DEPARTMENT OF MARINE BIOLOGY
OF
THE CARNEGIE INSTITUTION OF WASHINGTON
ALFRED G. MAYOR, Director

VOLUME X

THE ECHINODERM FAUNA OF TORRES STRAIT:

ITS COMPOSITION AND ITS ORIGIN

BY
HUBERT LYMAN CLARK
OF THE MUSEUM OF COMPARATIVE ZOÖLOGY

WASHINGTON, D. C.
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The "lithothamnion ridge" along the outer edge of the southeast reef of Mer Island. The ridge is shown laid bare at the low spring tide of September 30, 1913.

Southeast shore of Mer Island, showing the wide southeast reef-flat and the stone fish-traps which were constructed in prehistoric times by the natives.

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COMPOSITION AND ORIGIN OF THE ECHINODERM FAUNA OF THE TORRES STRAIT REGION AND QUEENSLAND.

PREFACE.

The present report, intended primarily as a contribution to zoögeography, has been made possible through the opportunity given me as a member of the Expedition of the Carnegie Institution of Washington to Torres Strait in 1913. Every possible facility was afforded for studying the littoral echinoderms, not only at Mer, the largest of the Murray Islands, where a laboratory was maintained for five weeks, but also at Green Island near Cairns in northern Queensland, at Thursday Island, at Erub (Darnley Island), and at Badu (Mulgrave Island). These brief glimpses of the reef life at widely scattered points were invaluable in acquainting me with the Torres Strait fauna, but it must not be supposed that they were adequate to give a satisfactory knowledge of its distribution. They merely served to show that local conditions may play a large part in the distribution of species and to make one cautious in drawing conclusions from observations so hastily made.

Besides its primary purpose, this report is offered as a contribution to our knowledge of echinoderms, particularly their natural history and taxonomy. Wherever a species has been observed in life by me, I have given all the data I could secure regarding its occurrence and habits. Oftentimes, of course, when species were taken but once or at best very rarely, these data amount to little, but they may perhaps be suggestive. As for the taxonomy, the new species of crinoids with which I met have already been described [1] and it has not seemed desirable to repeat the original descriptions, but figures of these new forms are given herewith for the first time. So, too, the new ophiurans have been described and figured by photograph,[2] but colored figures of some of the most notable species are given in the present report. No new echini were found by the Carnegie Institution's party. The new asteroids and holothurians are here described and figured for the first time.

In view of the fact that the local use of this memoir will be infrequent and small, it has not seemed desirable to give artificial keys to all the species. Instead of this I have taken occasion to make revisions of certain genera or families which are unusually well represented in the Torres Strait region and it is hoped that these will be of service to students of echinoderms, quite regardless of the narrow geographical limits to which this report is confined.

It would be most ungracious if I failed to express in this brief introduction my gratitude to those whose assistance has made the present work possible. To Dr. Alfred Goldsborough Mayor, Director of the Department of Marine Biology of the Carnegie Institution of Washington, I owe thanks not merely for the opportunity of visiting Torres Strait and enjoying the privileges of the laboratory at Mer, but for his unfailing interest in my work and his determination that nothing he could do should be left undone to make that work successful. No words could adequately express my appreciation of what I owe to him, but even these few lines

[1] See H. L. Clark, 1915. Comatulids of Torres Strait. Carnegie Inst. Wash. Pub. No. 212, pp. 97–125.
[2] See H. L. Clark, 1915. Catalogue of Recent Ophiurans. Mem. M. C. Z., *25*, pp. 163–376, plates 1–20.

are contrary to his expressed wishes and are offered merely for the satisfaction of my own feelings. To Mr. E. M. Grosse, of Sydney, who went with us to Torres Strait as artist, my heartiest thanks are due, not only for the beautiful figures which adorn the first nineteen plates of this memoir, but also for his careful supervision of the lithographing of those plates at the New South Wales Government Printing Office in Sydney. Mr. Grosse's skill is amply attested by the plates themselves, but only those who were in our party can fully appreciate the patience, persistence, and enthusiasm with which his work was done. To Lieut. Frank A. Potts, M. A., of Cambridge, England, Dr. E. Newton Harvey, of Princeton, and Professor David H. Tennent, of Bryn Mawr, the other members of the party, I am glad to express my thanks, not only for their constant kindness and coöperation, but for many valuable specimens. Mr. John W. Mills, our engineer, was always eager to help in every possible way, and many a fine specimen I owe to his enthusiastic interest. Mr. John S. Bruce, government teacher and magistrate on Mer, was constantly helpful and placed me under great obligation to him. Mr. Thomas A. Williams, who, at the time of our visit was magistrate on Erub, was also most hospitable. I am under very real obligations to Mr. George Clark, of Thursday Island, for his kindly help. The late Mr. R. Etheridge, curator of the Australian Museum, was untiring in his efforts to have me properly equipped for collecting in Torres Strait; it gives me great pleasure to acknowledge here his many kindnesses and his unfailing interest. The assistant curator, Mr. Charles Hedley, was also most helpful, and to him I feel under special obligation, for it was largely due to his advice that we went to Mer. Finally, I wish to thank Mr. Samuel Henshaw, Director of the Museum of Comparative Zoölogy, for the extended leave of absence which made the trip possible, and also for helpful suggestions in connection with the preparation of the plates for this report.

THE ECHINODERM FAUNA OF TORRES STRAIT:

ITS COMPOSITION AND ITS ORIGIN

BY

HUBERT LYMAN CLARK

OF THE MUSEUM OF COMPARATIVE ZOÖLOGY

INTRODUCTION.

The marine fauna of Torres Strait is of more than usual interest because the region is generally believed to be one of relatively recent subsidence, and the question naturally arises whether the strait so formed has been a migration route of importance in the distribution of marine life. Have East Indian species passed eastward through the Strait to give rise to or mingle with the Australian east-coast fauna? Or have Australian species passed westward through the Strait and entered the East Indian fauna? Correct answers to these questions would throw a great deal of light on the origin of the faunæ of the Australian east coast and of the islands in the western Pacific south of the equator. Indirectly, at least, light would also be thrown on the whole geological history of those regions.

Hedley, in his interesting and important paper on the Marine Fauna of Queensland (1909), has touched on these matters and has hinted at some of the evidence shown by the distribution of mollusks, but otherwise the questions have hardly been approached from a zoölogical point of view. The intensive study of the littoral echinoderms of Torres Strait, which was made possible by the expedition of the Carnegie Institution of Washington in 1913, suggests that such studies may result in finding the true answers to these and similar queries. At any rate the results here set forth throw some light on the obscure problems involved.

Littoral echinoderms are at present one of the best groups of marine organisms for the study of such questions because their conspicuousness invites the attention of all collectors and has led to the larger common species being well known for many years and hence recorded from many places. Moreover, each class of echinoderms is sharply defined and none contains such a large number of species as to make a reasonable familiarity with all an impossibility for a specialist. Finally, no echinoderms are so active or such wanderers in the adult condition, even when they are free-swimming forms, as to lead to a rapidly widening dispersion. It is true that a large proportion of the known species of echinoderms are believed to have pelagic larvæ of more or less activity and the dispersal of the species almost certainly takes place chiefly by means of the scattering of those larvæ by currents, surface or deeper. Nevertheless, many species have a relatively restricted range and the group as a whole contains comparatively few cosmopolitan or even tropicopolitan species. It is also important to note that strictly littoral echinoderms have a limited bathymetrical range and species which can be collected on the reefs and along shore rarely extend into water over 30 fathoms deep. To such species, therefore, a channel or larger area of greater depth than that forms a barrier which, while far from insurmountable, is nevertheless of real importance.[1]

Obviously, to make use of a littoral fauna as an agency for throwing light on such a problem as the function of Torres Strait in the distribution of marine life, the composition of that fauna must be worked out as completely as possible, and the first part of this memoir is therefore occupied with an account of the species of echinoderms which are known to occur in the Torres Strait region. It is no doubt true that this fauna is as yet imperfectly known, for our knowledge is based on

[1] The views here expressed are, I am aware, directly contrary to those held and expressed by Bell (1909), who considers that the Indo-Pacific echinoderms can "throw no light" on the relation of islands to each other.

the collections of but four workers, of whom only one was particularly interested in echinoderms. But the material gathered into these four collections reveals a fauna of wonderful richness, well worthy of more exhaustive investigations. It is particularly notable for the abundance of comatulids, whose beautiful colors and graceful movements make them the most striking feature of echinoderm life on the reefs.

For the purpose of this study, the Torres Strait region is limited strictly to the district between 141° and 145° E. longitude and 9° and 11° S. latitude, an area of about 37,000 square miles, of which little more than 3,000 is land. Except outside the Barrier Reef, which is approximately in longitude 144°, the 34,000 square miles of sea is very shallow, rarely exceeding 25 fathoms in depth, and usually not over 10 or 12. It is, moreover, crowded with reefs and sand bars, many of which

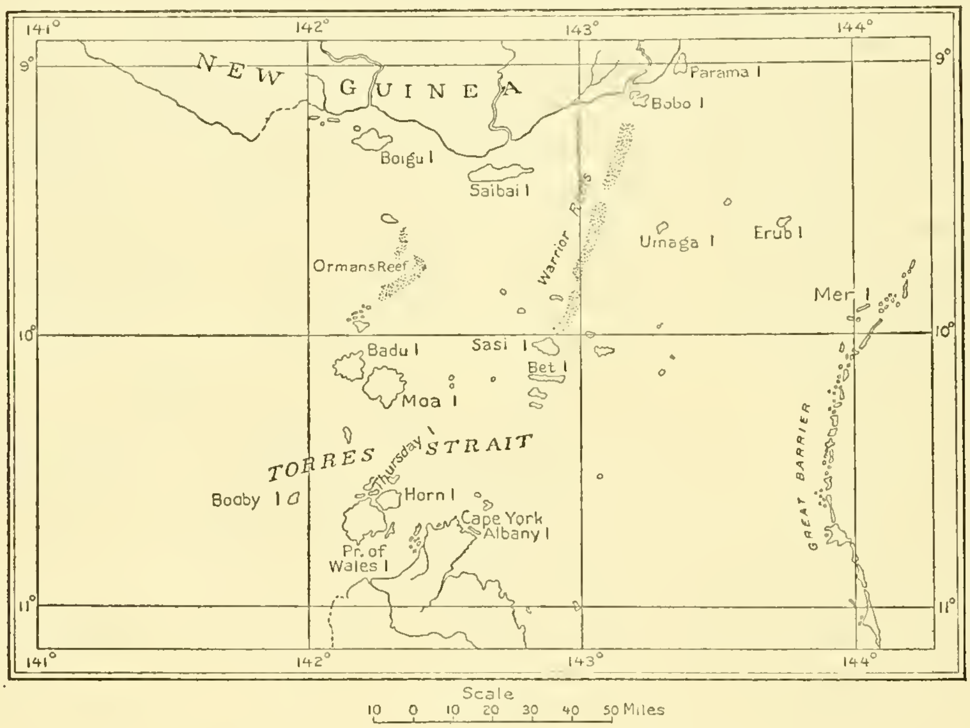


FIG. 1.—Chart showing the Torres Strait region.

rise into islands and islets of greater or less extent, but only a few feet above water. There are also volcanic islands like Erub and Mer, or sunken and eroded mountains like Badu and Moa, which are extensively bordered by reefs and reef flats. As a consequence of these physical conditions, the region teems with marine life, and where the combinations of tidal currents and surface conditions are particularly favorable the richness of the coral reefs in invertebrate life really passes description. At Mer, where the Carnegie Institution's laboratory was maintained for five weeks, and where echinoderms were particularly sought for, additional species were discovered every day and a large proportion proved to be new to science. But the reefs were far from exhausted by our constant and intensive search, for on the last day of our stay four species were found which we had not previously seen. Nothing is known of the fauna in the deep water east of the Great Barrier reef.

The first workers to collect echinoderms in Torres Strait were the naturalists of the *Challenger*, who made Somerset on Albany Pass, about 30 miles southeast of Thursday Island, their headquarters from September 1 to 8, 1874, and on September 9 visited Booby Island and also dredged and trawled in that vicinity.[1] Challenger Station 186 was near Wednesday Island, in 8 fathoms of water, where three hauls with a dredge were made on a bottom of sand, shells, and gravel. Station 187 was near Booby Island, in 6 fathoms, where two hauls with a dredge and one with a trawl were made on a deposit of sand and shells. Station 188, at which a number of interesting echinoderms were secured, lies just west of the Torres Strait region, as here limited; 27 species of echinoderms were taken at station 186, quite equally divided between the five classes, but at station 187 only 14 species were taken, and of these 9 were sea-stars, while there were no holothurians. The list of echinoderms gathered by the *Challenger* naturalists, including the littoral collections, follows; species which were described as new to science are indicated by *italics*. Where the species is discussed in the present report under a different name, that name follows the sign =.

CRINOIDEA:
- Antedon microdiscus = Zygometra microdisca.
- *multiradiata* = Zygometra microdisca.
- variipinna = Heterometra crenulata.
- Actinometra *belli* = Comaster belli.
- *maculata* = Comatella maculata.
- multiradiata = Capillaster multiradiata.
- parvicirra = Comanthus annulata.
- *paucicirra* = Comatula rotalaria.
- pectinata = Comatula pectinata.
- solaris = Comatula solaris.
- *valida* = Comanthus annulata.

ASTEROIDEA:
- Astropecten *zebra*.
- *zebra* var. *rosca*.
- Luidia *forficifer*.
- Stellaster incei.
- *princeps*.
- Anthenea tuberculosa.
- Pentaceros *callimorphus* = Oreaster gracilis.
- turritus = Oreaster nodosus.
- Nepanthia brevis.
- Ophidiaster *helicostichus* = Hacelia helicosticha.
- *tuberifer* = Tamaria tuberifera.

ASTEROIDEA—*continued*:
- Metrodira subulata.
- Retaster *insignis*.

OPHIUROIDEA:
- Ophiolepis annulosa = Ophiolepis superba.
- cincta.
- Ophiothrix longipeda.
- stelligera.
- Ophiomaza cacaotica.
- Euryale aspera.

ECHINOIDEA:
- Phyllacanthus annulifera = Prionocidaris bispinosa.
- verticillata = Prionocidaris verticillata.
- Pleurechinus bothryoides = Temnotrema bothryoides.
- Salmacis globator = Salmacis virgulata alexandri.
- rarispina = Salmacis belli; S. dussumieri.
- Laganum depressum.
- Peronella decagonalis = Peronella orbicularis.
- Breynia australasiæ.

HOLOTHURIOIDEA:
- Synapta *verrilli* = Protankyra verrilli.
- Colochirus *challengeri* = Pentacta challengeri.
- *Actinocucumis typicus*.
- *Thyone fusus* var. *papuensis* = Thyone papuensis.

[1] In 1878 J. E. Tenison-Woods listed the following Echini from the Torres Strait region, as having been collected by Sir William Macleay in 1875. According to Hedley (1909), Macleay's vessel, the *Chevert*, was at Erub from July 31 to August 13.

Goniocidaris geranioides. Erub.
Diadema setosum. Erub, "10–20 fms."
Astropyga radiata. Erub, "10–20 fms."
Heterocentrotus mammillatus. Erub, "10–20 fms."
Echinometra lacunter. Erub.
Strongylocentrotus eurythrogrammus. Cape York.
Temnopleurus toreumaticus. Erub, "10–20 fms."
Salmacis bicolor. Erub.
Salmacis rarispina. Erub; Cape York.
Echinus daraleyensis. Erub; Cape Grenville.
Hipponoë variegata. Erub; Cape Grenville.
Fibula volva. Burar.
Arachnoides placenta. Erub; Cape Grenville.
Maretia planulata. Erub; Cape Grenville.
Eupatagus valenciennesi. Cape Grenville.
Breynia australasiæ. Cape York.

I have transcribed the names of the echini as given in the list regardless of spelling, but I have used the native names of the islands in giving the localities. This paper of Tenison-Woods is the first published dealing with Torres Strait echinoderms, although the material was collected about a year after the *Challenger's* visit to the region. But the presence in the list of *Goniocidaris geranioides*, *Strongylocentrotus erythrogrammus*, and *Eupatagus valenciennesi*, southern species not otherwise known on the eastern coast of Australia north of Port Jackson, has so shaken my faith in its reliability that I have decided to leave it out of account. This decision is strengthened by noting that the depths given for *Diadema* (= *Centrechinus*) and *Heterocentrotus* are highly improbable for such very littoral species. Moreover, it is impossible now to determine what the species of *Salmacis* really were. The indications are that, even if there are no misidentifications, in some way a shifting of labels took place, which has led to some highly improbable records. Consequently I have ignored this list throughout this report except in the case of *Echinus darnleyensis*. Ramsay (1885) has virtually discarded Tenison-Woods' list and records none of its species from the Torres Strait region, except *Echinus darnleyensis*, *Fibularia volva*, and *Breynia australasiæ*.

There are 11 crinoids, 13 asteroids, 6 ophiurans, 8 echinoids, and 4 holothurians in this list, a total of 42 species and varieties, of which 16 were supposedly new to science. As revised in the light of present knowledge, there are but 41 species and varieties and only 12 really new.

The next collector of echinoderms to visit the Torres Strait region was Dr. R. W. Coppinger, of H. M. S. *Alert*, who spent the months of June to September 1881 at Thursday Island. He was a remarkably intelligent and skilful naturalist, and though not especially interested in echinoderms, he brought to the British Museum a large and valuable collection of those animals, which was studied and reported on by F. Jeffrey Bell.

The following species were contained in the *Alert* collection from the Torres Strait region:

CRINOIDEA:[1]
- Antedon *bidens* = Oligometrides adeonæ.
  - *decipiens* = Heterometra crenulata.
  - *elegans* = Zygometra elegans.
  - *gyges* = Lamprometra gyges.
  - *irregularis* = Comatula pectinata. Zygometra elegans. Heterometra crenulata.
  - milberti = Amphimetra discoidea, Oligometra carpenteri.
- Actinometra intermedia = Comatula solaris.
  - jukesi = Comatula rotalaria.
  - multifida = Comaster novæguineæ, Comanthus schlegelii.
  - parvicirra = Comanthus parvicirra.
  - *paucicirra*[2] = Comatula rotalaria.
  - robusta = Comatula solaris.
  - solaris = Comatula solaris, pectinata, purpurea, and Heterometra crenulata.
  - *variabilis* = Comaster multifida.

ASTEROIDEA:
- Echinaster purpureus = Echinaster luzonicus.
- Linckia megaloplax = Tamaria fusca.
  - nodosa = Haccelia helicosticha.
- Metrodira subulata.
- Stellaster incei.
- Pentagonaster *coppingeri* = Goniodiscaster coppingeri.
  - *validus* = Goniodiscaster pleyadella.
- Dorigona longimana = Iconaster longimanus.
- Asterina cepheus = Asterina burtonii.
- Asterina (Nepanthia) brevis.
- Astropecten *coppingeri* = Astropecten zebra.
- Retaster insignis.

OPHIUROIDEA:
- Pectinura infernalis = Ophiarachnella infernalis.
- Ophiopinax stellatus = Ophiochasma stellatum.
- Ophiopeza conjungens = Pectinura yoldii.
- Ophionereis dubia = Ophionereis semoni.
- Ophiothrix martensi.
  - *melanogramma.*
  - punctolimbata.
  - rotata.
  - striolata.
- Ophiomaza cacaotica.

ECHINOIDEA:
- Phyllacanthus annulifera = Prionocidaris bispinosa.
- Salmacis *alexandri* = Salmacis virgulata alexandri.
- Temnopleurus bothryoides = Temnotrema bothryoides.
  - toreumaticus.
- Echinus angulosus = Lytechinus verruculatus.
  - darnleyensis = Nudechinus darnleyensis.
- Fibularia volva.
- Laganum decagonale = Peronella orbicularis.
  - depressum.
- Echinoneus cyclostomus.
- Lovenia elongata.
- Breynia australasiæ.

HOLOTHURIOIDEA:
- Cucumaria *semperi.*
- Colochirus tuberculosus = Pentacta tuberculosa.
- Actinocucumis *difficilis.*
- Thyone sacellus.
- Thyonidium schmeltzii = Phyllophorus schmeltzii.
- Phyllophorus proteus.
- Holothuria lineata = Holothuria pardalis.
  - modesta ?
  - peregrina = Holothuria pardalis.

There are 14 crinoids, 12 asteroids, 10 ophiurans, 12 echinoids, and 9 holothurians in this list, a total of 57 species, of which 15 are described as new to science. As revised in the light of present knowledge, there were 56 species in this collection, but only 7 were new to science at the time. It is a striking fact that only 13 of the

[1] The corrected identifications of the *Alert* comatulids are due to Mr. A. H. Clark's revision of the crinoids of the British Museum (1913).

[2] This species is also recorded, in the *Challenger* list, as new to science, but it was described from the *Alert* collection. That is, it was first *taken* by the *Challenger*, but was first *described* in the *Alert* report.

57 species taken by Dr. Coppinger are in the *Challenger* lists.[1] The fact is not hard to understand, however, when we consider that Dr. Coppinger's work was all in shallow water, from which the naturalists of the *Challenger* were more or less debarred by the very specific purpose of that vessel's voyage. The two British vessels together revealed an echinoderm fauna in Torres Strait of at least 80[2] species, of which more than a third appeared to be endemic or at least confined to Torres Strait and the tropical coast of Queensland.

In 1892 Dr. Richard Semon made Thursday Island his headquarters from February 13 to April 4, and with the aid of a sailboat dredged and collected extensively in the Strait. His collections of echinoderms were subsequently studied by Döderlein and by Sluiter, the latter reporting on the holothurians. The following species were in Semon's Torres Strait collection:

CRINOIDEA:
- Antedon bidens = Oligometrides adeonæ.
  - elegans = Zygometra elegans.
  - microdiscus = Zygometra microdisca.
- Actinometra belli = Comaster belli.
  - paucicirra = Comatula rotalaria.
  - pectinata = Comatula pectinata.
  - solaris = Comatula solaris.

ASTEROIDEA:
- Astropecten granulatus.
  - zebra.
- Luidia maculata.
- Iconaster longimanus.
- Stellaster incei.
- Goniodiscus pleyadella = Goniodiscaster pleyadella.
- Anthenea tuberculosa (tuberculata on p. 305).
- Pentaceros turritus = Oreaster nodosus.
- Nepanthia brevis.
- Ophidiaster tuberifer = Tamaria tuberifera.
- Retaster cribrosus = Retaster insignis.

OPHIUROIDEA:
- Ophiopeza conjungens = Pectinura yoldii.
- Pectinura arenosa.
- Ophiactis modesta.
- Amphiura *brocki* = Amphiodia brocki.
- *Ophiotriton semoni* = Ophionereis semoni.
- Ophiothela danæ.
- *Ophiophthirius actinometræ.*

OPHIUROIDEA—*continued.*
- Ophiothrix *belli.*
  - longipeda.
  - martensi.
  - punctolimbata.
  - stelligera.
  - striolata.
- Ophiomaza cacaotica.

ECHINOIDEA:
- Leiocidaris bispinosa = Prionocidaris bispinosa.
- Pleurechinus bothryoides = Temnotrema bothryoides
- Salmacis sphæroides var. *belli* = Salmacis belli.
- Echinometra lucunter = Echinometra mathæi.
- Arachnoides placenta.
- Laganum decagonale = Peronella orbicularis.
- Echinodiscus auritus var. tenuissima = Echinodiscus tenuissimus.
- Breynia australasiæ.

HOLOTHURIOIDEA:
- Synapta glabra = Opheodesoma glabra.
  - godeffroyi = Euapta godeffroyi.
  - grisea var. *alba* = Opheodesoma grisea.
  - indivisa = Synaptula indivisa.
  - similis? = Protankyra similis.
- Colochirus cucumis = Pentacta cucumis.
- Mülleria echinites = Actinopyga echinites.
  - *lubrica* = Actinopyga lubrica.
- Holothuria monocaria.
  - pardalis.

There are thus 7 crinoids, 11 asteroids, 14 ophiurans, 8 echinoids, and 10 holothurians in the Semon collection, a total of 50 species, but only 7 are undescribed forms. Of the 50, 34 were apparently not taken by the *Challenger,* 35 are not on the *Alert's* list and 26 do not seem to have been taken by either vessel. Dr. Semon thus apparently increased the number of species of echinoderms known from Torres Strait to 112, but the revised lists show that there were only 29 species not taken by the *Challenger,* only 28 that the *Alert* did not get, and only 20 not taken by either vessel. Semon thus raised the number of known echinoderms from Torres Strait to just 100. It is interesting to note that 12 species were present in all three collections, that Semon found no crinoids not in the other collections, but on the other

[1] We now know that the two collections had 17 species in common.
[2] The two lists seem to show 86 different forms, but the corrected lists reduce this number.

hand only one of his holothurians was found by the earlier collectors. Whether these peculiarities of Semon's collection are in any way connected with the season of the year when his work was done, can not be asserted, but it is not at all unlikely. The *Challenger* and *Alert* collections were made in the early spring, while Dr. Semon was at Thursday Island in the late summer and early fall. Nothing is known definitely as yet of the seasonal changes in the fauna of a coral reef, or indeed of any circumscribed marine area, at least so far as the invertebrates are concerned. Mr. Bruce, of the Murray Islands, once remarked to me that he wished I could stay on through the rainy season (summer) because I would then find many marine animals which were not to be found in September and October.

In September 1913 the Department of Marine Biology of the Carnegie Institution of Washington established a laboratory in Torres Strait, and I was so fortunate as to be one of the party that enjoyed its privileges. For a few days we were at Thursday Island and that immediate vicinity; we had three days at Erub and a hasty visit was paid to Badu, but most of our time was spent at Mer, the largest of the Murray Islands. There, as already mentioned, we searched the reefs diligently for five weeks, but we were ab'e to do no dredging. A little use was made of "tangles," but they were not very successful. One afternoon a Japanese diver collected for us in the deeper water outside the reef, but with comparatively poor results. In spite of the collecting being thus almost entirely confined to the reefs and reef-flats, we secured a notable collection of echinoderms made up of the following species:

Echinoderms collected by Carnegie Expedition in Torres Strait in 1913.

CRINOIDEA:
- Capillaster multiradiata.
- Comatella maculata.
  - nigra.
  - stelligera.
- Comatula pectinata.
  - purpurea.
- Comanthus alternans.
  - annulata.
  - *callipepla.*
  - *luteofusca.*
  - parvicirra.
  - samoana.
  - schlegelii.
- Heterometra *delicata.*
- Stephanometra *callipecha.*
  - monacantha.
  - *stypacantha.*
- Lamprometra *brachypecha.*
  - gyges.
- Oligometra *anisa.*
- Tropiometra afra.
- Dorometra nana.

ASTEROIDEA:
- Anthenea tuberculosa.
- Oreaster nodosus.
- Culcita novæguineæ.
- Asterope carinifera.
- *Habroporina pulchella.*
- Fromia *elegans.*
  - milleporella.

ASTEROIDEA—*continued.*
- Nardoa mollis.
  - novæcaledoniæ.
  - pauciforis.
  - *rosea.*
- Ferdina *ocellata.*
- Linckia lævigata.
- Bunaster *uniserialis.*
- Leiaster speciosus.
- Ophidiaster granifer.
  - *lioderma.*
  - squameus.
- Tamaria tuberifera.
- Nepanthia brevis.
- Asterina *anomala.*
  - burtonii.
  - exigua.
  - *nuda.*
- Echinaster luzonicus.
- Acanthaster planci.
- Valvaster *spinifera.*

OPHIUROIDEA:
- Ophiacantha confusa.
  - discoidea.
- Amphiura *microsoma.*
  - *septemspinosa.*
- Amphiocnida dilatata.
- Ophionephthys *octacantha.*
- Amphipholis squamata.
- Amphiodia *mesopoma.*
- Amphioplus *parviclypeus.*
  - relictus.

Echinoderms collected by Carnegie Expedition in Torres Strait in 1913—Continued.

OPHIUROIDEA—*continued.*
- Ophiactis *delicata.*
  - *hemiteles.*
  - *luteomaculata.*
  - savignyi.
- Ophiothrix demessa.
  - *dyscrita.*
  - hirsuta.
  - *liodisca.*
  - longipeda.
  - martensi *australis.*
  - melanosticta.
  - nereidina.
  - propinqua.
  - *rhabdota.*
  - stelligera.
  - striolata.
  - trilineata.
  - virgata.
- Ophiomaza cacaotica.
  - cacaotica var. picta.
  - obscura.
- Ophiothela *hadra.*
- Ophionereis porrecta.
  - semoni.
- Ophiocoma brevipes
  - brevipes var. variegata.
  - erinaceus.
  - *parva.*
  - pica.
  - schœnleinii.
  - scolopendrina.
- Ophiomastix annulosa.
  - asperula.
  - caryophyllata.
  - *corallicola.*
  - flaccida.
  - janualis.
  - mixta.
- Ophiarthrum elegans.
  - pictum.
- Ophiarachna incrassata.
- Ophiopezella spinosa.
- Ophiarachnella gorgonia.
  - infernalis.
  - septemspinosa.
- Ophiura kinbergi.
- Ophiolepis cincta.
  - superba.
- Ophioplocus imbricatus.

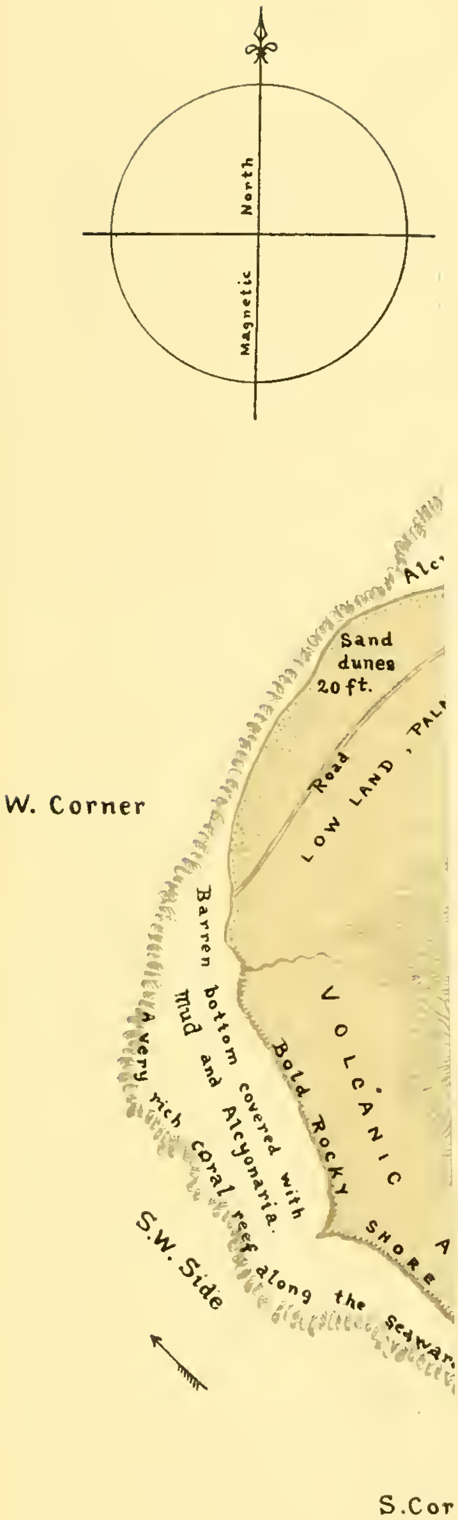
ECHINOIDEA:
- Phyllacanthus imperialis.
- Centrechinus savignyi.
  - setosus.
- Echinothrix calamaris.
  - diadema.
- Tripneustes gratilla.
- Salmacis virgulata alexandri.
- Temnotrema sculpta.
- Stomopneustes variolaris.
- Echinostrephus molare.
- Parasalenia gratiosa.
- Echinometra mathæi.

ECHINOIDEA—*continued.*
- Heterocentrotus mamillatus.
- Fibularia volva.
- Peronella lesueuri.
  - orbicularis.
- Echinoneus cyclostomus.
- Schizaster lacunosus.
- Brissus latecarinatus.
- Breynia australasiæ.
- Lovenia elongata.

HOLOTHURIOIDEA:
- Euapta godeffroyi.
- Opheodesoma grisea.
- Polyplectana kefersteinii.
- Synapta maculata.
- Synaptula nigra.
  - recta.
- Leptosynapta *latipatina.*
- Chiridota rigida.
- Trochodota *maculata.*
- Thyone buccalis.
  - okeni.
- Phyllophorus schmeltzii.
- Pseudocucumis aciculus.
  - africanus.
  - *eurystichus.*
- Pentacta *trimorpha.*
  - tuberculosa.
- Labidodemas semperianum.
- Holothuria *altimensis.*
  - arenicola.
  - argus.
  - atra.
  - *axiologa.*
  - coluber.
  - *cumulus.*
  - edulis.
  - fuscocinerea.
  - *hypamma.*
  - immobilis.
  - impatiens
  - impatiens vars. *concolor, lutea, pulchra.*
  - leucospilota.
  - marmorata.
  - modesta.
  - monocaria.
  - pardalis.
  - pervicax.
  - remollescens.
  - rugosa.
  - scabra.
  - *subverta.*
- Stichopus chloronotus.
  - horrens.
  - variegatus.
- Thelenota ananas.
  - *anax.*
- Actinopyga lecanora.
  - mauritiana.
  - miliaris.
  - nobilis.
  - parvula.

The above list contains the names of 22 crinoids, 27 asteroids, 59 ophiurans, 21 echinoids, and 53 holothurians, a total of 182 forms, 177 distinct species, and 5 additional color varieties. Three of the color varieties and 41 of the species were previously unknown to science, or at least unnamed.

On comparing the list of echinoderms taken by the Carnegie expedition with those of the earlier collectors, some interesting facts are brought out which throw a little light on questions of distribution. Only 5 names (*Comatula pectinata*, *Nepanthia brevis*, *Ophiomaza cacaotica*, *Peronella orbicularis*, and *Breynia australasiæ*) occur in all four lists, 21 occur in three lists, and 56 in two lists. Of the *Challenger's* 42 species we met with only 16; of the 57 forms taken by Dr. Coppinger, we found but 22; while of Dr. Semon's 50 we collected only 17. Of the 100 echinoderms known from Torres Strait, we met with only 36, no doubt because we did so little dredging and so little collecting in the vicinity of Cape York and Thursday Island. On the other hand, by going to Mer and collecting the echinoderms of that single spot as completely as time permitted, we added 146 forms to the Torres Strait list, bringing it up to a grand total of 246 species and varieties. No region of similar extent anywhere in the world is as yet known to harbor an echinoderm fauna of such variety, but it is quite possible that favorable areas in the southern Philippines or in the Dutch East Indies will, when intensively examined, reveal a similar wealth of forms.



North
Magnetic
Sand dunes 20 ft.
Road
LOW LAND
W. Corner
Barren bottom covered with Mud and Alcyonaria.
VOLCANIC
Bold Rocky
SHORE
A very rich coral reef along the
S.W. Side

PLATE A

MER ISLAND

S. Lat. 9° 55′ E. Long. 144° 2′
From surveys by Captain Owen, 1891
and A. G. Mayor, 1913
0 500 1000 1500 2000 Ft.

PART I.—ANNOTATED LIST.[1]

CRINOIDEA. FEATHER-STARS.

Although conditions are not suitable for the occurrence of stalked crinoids, the reefs of Torres Strait provide many a satisfactory home for comatulids and at certain points, such as the southwest reef at Mer, these exquisite animals are very abundant. Their remarkable delicacy and grace combined with their varied and often brilliant colors make them conspicuous even among the beauties of the reef, so that they are sure to attract the attention of anyone so fortunate as to visit such an area. At Mer we found no fewer than 21 species, and at Friday Island we secured a single specimen of still another. Of these 22 species, 7 seem to have been new to science when we took them,[2] and 7 others were not previously known from the Torres Strait region. In 1874 the *Challenger* had taken 9 species, and seven years later Dr. Coppinger, of the *Alert*, secured 4 of these, adding 9 more not taken by the earlier naturalists. Semon, in 1892, collected only 7 species at and near Thursday Island, adding none to the list of 18 already taken. Of these 18, we took but 8, so that the total number of species now known from Torres Strait is 32.

The most common and the most beautiful of the Torres Strait comatulids are members of the family Comasteridæ. They live a very sedentary life, either in crannies among the living corals or attached to the lower surface of large rock-fragments. Observations on their habits [2] show that they are very sluggish with little tendency to move about or even to change position. Movement, when it does occur, is effected by creeping, using the arms and not the cirri for this purpose. Comatulids of other families swim actively and very gracefully, but the comasterids apparently never do so under normal conditions. Their color diversity is very great and, in some cases at least, is entirely unreliable as a clue to the species. No correlation was noted between the brilliancy of the color and the light or shade of the habitat, but some evidence was found for believing that colors become deeper with age and, in some species at least, old individuals tend to become a deeper and deeper brown, or even black.

Until 1907 the great *Challenger* monograph by P. H. Carpenter contained most of what was known about comatulids, although one or two other Englishmen and several German writers had made some contributions to the subject. But since 1907 our knowledge has been enormously extended and the taxonomy of the group has been revolutionized by the work of Mr. Austin Hobart Clark, of the United States National Museum. The unusually keen systematic sense, excellent powers of observation, and remarkably clear use of language in description revealed in his publications, have placed all students of echinoderms under great obligations to him and have made him easily our foremost authority on the Recent Crinoids. In my work on the comatulids of the Torres Strait region I have been under con-

[1] Families and genera are arranged with reference to a taxonomic sequence, but species are arranged alphabetically except in the families Ophidiasteridæ and Ophiocomidæ, where they follow the sequence of the artificial keys.

[2] See The Comatulids of Torres Strait, pp. 97–125 of Pub. No. 212, Carnegie Inst. Wash., 1915.

stant obligation to him not only for his publications, but for the loan of books and specimens as well as for opinions and suggestions made both orally and in letters. It is therefore to be regretted that I find myself often in disagreement with him, particularly in regard to the status of a number of comatulids which I myself collected. In his report on the *Siboga* Comatulids (1918) Mr. Clark assigned my seven supposedly new species (See H. L. Clark, 1915) to the synonymy of half a dozen forms, previously more or less well known. This is done without word or comment, which Mr. Clark tells me is due to lack of opportunity, as his manuscript was completed when the reprint of my paper was received. Of course, in view of his opinions, I have carefully reviewed my descriptions, re-examined my material, and given new attention to publications bearing on the species in question. During the summer of 1919 Mr. Clark spent some weeks in Cambridge, studying the crinoids of the Museum of Comparative Zoölogy collection, and of course reviewed my Australian material. As a result he has modified some of his opinions, but we are still not in agreement on every case. His position with reference to each species concerned is discussed in the proper place in the following pages.

Since Mr. Clark's reports on the crinoids of Australia (1911), the crinoids of the Indian Ocean (1912), and the *Siboga* comatulids (1918) give an abundance of keys and of bibliographical references, I have limited myself to the least possible synonymy.

COMASTERIDÆ.

Comatella maculata.

Actinometra maculata P. H. Carpenter. 1888. *Challenger* Comat., p. 307, pl. lv, fig. 2.
Comatella maculata A. H. Clark. 1908. Smithson. Misc. Coll. *52*, p. 207.

(Plate 3, Figure 1.)

This widespread species, which ranges from the islands of the southwestern Indian Ocean to Rotuma and the Carolines, was originally taken by the *Challenger* in Prince of Wales Channel, Torres Strait, in 8 fathoms. It was not met with by either Coppinger or Semon, but we found it common at Mer on both the southeastern and southwestern reef-flats. It lives on the lower surface of large rock fragments and seems to avoid bright light, for when the rock is overturned the comatulids move quickly towards the lower side. When placed in a basin, some individuals are quite active and move around and around the basin at a rate of 2 or 3 inches per minute. If the basin is placed in the sun, the comatulid folds the arms over the disk and makes various other movements indicating physiological disturbance. At Mer, there was not much diversity of color in this species, the typical appearance being well shown in figure 1, plate 3. Very large specimens (150 mm. across) tend to become very dark, approaching black, but the tinge is always purplish, not brown. Although known from the northern part of the East Indian region, from New Caledonia, and as far as 20° S. on the Queensland coast, *maculata* is not known from the Arafura Sea or the islands between New Guinea and Timor.

Comatella nigra.

Actinometra nigra P. H. Carpenter. 1888. *Challenger* Comat., p. 304.
Comatella nigra A. H. Clark. 1908. Smithson. Misc. Coll., *52*, p. 207.—1912. Crinoids Indian Ocean, p. 68, 69, fig. 1.—1918. *Siboga* Comat., p. 5, pl. i (colored).

The discovery of *nigra* at Mer, where it is comparatively rare, extended considerably to the southward, the known range of this species, which is common in the northern East

Indies and Philippines. A single large specimen is recorded by Reichensperger (1914) from the Aru Islands. At Mer, *nigra* occurred only near the outer margin of the southwestern reef-flat. The Museum of Comparative Zoölogy has a series of 33 specimens from Port Galera, Mindoro, Philippine Islands, most of which are accompanied by careful notes on the color in life. For these notes thanks are due to Dr. L. E. Griffin. They show that *nigra* ordinarily has the ground-color a deep wine-red or even blood-red, tending to become almost black; one specimen, however, was essentially light brown and one was distinctly olive-green; many specimens showed a stippling or spotting with olive-green or olive-yellow, and in most specimens the cirri were tipped with a light shade, usually recorded in the notes as "silver" or "glassy." Preserved specimens are commonly a dull brown of some shade, often nearly black, but are sometimes quite bright brown. When dry, they give little indication of stippling or spotting with lighter shades. The species grows to a large size, 300 to 350 mm. across with usually from 40 to 70 arms.

It seems to me by no means certain that *nigra* is specifically distinct from *stelligera*, which is exceedingly common at Mer. When taken, the specimens of *nigra* were supposed to be only old specimens of the common species, and I still think that is a possible interpretation of their peculiarities, but in deference to Mr. A. H. Clark's contrary opinion, based on more extensive material, I do not at present unite the two forms under a single name.

Comatella stelligera.

Actinometra stelligera P. H. Carpenter. 1888. *Challenger* Comat., p. 308, pl. lviii.
Comatella stelligera A. H. Clark, 1908. Smithson. Misc. Coll., *52*, p. 207.—1918. *Siboga* Comat., p. 5, pl. ii (colored).

(Plate 2, Figure 2.)

This is a very common comatulid at Mer and its diversities of color were very perplexing. The first one taken was "deep purple, with every joint or syzygy yellow-green," except those on the calyx which were orange-yellow; the centrodorsal was purple with yellow spots; pinnules with purple segments and orange joints; cirri absent. But the same day at the same place, I took the brilliantly green individual shown on plate 2, and such green specimens were by no means rare. Other specimens had the calyx and basal part of arms purple, with the distal half of arms more or less green; the transition from purple to green is not abrupt. A small specimen with 35 arms, taken September 28, had disk and basal part of arms orally bright rose-purple; calyx and aboral side of arm bases light yellow brown, becoming dusky near middle of arms; distal part of arms bright yellow, with or without a transverse band of rose-purple; cirri rose-purple. One specimen is recorded in my field notes as "uniformly black," but quite possibly this was a specimen of *nigra*, as the two species were not distinguished in the field.

A specimen of *stelligera* in the Australian Museum is said to be from Port Jackson, but I think such a record needs confirmation, as the species was not taken by either the *Thetis* or the *Endeavour*, nor was it known to Whitelegge, perhaps the best-informed man in the world, early in the present century, on the marine fauna of Port Jackson. The *Alert* did not find *stelligera* anywhere on the coast of Queensland, not even in Torres Strait, nor did the *Challenger* nor Semon meet with it. Under the circumstances, I consider the supposed Port Jackson specimen the result of an erroneous label, though possibly an individual might have reached that harbor on a foul ship bottom. At any rate, the record may well be ignored in delimiting the range of the species, which extends from Ceylon on the west to Samoa on the east. Aside from Mer, the only place in the Torres Strait region where it has been taken is at the reef of Attagor, west of Erub; Jukes collected a specimen here which is now in the British Museum. No specimens have been taken in the Arafura Sea or among the islands in that immediate vicinity.

Capillaster multiradiata.

Asterias multiradiata Linné. 1758. Sys. Nat., ed x, p. 663.
Capillaster multiradiata A. H. Clark. 1909. Vid. Med., p. 134.—1918. *Siboga* Comat., p. 14, pl. iii (colored).

