaris)	400
tricarinata (Stereocidaris)	266
triplopora (Rhynchocidaris)	140
trispinata (Rhabdocidaris)	490
trouvillensis (Cidaris)	480
tubaria (Goniocidaris)	156
tuberculata (Goniocidaris)	204
tuberculosa (Porocidaris)	488
tubifera (Stereocidaris)	260
Tylocidaris	485
Typocidaris	225, 228
umbraculum (Goniocidaris)	164
unicolor (Phyllacanthus)	508
urii (Archæocidaris)	59
valfinensis (Cidaris)	476
variabilis (Histocidaris)	82
varucensis (Parrhabdocidaris)	546
venulosa (Rhabdocidaris)	436
venusta (Mikrocidaris)	64
veronensis (Porocidaris)	488
verrucosa (Miocidaris)	62
verticillata (Cidaris)	433
verticillata (Plococidaris)	148, 428
vexillifera (Tylocidaris)	486
viridis (Rhopalocidaris)	216
vivipara (*Goniocidaris*)	141
Walcotti (Tylocidaris)	486
Welleri (Nortonechinus)	60
Xenocidaris	59, 60
Zschokkei (Cidaris)	478

TH. MORTENSEN

STUDIES OF THE DEVELOPMENT AND LARVAL FORMS OF ECHINODERMS

WITH 33 PLATES AND 102 FIGURES IN THE TEXT

1921

G. E. C. GAD · COPENHAGEN

PRICE 42 SH.

*

TH. MORTENSEN

HANDBOOK OF THE ECHINODERMS OF THE BRITISH ISLES

1927

HUMPHREY MILFORD
OXFORD UNIVERSITY PRESS · LONDON

PRICE 38 SH.

BIANCO LUNO · COPENHAGEN

9 11 JAN. 1964