A single specimen, with 19 arms and the cirri XXI, 20–24, was taken with a "tangle," in 5 to 6 fathoms of water just outside the reef at Mer. The color in life was black orally, brown dorsally, with joints between the segments much darker; whole dorsal surface including the cirri heavily silvered or frosted with white. The dry specimen is light gray, the joints noticeably darker. The half-dozen specimens in the Museum of Comparative Zoölogy, from Port Galera, Philippine Islands, on which we have color notes, thanks to the kindness of Dr. L. E. Griffin, were brown of some shade in life, sometimes nearly black, usually with white or silver on the cirri, but seldom elsewhere. The range of *multiradiata* extends from Ceylon to the Caroline Islands, north to Formosa and south to Dirk Hartog Island, West Australia, and Flinders Island, Queensland.

Comatula pectinata.

Asterias pectinata Linné. 1758. Sys. Nat., ed. x, p. 663.
Actinometra pectinata P. H. Carpenter. 1888. *Challenger* Comat., p. 284, pl. liii, figs. 15–22.
Comatula pectinata A. H. Clark. 1908. Proc. U. S. Nat. Mus., *33*, p. 685.

(Plate 1, Figure 3; Plate 3, Figure 2.)

This species is certainly not common in the Torres Strait region, but it is recorded as taken by the *Challenger*, the *Alert*, and Dr. Semon. We found a specimen on the sandy flat south of Friday Island, and at Mer we took 4 specimens. One of these, a young one, was notable for its color (pl. 3, fig. 2), so much more brilliant than that of any adults we saw, their general tone being deep brownish-purple (pl. 1, fig. 3). The range of this species is from Singapore and the Philippine Islands, southward to Baudin Island, West Australia, and to Port Molle, Queensland. I doubt the validity of the Port Jackson record for the same reasons that I have questioned the occurrence of *Comatella stelligera* there.

Comatula purpurea.

Alecto purpurea J. Müller. 1843. Arch. f. Naturg., *9*, pt. 1, p. 132.
Comatula purpurea A. H. Clark. 1910. Proc. Biol. Soc. Wash., *23*, p. 96, fig. on p. 97.—1918. *Siboga* Comat., pl. xiv, fig. 16.

This species ranges along the northern coasts of Australia from Port Denison, Queensland, to Shark Bay, West Australia, and northward to the Philippine Islands. It is recorded from both the Aru and Kei Islands and the *Alert* took it in Torres Strait. We did not find it at Friday Island, Badu, or Erub, but it is exceedingly common at Mer in all sorts of situations, some of which are quite unlikely places for a comatulid. It was first noted among sea-weed and rocks at the edge of the reef-flat near the northern corner of the island on the west side. The individuals found here, where conditions seemed unfavorable to echinoderms and few occurred, were all small, rarely more than 90 mm. across when fully expanded, and in ordinary light seemed to be black. Some, when critically examined in bright light, were found to have a distinctly greenish cast, while others were brownish. In a solution of Epsom salts ($MgSO_4$) in which they were placed for narcotization, they gave out rapidly and copiously a brownish-red color. As the color was given out to an unequal degree, preserved specimens show much diversity of shade. At first these small individuals from the northwestern reef were supposed to be young, but the very dark color suggests they are adults stunted by adverse conditions under which they live. On the eastern and southern reefs, *purpurea* proved to be very common and reached a larger size. The biggest ones found were about 250 mm. across. Under the very favorable living conditions on these reefs great diversity of color was shown, especially among the smaller individuals; some were bright red, some madder red, some simply reddish, and occasionally one was yellowish olive, yellowish brown, or gray. Sometimes there were white stripes on the arms and pinnules, and the joints of the pinnules were white, but as a rule specimens were unicolor. The colors are very fugitive by any method of preservation, but are best retained by killing in an aqueous solution of mercuric chloride and then drying.

Adults of *purpurea* are readily distinguishable from specimens of *pectinata* of the same size by the characteristic number and arrangement of the cirri. I have seen no specimen which could not be promptly assigned to one species or the other by this test alone, but I have failed to find any other difference between the two species and I do not feel certain that they are really distinct. The fact that specimens of *pectinata*, large and small, were found at Mer associated with *purpurea* and distinguishable only by their more numerous and more continuously arranged cirri, makes me somewhat sceptical. Some of the largest specimens of *purpurea* lack cirri altogether, but the sockets, usually paired, sometimes single, at the five corners only of the centrodorsal are unmistakable.

Comatula rotalaria.

Lamarck. 1816. Anim. s. Vert., *2*, p. 534.—P. H. Carpenter. 1888. *Challenger* Comat., pl. liv (as *Actinometra paucicirra*).

Although this species was taken by the *Challenger*, the *Alert*, and Dr. Semon, we did not meet with it. Known only from northern Australia and the Aru Islands.

Comatula solaris.

Lamarck. 1816. Anim. s. Vert., *2*, p. 533.—Herklots. 1869. Bijd. Dierk., *9*, p. 10, pl. ix (colored).

Another well-known species, ranging from Port Curtis, Queensland, to Singapore and Hong Kong, with which we did not meet, although the *Challenger*, *Alert*, and Dr. Semon took specimens in Torres Strait.

Comaster belli.

Actinometra belli P. H. Carpenter. 1888. *Challenger* Comat., p. 334, pl. lxiv, figs. 1, 2.
Comaster belli A. H. Clark. 1908. Proc. U. S. Nat. Mus., *33*, p. 686.

Known from various stations on the coast of northern Australia including one or more in Torres Strait, but we did not meet with it.

Comaster multifida.

Alecto multifida J. Müller. 1841. Arch. f. Naturg., *1*, pt. 1, pp. 144, 147.
Comaster multifida A. H. Clark. 1909. Proc. Biol. Soc. Wash., *22*, p. 87.

Owing to the fact that in each of three of his most important papers (1911, 1913, 1918) Mr. A. H. Clark has used a different nomenclature for the Comasters of Torres Strait, it is very difficult, if not impossible, to determine which of the various records belong to any one of the species. There seems to be no doubt that Mr. Clark believes there are three species in the Torres Strait region, but as we did not meet with even one, I can throw no light on the subject.

Comaster novæguineæ.

Alecto novæguineæ J. Müller. 1841. Arch. f. Naturg., *7*, pt. 1, p. 146.
Comaster novæguineæ A. H. Clark. 1908. Proc. U. S. Nat. Mus., *33*, p. 686.—See P. H. Carpenter. 1888. *Challenger* Comat., pl. lvii, fig. 1 (as *Actinometra typica*).

Known from several stations in Torres Strait, but not met with by us, this species has a far wider range than the preceding two, reaching Fiji on the east and Singapore and the Philippines on the north. The notes on our Philippine specimens from Dr. L. E. Griffin's collection show that in life this comatulid is usually brown of some shade, ranging from dark chocolate to burnt orange; one specimen, however, was chiefly olive with the cirri and pinnules "blue."

Comanthus[1] alternans.

Actinometra alternans P. H. Carpenter. 1881. Notes Leyden Mus., *3*, p. 208.
Comanthus alternans A. H. Clark. 1908. Smithson. Misc. Coll., *52*, p. 206.

(Plate 20, Figure 1.)

A single specimen of this species, which ranges from Port Molle, Queensland, to the Philippine Islands, was found at Mer. It was taken by the Japanese diver in 18 fathoms, outside the northwestern reef. The color was orange-brown with the young arms and distal part of many old ones bright brownish-orange. When placed in alcohol, this specimen reacted vigorously, quite differently from the many other individuals of *Comanthus* treated in the same way, rupturing the arms, so that only one and part of a second remained attached to the calyx (pl. 20, fig. 1).

Mr. A. H. Clark has now (1913, Smithson. Misc. Coll., *61*, No. 10) raised to full generic rank certain sections of *Comanthus* which he originally proposed as subgenera (1909, Vid. Med., p. 141). These are based on the frequency and position on the arm of the occurrence of division series of 2 and of 4 (3+4) segments. This is a very variable character and one which increases in variability with the increase in the number of arms, and while it is of great service in distinguishing species, it seems to me an exaggeration of its importance to base genera thereon. I must therefore decline to recognize Mr. Clark's subdivisions of *Comanthus*.

Comanthus annulata.

Actinometra annulata Bell. 1882. Proc. Zool. Soc. London, p. 535, pl. 35.
Comanthus (Vania) annulata A. H. Clark. 1911. Mem. Austral. Mus., *4*, pt. 15, p. 757.

(Plate 1, Figures 2 and 8; Plate 3, Figure 3.)

This is decidedly the most noticeable comatulid of Mer and probably of the Torres Strait region. While it is perhaps no more abundant than *Comatula purpurea*, it is much more conspicuous from its more brilliant color as well as from its larger size. It is obviously *the* feature of the animal life on the reefs where conditions are suitable. While it was not uncommon on the southeastern reef at Mer, the southwestern reef was the best place for it. The diversity of colors shown is really extraordinary and it is doubtful if anything more beautiful can be found in the sea than a selected group of these exquisite comatulids. A dozen assorted specimens in a large white basin of sea-water rivals in beauty of texture and form, as well as of color, the finest bouquet a florist can produce. When seen thus, the appropriateness of the name "sea-lilies" is obvious. It is surprising how little correlation between size (and age?) and color, specimens of *annulata* show. Some of the smallest specimens were very dark olive or dark brown, nearly or quite black, rarely they were red; specimens 50 to 75 mm. across were often light brown, yellowish, greenish, or even blue (pl. 3, fig. 3); larger specimens were commonly brown, olive, green, or purplish (pl. 1, fig. 2); big specimens were often very dark and occasionally almost dead-black. Few individuals were unicolor; the change of shade or even of color between the base and the tip of the arm was usually marked (pl. 1, fig. 8). The following quotations from my field notes will serve to emphasize the diversity of color shown: (1) Light dull flesh-red; dorsal surface light purplish with white bands near base of arms. (2) Lovely yellow-green, the pinnules with white tips. (3) Pale grayish-blue, pinnules with orange tips. (4) Delicate pale gray and black. (5) Oral surface blackish, dorsal side dull whitish or pale gray-brown, with each

[1] Although the Greek word ἄνθος is neuter, it is the opinion of the best authorities that *Comanthus* should be regarded as of so-called "common" gender. Since Mr. A. H. Clark, the author of the genus, designates his type as *intricata*, subsequently stated to be equivalent to the earlier name *valida*, using the feminine termination in both cases, I have decided to abandon the neuter termination to the specific names in the genus, which I have previously used, and shall hereafter uniformly adopt the feminine.

joint and syzygy black; pinnule segments almost white; cirri pale yellowish. (6) Disk very dark, variegated or speckled with green; basal third of arms brown, all syzygies and joints dark brown; distal two-thirds of arms bright yellow-green with joints, syzygies, and oral surface dark brown; cirri dull light-blue. (7) Dull black; oral side of terminal half of arms white. (8) Dead-black; only the bases of the oral pinnules white.

The diversity of size, arm-number, and number of cirri is no less noteworthy. In size the range was from less than 50 mm. diameter up to approximately 300 mm. The number of arms ranged from 13 to 47, but the great majority of individuals had between 32 and 43; only 11 were noted with more than 43 arms. The division series are very generally 4 (3+4) and it is not difficult to find individuals with 38 to 40 arms in which every series is thus. On the other hand, most individuals have one or more series simply 2, and in one specimen no fewer than 13 series are of this number. Brachials of the third (iii Br) series are of course present in specimens with more than 20 arms, and brachials of the fourth series (iv Br) are very generally present; in two specimens, one with 40 and one with 42 arms, a v Br series is present. The number of cirri ranges from none, a very common condition, to as many as 18 or 19, but as a rule they are few and weak.

The range of *annulata* is from Ceylon eastward to Fiji and Tonga, and southward to Port Denison, Queensland, and to the northwest coast of Australia.

Comanthus annulata var. xantha.

H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 102.

(Plate 1, Figure 6.)

A superb comatulid, bright red and yellow in color, was found in the cavity of a large sponge, brought up by the Japanese diver from 18 fathoms off the northwestern reef at Mer, October 13, 1913. The following day two similar specimens were found near the edge of the southwestern reef. Except for the color, I fail to detect any characters by which this form can be distinguished from *annulata* and I therefore suppose it is only a color variety. But it is so well marked and easily recognized that it seems to me worth while to give it a name.

Comanthus callipepla.

H. L. Clark. 1915. Carnegie Inst. Pub. No. 212, p. 102.

(Plate 1, Figure 1.)

In his *Siboga* report, Mr. A. H. Clark (1918, p. 43, 44) assigns this species to the synonymy of *C. briareus,* in spite of my definite assertion to the contrary. Of course, in view of this action I have again been over the evidence and I am confident that Mr. Clark is wrong. The Museum of Comparative Zoölogy has a fine series of 28 specimens of *briareus* from the Philippines, most of which are accompanied by Dr. Griffin's valuable notes on their color in life. Some of these are rather small and on one several cirri are present. The presence of cirri in *callipepla* is not in itself, therefore, a character to distinguish the species invariably from *briareus;* indeed, it is quite possible that the Murray Island species may lack cirri when old and particularly when senescent. But comparison of a cirrus of *briareus* with one of *callipepla* brings out another distinguishing character not emphasized in my original description. In *briareus* the cirri, when present, are composed of about 11 segments and end in a conspicuous curved claw, while in *callipepla* there are 16 segments and the terminal claw is minute and scarcely at all curved. The form of the individual segments in the two species is also seen to be markedly different when the cirri are placed side by side. The difference between *briareus* and *callipepla* in the form of the I Br and II Br series is very striking, and by itself is ample to separate them. As for the difference in color, *briareus* is commonly brown of some shade or very deep reddish; it is often sprinkled, speckled, blotched, or variegated with yellow-green or yellow, but in none of the Philippine specimens, nor in any recorded cases, is there any approach to the green and yellowish-white coloration of *callipepla*.

Since examination of the holotype (M. C. Z. No. 579) Mr. Clark has decided that it is *annulata*, an opinion in which I can not possibly concur. Among hundreds of *annulata* seen at Mer, the maximum number of arms noted was 47 and the largest number I have found recorded is 68. Moreover, the coloration of *callipepla* is quite different from that of any of the multitudinous color forms of *annulata*. Finally the iii Br series is 2, not 4 (3+4), and hence by Mr. Clark's own system of generic division *callipepla* is a *Comantheria* and not a *Comanthus* at all! I am glad, however, that he is ready to admit it is not *briareus*.

The only individual of this superb comatulid which we saw was found among living "stag-horn" corals near the outer edge of the reef-flat at Mer. It was kept alive in the laboratory nearly 24 hours while the colored figure was being made, but it died and broke to pieces early in the morning of the second day. Hence, as a holotype it is now in a fragmentary condition, but still reveals all the essential characters, and even the colors are but little changed.

Comanthus luteofusca.

H. L. Clark. 1915. Carnegie Inst. Pub. No. 212, p. 102.

(Plate 20, Figures 2 and 3.)

This pretty little comatulid is not at all rare at Mer, though not abundant. It occurs with *annulata* but is readily distinguished from that species. The color shows little diversity, ranging only from a rather light to a rather dark yellow-brown; occasionally the brown is dark and has a greenish cast and rarely the distal part of the arms is green or greenish yellow; the cirri are bright brown or yellowish. Before seeing specimens, Mr. A. H. Clark (1918, *Siboga* Comat., p. 56) was of the opinion that this is only a form of *parvicirra;* it is, however, much nearer *annulata*, and if these two species are to be maintained as distinct from each other *luteofusca* would seem to be entitled to recognition. Mr. Clark distinguishes *annulata* from *parvicirra* only by the more numerous arms and the absence of cirri. Naturally, under such an arrangement *luteofusca* would seem to be identical with *parvicirra*, but anyone who will take the trouble to examine carefully the original description of the Murray Island species will see easily why such is not the case. On the other hand, the line between *luteofusca* and small, dark specimens of *annulata* with 16 to 18 cirri is not so easy to draw, and I hesitated whether to consider the small brown individuals merely a variety of *annulata* or to rank them as a distinct species. The latter course seemed to me better and I see no reason to regret it.

Since examining my material (M. C. Z. Nos. 536 to 542 and 580; holotype, No. 536) Mr. Clark suggests that *luteofusca* is identical with *samoana*, and after comparison of specimens I think he is probably right. But I am letting the name stand for the present because I find that there are two forms now included in the Museum of Comparitive Zoölogy collection, both from Mer and both identified by Mr. Clark as *samoana*. One of these has very rough cirri and is what I have called *luteofusca;* the other has smooth cirri and I have called it *samoana*. Mr. Clark has labeled one of these latter "nearly typical *samoana*." Whether these two forms represent different species or not, I am not prepared to say. They are easily distinguished from each other but I hardly think the difference will prove reliable. My first thought was to let *luteofusca* stand as the name for the form with the rough cirri and use *samoana* as the name of those which have the cirri smooth. But reference to Mr. Clark's original description of *samoana* unfortunately shows that his types were the form with rough cirri. Hence it is the form with smooth cirri which lacks a name! For the present, however, the matter may rest, awaiting light on the relationship of the two forms.

Comanthus parvicirra.

Alecto parvicirra J. Müller. 1841. Arch. f. Naturg., *7*, p. 145.
Actinometra parvicirra P. H. Carpenter. 1888. *Challenger* Comat., p. 338, pl. lxvii, figs. 3, 4.
Comanthus parvicirra A. H. Clark. 1908. Smithson. Misc. Coll., *52*, p. 203.

(Plate 1, Figures 5 and 7.)

This is the most perplexing comatulid found at Mer, for while typical specimens are easily recognized, the intergradations with *annulata* are very puzzling. Moreover, the individuals which seem to be undoubtedly *parvicirra* differ so among themselves that it is hard to believe they represent a single species. This is well shown on plate 1, where figure 5 represents an arm of a red and white form and figure 7 represents the arm of a very different-appearing grayish form. It will be noted at once that not only in color but in the shape of the arm the differences are very great. The preserved specimens look less unlike each other and a careful comparison fails to show any good reason why they should not both be called *parvicirra*. It will be observed that the grayish individuals have the arm-segments yellow-brown with the joints and the pinnules purplish-brown, but the general effect both in life and in alcohol is gray. One of the most strikingly colored individuals seen was greenish-yellow and rich red-purple, while another had the basal half of the arms red and white (as in pl. 1, fig. 5) with the distal half bright-greenish-yellow. It is evident, therefore, that little reliance can be placed on color to help in distinguishing *parvicirra*, yet it is certain that very dark-colored specimens were not noted at Mer and, except for the grayish specimens, bright colors were the rule. The shade of red in the red and white individuals is elusive, for while in bright sunlight it seems to be almost rose-red, with less illumination it is more a dull blood-red and in shade it becomes almost a light liver-brown. It is quite fugitive in alcohol, the specimen becoming more or less light brown. Aside from the matter of color, *parvicirra* is distinguishable from *annulata* by its lighter, more fragile structure, the presence of some cirri, and the relatively small number of arms. As many specimens of *annulata*, however, have only 21 to 29 arms and often have cirri, sometimes 18 or 19, it is only by a careful weighing of all the characters that the two species can be distinguished. I am by no means sure that they really ought to be regarded as distinct, but on the other hand it seems to me unwise to include them under a single name. Perhaps further observations on living specimens may reveal a more natural line of division than is at present known. There is little danger of confusing *parvicirra* with *luteofusca*, the former has so much longer and more slender arms, fewer and shorter cirri, and lacks, moreover, the characteristic coloration of *luteofusca*.

There are records of *parvicirra* from the Seychelles on the west to the Tonga Islands and Samoa on the east; northward it is said to reach southern Japan, while southward it extends at least as far as Port Molle, Queensland. Whether all the records really refer to *parvicirra* seems to me open to question. For example, I think there is little doubt that Reichensperger's record from the Aru Islands (1914, p. 89) refers to a specimen of *annulata*.

Comanthus samoana.

A. H. Clark. 1909. Proc. U. S. Nat. Mus., *37*, p. 30.

(Plate 20, Figure 4.)

This species was found with *annulata* and *parvicirra* on the reefs at Mer, but so inconspicuous are its specific characters that not until the specimens of *Comanthus* collected in Torres Strait were being sorted at Cambridge was its occurrence there discovered. Eight specimens were found at the Murray Islands and a ninth subsequently at Badu. The species is now known from the Bay of Bengal eastward to Samoa and south to New Caledonia, but it has not yet been found west or southwest of New Guinea. (For a discussion of the relationship between *samoana* and *luteofusca*, see antea, p. 18.)

Comanthus schlegelii.

Actinometra schlegelii P. H. Carpenter. 1881. Notes Leyden Mus., *3*, p. 210.
Comanthus schlegelii A. H. Clark. 1911. Proc. U. S. Nat. Mus., *39*, p. 536.—See P. H. Carpenter. 1888. *Challenger* Comat., pls. lxiv, fig. 3 (as *A. duplex*), lxv (as *A. nobilis*), and lxviii (as *A. regalis*).

Only three specimens of this species were collected at Mer, two from the deeper water (18 fathoms) outside the northwestern reef and one from the Great Barrier Reef itself, but there is a fine series of a dozen specimens from Port Galera, Mindoro, Philippine Islands, in the Museum of Comparative Zoölogy collection, and with 10 of these, thanks to Dr. Griffin, we have notes on the color in life. These notes reveal as a fact what was suspected from the two Murray Island specimens, that *schlegelii* shows great diversity in coloring, nearly all specimens being more or less variegated or marked with white or yellow. One of the individuals collected at Mer was "black, passing into olive at tips of arms; distal half of each pinnule chrome-yellow passing through brown into the dull olive or black of basal half; cirri lemon-yellow." The other was strikingly different as it was "bewilderingly variegated with shades of yellow, green, brown, blackish, and white; general impression bright yellow with black markings; cirri yellow with two dusky dark bands."

This species is said to range from the Maldives to the Caroline Islands and New Britain, and south to Percy Island, Queensland, about lat. 21° 30′ S., where the *Alert* took a specimen with 63 arms and only 1 cirrus. Merton took a superb specimen with 151 arms, 140 mm. long, and no cirri, in Dobo Strait, Aru Islands, in about 9 fathoms. The specimens from Murray Islands are notable for having the cirri xx-xxi, 15–17, the maximum development of cirri in the species. They have 60, 70, and 76 arms respectively, but only in the last does every ray have the iii Br series typically arranged; in the specimen with 70 arms, only two rays show the typical arrangement, each of the other rays having an inner iii Br series 2 instead of 4; in the specimen with 60 arms, four rays are typical but the fifth has the arrangement reversed, the inner iii Br series being 2 and the outer 4(3+4). The iv Br series occurs 77 times in the three specimens, and in only 10 is it 2. The v Br series occurs 9 times and only once is it 2.

ZYGOMETRIDÆ.

Zygometra elegans.

Antedon elegans Bell. 1884. *Alert* Rep., p. 162, pl. xiii, figs. B, Ba.
Zygometra elegans A. H. Clark. 1907. Smithson. Misc. Coll., *50*, p. 348.

We found no specimens of this characteristic north Australian species. It was taken by the *Alert* at Port Molle and in Torres Strait, and by Semon at Thursday Island, and the *Challenger* took specimens at her station 190 in the Arafura Sea. It is also known from the coasts of northwestern Australia; and on the eastern coast it ranges as far south as Sandon Bluffs, New South Wales, where the *Endeavour* took it in 35 to 40 fathoms.

Zygometra microdisca.

Antedon microdiscus Bell. 1884. *Alert* Rep., p. 163, pl. xv.
Zygometra microdiscus A. H. Clark. 1907. Smithson. Misc. Coll., *50*, p. 348.

This species, with a range very similar to that of the preceding, also escaped our notice. Yet it was taken by the *Challenger* at several points in Torres Strait, and Semon found it at Thursday Island. The *Endeavour* took a single small specimen near the Capricorn Islands, off Port Curtis, Queensland, in 70 to 74 fathoms.

It is a little odd that we found no Zygometras at the Murray Islands and there is a possibility that the genus does not extend to the group. This is so improbable, however, that it is more likely local or seasonal conditions prevented our finding specimens.

HIMEROMETRIDÆ.

Heterometra crenulata.

Antedon crenulata P. H. Carpenter. 1882. Jour. Linn. Soc. Zool., *16*, p. 507.
Heterometra crenulata A. H. Clark. 1918. *Siboga* Comat., p. 79.—See P. H. Carpenter. 1888. *Challenger* Comat., pls. xxxvi, figs. 1–6; xlviii, figs. 3–5, xlix, figs. 1, 2 (as *A. variipinna*).

Although this comatulid was taken in Torres Strait by both the *Challenger* and the *Alert*, neither Semon nor we came across any specimens. The *Endeavour* took a fine specimen in 25 to 26 fathoms, 13 miles north by west from Double Island Point, southern Queensland. From this, the southernmost point of its range, it extends to Singapore, southern China, and the Philippines. It also occurs along the northern and northwestern coasts of Australia, and Merton found it common at the Aru Islands.

Heterometra delicata.

H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 105.

(Plate 21, Figure 6; Plate 36, Figures 4*a* to *f*.)

In his *Siboga* Comatulids (1918, pp. 62, 63) Mr. A. H. Clark lists this as *Zygometra punctata*, which he adds is a very perplexing and troublesome species. As a matter of fact, however, the holotype of this species does not seem to be one of the Zygometridæ at all. There is no trace of zyzygies or pseudosyzygies in the i Br series, but the joints are perfectly normal muscular articulations. I Br is not short and band-like, as in *Z. punctata*, but the width is only a little more than twice the length. I Br_2 (the axillary) is pentagonal, not twice as broad as long. The radials are not concealed by the centrodorsal. None of the basal segments of the cirri is twice as broad as long. Finally the color is quite unlike *Zygometra punctata* or any other member of that genus; there is no white save on the cirri, which are more or less light-colored. This puzzling little comatulid (M. C. Z. No. 587) is very probably a young individual not yet revealing its species characters. It may possibly be a young *Amphimetra*. It was found on the sand flat southwest of Friday Island, September 13, 1913. Since examining it, Mr. Clark has decided it is "altogether too young for determination."

Amphimetra discoidea.

Himerometra discoidea A. H. Clark. 1908. Smithson. Misc. Coll., *52*, p. 215.
Amphimetra discoidea A. H. Clark. 1909. Proc. U. S. Nat. Mus., *37*, p. 32.—1918. *Siboga* Comat., p. 87, pls. vi (colored), xviii, fig. 35.

The *Alert* found this species common in Torres Strait at depths of 7 to 10 fathoms, but we did not have the good fortune to meet with it. It ranges from Port Molle, Queensland, to Formosa, and also occurs on the northwestern coast of Australia. Merton found it rather common at the Aru Islands.

STEPHANOMETRIDÆ.

Stephanometra callipecha.

Lamprometra callipecha H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 104.

(Plate 1, Figure 9; Plate 36, Figures 2*a* to *e*.)

The reëxamination of the holotype of this species, resulting from Mr. A. H. Clark's (1918, pp. 100, 101) assigning it to the synonymy of *Lamprometra protecta*, leads me to believe it should be regarded as a *Stephanometra* rather than as a *Lamprometra*, and that it is possibly identical with *S. indica* (E. A. Smith). Unfortunately I have no specimens of *indica* for comparison, but a rereading of Smith's description shows that it applies to the Murray Island comatulid in very few respects. I think, therefore, it will be well to let the name *callipecha* stand. The holotype was found on the southwestern reef at Mer, on the last day of our stay, October 27, 1913. It proved to be an active individual and was a very graceful swimmer.

Since examining the holotype (M. C. Z. No. 592), Mr. Clark has decided it is *indica*, but I prefer to await comparison with examples of that species, the type locality for which is Rodriguez.

Stephanometra monacantha.

Antedon monacantha Hartlaub. 1890. Nachr. Ges. Göttingen, No. 5, Mai 1890. p. 179.—1891. Nov. Act. Akad. Germ., *58*, p. 59, pl. iii, figs. 33, 38.
Stephanometra monacantha A. H. Clark. 1909. Proc. Biol. Soc. Wash., *22*, p. 10.—1912. Indian Ocean Crin., p. 136, fig. 14.

We took a single specimen of this species on the southwestern reef at Mer on October 11, 1913. Mr. A. H. Clark (1918, pp. 94, 97) recorded this individual as *indica* rather than *monacantha*, whose range he gives as from the Andaman Islands to Fiji and the Tonga Islands. I have reëxamined the specimen in the light of Mr. Clark's key to the species of *Stephanometra* and compared it with what seem to be unquestionable examples of *monacantha* from the Philippines and from Tutuila, Samoa, and I see no reason to change my original identification, granting of course that *monacantha* and *indica* are really distinct. Since he has examined the specimen (M. C. Z., No. 599) Mr. Clark is satisfied it really is *monacantha*.[1]

Stephanometra stypacantha.

H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 103.

(Plate 22, Figure 4; Plate 36, Figures 3*a* to *e*.)

Mr. A. H. Clark (1918, p. 95) suggests that the individual which served as the holotype of this species (M. C. Z. No. 600) is to be regarded as an example of *Stephanometra spicata* P. H. C., and he is of the same opinion now that he has examined the specimen. I have had no specimens of *spicata* for comparison, but certainly the differences revealed on comparing my description of *stypacantha* with Carpenter's and with Clark's descriptions of *spicata* are numerous and striking. While, therefore, Mr. Clark may be correct in his opinion as to the validity of this species, it seems better to let it stand until further material is available. The only specimen seen was found on the southwestern reef at Mer, October 14; the 16 arms, about 70 mm. long, were of a uniform deep red-purple, but the 33 cirri were light-colored except at tip. Mr. Clark gives a fine, colored figure of *S. spicata* (1918, pl. VII) revealing a type of coloration quite different from that of *stypacantha*, but of course this may not be of any significance.

MARIAMETRIDÆ.

Lamprometra brachypecha.

H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 104.

(Plate 2, Figure 1; Plate 22, Figures 1, 2.)

This was the most remarkable comatulid we found at Mer, at least in many respects, and I regretted much that we found only four individuals. These all occurred on the under side of large rock fragments on the southeastern reef-flat at Mer. They differed little in size or color and were not at all active, but showed certain reactions to light and touch which made it seem probable that they would be very interesting subjects for research on behavior. When the rock was overturned, the arms would be more or less closed over the mouth, the whole animal appearing like a tuft of green sea-weed, but on being touched the arms instantly and all together were laid back flat against the rock and the broad white band flashed into view. The immediate effect was obliterative and one's first thought was that the animal had vanished. That this reaction is protective seems possible, but of

[1] Mr. Clark (1918) records *indica* from Torres Strait and I have therefore included it in the "Tabulated List" (p. 192). As I know nothing of the specimen on which the record rests, but believe it is my specimen of either *callipech* or *monacantha*, I am not including the species here.

course much more critical study of the comatulid and its natural enemies is necessary before the truth can be determined.

Mr. A. H. Clark (1918, pp. 100, 101) regards *brachypecha* as a synonym of *L. protecta*, which according to his interpretation is a protean species indeed. He even places his own species, *Himerometra heliaster*, in the synonymy of *protecta*, but a reëxamination of the holotype of that species, which is in the Museum of Comparative Zoölogy collection, shows it is not a *Lamprometra* at all, so it can hardly be synonymous with *protecta*.[1] There are specimens of *L. protecta* in the Museum of Comparative Zoölogy from Ceylon and from the Philippines and I see no ground for considering *brachypecha* identical with them; the differences are obvious. There is no evidence that *protecta* occurs in the Torres Strait region or elsewhere on the coast of Australia. On the other hand a dry comatulid in the Museum of Comparative Zoölogy Collection from Fiji seems to be *brachypecha* and Mr. Clark lists *protecta* from Fiji. Perhaps intensive reef-work at Fiji would settle the question as to the relationship of the two forms.

The holotype of *brachypecha* is M. C. Z. No. 551, while the paratypes are Nos. 590 and 591. The latter is the original of plate 2, figure 1. Mr. Clark says, *in litt.*, of the holotype: "A form of *L. protectus* with the lower pinnules rather more slender than usual."

Lamprometra gyges.

Antedon gyges Bell. 1884. *Alert* Rep., p. 160, pl. xii, figs. *B, a, b.*
Lamprometra gyges A. H. Clark. 1913. Proc. Biol. Soc. Wash., *26*, p. 144.
Lamprometra tenera H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 104.

(Plate 1, Figure 4; Plate 21, Figures 4 and 5; Plate 22, Figure 3.)

We found only one comatulid at Mer, which can be referred to this species, and even this one (M. C. Z. No. 593) is strikingly different from four dark-colored specimens which Mr. Frank A. Potts, of our party, collected on a reef north of Mabuag, Torres Strait, in November 1913, and which Mr. A. H. Clark kindly identified as *gyges*. The specimen from Mer has 27 arms about 60 mm. long; the color in life is shown on plate 1, figure 4, but in alcohol the blue and yellow tints are lost and the colors are dull reddish-purple and reddish-white; P_2 is conspicuously the biggest pinnule on each arm, but is only about 8 mm. long and made up of only 17 or 18 segments; none of the basal pinnules is noticeably flagellate at tip, as they are in the specimens from Mabuag; the cirri in the individual from Mer, are xx, 18–24 with evident sockets for about 10 more cirri, apparently very recently lost. A photograph of one of the specimens from Mabuag is shown on plates 21 and 22. If the individual from Mer is really conspecific with those from Mabuag, *gyges* must be as protean a species as *protecta*. Mr. Clark gives the distribution of *gyges* as the coasts of Australia (excepting the southern) and New Guinea. After examination of the specimen from Mer, Mr. Clark considers it *gyges*.

COLOBOMETRIDÆ.

Oligometra anisa.

H. L. Clark. 1915. Carnegie Inst. Wash. Pub. No. 212, p. 105.

(Plate 1, Figure 10; Plate 4, Figures 1, 3; Plate 21, Figures 1 to 3; Plate 36, Figures 1*a* to *e*.)

The great diversity in color shown by this species led me to suppose I had found several species of 10-armed colobometrids at Mer, but critical study in Cambridge brought me to the conclusion that all represent a single species. In spite of my somewhat detailed description of the pinnules, Mr. A. H. Clark puts *anisa* in the synonymy of *Oligometrides adeonæ*, whereas it is evidently an *Oligometra*. Even after examination of the holotype (M. C. Z. No. 594) and all the other specimens (M. C. Z. Nos. 552, 595 to 598), Mr. Clark insists

[1] Mr. Clark after reëxamination of his type considers it a specimen of *Stephanometra monacantha*.

they are *adeonæ*. He has, however, kindly loaned me specimens of that species from the Aru Islands and I have compared them carefully with the Murray Island material. There is no doubt in my mind that the two species are quite distinct; the cirrus joints have conspicuous transverse ridges in *adeonæ* which are wanting (or at most very faint) in *anisa*, while the difference in the lower pinnules is even more marked. In *adeonæ*, P_1 is the largest, P_2 slightly smaller, P_3 still smaller, and P_4 still smaller, but similar. In *anisa*, P_1 is smaller than P_2 which is much larger and with more segments than in *adeonæ;* P_3 is about as large as P_1 or a little smaller; P_4 is abruptly smaller than P_3 and quite different in form. In *adeonæ*, the lower pinnules tend to be prismatic while in *anisa* they are more terete. In some of the specimens of *anisa* certain of the lower pinnules have been broken off and are regenerating, a condition which is quite deceptive at first sight. There is also some diversity in the size and proportions of the lower pinnules, which is probably due in large part to differences in age. The characteristic features of the species are, however, quite constant. It seems to be most nearly related to *O. japonica* Hartlaub, but differences in the cirri, the number and arrangement of the syzygies, and in the lower pinnules make me think it is probably distinct, and until specimens can be compared it is better to keep the two forms separate.

The first specimen taken at Mer is described in my field notes as "A lovely bright-yellow, 10-armed species. On 4 arms the basal segments and 2 or 3 near middle of arm have purple spots on dorsal side, but these are not conspicuous. South Reef on stag-horn coral at edge of reef, Mer, September 29, 1913." The next one found was also a small one and was drawn by Mr. Grosse (pl. 4, fig. 3); although there was much purple in the coloration I suspected this was the same species as the bright-yellow one. On October 10 I found what I felt sure was a new form; it was rather deep maroon with white markings on arms and pale purplish cirri. On October 14, a fine specimen, 120 mm. across, was found on the southwestern reef and Mr. Grosse made a colored drawing (pl. 4, fig. 1) as I supposed it was certainly something we had not found previously. On October 22, a fine orange-brown and white individual again deceived me and Mr. Grosse sketched one arm (pl. 1, fig. 10). This specimen was notable for its very conspicuous lower pinnules and the stout cirri, features well shown in a side-view photograph of the preserved specimen (pl. 21, fig. 1). In spite of these individual diversities the species is really not very variable in its essential specific characters. It was the commonest comatulid, *not* a comasterid, at Mer, but was not really common since we found only 12 specimens in five weeks of diligent search.

Oligometra carpenteri.

Antedon carpenteri Bell. 1884. *Alert* Rep., p. 157, pl. x, figs. *A*, *a* to *c*.
Oligometra carpenteri A. H. Clark. 1908. Proc. Biol. Soc. Wash., *21*, p. 126.

This species ranges from Port Curtis, Queensland, to Baudin Island, northwestern Australia, and northward to the Aru Islands. Merton took 5 specimens in June 1908, on the northern coast of Little Kei Island. The *Alert* took one specimen in Prince of Wales Channel, Torres Strait, in 7 to 9 fathoms. We did not meet with it. It can not be confused with the preceding species from Mer.

Oligometrides adeonæ.

Comatula adeonæ Lamarck. 1816. Anim. s. Vert., *2*, p. 535.
Oligometrides adeonæ A. H. Clark. 1913. Smithson. Misc. Coll., *61*, No. 15, p. 37.—1918. *Siboga* Comat., pl. xxviii, figs. 107-109.—Bell. 1884. *Alert* Rep., pl. xi, figs. *A* to *Ac* (as *A. bidens*).

With a range very similar to that of the preceding species, *adeonæ* also escaped our search at Mer and elsewhere in Torres Strait. Merton found it fairly common at the Aru Islands in 1908, as he took 8 specimens at four different stations, in water 3 to 9 fathoms deep. Through the kindness of Mr. A. H. Clark I have been able to examine some Aru Island specimens taken by the *Siboga*.

TROPIOMETRIDÆ.

Tropiometra afra.

Antedon afra Hartlaub. 1890. Nova Acta Akad. Germ., *58*, p. 86; pl. 5, figs. 50, 52.
Tropiometra afra A. H. Clark. 1907. Smithson. Misc. Coll., *50*, p. 349.—1918. *Siboga* Comat., pl. xxviii, fig. 106.

In his "Recent Crinoids of Australia" (1911, p. 780) Mr. A. H. Clark says that only three Australian specimens of this fine species were at that time known, and two of these were from Bowen, Queensland. In his *Siboga* Comatulids (1918) he gives the range of the species as: Australia, except southern coast, to northwestern New Guinea. We were so fortunate as to obtain three specimens of *afra* at Mer, all found among the stag-horn corals of the extreme margin of the southwestern reef, a region accessible only at the lowest tides. They attracted attention by their very dark color, their extreme rigidity, and their inertness. The color, at first sight black, proved on closer examination in bright light to be deep purple. Unlike the other comatulids watched under their natural conditions, *afra* was erect and apparently rigid, firmly attached by its numerous, long, stout cirri to a branch of coral. There was no graceful movement of the arms, nor did they sway freely back and forth in the currents of water as did those of the large dark-colored *Comanthus* near by. In pail or basin at the laboratory, *afra* remained most inert, making no efforts to move and showing no response to mechanical stimuli.

ANTEDONIDÆ.

Dorometra nana.

Antedon nana Hartlaub. 1891. Nova Acta Akad. Germ., *58*, p. 89; pl. 5, figs. 57, 58.
Iridometra nana A. H. Clark. 1909. Vid. Med., p. 192.—H. L. Clark, 1915. Carnegie Inst. Wash. Pub. No. 212, p. 22.
Dorometra nana A. H. Clark. 1917. Jour. Wash. Acad. Sci., *7*, p. 128.

This is a widespread little comatulid, ranging from the Maldive Islands to Tonga, north to Macclesfield Bank and south to Torres Strait. The two specimens which we found at Mer are very unlike in coloration but in other respects seem to be identical. The first was taken on the southwestern reef, October 10, 1913, and attracted attention because of its very dark color and delicate arms. On being detached from the piece of coral and placed in a bucket of sea-water, it began to swim, and its activity, so different from the inertness of most of the comatulids collected, was very interesting. "Swimming was accomplished by using the arms in sets of five alternately, so that when arms 1, 3, 5, 7, and 9 were brought up almost vertically over the disk, arms 2, 4, 6, 8, and 10 struck backward forcibly with pinnules fully extended, until they nearly met behind the cirri. Only a single stroke was made but as arms 2, 4, 6, 8, and 10 were relaxed and drawn in and upward over the disk another similar stroke was made by the alternating five arms. Of course the movement was much more rapid than a description indicates, but it decreased in rapidity as the comatulid became fatigued. At the start the strokes were at the rate of about 100 per minute but they rapidly dropped to much less than that and usually ceased altogether in less than a minute. Each stroke appeared to carry the individual about the length of its own arms." [1] This specimen of *nana* had arms 40 to 45 mm. long and the color was black, with a purplish tinge in bright light, though the cirri were light brown. On October 27 a second individual was discovered, far out on the southwestern reef; while similar in its reactions, this was light brown in color and was not recognized as identical with the dark-colored one until after returning to Cambridge.

[1] Carnegie Inst. Wash. Pub. No. 212, p. 110.

ASTEROIDEA. SEA-STARS.

The sea-stars of the Torres Strait region are as a rule notably conspicuous, sometimes because of their size, but much more often because of their brilliant colors. The larger species usually lie exposed on sandy bottoms, but the smaller forms occur mostly under rock fragments on the reef-flats, generally near the living reef. It is a remarkable fact that of the 41 species included in this report, only 2 (*Linckia lævigata* and *Echinaster luzonicus*) can be called abundant even locally, and not more than 10 others can be considered common. Indeed, 15 of them are known from fewer than 5 specimens, and of the 23 species taken at Mer, 6 are represented in the collection by only a single specimen each. It is difficult to account for this relative scarcity of sea-stars in a region where 41 species occur, but it may be that most of the species find their real home in that inaccessible area on the face of the reef where wading and dredging are alike impossible, and that only a few wanderers from this region come up into the accessible shallow water of the reef-flat.

An examination of the list of species brings out the noteworthy fact that there is not a single representative of the order Forcipulata, the group which makes up so large a part of the shallow-water sea-star fauna of the North Pacific. The group, however, is not common in the tropics anywhere and is represented by very few species in the Australian fauna, hence it is not strange that it does not reach Torres Strait. Even the Spinulosa are represented by only 10 species divided among 6 families; the Asterinidæ, however, claim 5 of these species, so the other families have only one each. On the other hand, the characteristically tropical family Ophidiasteridæ is a notable feature of the Torres Strait fauna, 16 species, or practically two-fifths of all the sea-stars of the region, belonging in this group. The commonest and most conspicuous sea-star at the Murray Islands is the brilliantly blue *Linckia lævigata*. The genus *Nardoa* is represented by 4 species on the reefs at Mer, while 3 species of *Ophidiaster* also occur there. Because of its prominence, the family seems entitled to special attention in this report, and a revision of all its known genera and species is therefore included.

PHANEROZONIA.[1]

ASTROPECTINIDÆ.

Astropecten granulatus.

Müller and Troschel, 1842. Sys. Ast., p. 75.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xviii, figs. 30, 30*a*.

The locality from which the original types of the present species came is unknown, but the *Challenger* took an *Astropecten* in the Arafura Sea, in 28 fathoms, which Sladen (1889), after comparison with Müller and Troschel's types, considered *granulatus*. Semon took a specimen somewhere in Torres Strait, which Döderlein (1896) identified as the same species, and Merton and Roux took at the Aru Islands a single individual which Koehler

[1] Sladen lists, in his *Challenger* report (1889), *Archaster angulatus* from Torres Strait, but I am unable to find any authority for such record or for the occurrence of any other member of the family Archasteridæ.

(1910) is sure is identical with Semon's. Fisher (1919) records a specimen from Ragay Gulf, Luzon, 128 fathoms. There are specimens in the Museum of Comparative Zoölogy collection from the coast of Natal, taken by the *Pieter Faure*, which agree with Döderlein's figures very exactly, and as they answer well to Sladen's description, save for a few details, they should apparently be called *granulatus*. The distribution of the species is thus quite puzzling, but if it is an Indian Ocean species it has not yet found its way through Torres Strait. It is not improbable that it will be found on the western coast of Australia, perhaps even on the southern coast, in which case it would be suggestive of a former connection between Australia and South Africa. We saw no Astropectens at Mer, nor indeed anywhere in Torres Strait.

Astropecten zebra.

Astropecten zebra Sladen, 1883. Jour. Linn. Soc., Zoöl., *17*, p. 261.—1889. *Challenger* Ast., p. 212, pl. xxxvi, figs. 3, 4, pl. xxxix, figs. 7–9.
Astropecten coppingeri Bell. 1884. *Alert* Ech., p. 132.

The status of the little Astropectens which are grouped under the name *zebra* is still open to question, and I do not see how any satisfactory solution of the problem can be reached until adult Astropectens are taken in Torres Strait. Sladen's types were taken in 8 fathoms, off Cape York; 3 additional specimens, much more brightly colored, were secured in 6 fathoms, a little further west; to these Sladen gave the varietal name *rosea*. The difference between *rosea* and typical *zebra*, however, are similar to, and no more striking than, those shown by specimens of *A. duplicatus* of differing ages and sizes or from different stations in the West Indian region. It may well be doubted whether a varietal name is worth retaining for forms whose constancy is so dubious.

In 1884 Bell described some young Astropectens from Torres Strait[1] as *A. coppingeri*. Döderlein (1896), when studying the good series of Astropectens taken in the vicinity of Thursday Island by Semon, convinced himself that *coppingeri* and *zebra* are identical. Although he had large specimens of *zebra*, he does not compare them with similar specimens of either *velitaris* or *hemprichii*. By 1904 Bell has decided that *zebra* is identical with *hemprichii;* he naïvely avoids any reference to *coppingeri* and figures as *hemprichii* 3 specimens labeled *zebra* by Sladen! Both von Marenzeller (in Koehler, 1910*a*) and Koehler (1910*a*) incline to think *zebra* may be the young of *hemprichii*. Goto (1914), however, considers *zebra* a valid species.

There are several young Astropectens in the Museum of Comparative Zoölogy collection which are of interest in this connection. Two are cotypes of *coppingeri* and are labeled "Alert Island," 2 are from the Murray Islands and labeled *zebra*, 1 is from Ceylon and is labeled *zebra*. The identity of the specimens from "Alert Island" and the Murray Islands is beyond question, but the individual from Ceylon is superficially quite different, although the differences are relatively insignificant. It seems to me very probable that *hemprichii* and some other Astropectens have young more or less variegated in color and showing more or less diversity in the armature of both the superomarginal and the inferomarginal plates. Whether *zebra*, when adult, is really entitled to recognition as a distinct species does not seem to be determinable at present.

The specimens of *zebra* in the Museum of Comparative Zoölogy collection from the Murray Islands were received in 1912 from the Australian Museum. They were undoubtedly taken by Hedley and McCulloch during their visit to the islands in 1907. As already stated, we met with no Astropectens during our visit to Mer. The range of *zebra* appears to be from the Murray Islands westward through Torres Strait and northward to the Mergui Archipelago and the coast of Madras.

[1] One of the localities given by Bell is "Alert Island." I am unable to find such an island on any chart or map accessible to me, but I infer that "Alert Rocks," lying near the entrance to Prince of Wales Channel, may be intended.

LUIDIIDÆ.

Luidia forficifera.

Sladen. 1889. *Challenger* Ast., p. 258; pl. xliv, figs. 5, 6; pl. xlv, figs. 5, 6.

This sea-star has not been found in the Torres Strait region since the *Challenger* found it near Booby Island, but both the *Thetis* and the *Endeavour* took Luidias off the coast of New South Wales which seem to be *forficifera*. The species has been recorded twice from the Mergui Archipelago, but has not yet been reported from anywhere in the East Indies.

Luidia maculata.

Müller and Troschel. 1842. Sys. Ast., p. 77.—Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 267, pl. xv, figs. 1, 2; pl. xvi, figs. 8, 9; xvii, fig. 8.—H. L. Clark. 1916. *Endeavour* Ech., p. 29, pl. v.

A single specimen of this large and easily recognized sea-star was taken by Semon near Thursday Island. It has been recorded from the coasts of eastern, southern, and western Australia, while its northward range reaches China and Japan. Westward it extends to Mozambique, but it does not seem to occur anywhere east of Japan, the Philippines, Torres Strait, and the coast of New South Wales. It would therefore appear to be a typically Indian Ocean species, which has not passed into the Pacific except along the coasts just mentioned. Its bathymetrical range is considerable, for while it has been recorded from "between tide-marks," Goto (1914) reports a specimen from a depth of 640 meters. There are usually 7 or 8 rays, but occasionally there are only 6, while sometimes there are 9. The largest I have seen has the rays 250 mm. long, but Koehler (1910*a*) records one from Balasor Bay, India, in which R = 350 mm.

GONIASTERIDÆ.

Iconaster longimanus.

Astrogonium longimanum Möbius. 1859. Neue Seesterne, p. 7, pl. i, figs. 5, 6.
Iconaster longimanus Sladen. 1889. *Challenger* Ast., p. 261.

The locality from which Möbius's type specimen came is unknown, but the one in the Paris Museum, listed by Perrier (1876), is supposed to be from the Strait of Malacca. The *Alert* took specimens in Prince of Wales Channel, Torres Strait, and at the Percy Islands, North Queensland. Semon secured a specimen at Thursday Island, and there is a specimen in the Museum of Comparative Zoölogy from Adolphus Island, Torres Strait. Bell (1894) records the species, without comment, from northwestern Australia, but he gives no definite locality. Bedford (1900) records a specimen from near Malacca. Koehler (1895) lists a specimen from the Sunda Islands, but there is no clue as to the exact locality. He also (1910) lists a specimen from the Aru Islands. Apparently the species is an East Indian one, ranging from the Strait of Malacca to northern Australia as far south as Percy Island.

Goniodiscaster coppingeri.

Pentagonaster coppingeri Bell. 1884. *Alert* Ech., p. 128.
Goniodiscaster coppingeri H. L. Clark. 1909. Bull M. C. Z., *52*, p. 110.

(Plate 23, figures 1 and 2.)

Bell's specimens were from Port Curtis, Queensland, and from Prince of Wales Channel, Torres Strait. The specimen here figured is in the Museum of Comparative Zoölogy collection, and came from Adolphus Island, near Cape York. Apparently the species is peculiar to northeastern Australia and has not been found elsewhere.

Goniodiscaster pleyadella.

Asterias pleyadella Lamarck. 1816. Anim. s. Vert., *2*, p. 553.
Pentagonaster validus Bell. 1884. *Alert* Ech., p. 129.
Goniodiscus pleyadella Döderlein. 1896. Jena Denkschr , *8*, p. 308; pl. xviii, figs. 34 to 34*f*.
Goniodiscaster pleyadella H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 110.

Very little is known about the distribution of this species, although it was described over a century ago. Both the *Alert* and Dr. Semon collected specimens near Thursday Island, but the only other record [1] I have found is Pfeffer's (1900) of a specimen taken by Kukenthal at Ternate. The type locality is unknown, but the original specimen was collected by Peron and Lesueur on their voyage to Australia, possibly at Timor.

Stellaster incei.

Gray. 1847. Proc. Zoöl. Soc. London, p. 76.—H. L. Clark. 1916. *Endeavour*. Ech, p. 47, pl. xii.

This common East Indian sea-star was taken near Thursday Island by the *Challenger*, by the *Alert*, and by Semon. It ranges southward on the Australian coast to northern New South Wales, and northward it extends to the coast of Asia. Sladen (1878) records a specimen of *Stellaster belcheri*, now generally agreed to be synonymous with *incei*, from the Korean Strait in 50 fathoms, but Goto (1914), in his monograph on Japanese sea-stars, does not list either *incei* or *belcheri*. Perhaps Sladen's single small specimen is better referred to *Stellaster equestris*. In that case the northern limit of *incei* in the east would seem to be near Balasor Bay on the Indian Coast.

The *Investigator* found *incei* common in the Persian Gulf, and Simpson and Brown (1910) record a single specimen from the coast of Mozambique. Bell (1894) records it from northwestern Australia (no exact locality) and (1902) from the Maldive and Laccadive Islands. Brown (1910) says that *incei* is "the commonest asteroid in the Mergui Archipelago." There are no records of *Stellaster* anywhere east of Australia and the East Indies.

Stellaster princeps.

Sladen. 1889. *Challenger* Ast., p. 323, pl. lviii, figs. 1–3.

This fine species is as yet known only from the specimens taken by the *Challenger* near Booby Island, Torres Strait, at a depth of 6 fathoms.

Anthenea tuberculosa.

Anthenea tuberculosa Gray. 1847. Proc. Zoöl. Soc. London, p. 77.
Anthenea mertoni Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 268, pl. xvi, figs. 1, 2.

(Plate 6, figure 1.)

This is one of the few sea-stars which seem to be confined to the North Australian region. Gray's types came from Port Essington, Northern Territory. The *Challenger* took a specimen near Booby Island. Semon found a small specimen near Thursday Island. The Museum of Comparative Zoölogy has a specimen from Restoration Island, North Queensland, just outside the Torres Strait region as here limited. Finally, Koehler (1910) describes in great detail and figures under the name *A. mertoni* a fine specimen from the Aru Islands.

This is a well-marked and perfectly distinct species of *Anthenea*, but it is unreasonable to expect all individuals to conform closely to Gray's brief description and single figure, or to Perrier's somewhat better account. Sladen was quite right, in my judgment, in refer-

[1] Von Martens (1866) records a specimen in the Amsterdam Museum from the Moluccas but Sluiter (1895) makes no reference to any such specimen. The record would therefore seem to be very dubious.

ring the specimen from Booby Island to Gray's species and I feel equally sure that Koehler's specimen from the Aru Islands is the same. Koehler lays great stress on the grouping of tubercles on the abactinal plates near the tips of the rays, but this is indicated in Gray's figure and is mentioned in Sladen's description. On the eastern coast of Australia from Fraser Island south to Port Jackson, occurs *A. acuta* Perrier, which is easily told from *tuberculosa* by the more or less swollen disk, more slender rays, more spiniferous abactinal surface, and much larger pedicellariæ on the inferomarginal plates; this difference in the inferomarginal pedicellariæ seems to be very constant. The other *Anthenea* to which *tuberculosa* seems most nearly allied is *A. pentagonula* (Lamarck) of the Chinese coast, but in this species the whole abactinal surface is thickly covered with pedicellariæ and spinelets, whereas in *tuberculosa* abactinal pedicellariæ and spines are relatively few and scattered, much of the surface being perfectly smooth. In *pentagonula*, too, the rays are more slender than in *tuberculosa*.

We met with *A. tuberculosa* in Torres Strait but twice. The first specimens seen were two large adults picked up on Prince of Wales Island, September 13, 1913; they had been out of water for some time and were thereby dry. The lower surface is dull yellowish, but the upper side is reddish yellow becoming rather bright at the ends of the rays, but deep and dusky near center of disk. These individuals are about the same size as Koehler's Aru Island specimen and his photographs would do fairly well for either of them except that the abactinal distal tubercles are less crowded in the Torres Strait specimens. One measures 140 mm across the aboral side (*i.e.*, R = 87 mm., r = 53) while the other is 152 mm. across (R = 96 mm., r = 56); R = 1.6—1.7r. Koehler's measurements (taken orally) indicate that his specimens had R = 2r, but measurements of his photograph of the abactinal surface show R = 1.75r.

Our second record of *Anthenea* was a young specimen, 75 mm. across in life, which I found September 15, on Madge Reef, Thursday Island, under a slab of rock, at low tide. Its beautiful coloration was a striking contrast to the dingy appearance of most museum Antheneas and Mr. Grosse's accurate drawing, made at once from life (pl. 6, fig. 1) records it splendidly. The lower surface was creamy white with the valves of many of the large pedicellariæ (but not all) deep grass-green. We found no Antheneas at Mer.

OREASTERIDÆ.

Oreaster gracilis.

Oreaster gracilis Lütken. 1871. Vid. Med., p. 260, 264.
Pentaceros callimorphus Sladen. 1889. *Challenger* Ast., p. 347.
Pentaceros rouxi Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 272, pl. xvii, figs. 1, 2.
Pentaceros mertoni Koehler. 1910. *Op. cit.*, p. 275.

Although we did not meet with this species in Torres Strait, material in the Museum of Comparative Zoölogy, in the Australian Museum at Sydney, and in the Western Australian Museum at Perth has enabled me to reach some very definite conclusions as to its status. There are 3 specimens in the Museum of Comparative Zoölogy, a small one with R = 133 mm. from an unknown locality, and 2 large ones, R = 200–235 mm., from Warrior Reef, Torres Strait. In the Australian Museum is a specimen from the coast of southern Queensland (lat. 24° S.), while the specimen at Perth is supposed to be from somewhere on the coast of West Australia.

The small specimen in the Museum of Comparative Zoölogy was identified and labeled by Perrier and so far as I can see is certainly Lütken's species. This specimen answers so well to Koehler's (1910) description and figures of his supposedly new species *rouxi* that the slight differences detectable are certainly due to age, plus some individual diversity perhaps. Koehler states that he has compared his specimens of *rouxi* with a specimen of *gracilis* in which R = 105 mm., and that they are "completely different." This can be accounted for in only one of three ways: either the specimens in the Museum of Comparative Zoölogy are not *gracilis*, or Koehler's specimen is not *gracilis*, or my honored French colleague has failed to make due allowance for individual diversity. He lays some stress on the fact that *gracilis* is "triplacanthid" while *rouxi* is "diplacanthid," but this is quite worthless as a distinction, for *gracilis* is at first diplacanthid, becomes triplacanthid with growth, and ultimately becomes, when fully grown, "tetracanthid." In the genus *Oreaster*, only secondary importance can be attached to the details of the adambulacral armature. Through a slip of the pen Koehler, on page 275 of his paper, writes "*P. mertoni*" where he obviously means *P. rouxi*.

The large specimens at hand from Warrior Reef answer so well to Sladen's description of *P. callimorphus*, which the *Challenger* took near Booby Island, that there can be little doubt of their identity. On the other hand, there is no room to doubt that they are identical with our smaller specimen labeled *gracilis*. It seems to be fairly certain, therefore, that *O. gracilis* is an Australian *Oreaster*, specially characteristic of the north coast, whose full-grown adult form has been described as *callimorphus* and whose youthful condition (one-third grown) has been described as *rouxi*. It is one of the largest species of the genus, reaching a diameter of half a meter when fully grown. The only record I have found for it outside the Australian region is that of Bell (1909) who records it without comment from Saya de Malha, in the western Indian Ocean, in 45 to 55 fathoms. Such a record requires confirmation, but of course is not impossible. Bell, in the *Alert* Report (1884), records this species from Port Denison, and Port Molle, but his notes indicate that these specimens may have been *australis*.

Oreaster nodosus.

Asterias nodosa Linné. 1758. Sys. Nat., ed x, p. 661.
Oreaster nodosus Bell. 1884. Proc. Zoöl. Soc. Lond., p. 70.

(Plate 24, Figure 1; Plate 25, Figures 1 and 2.)

Although so long known and so widely distributed, this species does not seem to have been figured hitherto, except by Fisher (1919), so I give figures of two New Guinea specimens, showing a little of the individual diversity characteristic of the species. Under the pre-Linnæan name *Pentaceros turritus*, Sladen records a *Challenger* specimen from near Booby Island; Döderlein (1896) records one from Thursday Island in Semon's collection, and Koehler (1910) lists it from the Aru Islands. The *Alert* took *nodosus* at Port Denison, Queensland, which is the southernmost point from which it has been recorded. Bell (1899) lists it from New Britain on the east and (1909) from Saya de Malha on the west. The Herdmans (1904) record it from Ceylon and Goto (1914) from the Linschoten Islands. It is well known from Ambonia, the Moluccas, and New Guinea.

We met with this species both at Erub and at Mer, but did not see it near Thursday Island. At Mer it was rare and only two specimens were seen, but at Erub, on the shallow sandy area off the southeastern coast, it was common and conspicuous for its brilliant colors. The ground-color is red and the tubercles and tips of the rays blue, but the exact shades and the distribution of the colors show very great diversity. There is considerable diversity, too, in the number and size of the tubercles, but none of the specimens seen by me shows any approach to *O. lincki*, with which species *nodosus* was thought by Dr. Willey to intergrade at Blanche Bay, New Britain. Nor, on the other hand, is there any approach towards *australis* or *gracilis*, the other Australian Oreasters. One of the specimens taken at Erub has but 4 rays. The largest specimen I have seen has R = 192 mm. It is a dry specimen in the Museum of Comparative Zoölogy and was collected at Warrior Reef, Torres Strait, in 1896.

Culcita novæguineæ.

Müller and Troschel. 1842. Sys. Ast., p. 38.

(Plate 5, Figure 1)

It is a notable fact that no Culcitas were taken in Torres Strait by the *Challenger*, or the *Alert*, or by Semon. We found them common at Erub and at Mer, and there is a specimen in the Museum of Comparative Zoölogy, from Warrior Reef. Gray's type of *C. pentangularis* is said to have come from the reef at Umaga (Keat's Island), which is about half-way between Warrior Reef and Erub. All of the specimens I have seen from this eastern end of the Torres Strait region are *novæguineæ* and I have no doubt that *pentangularis* is the same thing. The species has a very wide range, from Mozambique to the Society Islands, and northward to the Andamans and to Kagoshima, Japan.

Few genera of star-fishes have given rise to more discussion on the specific limits of the forms they contain than has *Culcita*. Several "revisions" of the genus have been published, but the species are so variable and the appearance of museum material is so dependent on methods of killing and preserving that we are still very much in the dark as to the number of valid species. The latest reviser, Goto (1914), admits 7 species, one of which has 2 named varieties, and another 4. Of the 7 species, however, *borealis* Sussbach and Breckner (1910) is so obviously not a *Culcita*, or even one of the family Oreasteridæ, that it is odd that Goto should have admitted it to his key. Of the other 6, *grex* and *coriacea* are two of Müller and Troschel's species, which are rare and still little known. I have seen neither. A third is Perrier's remarkable *C. veneris*, from the island of St. Paul and recorded by Bell from the coast of South Africa also. A fourth species, *C. niassensis* Sluiter (1895) is apparently a *Choriaster*, if not indeed *Ch. granulatus* Lütken. There are then left only *novæguineæ*, with its varieties, *plana*, *typica*, *arenosa*, and *acutispinosa;* and *schmideliana*, with varieties *ceylonica* and *africana*. There is not sufficient material at hand for me to satisfy myself as to the status of these forms, but I am sure that the *Culcita* found at the Hawaiian Islands, and of which I found an excellent living specimen at Hilo, is absolutely different from the species found at Erub and Mer. Since this Hawaiian Island form is the original of *arenosa*, I can not admit it merely as a variety of *novæguineæ*. Several writers have intimated that *novæguineæ* and *schmideliana* intergrade, but so far as my experience goes each seems a valid species, although each is very variable.

At Erub and Mer adult Culcitas occurred on the reef flats on open sandy bottom, where the water even at low tide was 2 feet or more in depth. They were of course absolutely inert, but on being taken from the water they contracted more or less markedly. If placed in a basin, they expelled water from the anal opening with sufficient force to make a jet 1 to 2 inches high. The contraction and consequent ejection of water led of course to a considerable decrease in bulk, but there was never any tendency to flatten out, the height of the animal in proportion to its horizontal diameter undergoing little change. Even when thus contracted a *Culcita* is not so rigid as it appears. One morning while wading ashore after several hours of collecting on the reef flat at Mer, I came upon a *Culcita*, which I wished to take back to the laboratory. My bucket was well filled with brittle-stars and comatulids and I felt sure they would be badly damaged if I put this heavy *Culcita* among them. Deciding to carry it in my water-glass, I found that it was too big to go in, so laying it on the open end of that instrument, I pushed on towards the beach. A few minutes later there came a crash and I found that the *Culcita*, whose horizontal diameter had seemed so much greater than that of the water-glass, had bent up the ends of its rays to such a degree that it had fallen straight down through the water-glass, taking the invaluable pane with it!

The diversity shown by adult Culcitas in the character of the dorsal surface, as well as in the coloration, is very considerable. In some specimens the small tubercles are scattered and inconspicuous, while in others they are numerous and more or less elevated. The upper surface is generally mottled with green or gray of various shades, and often with blue or yellow markings. The specimen figured (pl. 5, fig. 1) is only about half-grown and is somewhat lighter colored than adults, but on the whole the figure gives a very good idea of a typical *Culcita novæguineæ*. The tubercles, which in this figure are grayish-blue, are in adults often bright yellow or they may be bright blue. The oral surface may be either light green, deep greenish, or slate-color. No two specimens were exactly alike, but it is equally true that no individual was seen which was not evidently *novæguineæ*.

Specimens under 80 mm. in diameter are not found in the open, but live sheltered under slabs of rock. The smallest seen was about 65 mm. in diameter. As is now well known, Culcitas pass through very interesting growth stages, three of which were described by Gray as *Hosia spinulosa*, *Goniaster sebæ*, and *Randasia granulata*, but it is by no means sure to which species of *Culcita* these names should be assigned, and it will be well to let them fall into complete disuse under the general synonymy of the genus. Some years ago I stated (1908, p. 281) that "*Goniodiscus sebæ* Müller and Troschel is the young of *Culcita novæguineæ*," but this statement needs modification, for while *G. sebæ* is beyond doubt the young form of a *Culcita* it is by no means certain to which species it should be referred, since the type material was from the Red Sea as well as from the Moluccas and New Guinea. Therefore the suggestion of Goto (1914) that *Goniaster sebæ* is the earliest post-Linnæan name for *Culcita novæguineæ* also requires a similar modification, which removes any necessity for changes in the nomenclature of this now well-known species.

ASTEROPIDÆ.

Asterope carinifera.

Asterias carinifera Lamarck. 1816. Anim. s. Vert., *2*, p. 556.
Asterope carinifera Müller and Troschel. 1840. Monatsb. Akad. Wiss. Berlin, p. 104.

(Plate 5, Figure 2.)

This is one of the commonest and perhaps the most widely distributed of Indo-Pacific sea-stars. It ranges from Mozambique, Zanzibar, and the Red Sea on the west, to the Hawaiian and Society Islands on the east, and from Queensland and New Caledonia on the south to Okinawa, Riu Kiu Islands, on the north. It is also reported from the Galapagos Islands, Panama, and La Paz, Lower California, but these records are all old and need verification. In September and October 1913, I found *Asterope* common at Mer, and in December I took many specimens at Hilo, Hawaii. On September 6, 1913, I found an adult specimen at Green Island, about 20 miles off the coast near Cairns, North Queensland, and this seems to be the southernmost record on the Australian coast. It is noteworthy that we did not find *Asterope* near Thursday Island, nor has it been taken in Torres Strait by any of the earlier collectors. Neither is it known from the Arafura Sea, the north coast of Australia, nor from the Aru or the Kei Islands. But it is known from Timor, the north coast of New Guinea, the Loyalty Islands, and New Caledonia.

Asterope lives, both when young and adult, on the lower side of slabs and rock fragments in shallow water on the reef-flats or along shore. The coloration is very variegated, shades of drab and olive-green predominating, but brown, white, black, bluish, yellowish, and reddish can usually be detected. Such a coloration closely resembles the surface on which it lives and the background against which it is seen, and whether one considers such a resemblance adaptive and protective or not, it is nevertheless very real and the sea-star may be easily overlooked even by an experienced collector. The colors are not usually well preserved after death, for no matter what killing method or agent is used the green shades disappear and often become more or less distinctly red. Some of the colors tend to fade, while others become deepened, so that preserved specimens rarely appear very much as they do in life.

Sluiter (1889) says that this species is quite active for a sea-star, but the specimens seen by me at Mer and at Hilo were quite inert. They were not, however, kept in an aquarium for any length of time as were the specimens watched by Sluiter. At Mer two 4-rayed individuals were found. The smallest specimen seen was only 19 mm. across (R = 10 mm.), while the largest has R = 68 mm. and is thus about 130 mm. in diameter.

PORANIIDÆ.

Habroporina.[1]

Stellate, with margin formed as in *Asterina* by inferomarginal series; superomarginals minute, overlying inner end of inferomarginals, each inferomarginal with 2 (rarely 1 or 3) sharp, slender, sacculate spinelets. Whole test covered with a moderately thick skin, obscuring the plates. Abactinal plates circular and small, or larger and of irregular shape, more or less imbricated (the upper edge of a plate overlying the lower edge of the one above, or the inner edge overlying the outer edge of one nearer the disk center), not in distinct series, either longitudinal or transverse. Papulæ large, single, scattered on disk and on upper surface of rays, nearly to tip. Adambulacral armature in two series: inner series of 3 or 4 slender, subequal, somewhat sacculate spinelets, parallel with the furrow; outer series of much larger sacculate spinelets, one on actinal surface of each plate. Actinolateral plates imbricating, many with single sacculate spinelets. No pedicellariæ.

Type species: *Habroporina pulchella* H. L. C. (*vide infra*).

This interesting genus differs from *Asterope* very obviously in the lack of a medioradial series of abactinal plates and spines, in the absence of any serial arrangement of the abactinal plates, in the character of the marginal series of plates and spinelets, and in the spinelets on the actinolateral plates. In some of these particulars it is nearer to *Porania*, but the marginal, actinal, and adambulacral spinelets all afford important differential characters. In certain important particulars, *Habroporina* is notably like certain Asterinidæ and more abundant material may show that its real position is in that family. The skin-covering of the skeleton, the absence of serial arrangement of the abactinal plates, and the sacculate nature of the spinelets have deterred me from putting it there. Its characters, however, certainly suggest that the Poraniidæ would be better placed as Dr. Fisher has suggested to me (*in litt.*) in the *Spinulosa* rather than in the *Phanerozonia*.

Habroporina pulchella.[2]

(Plate 4, Figure 2; Plate 24, Figures 2 and 3; Plate 26, Figures 4 and 5.)

R = 19 mm.; r = 8 mm.; R = 2.37r: Br = 9 mm. at base of ray, and 7 mm., 7 mm. from tip. In life R was nearly 25 mm., but in killing and drying the shrinkage has been very marked. Disk moderately elevated, 4 to 5 mm. high, but more or less flattened; rays correspondingly high and yet flattened. Body-margin sharply defined by inferomarginal plates, each with 2, rarely 1 or 3, sharp, slender, but sacculate spinelets; in drying, these spinelets have usually been drawn together and often look like a single pointed pedicellaria; they are for the most part erected dorsally or even laid back against the dorsal surface. Superomarginals minute, lying at inner end of inferomarginals, often separated from each other by still smaller abactinal plates, and hence forming an imperfect and easily overlooked marginal series. Entire abactinal surface covered with a smooth skin, without spinelets of any kind, in life completely concealing all the skeletal plates. In the smaller specimen, from which figure 2, plate 4, was made, this skin is thin and delicate, and when

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[1] *ἁβρός* = pretty + *πώρινος* = made of tufa, in reference to the colors in life and to the color and surface of the dry specimens.

[2] *Pulchella* = beautiful; of obvious application.

the specimen was ultimately dried all the skeletal plates became quite clearly revealed. In this specimen, too, the rays are noticeably narrower than in the larger, but the chief reason why the rays in figure 2, plate 4, are so much narrower than in figure 4, plate 26, is because the whole marginal fringe is erect or even laid back dorsally in the former, and is nearly horizontal in the specimen photographed. In the larger specimen the abactinal skin is moderately thick and, even dried, more or less conceals the outlines of the plates; many of the latter, however, show as irregular elevations giving the surface a rough appearance, except along the sides of the rays and in the interbrachial arcs. Papulæ, large, single, scattered over disk and a large part of the elevated, flattened area of rays. Madreporite small, flush with surface, nearer center of disk than margin. Terminal plate rather small, about one-third as wide as tip of ray, with 1 to 3 minute, sacculate spinelets at its distal end.

Actinal surface with moderately developed actinolateral areas, the plates of which are more or less concealed by the skin. Many of these plates bear single, rather large sacculate spinelets, but near the oral plates and near the arm-tips such spinelets are lacking. Besides the adambulacral plates and the inferomarginals, only one series of plates extends to the very tip of the rays; this retains its position close to the adambulacrals clear to the oral plates, and is obviously the first series of actinolaterals. Beginning at about the third (from the terminal plate) inferomarginal, a small, swollen plate lies on the lower end of each marginal; these soon became flatter, larger, and more elongate, and form the second series of actinolaterals. At about the fifth (from tip) inferomarginal, another series of actinolaterals begins, and this process is repeated until at the base of the ray there are 7 series of actinolateral plates; these plates are imbricated from the margin towards the furrow; *i. e.*, the furrow margin of each plate overlies the outer margin of the adjoining plate of the next inner series; the lateral margins of the plates are usually in contact but rarely overlap; the transverse serial arrangement of the actinolaterals is not marked. Adambulacral plates rather large, a little wider than long; on the furrow margin of each is a series of 4 or 3 slender, slightly sacculate spines; when 3 are present, the middle one is a trifle the longest; when 4 are present, the adoral one is evidently the smallest, the other 3 being subequal or the middle one longest; these furrow spinelets may possibly be united in a common membrane, but to judge from the condition shown by the smaller specimen, they are distinct; on the actinal face of each plate is a large sacculate spinelet, much longer than the width of the plate. Oral plates rather large, each with 5 marginal spinelets, of which the innermost is largest and the outermost smallest; the innermost is as large as the actinal adambulacral spinelets; the 10 spines are more or less connected, at least basally, by a common membrane; on the surface of each oral plate is a small sacculate spinelet, homologous with the actinal adambulacral spinelet, but usually not so large. Tube-feet in two series, moderately large, with well-developed sucking disks. No pedicellariæ anywhere. Color in life, nearly white beneath, beautifully variegated with green and white above, and with bright blue near the tips of the rays (pl. 4, fig. 2). Preserved specimens lose their color and become dingy buff or reddish-yellow.

Holotype: M. C. Z. No. 2289; southeastern reef-flat, Mer, Murray Islands, Torres Strait.

Only two specimens of this lovely little sea-star were found, and each of these was on the under side of a rock fragment in shallow water near the outer edge of the reef flat. They agreed well in color, but the smaller individual had somewhat narrower arms and appeared to be distinctly the younger. It was found September 27 and the colored figure was made at once. The larger specimen was not discovered until October 22. In life there is no noticeable similarity to young Asteropes of the same size, but on the other hand there was no suspicion of resemblances to *Asterina* or *Nepanthia* until after the specimens were dried.

OPHIDIASTERIDÆ.[1]

As already mentioned, the Ophidiasteridæ are by far the most numerous and conspicuous family of sea-stars on the reefs at Mer. Since 10 of the 20 genera which comprise the family are found in Torres Strait and 7 others are represented in the Museum of Comparative Zoölogy collection, it seems appropriate to give here a complete revision of the family. A very useful key to the genera was published by Sladen (1889) and this has been revised and improved by Fisher (1911), but the key here offered (p. 37) includes 9 genera not recognized by those writers.

The Ophidiasteridæ are essentially a tropical, shallow-water family and very few species are known from outside the tropics or from water over 20 fathoms deep. Most of them occur among rock fragments and corals on reef flats or along shore, but large individuals often lie exposed on sandy bottoms or on the surface of the reef. Most species have remarkably small disks and long cylindrical arms, but trigonal arms are fairly frequent and in *Fromia* and *Ferdina* the disk is often relatively large and the arms quite flat. The coloration is usually pleasing and often brilliant in life, only a few species being inconspicuous, or dull. Preserved specimens are usually brown or gray of some shade, or more or less bleached of color, and give little indication of their beauty in life. In *Linckia*, *Leiaster*, and *Ophidiaster*, at least, autotomy is common and in some species of *Linckia* at any rate asexual reproduction by that means occurs regularly throughout youth, if not after maturity is reached.

The basis for generic divisions in the family have long been recognized in the distribution and arrangement of the papulæ, with the concomitant arrangement of the plates of the abactinal skeleton, the form of the rays, the character of the adambulacral armature, the character of the skin, and the nature and form of its granules. Spines, particularly erect movable spines, apart, of course, from those of the adambulacral and oral plates, rarely occur in the family, and their presence may be of generic importance. Differences of opinion in regard to the classification of the family are due to the relative weight given to these various characters. My studies have led me to believe that it is best for practical purposes to make the primary basis of division in the family the arrangement of the abactinal skeletal plates. It must be admitted that certain Ophidiasters, and a few species in other genera, give some trouble in this particular, especially when the specimen is either youthful or senescent, but, on the whole, the arrangement is in general easily determined and most of the doubtful cases show their true affinities in some other obvious ways. I have felt it desirable to revive all[2] of the generic and subgeneric names proposed by Gray in 1840, but rejected by Perrier in 1875 and by later writers. As Fisher says (*in litt.*) "Gray had a pretty good 'generic sense'," and although his diagnoses are poor and often worthless, his proposed genera and subgenera usually prove to be natural groups. One of them, *Cistina*, has been rejected because no specimen seems to be extant and the diagnosis indicates a most unusual feature in an ophidiasterid, but as the type was said to be from the west coast of Colombia, it is quite possible that when that now virtually unknown coast is thoroughly explored, this remarkable sea-star will again be found. At any rate it does not seem to me we have any right to reject the genus until we do know fully the Colombian marine fauna.

In drawing the line between *Linckia* and *Ophidiaster* and its allies, I have not found that the character of the adambulacral armature is of much assistance. Of course the difference, in this matter between a typical *Ophidiaster* and a typical *Linckia* is obvious, but in each genus there are species which approach the other, and in such cases I have

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[1] While I greatly regret to differ with Fisher on a matter of nomenclature, I see no valid reason for abandoning Verrill's name for this family proposed several years before the commonly used name Linckiidæ. Other things being equal, priority may well fix family names.

[2] Except *Acalia*. See footnote, p. 63.

Key to the Genera of Ophidiasteridæ.

A. Abactinal plates of ray not in regular longitudinal series (except on basal part of ray in *Narcissia*, *Certonardoa*, and *Plenardoa*).[1]
B. Adambulacral armature spiniform, often subprismatic, in 1 to 3 series, often quite goniasteroid. (In some genera the distinction between spiniform and granuliform armature becomes very obscure.)
C. Actinal intermediate area rather large, many of the plates with conspicuous stout spines; primary plates of disk also with stout spines .... *Dissogenes*
CC. No conspicuous spines on abactinal plates or on small actinal intermediate areas.
D. Papulæ on actinal surface as well as on abactinal.
E. Papulæ isolated.
F. Size moderate or small, usually much less than 100 mm. across alternate rays; seldom more than two series of actinal papulæ .... *Fromia*
FF. Size large, 100 mm. or more across alternate rays; 3 to 6 series of actinal papulæ *Austrofromia*
EE. Papulæ in groups; adambulacral armature in 3 (rarely 2) series; rays more or less terete .... *Nardoa*
DD. No papulæ on actinal surface. (Very rarely single isolated papulæ occur just between lower corners of inferomarginals.)
E. Many abactinal plates swollen to form conical tubercles with naked acute tips.. *Gomophia*
EE. No abactinal plates conical with naked acute tips.
F. Adambulacral armature more or less goniasteroid in 2 or 3 series; rays more or less trigonal at base.
G. Papulæ in groups; abactinal plates at base of ray in longitudinal series.. *Certonardoa*
GG. Papulæ isolated.
Many (16 or 18) series of plates on abactinal surface of ray............ *Plenardoa*
Few (7 to 13) and irregular series of plates on abactinal surface of ray... *Narcissia*
FF. Adambulacral armature in a single series................................ *Ferdina*
BB. Adambulacral armature granuliform, in 2 or 3 series (rather spiniform in *Phataria*); disk small; rays not flattened.
C. Papulæ in groups, rarely on actinal surface; skeletal plates covered with granules.
D. Papular groups irregularly scattered among abactinal ossicles; rays more or less cylindrical.. *Linckia*
DD. Papulæ in one or two continuous series of groups on each side of trigonal rays..... *Phataria*
CC. Papulæ on both actinal and abactinal surfaces, usually single, but sometimes in groups of 2 to 4; skeletal plates swollen, bare, separated by granules.......... *Bunaster*
AA. Abactinal plates in regular longitudinal series. (Not clearly shown in some Ophidiasters.)
B. Body-wall rigid with well-developed abactinal skeleton; never more than 10 series of papular areas on a ray.
C. Rays cylindrical, nearly smooth, formed of rows of 3-lobed flat ossicula, each furnished with a central mobile spine (Gray)................................ *Cistina*
CC. No central mobile spines on abactinal surface of rays.
D. Whole test covered with a thick, smooth, membranous skin..................... *Leiaster*
DD. Whole test granulose; *i.e.*, underlying a membrane more or less covered with granules or little tubercles.
E. Madreporic body large, becoming compound in adults (even in young, it is one-fifth of disk diameter); papular areas becoming confluent laterally in adults *Pharia*
EE. Madreporic body simple, its diameter less than one-fifth of disk diameter.
F. Papular areas present on actinal surface, at least one series below inferomarginals.
G. Papular areas in 8 series, only one below inferomarginals on each side;[2] rays cylindrical.
H. Skin uniformly granulose, though granules are commonly largest on convexities of skeleton.. *Ophidiaster*
HH. Skin naked and thin except on convexities of skeleton, each of which carries a cluster of unequal, coarse, squamiform or spinuliform grains or tubercles.. *Dactylosaster*
GG. Papular areas in 10 series, one nearest adambulacrals made up of twice as many areas as others but often more or less incomplete ; rays often somewhat trigonal at base .... *Hacelia*
FF. Papular areas in 6 series, wanting on actinal surface or below inferomarginals; though isolated papulæ and rarely scattered groups of 2 or 3 are sometimes present there .... *Tamaria*
BB. Body-wall thick and leathery without a rigid abactinal skeleton; in adults, 12 series of papular areas may be found at base of high trigonal rays............. *Pseudophidiaster*

[1] In some Ophidiasters the serial arrangement may be obscured, particularly in old age, and such specimens may be vainly placed in this section of the key, but the general facies is usually sufficient to make an *Ophidiaster* recognizable.
[2] Isolated papulæ may occur between actinolateral plates, but this is very unusual.

felt that the arrangement of the abactinal plates should be given more weight. So certain species like *marmorata* and *dubiosa* which Bell and Koehler have called *Linckia* will not be found in that genus in the present report. Next to the arrangement of the abactinal plates, the character which seems to me of greatest importance is the occurrence of papulæ on the actinal surface and their arrangement there. Their entire absence below the inferomarginal plates seems to me of great significance, and it is for this reason I have revived Gray's genus *Tamaria*. The presence or absence of pedicellariæ may be a good character, but in certain species great diversity is shown especially with age, and in such cases no reliance can be placed on this feature. The form of the pedicellariæ when they are present is, however, a reliable character.

The genera *Chætaster* and *Metrodira*, included by Sladen in his key, are no longer regarded as members of the family. With their removal the group becomes a very homogeneous one. There are 11 genera in the following key not included by Sladen; 5 of these date back to Gray, but were rejected by subsequent writers until the revival of *Hacelia* by Ludwig in 1897; 3 of the 11 have been described since Sladen's monograph was published, and 3 are proposed for the first time in the present report. Of the 11 genera, 7 are monotypic and of these 3 occur only along the western coast of tropical America, 2 are known only from the East Indies, one is found south of Australia at the notable depth (for this family) of 60 to 200 fms., and the seventh ranges from East Africa to Samoa. The remaining genera are chiefly Indo-Pacific, but *Austrofromia* is south temperate in its range and *Narcissia* occurs only in the tropical Atlantic and Gulf of Mexico. The only other genera of the West Indian region are *Linckia, Hacelia*, and *Ophidiaster*, each represented by a single species, with a second *Ophidiaster* occurring in very deep water. The genera *Fromia, Nardoa, Ferdina, Linckia, Bunaster, Leiaster, Ophidiaster, Dactylosaster, Hacelia*, and *Tamaria* are known to occur in Torres Strait, and it is possible that *Gomophia* and even *Dissogenes* will be found there eventually.

DISSOGENES.

Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 212.—1919, Bull. 100 U. S. Nat. Mus., p. 367.

Genotype: *Dissogenes styracia* Fisher. Monotypic.

This genus seems to be a connecting link between the Ophidiasteridæ and the Goniasteridæ, but is placed by Fisher in the present family because of its irregular abactinal skeleton, small marginal plates, and the close granulation which covers the body and obscures the underlying plates. "The general appearance suggests the Linckiidæ," says Fisher, but the actinal surface reminds one of *Calliaster*. The papulæ are small, isolated, and confined to the abactinal surface, as in *Ferdina*.

Dissogenes styracia.

Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 212.—1919, Bull. 100 U. S. Nat. Mus., p. 368; pls. 102, fig. 1; 103, fig. 1; 131, figs. 1–1*b*.

This interesting ophidiasterid was taken by the *Albatross* off Ternate in 131 fathoms. It is one of the larger members of the family, as the holotype was nearly 9 inches across.

FROMIA.

Gray. 1840. Ann. Mag. Nat. Hist. *6*, p. 286.

Genotype: *Asterias milleporella* Lamarck, 1816. Anim. s. vert., *2*, p. 564. Monotypic.

This genus remained monotypic until 1875, when Perrier pointed out that *F. milleporella* Müller and Troschel was not the same as *F. milleporella* Lamarck. To the former he gave the name *monilis* and at the same time he described two additional species, *indica* and

Key to the Species of Fromia.

A. Superomarginal plates decreasing in size distally with a fair degree of uniformity (though small ones may come between large ones now and then), not conspicuously swollen.
  B. Second series of actinolateral plates well developed, extending more than half length of ray; 2 or rarely 3 series of actinal papulæ at base of ray.
    C. Rays short and wide, R = 2.5–3.8 r and 2.5–3.3 br.
      D. Abactinal plates rather small and numerous, in about 5 to 7 irregular longitudinal series on each ray.
        E. Plates of actinal surface covered by a close granulation.
          F. Disk and rays flat; rays often more than 5, and madreporites often 2 or 3; furrow spinelets 3 (rarely 4) on each adambulacral plate; marginal plates relatively large and conspicuous .... *milleporella*
          FF. Disk and rays convex or even tumid; rays 5 and madreporite single; marginal plates relatively small and inconspicuous.
            G. Rays rather tumid; actinolateral plates in not more than 3 series at base of ray; 3 furrow spinelets .... *balansæ*
            GG. Rays convex but not tumid; actinolateral plates in 4 series at base of ray; only 2 furrow spinelets .... *andamanensis*
        EE. Plates of actinal surface covered with stout spinelets .... *tumida*
      DD. Abactinal surface of each ray covered by about 3 irregular series of large, somewhat swollen, plates mingled with many much smaller ones; rays 5 or 6, flattened *indica*
    CC. Rays always 5, long and narrow, R = 3.5–5.5 r and 4–5 br.
      D. No actinal pedicellariæ.
        E. Abactinal surface covered with a uniform coat of fine granules; 3 furrow spinelets; R = 4.5–5.5 r .... *pacifica*
        EE. Abactinal granulation coarse, granules of each plate forming a distinct group, central granules no larger or smaller than those of margin; only 2 furrow spinelets; R = 3.5–4 r .... *elegans*
      DD. Abundant actinal pedicellariæ .... *eusticha*
  BB. Second series of actinolateral plates poorly developed, not extending half the length of ray; not more than one series of actinal papulæ and that often more or less incomplete.
    C. Abactinal granulation fine or moderately coarse but none of the plates with large tubercle-like granules.
      D. Adambulacral armature with 3 (2 to 4) broad, flat, more or less spatulate furrow spines; 2 or 3 shorter, heavier, but not broader subambulacral spines; 2 or 3 large granules and a second series of smaller granules; R less than 4 br.; tubercle-like granules on distal marginal plates, conspicuous and more or less numerous .... *hemiopla*
      DD. Adambulacral armature with 2 (very rarely 3) thick furrow spines, which are not at all broad or flat, or spatulate; conspicuous subambulacral spine, much wider, stouter, and sometimes even longer than furrow spines, occasionally accompanied by a second much smaller spine or high tubercle; and a few granules like those on the actinolateral plates; R more than 4 br.; tubercle-like granules on distal marginal plates, small, few and inconspicuous...... *hadracantha*
    CC. Abactinal granulation coarse, many abactinal plates with large, tubercle-like granules. *armata*

AA. Superomarginal plates on distal half of ray with large ones conspicuously swollen, alternating with small, flat ones (or, as described by Perrier, separated by a wide space) giving distal part of arms, when seen from above, a somewhat moniliform appearance .... *monilis*

balansæ. All of the four species were based on material in the Paris Museum. In 1881, apparently forgetful of his own species, he described a specimen of *monilis* from Japan in the Museum of Comparative Zoölogy collection as *F. japonica.* In 1882 Bell described and figured a species as *F. tumida,* which is remarkable for the spinulation of the actinal surface. In 1894 Perrier again introduces a needless name by describing young specimens of *Narcissia canariensis* as *F. narcissiæ.* Koehler, in 1895, described a very large specimen of *monilis* under the name *major* and in 1909 and 1910 he described two interesting new species in the Indian Museum as *F. andamanensis* and *F. armata.* In 1910, Döderlein described a large species *F. schultzei* from the Cape of Good Hope, but I am including it in the new genus *Austrofromia* (p. 48). In 1913 Fisher described two well-marked new species, *F. eusticha* from the Sulu Archipelago and *F. hemiopla* from Mindanao.

In 1916 I described from the southern coast of Australia a large species, *F. polypora,* but I am now making it the type of the new genus, *Austrofromia* (p. 48). The Museum of Comparative Zoölogy collection contains a number of Fromias whose identification has been a source of some difficulty. One from the Gilbert Islands, together with a similar one from Hawaii, represents a new species which I describe beyond under the name *pacifica* (p. 42). A specimen from the Philippine Islands also seems to belong to an undescribed species which I am calling *hadracantha* (p. 45). A number of specimens taken at Mer represent a very well-marked and handsome species which I have named *elegans* (p. 43). Finally, there are two small specimens from Samoa which may represent a new species, but which I believe are probably the young of *monilis.*

Perrier's *F. mexicana,* a *nomen nudum* of his *Blake* report (1884, p. 172 and p. 184), is not a *Fromia,* as might have been guessed from the West Indian locality. The holotype lies before me; it is a goniasterid, too young for determination. The *F. pistoria* of Perrier (1881, p. 15) is identical with *milleporella;* at any rate in 1875 (p. 173 or 357) Perrier considered *Scytaster pistorius* Müller and Troschel and *Linckia pistoria* von Martens as identical with *milleporella.* It is perfectly evident, however, from the paragraph in which the name *F. pistoria* is used, that Perrier was not using it as synonymous with *milleporella,* but it is obviously impossible to determine now what he had in mind.

As here restricted, the genus *Fromia* includes a dozen species of small sea-stars finding their center of abundance in the East Indian region but extending eastward to Hawaii and westward to the Red Sea and Madagascar. Excepting only *F. andamanesis,* which is said to have been taken at a depth of 238 to 290 fathoms, but shows no corresponding peculiarity in its structure, the species occur on reefs and reef-flats in shallow water and even up to and above low-water mark. Judging from the species found at Mer, they occur on the under side of coral slabs and rock fragments. The coloration is notably pretty in life, but fugacious after death.

The species may be distinguished from each other when adult, as indicated in the key on the preceding page, but young specimens (R = 20 mm. or less) will usually fall in group BB, since they do not develop their actinolateral plates and papulæ until after they are half grown.

Fromia milleporella.

Asterias milleporella Lamarck. 1816. Anim. s. Vert. *2,* p. 564.
Fromia milleporella Gray. 1840. Ann. Mag. Nat. Hist., *6,* p. 286.—De Loriol, 1885. L'Ile Maurice Stell., p. 44, pl. xvi, figs. 2–4.
Fromia pistoria Perrier. 1881. Bull. M. C. Z., *9,* p. 15.

(Plate 7, Figures 4 and 5.)

This pretty little sea-star is not very common at Mer and the specimens taken are rather small. We did not find it elsewhere in Torres Strait, nor is it known from the mainland coast of Australia. It does occur, however, at the Loyalty Islands and it is also recorded from Fiji and Samoa. The Museum of Comparative Zoölogy collection has an old specimen, labeled "Low Archipelago: U. S. Exploring Expedition." Aside from the locality, this specimen is of interest because every arm is regenerated.

The range of *F. milleporella* to the westward reaches the Red Sea, Mauritius, and Madagascar, while it is recorded from as far north as the Riu Kiu Islands, Japan. Gray says: "Rays 5–8," but I have seen only one specimen with as many as 6 rays; that one was taken at Mer and is quite symmetrical; it has 3 madreporites. Koehler (1910, pl. 15, fig. 7) figures a *Fromia* with 6 rays and 2 madreporites, from the north coast of Little Kei Island, which I think must be referred to *milleporella.* It is very asymmetrical and looks as though it were the result of autotomy. Koehler says it is unquestionably *F. major,* but as that species differs from *milleporella* mainly, if not wholly, in the greater length and lesser width of the rays and in the alternation of large, swollen superomarginals with smaller, flatter ones on the distal half of the ray, if his identification is correct, I do not see how the specific distinctness of the two species is to be maintained. There is no doubt that, so far as Museum specimens show, the two are nearly allied, for specimens of *milleporella* commonly show more or less alternation of large and small superomarginals distally. At the same time, I have never seen a specimen of either species which was not easily recognizable at a glance.

De Loriol says (*l. c.*) that 6-rayed specimens are not rare, but he does not refer to any with a larger number of rays; he does, however, record a 4-rayed individual. Specimens in the Museum of Comparative Zoölogy from Mauritius show considerable diversity in form and proportions. In a few the rays are unusually narrow and the second row of actinolateral plates is unduly short. So far, however, as the observations made at Mer go, *milleporella* is not a very variable species. All the specimens taken were quite flat and broad-rayed in form and bright red in color (see pl. 7, fig. 5), lighter below and orange or yellowish along the ambulacral furrows; the tube-feet are reddish-yellow (pl. 7, fig. 4). The papulæ are dark purple or brown and the number and degree of distention of these tend to tone down the bright red of the dorsal side. The largest individual seen was only about 60 mm. across, and 70 mm. would seem to be about the maximum diameter for the species. All the specimens taken were on the under surface of rock fragments in very shallow water.

Fromia balansæ.

Perrier. 1875. Rev. Stell., Arch. Zool. Exp. *4*, p. 178 (442).
Koehler. 1910. Indian Mus. Ast., p. 140, pl. xviii, figs. 7, 8.

This species would appear to be very rare, as it is known as yet only from the holotype which was collected in New Caledonia in 1872 by M. Balansa and has since been in the Paris Museum. Koehler's photographs are most valuable and show that the species is seemingly quite distinct from the other members of the genus.

Fromia andamanensis.

Koehler. 1909. *Investigator* Ast., p. 105; pl. vii, figs. 5, 6.

This species is notable for the depth at which the holotype (and only known specimen) was taken, namely 238 to 290 fathoms, near the Andaman Islands. The fact that there is no peculiarity of structure corresponding to this unusual habitat makes one a little suspicious that there is some mistake about the label, especially since there is only one specimen, and the locality given is the general one, "Iles Andaman," from which numerous shallow-water sea-stars are in the Indian Museum. That *andamanensis* is closely allied to *milleporella* is obvious, but the general facies and the presence of only 2 furrow spines in the adambulacral armature would seem to be quite distinctive.

Fromia tumida.

Bell. 1882. Proc. Zool. Soc. Lond., p. 124, pl. vi, figs. 4, 4*a*.

Except that it occurs in Ceylon and at the Andaman Islands, nothing is known of this species. The holotype and a paratype are in the British Museum. The wide, bluntly pointed rays are noteworthy, but the character of the actinal surface is the most unusual feature. Bell says: "All the plates on the actinal surface, with the exception of those of the marginal series, are closely covered with stout spines, from which the spines of the adambulacral series are distinguished by their smaller size." That the adambulacral series should be the smallest on the actinal surface is certainly remarkable for in all other Fromias they are conspicuously longer than the granules or spinelets of the actinolateral plates. Bell is the only zoölogist who has met with this species and he (with his frequent if not customary brevity) tells us as little as possible.

Fromia indica.

Scytaster indicus Perrier. 1869. Ann. Sci. Nat. (5), *12*, p. 255.
Fromia indica Perrier. 1875. Rev. Stell., Arch. Zool. Exp. *4*, p. 177 (441)—Koehler. 1910. Indian Mus. Ast., p. 140, pl. xvii, figs. 7, 8.

Koehlerhas again placed all students of sea-stars under great obligation by his figures of the holotype of this species. Bell (1882, p. 123) records a 5-rayed specimen in the British Museum without locality. In 1887 he records the species from the Andaman Islands, but most exasperatingly fails to give any information about the specimen or specimens. Judging from the original description and Koehler's figures it does not seem to me that *indica* is beyond the limits of possible diversity of *milleporella*. I have not, however, seen any specimen of the common *Fromia* in which there were three so conspicuous series of swollen plates on each ray, but some individuals from Mauritius approach the appearance of *indica* so closely as to suggest identity. It should be remembered that the holotype of *indica* is hexamerous and has R only 26 mm.

Fromia pacifica[1] sp. nov.

(Plate 31, Figures 5 and 6).

R=36 mm., r=7 mm., R=5 r+; br=8 mm., R=4.5 br. Disk small and flat. Rays long, narrow, tapering to tip, flat. Abactinal skeleton made up of relatively large, slightly convex plates; there are three more or less regular longitudinal series on each ray, but only the middle one reaches the tip, though it is usually accompanied on one side or both by isolated plates representing the lateral series; the plates are flatter and less regularly arranged on disk than on the rays. Whole abactinal surface, including the superomarginals, covered by a close, uniform coat of small granules (about 30 to a square millimeter); these are smallest along the lateral sutures of the marginals and largest near the center of the abactinal plates, but the difference between largest and smallest is very slight. Superomarginals about 22 on each side of a ray, but the number varies more or less, owing to the intercalation of smaller plates between larger ones on distal half of ray; there seems to be no regularity about this intercalation. (In the paratype, with R=37 mm., there are only 17 or 18 superomarginals and the intercalation of smaller plates is exceptional.) The basal half dozen and the terminal 4 or 5 are wider (or higher) than long; the others are longer than wide, often markedly so. On the abactinal and superomarginal plates near arm-tip, some of the granules distal to center are somewhat enlarged, but not conspicuously so. Terminal plate small, thick, and bare; the abactinal granulation does not encroach on the basal half and there are no tubercles or granules on it anywhere. Inferomarginal plates somewhat more numerous than those of upper series, there being 20 or 21 on a side in the paratype and 24 or 25 in the holotype; they are very similar to the superomarginals in size and appearance, except that on the distalmost 6 or 8 the central granules are much more evidently enlarged; but these large granules are not conspicuous enough to attract attention. Actinolateral plates in 3 series, the second extending well beyond middle of ray; the third series is more or less rudimentary and does not extend beyond the fifth or sixth inferomarginal; it is not easy to distinguish in the holotype; granulation of actinolateral plates coarser than that of marginals, especially at center of each plate. Papulæ isolated, as usual in the genus; abactinally there are 5 to 7 around the larger plates, but they do not extend to arm-tip; actinally there are two series, the inner extending nearly or quite to the twentieth inferomarginal, the outer ending at about the twelfth; there are also a few intermarginal papulæ; none is surrounded by conspicuously enlarged granules as they usually are in *F. monilis*. No pedicellariæ anywhere. Madreporite small, flat, and inconspicuous, separated from the superomarginals by less than its own width.

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[1] *Pacifica* =of the Pacific, in reference to the distribution.

Adambulacral plates numerous, not much wider than long, about 2 to each inferomarginal. Armature in 2, or occasionally 3, series; furrow series of 3 (rarely 2 or 4) thick, blunt spinelets, each about as long as the plate; subambulacral series usually of 2 spinelets, noticeably shorter and stouter than those of the furrow series; these two spinelets may be subequal, but usually one is much the larger (generally the aboral one) and sometimes there is only one present; the two are usually equidistant from furrow, but they may be set quite obliquely. On the outer margin of each adambulacral plate are a few small granules and these may be more or less enlarged to form a third series of spinelets; this is conspicuously so in the paratype, which has this third series of adambulacral spinelets very well developed; in the paratype, too, there are often 3 spinelets in the second series; the adambulacral armature is thus much better developed and spinier in the paratype than it is in the holotype. Oral plates small, damaged in the holotype, but in the paratype showing about 2 or 3 suboral spines at distal margin of each plate. Color of holotype brown, with a slight purple cast; the paratype is quite bleached to a dirty white or pale yellowish.

Holotype, M. C. Z. No. 747; Hawaiian Islands.

Paratype, M. C. Z. No. 1796; Gilbert Islands.

The specimen from the Gilbert Islands was collected by A. Garrett and was received from him in 1860. The holotype bears only the label "Sandwich Islands," but it, too, was probably collected by Garrett during the years 1857–59, when he was making special collections there for the Museum. The specimens have never been identified, but have long been catalogued under *Fromia*. The species is easily distinguished from *monilis* by the development of the actinolateral plates and by the relatively short, non-swollen superomarginals. The combination of long, narrow, flat rays with well-developed actinolateral plates and two series of actinal papulæ is quite distinctive. In form and proportions *pacifica* resembles *eusticha*, but the entire absence of pedicellariæ is a sufficient distinguishing mark.

Fromia elegans[1] sp. nov.

(Plate 7, Figure 3; Plate 29, Figures 5 and 6).

R=36–38 mm.; r=8.5 mm. (In life, r was nearly 10 mm.); R=4 r; br=9 mm.; R=4 br. Disk flat or moderately elevated; interbrachial arcs broadly curved, so that it is hard to determine the width of ray at base; at 6 mm. from center of disk it measures 10 mm., but at 8 mm., which is practically the disk margin, it is only 9 mm. across; at 10 it is 8, at 15 it is 7, at 20 it is 6, at 30 it is 4, and at tip it is less than 3. Rays sometimes rather flattened with rounded margins but usually well arched, and on distal half nearly or quite cylindrical or terete. Abactinal skeleton made up of plates of very diverse size and form; most are rather small, flat, and, on the rays at least, wider than long; others are conspicuously larger, nearly circular, and, on the rays at least, distinctly convex. These larger plates form a series more or less irregular along each side of the ray; 5 primary interradial plates on the disk, one of which is the madreporite, are in the same class. These larger plates are quite conspicuous on the holotype, but on other specimens they are scarcely convex and much less noticeable. Granulation of abactinal surface, including superomarginals, coarse but quite uniform; excepting the smallest, the plates are provided with well-defined marginal series of granules, so that each plate stands out sharply defined by itself; on an average-sized plate there are 18 to 20 marginal granules and 9 to 12 within that series, but on the large plates (one of the primary interradials, for example) there are 28 to 30 marginal granules and 44 to 46 within; on some of the larger convex plates the central granules are a little larger and less close together than elsewhere, and at the center of the superomarginals they may be a trifle smaller and more crowded, but these differences are trivial; at the tip of the ray, however, the central granules on all the plates are conspicu-

[1] *Elegans* = charming, in reference to the elegance of form and coloration in life.

ously larger and more separated. Superomarginals 25 to 27, wider (or higher) than long, though a few tend to be squarish; the series diminishes distally with a fair degree of uniformity; on the last 9 or 10 the central granules become increasingly conspicuous, but even at the very tip of the ray they are not large enough to be called tubercles. Terminal plate moderately large, swollen, but completely covered by very coarse granules. Inferomarginals correspond in number and position more or less exactly with the upper series, but they are distinctly smaller and, as this is due to a lesser width, some of them are noticeably longer than wide; the distal ones have the central granules markedly enlarged. Actinolateral plates in 3 series, but the outermost is very poorly developed and does not extend beyond the sixth inferomarginal; the second series is fairly well developed and extends to the fourteenth inferomarginal; the first series almost reaches the end of the ray; the granulation on the actinolaterals is distinctly coarser than on the inferomarginals. Papulæ of abactinal surface rather small, irregularly scattered, and reaching almost to terminal plate; on actinal surface they are larger and form two very distinct series at base of ray; intermarginal papulæ well developed; nowhere are the papulæ surrounded by specialized granules. No pedicellariæ anywhere. Madreporite small and inconspicuous, half-way between disk-center and margin.

Adambulacral plates small and numerous, 2 or rarely 3 to each inferomarginal. Armature in 3 series; furrow series of 2 subequal flattened spinelets, with bluntly rounded tips; subambulacral series of 2 shorter, thicker, and blunter, more tubercle-like spines; on outer margin of plate is a pair of (or occasionally only one) similar but smaller tubercles or coarse granules, little larger, if any, than those on the actinolateral plates. Oral plates small, each with 4 marginal and 2 suboral spines, which are similar to the furrow spines but less flattened, and are the largest spines on the animal. Color in life (pl. 7, fig. 3) bright brown, the interspaces between plates purple-black, in sharp and beautiful contrast, giving a peculiarly elegant appearance to the abactinal surface. Ambulacral and oral spines reddish, dull and light; feet translucent yellowish; papulæ translucent gray. Alcohol tends to turn the specimens red and destroys the distinctness of the network of dark lines.

Holotype, M. C. Z. No. 2306; reef flat, Mer, Murray Islands, Torres Strait.

This fine species occurred in similar situations at Mer with *F. milleporella*, though they did not actually occur under the same rock fragment. It was not very common, only 8 specimens being taken; one of these is perfectly tetramerous. The largest is the holotype, while the smallest has R = 18 mm., r = 5 mm., and br = 5 mm.; the rays are thus somewhat shorter and wider than in the adult. In this half-grown specimen, there are two irregular series of large plates on abactinal surface of each ray, with only a very few small plates, but only on the distal half of the arm are any of the large plates markedly convex; the interradial plates are conspicuously large but quite flat; the madreporite occupies only a part of its interradial; the second series of actinolateral plates is little developed and the single series of papulæ only reaches the eighth of the 14 inferomarginals. In a specimen with R = 26 mm. the second series of actinolaterals is well developed.

At any stage, after it is half-grown, *elegans* is unmistakable because of the distinctness of the plate-groups of coarse granules, the more or less terete rays, the adambulacral armature, the terminal plates being covered with large granules, and the correspondence in number and position between the two series of marginal plates. It is not nearly related to any other member of the genus but stands rather apart by itself.

Fromia eusticha.

Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 213.—1919. Bull. 100 U. S. Nat. Mus., p. 375; pl. 95, fig. 2; pl. 105, fig. 1; pl. 106, fig. 1; pl. 107, figs. 3, 5.

This species differs notably from the other members of the genus in the presence of numerous pedicellariæ, which Fisher describes as "granuliform, 2- or 3-jawed, from 2 to 5 times the diameter of adjacent granules." The arrangement of the abactinal plates of the rays proximally, in regular longitudinal series, would appear to be another good distinctive character. The only known specimen of this interesting species was taken by the *Albatross* in 24 fathoms, in the vicinity of Siasi, Sulu Archipelago. It has R=41 mm.

Fromia hemiopla.

Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 213.—1919. Bull. 100 U. S. Nat. Mus., p. 377; pl. 95, fig. 3; pl. 105, fig. 2; pl. 106, fig. 3; pl. 107, figs. 2, 4.

The *Albatross* took this well-marked species at Tonquil Island, Gumila Reef, south of Zamboanga, Mindanao, in the Philippines. Dr. Fisher has seen the type of the following species (*hadracantha*) and thought it was probably *hemiopla*, so it has seemed to me unreasonable to separate them widely. But his figures show that the actinal papulæ are better developed than in *hadracantha* and one might be led thereby to look for *hemiopla* in the previous section of the genus near *pacifica*. The type of *hemiopla* has R=36 mm.

Fromia hadracantha[1] sp. nov.

(Plate 31, Figures 3 and 4.)

R=30 mm.; r=6 mm.; br=6 mm. R=5 r and also 5 br. Abactinal surface flat; rays narrow, tapering, with vertical sides, nearly 2.5 mm. high. Abactinal skeleton made up of more or less nearly circular plates, the largest about 1.5 mm. in diameter; on each ray are 3 fairly regular longitudinal series but the lateral series are of smaller plates than the median; the plates of the lateral series alternate with those of the median, and only the latter reach the tip of the ray; whole abactinal surface covered by a very fine granulation, 80 to 90 granules to the square millimeter; the granules around the papular pores are larger than those near center of plates. Superomarginals 15 or 16, decreasing in size distally, quite uniformly longer than wide, except at base and near tip of ray; beginning on the seventh there is a minute tubercle which becomes more conspicuous on the last plate or two where it is also accompanied by a few granules, coarser than usual, but never conspicuous. Terminal plate rather large, truncated conical, bare, except that the basal part is encroached on by the fine abactinal granulation and the tip carries 6 to 8 tubercle-like granules. Inferomarginal plates 18 to 20, not corresponding well to the superomarginals, but of about the same size, except distally; beginning on the eleventh, the granules at center (or distal to it) are coarse and soon one may be called a tubercle; on the distalmost plates, there are 2 or 3 of these tubercles, but one is usually larger than the others. Actinolateral plates greatly reduced, the series adjoining the adambulacral extends to middle of ray or beyond, but the second series consists only of an unpaired interradial plate with 3 much smaller plates on each side. Granulation on actinolateral plates no coarser than on marginals. Papulæ abundant and conspicuous above, extending to tip of ray, but few and small actinally and between the marginals; on each side of a ray one can find 6 to 9 actinal papulæ, adjoining the inferomarginals and there are about as many along the upper margin of the same plates. No pedicellariæ anywhere. Madreporite moderate, slightly convex, separated from the superomarginals by less than its own breadth.

Adambulacral plates moderate, averaging about 2 to each inferomarginal. Armature of 2 (rarely 3) thick, blunt, subequal furrow spines which are not at all broad or flat or spatulate; 1 conspicuous subambulacral spine, much wider, stouter, and sometimes longer than furrow spines, occasionally accompanied by a second much smaller spine or high tubercle; and a few granules like those on the actinolateral plates, only 1 or 2 of them are somewhat larger. Oral plates with 3 or 4 marginal spines, longer, more cylindrical and more pointed than the furrow spines, and 1 or usually 2 suboral spines a little smaller than the

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[1] ἁδρός=stout; ἄκανθα=spine, in reference to the very stout subambulacral spines.

marginal. Just distal interradially, to the oral plates, the granulation is much coarser than anywhere else on the actinal surface. Color (dry) deep dull purplish, both above and below.

Holotype, Museum of Comparative Zoölogy, No. 2490; Philippine Islands.

This interesting specimen was collected by Dr. L. E. Griffin in 1912, but unfortunately when received at the Museum it bore no label. The exact locality is therefore not known. It is quite different from any other *Fromia* in the collection, but is undoubtedly allied to *hemiopla.* In view of the fact that the tubercle-like granules on the distal marginals are not very conspicuous, that the rays are distinctly longer and narrower than in *hemiopla,* and that the adambulacral armature seems to be quite different, I doubt if this specimen belongs to that species. While its peculiarities may be individual and within the limits of the specific diversity of *hemiopla,* until more material is available it had better rest under another name.

Fromia armata.

Koehler. 1910. Indian Mus. Ast., p. 141, pl. xvi, figs. 8, 9.

This well-marked species is known as yet only from Port Blair, Andaman Islands. One of the types is now in the Museum of Comparative Zoölogy collection, but I have nothing to add to Koehler's very full description. The species can not be confused with any other member of the genus.

Fromia monilis.

Linckia milleporella von Martens. 1866. Arch. f. Naturg., *32,* pt. 1, p. 69.
Fromia monilis Perrier. 1875. Rev. Stell., Arch. Zool. Exp. *4,* p. 179 (443).
Fromia japonica Perrier. 1881. Bull. M. C. Z., *9,* p. 14.—1884, *Blake* Stell., p. 227, pl. 4, fig. 2.
Fromia major Koehler. 1895. Mem. Soc. Zool. France, *8,* p. 399, pl. ix, figs. 3, 4.—1910. Ast.et Oph. des iles Aru et Kei, p. 283, pl. xvi, figs. 6, 7.

It is not without some hesitation that I have grouped the above names as synonymous, but a careful comparison of the holotype of *japonica* with Perrier's description of *monilis* and with Koehler's description and figures of *major* have led me to this conclusion.[1] I have also taken into account von Martens' (1866) description of a *Fromia* which he calls *milleporella,* but which Perrier (1875) says is really *monilis,* and Studer's remarks on a large *monilis* taken by the *Gazelle.* Moreover, there are two small Fromias from Samoa in the Museum of Comparative Zoölogy collection which I believe to be young *monilis.* The fact is that there exists a series of Fromias, ranging from about 40 mm. in diameter to 103 mm., which agree in having the distal half of the arm rendered more or less moniliform by the alternation of long, swollen superomarginals, with short, flat plates, which are probably best interpreted as being also superomarginals, though it is not strange that in some of the descriptions this has not been recognized and the superomarginals are said to be separated by wide spaces. Although agreeing in this important particular, these specimens do not agree exactly in their adambulacral armature, and this is what has led to the recognition of three species. There is also some diversity in the tuberculation or granulation of the distal actinolateral and marginal plates, and this, too, has been a source of confusion. But if we compare the smallest available specimens with one more than half-grown and the latter with Koehler's type of *major,* we find the following situation:

The smallest specimen has R = 20 mm. There are 10 superomarginals on each side but (counting from the interradius) the fourth, sixth, and eighth are small, nearly flat plates; while the first is large but little swollen, the second is more evidently swollen, and the third, fifth, seventh, ninth, and tenth are markedly swollen and all but the third have a minute central tubercle, and the distal ones have some markedly enlarged granules also. The terminal plate is moderately large, smooth, but with half a dozen large granules on the oral distal surface and with the fine granulation of the abactinal surface encroaching

[1] Fisher (1919) has already united *japonica* and *major* and pointed out the similarities of *monilis,* so I feel more assured of the correctness of the synonyms given above.

on its basal part. The abactinal surface of the ray is covered by a single longitudinal series of about 10 circular, slightly convex plates, the last 2 or 3 of which are quite small and alternate with the superomarginals. On each side of this series are 3 well-separated plates, the first indications of lateral series. Papulæ extend to the terminal plate. There are 11 inferomarginals, the first two underlying the first two superomarginals, but distal to that point they lie more or less clearly alternating with the superomarginals. They decrease in size rather uniformly. The proximal ones are much longer than high, but the distalmost three are markedly higher than long; these three are also much swollen and bear 4 or 5 very large tubercle-like granules at the center. On plates 4 to 8 there are some indications of enlarged central granules but they are quite inconspicuous. The first actinolateral series is fairly well developed with an unpaired plate just outside the oral shields and about 14 plates, extending distally from it, adjoining the adambulacrals; the series reaches the seventh inferomarginal; excepting the first 2 or 3, these plates are increasingly convex with relatively very coarse central granules and, on the distalmost two or three, one of these granules is tuberculoid. A second series of actinolateral plates is indicated by about 3 minute plates, and there are 2 or 3 actinal papulæ with usually 1 intermarginal papula. The adambulacral armature is in two distinct rows, a furrow series of 3 (usually 4 proximally and mostly only 2 distally) flattened, blunt, subequal spinelets, and a subambulacral series of 2 (very rarely 3) shorter, stouter, subequal ones. There are a few (1 to 4) very small granules on the outer margin of each adambulacral plate.

The next larger specimen, with R=22 or 23 mm., differs scarcely at all abactinally, but on the lower surface we find a better development of actinolateral plates and a slight difference in the adambulacral armature. The first series of actinolaterals reaches the eighth inferomarginal, while the second is made up of 6 or 7 plates and reaches the fourth inferomarginal. There are 5 to 7 actinal and 1 to 5 intermarginal papulæ. With rare exceptions there are only 2 spinelets in the furrow series, as well as in the subambulacral, and there are never 4. The granules on the outer margin of each adambulacral plate are coarser and a few are quite tuberculoid, so that one might almost consider them as a second subambulacral series.

The holotype of *F. japonica*, with R=32 mm., has the lateral series of abactinal plates well developed; scattered, still smaller plates are also present, indicating a second irregular series on each side. The abactinal granulation is relatively finer than in the small specimens. There are 14 or 15 superomarginals on each side, of which the fourth, sixth, eighth, tenth, and twelfth are small and nearly flat; but it must be added that no 2 series of the 10 are exactly alike in size, proportions, form, and position of the superomarginals. Tuberculoid granules on the distalmost are quite conspicuous. The inferomarginals are quite irregular in number, size, and form, and the tuberculoid granules on the distalmost are often very conspicuous. The first series of actinolaterals reaches the tenth inferomarginal but the second and the papulæ show about the same condition as in the specimen with R=22 mm. The adambulacral armature is also much as in that individual, differing only in two insignificant points; the furrow spines are longer, more slender, and more pointed; the subambulacral series often has one of its two spines much larger than the other which is sometimes reduced to a mere granule. There seems to be no good reason why the small Samoan Fromias should not be considered the young of the species of which the type of *F. japonica* is the adult or at least more than a half-grown specimen.

The type of *F. major*, with R=55 mm., has numerous abactinal plates on the rays, the second lateral series being pretty well developed. There are 21 or 22 superomarginal plates, of which every other one beginning with the fourth (or usually the sixth, in one series the seventh) and extending to the eighteenth or nineteenth, is small and flat and was considered by Koehler in his description as merely "un espace très marqué." The tuberculation of the distal superomarginals is evident though not very conspicuous. There are about as many inferomarginals as superomarginals, but Koehler does not give the number, and examination of the figure given is not convincing. The actinolateral series shows a slightly greater development than in younger specimens, the first series reaching the fourteenth inferomarginal, and the second series, with 10 to 12 plates, reaching the seventh; a third series is represented by 2 or 3 plates on each side of the interradius. There are a dozen or more actinal papulæ. There are 3 spines in the furrow series and 2 in each of 2 subambulacral series, but the outer of these are hardly more than large granules. Koehler has examined additional material from the Kei Islands, but they were very similar to the holotype from the Sunda Islands, only some slight differences in the adambulacral armature and in the abactinal granulation being noted.

On consideration being given to all the evidence, it seems to me clear that the above specimens belong to a single species of *Fromia* characterized by the alternation of large and small superomarginals, very slightly developed actinolateral areas, and an adambulacral armature which tends to show some diversity in number and proportions of the spinelets. In the typical form (*major*) there are 3 or even 4 furrow spinelets and 2 subambulacral spinelets on each adambulacral plate, with coarse granules forming a more or less distinct third series on the outer margin. In the form called *japonica* there are nearly always only 2 furrow spinelets and the subambulacral spinelets are very unequal, often only one remaining in evidence. The form called *monilis* also has but 2 furrow spinelets and the reduction of the subambulacral series to a single spinelet has become fixed. To how great an extent these differences are due to age remains to be seen, but I am satisfied they are not specific. This species is recorded from Japan, the Sunda Islands, Amboina, McClure Gulf, western New Guinea, and the Kei Islands, and as already stated there are 2 specimens from Samoa in the Museum of Comparative Zoölogy collection. Nothing is known of habitat, habits, or color in life.

AUSTROFROMIA[1] gen. nov.

Size moderate; disk not particularly small; rays rather stout, terete, blunt; marginal plates small and numerous. Abactinal plates numerous, not arranged with any regularity. Actinolateral plates numerous in 3 to 6 series, with correspondingly numerous large isolated papulæ. Granulation of plates above and below rather coarse, but there are no conspicuous tuberculoid granules on distal plates of rays. Adambulacral armature spiniform and more or less prismatic, especially the furrow series; subambulacral spinelets usually in about 3 series of 2 or 3 each, short and stout, the outer grading into the coarse granulation of the actinolaterals. No pedicellariæ.

Type-species: *Fromia polypora* H. L. Clark.

While the differences between this genus and *Fromia* are not of great significance in themselves, they serve to give the species concerned a different facies; and since these species are of south temperate shores, rather than of the Indo-Pacific tropical region, it seems desirable to recognize the group. The two species at present known are distinguishable by their adambulacral armature as follows:

Key to the Species of Austrofromia.

Adambulacral armature of 10 to 14 spinelets and angular granules arranged in a furrow series of 3 (distally 2) and about 3 (rarely 4) subambulacral series of 2 or 3 .... *polypora*
Adambulacral armature of about 6 spinelets arranged in 3 regular series of 2 each .... *schultzei*

Austrofromia polypora.

Fromia polypora H. L. Clark. 1916. *Endeavour* Ech., p. 51, pl. xiv, figs. 1, 2.

This species is based on three specimens from Tasmania, with which are allied a specimen from Victoria and one from Western Australia. Those from Tasmania were

[1] *Auster* = south wind, southern, in reference to the geographical distribution of the genus as compared with *Fromia*.

taken at a depth of 78 fathoms. The other two specimens look different, and it is quite possible that more material will show that there are 2, and perhaps 3, *Austrofromias* on the temperate coasts of Australia. The specimens described have R = 65 to 86 mm.

Austrofromia schultzei.

Fromia schultzei Döderlein. 1910. Schultze's Ergeb. Südafrika, *4*, pt. 1, p. 249, pl. iv, figs. 3–3*b*.

A single specimen, taken in False Bay, Cape of Good Hope, is the basis of this species which is obviously near the preceding. It has R = 49 mm. and r = 14 mm. The regularity of arrangement of the relatively few spines in the adambulacral armature serves to distinguish easily the South African species.

NARDOA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 286.

Genotype: *Asterias variolatus* Lamarck. 1816. Anim. s. Vert. *2*, p. 565.

Type here designated for the first time. The first species mentioned by Gray, and one of the most typical, as well as longest known, is selected.

This genus has proved to be one of the most difficult in the family to revise, specific limits being unusually difficult to draw. This is due not only to considerable individual diversity but also to the fact that the adambulacral armature is quite uniform and in most of the species affords no distinctive characters. The individual diversity is most marked in the relative length and form of the rays, in the size and number of the abactinal plates, and in the number and arrangement of the actinolateral and lower marginal plates. Study of the available material, descriptions, and figures, has led me to believe that the most important characters for distinguishing the species are the presence or absence of conspicuous abactinal tubercles, the arrangement of the superomarginal plates, the relative sizes of the abactinal plates, and the contrast (or lack of it) between the basal and terminal portions of the rays in the character of their dorsal skeleton.

Gray included 3 species in the genus, *variolata*, *agassizii*, and *tuberculata*. It has been generally agreed for a long time that the second is synonymous with the first. Subsequent writers for many years failed to recognize the genus *Nardoa*, *Scytaster* being a more or less approximate substitute. Perrier (1875), however, divided *Scytaster* into 2 sections, the first including *Nardoa* and *Gomophia*, the second *Narcissia*. In the first section, he included (besides Gray's species) 3 new species, *novæcaledoniæ*, *obtusa*, and *gomophia*. The first was in the Paris Museum, the last two in London. So far as I can see *gomophia* is a relatively small specimen of *novæcaledoniæ*, but this will be discussed in detail under the latter species. In 1889, Sladen, supporting (apparently unconsciously) Verrill's action of 1867 (p. 285) retaining *Nardoa* of Gray, pointed out with some detail the propriety of recognizing *Nardoa* and discarding *Scytaster*. He, however, followed Perrier in making *Gomophia* a synonym of *Nardoa*, a course which seems to me quite unwarranted, as *Gomophia* is a more highly specialized type. Sladen included in *Nardoa*, besides the species already mentioned, *Scytaster galatheæ* Lütken, *Linckia pauciforis* and *semiseriata* of von Martens, and *Scytaster semiregularis* Müller and Troschel. The first two of these seem to me to be properly assigned to *Nardoa*, but the very characteristic form and the regular longitudinal arrangement of the abactinal plates in *semiregularis* incline me to make it the type of a new genus (*Certonardoa*), and the isolated papulæ and very numerous longitudinal series of abactinal plates in *semiseriata* necessitate a new genus (*Plenardoa*) for it.

In 1891, de Loriol added 2 new species to *Nardoa*: *mollis*, which is a well-marked species, and *finschi*, which seems to be synonymous with *pauciforis*. No further additions were made to the genus until 1910(*a*), when Koehler described 4 new species and referred to 2 others, which exist in name only, at the point where he mentions them. His *carinata* and *squamulosa* are based on very young individuals, which I think may prove to be the young of a *Certonardoa;* at any rate, the species may be placed in that genus. The species *frianti* is a well-marked one but *lemonnieri* is, I believe, undoubtedly synonymous with *mollis.* Koehler's reference to "*N. indica* (Perrier)," p. 171, apparently means *Fromia indica,* although on page 140 and on plate xvii it is considered a *Fromia* without a hint that it might be a *Nardoa.* The species "*N. bellonæ* de Loriol" (p. 164–165) is purely imaginary and almost certainly refers to *N. mollis,* which is figured by de Loriol on the same plate with *Luidia bellonæ* Lütken. In 1917, Fisher described a *Nardoa tumulosa* from the Sulu Archipelago, which is allied to *frianti* but seems to be quite distinct.

Although no species of *Nardoa* has previously been recorded from the Torres Strait region, on the reef flat at Mer the genus is well represented, 4 species occurring, not in great abundance, but 3 at least by no means rarely. They are found under large rock fragments or, less commonly, partly or wholly exposed on the sand. The most common species is *pauciforis,* but *novæcaledoniæ* is little more rare. These two species are so much alike in size, color, and form that the difference in size of the abactinal plates of disk and ray-bases, which is remarkably constant, suggested a sex difference. But Dr. E. N. Harvey very kindly made examination of the gonads of a number of living specimens and found there was no correlation between sex and size of plates. While it is possible that the two forms represent a single dimorphic species, that can only be determined by breeding experiments; it is therefore necessary for the present to designate them by different specific names. No individuals were found which could be considered intermediate between the two forms, which were invariably recognizable at a glance. The fine species, *mollis,* is much less common than *pauciforis;* it reaches a larger size and is always of much darker color and more elegant appearance. The fourth species occurring at Mer is the least common and the handsomest. It appears to be undescribed and because of its strikingly beautiful coloration in life I am calling it *rosea.* It was interesting to see that while these 4 species of *Nardoa* occurred indiscriminately on the reef flat, they do not seem to hybridize or intergrade in any way. There is no difficulty, either in living or preserved material, in assigning each specimen at once to its proper species.

The 10 species of *Nardoa* which seem to me valid may be distinguished from each other as follows:

Key to the Species of Nardoa.

A. No abactinal or marginal plates noticeably tuberculiform.[1]
  B. Superomarginal plates not alternately large and small.
    C. Adambulacral armature in 3 or 4 series of 3 or, in the furrow series, 4 spinelets each.
      D. Rays long, R = 5–9 r; actinolateral series extending far beyond middle of ray.
        E. Abactinal plates on distal part of ray not markedly and rather abruptly different from those on basal part.
          F. Many large abactinal plates (3 to 5 mm. in diameter) on disk and rays....... *variolata*
          FF. No large abactinal plates, few exceeding 2 mm. across....................... *pauciforis*
        EE. Abactinal plates on distal part of ray markedly, and somewhat abruptly, smaller and more crowded than basally.
          F. Many large abactinal plates 2.5 mm. in diameter or more; ground-color fawn or light brown .... *novæcaledoniæ*
          FF. Few or no large abactinal plates; usually dorsal plates are under 2 mm. in diameter; ground-color deep rich brown, in life............................. *mollis*
      DD. Rays short, R = 4 r+; actinolateral series not extending beyond middle of ray ...... *obtusa*
    CC. Adambulacral armature in 2 series of 4 spinelets each.............................. *galatheæ*
  BB. Superomarginal plates more or less regularly alternating, large and small.................. *rosea*
AA. Some, and often many, abactinal plates (and marginals, in *frianti*) swollen and more or less conspicuously tuberculiform.
  B. Tubercles scattered, small (2 mm. or less in diameter), none in superomarginal series....... *tuberculata*
  BB. Tubercles large, 3 to 5 mm. in diameter.
    C. Tubercles numerous, occurring near tip of ray and on marginal plates as well as elsewhere *frianti*
    CC. Tubercles few, confined to abactinal surface of basal two-thirds of ray................. *tumulosa*

[1] Fisher (1919) suggests that the type of *obtusa* is a young *tuberculata* with the tubercles "a little more prominent than usual." Perrier's description implies an absence of tubercles, and I have therefore included *obtusa* in this section of the genus, but Fisher has seen the type and his views of its real affinities are no doubt correct.

Nardoa variolata.

Asterias variolatus Lamarck. 1816. Anim. s. Vert., *2*, p. 565. Tab. Encyc. Meth., pl. 119, figs. 4, 5.
Nardoa variolata Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 286.
Nardoa agassizii Gray. 1840 Ann. Mag. Nat. Hist., *6*, p. 287.

(Plate 28, Figures 3 and 4.)

The original locality assigned to this species was "Mediterranean Sea," but it later transpired that this was a mistake. Zanzibar and Mauritius are the localities from which it is best known; it occurs as far south on the mainland coast as Matemo Island, Portuguese East Africa, and northward it extends to the Red Sea. It has been reported from the Amirante Islands, from the Maldives, and from Ceylon. Records from further east are probaby due to confusion with *N. novæcaledoniæ.* It is one of the smaller species of the genus, R rarely exceeding 90 mm. The color is apparently not conspicuous, as none of those who have seen the species alive have thought it worth while to speak of it. To judge from the very unreliable evidence of dry and alcoholic material, the color in life is a uniform dark grayish-brown.

Nardoa pauciforis.

Linckia pauciforis von Martens. 1866. Arch. f. Naturg., *32*, pt. 1, p. 69.
Nardoa pauciforis Sladen. 1889. *Challenger* Ast., p. 412.
Nardoa finschi de Loriol. 1891. Mem. Soc. Phys. Hist. Nat., Genève. Suppl. vol., No. 8, p. 28, pl. ii (xi), figs. 4–4*g*.

It is remarkable that de Loriol in describing *finschi* makes no reference to *pauciforis*, but it may be because he did not think any species with 12 to 20 pores in each papular area could possibly be called *pauciforis.* Indeed, von Martens particularly states that the number of papulæ is only 4 to 6 in an area, and it is not strange therefore that de Loriol thought his specimen could not be that species. As a matter of fact, *pauciforis* shows great diversity in this particular, although I have seen no specimen of which it could be said "papulæ only 4–6 to an area." Nevertheless I feel no doubt that *finschi* and *pauciforis* are synonymous, for Fisher says, *in litt.:* "*N. finschi* is a synonym of *N. pauciforis.* * * * * I saw specimens of *pauciforis* in the British Museum probably identified by Perrier. The species is distinguished by the small abactinal plates—12 or 13 across the base of ray between the two superomarginal series: No. 2322 seems to be typical." Now, No. 2322 is one of the specimens which I took at Mer, and of which there is a good series in the Museum of Comparative Zoölogy. There are 4 to 14 papulæ in each area.

This is one of the larger species of the genus, for, while von Martens says R = 100 mm. and de Loriol says 115 mm., the Museum of Comparative Zoölogy series ranges in length of ray from less than 70 to over 140 mm. Besides the specimens from Mer, we have one labeled "Alaska" (obviously a blunder); two from Bantayan Reef, Cebu, Philippine Islands; one from Erub, Torres Strait; two from Green Island, Queensland, and seven from an unknown locality. These last are labeled "Mauritius?" but it is probable they are from the Ward North Queensland collection. The original specimens of *pauciforis* were from Flores, and the *Alert* took three specimens at Bird Island, North Queensland, just south of the Torres Strait region. It is also known from Amboina.

At Green Island, near Cairns, Queensland, at Erub, and at Mer, this *Nardoa* is fairly common but not abundant. In life it is more or less bright buff or fawn-color, palest on the convexities of the skeleton, and deepest in the intervening concavities. The color changes little in alcohol but in drying it tends to become paler where pale and browner where dark, and duller everywhere. Both on the reef-flat and in an aquarium this sea-star is very sluggish and makes no attempt to reach either sunshine or shadow, remaining inertly where placed.

Nardoa novæcaledoniæ.

Scytaster novæcaledoniæ Perrier. 1875. Rev. Stell., Arch. Zoöl. Exp., *4*, p. 162 (426).
Scytaster gomophia Perrier. 1875. *Op. cit.* p. 431 or 167.
Nardoa novæcaledoniæ Sladen. 1889. *Challenger* Ast., p. 412.

It seems surprising that Perrier should have given two names to the same species in the same paper, but the explanation probably lies in the fact that the type of *gomophia* was in the British Museum, while that of *novæcaledoniæ* was in Paris. When the description of *gomophia* was drawn up, a comparison was made with *Gomophia egyptiaca*, but when *novæcaledoniæ* was described the differences between it and *variolata* were what Perrier was seeking to emphasize. Fisher very kindly called my attention to the fact that some of my Nardoas from Mer were apparently *gomophia*. I subsequently discovered that they answer very exactly to Perrier's description of *novæcaledoniæ* and I am now satisfied the two species are the same; the longer name has page precedence. Fisher says *in litt.*:

"Let me say that Perrier's description of *gomophia* is misleading. The species is hardly distinguishable from *novæcaledoniæ*, or the specimens labeled as such by Perrier in the British Museum. I compared the type of *gomophia* side by side with these specimens. Perrier compares his specimen of *gomophia* with *ægyptiaca*. Unless labels have been shifted accidentally to another specimen, this is very misleading, for *N. gomophia* does not resemble *ægyptiaca* at all.

The differences between *variolata* and *novæcaledoniæ* are very slight and I at first called my specimens from Mer *variolata*. Besides the difference in the size of the distal abactinal plates, the central granules on those plates are very conspicuous in *novæcaledoniæ* and not so in *variolata*.

There are specimens of *novæcaledoniæ* in the Museum of Comparative Zoölogy from Green Island, Queensland, from Mer, and from Port Galera, Mindoro, Philippine Islands. The species was previously known from New Caledonia, the type locality for both *novæcaledoniæ* and *gomophia*. Bell records it from the Andaman Islands and also from the Maldives and Minikoi, but I doubt the latter identification at least, for at Green Island and Mer the color of this species was indistinguishable from that of *pauciforis*, *i.e.*, light (convexities) and dark (low places), buff or fawn, while Bell says the specimens he had were either brown or blue. Blue is certainly an extraordinary color for a *Nardoa* and I do not believe the same species is both blue and brown. The specimen in the Amsterdam Museum from New Ireland, called *variolata* by Sluiter, is probably *novæcaledoniæ*. One of our specimens from Mindoro is perfectly tetramerous and has remarkably long, terete, attenuate rays, for R = 115 mm., and r = only 12, and br only 15. The abactinal plates of this specimen are not typical, the contrast between the terminal and basal portions of the rays being very poorly marked.

At Mer and Green Island, this species occurs with *pauciforis* and was supposed to be only a form of that species, but the difference is so constant that it seems best to consider it specific. As stated on page 50, it is certainly not a sex difference. At Port Galera, Mindoro, the specimen of *novæcaledoniæ* was taken with *tuberculata*, and the resemblance of the two species in color is notable.

Nardoa mollis.

Nardoa mollis de Loriol. 1891. Mem. Soc. Phys. Hist. Nat. Genève, Suppl. vol., No. 8, p. 26, pl. iii (xii), figs. 4-4*f*.
Nardoa Le Monnieri Koehler. 1910. Indian Mus. Ast., p. 161, pl. xviii, figs. 1, 2.
Nardoa bellonæ Koehler. 1910. Indian Mus. Ast., p. 164.

I would not feel sure of the identity of *mollis* and *lemonnieri* were it not for the series of specimens collected at Mer; one of these agrees so closely with the description and figure of *mollis* that I am sure it is that species, while another answers equally well to Koehler's account of *lemonnieri*. Koehler compares his species with *novæcaledoniæ* and with a mythical "*bellonæ*," which is, as already stated, probably *mollis*. The differences from *novæcaledoniæ* are tangible enough, but those which are supposed to separate *lemonnieri* from "*bellonæ*" are insignificant. New Britain is the only known locality for *mollis* and the Andaman Islands for *lemonnieri*. Fisher (1919) keeps *lemonnieri* separate from *mollis* and suggests the form of the denuded abactinal plates as a possible distinction. After another examination of our series of *mollis*, I have no faith in the reliability of this character. This is one of the finest sea-stars found at Mer, where, however, it occurs only sparingly on the reef-flat. The specimens found range from R = 65 to R = 128 mm.; the last is somewhat larger than Koehler's largest specimen of *lemonnieri*, but its proportions are the same. In life the color is a deep olive-brown and the surface of the animal has a velvety texture, so that no confusion with *pauciforis* or *novæcaledoniæ* was possible. The color becomes lighter in preserved specimens.

Nardoa obtusa.

Scytaster obtusus Perrier. 1875. Rev. Stell., Arch. Zool. Exp., *4*, p. 169 (433).
Nardoa obtusa Sladen. 1889. *Challenger* Ast., p. 412.

Nothing is known of this species beyond Perrier's original description. The type is in the British Museum and came from the Philippine Islands. The rays are much shorter than in other members of the genus, but I think this may prove to be only an extreme individual divergence. A specimen of *pauciforis* which I found at Mer has R = 63 and r = 11 (R = 5.7r) and the rays are very blunt and scarcely taper at all. The actinolateral plates and the adambulacral armature in this specimen are like other examples of *pauciforis* and not at all as in *obtusa*. Fisher (1919) gives some additional data about this species, the type of which he saw at the British Museum. It is a small specimen with R = 35 mm. and r = 8 mm. The plates which Perrier calls "légèrement" larger and more protruding, must be rather decidedly so, as Fisher suggests (p. 385) that the specimen may be "a young *tuberculata* with the tubercles a little more prominent than usual," or it may be (p. 387) a young *tumulosa*. One would not suppose from Perrier's description that the affinities were with that section of the genus.

Nardoa galatheæ.

Scytaster galatheæ Lütken. 1864. Vid. Med., p. 167.
Nardoa galatheæ Sladen. 1889. *Challenger* Ast., p. 412.

Although Lütken suggests that this species is most nearly allied to *semiregularis*, his diagnosis shows that the form of the rays and the character of the abactinal skeleton indicate its position is in *Nardoa* as here restricted. The adambulacral armature is, however, unique in the genus and should make the recognition of the species easy but it does not seem to have been met with since originally described, unless the locality "Togean Island" given by Sladen (1889, *Challenger* Ast., p. 788) is to be so construed. The type-locality is "Nikobar," while Togean Island is in the Gulf of Tomini, Celebes. I have been unable to find any record of echinoderms from that island and Sladen gives no authority. Lütken gives the diameter of *galatheæ* as 5 inches, which would rank it among the smaller species of the genus.

Nardoa rosea[1] sp. nov.

(Plate 10, Figure 1; Plate 29, Figures 1 and 2.)

R = 70 mm.; r = 12 mm. in life, 10 mm. in the dried specimen; br = 11 mm., R = 6 to 7 r. Disk small, slightly elevated; interbrachial arcs acute. Rays terete, only slightly tapering in life, more so in preserved material. Abactinal skeleton made up of plates, very diverse in size and shape, 1 to 2.5 mm. in diameter, more or less convex or swollen, the convexity increasing with size; neither on disk nor rays is there any regularity of arrange-

[1] *Roseus* = rosy-red, in reference to the color.

ment. The whole abactinal surface is covered with rather coarse, spaced, rough granules, of diverse sizes, the largest at the summit of the conical plates, especially near the tip of the rays. Papular areas rather small with 3 to 10 papulæ; near the tip of the rays the papulæ are often single. Madreporite small, rounded, triangular, 1.5 mm. across, a little nearer center of disk than margin. Terminal plate small, covered with coarse granules, of which a few are conspicuously bigger than the others.

Superomarginals 39, of which Nos. 5, 8, 14, 16, 18, 20, 22, 24, 26, 28, 30, and 32 are short and nearly flat, while the others, though of moderate size, are distinctly convex; all are covered with a coarse granulation, especially near center of plate and particularly near tip of ray; the largest superomarginals are not 2 mm. square. Inferomarginals 38, proximally smaller than those of the upper series, but becoming equal farther out on ray, only corresponding with them in position at irregular intervals; all are granulated like the superomarginals, but the dozen distalmost carry very coarse granules, of which 1, or often 2, become small tubercles. Actinolateral series well developed, reaching the twentieth inferomarginal or beyond; at base of ray there may be 2 actinolaterals to each inferomarginal, but for the most part there is only 1; the granulation of these plates is somewhat coarser than that of the lower marginals. There are small groups (2 to 5) of large papulæ between the two series of marginals and between the inferomarginal and actinolateral plates.

Adambulacral plates rather large, averaging about 3 to each pair of inferomarginals; their armature consists of a furrow series of 4 subequal, flattened, but thick spinelets, with rounded and sometimes a little thickened tips; on a few of the proximal plates there is a fifth spinelet on the adoral corner of the plate, but this is noticeably shorter than the others; back of the furrow series is a second series of 3 (very rarely 4) shorter and thicker spinelets; the middle one of the 3 is usually the largest and may be conspicuously bigger than the others; on the outer margin of the plate are 2 or 3 smaller, more granule-like spinelets, of which 1 is often conspicuously larger than the others. Oral plates each with two series of spines, a marginal with 7 spines, of which the innermost is largest (nearly 2 mm. long) and a suboral with 5 spines of which the fourth, next to the outermost, is longest and stoutest. Color in life dull brown, quite dark, with all tubercles and the adambulacral armature bright rose-red. Under a lens the epidermis appears very dark brown, the papulæ transparent gray, the granules on the tubercles rose-red, while those on the intertubercular spaces are dull yellowish or pale brown; the oral surface has a very slight orange tint; feet transparent white. Alcohol tends to bleach the specimens, and preserved material is light yellowish brown.

Holotype, Museum of Comparative Zoölogy, No. 2325; southwestern reef-flat, Mer, Murray Islands, Torres Strait.

This is the least common and the handsomest *Nardoa* occurring at the Murray Islands, its fine color making it instantly recognizable. Not only is the color distinctive, but the openly spaced granulation and the alternating arrangement of the superomarginal plates make the species easily recognized. Only 4 specimens were found altogether, and these occurred under coral slabs below low-water mark. The largest has R = 78 mm., one ray has been broken (bitten?) off at the base, but has regenerated nearly 15 mm. Another specimen shows even more extensive injury; only one ray (R = 63 mm.) is normal; two others, one on each side of the normal one, were broken (or from the appearance more probably bitten) off close to the disk but have begun to regenerate; the original fourth and fifth rays and more than half the disk are missing, but regeneration is well under way, the new rays showing ambulacral furrows over 2 mm. long. Even the holotype has one ray broken (pl. 29, fig. 1) about 15 mm. from the base, with a regenerated tip nearly 10 mm. long. These facts at least suggest that this species is peculiarly liable to injury, apparently from predatory fishes, and has its powers of regeneration correspondingly well developed.

Nardoa tuberculata.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 287.—Koehler. 1910. Indian Mus. Ast., pl. xvii, figs. 1, 2.

The type locality for this species is Port of Sual, Luzon, Philippine Islands; it is known, however, not only from other points in the Philippines, but also from Ceylon, Java, Batjan, Flores, Amboina, Halmaheira, Timor, and Dutch New Guinea. Bell reports it from Cargados Carajos, western Indian Ocean, 30 fathoms; from northwestern Australia, 9 to 38 fathoms; from Macclesfield Bank, 30 to 46 fathoms; Sandal Bay, Loyalty Islands; and from the Enganin Group, British New Guinea. He also records *tuberculata* from the Arafura and Banda Seas, but as he gives the definite locality as "Parry Shoal," which is on Macclesfield Bank, this record need cause no trouble. The species is one of the larger members of the genus, R reaching at least 130 mm. The color of this species is either unusually variable for a *Nardoa* or more than one species is included at present under the name *tuberculata*, for von Martens says the color in life is brown-yellow, with dark blood-red transverse bands, while Herklot's colored plate shows a gray-brown ground-color with 4 or 5 broad, sharply defined, dark-gray bands across each arm. Sluiter and de Loriol say their specimens show no crossbands, and there is no hint of such bands on any of the specimens in the Museum of Comparative Zoölogy. There is great individual diversity in the size, number, and arrangement of the tubercles. Two specimens in the Museum of Comparative Zoölogy from Port Galera, Mindoro, Philippine Islands are notable because the tubercles are so low and broad; in typical specimens the tubercles are about 2 mm. in diameter at base and about 1.5 mm. high, but in these specimens they are 2 to 2.5 mm. in diameter and only 0.5 to 1 mm. high.

Nardoa frianti.

Koehler. 1910. Indian Mus. Ast., p. 158, pl. xvii, fig. 3, 4.

A very well-marked species, taken at the Andaman Islands in 20 fathoms and recorded also from Tawi Tawi, Sulu Archipelago, in 10 fathoms. The largest specimen has R = 126 mm.

Nardoa tumulosa.

Fisher. 1917. Proc. Biol. Soc. Wash., *30*, p. 90.

The *Albatross* took the type of this species in 12 fathoms off Tinakta Island, Tawi Tawi group, Sulu Archipelago, on a sandy bottom. R = about 90 mm. while r = about 14, so the rays are rather short for a *Nardoa;* they are also wider (17 mm. at base) relatively than in *frianti*. Fisher (1919) thinks it possible that this may be the adult of *obtusa* Perrier, which is based on a small *Nardoa* with R only 35 mm.

GOMOPHIA.

Gray. 1840. Ann Mag. Nat. Hist., *6*, p. 286.

Genotype: *Gomophia egyptiaca* Gray. Monotypic.

Although Perrier and Sladen merged this genus in *Scytaster* and *Nardoa* respectively, it seems to me a mistake to ignore its unusual characters. While the conspicuous pointed tubercles serve best for the distinguishing character in an artificial key, as given above (p. 37), this feature is not of nearly so much importance as the reduction and irregularity of the superomarginal plates and the presence of a well-developed series of intermarginal plates on the basal part of the ray. All these characters combined warrant maintaining the genus quite apart from *Nardoa*.

Gomophia egyptiaca.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 286.—Koehler. 1910. Indian Mus. Ast., p. 157, pl. xvii, figs. 5, 6.

This species has a wide distribution, ranging from Mauritius to Samoa. Sladen records it from the Hawaiian Islands; while this is probably a mistake, its occurrence there would not be strange. Koehler records a specimen in his collection, from Mindanao, which has R = 100 mm. The largest specimen in the Museum of Comparative Zoölogy collection is little more than half so large. Individual diversity is shown chiefly in the size and number of the tubercles; one before me from Samoa with R = 50 mm. has only 10 to 12 tubercles on each ray but many of them exceed 2 mm. in height and in basal diameter; on the other hand, one from Fiji with R = 58 mm. has about 35 tubercles on each ray, but the largest of these are only about 1.5 mm. in height and basal diameter. Koehler (*l.c.*) has pointed out that the apparently bare tip of the tubercles is really an enlarged, smooth, conical granule. I have found no statement in regard to the color of this species in life.

CERTONARDOA[1] gen. nov.

Similar to *Nardoa*, but the rays are actinally flat, widened, and trigonal at base, and the abactinal plates are arranged in regular longitudinal series on the basal part of the rays. As in *Nardoa*, the papulæ are in groups, but there are none on the actinal surface.

Genotype: *Scytaster semiregularis* Müller and Troschel.

Nardoa is a much more homogeneous group with *semiregularis* removed. This species approaches *Narcissia* in general form, but that Atlantic genus is easily distinguished by the isolated papulæ. Besides the type-species, *Certonardoa* contains 2 species, described by Koehler, based on several small specimens (R = 18 to 40 mm.) taken in 10 to 53 fathoms on the eastern side of the Bay of Bengal. The form called by von Martens *semiregularis* var. *japonica* does not appear to be worthy of a varietal name. Its peculiarities are well within the limits of diversity caused by the method of preservation.

Key to the Species of Certonardoa.

Abactinal plates at base of ray quadrilateral, in regular longitudinal and transverse series; 7 to 9 longitudinal series; granules on papular areas not larger than elsewhere.................... *semiregularis*
Abactinal plates at base of ray rounded, in 3 to 7 longitudinal series which quickly become indistinct distally; granules on papular areas larger than elsewhere.
Rays dorsally carinate; distal subambulacral spinelets not notably enlarged.................... *carinata*
Rays dorsally not carinate; distal subambulacral spinelets (1 on each plate) conspicuously enlarged *squamulosa*

Certonardoa semiregularis.

Scytaster semiregularis Müller and Troschel. 1842. Syst. Ast., p. 36.
Linckia semiregularis var. *japonica* von Martens. 1865. Arch. f. Naturg., *31*, pt. 1, p. 351.
Nardoa semiregularis and var. *japonica* Sladen. 1889. *Challenger* Ast., p. 412 and 788.—Ives, 1891. Proc. Acad. Nat. Sci. Phila., pl. vii, figs. 1–4.

This species ranges from Java and the Moluccas to southern Japan, where it seems to be quite common. The color in life is said to be "gorgeous orange-red," quite different from any species of *Nardoa*. In large specimens, R = 90 mm. Von Martens designated his Japanese specimens by a varietal name because R = 4.5–5r, whereas Müller and Troschel state that R = 7.5r. The specimen of von Martens, however, had R = 55 mm., while in Müller and Troschel's specimen R was about 80 mm. Moreover, aside from individual diversity, a specimen preserved with muscles contracted and disk high will have r much shorter than if the muscles are relaxed and the disk flattened.

Certonardoa carinata.

Nardoa carinata Koehler. 1910. Indian Mus. Ast., p. 165, pl. xv, fig. 6; pl. xvi, figs. 10, 11.

Until the growth-stages of *C. semiregularis* are worked out, it can not be asserted positively whether *carinata* is the young of that species or not, but in view of Fisher's (1919) figure of a young *semiregularis* with R only 29 mm., it seems highly improbable. One of the specimens of *semiregularis* in the Museum of Comparative Zoölogy from Japan, with R = 55 mm., has the arms high, though not truly carinate, but the largest specimen of *carinata* had R only 40 mm. No doubt too, the degree of carination will be influenced by the condition when preserved and the method of preservation. The type-locality for *carinata* is the Andaman Islands, 10 to 53 fathoms.

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[1] *Certus* = regular, orderly + *Nardoa*, in reference to the arrangement of the abactinal plates at the base of the arms.

Certonardoa squamulosa.

Nardoa squamulosa Koehler. 1910. Indian Mus. Ast., p. 168, pl. i, fig. 8; pl. xv, figs. 7, 8.

This species is based on a single specimen, with R = 37 or 38 mm., dredged off Cape Negrais in 40 fathoms. Koehler himself says it is very near *carinata* and may prove to be identical with it. Fisher (1919) records two specimens from the Philippines, but even the larger exceeds Koehler's type by only a trifle, so they do not throw much light on the species.

PLENARDOA[1] gen. nov.

Similar to *Certonardoa* in many respects, but with papulæ isolated and not in groups. It thus resembles *Narcissia* in the distribution of the papulæ, but the number and arrangement of the longitudinal series of abactinal plates precludes placing the East Indian species for which the genus is established, in that Atlantic group.

Genotype: *Linckia semiseriata* von Martens.

It is with no little hesitation that I establish this monotypic genus, but since von Martens particularly states that the papular pores are single in his *L. semiseriata*, the species can not be placed in either *Nardoa* or *Certonardoa*. On the other hand, although that type specimen was a small one, it has a far greater number of abactinal plates than either of the known species of *Narcissia*, and their arrangement in longitudinal series is highly characteristic. I see no other course open, therefore, than the formation of a new genus.

Plenardoa semiseriata.

Linckia semiseriata von Martens. 1865. Arch. f. Naturg., 31, pt. 1, p. 355.
Nardoa semiseriata Sladen. 1889. *Challenger* Ast., p. 412.

This species is unfortunately known only from the holotype, in which R = 39 mm. It was taken at 7° latitude in the South China Sea, at a depth of 40 fathoms. The color in alcohol was yellowish. The skeleton of each arm is made up on each side of the adambulacral plates thus: a series of actinolaterals, the inferomarginals and superomarginals, and 7 series of dorso-laterals, of which the 4 uppermost are larger than the 3 between them and the superomarginals; the median abactinal surface of the arm is covered by 3 or 4 series of plates alternating with each other. No other linckiid has an arm structure corresponding to this.

NARCISSIA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 287.

Genotype: *Narcissia teneriffæ* Gray = *Asterias canariensis* d'Orbigny. Monotypic.

This genus of small linckiids seems to be confined to the tropical Atlantic. It is easily recognized by the trigonal, tapering rays with few series of abactinal plates, and the isolated papulæ confined to the abactinal surface. Only 2 species are known and neither of these is at all common. They are distinguished as follows:

Key to the Species of Narcissia.

Rays long and slender, R = 7–9 r .... *canariensis*
Rays shorter and wider, R = 4–5 r .... *trigonaria*

Narcissia canariensis.

Asterias canariensis d'Orbigny. 1839. Voy. de Webb et Berthelot aux îles Canaries, p. 148, Echinod., pl. 1, figs. 8–15.
Narcissia teneriffæ. Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 287.
Scytaster (*Narcissia*) *canariensis* Perrier. 1875. Rev. Stell., Arch. Zool. Exp., *4*, p. 170 (434).
Narcissia canariensis Sladen. 1889. *Challenger* Ast., p. 413.
Fromia narcissiæ Perrier. 1894. *Trav.* et *Tal.* Stell., p. 331.

Although Sladen had a specimen of this little-known species, taken by the *Challenger* at the Cape Verde Islands, he gives us no details whatever with regard to it except the brief

[1] πλήν = *beyond* + Nardoa, in reference to the development of abactinal plates beyond anything known in Nardoa.

statement that there are a few entrenched pedicellariæ on the marginal plates. He does not mention the size of his specimen, so one can not determine whether the pedicellariæ may be associated with youth, as is apparently true in some sea-stars. Quite small specimens of this species were described by Perrier as a new species of *Fromia*, although they had no actinal papulæ. The only known localities for *canariensis* are in the Canary and Cape Verde Islands. The largest specimen has R = 115 mm.

Narcissia trigonaria.

Sladen. 1889. *Challenger* Ast., p. 414; pl. lxv, figs. 5–8.

The type of this species with R = 62 and r = 13 mm. was taken near Bahia, Brazil. A species of *Narcissia* was taken by the *Albatross*, February 7, 1885, in 25 fathoms on the fishing banks south of Cape San Blas, Florida. Verrill (1915, p. 98) refers these specimens to Sladen's species. One of them is in the Museum of Comparative Zoölogy collection. It differs from *trigonaria*, however, in the absence of tubercles on the abactinal median plates of the basal part of the rays. These plates are scarcely at all swollen or enlarged and the rays are not carinate, but these peculiarities may be due to youth, as R is less than 40 mm. Sladen's figure shows about 13 irregular series of abactinal plates on each ray, while there are only about 9 on the Florida specimen. The latter has narrow, entrenched pedicellariæ on some of the basal superomarginal and abactinal plates, whereas Sladen makes no reference to such organs in the type. The madreporic body is elliptical in the Florida specimen and subtriangular in the one from Brazil. These differences are all well within the probable limits of growth-change and individual diversity.

FERDINA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 282.

Genotype: *Ferdina flavescens* Gray, *l. c.* Type designated by Fisher, 1919.

This genus is relatively little known and few species have been assigned to it. Besides the type species, Gray included a second form, *F. cumingii*, of which Perrier subsequently (1875) gave an adequate description. Sladen (1889) added the *Scytaster kuhlii* of Müller and Troschel and the *Scytaster cancellatus* of Grube. No further additions to the genus were made for twenty years, when Koehler described *F. offreti*. Finally in 1913 Fisher added a species from Celebes, *F. glyptodisca*. At Mer, I found a single specimen of a beautiful species allied to these but apparently distinct. There are, then, 7 species to be recognized in the genus, but 5 of these are known from only 1 specimen each (or at most 2), while one of the others is known only from the original dry specimens, which have been in the British Museum for more than 75 years. It is obvious, then, that it is still open to question whether the 7 species are all valid and congeneric. It seems to me quite possible

Key to the Species of Ferdina.

No marginal or abactinal plates bare.
  Abactinal plates relatively few, large, convex; two series of actinolateral plates .... *flavescens*
  Abactinal plates more numerous and mostly smaller, but some strongly convex, tubercle-like; only one series of actinolateral plates .... *cumingii*
Some marginal and abactinal plates conspicuously convex and bare.
  Rays short and wide, R = 3–3.5 r.
    Superomarginal plates in fairly regular series on each side of ray.
      Adambulacral spines, 2; granules at center of abactinal plates larger than around margins. *offreti*
      Adambulacral spines, 3; granules at center of abactinal plates smaller than around margins *glyptodisca.*
    Superomarginal plates in irregularly alternating series of large and small plates.
      5 or 6 transverse series of small but conspicuous, convex, bare plates on abactinal surface of each ray, corresponding in position to smaller superomarginal plates .... *cancellata*
      No transverse series of bare abactinal plates but 2 to 4 such plates occur on distal half of each ray .... *ocellata*
  Rays long and narrow, R = 5 r. .... *kuhlii*

that *cancellata* and its allies are not congeneric with *flavescens* and *cumingii*, and furthermore that a large series of *cancellata*, showing growth stages, would make clear that too many species are here recognized in that section of the genus.

Ferdina is undoubtedly an East Indian genus reaching Fiji on the east and Zanzibar on the west. The type locality given for *F. cumingii* is probably erroneous, as explained below under that species. Naturally, in view of the rarity of the species, nothing is known of their habits. All are of relatively small size, though *kuhlii* is said to be 5 inches across.

Ferdina flavescens.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 282.—De Loriol. 1885, Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 47, pl. xv, figs. 8–8*e*.

This species is not rare at Mauritius, and de Loriol has figured it well. His largest specimen has R = 38 mm.; Gray's specimens were a trifle smaller. The color of dried specimens is said by Gray to be "yellow, brown varied." De Loriol's colored figure is varied yellow-brown, but it is not made clear whether the figure is colored from life or from a preserved specimen. There is no record for this species away from Mauritius, except possibly Pfeffer's (1896) record of a single arm of *F. kuhlii* from Tumbatu Island, Zanzibar, which Ludwig (1899) very naturally suggests may prove to be an arm of *flavescens*. But it is hard to see how Pfeffer could have confused the two species.

Ferdina cumingii.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

There are two puzzling things about this species, and I regret I can throw no light on either of them. The first is in regard to the locality; it is highly improbable that *Ferdina* occurs on the west coast of South America; nevertheless Gray and Perrier, in giving the locality of the type material, both say "West coast of Colombia." Gray, however, adds "H. Cuming esq." as the collector, and it is well known that Cuming collected extensively in the Philippines and also that his locality labels were not reliable. There seems to me little doubt, therefore, that the type locality for this species is in the Philippine Islands.

The second puzzling matter is in Gray's innocent-looking statement: "the larger tubercles on the side are red when the granules are rubbed off, which they often are." Anyone who has seen the marginal plates of *cancellata* or one of the allied species will at once infer that Gray is mistaken about the granules being "rubbed off," and will recognize the condition of the marginals characteristic of the *cancellata* group. But Perrier, after study of Gray's material, says "tout le corps" is covered by a uniform granulation finer than in *flavescens*, and he does not even hint that some of the marginals are bare. I am at a loss to explain this puzzle but it occurs to me that Gray might have found a specimen of the *cancellata* group with his *cumingii* material and this was subsequently removed before Perrier saw the material. A reëxamination of the British Museum Ferdinas would possibly clear up this difficulty.

Ferdina offreti.

Koehler. 1910. Indian Mus. Ast., p. 143, pl. xvi, figs. 2–5.

The description and figures of this fine species leave nothing to be desired except that I do not think there is any inner series of actinal intermediate plates (see next species). The holotype was taken near Little Andaman Island in 10 fathoms, but a much smaller specimen was collected in 34 fathoms near Ceylon.

Ferdina glyptodisca.

Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 213.—1919, Bull. 100 U. S. Nat. Mus., p. 370, pl. 56, fig. 5; pl. 95, figs. 4–4*b*; pl. 104, fig. 2; pl. 106, fig. 4.

There seems to be no ground for doubt that this species is distinct from *offreti*. In one point, however, I think the difference imaginary. Fisher says: "inner series of small actinal intermediate plates lacking." I believe Koehler is mistaken in describing *offreti* as having such a series, for on comparing my specimen of *ocellata* with his description of *offreti,* I was at first led to believe such a series was present in the Murray Island species, but later I was struck by the close correspondence between this series and the adambulacral series and a little examination and dissection under the microscope soon showed that what seems like a series of actinolateral plates is really composed of the outer ends of the adambulacral plates. The supposed inner series of small actinolaterals is, I think, non-existent. A comparison of Koehler's plate XVI, figure 3, with Fisher's plate 106, figure 4, shows the series of supposedly separate plates as plainly in one as in the other.

The only known specimen of *glyptodisca* was taken by the *Albatross* in Buton Strait, Celebes, in 24 fathoms, on a bottom of sand and broken shells.

Ferdina cancellata.

Scytaster cancellatus Grube. 1857. Arch. f. Naturg., *23*, pt. 1, p. 340.—Nova Acta Acad. Leop., *27*, p. 9; pl. ii,[1] figs. 3, 3*a*.
Ferdina cancellata Sladen. 1889. *Challenger* Ast., p. 780.

The locality whence came Grube's type is not known, but Lütken (1871) records a specimen in the Copenhagen Museum from the Fiji Islands. The holotype was a small sea-star only 2 inches across, and it is quite possible some of its peculiarities are due to youth.

Ferdina ocellata[2] sp. nov.

(Plate 6, Figure 5; Plate 31, Figures 1 and 2.)

R = 42 mm., r = 13 mm.; br = 14 mm.; R = 3.2 r and 3 br. Disk and rays very flat and rather rigid; interbrachial arcs subacute. Abactinal surface covered by a pavement of plates, ranging in diameter from 0.5 to 2 mm., and in convexity from nearly flat to tubercular; these plates show no regularity of arrangement, but there is an indefinite series of larger plates along the median line on the basal half of each ray and even less definite transverse series of medium-sized plates across the rays, 2 to 5 of these on each ray; the middle and distal part of each ray has 2 to 5 tubercle-like plates. Superomarginal plates 13 to 15, in an irregular series, made up of alternating larger, swollen, and smaller, flatter plates; the alternation is not perfect and the smaller plates are of quite diverse sizes and form. As a rule, the transverse series of medium-sized plates on abactinal surface of ray lie opposite small superomarginals; the first superomarginal of each series is very large, but nearly flat; it lies close against its fellow of the adjoining series of the next ray, the two together forming a conspicuous area on the interradial margin of disk, 5 mm. wide by 3.5 mm. along the interradial suture. Terminal plate rather small, diamond-shaped, somewhat swollen, bare and smooth, with a single terminal tubercle. Madreporic body conspicuous, elevated, about 3 mm. across, nearer center of disk than margin. Anus central, conspicuous because of the group of 10 to 12 coarse granules by which it is surrounded. Whole abactinal surface, except madreporite, tubercular abactinal plates, swollen superomarginals and terminal plate, covered by a very close and fine granulation, 200 to 400 to a square millimeter, which is coarsest around the papulæ but is coarser at the center of each plate than it is near the margin; the tubercular abactinal and swollen marginal plates have their margins concealed by this fine granulation, but the larger part of their surface is bare and the boundary line between bare and granulated portion is very sharply drawn. Papulæ large, isolated, numerous, with no regularity of arrangement whatever, each surrounded by a circle of coarse granules.

[1] In the text and in the explanation of plates, plate ii is called plate i and vice versa. This has led to erroneous references to these figures.
[2] *Ocellatus* = having little eyes, in reference to the eye-like red spots on the superomarginal plates.

Inferomarginal plates 16 to 18 of quite diverse sizes and form, making an irregular series, not sharply defined on either side; 4 to 8 are more or less swollen and bare like the larger superomarginals, and particularly at the tip of arm these swollen inferomarginals are conspicuous; but the last 3 to 6, instead of being smooth, have a group of granules on their distal sides increasingly coarse and conspicuous until the distalmost are capped by 3 to 6 tubercle-like grains. Adambulacral plates numerous (55 to 60) and small, squarish; each carries 2 (very rarely 3, and distally often only 1) short, wide furrowspinelets with rounded tips; generally the adoral spinelet is wider than the other; when a third spinelet is present it is adoral to the stouter spinelet of the typical pair. There are no other spinelets on the adambulacral plates, and the fine granulation of the abactinal and marginal plates not only covers them (as it does the actinolaterals) but it extends up on the outer side of the furrow spinelets for fully half their length, thus uniting them basally by the membrane that carries the granulation. Actinolateral areas remarkably well developed for a linckiid; the first series of actinolateral plates (adjoining the adambulacrals) extends nearly to the tip of the ray. A second series reaches the twelfth to fourteenth inferomarginal; a third series goes as far as the tenth or eleventh; a fourth may reach the eighth inferomarginal, but usually does not extend so far; a fifth series, consisting of half a dozen or more plates, is present in all the interradial areas; all the series are fairly regular, but none is perfectly so, and there are a good many odd plates intercalated here and there, especially near the interradial line; distally the series become disconnected and are indicated by isolated plates. There are no actinal and almost no intermarginal papulæ. No pedicellariæ anywhere. Oral plates small, completely concealed by the granulation; each carries only 4 or 5 marginal spinelets, which are more or less markedly compressed, wide, and blunt, the innermost biggest.

Color in life (shown in fig. 5, pl. 6) varied and beautiful beyond description. In the preserved specimen, the blue shades have wholly disappeared and the green nearly so, the ruby-red has become dull, and the nearly white basal superomarginals are now dingy yellowish; the rusty-red has remained with little change. The oral surface in life was yellowish-white with bright rusty-red outlining the plates more or less plainly, and in the preserved specimen this is changed only in that the ground-color is now light buffy-yellow.

Holotype: Museum of Comparative Zoölogy No. 2302, southwestern reef-flat, Mer, Murray Islands, Torres Strait.

This exquisite sea-star was found by our engineer, Mr. John W. Mills, among coral near the edge of the reef, in shallow water at an unusually low tide, on September 29. The most careful search in the same and similar places failed to find another specimen. It can not well be referred to any of the previously known species of *Ferdina*, for the numerous small abactinal plates and the very irregular marginal series debar it from both *offreti* and *glyptodisca*, while the absence of transverse series of bare, tubercular plates on the rays distinguish it at once from *cancellata*. In Grube's species, moreover, the abactinal papulæ are arranged in very regular series, of which there is no indication in the present form. Nevertheless the presence of indistinct transverse series of medium-sized granulated plates on the abactinal surface of the rays in *ocellata* indicates a somewhat nearer relationship to *cancellata* than to other members of the genus, and it is by no means impossible that a series of specimens would show that what now seem like good specific differences are to be accounted for by growth-changes and individual diversity.

Ferdina kuhlii.

Scytaster kuhlii Müller and Troschel. 1842. Sys. Ast., p. 36.
Ferdina kuhlii Sladen. 1889. *Challenger* Ast., p. 780.

Nothing is known of this remarkable sea-star beyond what is contained in the original description. The type specimen was from Java, measured 5 inches across, and had R = 5 r. It is presumably in the Leyden Museum. Being of so much larger size (R = 70 mm. ±)

that any *Ferdina* since collected or described (R = 35–42 mm.) it is hard to compare it with the other members of the genus, but apparently the relatively very long rays are sufficiently distinctive. Pfeffer (1896, p. 43) records a single ray from Tumbatu Island, Zanzibar, but (as Ludwig has suggested) one can hardly accept this identification. If the arm is really that of a *Ferdina*, it is more probably *flavescens* than *kuhlii*.

LINCKIA.

Nardo. 1834. Oken's Isis, p. 717.

Genotype: *Linckia typus* Nardo, *l. c.* Type designated. It is now generally agreed that *L. typus* = *Asterias lævigata* L., a perfectly unmistakable and well-known species.

This has long been an exceedingly confused group, to which no fewer than 45 nominal species have been referred. As established by Nardo and indorsed the next year by Agassiz, it contained 3 species. One of these (*variolosa* = *variolata*) was made the type of *Nardoa* by Gray in 1840, and a second (*franciscanus*) is not identifiable, but the third (designated as the genotype by its name, *typus*) is identical with Linné's *Asterias lævigata*, a species which is fortunately unmistakable, thanks to the fact that the 3 figures to which Linné refers do, in this case, all represent the same species of sea-star.[1] In 1840 Müller and Troschel added *Asterias milleporella* Lamarck to the genus, an unfortunate blunder. The same year Gray removed *variolata* to *Nardoa* and *milleporella* to *Fromia*, and added 11 species to *Linckia* (see below). In 1842 Müller and Troschel went to the other extreme and abandoned *Linckia* altogether, dividing its species between *Ophidiaster* and *Scytaster*—hardly a forward step! Von Martens, in his papers on oriental echinoderms (1865–67) returned toward Gray's conception of the genus by uniting *Scytaster* and *Ophidiaster* with *Linckia*. He names 15 species as belonging in the group. In 1871 Lütken added a new species, *L. nicobarica*, to the already unwieldy genus. In 1875 Perrier attempted to bring some order into *Linckia* by a study of the material in both Paris and London, but (much of the type-material having been lost) some of Gray's species were not to be identified. However, Perrier discusses 7 of the species previously known and described 2 supposedly new ones. In 1885 de Loriol gave some very useful descriptions and figures of the Linckias occurring at Mauritius; the colored figures in particular are important. In 1889 Sladen gave, in his *Challenger* Report, a list of the Linckias which seemed to him entitled to recognition, and this list includes 15 species and 1 variety. Since it was published, only 3 additions have been proposed, one by Russo (1894), a second by Koehler (1910*a*) and one by H. L. Clark (1914).

The large series of Linckias in the Museum of Comparative Zoölogy collection has enabled me to make a critical study of the genus and I have reached some very definite conclusions. In the first place, the earlier descriptions are so brief that they are often of little value, and this is particularly true of Gray's diagnoses. Again, the widely spread species show so much diversity in the relative proportions of R, r, and br, that specimens often look quite unlike superficially when they are in fact the same. Some of the species at least reproduce asexually by autotomy, especially when still of small size, and as a result specimens with 4, 6, 7, or even 8 arms occur more or less commonly, and symmetrical 5-rayed specimens of such species are relatively rare. The number of madreporites is equally variable in these forms ranging from 1 to 4; occasionally a madreporite occurs on the base of a ray rather than on the disk proper. Color is probably of more value as a specific character in the genus than has been previously granted, but unfortunately it is very fugacious and of almost no help in identifying museum material. Study on the reefs of the living specimens will doubtless show the specific colors in the genus. The size and arrangement of the papular areas are subject to growth change as well as to considerable

[1] Since both Perrier and Sladen go back to Linck (1733) for specific names, it is not strange that both have ignored the tenth edition of the "Systema Naturæ" with its perfectly definite *Asterias lævigata*.

individual diversity and I do not think they afford any reliable specific characters. The nature of the adambulacral armature, on the other hand, is of very great importance, but the development of a second series of subambulacral spines is subject to great diversity and it may be wholly wanting or more or less well developed in one and the same species. The size and character of the abactinal plates furnish good specific characters in several species, but their arrangement is subject to very great diversity in all.

The results of the study of the available material and literature are shown in the following list of species hitherto referred to *Linckia*, showing their present status in my judgment, and in the key to the species which seem to me valid. The study of living material will greatly improve the accuracy and usefulness of the key.

List and present Status of Sea-stars which have been referred to Linckia.[1]

[The names in black-face type are those of valid members of the genus.]

ægyptiaca (Gray) von Martens, 1866 = *Gomophia ægyptiaca.*
bifascialis Gray 1840 = *Phataria unifascialis.*
bouvieri Perrier, 1875, is valid.
brownii Gray, 1840, is an *Ophidiaster* by description but is obviously *L. lævigata* by the figures to which reference is made.
columbiæ Gray, 1840, is valid.
costæ Russo, 1894, is apparently *multifora* but as no measurements are given and the description is otherwise quite inadequate, the species can not be certainly identified.
crassa Gray, 1840, is the short-armed form of *lævigata.*
cylindrica (von Martens) 1866 = *Dactylosaster cylindricus.*
diplax (Müller and Troschel) Lütken 1871, is a species of doubtful validity.
dubiosa Koehler, 1910*a* = *Tamaria dubiosa.*
echinulata (Müller and Troschel) Gray, 1866 = *Mithrodia clavigera.*
ehrenbergii (Müller and Troschel) Gray, 1866 = *L. guildingii.*
erythræa Gray, 1840, is quite unknown.[2]
franciscanus Nardo, 1834, is not identifiable but is probably an *Ophidiaster.*
guildingii Gray, 1840, is valid.
hemprichi (Müller and Troschel) von Martens, 1866 = *Dactylosaster cylindricus.*
intermedia Gray, 1840, is quite unknown.[2]
kuhlii (Müller and Troschel) von Martens, 1866 = *Ferdina kuhlii.*
lævigata (Linné) Lütken, 1871, is valid.
leachii Gray, 1840 = *L. multifora.*
marmorata (Michelin) von Martens, 1869 = *Tamaria marmorata.*
megaloplax Bell, 1884 = *Tamaria fusca.*
miliaris (Müller and Troschel) von Martens, 1866 = *L. lævigata.*
milleporella (Lamarck) Müller and Troschel, 1840 = *Fromia milleporella.*
milleporella (Lamarck) von Martens, 1866 = *Fromia monilis.*
multifora (Lamarck) Lütken, 1871, is valid.
multiforas Gray 1840 = *L. multifora.*
multiforis (Müller and Troschel) von Martens, 1866 = *L. multifora.*
nicobarica Lütken, 1871 = *L. guildingii.*
nodosa Perrier, 1875 = *L. bouvieri.*
nodosa Bell, 1884 = *Hacelia helicosticha.*
ornithopus (Müller and Troschel) Verrill, 1866 = *L. guildingii.*
pacifica Gray, 1840 = *L. guildingii.*
pauciforis von Martens, 1866 = *Nardoa pauciforis.*
pistorius (Müller and Troschel) von Martens, 1866 = *Fromia milleporella.*
pulchella Gray, 1840, is quite unknown.[2]
pusilla (Müller and Troschel) von Martens, 1866 = *Tamaria pusilla.*
pustulata von Martens, 1866 = *Ophidiaster pustulatus.*
rosenbergi von Martens, 1866, is of uncertain validity.
semiregularis (Müller and Troschel) von Martens, 1866 = *Certonardoa semiregularis.*
semiseriata von Martens, 1866 = *Plenardoa semiseriata.*
subulata (Gray) von Martens, 1866 = *Metrodira subulata.*

[1] Many of the conclusions shown in this table are not original but were reached years ago by Verrill, Lütken, Perrier, and Sladen.

[2] The three species, *erythræa*, *intermedia*, and *pulchella* which made up Gray's subgenus *Acalia* are entirely unknown. I have never seen a sea-star which seemed to meet the diagnostic requirements of the group, nor has any writer since Gray been able to throw any light on the mystery.

List and present Status of Sea-stars which have been referred to Linckia—continued.

suturalis von Martens, 1866 = *L. lævigata;* it is clearly not *Ophidiaster suturalis* Müller and Troschel which = *Phataria unifascialis.*

tuberculata (Gray) von Martens, 1866 = *Nardoa tuberculata.*

tyloplax H. L. Clark, 1914, is valid.

typus Nardo, 1834 = *L. lævigata.*

unifascialis Gray, 1840 = *Phataria unifascialis.*

variolaris Nardo, 1834 = *Nardoa variolata.*

variolata (Lamarck) Agassiz, 1835 = *Nardoa variolata.*

Key to the Species of Linckia.

A. Granulation of actinal surface extending upon sides of ambulacral grooves so that furrow spines are separated from each other by vertical series of minute granules.

B. Rays relatively short and stout, R = 5–10 br; 1 madreporite; color of adult in life brilliant deep blue *lævigata*

BB. Rays longer and more slender, R = 10–12 br; 2 madreporites; no blue in coloration . . . . *multifora*

AA. Granulation of actinal surface not extending up into ambulacral grooves; furrow spines not separated by granules.

B. No abactinal plates conspicuously enlarged and swollen.

C. Poriferous areas between superomarginals and inferomarginals in an unbroken, continuous series, more or less circular, each with about 10 pores; actinolateral plates in four series on each side . . . . *rosenbergi*

CC. Intermarginal poriferous areas not in a continuous series.

D. Abactinal plates relatively large and few; papular areas small in 5 to 7 more or less regular series; papulæ few (5 to 12) and large, the pores usually much larger than granules on adjoining plates; size small, R less than 100 mm. . . . . *columbiæ*

DD. Abactinal plates relatively small and numerous; papular areas large in 8 to 12 or more series, the median ones very irregular and difficult to make out; papulæ numerous (12 to 40) small, the pores usually much smaller than the larger granules of adjoining plates; size large, R often 150 to 200 mm.

E. Color in life: when young dull reddish or purple, more or less variegated with darker shades, becoming when adult purplish, reddish brown, or uniformly yellow-brown *guildingii*

EE. Color in life: brown and blue with black dots or greenish blue, with black dots; oral surface purplish red . . . . *diplax*

BB. Some or many abactinal plates swollen into big, more or less hemispherical nodules.

C. Rays slender, tapering but little; few swollen plates; no actinal papulæ . . . . *bouvieri*

CC. Rays stout at base, tapering markedly; numerous swollen abactinal plates; actinal papulæ present . . . . *tyloplax*

Linckia lævigata.

Asterias lævigata Linné. 1758. Syst. Nat. Ed. 10, p. 662.
Linckia typus Nardo. 1834. Oken's Isis, p. 717.
Linckia lævigata Nardo. 1834. Oken's Isis, p. 717.[1]
Linckia crassa Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284.
Linckia brownii Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.
Linckia miliaris auct. mult., 1866–1910.

(Plate 9, Figures 1 and 2; Plate 26, Figure 1.)

There are a number of early figures of this well-known species, and Saville-Kent (1893, Great Barrier Reef of Australia, p. 358, chr. pl. XI, fig. 8) gives a colored illustration supposed to be from life, but an accurate drawing of the brilliantly blue living animal and a photograph of a dry specimen seem to be still needed. Young specimens (*i.e.*, before R = 50 mm.) live on the under side of stones and coral fragments and show but little blue. Their appearance at this stage is well shown in figure 1, plate 9, but no two specimens are colored just alike. Soon after R = 50 mm. they come out of their sheltered habitats and are found lying more or less fully exposed on the sandy bottom. The development of blue pigment seems to take place rapidly at this time. Even in young specimens the papulæ are blue. The tube feet are very pale yellow in small specimens, but become quite deep yellow in adults. The blue pigment shows very curious chemical reactions, becoming dull orange-red in alcohol very quickly. (See Harvey, 1915, p. 207.) It retains its color to some extent in formalin.

[1] While Nardo uses the combination *Linckia typus* nob. he refers directly to *lævigata* as the species he has in mind, so that this is really the first reference of *lævigata* to Linckia, even though Nardo does not actually use the combination.

The smallest specimen I have seen has R = 18 mm. The madreporite is small but distinct, and there are 5 subequal rays. On the abactinal surface of each ray is a median series and on each side of it a laterodorsal series of plates, while between them there is on each side the beginnings of an additional series of much smaller plates. The terminal plate and a number of markedly convex abactinal plates near it are quite bare. There are 3 or 4 papulæ in each area. There are 3 quite distinct series of actinolateral plates on each side of the ambulacral furrow. The adambulacral armature at this youthful stage is very interesting for the furrow spines are not separated at all by granules. On each adambulacral plate are 3 furrow spinelets, the most adoral largest and the distalmost scarcely half as large as the middle one; the 3 are closely appressed in a slightly oblique, sloping series. Specimens only a little older have 2 granules between the larger spines, which are pushed apart by their development. The adult commonly has 5 furrow spinelets on each plate, for not only does the small one persist but two others, each a little smaller than the preceding, arise distal to it; the development of these spinelets accompanies the increase in number of granules between the larger spinelets. The small spinelets are so high up within the ambulacral furrow that they are ordinarily quite out of sight. In specimens with R = 25 mm. or more the terminal plates as well as all the distal abactinal plates are covered with granules.

Multiplication by autotomy does not occur ordinarily in *lævigata*, but new rays may arise from an old one, at least if part of the disk is present. There is in the Museum of Comparative Zoölogy a specimen consisting of an old ray 70 mm. long, an adjoining old ray 30 mm. long with a regenerated tip of 15 mm. additional, an adjoining third ray 15 mm. old and 15 mm. new, and 3 new rays, 27 to 30 mm. long. In this peculiar specimen there are 4 madreporites; 3 form a curved, irregular series, more or less in contact with each other along an interradial line, while the fourth is in the next interradius. More than one madreporite is very unusual in *lævigata* and specimens with 6 rays are very rare. Specimens with 4 rays are, however, fairly common; at Mer about one specimen in every 200 was tetramerous. Specimens from different localities show considerable diversity in the relative length and slenderness of the arms. At Mer all the individuals found (many hundred) were of the short-rayed form to which Gray gave the name *crassa;* in these R = 5–6br. In large specimens from Zanzibar R = 8–10br, but intermediate specimens occur between these two extremes. An individual from Fiji which I have referred to this species (Museum of Comparative Zoölogy No. 2658)is notable because in alcohol its color was a deep greenish-blue and the surface of the body was almost as smooth as in *Leiaster*. Dried, however, this individual can not be distinguished from *lævigata* by any tangible characters and I am quite at a loss to account for its peculiarities.

The limits of the distribution of this species are somewhat uncertain because of its confusion with other species, but it certainly occurs in the Philippines, at Fiji, in the New Hebrides, at Samoa, at Erub and Mer in Torres Strait, and at Green Island off Cairns, Queensland. It extends southward on the Barrier Reef at least to the Palm Islands (lat. 19°), but it does not occur at Thursday Island or in that part of Torres Strait. Koehler lists it from the Aru Islands and it is common on the north coast of New Guinea. Westward it seems to reach Zanzibar, but Simpson did not find it on the Portuguese East African coast. It probably reaches the Red Sea and certainly occurs at Ceylon. Eastward it reaches the Society Islands but apparently does not occur at the Hawaiian Islands. It has not yet been recorded from that group, which would hardly be true if so conspicuous a shore form were found there. In the Museum of Comparative Zoölogy collection are two supposedly Hawaiian specimens, one labeled "Sandwich Islands" and one labeled "Hilo," but in neither case is the label sufficiently well authenticated to make it reliable. There are indubitable specimens, however, from the Society, Caroline, Marshall, Gilbert, Fiji, Samoan, and Solomon Islands, and from Amboina, Halmaheira, Jappen Island (New Guinea), and from the New Hebrides.

At Mer *lævigata* is the most abundant and naturally the most conspicuous of the sea-stars. We gathered them literally by the peck for Harvey's use in studying the blue pigment. They are exceptionally inert creatures and never showed any inclination to move. Young specimens were decidedly rare and it seems probable that the early development, after metamorphosis, takes place near the edge of the reef in its inaccessible nooks and crannies. With age, the young seem to move shoreward, but remain in hiding under rock fragments until a third (or more) grown. They show great diversity of color. The following notes made at Erub and Mer bring this out clearly: "In young the blue is duller and deeper and is more or less lacking on oral surface." "No sharp contrasts of color; general impression dull gray, quite deep above, where it is blotched with brown; paler below; along ambulacral furrows, blue; anal region, green-yellow; feet, transparent whitish; papulæ transparent blue." "Dull green-blue above with a few large blotches of a darker color." "Colors as shown in Mr. Grosse's figure" (pl. 9, fig. 1). These specimens all had R less than 55 mm. Adults at Mer had R = 80–125 mm., but the species grows to a much larger size than that. The biggest one I have seen (from an unknown locality, unfortunately) has R = 200 mm. and br 25–30 mm.

Linckia multifora.

Asterias multifora Lamarck. 1816. Anim. s. Vert., *2*, p. 565.
Linckia leachii Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.
Linckia multiforas Gray. 1866. Syn. Starf., p. 14.
Linckia multiforis von Martens. 1866. Arch. f. Naturg., *32*, pt. 1, p. 65.
Linckia multifora Lütken. 1871. Vid. Med., p. 267.—DeLoriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 27, pl. ix, figs. 1–12.
Linckia costæ Russo. 1894. Boll. Soc. Nap., *7*, p. 163.

This is a species of which I have seen no living or fresh material, but de Loriol's figures are convincing proof that it is quite different from *lævigata*. Nevertheless, it is almost impossible to point out any character or group of characters by which a museum specimen of the usual indistinctive color can be distinguished from a small, slender-armed *lævigata* with 2 madreporites—and such examples of indubitable *lævigata* do occur. Owing to this difficulty of distinguishing the two species, there is no doubt the records of their occurrence are much confused, but *multifora* is not known to occur in the Torres Strait region nor on the Great Barrier reef. It appears to be particularly common at Mauritius and it is also fairly common at Samoa. It seems to reach southern Japan and the Gilbert Islands but there is no reliable record from the Hawaiian Islands. Nothing is known of its habits beyond the fact that it obviously reproduces autotomously when relatively young, and as a result symmetrical specimens are very scarce. The species does not grow to a large size, de Loriol's biggest specimen having R only 95 mm. The color is said to be vermilion red and dusky green, but the figure given is brown-orange and green. The general appearance indicates the species may be more associated with corals than is *lævigata*.

Linckia rosenbergi.

Von Martens. 1866. Arch. f. Naturg., *32*, pt. 1, p. 63.

Nothing is known of this species beyond the original description. The unique holotype was from Amboina and had R = 39 mm., = 5 r and = 5.5 br. It was very possibly an aberrant *Ophidiaster*.

Linckia columbiæ.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.—Fisher. 1911. Bull. 76 U. S. Nat. Mus., p. 242, pl. 48, figs. 1–7.

Examination of the specimens in the Museum of Comparative Zoölogy collection, from San Diego and Laguna Beach, California, and La Paz and San Francisquito Bay, Lower California, confirms Fisher's opinion as to the distinctness of this form. It is a small species (R less than 100 mm.), in life mottled with reddish brown and ash-color.

Like *guildingii* and *multifora,* it multiplies autotomously while young and hence the number of rays ranges from 4 to 9 and the number of madreporites from 1 to 5. Fisher's admirable account of the species should be consulted.

Linckia guildingii.

Linckia guildingii Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.—A. Agassiz. 1877. Mem. M. C. Z., *5*, p. 105, pl. xiv, figs. 1–6.
Linckia pacifica Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.
Ophidiaster ornithopus Müller and Troschel. 1842. Sys. Ast., p. 31.
Ophidiaster ehrenbergii Müller and Troschel. 1842. Sys. Ast., p. 31.
Linckia nicobarica Lütken. 1871. Vid. Med., p. 265.
Linckia ehrenbergii de Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 31, pl. x, figs. 1–7*a*.

This seems to be a truly tropicopolitan species of sea-star, absent only from the western coast of America. There are specimens in the Museum of Comparative Zoölogy from Bermuda, the Bahamas, Florida, Cuba, Jamaica, St. Kitts, Tobago, Brazil, Lower Guinea, Zanzibar, Queensland (Masthead Island), and Society Islands. It is also known from Vera Cruz, several West Indian stations besides those given, Cape Verde Islands, Mauritius, Madagascar, Mozambique, Red Sea, Ceylon, Andaman and Nicobar Islands, Samoa, and Tonga. Its occurrence in Hawaii is probable but remains to be definitely determined. The species grows to a very large size; the largest before me (from Bermuda) has R = 215 mm. There is much diversity in proportions, R = 8–12br. and 7–13r. There are commonly 2 madreporites but specimens with only one are not rare, especially in the Pacific. Reproduction by autotomy while still young is prevalent and hence symmetrical 5-rayed specimens are very uncommon and are usually of large size. I have tried in vain to find some ground by which *pacifica* or *ehrenbergii* could be distinguished from *guildingii,* but none of the supposed distinctive features have any constancy. In life, *guildingii* has quite a constant coloration. Young specimens, which live under rocks and in all sorts of crevices and crannies, are dull reddish, brownish, or purplish, usually variegated with darker shades. As they increase in size the color tends to become quite uniform and somewhat lighter. If, as apparently happens in the ordinary course of events, they abandon their concealed life and come out on the surface of the reef or reef-flat, they soon become uniformly yellow-brown. (See de Loriol's pl. x, fig. 1.) Specimens which retain their red or purple tints appear to have continued a more or less protected life. The suggestion here made that the change in color is associated with change in habits and habitat, lacks full demonstration but seems to be warranted as a hypothesis. Dry specimens are usually dull gray-brown or yellow-brown. At Papeete, Tahiti, in August 1913, I found on the surface of the reef in very shallow water a large *guildingii* of exactly the same shade of yellow-brown as a specimen which I found in Bermuda in April 1899. At Tobago, in April 1916, a specimen of the same color was found on sand in shallow water in Buccoo Bay. Such specimens undergo little color change either in alcohol or when dried.

Linckia diplax.

Ophidiaster diplax Müller and Troschel. 1842. Sys. Ast., p. 30.
Linckia diplax Lütken. 1871. Vid. Med., p. 269.

Were it not for the account of this species given by Simpson and Brown (1910, p. 55), I should have referred *diplax* to the synonymy of *guildingii,* but it is obvious, I think, that the sea-star of which they write is not identical with the common West Indian *Linckia.* Their description of the color is as follows, and it should be noted that no reference is made to any change in color during growth: "The two predominant general colors are brown and blue, with black dots. Many, however, are greenish-blue on the aboral surface and bear minute black dots which give the whole the appearance of a branching coral. The oral surface is purplish-red."

Since the species is said to be "apparently one of the commonest Asteroids on the coast" and the observations were based on "numerous specimens," it is evident that the coloration was a constant feature. Only further study of living material at Zanzibar or Mauritius will solve the problem of the true status of *diplax.* It has been recorded from many stations between Portuguese East Africa and Hawaii and the Paumotus inclusive, but how many of these references are to the sea-star collected by Simpson and Brown and how many refer to *guildingii* it is impossible to even guess. It is of course open to question whether the species of Simpson and Brown is really the *diplax* of Müller and Troschel, but there is no good reason why it may not bear the name for the present.

Linckia bouvieri.

Linckia bouvieri Perrier. 1875. Arch. Zool. Exp., *4*, p. 150.
Linckia nodosa Perrier. 1875. Arch. Zool. Exp., *4*, p. 153.—Verrill. 1915. Univ. Iowa, Bull. Lab. Nat. Hist., *7*, p. 93, pl. xiii, figs. 2, 2*a*; pl. xxix, figs. 1*a*, 1*b*.

It seems incredible that Perrier should have described two consecutive species which are indistinguishable, but I have sought in vain for any way by which *nodosa* is to be distinguished from *bouvieri.* The number of marginals will not do, because while the large specimen of *bouvieri* had 45 and the type of *nodosa* about 60, each having R = 91, a specimen in the Museum of Comparative Zoölogy with R = 91 mm. has about 53 marginals and hence might be either. This specimen is of further interest because it was in Perrier's hands when he described his two species and he first labeled it *bouvieri.* Subsequently he drew a line through the specific name and substituted *nodosa.*

This species is known from the vicinity of Florida and Cuba and from the Cape Verde Islands and Sao Thomé. The bathymetrical range is notable for a *Linckia,* 6 to 130 fathoms. Verrill's (1915, *op. cit.*, p. 96) statement that the *Blake* took *nodosa* "off Moro Light, in 250 to 400 fathoms; off Tortuga I., Antilles, in 6 fathoms" is based on a misreading of labels. The specimens concerned were taken by Pourtales in January 1869, near the Tortugas in 6 fathoms, not by the *Blake* at all. The label says "No. 100" and Verrill construed that as meaning Blake Station 100, which is "off Moro Castle, 250 to 400 fathoms." One of these specimens has R = 15 mm., the other has R = 22 mm. They are readily distinguished from *guildingii* of a similar size by the large tubercle-like granules on the distal marginal plates, as well as by the much bigger dorsal plates. The largest specimen recorded of this species has R = 125 mm. Nothing is known of the color in life of specimens from the West Indian region, but those from the eastern Atlantic are "violet" when "fresh."

Linckia tyloplax.

H. L. Clark. 1914. Rec. W. Aust. Mus., *1*, p. 147, pl. xx.

This remarkable linckiid differs so much from the other members of the present genus, it might well be made the type of a new one. But such action had better await further material. The most striking feature is the presence of well-marked actinal papulæ, but the numerous swollen abactinal plates of markedly darker color than the interspaces give a very characteristic appearance. The species is from deep water, 80 to 120 fathoms, off the western Australian coast and reaches a large size, the holotype having R = 150 mm. It would be of great interest to know the color in life.

PHATARIA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285. As a subgenus of Linckia.
Sladen. 1889. *Challenger* Ast., p. 398. As a genus.

Genotype: *Linckia unifascialis* Gray, 1840, *l. c.* Only two species are named in the subgenus and it is now generally agreed that they are synonymous.

Not only is this genus monotypic but its geographical range is very limited.

Phataria unifascialis.

Linckia (Phataria) unifascialis Gray. 1840. Ann. Hag. Nat. Hist., *6*, p. 285.
Linckia (Phataria) bifascialis Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 285.
Ophidiaster suturalis Müller and Troschel. 1842. Sys. Ast., p. 30.
Phataria unifascialis Sladen. 1889. *Challenger* Ast., p. 786.—H. L. Clark, 1910. Bull. M. C. Z., *52*, p. 335, pl. 5, fig. 1.

This is a characteristic species of the west coast of tropical America from Lower California to northern Peru. The records for Timor and Celebes are undoubtedly mistakes. The largest specimens have R = 125 mm.; R = about 9r. The color in life is probably red of some shade, but there is no published statement on this important point. Many specimens, not always the largest, have the bifasciate arrangement of the series of papular areas on the base of the rays, but this seems to be a matter of individual diversity and not correlated with age or locality. It may be well to state here that the supposed "Phataria" on which Miss Monks based her paper, "Variability and Autotomy of Phataria" (1904) is, as already pointed out by Fisher, *Linckia columbiæ.*

BUNASTER.

Döderlein. 1896. Jena Denks., *8*, p. 317.

Genotype: *Bunaster ritteri* Döderlein, 1896, *l. c.* Monotypic.

The curious little sea-stars composing this genus are as yet too rare to permit any discussion of their affinities to be either reliable or profitable. Only 3 specimens have been taken and each of these seems to represent a distinct species, one of them being described below for the first time. The 3 supposed species are distinguishable from each other as follows:

Key to the Species of Bunaster.

Abactinal plates on basal half of rays in 3 irregular series; actinolateral plates in 2 series proximally:
No pedicellariæ; "ball and socket" plates present; subambulacral spines not nearly twice as long as broad .... *ritteri*
Pedicellariæ present; no "ball and socket" plates; subambulacral spines about twice as long as broad *lithodes*
Abactinal plates in a single conspicuous series on each ray; only one series of actinolateral plates........ *uniserialis*

Bunaster ritteri.

Döderlein. 1896. Jena Denks., *8*, p. 317, pl. xxii, figs. 1–1*g*.

The only known specimen of this species was taken at Amboina by Semon. It is very small, R only 10 mm., but rather stout, the disk being 4 mm. high and the rays 2.6 mm. wide. The color is variegated red-brown, dusky brown, and milk-white.

Bunaster lithodes.

W. K. Fisher. 1917. Proc. Biol. Soc. Wash., *30*, p. 91.—1919. Bull. 100 U. S. Nat. Mus., p. 398; pl. 95, figs. 8–8*b*; pl. 124, fig. 4.

A relatively large species with R = 22 mm. The rays are short and stout. The papulæ are often in groups of 2 to 4 (usually 3), but they are well spaced and do not form well defined areas. The color is variegated brown and buff of several different shades. The only known specimen was taken on Apo Reef, Mindoro Strait, Philippine Islands, by Dr. L. E. Griffin, December 24, 1911, and is now in the Museum of Comparative Zoölogy.

Bunaster uniserialis [1] sp. nov.

(Plate 7, Figure 2; Plate 36, Figures 5–7.)

R = 11 mm.; r = 2.3 mm., br = 2.8 mm., R = 4.8r but only 4br. In the living specimen R = 12 mm., r and br, each 3 mm., hence R = 4r or br. Abactinal surface quite flat; vertical diameter of disk and arms at base, not quite 2 mm. Rays (in dry specimen) quadrangular in cross-section, the sides being vertical, very slightly tapering, until close to tip, blunt;

[1] *Uniserialis* = in a single series, in reference to the abactinal plates on the ray.

in the living specimen, the rays were more rounded on the sides. Abactinal surface of disk covered by 35 to 40 plates of which one at center is largest; this central plate is kidney-shaped with its long axis in the interradial line of the madreporite and at its concave side lies the anus, surrounded by 8 to 10 granules; 5 large interradial plates can be distinguished, the largest occupied almost wholly by the elliptical madreporite, whose surface is marked by only 7 radiating and more or less angular or curved furrows; the madreporite is half-way between center and margin of disk; 5 large radial plates, about as large as the interradial but more nearly circular, lie at the base of each ray and can not be distinguished by any obvious character from the plates which cover the abactinal surface of the rays. The remaining plates on the disk are much smaller and show no particular regularity of arrangement. All the disk plates are bare and more or less markedly convex; they are separated, or at least surrounded, by relatively coarse granules of various shapes and sizes. The abactinal surface of each ray is covered by the big superomarginal plates, 14 or 15 on each side and a single median series of 12 or 13 similar plates; none of these plates is circular or squarish, but otherwise they show much diversity of form; typically they are much longer than wide and the long axis lies obliquely to the long axis of the ray; all are bare and more or less strongly convex, especially distally; the median series is not always as perfectly regular as the marginals, a smaller plate occasionally being intercalated. At the base of the ray there are some half dozen very small plates intercalated between the median and marginal series, but they are so much smaller than the others that they might be easily overlooked.

It is unfortunate that the colored figure (pl. 7, fig. 2), which was made primarily to show colors in life, shows the upper ends of the inferomarginal series so that there seem to be 5 series of plates on the upper side of the ray. In the dry specimen the inferomarginals do not show from above. Granules of relatively considerable size occur between or around all the plates but they are not at all conspicuous or numerous; they are not often present between the plates of the median series, but between each two superomarginals is a series of 3 to 7, often elongated, sometimes more than twice as long as wide. The terminal plate of each ray is very large, swollen, hemispherical, twice as large as the largest marginal. Papulæ large and always isolated, about 20 on the disk and 25 on each ray; on the rays they form an imperfect series on each side, with a papula between the inner ends of nearly every 2 marginal plates; the openings are surrounded by about 3 granules or granules and a pedicellaria. Pedicellariæ fairly common, 4 or 5 on the disk and 7 to 10 on each ray; they are low, bivalved, much larger than one of the granules and conspicuous in the dry specimen because of their pure white color. One is rarely on an abactinal plate; as a rule they are between plates among the granules.

The inferomarginal series consists of 14 plates, the most proximal narrow and nearly vertical in position, so that it is 3 times as high as it is wide, but the plates gradually widen and take on a horizontal position so that the terminal one is twice as long as high; all are convex, but the last 3 to 5 tend to develop a tubercle near the center. At the base of the ray between the two marginal series are about 4 well-developed intermarginal plates; on the sides of the ray between the 2 marginal series are granules, 7 to 11 papulæ and 3 to 6 pedicellariæ. Inferomarginal plates separated (?) from each other by imperfect series of minute granules. Actinolateral plates about 13, in a conspicuous single series, which, at least proximally, correspond to the inferomarginals; distally the actinolaterals decrease greatly in size and the series does not quite reach the tip of the ray; there is a small interradial plate back of the orals, from either side of which an actinolateral series starts. All these plates are separated (superficially, of course) from each other, and from the inferomarginals, adambulacrals, and orals by granules, and here and there is a pedicellaria. A series of about 10 papulæ runs along each side of the ray, one between the lower or inner ends of every 2 inferomarginals until about the eleventh. Adambulacral plates about 28, approximating 2 to each inferomarginal, and basally to each actinolateral; the armature is very simple, consisting of a furrow series of two subequal, flattened spinelets with rounded, slightly widened tips, standing closely side by side, and a conspicuous, oval, flattened, subambulacral spine; this spine is half as wide again as the tip of one of the furrow spinelets, its length (0.40 to 0.50 mm.) a little exceeds its width, and its free end (the narrow end of the oval) is distinctly pointed; this subambulacral spine is on the adoral side of the plate, the aboral side being occupied by 2 to 4 coarse granules. Oral plates small, their armature just what would be expected from the fusion of 2 adjoining adambulacrals, but the suboral spines are much reduced in size and have rounded tips, while the innermost spines are a trifle longer and heavier. Tube-feet few, in 2 well-spaced series.

Color in life, prettily variegated with maroon, brown, and bluish-white; the figure (pl. 7, fig. 2) gives a better idea of it than can any description. The dried specimen is brown of several shades, with two noticeable but indefinite cross-bands of buffy-white on the rays, one near base and one near tip; the lower surface, especially the subambulacral spines, is lighter than the upper; as already said, the pedicellariæ, both above and below, are conspicuous for their pure white color, but they are not at all numerous.

Holotype, M. C. Z., No. 2313; southwestern reef, Mer, Murray Islands, Torres Strait, October 18, 1913.

This dainty little sea-star was found among the crannies of some coral in water 5 or 6 feet deep. No other specimen was found. The species differs obviously from *lithodes* in the much sparser granulation, the more slender rays, the single series of actinolateral plates, the single series of conspicuous abactinal plates on each ray, the large isolated papulæ, and the very different subambulacral spines. It is nearer to *ritteri*, but is at once distinguished by the narrower rays and correlated simple arrangement of plates, by the presence of pedicellariæ and the absence of the remarkable "ball and socket" plates.

CISTINA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

Genotype: *Cistina columbiæ* Gray, 1840, *l. c.* Monotypic.

This remarkable genus may not belong in the Ophidiasteridæ at all, as there is nothing in Gray's diagnosis which makes its position certain, but apparently it is a member of this family, differing from all its relatives in the possession of a central, mobile spine on each skeletal plate. No sea-star has been discovered in recent years which belongs in such a genus, and the following is therefore still the only known species.

Cistina columbiæ.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

There is no indication of the size of the two specimens upon which Gray based this species but the rays are said to be more than 8r and provided with 7 series of spines; the color is given as yellow; the larger specimen had 2 distinct madreporites but only one was found on the smaller. The locality is given as the west coast of Colombia, where H. Cuming collected them. The types are no longer in the British Museum and their fate is unknown. It is greatly to be hoped that the shores of northwestern South America may soon be thoroughly explored by a competent marine zoölogist, so that some of Gray's remarkable species from that area may be rediscovered.

LEIASTER.

Peters. 1852. Monatsb. d. k. Preuss. Akad. Wiss. Berlin, p. 177.

Genotype: *Leiaster coriaceus* Peters, 1852, *l.c.* Type designated by Fisher, 1919.

Although Peters proposes *Leiaster* as a subgenus (presumably of *Ophidiaster* but not so stated) he uses the name in combination in full generic sense. The group is well circumscribed and made up of a few species, characteristic of the Indo-Pacific region, but apparently extending to the west coast of tropical America. These species are easily recognized in life by the slimy skin which covers the body; in dried material this becomes so thin and tightly drawn that the outlines of the skeletal plates show more or less distinctly. Save for this skin and the accompanying lack of granules and tubercles, the genus is very close to *Ophidiaster*. The species are distinguished from each other by the character of the adambulacral armature, by the relative proportions of the disk and rays, and by the color. The last seems to be a fairly constant and useful character, since dried specimens retain quite well the general tint of life.

I doubt if the presence or absence of pedicellariæ can be relied on without a good deal of care. The type of *speciosus* had the skin "richly beset" with pedicellariæ, while the Museum of Comparative Zoölogy specimen from the Philippines has only about 30 and my large one from Mer has none at all, or possibly the remains of one or two. Perhaps the development of the skin may offset the number of pedicellariæ, increased thickening of the skin tending to eliminate these little organs.

One of Peter's original species, *coriaceus*, has been fully described and figured by de Loriol in his invaluable work on the sea-stars of Mauritius, and the same monograph reveals equally well the distinguishing characters of Gray's species, *leachii*, from which I am unable to distinguish Peter's second species, *glaber*. The species described by von Martens in 1866, *speciosus*, is a very well-marked one, and the same is true of Fisher's *callipeplus* described in 1906. Verrill's *Lepidaster teres* does not seem to have been met with since its original description, but the name *Lepidaster* was preoccupied and in any case seems to be synonymous with *Leiaster;* the species *teres* seems valid beyond doubt. Fisher's recently described species *analogus* completes the list of known species in the genus. A specimen in the Museum of Comparative Zoölogy collection from the Hawaiian Islands represents an undescribed species.

Key to the Species of Leiaster.

Furrow spines of adambulacral armature 3 or 4 to a plate, with a more or less conspicuous longitudinal groove on the inner face.
- R about 6 br; no pedicellariæ; abactinal papulæ not in well-defined areas........................ *coriaceus*
- R about 8–9 br; pedicellariæ numerous; abactinal papulæ in definitely circumscribed areas........ *analogus*

Furrow spines not grooved on inner surface, or in very large specimens, slightly so on basal half.
- Furrow spines 3 to a plate; no pedicellariæ.
  - Rays slender, tapering; middle furrow spine usually longest; skin soft and thin; color in life unknown.. *teres*
  - Rays short, stout, not tapering; furrow spines equal; skin thick, tough, smooth; color in life deep maroon-purple; tube-feet deep yellow............................ *callipeplus*
- Furrow spines 2 to a plate, rarely 3 on individual plates.
  - Furrow spines long and slender, the length twice the width of a pair or more; color in life, or dry, red, more or less bright crimson, in very large specimens sometimes nearly black, when dry.
    - R about 10–11 br; usually no pedicellariæ.................................... *leachii*
    - R about 7–8 br; pedicellariæ present.. *speciosus*
  - Furrow spines short and wide, the length about equal to width of a pair, or a little more; color (dry) dull purplish-gray (probably purple in life)........................ *brevispinus*

Leiaster coriaceus.

Peters. 1852. Monatsb. d. k. Preuss. Akad. Wiss. Berlin, p. 177.—De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 37; pl. xiii, figs. 2–3*d*.

The excellent account of this species given by de Loriol makes it possible to recognize it easily. It is known only from Kwerimba Island, Mozambique; Zanzibar; Wasin, B. E. A., and Mauritius. It reaches a large size, R = 150 mm., and when adult is covered by a notably thick, coriaceous skin. The color in life is not known, but in dry specimens is deep purplish or greenish brown, more or less dull orange on the lower side according to de Loriol.

Leiaster analogus.

W. K. Fisher. 1913. Proc. U. S. Nat. Mus., *46*, p. 215.—1919. Bull. 100 U. S. Nat. Mus., p. 396, pl. 84, fig. 1; pl. 95, fig. 7; pl. 112, fig. 1.

The *Albatross* took this sea-star in the Sulu Archipelago, in 9 fathoms on a coral bottom. Nothing is said of the color, but the size is indicated by R = 125 mm.

Leiaster teres.

Lepidaster teres Verrill. 1871. Trans. Conn. Acad., *1*, p. 578.
Leiaster teres Sladen. 1889. *Challenger* Ast., p. 408.

This species has never been figured and indeed does not seem to have been met with since the original description was published. It is the smallest species known (R = 47 mm.). Nothing is said of the color in life but the dry specimen was pale yellow; that may have been, however, after immersion in alcohol or some other preservative. The type was taken at La Paz, Lower California.

Both in the generic diagnosis of *Lepidaster* and in the description of the species, the statement in regard to the papulæ is so ambiguous that it is impossible to feel sure whether those organs are isolated or grouped. Of course if they are isolated, *teres* is unique among Leiasters and probably represents a new genus.

Leiaster callipeplus.

W. K. Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1083; pl. xxx, figs. 1, 1*a*; pl. xxxi, fig. 3.

At four different stations in the Hawaiian Islands, the *Albatross* met with this interesting *Leiaster*, in 32 to 68 fathoms. Although R is only a little greater (52 mm.) than in *teres*, the animal is considerably larger and heavier, owing to the stout, blunt rays. In life the striking color is a good character which might perhaps be retained by dry specimens but is wholly lost in alcohol.

Leiaster leachii.

Ophidiaster leachii Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284.
Leiaster glaber Peters. 1852. Monatsb. d. k. Preuss. Akad. Wiss. Berlin, p. 177.
Leiaster leachii de Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 40; pl. xiv, figs. 1–2c.

Although de Loriol earnestly discusses the differences between *leachii* and *coriaceus*, he makes no reference whatever to *glaber*, which is odd because he was not ignorant of the characters of that species, as he refers to it at the top of p. 40 (*op. cit.*). And yet I am unable to find any reason for doubting that Peter's single small specimen, on which the species *glaber* is based, was a young example of *leachii*. Of course, Peters is not to blame at all, for Gray's account of *Ophidiaster leachii* is characteristically insignificant and it is only since de Loriol's admirable account was published that the species can be said to be known. Originally described from Mauritius, *leachii* is now known also from Amirante, the Seychelles and Cœtivy Reef. Off Amirante, it was taken at a depth of 25 to 80 fathoms. Peters's type of *glaber* was from Kwerimba Island, Mozambique. Bell records, with a question mark, a young specimen of *leachii* from Macclesfield Bank; it certainly seems improbable that the species occurs so far to the east. Sluiter (1895) records a specimen in the Amsterdam Museum from the Moluccas, but I believe this will prove to be *speciosus*. Large specimens from Mauritius have R = 150 mm. or more but in such the diameter of the arm is only from 12 mm. up. In any case the rays seem to be more slender than in *coriaceus*. The color, in life or dry, is usually deep red, but I am referring to *leachii* a huge *Leiaster* from Mauritius, belonging to the South African Museum, Cape Town, which is not at all red. This specimen has R = 255 mm., while the diameter of the ray was probably about 20 to 22 mm.; it is now dry and quite flat. A few small pedicellariæ are scattered on the actinal surface of the rays. There are occasionally 3 furrow spines to an adambulacral plate, and these spines are frequently furrowed longitudinally near base, as in *coriaceus*.

To cap the climax the color is very dark, almost black, and not at all red. This specimen may perhaps be senescent, but it certainly does not answer well to the account of any known *Leiaster*, though it seems nearest to *leachii*.

Leiaster speciosus.

Von Martens. 1866. Arch. f. Naturg., *32*, pt. 1, p. 70.

(Plate 11, and Plate 27, Figures 1 and 2.)

The type of this sea-star was taken at Larentuka, Flores, Dutch East Indies, and is said to have had an "arm radius" of 255 mm. If this is not a typographical error, *speciosus* is not only one of the largest Leiasters but one of the largest linckiids known. The fine specimen taken at Mer had R = 150 mm., and its gorgeous color is perfectly shown on plate 11. The color is well preserved in the dry specimen. Sladen says nothing of the size or color of the specimen he reports from Kandavu, Fiji (1889, p. 408).

There is a specimen in the Museum of Comparative Zoölogy from Port Galera, Mindoro, Philippine Islands, which has R = 115 mm. It shows the same brilliant color as the Torres Strait specimen. The only other record of the species I have found is Bell's, of a young one from Macclesfield Bank. The specimen of *Leiaster* in the Amsterdam Museum, from the Moluccas, recorded by Sluiter (1895) as *leachii*, is probably *speciosus*.

There is no doubt that the species is nearly allied to *leachii* but in all the specimens as yet taken the rays are much stouter and pedicellariæ are present. The latter character needs further demonstration, for prolonged search on the specimen from Mer reveals at most only one or two rudimentary pits which may be the last remains of pedicellariæ. As the Philippine specimen has about 30 pedicellariæ, it occurred to me, as suggested above, that the pedicellariæ are lost with increased size and the development of the thick, slimy skin. This is obviously not the case if von Martens' measurement of his type is correct as printed; if the diameter is meant (which would give R = 120 mm. ±) it might be true. Sladen's specimen from Fiji is said to have pedicellariæ present but "not nearly so numerous" as in the type. No doubt there is much individual diversity in the matter. Possibly larger series of specimens will demonstrate that *speciosus* is an eastern subspecies of *leachii*, or even that the supposed differences are matters of individual diversity only, but for the present the two forms may well be kept separate.

The only specimen of this brilliant sea-star which we found at Mer, and the only *Leiaster* yet known from the Torres Strait region, was found among the corals near the outer edge of the western end of the southwestern reef at extreme low tide on September 29, 1913. It was very smooth and slimy to the touch and responded to handling by a prompt autotomy of two of its rays. It was subsequently narcotized with magnesium sulphate and preserved without further damage. Prolonged search during the following four weeks failed to reveal another specimen, but it must be admitted we did not again during our stay have so low a tide as on that notable day.

Leiaster brevispinus [1] sp. nov.

(Plate 30.)

R = 130 mm.; r = 11 mm.; br = 13 mm. R = 12r or 10br. Rays long and cylindrical, moderately slender and not tapering appreciably until near tip. Disk small and rather flat in the dry specimen. Abactinal skeleton, as usual in *Leiaster*, made up of 3 longitudinal series of plates besides the 2 series of marginals on each side; all are finely granulated at center but it is probable (one might almost say certain) that in fresh or alcoholic material this granulation would be entirely concealed beneath the skin. Madreporite, as usual in

[1] *Brevis* = short + *spinus* = a spine, in reference to the short furrow spines.

the genus, large (4 mm. in diameter), elevated a trifle, slightly concave, with very numerous furrows. Terminal plate small (2 mm. in diameter), swollen, and smooth. Papular areas quite distinct, each with about 20 papulæ; distally, of course, the areas are steadily smaller with fewer papulæ.

Actinal skeleton as usual, of an adambulacral series, an actinolateral series of small plates corresponding in number to the adambulacrals, and a second series of only half as many "transverse ossicles," as Fisher calls them; these correspond in number to the inferomarginal plates and connect each pair of actinolaterals with an inferomarginal; the exact position of the transverse ossicle with reference to the pair of actinolaterals varies much; it may touch both members of the pair or only the distal or more rarely only the proximal. Papular areas are well developed between the transverse ossicles. Pedicellariæ of the usual entrenched type occur on the actinolateral plates at the base of the rays but they are very few, only 1 to 3 on each ray. Adambulacral armature made up of the usual furrow series and subambulacral spines; the furrow series forms a very even row set in a fold of skin, with not even their tips really free; there are 2 spinelets on each plate, the bases close together, the slightly narrower tips a trifle separated; each pair is a little separated from its neighbors; the spinelets are rather flat with rounded tips; each is a millimeter long, but the pair is hardly a millimeter wide; there is no trace of a furrow on the inner face. Subambulacral spines about 2 mm. long but becoming much shorter, smaller, and more tubercle-like distally; near mouth, these spines are about 0.60 mm. wide, but near middle of arm they are fully 1.20 mm.; the tip is truncate and flattened but hardly chisel-shaped. Each of the first 20 (more or fewer) adambulacral plates has a subambulacral spine, but after that there is one on every third or fourth only; the proximal spines are united by a fold of skin which is continuous across the interradius so that the series of spines on the right-hand side of each ray is united with the left-hand series of the adjoining ray. The 2 innermost spines, at the apex of the V-shaped group are longest and are presumably the suboral spines of that mouth angle. Each mouth plate also carries 4 marginal spines, not distinguishable from the furrow spines of the adambulacral plates save that they may be a trifle longer.

Color in life unknown but probably purple, as the dried specimen (which was once in alcohol, as shown by the original label) is a very distinct though dull purplish-gray; the madreporite is pale brown.

Holotype, M. C. Z. 765; Hawaiian Islands; A. Garrett, 1860.

The catalogue entry of this specimen in 1860 says "dried from alcohol" and the original label reads "*Ophidiaster* 6th genus. Species c. Sandwich Islands." There is no doubt whatever that it is a *Leiaster*, but it is equally obvious that it is not nearly related to *callipeplus*, the other Hawaiian species, for that form has 3 furrow spines and short stout rays. The color, too, must be fundamentally different, for Fisher particularly states that the purple of *callipeplus* is "all" lost in alcohol and "the specimen becomes a dirty faded yellow"; moreover, *callipeplus* was taken only at depths over 30 fathoms, while it is reasonably certain that *brevispinus* was found on a reef in shallow water. Although similar to *leachii* in form and to *speciosus* in pedicellariæ, this new Hawaiian species differs obviously from both, in its color and in its short, wide furrow spines.

PHARIA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284. As a subgenus of *Ophidiaster*.
Sladen. 1889. *Challenger* Ast., p. 398. As a genus.

Genotype: *Ophidiaster pyramidatus* Gray, 1840, *l.c.* Monotypic.

Like *Phataria*, this is a characteristic genus of the Panamic region, containing but a single species.

Pharia pyramidata.

Ophidiaster (*Pharia*) *pyramidatus* Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284.
Ophidiaster porosissimus Lütken. 1859. Vid. Med., p. 33, 87.
Pharia pyramidata Sladen. 1889. *Challenger* Ast., p. 784.—H. L. Clark. 1910. Bull. M. C. Z., *52*, p. 335, pl. 5, fig. 2.

This large and easily recognized sea-star ranges along the western coast of America from the Gulf of California to Zorritos, Peru. It has been recorded from Valparaiso, but it is highly improbable that it occurs naturally so far south. Large specimens have R = 150–160 mm. Preserved specimens are dull purplish or reddish brown, but there is some doubt about the color in life. In 1868 Verrill said the color is "in life variegated above with purple and brown," but in 1871 he said: "The dry specimens in best condition are light straw-color beneath; the poriferous zones are bright orange; the rows of large plates on the back and sides olive-green; madreporic plate large, dark olive-green." Such a coloration seems quite impossible for a sea-star which was only "variegated purple and brown" when alive, but indicates what the real color in life may be.

OPHIDIASTER.

Agassiz. 1835. Mem. Soc. Sci. Nat. Neûchatel, *1*, p. 191.

Genotype: *Asterias ophidiana* Lamarck, 1816. Anim. s. Vert., *2*, p. 567. Monotypic.

More species have been referred to this genus than to any other in the family, not even excepting *Linckia*, but most of them belong elsewhere or are purely nominal forms. Agassiz's diagnosis shows that there was no clear distinction in his mind between *Ophidiaster* and *Linckia*, but Gray in 1840 distinguished them perfectly. Indeed, he showed an extraordinary grasp of the essential differences between the various sea-stars now placed in the Ophidiasteridæ, grouping them in 14 consecutive genera and subgenera. While it need not be maintained that these 14 groups are of equal merit, they seem to be remarkably natural and, as already said (p. 36), it has seemed to me desirable to restore them to use. Even in dealing with the perplexing genera *Linckia* and *Ophidiaster*, Gray shows no confusion, for every one of his 7 species of *Linckia* s.s. is a true *Linckia* and his 3 *Ophidiaster* s.s. are true Ophidiasters except *leachii*, which is a *Leiaster*, a genus not easily distinguished from *Ophidiaster* when the specimens are dry.

This remarkable taxonomic achievement of the English zoölogist stands out even more strikingly when contrasted with the attempt of Müller and Troschel (1842) to group the members of the family. They recognized but two genera, *Ophidiaster* and *Scytaster*, abandoning *Linckia* altogether. In 1866 von Martens went to the other extreme, abandoning *Ophidiaster* altogether and using *Linckia* in a very broad sense. In 1871 Lütken clearly recognized the distinctness of *Linckia*, *Ophidiaster*, *Scytaster*, and *Leiaster*. His only slip was in including *Mithrodia* in the same family, but Müller and Troschel had actually not distinguished *Mithrodia* from *Ophidiaster*, although Gray had placed it in an entirely separate section of his system. Perrier in 1869 was a follower of Müller and Torschel's simple plan, but in 1875 he accepted Lütken's results and used *Ophidiaster* in a definite way. He failed, however, to appreciate Gray's work and hence his *Ophidiaster* is still a rather heterogeneous group. Sladen, in the *Challenger* Report (1889), followed Perrier in his use of *Ophidiaster*, but Ludwig in 1897 pointed out that *Hacelia* Gray was quite distinct from typical *Ophidiaster* and should be given generic rank. This view was concurred in by Fisher, 1911.

The following list shows the species which have been assigned to *Ophidiaster*, or at least the specific names which have been published in conjunction with that generic term, and the conclusions I have reached regarding their true position. Obviously, many of these conclusions were reached by other writers years ago.

List and present status of Sea-stars which have been referred to Ophidiaster.

[The names in black-face type are those of valid members of the genus.]

æqualis (Stimpson) Dujardin and Hupé, 1862 = *Mediaster æqualis.*
agassizii Perrier, 1881, is valid.
alexandri Verrill, 1915, is valid.
arenatus (Lamarck) Dujardin and Hupé, 1862, is not identifiable.
armatus Koehler, 1910, is valid.
asperulus Lütken, 1871 = *Dactylosaster cylindricus.*
attenuatus Gray, 1840 = *Hacelia attenuata.*
attenuatus Perrier, 1869, is quite unknown, having been abandoned by its founder without a word of explanation. It is possibly a Nardoa.
aurantius Gray, 1840 = *O. ophidianus.*
bicolor (Lamarck) Dujardin and Hupé, 1862, is not identifiable.
campbelli Filhol, 1885, is a *nomen nudum;* probably a Stichaster.
canariensis Greef, 1872 = *O. ophidianus.*
chinensis Perrier, 1875, is probably valid.
clathrata Grube, 1864 = *Linckia lævigata.*
colombiæ Dujardin and Hupé, 1862 = *Linckia columbiæ.*
columbiæ Müller and Troschel, 1842, p. 33 = *Linckia columbiæ.*
columbiæ Müller and Troschel, 1842, p. 34 = *Cistina columbiæ.*
confertus H. L. Clark, 1916, is valid.
coriaceus (Grube) Müller and Troschel, 1842 = *Hacelia attenuata.*
crassus (Gray) Dujardin and Hupé, 1862 = *Linckia lævigata.*
cribrarius Lütken, 1871, is valid.
cylindricus (Lamarck) Müller and Troschel, 1842 = *Dactylosaster cylindricus.*
diplax Müller and Troschel, 1842 = *Linckia diplax.*
duncani de Loriol, 1885, is valid.
echinulatus Müller and Troschel, 1842 = *Mithrodia clavigera.*
ehrenbergii Müller and Troschel, 1842 = *Linckia guildingii.*
flaccidus Lütken, 1859 = *Linckia guildingii.*
floridæ Perrier, 1881 = *Tamaria floridæ.*
fusca (Gray) Müller and Troschel, 1842 = *Tamaria fusca.*
germani Perrier, 1875 = *O. cribrarius.*
gracilis (Gray) Müller and Troschel, 1842 = *Dactylosaster gracilis.*
granifer Lütken, 1871, is valid.
guildingii Gray, 1840, is valid.
guildingii (Gray) Müller and Troschel, 1842 = *Linckia guildingii.*
helicostichus Sladen, 1889 = *Hacelia helicosticha.*
hemprichii Müller and Troschel, 1842 = *Dactylosaster cylindricus.*
hirsutus Koehler, 1910*a* = *Tamaria fusca*
irregularis Perrier, 1869, is a *Linckia* but, as it was abandoned in 1875 without a word of explanation, its identity is uncertain.
kermadecensis Benham, 1911, is valid.
lævigatus (L.) Müller and Troschel, 1840 = *Linckia lævigata.*
leachii Gray, 1840 = *Leiaster leachii.*
lessonæ Gasco, 1876 = *Hacelia attenuata.*
linearis Perrier, 1869 = *Metrodira subulata.*
lorioli Fisher, 1906, is valid.
ludwigi de Loriol, 1900, is valid.
marmoratus Michelin, 1844 = *Tamaria marmorata.*
miliaris Müller and Troschel, 1840 = *Linckia lævigata.*
multiforis Müller and Troschel, 1842 = *Linckia multifora.*
ophidianus (Lamarck) Agassiz, 1835, is valid.
ornatus Koehler, 1910 = *Tamaria fusca.*
ornithopus Müller and Troschel, 1842 = *Linckia guildingii.*
perrieri de Loriol, 1885, is valid.
porosissimus Lütken, 1859 = *Pharia pyramidata.*
purpureus Perrier, 1869 = *O. pustulatus.*
pusillus Müller and Troschel, 1844 = *Tamaria pusilla.*
pustulatus von Martens, 1866, is valid.
pyramidatus Gray, 1840 = *Pharia pyramidata.*
rhabdotus Fisher, 1906, is valid.
robillardi de Loriol, 1885, is valid.
sclerodermus Fisher, 1906 = *Tamaria scleroderma.*
squameus Fisher, 1906, is valid.
suturalis Müller and Troschel, 1842 = *Phataria unifascialis.*
tenellus Fisher, 1906 = *Tamaria tenella.*
triseriatus Fisher, 1906 = *Tamaria triseriata.*

List and present status of Sea-stars which have been referred to Ophidiaster—continued.

tuberculatus Müller and Troschel, 1842 = *Nardoa tuberculata.*
tuberifer Sladen, 1889 = *Tamaria tuberifera.*
tumescens Koehler, 1910 = *Tamaria tumescens.*
trychnus Fisher, 1913 = *O. granifer.*
vestitus Perrier, 1869, is an Echinaster.

In addition to the 18 valid Ophidiasters listed above, a nineteenth species (*lioderma*) is included in the following key and is fully described and figured on page 80.

Key to the Species of Ophidiaster.

A. No granules occur between furrow spinelets on inner surface of furrow; madreporite single.
  B. No spinelets or conspicuous spiniform granules on marginal or abactinal plates of distal part of ray.
    C. No pedicellariæ present.
      D. R = 6–10 br.
        E. Rays cylindrical; no isolated papulæ between actinolateral plates.
          F. Adambulacral spines very stout, furrow pair markedly thickened at tip, and subambulacral often nearly as thick as long .... *ophidianus*
          FF. Adambulacral spines much flatter, furrow pair thinner and often somewhat spatulate, subambulacral much longer than thick .... *guildingii*
        EE. Rays flattened ventrally, with isolated papulæ between actinolateral plates..... *perrieri*
      DD. R = 5–5.4 br. .... *chinensis*
    CC. Pedicellariæ present.
      D. Adambulacral plates usually with a small supplementary spinelet at base of subambulacral spine, between it and furrow spinelets; R = about 5.5r.......... *alexandri*
      DD. Adambulacral plates with no such supplementary spinelet.
        E. R = 7–9.5 r or br; alveolæ of pedicellariæ curved.
          F. Rays rather slender, conspicuously fluted; granules at base of subambulacral spines and between them and furrow spinelets, few, coarse, and scattered... *rhabdotus*
          FF. Rays stouter, not fluted; granules on actinolateral and ambulacral plates very numerous, small, and crowded, sheathing bases of spines.
            G. Alveolæ of pedicellariæ form a semicircle.......... *duncani*
            GG. Alveolæ of pedicellariæ only moderately curved.......... *lioderma*
        EE. R about 4.5 r or br; alveolæ straight .... *ludwigi*
  BB. Marginal and often many abactinal plates on distal part of ray with conspicuous spinelets or spiniform granules.
    C. Rays stout; R about 4–4.5 br; distal spinelets moderate; actinal papular areas well developed; pedicellariæ usually present.......... *granifer*
    CC. Rays more slender; R = 5–7 br; distal spinelets well marked; actinal papular areas only on basal part of ray and even wanting in some young individuals; pedicellariæ wanting.......... *armatus*

AA. One or more granules present between furrow spinelets on inner surface of furrow.
  B. Madreporite single.
    C. Papular pores numerous (10 to 20 in each area); pedicellariæ very numerous on poriferous areas, which are conspicuous.
      D. Pedicellariæ with elliptical alveolæ, whose ends have several notches to correspond with wide, serrate (3 or 4 teeth) blades of pedicellariæ.......... *confertus*
      DD. Pedicellariæ with boat-shaped alveolæ, whose pointed ends sometimes have a single median notch to correspond with narrow blade of pedicellaria, which ends in a single long, slender tooth (with or without a little tooth at the base on one or both sides) or in a pair of such teeth.
        E. Papular areas wider (or higher) than long, distinct but crowded; little or not at all sunken; abactinal plates, numerous, rather small, little elevated........ *agassizii*
        EE. Papular areas somewhat diamond-shaped, about as wide as long, decidedly sunken; abactinal plates larger and decidedly elevated at center........... *kermadecensis*
    CC. Papular pores few (3 to 8 in each area); few or no pedicellariæ; poriferous areas not conspicuous.
      D. Ray, measured alongside, about 7 times its basal width; principal color purple.... *pustulatus*
      DD. Ray, measured alongside, only about 5 times its basal width; principal color bright red *squameus*
  BB. Madreporites 2.
    C. Pedicellariæ narrow; 2 (1 to 3) teeth at ends of alveolæ; subambulacral spine very short, wide, and blunt, scarcely projecting even at tip.......... *cribrarius*
    CC. Pedicellariæ wide; 5 (4 to 6) teeth at ends of alveolæ; subambulacral spines a little longer, more pointed and more free.
      D. Rays flattened orally, tapering; granules at center of abactinal plates not much enlarged, little larger than adjoining papular pores.......... *robillardi*
      DD. Rays cylindrical, blunt, scarcely tapering; granules at center of abactinal plates much enlarged, several times as large as largest adjoining papular pores.... *lorioli*

Ophidiaster ophidianus.

Asterias ophidiana Lamarck. 1816. Anim. s. Vert., *2*, p. 567.
Ophidiaster ophidianus Agassiz. 1835. Mem. Soc. Sci. Nat. Neûchatel, *1*, p. 191.—Ludwig. 1897. Seesterne des Mittelmeeres, p. 300; pl. 3, figs. 4, 5; pl. 8, figs. 18–30.

Ludwig's (*l.c.*) full account of this species is most satisfactory. It is the largest species of the genus, with R = 140–150 mm. or even more (as much as 265 mm. is recorded but this is perhaps an estimate) and has a brilliant coloration. The normal color is some shade of bright red or orange without spots or blotches. The geographical range is not extensive, including only the western Mediterranean and the Azores, Madeira, and Canary Islands. The bathymetrical range is small, for there is only one record and that a dubious one (near the Azores, 823 m., a very small individual in the *Challenger* collection) at a depth over 105 m. The typical habitat is just below low-water mark and down to about 30 m. among and under stones and rocks. Greef (1882) records *ophidianus* from Sao Thomé and Rolas in the Gulf of Guinea, but as his specimens had the dorsal side variegated red or reddish-yellow with indistinct dusky bluish patches, it is more probable that they belong to the following species (*guildingii*). Unfortunately he says nothing as to their size.

Ophidiaster guildingii.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284.

Although it has never yet been figured or even fully described, this is the common West Indian species of the genus and ranges from the Tortugas, Florida, to Tobago. It occurs on the under side of rocks and coral fragments near low-water mark. Verrill (1915) says that "a medium-sized specimen" has R = 60 mm. and r = 5 mm. The largest specimen I have seen, among some 50 I have collected at the Tortugas, Jamaica, and Tobago, has R = 56 mm. and r = 7 mm. This proportion (R = 8r) is typical of all the individuals I have found. Color in life is very variable. Young specimens (R = 6 mm.) have no pigment, but by the time R = 12 mm. they are considerably blotched with color. In mature specimens the ground-color ranges from pale yellowish through orange and scarlet to brownish-red, but this is more or less blotched with bluish, purple, maroon, or brown; some specimens show an almost uniform color, but this is unusual. Many specimens are almost identical in color with young *Linckia guildingii*, which occur in the same habitat. Mortensen found this *Ophidiaster* was breeding at Tobago in April 1916, and he succeeded in securing some early developmental stages.

Undoubtedly *O. guildingii* is very nearly allied to *O. ophidianus*, but when specimens of the same size are compared side by side it is obvious that *guildingii* has more slender rays, coarser granulation, and larger and fewer papulæ, besides the perfectly evident differences in the adambulacral armature, pointed out above. Apparently the West Indian species is much smaller than that of the Mediterranean, and its mottled coloration is also a distinguishing character. If the *Ophidiaster* which Greef (1882) found common at Sao Thomé and Rolas in the Gulf of Guinea proves to be this species, is will probably be found also at the Cape Verde Islands, a distribution corresponding to that of *Linckia bouvieri*, *Eucidaris tribuloides*, and several other echinoderms.

Ophidiaster perrieri.

De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 17, pl. vii, figs. 3–3*j*.

This species is known only from Mauritius, whence Robillard sent de Loriol a single specimen. The description and figure given are entirely satisfactory, as is so generally true of de Loriol's careful work. The species is notable for the isolated papulæ on the actinal surface, the presence of which indicates a trend towards *Hacelia*.

Ophidiaster chinensis.

Perrier. 1875. Rev. de Stell., Arch. Zool. Exp., *4*, p. 123 (or 387).

Nothing is known of this species beyond Perrier's brief description of two specimens from Canton. It is hard to see from that how it is essentially different from either *ophidianus* or *guildingii*. If there are really of the subambulacral spines, "deux pour trois piquante internes," as Perrier says, we have a remarkable arrangement not known in any other *Ophidiaster*, viz.: every other adambulacral plate carries 2 equal, large subambulacral spines. The types of *chinensis* were small with R = 48 mm. The species has not been figured.

Ophidiaster alexandri.

Verrill. 1915. Bull. Lab. Nat. Hist., Univ. Iowa, *7*, p. 91, pl. xiii, figs. 3–3*b*; pl. xxv, fig. 2.

Thanks to the kindness of Dr. Paul Bartsch, I have had the opportunity of examining two of Verrill's original specimens from the collection of the U. S. National Museum. In one R = 23 mm.; the other is much larger, as R = 41 mm. In both, pedicellariæ are numerous on the actinal surface, a point which Verrill does not mention. The form of the rays reminds one of *Hacelia* and it might be thought that the sea-star described beyond as *Hacelia superba* (p. 87) is only the adult of this species. Aside from any question of generic difference, the adambulacral armature of the present species is perfectly distinctive. Verrill says of the subambulacral spines that they are "tapered," and of the supplementary spinelets that they are acute. In the specimens before me the subambulacral spines are wide, flattened, and blunt at tip, in no respect tapered, and the supplementary spinelets are short, thick, and blunt, not at all acute. The species is therefore evidently variable in these particulars. It is known as yet only from off Georgia and Florida, in 200 to 276 fathoms. Of all members of the family it thus lives at the greatest depth.

Ophidiaster rhabdotus.

Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1082, pl. xxx, fig. 2; pl. xxxi, fig. 8.

This species is known only from a single specimen, with R = 80 mm., taken near Kauai, Hawaiian Islands, in 40 to 233 fathoms. The color in life was not recorded; in alcohol it was dull dark-brown.

Ophidiaster duncani.

De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 15, pl. xi, figs. 2–2*i*.

This species also is based on a single specimen sent from Mauritius by Robillard, and beautifully described and figured by de Loriol. It had R = 93 mm. and the color (dry) was variegated brown-violet and deep purple.

Ophidiaster lioderma [1] sp. nov.

(Plate 27, Figures 3 and 4.)

R = 115 mm.; r = 11 mm.; br = 13 mm.; R = 10.5 r or 8.8 br. Disk relatively small and flat. Rays very unequal (115, 95, 93, 85, 78 mm.), cylindrical, tapering only on the distal fourth or third. Entire animal, clear to the furrow spines themselves, incased in a very smooth, loose skin, uniformly covered with fine granules, 50 to 75 to a square millimeter; even at the centers of the abactinal plates the granules are not noticeably larger than elsewhere; near the adambulacral furrow, however, they are larger than on the dorsal surface. Papulæ in 8 well-marked series of little sunken areas, 12 to 20 to an area; each area is about as large as a dorsal plate but is clearly smaller than the marginal plates. Terminal plate small, about 2 mm. across, smooth and bare, with 2 to 4 more or less prominent tubercles; it is distinctly imbedded in the granular skin. Madreporite smooth, about 2 to 3 mm. across.

[1] λεῖος = smooth + δέρμα = skin, in reference to the unusually smooth surface of the body.

Pedicellariæ present, scattered on abactinal surface, on plates or on papular areas indiscriminately apparently, not very numerous, yet by no means uncommon, but confined almost entirely to basal half of ray; each pedicellaria is curved, sometimes only very slightly, often very distinctly, but never anywhere nearly enough to appear semicircular as in *duncani;* the valves are 0.50 to 0.75 mm. long, rather narrow, wider at tip than at base, not denticulate but with a somewhat crenulate margin; the margins of the alveolæ appear to be smooth. A few of the pedicellariæ on the actinal or adambulacral plates near the base of the ray are remarkable for the fact that the area on their concave side is entirely occupied by a single, swollen ellipsoidal granule, almost as large as the distal half of a subambulacral spine.

Adambulacral armature as usual, in two series; furrow spines arranged very clearly in pairs, subequal, about three times as long as wide, quite flat, the thickness about one-half the width, only slightly rounded at tip. There are no granules on the inner face, but on the outer side the granular membrane of the actinal surface extends up nearly to their tips. Subambulacral spines stout, terete, bluntly pointed, often distinctly curved; the largest are 1.3–1.5 mm. long and 0.50 to 0.70 mm. thick; the very base is conspicuously sheathed by the granular actinal membrane. At base of ray there is a subambulacral spine on each adambulacral plate, but beyond about the twentieth (on one ray the tenth) adambulacral there is, as a rule, a subambulacral spine only on every other plate. Oral plates not marked in any way, concealed by the actinal membrane; oral angles crowded with the usual 8 marginal and 2 suboral spines; suborals noticeably smaller than the first subambulacrals. Color in life dull light-brownish-red, which by preservation (in formalin and drying) has become an orange-brown.

Holotype, M. C. Z. No. 2266; southwestern reef at Mer, Murray Islands, Torres Strait, October 27, 1913.

On the afternoon of our last day at Mer, a very low tide enabled me to get far out on the southwestern reef, and under a coral fragment I found this well-characterized *Ophidiaster.* While nearly allied to *duncani,* the Torres Strait species will not be confused with the one from Mauritius, the difference in the pedicellariæ alone being very striking. But in both species the fine uniform granulation is notable, serving to distinguish them from some of their allies. In *lioderma,* under a magnification of 95 diameters, the granules are seen to be somewhat squamiform and very evidently papillose.

Ophidiaster ludwigi.

De Loriol. 1900. Rev. Suisse Zool., *8,* p. 78, pl. 8, figs. 1–1*f.*

This well-marked species is known only from the original small specimen (R = 40 mm.), which bore only the locality label "Perou." The color was brown-violet. Whether this specimen came from Peru, South America, or from Peru, Caroline Islands, remains to be determined.

Ophidiaster granifer.

(Plate 7, Figure 1; Plate 29, Figures 3 and 4.)

Lütken. 1871. Vid. Med., p. 276.

Early in the morning of September 6, 1913, during low tide, I had the privilege of collecting on the reef-flat at the southern end of Green Island, a coral islet about one-sixth of a mile in diameter, some 18 miles east by south from Cairns, Queensland. Under a rock near low-tide mark at the edge of the reef-flat, I found a small sea-star quite new to me. About 2 weeks later I found several specimens of the same thing, in a similar habitat at Erub (Darnley Island), Torres Strait. On the east flat at Mer the same sea-star was fairly common, more than 20 individuals being found there. The largest specimen collected has R = 32 mm., r = 6 mm., and br = 7 mm.; the smallest are not half so large. The coloration in life (pl. 7, fig. 1) was gray blotched with brownish red, but some individuals were much darker than the one figured. Preserved material is gray or brown indistinctly blotched with a darker shade. Individuals brought into the laboratory were hardy but sluggish and revealed nothing of interest in their habits.

On studying my Australian material after my return to Cambridge, I decided this sea-star was an undescribed species of *Ophidiaster* and I was interested to find in the Museum collection 3 specimens of what is evidently the same species, from Port Galera, Mindoro, Philippine Islands. Some months later Dr. W. K. Fisher visited the Museum and examined our Australian and East Indian sea-stars. He took a Murray Island specimen of this species away with him and subsequently when returning it wrote:

"This seems to me to be but a variety of my *O. trychnus* (1913, p. 215). It is as much like it as two peas, except it has no pedicellariæ, and the transverse series of two subambulacral spines is at base of ray only. See if your Mindoro specimen has pedicellariæ. I don't think Gray has described this form."

Examination of other specimens soon showed that the one Fisher had taken is the only dry one in the collection which has no pedicellariæ; they are present in all other individuals even the smallest. The degree of completeness of the two series of subambulacral spines is subject to great diversity in different specimens. I was therefore expecting to label the material *Ophidiaster trychnus* Fisher, when a careful examination of Lütken's diagnosis and description of his *O. granifer*, from the Tonga Islands, impressed me with the conviction that he was dealing with this same sea-star. Further study confirmed this conviction and I therefore concluded *trychnus* is a synonym of *granifer*. But to settle the matter beyond question I sent a specimen to Dr. Mortensen, who compared it with Lütken's type from Tonga which is in the Museum at Copenhagen. He assures me there is no doubt that the species is identical with Lütken's.

Fisher's only specimen is about two-thirds grown (R = 19 mm.) and was taken at Port Palapag on the north coast of Samar, probably on a reef. Lütken's material from Tonga has R = 30 mm. and the color was "brown, here and there gray with dark spots." Perrier (1875, p. 392) carelessly puts *granifer* as a synonym under *O. pusillus*, quite unmindful of Lütken's definite statement that there are 8 series of papular areas, whereas he himself says of *pusillus*, "les aires porifères forment six rangées longitudinales." Sladen (1889, p. 782) rescued *granifer* from this untimely fate, and I trust the present account and figures given may suffice to preserve it indefinitely. The present known range of the species is from the Philippines southward to Queensland and southeastward to the Tonga Islands.

Ophidiaster armatus.

Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 277, pl. xv, fig. 8; pl. xvii, fig. 6.

This is a well-marked species, not always, however, attaining its generic and specific characters completely until full-grown, *i.e.*, with R = 50 mm. or more, for Koehler says that in one specimen with R = 45 or 46 mm. the actinal series of papular areas seemed to be quite wanting. In a specimen before me from Ponape, Caroline Islands, with R = 29 mm., the actinal series of pores are imperfect, but they are evident nevertheless on the basal half of each ray. Possibly Koehler's anomalous specimen was not really this species but was actually a species of *Tamaria*. In any case, *armatus* seems to be more nearly allied to *Tamaria* than is any other Ophidiaster. Besides the types from the Aru Islands and the specimen at hand from Ponape, the only known example of this species is a very small one (R = 17 mm.) recorded by Koehler from the Andaman Islands. It is difficult to see how a specimen of this size could be certainly distinguished from *Tamaria fusca*.

Ophidiaster confertus.

H. L. Clark. 1916. *Endeavour* Rep., p. 53, pl. xv, figs. 1, 2.

This species, known as yet only from Lord Howe Island, has very characteristic pedicellariæ which distinguish it readily from its nearest allies. It is one of the larger species of the genus (R = 80 mm. or more). The dry specimens are yellow-brown but nothing is recorded of the color in life.

Ophidiaster agassizii.

Perrier. 1881. Bull. M. C. Z., *9*, p. 10.

This species has been taken as yet only at the island of Juan Fernandez. While allied to both the preceding and following species, it is perfectly distinct from each.

Ophidiaster kermadecensis.

Benham. 1911. Trans. Proc. N. Z. Inst., *43*, p. 148, with figures.

The admirable account given of this fine species by Benham leaves nothing to be desired. It is known only from Raoul Island, Kermadecs, and the adjoining Meyer Islet. It reaches a large size (R = 120 mm.) and the color in life is bright orange.

Ophidiaster pustulatus.

Linckia pustulata von Martens. 1866. Arch. f. Naturg. *32*, pt. 1, p. 62.
Ophidiaster purpureus Perrier. 1869. Ann. Sci. Nat., *12*, p. 253.—De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 22, pl. xiv, figs. 3–3*h*.
Ophidiaster pustulatus Perrier. 1878. Nouv. Arch. Mus. (2), *1*, p. 18.

Döderlein (1896, p. 317) has definitely shown what some earlier writers intimated, that *pustulatus* and *purpureus* are identical. The species is a relatively small one, with R less than 60 mm. Von Martens says the color in life is clear purplish-red with deep-red cross-bands. De Loriol gives the color of preserved specimens (dry) as deep purple tinged with brown and blotched here and there with yellowish. The known range is from Mauritius to Amboina.

Ophidiaster squameus.

Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1079, pl. xxxi, figs. 6–6*b*; pl. xxxvii, fig. 4.

(Plate 8, Figure 2.)

The original specimens of this species were very small (R = 19 mm. or less) and were taken in 18 to 151 fathoms in the Hawaiian Islands. The color in life is said to have been vermilion. On the southwestern reef at Mer I found two specimens of an *Ophidiaster* which Dr. Fisher suggests to me are the adults of *squameus.* Certainly it is impossible to point out any distinguishing character, but I am not sure that, were Hawaiian specimens, as large as those from Mer, available for comparison, we should find them conspecific. The Murray Islands specimens have R = 47 and 53 mm., while br is 9 mm. or more; owing to a marked difference in the degree of contraction of the disk when preserved, one has R = 9r, while in the other R is only a little more than 7r. This is a good illustration of the fact that the proportion of R to r when measured on preserved material must be used with caution for a specific character. The specimens of *squameus* found at Mer were very handsomely variegated (pl. 8, fig. 2) with red, reddish, and whitish. The dry specimens are dull orange-red blotched with a dark brick-red. There is a small specimen (R = 23 mm.) of *squameus* in the Museum of Comparative Zoölogy from the Paumotus, collected by the *Albatross* in 1899 and identified by Ludwig as *Ophidiaster cylindricus.*

Ophidiaster cribrarius.

Lütken. 1871. Vid. Med., p. 277.

This small species (R =30–50 mm.) is known as yet only from New Caledonia and Tonga. Lütken says that 6 of 24 specimens had 6 rays, while Perrier says one of his 8 had 7. The only specimen in the Museum of Comparative Zoölogy has 5 very unequal rays and is from an unknown locality. Although no true comet forms have yet been recorded, all the indications are that *cribrarius* is one of the very few species of *Ophidiaster* which reproduce by fission.

Ophidiaster robillardi.

De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 24, pl. xv, figs. 1–5*a*.

This is the smallest member of the genus and is known as yet only from Mauritius, where it seems to be common. There are 18 specimens in the Museum of Comparative Zoölogy, collected by Nicholas Pike, U. S. Consul at Mauritius many years ago, to whom the Museum is indebted for many echinoderms, not to mention animals of other groups. The largest of these *robillardi* has R =29 mm. and is thus much bigger than de Loriol's largest, which had R = 17 mm. All of the specimens have 5 rays, except 4 which are perfectly tetramerous. There seem to be always 2 madreporites and, as a rule, the rays are very unequal. There are two perfect "comets," one with the 4 new rays just visible, the other with them about 3 mm. long. There is no doubt that asexual reproduction by autotomy occurs regularly and normally in this little *Ophidiaster* as in *Linckia guildingii.* It is worthy of note that the largest specimen among the 18 is one of the most symmetrical, and the tetramerous individuals also have their 4 rays remarkably equal. A parasitic gastropod, kindly identified for me by Mr. W. F. Clapp as a species of *Stylifer*, seems to be a serious enemy to this sea-star, as 6 of the specimens were serving as hosts and in one of these the swollen ray is occupied by 3 of the shells, each 4 to 5 mm. long by 2 to 3 mm. in diameter.

Ophidiaster lorioli.

Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1077, pl. xxxi, figs. 4–4*d;* pl. xxxix, fig. 3.

This little species was taken on the reefs along the southern coast of Molokai, Hawaiian Islands. Probably the specimens of *Ophidiaster* from Oahu, called *pusillus* by Ives, 1889, were the same form. The holotype has R =31 mm., but a specimen in the Museum of Comparative Zoölogy from Samoa has R =41 mm. This individual was taken in Pagopago harbor, Tutuila, in 1917, by Mr. John W. Mills. It differs from Fisher's description and figures only in a few details due to its larger size and probably greater age. For example there are commonly 5 or 6 papulæ in the abactinal area and 3, rarely 4, actinally. No two of the rays are of the same length but all are notably cylindrical and blunt, markedly different from the rays of *robillardi.* The furrow spines are barely separated from one another by small, flat granules, *i.e.*, one granule between every two spines. This condition occurs also in *robillardi* when adult, and there is no constant difference between the two species in this particular. In both species, even in large specimens, the granule is often lacking. Fisher says the color in alcohol is "bleached yellowish." My Samoan specimen, dried from alcohol, is pale fawn-color, almost whitish, with very faint indications of reddish blotches on the upper surface.

DACTYLOSASTER.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

Genotype: *Asterias cylindrica* Lamarck, 1816. Anim. s. Vert., *2*, p. 567. Type here designated for the first time.

I have hesitated not a little over recognizing this genus, but have finally decided to do so because there is a very obvious peculiarity in the body covering, which makes the group easy to recognize. While *Leiaster* has a perfectly smooth, shiny skin, quite free from granules, and *Ophidiaster* and *Tamaria* have a wholly granulated skin, *Dactylosaster* shows a very constant and easily recognized feature in a smooth, somewhat shiny skin, with granules only at the approximate center of each skeletal plate. Although Gray put two species in the genus, only one is at all generally known, the second being one of the many "lost species" of the famous British naturalist. The two are supposed to be distinguished from each other as follows:

Key to the Species of Dactylosaster.

Granules on skeletal plates squamiform .... *cylindricus*
Granules on skeletal plates spiniform .... *gracilis*

Dactylosaster cylindricus

Asterias cylindrica Lamarck. 1816. Anim. sans Vert., *2*, p. 567.
Dactylosaster cylindrica Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.
Ophidiaster cylindrica de Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 20; pl. xi, figs. 3–4*b*.

De Loriol's admirable account of this species with his excellent figures leaves little further to be noted here, but it may be said that his figure 3 gives a better idea of the color of well-preserved specimens than his description. In life the color is quite a bright red and this may be very well retained by specimens preserved in formalin or dried therefrom. Simpson and Rudmose-Brown (1910) say:

"In life the colour schemes of this species are extremely striking and by far the most brilliant in the associated fauna. Many specimens are dark red all over; others are of a bright yellow with dark red to vermilion blotches on the arms. They are somewhat slimy to the touch when alive. There is never more than one madrepore-plate."

It is interesting to note that while pedicellariæ seem to be always present in specimens from Mauritius (though they are often very few in adults), they are apparently wanting in Hawaiian specimens. The species has not hitherto been recorded from Hawaii, but specimens have been in the Museum of Comparative Zoölogy for nearly 70 years which were taken there, and when I was at Hilo in December 1913 I found a fine adult specimen under a rock near low-water mark. In spite of the very extended range (Portuguese East Africa to Muscat and eastward to Fiji and Hawaii), *cylindricus* is not yet known from the Torres Strait region nor from any part of the Australian coast, nor even from New Caledonia. The largest specimen I have seen has R = 75 mm. but on the East African coast it reaches a very large size, with R = 146 mm.

Dactylosaster gracilis.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

All that we know of this species is contained in Gray's very brief diagnosis and his statement that it is from the west coast of Columbia. When that region is again explored zoölogically, this remarkable sea-star may be rediscovered.

HACELIA.

Gray, 1840. Ann. Mag. Nat. Hist., *6*, p. 284, as a subgenus of *Ophidiaster*.

Genotype: *Ophidiaster attenuatus* Gray, 1840, *l.c.* Monotypic.

This well-marked group was ignored by Perrier and Sladen, but was revived by Ludwig in 1897 and fully established by him. It should be emphasized, however, that the important character is not the mere presence of three series of actinolateral plates, but the doubled number of each series as compared with the inferomarginals, the arrangement among themselves, and particularly the resulting arrangement of the papular areas. There is not merely an extra actinal series of these areas on each side, but when typically developed this extra series contains twice as many areas as do the other series. Associated with this development of the actinal surface, there is more or less of a tendency to have the rays widened at the base and somewhat trigonal there.

Although a small group and little known, *Hacelia* seems to be distributed throughout the tropics except only the west coast of America and the Pacific Islands. The genotype is the only species of which we know anything about the color in life or about its habitat and natural history. Two of the other three species are known from only a single specimen each.

Key to the Species of Hacelia.

Furrow spinelets unequal, adoral distinctly wider; pedicellariæ usually present, at least on actinal surface in adults.
- Rays tapering steadily from distinctly widened base; adoral furrow spine little wider at tip than at base; pedicellariæ with sides of alveolar pit not conspicuously thickened or swollen .... *attenuata*
- Rays more cylindrical; adoral furrow spine very much wider at tip than at base; tip thick and rounded; sides of alveolar pit of pedicellariæ more or less conspicuously thickened or greatly swollen .... *helicosticha*

Furrow spinelets equal; no pedicellariæ.
- Distalmost marginal plates covered with granules, of which one or more central ones are more or less enlarged; granulation rather coarse, about 15 to 20 per square millimeter on actinolateral plates; R = 6.3 r ± .... *inarmatus*
- Distalmost marginal plates bare and somewhat swollen at center; granulation finer and smoother, about 25 to 40 granules per square millimeter on actinolateral plates; R = 5.3 r ± .... *superba*

Hacelia attenuata.

Ophidiaster (Hacelia) attenuata Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 284.
Hacelia attenuata Ludwig. 1897. Seesterne des Mittelmeeres, p. 272, pl. 3, figs. 6, 7; p . 11, figs. 1-17.

Nothing I can say would add to Ludwig's account of this species, known only from the Mediterranean and at the Azores. The largest specimen seen by Ludwig had R = 150 mm., but this was exceptionally big.

Hacelia helicosticha.

Ophidiaster helicostichus Sladen. 1889. *Challenger* Ast., p. 405, pl. lxix, figs. 5-7.
Hacelia helicostichus H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 111.

I have already pointed out (1909, *l.c.*) that Bell's "*Linckia nodosa*," of the *Alert* report, is really Sladen's fine species. Of course, since Sladen's species was not described for five years after the *Alert* report appeared, it is not strange that Bell failed to recognize the species, but why he should have ever supposed his specimens were Perrier's *L. nodosa* I do not understand. It is obvious that the reason Sladen did not note the close relationship to *H. attenuata* was because he overlooked the actinal series of papulæ. The two species are really much alike and the differences are not at all striking. Sladen's failure to detect the actinal series of papulæ between the actinolateral plates was no doubt due to his failure to dry the specimen, for the areas in these series contain only 1 to 3 papulæ each and they are often undeveloped, so that the series is not regularly continuous, and unless the specimen is well dried they are very hard to make out.

As yet, *helicosticha* is known only from the western end of the Torres Strait region, the Arafura Sea, Holothuria Bank, and northwestern Australia. The Herdmans' record from Ceylon (1904, p. 145) is too dubious to have any weight. Koehlers' record from the Sunda Islands refers to the following species, *inarmata*. Bell's suggestion (1894) that his *Linckia megaloplax* is probably the young of *H. helicosticha* is not unnatural but, as Koehler suggested (1895), it is quite certainly wrong as the two forms are not nearly related. While the type of *helicosticha* had R = 130 mm., Bell (1884, p. 124) records (as *Linckia nodosa*) a specimen with R = 213 mm. Nothing is known of the color in life.

Hacelia inarmata.

Ophidiaster helicostichus Sladen var. *inarmatus* Koehler. 1895. Mem. Soc. Zool. France, *8*, p. 400, pl. ix, figs. 6, 7.

It seems to me quite clear that Koehler's specimen (R = 95 mm.) from the Sunda Islands is a *Hacelia*, as his careful description reveals the generic features plainly. Moreover, the specimen can not well be referred to *helicosticha* because of the absence of pedicellariæ and the uniform size of the furrow spines. The only course seems to be to raise it to the rank of a valid species.

Hacelia superba[1] sp. nov.

(Plate 32.)

R = 75–78 mm.; r = 13–14 mm.; br = 16–17 mm.; br half-way to tip of ray, 12 mm., and three-fourths of the way, 8.5 mm.; R = 5.3–6 r and 4.4–5 br; vertical diameter of disk and height of base of ray about 15 mm. Disk high, but flat. Rays high, wide, and somewhat trigonal at base, flattened on actinal surface, tapering steadily from base to tip. Skeletal plates more or less octagonal, becoming nearly circular distally, basally wider than long, somewhat swollen, so that the papular areas are notably sunken, covered by a smooth coat of granules of uniform height and showing only a little diversity in size and shape; over most of each of the larger plates the granules are hexagonal and closely packed, 0.20 to 0.25 mm. across, while elsewhere they are more nearly circular, less closely packed and only 0.10 to 0.15 mm. in diameter, but the intergradations are gradual and complete. Papular areas nearly circular 1 to 2 mm. across, markedly depressed, with 8 to 22 papulæ. On basal part of ray, marginal plates similar to abactinal, but distally they become squarish or wider than long, and the last 3 to 6 in each series are more or less bare; the bare area is convex, smooth, and circular, or elliptical with the greater axis vertical. Terminal plate hemispherical, naked, and swollen, about 2 mm. in diameter. Madreporite triangular, 3.5 mm. high and 3 mm. across the upper margin, slightly elevated, but with a somewhat concave surface. No pedicellariæ anywhere.

Skeletal plates of actinal surface, so far as can be judged without removal of the closely granulated skin, just as in *H. attenuata* as described and figured by Ludwig (1897). Actinal series of papular areas perfectly evident but more or less incomplete and extending only to about the middle of the ray; each area contains from 2 to 8 papulæ and as a rule the areas directly below the inferomarginal areas are noticeably smaller and more likely to fail altogether than the alternate ones. Furrow spinelets long, conspicuous, subequal, with rounded tips; they are about 1.20 to 1.50 mm. long, 0.40 to 0.50 mm. wide and 0.20 to 0.30 mm. thick. Subambulacral spines very regularly one to each plate; proximally they are 1.75 to 1.90 mm. long, 0.70 to 0.90 mm. wide and about 0.30 mm. thick, but distally they become shorter and stouter, so that near tip of ray they are less than a millimeter long, while the width and thickness may be 0.60 to 0.70 mm. On the first adambulacral plate, adjoining the orals, there are often 2 subambulacral spines, one behind the other. Oral plates not peculiar in any way, but with only one suboral spine on each. Color in life unknown; the dry specimen is fawn-color.

Holotype, M. C. Z., No. 764; off Barbados, 100 fathoms. *Hassler* expedition.

This fine sea-star has lain undescribed in the Museum of Comparative Zoölogy collection for nearly half a century. It is somewhat remarkable that no other representative of the species has during that time been found by either the *Blake*, the *Albatross*, or any of the other parties that have collected in the West Indies. The relationship to *H. attenuata* is of course obvious, but the general appearance is not very similar to that of the Mediterranean species.

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[1] *Superbus* = magnificent, in reference to the exceptionally symmetrical and fine appearance, as shown by the holotype.

TAMARIA.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 283.

Genotype: *Tamaria fusca* Gray, 1840, *l. c.* Monotypic.

It is somewhat unfortunate that *fusca* is necessarily the type of this genus, for it is not only a very variable species, but it is not ordinarily very typical of the group; young individuals are more generally typical than adults. As a whole, the genus is a fairly homogeneous one and easily distinguished from *Ophidiaster* by the absence of papular areas below the inferomarginal plates. It is true that papulæ do sometimes occur on the actinal surface but they are always isolated or at most only 2 or 3 together and never form distinct areas, so that no species of *Tamaria* has actinally the facies of an *Ophidiaster.*

As Gray's name has never been in use, all of the species, which it seems to me should be brought together here, have been described as Ophidiasters, except *dubiosa,* which was placed in *Linckia,* when first described. As these species are included in the table given above (p. 77) of forms called *Ophidiaster,* it is not necessary to give a full bibliography here with each species.

The characters which seem to differentiate the members of the genus are the nature of the abactinal and marginal plates, the size and arrangement of the papular areas, the presence and character of pedicellariæ, the form and proportion of the rays, and the distribution of spines or spinelets on the actinal surface.

Key to the Species of Tamaria.

A. Abactinal plates relatively low, convex or flattened, not at all tumescent.
  B. Abactinal and marginal plates, at least on distal half of ray, with one or more central granules conspicuously enlarged to form a tubercle or tubercles.
    C. Tubercles erect, more or less pointed, often solitary; pedicellariæ present as a rule in adults but often wanting in young.
      D. Papular areas moderate with usually fewer than 10 pores; tubercles developing with age; rays tapering, bluntly pointed.......... *fusca*
      DD. Papular areas large, forming very conspicuous regular series, each with 10 or more pores; tubercles disappearing with age; rays more cylindrical, stout, blunt.. *tuberifera*, juv.
    CC. Tubercles low, rounded, in groups on every abactinal and marginal plate; no pedicellariæ. *lithosora*
  BB. Abactinal and marginal plates without tubercles, though central granules may be a little larger than those around them.
    C. Pedicellariæ present, at least on actinal surface.
      D. Disk small (R = 7–8 r) and rays slender (R = 5.5–7 br).
        E. Papular areas large with numerous (10 or more) papulæ; pedicellariæ wide, straight, with jaws denticulate.......... *tuberifera*
        EE. Papular areas small with 1 to 3 pores; pedicellariæ narrow, curved, with jaws smooth.......... *tenella*
      DD. Disk large (R = 3.5–5 r) and rays stout (R = 4–5 br).
        E. Rays very short and stout, R = 3.5–4 r; measured alongside, ray is about 2.5 times as long as wide at base; interradial actinal areas, each with 12 to 15 flat, rounded spinelets similar to subambulacrals.......... *floridæ*
        EE. Rays longer (R = 4.5–5 r) and less stout; no actinal interradial spinelets.
          F. Pedicellariæ straight, wide, S-shaped with denticulate jaws; few (3 to 5) papulæ to an area; subambulacral spinelets in two series.......... *pusilla*
          FF. Pedicellariæ often curved, narrow, with jaws not denticulate; 9 to 14 papulæ to an area; subambulacral spines in one conspicuous series.......... *scleroderma*
    CC. Pedicellariæ wanting.
      D. Subambulacral spines in two series, one often more or less indistinct or incomplete, well separated from furrow-spines; R = 7–8 r.......... *marmorata*
      DD. Subambulacral spines in one series, contiguous to furrow spines; R = 5–6 r.......... *dubiosa*
AA. Abactinal plates (at least many on distal half of ray) conspicuously tumid.
  B. Rays stout, R = 4–5 r; abactinal plates unequally and irregularly tumid; subambulacral spinelets in two series, the inner of much smaller spinelets.......... *triseriata*
  BB. Rays more slender, R = 7–8 r; abactinal plates uniformly tumid; subambulacral spines in a single series.......... *tumescens*

Tamaria fusca.

Tamaria fusca Gray. 1840. Ann Mag. Nat. Hist., *6*, p. 283.
Ophidiaster fuscus Perrier. 1875. Rev. Stell., Arch. Zool. Exp., *4*, p. 132 (396).
Linckia megaloplax Bell. 1884. *Alert* Ech., p. 126.
Ophidiaster hirsutus Koehler. 1910. Indian Mus. Ast., p. 149, pl. xviii, figs. 5, 6.
Ophidiaster ornatus Koehler. 1910. Indian Mus. Ast., p. 151, pl. xviii, figs. 3, 4.

(Plate 28, figures 1, 2.)

This small species is one of the most variable in the family and, as material is still very scanty in our museums, it is possible that the above synonymy is not correct. Perrier's description is based on Gray's own specimen and is sufficiently detailed to make up for Gray's brevity. My reason for including Bell's *Alert* species here is that two specimens from Holothuria Bank, identified and labeled by Bell himself, are in the Museum of Comparative Zoölogy collection; these specimens have been examined by Dr. W. K. Fisher and he writes me as follows regarding them:

"*Linckia megaloplax* Bell. This is Gray's *Tamaria fusca*=*Ophidiaster fuscus*. Koehler's *O. hirsutus* is but a variety. It is a very variable species, as my specimens show. The one I figure[1] has a heap of small tuberculate granules on the abactinal plates. I saw the type in the British Museum and it is distinctly of this type."

One of the Holothuria Bank specimens before me is obviously very young (R =22 mm.) and the marginal spines are confined to the distal superomarginals though present on all but the basal 3 or 4 inferomarginals. On only a few distal, abactinal plates is the central granule sufficiently enlarged to be evident as a spiniform tubercle, and it is never noticeable. This specimen resembles very closely Koehler's unique holotype of *Ophidiaster ornatus* but is a little larger and on only a few adambulacral plates are there 2 subambulacral spines distinctly evident. The type of *ornatus* is obviously a very immature individual and might be the young of any one of several species of *Tamaria;* if it is not *fusca*, it is probably *marmorata*.

The larger specimen from Holothuria Bank has R =44 mm. and is notable for the presence of large pointed tubercles not only on the marginals, but on many abactinal plates as well. It is thus similar to the unique holotype of *Ophidiaster hirsutus* Koehler, but being somewhat larger it has more tubercles developed on the abactinal surface. There is no doubt, I think, that this specimen of Bell's *megaloplax* is identical with Koehler's *hirsutus* and I see no reason to question Fisher's opinion as expressed above, that both are in reality *Tamaria fusca* Gray.

A third specimen in the Museum of Comparative Zoölogy is one of the *Gazelle* specimens from northwestern Australia, identified by Studer as *Ophidiaster fuscus*. The *Gazelle* took 3 specimens near the Dampier Archipelago in 50 fathoms, the largest having R =22 mm. The one now in the Museum of Comparative Zoölogy, received in exchange from Berlin in 1908, has R about 21 mm. It differs from Studer's description in three particulars; pedicellariæ are present, at least on abactinal surface; there is no trace of actinal papulæ and the color is pure white. These differences are not difficult to understand, for the long sojourn in alcohol has bleached out all the original color while the present dry condition brings out the pedicellariæ which might be quite overlooked in the alcoholic specimen. As for the actinal papulæ, it seems to me possible Studer was mistaken as to the nature of the bodies he so designated.

The largest specimen of *fusca* recorded is the type with R =about 36 mm., but Bell says his largest *megaloplax* had R =67 mm. Unfortunately it is not improbable that more than one species of ophidiasterid is included by Bell under his original description, which in certain particulars applies poorly to *fusca*. This uncertainty as to the forms included under the original description of *megaloplax* enters into the matter of the geographical

[1] W. K. Fisher, 1919. Bull. 100 U. S. Nat. Mus., pl. 103, fig. 4; pl. 104, fig. 1; pl. 111, figs. 5, 6.

distribution of *fusca*. While Bell records *megaloplax* from Albany Island in Torres Strait, it is not certain that *fusca* occurs in that region; it is quite possible that Bell's specimens were young *Tamaria tuberifera*. There is no doubt, however, that *fusca* occurs on the coast of northwestern Australia (Dampier Archipelago and Holothuria Bank), in the Philippines (Migupou, wherever that may be!), and at the Andaman Islands. Bell (1903, p. 245) records it from Zanzibar, 3 to 5 fathoms, but as he gives no data whatever about the specimens it is possible they really belong to the form described beyond as *T. lithosora*. Possibly *fusca* also occurs on the coast of Ceylon. It is obviously not a common species at any place it is as yet known to inhabit.

Tamaria tuberifera.

Ophidiaster tuberifer Sladen. 1889. *Challenger* Ast., p. 404, pl. lxv, figs. 1–4.

(Plate 8, Figure 1.)

This is one of the finest sea-stars in the Ophidiasteridæ, the conspicuous papular areas giving an elegant appearance to the symmetrical, cylindrical rays. The color is striking because unusual and is well preserved in dry specimens, save for the loss of the delicate tints of red and green, which are evident in life. Near Badu, on November 1, 1913, in water 8 to 12 feet deep, we found two specimens of this species, which are notable for their large size and the complete absence of tubercles. Sladen's type had R = 48 mm. and the specimen taken by Semon at Thursday Island was only a little larger (R = 55 mm.), while Koehler's specimen from the Andaman Islands was smaller, though no measurements are given. One of our specimens (pl. 8, fig. 1) has R = 96 mm. The proportions are not noticeably different in these big specimens, but the entire lack of tubercles is very striking and recalls at once Koehler's statement (1910, p. 148) that his specimen lacked tubercles on the carinal plates and on many of the superomarginals. Apparently the presence of the tubercles is a youthful character, but subject to no little individual diversity. Save for Koehler's specimen from the Andaman Islands, this species is known only from Thursday Island and Badu, in Torres Strait.

Tamaria lithosora[1] sp. nov.

(Plate 31, Figures 7 and 8.)

R = 40–42 mm.; r = 7–8 mm.; br = 8–9 mm.; R = 5.5–6 r or 4.5–5 br. Disk flattened, but elevated. Rays tapering steadily from base to bluntly pointed tip. Papular areas rather large with 8 to 10 papulæ (on basal half of ray), not much sunken; the median series on each side does not extend clear to tip of ray, so there are only 4 series on terminal 6 to 7 mm. Abactinal plates somewhat elevated, in 3 series above superomarginals as usual, a carinal row and a lateral one on each side; lateral rows dwindle distally and disappear about 6 mm. from tip of ray. Whole animal covered by a thick skin bearing a coarse and uneven granulation; at the center of each abactinal and marginal plate is a single, low, rounded, smooth tubercle or more commonly about 3 such tubercles more or less fused (apparently) into one; when single this tubercle is 0.50 to 0.75 mm. in diameter, but when the result of fusion it may be a full millimeter; surrounding this tubercle or tubercle-group are a few coarse grains, smooth and rounded, and these gradually pass into smaller granules on the lower parts of the plates and on the papular areas. On the disk plates the tubercle-group may contain 5 to 8 tubercles, but nowhere is the contrast between the tubercle groups and the surrounding grains and granules abrupt. Terminal plate hemispherical, smooth, 1.5 mm. in diameter, without tubercles. Madreporic plate elevated, convex, circular, 2.75 mm. in diameter. No pedicellariæ anywhere.

Actinal surface densely clothed with thick, somewhat squamiform granules, without sign of papulæ or pedicellariæ. Very narrow furrows, mere lines, run at right angles to ambulacral furrow from adambulacral to inferomarginal plates, every other one continuing

[1] *λίθος = stone + σωρός = heap*, in reference to the heaps of granules on the abactinal plates.

up between inferomarginals. Distal inferomarginal plates with a conspicuous but low central tubercle, 0.5 mm. in diameter. Probably 2 series of actinolateral plates on basal half of ray, and possibly a few plates of a third outer row; these details are not important and could be determined only by greater injury to the specimen than the matter warrants. Adambulacral armature as usual, of 2 furrow and one subambulacral spines to each plate. Furrow spines about 0.75 to 0.80 mm. long, slightly prismatic (especially the adoral) but with flattened inner surface, on which is a small but rather conspicuous concavity; adoral spine more or less markedly the larger, its tip in particular being noticeably more widened. There are no granules on inner side of the furrow spines. Subambulacral spines short, stout, and thick, almost spherical or hemispherical, about 0.5 mm. in diameter; separated from furrow spines by only a single series of rather coarse granules. Oral plates small but conspicuous because of the unusually coarse granules with which they are densely covered and the apparent absence of any suboral spine. Color in life unknown; dry specimen dusky gray, lighter beneath; there are faint indications of dark blotches or indefinite bands on rays.

Holotype: M. C. Z. No. 761. Zanzibar. Collected by Edward Ropes, in 1861.

This species is so well marked that it is strange it has not been previously described. It is quite possible that the Tamarias listed by Bell from Zanzibar in 1903 as *Ophidiaster fuscus* represent this species, but until those specimens are reëxamined the matter must remain in doubt. Simpson's and Rudmose-Brown's (1910, pp. 58, 59) figures 1, 2, and 4 of the sea-star they call *Linckia marmorata* are almost certainly made from a specimen of *lithosora*. The only difficulty is that they represent the ray without a distinct terminal plate. This is probably a mistake, however, as very few Ophidiasters or Tamarias have the terminal plate concealed. A further discussion of their remarkable description and figures will be given under *T. marmorata*. There is no reason to confuse *lithosora* and *fusca*, since the character of the skin and granulation is quite unlike in the two forms. The total absence of pedicellariæ in *lithosora* is probably also a constant difference.

Tamaria tenella.

Ophidiaster tenellus Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1082, pl. xxxi, figs. 5, 5*a*.

The unique holotype of this species was taken in 1902 by the *Albatross* in Pailolo Channel, Hawaiian Islands, in 130 to 151 fathoms. It seems to be a very well-marked form.

Tamaria floridæ.

Ophidiaster floridæ Perrier. 1881. Bull. M. C. Z., *9*, p. 9.—1883. Nouv. Arch. Mus. Hist. Nat. (2), *6*, p. 221, pl. iv, fig. 1.

This remarkable sea-star, so different in general appearance from *Tamaria fusca*, might not improperly be made the type of a new genus, especially as it is the only *Tamaria* occurring outside the Indo-Pacific region. But in view of the fact that only one other specimen is known besides the holotype, it would seem better to wait for more material. Owing to typographical errors, carelessness, or both, a number of misstatements have been published about the holotype, which is M. C. Z. No. 757. In the original description the width of the ray 5 mm. from the tip is given as 415 mm., presumably 4.75 mm. is meant. The number of pores in each area is given as "deux à quatre" but not rarely there are 5 or 6 and occasionally 7. There is no hint as to the origin of the specimen. In the final report (1883) the dimensions are misprinted: R = 33 mm., 5; r = 8 mm.; R = 3.7r. The 8 is obviously an error for 9 but the significance of the 5 is puzzling. It may be purely a typographical error but I think it means that there are 5 rays, even though "Cinq bras" is the first statement in the line above. The specimen is said to be from "123 pieds de profondeur dans le détroit de Floride. Communiqué par M. Alex. Agassiz avant les dragages du *Blake*." Examination of Pourtales's reports and Mr. Agassiz's list of star-fishes taken in Florida Strait has satisfied me that *Tamaria floridæ* was taken by the *Bibb* in 1868, either on May 9, off the Samboes, or on May 11, off Sand Key; each of these stations was at 123 fathoms. Verrill (1915, pp. 90, 91) gives the lesser radius of the type as 5 mm. instead of 9, evidently misreading the perplexing 5 in Perrier's final report, already mentioned. But worse than this, Verrill makes the amazing remark regarding the holotype: "It is perhaps the young of *O. guildingii*, the common shallow-water West Indian species." It would be difficult to make a guess about the specimen that would be much further from the mark! There is a superficial appearance in form to *Hacelia superba*, but even a casual examination prevents any confusion with that species. Verrill records (1915, p. 91) a specimen from off eastern Florida, 277 fathoms, *Albatross* collection, but in view of the great depth and the above-quoted remark I think perhaps this specimen may not be *Tamaria floridæ*. At any rate it is unfortunate that Verrill gives no data whatever regarding this supposedly second example of this remarkable species.

Tamaria pusilla.

Ophidiaster pusillus Müller and Troschel. 1844. Arch. f. Naturg., *10*, pt. 1, p. 180.

This species, recorded from the Philippine Islands, Dutch East Indies, and New Caledonia, I have never seen. Ives's (1889, p. 172) record from Oahu, Hawaiian Islands, is probably based either on *O. lorioli*, as suggested by Fisher, or even on *O. squameus*. It is apparently a small species, with R only 30 to 35 mm. long. Perrier (1875, p. 128 [392]) is certainly in error in making *O. granifer* Lütken a synonym of *pusilla*, for Lütken's species has 8 series of papular areas and is hence a true Ophidiaster.

Tamaria scleroderma.

Ophidiaster sclerodermus Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1081, pl. xxx, figs. 4, 4*a*; pl. xxxi, figs. 2, 2*a*.

This fine species, orange-yellow and maroon in life, is known only from the two specimens taken by the *Albatross* in 99 to 106 fathoms off the north coast of Maui, Hawaiian Islands.

Tamaria marmorata.

Ophidiaster marmorata Michelin. 1844. Rev. Zool., *7* p. 173.—1845. Mag. Zool., *7*, p. 193 (21); pl. x, figs. a–f.
Linckia marmorata von Martens. 1869. Von Decken's Reise, p. 130.—De Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 35; pl. xiii, figs. 1–1*e*.

Few members of the family have been so needlessly shifted about as has this handsome sea-star. Owing to the very small size of the holotype and to some probable misidentifications, the status of *marmorata* is at the present time quite uncertain, but that it is not a *Linckia* seems to me beyond question. The trouble began with von Martens' transfer of the species to *Linckia*, which it is fair to believe he would never have made had he recognized the genus *Ophidiaster* at all. Lütken (1871) seems to have overlooked *marmorata* altogether, while Perrier (1875), admitting some embarrassment in so doing, decided to leave it in *Linckia*. Later writers have followed that lead and hence the real relationships of the species have been obscured and the natural limits of *Linckia* could not be drawn while it remained therein. In the *Alert* Report (1884, p. 125) Bell discusses a series of diversified ophidiasterids from tropical Australia under the heading "*Linckia marmorata*" which he says "are clearly enough all representatives of the same species." I am inclined to doubt whether these do all represent one species, but in any case those from Prince of Wales Channel are pretty sure to prove to be *Tamaria tubifera*. It is very unlikely that any are the real *marmorata*. This identification of Australian material by Bell as *Linckia marmorata* proved a stumbling block to Simpson and Rudmose-Brown, whose account (1910, p. 56–60) of certain sea-stars from the coast of Portuguese East Africa contains some most unfortunate blunders. Their figures are fortunately clear and apparently accurate, but they do not represent *marmorata!* I should not be so sure of my ground were it not for the material before me in the Museum of Comparative Zoölogy collection. This includes a specimen from Zanzibar with R = 31 mm. identified by Perrier; a very fine specimen from Mauritius with R = 52 mm. received from the British Museum and identified (or at least labeled) by Bell; and two very large specimens from Zanzibar, with R = 58 and R = 70 mm. respectively, which were taken by C. Cooke and have been in the Museum of Comparative Zoölogy collection for many years. This material agrees well with de Loriol's notes and figures (*l. c.*) and the Mauritius specimen shows exactly the coloration which he describes. Michelin's colored figure differs only in being lighter and brighter. It is very unfortunate that Simpson and Rudmose-Brown seem to have overlooked de Loriol's paper. Had they examined his figures they would have avoided some unnecessary blunders. It is certain that they have at least two species included in their *Linckia marmorata,* and perhaps there are three. At any rate, one does not need to have more than an elementary knowledge of sea-stars to realize that their figures 2 and 3 can not represent the same species! Moreover, their description of the adambulacral armature and their figure 3 are certainly not made from any known species of *Linckia*, *Ophidiaster*, *Hacelia*, or *Tamaria*, nor can I guess what sea-star they might represent. It is possible that figures 1, 2, and 4 represent some form of *marmorata*, but none of the specimens I have seen is like them. On the other hand, they are (as suggested above) very much like *T. lithosora*, and I think may possibly represent that species. In Simpson and Rudmose-Brown's description are some odd statements which certainly do not apply to *marmorata*. Thus, they say of the skeletal plates that there are only 4 series—"one mid-dorsal series; 2 sub-lateral series; 1 very broad sub-ventral series." No doubt, however, they mean 2 sublateral and 1 subventral series on each side. Even then, however, they distinguish only 7 series, whereas my smallest specimen shows 9 (besides the adambulacrals), while the finely preserved specimen from Mauritius has undoubtedly 13 on the basal part of each ray. Of course, the explanation is simple; the granulation is so close that the English authors have considered the inferomarginals and the 1 to 3 series of actinolaterals as a single broad "subventral" series, and have entirely overlooked the real skeletal arrangement. In regard to the papular areas, they assert that they are larger than the corresponding plates and that "the average number of pores in each group is about fifteen." Their figure 1 contradicts these statements, the average number of pores shown being fewer than 8 to each area, and the areas certainly not averaging as large as the plates. But this is not strange, for the figure represents the distal part of the ray. However, in the largest specimens of *marmorata*, I have not found a single area with as many as 15 papulæ and the average is about 10; rarely is an area as large as one of the adjoining plates. In the typical *marmorata* from Mauritius the areas are not half as large as the plates and there are rarely more than 8 pores. As already stated, the English authors' description of the adambulacral armature is impossible, but just how it is to be accounted for I do not see, as their figure 2 is an admirable representation of the adambulacral appearance of a *Tamaria*. The description of the coloration indicates some other sea-star than *marmorata*, especially if made from fresh or perfectly preserved material, a point not even mentioned.

The specimens in the Museum of Comparative Zoölogy collection need little comment. The fine specimen from Mauritius has moderately slender and terete rays, which at middle are only about 1/10R in width. The large Zanzibar specimens are stouter and have the rays more cylindrical, with the breadth at middle about 1/7 R. As already mentioned, the Zanzibar specimens have much larger papular areas, with more numerous pores. Their color is now dingy gray, but there are distinct indications of irregular darker and apparently once deep purple markings on the rays. In the Mauritius specimen the actinolateral plates are unusually well-defined, and more remarkable still, there are papulæ below the inferomarginals; these papulæ are insignificant and scattered, except on the ray opposite the madreporite, where they occur on both sides and on the right-hand side are in 4 consecutive groups, with 3 or 4 in a group. The larger Zanzibar specimens have no such inferomarginal papulæ. The number and arrangement of subambulacral spines is subject to great individual diversity. In the Zanzibar material, both large and small, the typical arrangement is well-marked, but in the Mauritius specimen there are very few plates with 2 distinct subequal subambulacral spines, and one might well assert that there is only one series of such spines; but the indications of a second series can be made out.

The geographical distribution of this species is uncertain. I know of no indubitable records except those from Mauritius and Zanzibar.

Tamaria dubiosa.

Linckia dubiosa Koehler. 1910. Indian Mus. Ast., p. 155, pl. xviii, figs. 10, 11.

This species is known only from a single small specimen (R = 28 mm.) from the Andaman Islands. It does not seem possible to refer it to any previously known species, although it seems nearly allied to *marmorata*.

Tamaria triseriata.

Ophidiaster triseriatus Fisher. 1906. Bull. U. S. Fish Comm. for 1903, p. 1080, pl. xxx, fig. 3; pl. xxxi, figs. 7, 7*a*.

Two young individuals, taken by the *Albatross* in 68 to 90 fathoms, off the coast of Kauai, Hawaiian Islands, are the only known specimens of this apparently well-marked species.

Tamaria tumescens.

Ophidiaster tumescens Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 281, pl. xvi, figs. 3, 4.

This very distinct species is known only from one specimen, taken at Sungi Barkai, Aru Islands, in 10 fathoms.

PSEUDOPHIDIASTER.

H. L. Clark. 1916. *Endeavour* Rep., p. 54.

Genotype: *Pseudophidiaster rhysus* H. L. Clark, 1916, *l. c.* Monotypic.

This remarkable genus is quite different from any other in the family, as it is the only one which has become modified by or for life in deep water. Several species of other genera live at nearly or quite as great depths, but none of them have been noticeably modified in conformity to such a habitat. The reduction of the skeleton in *Pseudophidiaster* would seem to be such a modification.

Pseudophidiaster rhysus.

H. L. Clark. 1916. *Endeavour* Rep., p. 55, pl. xvi, figs. 1, 2.

Further study of a large dried specimen has brought out the interesting fact, which the original description fails to note, that at the base of the ray there is a series of actinal poriferous areas between the actinolateral plates as in *Hacelia* and, as in that genus, the areas in this series are twice as numerous as in the abactinal and marginal series. In *Pseudophidiaster* this actinal series occurs only in the largest specimens and does not extend far beyond the disk. Another peculiarity of the big specimen (R = 150 to 160 mm.) is that the series of papular areas above the superomarginals is *double* for a considerable part of its length; at the very base of the ray and distally the areas are as usual, but just outside of the disk an area is twice as high as wide and constricted at the middle; in the next one the two halves are quite separate, but one is above the other; and thereafter they are more or less irregular in their position with reference to each other. There are thus in this genus, just outside of the disk, 12 series of papular areas. Possibly better preserved material would reveal other peculiar features in this very unusual sea-star. It is as yet known only from the region south of Australia in 60 to 200 fathoms.

SPINULOSA.

ASTERINIDÆ.

Nepanthia brevis.

Asterina (*Nepanthia*) *brevis* Perrier. 1876. Rev. Stell., Arch. Zool. Exp., *5*, p. 241 (321).
Nepanthia brevis Sladen. 1889. *Challenger* Ast., p. 387, pl. lxiii, figs. 3–5.

(Plate 6, Figures 3 and 4.)

This may be called the characteristic sea-star of Torres Strait, for it is the only species taken by all four expeditions to the region and it is not known from anywhere else, except the northwestern coast of Australia, whence Studer reports two specimens taken by the *Gazelle*. It is a very noteworthy fact, however, that no *Nepanthia* was found at Erub or the Murray Islands, although five specimens were taken at Thursday Island during the two mornings' collecting which we had there. It looks as though the eastern limit of the range of the species is about at the Cape York peninsula, the *Alert* having taken it at Albany Island.

Although both Bell and Sladen have figured this pretty sea-star, I am glad to be able to give colored figures, drawn from life. The figures were made from a specimen taken on the underside of a rock fragment, about half-way between high and low tide, on the northeast side of Thursday Island, September 12, 1913. On September 15 Mr. Grosse and I collected four specimens in a similar habitat on Madge Reef across the ship-channel from Thursday Island dock. None of my specimens is quite as large as the maximum size given by Bell, R = 44 mm. The colors are very fugitive in alcohol and are difficult to preserve either in formalin or in dry specimens.

Asterina anomala [1] sp. nov.

(Plate 7, Figure 8; Plate 23, Figure 5; Plate 26, Figures 2 and 3.)

Rays 6 to 8. R = 8 mm.; r = 4 mm.; br = 4.5 mm.; R = 2 r. Body-form irregular in all available specimens, owing to autotomous reproduction; in two specimens there are only 3 rays, the recently severed surface having healed, but not as yet given rise to any new rays (one of these specimens is shown on plate 23, the lower left-hand example in figure 5); in the specimen from which the colors shown in figure 8, plate 7, were taken there are 2 rays, adjoining each other, with R = 8 mm., 2 rays side by side, next to them with R = 4 mm., and opposite these 4 rays are 4 more, each less than a millimeter long; another 8-rayed specimen is somewhat less asymmetrical; a 7-rayed specimen (pl. 23, fig. 5, lower right-hand example) is fairly symmetrical, except that one ray is injured at the tip; another 7-rayed specimen is less symmetrical, a recent autotomous division being quite evident; one specimen has 6 rays, 2 of which, side by side, are little more than half as big as the other 4; in life the rays are distinctly narrower, higher, and more arched than in preserved material, as is easily seen on comparing figure 8, plate 7, with figure 5, plate 23.

Abactinal skeleton as usual in *Asterina*, made up of imbricating plates, more or less crescentic (except near tip and margins of ray), each of the larger ones at least with a large papula on its inner concave side; there are 4 to 6 series of papulæ on each ray at its middle, and some additional ones on disk. Each plate carries a small cluster or double series of minute thorny spinelets, most numerous on the plates near the margin. Madreporite very small and distinguishable only with difficulty or quite wanting. Terminal plates small, hemispherical, distinctly on the upper surface of ray, covered with minute thorny granules, but these are so easily rubbed off, the plate is often quite bare. No pedicellariæ.

[1] ἀνώμαλος = *irregular*, in reference to the body form and number of rays.

Actinolateral plates in only about 3 series, each with a group of 3 to 5 very thorny spinelets, which may form a single series or be in 2 series or in an irregular cluster. Adambulacral armature in 2 series, a furrow set of 4 or 5, and a subambulacral group of 3 to 5; near base of ray the furrow spinelets are wide and blunt (relatively) but they become narrower, more pointed, and more thorny distally; the subambulacral group on the proximal plates is usually of 3 rather slender spinelets, but they increase distally in number, size, and thorniness, so that near the tip of the ray they predominate over the furrow spinelets. Oral plates rather large and keeled, bare except for a single short, curved, crowded series on the keel, of about 3 thorny suboral spines, the most proximal largest; marginal oral spines 6 to 8 on each plate, very conspicuous, the innermost pair nearly or quite a millimeter long, flattened, blunt, wider at tip than at base; the following spines closely appressed side by side, successively shorter, narrower, and more pointed.

Color in life green, prettily variegated with white and rusky, with traces of red and yellow along the margins. Alcohol changes the greens to red and soon bleaches the specimen altogether. Dry specimens are yellow-brown—"museum color," as it has been called!

Holotype, M. C. Z. No. 2300; crevice in a coral fragment, reef-flat, Mer, Murray Island, Torres Strait, October 6, 1913.

Only 7 specimens of this pretty little *Asterina* were found, so it can not be considered common even at Mer. It was supposed, because of its obvious autotomy and large number of rays, to be *A. wega* Perrier, but comparison with specimens of what I take to be *wega* from Mauritius show it is not that species. It may be mentioned in passing that these Mauritius asterinas agree with Perrier's original description (1869) better than with the later one (1875), for they have, as a rule, 1 spinelet on each adambulacral plate. At Hilo, Hawaii, I collected 2 little Asterinas, each with 6 rays, which are unquestionably of the same section of the genus as *anomala* and *wega*, for the indications of autotomy are obvious. Neither specimen is large enough to satisfy me that it is adult, but the characters of the larger (R = 6 mm.) are sufficiently well defined to show that it is not *wega*, nor do I think it can be properly referred to *anomala*. Until more abundant and more certainly adult material is obtained, however, this Hawaiian species may remain nameless.

Asterina burtonii.

Asterina burtonii Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 289.
Asteriscus cepheus Müller and Troschel. 1842. Sys. Ast., p. 41.
Asterina cephea de Loriol. 1885. Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 69; pl. xxi, figs. 1–5.

(Plate 6, Figure 2.)

The abandoning of Gray's name for this sea-star seems to me quite unjustifiable, even though the type specimen is lost, for in my judgment the original diagnosis is unmistakable when considered in connection with the locality given. I do not know of any other *Asterina* of the western Indian Ocean with which there can be any confusion, and I have not the least doubt in my mind as to what *Asterina* Gray had in hand when he described *burtonii*. Under such circumstances I can use no later name, even if it is accompanied by a fuller diagnosis.

The specimens of *burtonii* that I found at Mer are not perfectly typical, for there are usually more than 3 spinelets on the actinal plates, but the species is so variable in the details of its spinulation I feel no hesitation in referring them to this widespread Indo-Pacific form, known from Mozambique, Zanzibar, and the Red Sea on the west to the Philippines and Torres Strait and far eastward into the Pacific. There are specimens in the Museum of Comparative Zoölogy from the Gilbert Islands, "Baker's Island" (presumably the island of that name near the 174th parallel on the equator) and "Barkly Island" (presumably in the Paumotus!). The smallest specimen found at Mer was nearly

25 mm. across and was notable for its conspicuous coloration (plate 6, fig. 2); the bright colors were lost on preservation and in its present dry condition it is less than 21 mm. in diameter. Two larger specimens were found, nearly 40 mm. across, but they lacked entirely any bright coloration, their greenish-gray dorsal surfaces harmonizing well with the under side of the rock fragments to which they clung. Either *burtonii*, like the West Indian *A. folium*, is very diversified in its coloration, or the adults lose the bright colors of youth as they mature.

Asterina exigua.[1]

Asterias exigua Lamarck. 1816. Anim. s. Vert., *2*, p. 554.
Asterina exigua Perrier. 1876. Rev. Stell., Arch. Zool. Exp., *5*, p. 222 (302).—Koehler. 1910. Indian Mus. Ast., p. 129, pl. ix, figs. 6, 7.

(Plate 7, Figures 6 and 7.)

This little sea-star is very abundant at Erub, but is much less common at Mer, where we met with only a few specimens near the northern corner of the island. At Erub it occurs by hundreds in tide-pools on the western side of the island, far above low-water mark. The upper surface is variegated with several shades of deep bluish-green with an olive tinge. There is great individual diversity in shade, some appearing light from the predominance of light shades of green, while others are very dark. The colors are very fugitive in alcohol and most preserved specimens are the usual brownish-yellow of museum sea-stars. Diversity in number of rays is marked but not excessive; of 558 specimens examined at Erub, 512, or nearly 92 per cent, had 5 rays, 10 had only four, 33, or nearly 6 per cent, had 6, while 3 had 7. Conditions at Erub seem to be very congenial to *exigua*, the individuals often reaching the maximum size for the species; the largest measurements I have found recorded are Fisher's (1919)—R = 20 mm.; r = 14 mm.—but at Erub a number of specimens 35 mm. across were seen. This is much larger than any of the numerous specimens from other localities in the Museum of Comparative Zoölogy collection, few of which are as much as 25 mm. in diameter. It was interesting to watch these Asterinas in the pools as the tide receded, for they were fairly active (for a sea-star!) and kept moving down the surface of the rocks as the water-level lowered. The rate of movement was approximately their own diameter per minute. They did not as a rule remain quietly above the water exposed to the air. The latter, as well as the current of receding water, apparently serves as a stimulus to make them move down a slope.

At Watson's Bay, Port Jackson, this little sea-star is nearly as abundant as at Erub, but I did not see such large specimens there. It is noticeable that, unlike many Asterinas, *exigua* does not occur ordinarily on the under side of rock fragments, but is found fully exposed on the open surface of rocks and ledges, sheltered, however, to some extent in the tide-pools, where the full force of the surf does not reach it.

The distribution of *exigua* is really remarkable. It is known from the shores of South Africa, from St. Paul Island, and from the southern and eastern coasts of Australia; it has not yet been recorded from the northwestern part of the Indian Ocean or Ceylon (Sladen records it from Mauritius and Madagascar, but I know not on what authority, and Bell lists it from the Salomon Atoll); it is found in the Andaman and Nicobar Islands, the Philippines, and Dutch East Indies; Sladen lists it from New Guinea, and there is a good series of specimens in the Museum of Comparative Zoölogy from Espiritu Santo, New Hebrides, which seems to be the easternmost point where it has been found. It would be fair to interpret such a distribution as indicating a southern origin, whence the species has spread northward along the east African coast and northward clear to the Andamans, along the east coast of Australia. Unfortunately, however, it seems probable that *Asterina* originated in the tropics.

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[1] Fisher (1919) accepts Verrill's generic name *Patiriella* for this species but I am not yet convinced of its desirability.

Asterina nuda[1] sp. nov.

(Plate 23, Figures 3 and 4.)

R = 18 mm.; r = 11 mm.; R = 1.64r; entire diameter, tip to tip of alternate rays, about 33 mm. Disk thin, rather flat, but considerably arched in preservation; interbrachial arcs quite distinct, but rays broad, flat, and rounded. Abactinal skeleton as usual in *Asterina*, of more or less imbricating plates, but these plates are nearly or quite naked; here and there, especially along the sides of the rays, one can detect with a lens lines or series of exceedingly minute short spinelets on the free inner margin of the plate, but these are insignificant; even on the plates of the disk margin the spinelets are very inconspicuous. Papulæ numerous but confined to the rays and the very center of the disk. Terminal plate of ray bare, more or less hemispherical, over 0.5 mm. in diameter. Madreporite triangular with rounded corners, about a millimeter along each side, situated less than 2 mm. from the center of the disk. No pedicellariæ.

Actinolateral plates in about 9 or 10 series at interradius, but in only about 6 or 7 near middle of ray, well-defined and very regularly arranged. Each plate carries at its center, which is distinctly elevated, a linear series of 3 to 5 very slender delicate spinelets, more or less united by a very delicate membrane. The plates are otherwise smooth and bare. Adambulacral armature of 2 curved series, one on the furrow-margin, the other on the surface of the plate; marginal series of 7 or rarely 8 very slender spinelets, the middle ones longest, united by a delicate membrane; subambulacral series almost identical, but somewhat more curved. Oral plates large and conspicuous, keeled, smooth, and bare, save for the linear series of 5 or 6 slender spinelets, placed nearly parallel to the outer margin; marginal spinelets, slender, acicular, 8 to 10 on each plate, more or less membrane united, nearly or quite a millimeter long; innermost spine on each plate noticeably the largest, being stouter than the others, though not much longer.

Color in life: upper surface deep pearl-gray, somewhat lighter in interradii and darkest on median part of rays; plates at tip of ray distinctly purple under a lens; marginal plates orange-brown; area around anus bright orange, madreporite white. Lower surface faintly mottled brown-orange and white; tube-feet whitish. Preserved specimen, dull brownish-yellow.

Holotype, M. C. Z. No. 2299; under side of a rock fragment, shallow water, Weier, Murray Islands, Torres Strait, September 30, 1913.

This seems to be a typical *Asterina*, yet quite distinct from any species hitherto described. While it agrees with *leptalacantha* in the nakedness of the upper surface, it differs in nearly every other character and is certainly not nearly allied to that species. It is equally distinct from the other Asterinas of Tropical Australia.

ECHINASTERIDÆ.

Echinaster luzonicus.[2]

Othilia Luzonica Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 282.
Echinaster luzonicus Müller and Troschel. 1842. Syst. Ast., p. 23.

(Plate 10, Figures 2 to 4.)

This is perhaps the most common sea-star of the Torres Strait region, for while it is not nearly so abundant at Mer as *Linckia lævigata*, it is abundant at Thursday Island (along the north shore), where the blue *Linckia* does not occur at all. It was also found at Erub and at Badu. At Thursday Island nearly all the specimens were rusty-red, speckled

[1] *Nudus* = naked, in reference to the smooth, bare condition of the abactinal surface.
[2] See Fisher, 1919, pp. 426 to 435, for a most important discussion of *Echinaster* and *Othilia* and some of their component species.

with blackish, and becoming very dark at tips of rays (pl. 10, figs. 2 and 3). In some specimens the speckling has increased to such an extent that the rusty-red is concealed and the general color is a deep olive-brownish more or less closely approaching black. In all specimens, however, the actinal furrows and more or less space on each side are reddish flesh-color. At Badu the color seemed a little darker than that of most Thursday Island specimens. At Erub and Mer the coloration is very dark, usually appearing black abactinally when in the water. It is not, however, at all purple. When placed in the preserving fluid (formalin+corrosive sublimate), these dark specimens became rusty red. Preserved specimens show great diversity of color, ranging from bright yellow-brown or dull greenish yellow through various shades of brown to almost black; many of the darker specimens have a distinctly reddish cast. There is not in any case a trace of purple.

Great diversity is shown by this species in the number of rays. Of 144 specimens examined at Thursday Island, 80 had 5 rays and 64 had 6. At Mer a 7-rayed specimen was found, and such individuals seem to be common in the Philippines, as there are several from those islands in the Museum of Comparative Zoölogy collection. As a rule, 5-rayed individuals have a single madreporite and 6 or 7 rayed specimens have 2, but occasionally a 5-rayed specimen has 2, while one with 6 rays may have 3. The madreporites are always small, though high and rather conspicuous for that reason. Abnormal arrangements of rays occasionally occur, and 2 found at Thursday Island are of considerable interest. In one of these an extra ray had grown out from the dorsal side of the basal half of a normal ray and overlay it for some distance, though it was both shorter and narrower. A still more remarkable case (plate 10, fig. 4) is that of a ray in a half-grown 6-rayed specimen, which had budded out a new ray on each side near the middle; the ambulacral furrows of the buds are continuous with the main furrow.

The most interesting material obtained at Mer is that which shows beyond question that this *Echinaster* reproduces by autotomy exactly as does *Linckia guildingii.* This might have been inferred perhaps from the irregularity in the number of madreporites and of rays, and the tendency of the latter to be unequal, but evidence has hitherto been lacking. At the Murray Islands, however, six distinctly "comet" forms were collected; the first is a ray 33 mm. long and 6 mm. in diameter, at the broad end of which are 5 rays 1 to 2 mm. long, the lateral largest, the median smallest; a second is a ray 26 mm. long by 5 mm. wide, with 4 rather symmetrical rays 7 to 8 mm. long at its wide end; a third has the main ray nearly 40 mm. long by 6 mm. in thickness and 4 very symmetrical rays 25 to 29 mm. in length; in the fourth, the main ray is 54 mm. by 9, while the 5 budding rays are about 12 to 18 mm. long; in a fifth the main ray is 66 by 11 mm. and the buds are 25 to 35 mm. long by 9 mm. wide; a sixth is less certainly a "comet," but is notable for having 7 rays, the main one 44 mm. by 6 and the others 16 to 37 mm.; the probability that this is not a comet is increased by the fact that the shortest ray is next to the main ray and not opposite. A 7-rayed specimen in the Museum of Comparative Zoölogy collection from the Philippine Islands is more certainly a comet, for here the main ray is nearly 9 mm. in diameter (its distal terminal part seems to have been bitten off), while the 6-budded rays are only about 5 mm. through and are 31 to 35 mm. long. This definite proof of autotomous reproduction in *luzonicus* is important, as the phenomenon is not otherwise known in the Echinasteridæ.

The identification of my Torres Strait material has forced me to face the question of the validity of the five species of *Echinaster* known as *eridanella, fallax, luzonicus, purpureus,* and *vestitus,* for the probability that they all refer to a single species has been increasing with the accumulation of material and knowledge. Fortunately, Savigny's (1809) superb figures of *purpureus* enable us to fix that species perfectly, for Gray himself names those figures in his Synopsis (1866). De Loriol refers specimens from Mauritius to that form and says the color is a very deep red-purple. There are specimens in the

Museum of Comparative Zoölogy from Zanzibar and Mauritius which agree so perfectly with Savigny's figures that I do not hesitate to call them *purpureus*, even though their color is now, after a sojourn in alcohol of half a century, an indistinctive dusky gray. The best of these was examined by Perrier and labeled by him *vestitus*, so I think we can safely relegate that ill-described species to the synonymy of *purpureus*. There seems to be no reasonable doubt that *fallax* is the same thing, as has been generally assumed. In regard to *luzonicus*, it is clear that Gray supposed it to be distinct from *purpureus* and points out its longer rays and its reddish-brown color as marks of distinction. Now, it is obvious, when the Torres Strait sea-star is compared with specimens from Mauritius, that they are not strictly identical, and for the present I think it is best to keep them separate, using *purpureus* as the name for the western form and *luzonicus* for the eastern. As for *eridanclla*, it is undoubtedly a synonym of *luzonicus*. Regarding the generic name, I think it possible that the species of the tropical American seas and those of the Indo-Pacific region are not all *Echinaster* in a strict sense, but I have not been able to find a satisfactory line between *Othilia* and *Echinaster*, so I am not using the former name. Very likely a careful revision of the family will result in the satisfactory definition of each group, with the use of both names.

The differences between *E. luzonicus* and *E. purpureus* may be expressed as follows:

R = 6–7 r and 5.5–6.5 br, with rays terete but stout; adambulacral plates commonly without a subambulacral spinelet near marginal spinelet, so there is a wide bare space, with or without spinelets, along the actinal surface of ray each side of the furrow (well shown in Savigny's figures); actinal spinelets few and relatively large. Color red-purple or deep purple, the color more or less retained or becoming ashy when dry. Found from Zanzibar to the Red Sea and at Mauritius *E. purpureus*

R = 7–10.5 r and 7–10.5 br, with rays more cylindrical and often very slender; adambulacral plates commonly with a distinct subambulacral spinelet, near the margin, so there is no conspicuous bare area on each side of the furrow; actinal spinelets rather numerous and small. Color rusty or red-brown, or in life, dark olive-brown and even almost black, but with no trace of purple; preserved specimens some shade of yellow-brown, brown, or dark red-brown, sometimes with a green cast. Found from Ceylon and the Philippines to northwestern Australia, Torres Strait, New Britain, and even New Caledonia[1] .... *E. luzonicus*

Whether these differences are entitled to be considered specific remains to be determined. They are certainly not as yet perfectly constant or firmly fixed.

About the Torres Strait islands, *Echinaster luzonicus* occurs exposed on sandy or even muddy flats in shallow water, often where considerable "eel-grass" (*Posidonia*) is growing. When removed from the water they contract perceptibly, and water is forced from the anus in a stream 25 to 50 mm. high, reminding one of the ejection of water from the respiratory tree of a holothurian. This naturally suggests that the so-called "rectal gland" is in reality a respiratory organ of much importance.

METRODIRIDÆ.

Metrodira subulata.

Gray. 1840. Ann. Mag. Nat. Hist., *6*, p. 282.—Koehler. 1910. Ast. et Oph. des îles Aru et Kei, p. 284; pl. xv, fig. 3; pl. xvii, figs. 3, 5.—Indian Mus. Ast. p. 172, pl. iv, figs. 1, 2; pl. xviii, fig. 9.

Koehler's very full and well-illustrated accounts of this remarkable sea-star leave nothing for me to add, since we did not meet with it in Torres Strait. The *Challenger*, however, took a specimen near Wednesday Island, and according to Bell the *Alert* collection contained specimens from "Flinders, Clairmont; Alert Island, 7 fathoms." As near as I can interpret these localities, from Dr. Coppinger's notes and other parts of the *Alert*

[1] Bell (1899, p. 138) records (with that brevity on which he frequently prides himself but which is very trying for his colleagues in search of information) both *E. purpureus* and *E. eridanella* in Dr. Willey's collection, but he does not say how he distinguishes the two. This is unfortunate for in at least one case he has identified as *E. purpureus* the very different *Metrodira subulata* (*q.v.*), and I do not think the true *E. purpureus* occurs on the coast of New Guinea or in the islands to the east thereof.

Report, aided by a good map, they are Flinders Island (a little south of latitude 14° S.) and Clairmont Island (north of lat. 14° S.) and either Albany Island near Cape York or the Alert Rocks near the western end of Prince of Wales Channel. If one could feel sure of the identification of the specimens, this would be most interesting. For *Metrodira* seems to be most common in the Bay of Bengal and extends from Ceylon and the Andaman Islands, southeastward to the Aru Islands and Torres Strait. If the *Alert* also found it on Clairmont and Flinders Island, there would be reason to believe it is extending its range through Torres Strait and down the coast of Queensland. But, unfortunately, I can not feel sure that these *Alert* specimens were Metrodiras, for there lies before me indisputable evidence that Bell is not familiar with this sea-star. Among specimens received by the Museum of Comparative Zoölogy from the British Museum in exchange in 1907, and labeled by Bell himself, are two fine Metrodiras from Holothuria Bank, northwestern Australia, which are identified and labeled as *Echinaster purpureus!* In his report on the Echinoderms of northwestern Australia (1894, Proc. Zoöl. Soc., p. 392), Bell lists both *Metrodira subulata* and *Echinaster purpureus* without comment; that there was no sharp distinction between the two in his own mind seems very evident. The larger of the two specimens from Holothuria Bank has R = 70 mm. and would seem to be the largest Metrodira as yet reported. Nothing is recorded of the color in life or of the habits of this sea-star. I follow Fisher (1919) in placing the genus in a family by itself, as I do also in the case of the two following forms, but I can not avoid the fear that we are emphasizing differences too much, rather than relationships, in thus multiplying families.

ACANTHASTERIDÆ.

Acanthaster planci.

Asterias planci Linné. 1758. Syst. Nat. ed. x, p. 823.
Acanthaster echinites Döderlein. 1896. Jena Denksch., *8*, p. 320, pl. xxi, figs. 2–7.
Acanthaster planci Verrill. 1914. Shallow-water Starf. N. Pac. coast, p. 364.

It was quite a surprise to find this extraordinary sea-star at Mer. Only 3 specimens were seen, the largest 400 mm. across. One had only 14 rays, but each of the others had 16. The color in life was bluish-gray with the spines reddish at tip; the change from gray to red is not abrupt but gradual, apparently due to increasing amounts of rusty-red pigment in the skin. In some specimens only the tips of the spines are red, but in others that color extends downward towards or even to the base; if it spread further in the dorsal skin, we should have red individuals, such as those Döderlein records from the Riu-Kiu Islands. The spines of the lower surface are dull reddish-purple and the feet are white or pale yellowish. The disk and the sides and upper surface of arms basally are covered by the dull reddish-purple or brownish papulæ. The entire coloration harmonizes so well with the general coloring of the reef that, in spite of its large size and remarkable spines, this sea-star is very inconspicuous and I doubt not is often overlooked. Those found at Mer were on the surface of the reef and not under rocks or coral slabs. Study of the 31 specimens in the Museum of Comparative Zoölogy from various localities extending from Zanzibar and the Arabian Gulf on the west to the Society and Hawaiian Islands on the east (including Warrior Reef, Torres Strait, as well as Mer) has not enabled me to recognize more than a single species of *Acanthaster*,[1] but I have not seen specimens from Mauritius. Döderlein, however (1896), had six Mauritius specimens, and after comparing with East Indian material, only recognized 1 species. De Loriol's account and figures of the Mauritius form (1885, Mem. Soc. Phys. Hist. Nat. Genève, *29*, No. 4, p. 6, pl. xii) are very important; his colored figure, however, is probably based on a dry specimen.

[1] I have never seen specimens from the western coast of America, where a second species (*ellisii*) occurs, nor would I seem to question the validity of *A. brevispinus* Fisher.

VALVASTERIDÆ.

Valvaster spinifera[1] sp. nov.

(Plate 6, Figure 6; Plate 33, Figures 8 and 9.)

R in life, 55 mm.; in dry specimen, 50 mm.; r in life = 20 mm., dry = 15 mm.; br in life 22 mm., dry, 16 mm. In life, R = 2.75 r or 2.5 br.; dry, R = 3.3 r or 3.1 br. Disk large, rather flat, but slightly elevated; median basal part of each ray higher than center of disk or sides or tip of ray; terminal part of each ray quite flat. Abactinal skeleton closely and irregularly reticulated, the papular areas ill-defined, with 2 to 5 papulæ in a group; sometimes the papulæ appear to be single; skeletal plates more or less distinctly carinate, bearing on the carina (which is straight, curved, or angular) one or more spinelets, a millimeter long, more or less; there are about a hundred spinelets to each square centimeter of surface; a thin but evident membrane or skin covers the entire skeleton, so that in life the spinelets are somewhat sacculate; the membrane is not granular, though there are a few widely scattered granules on it; very rarely a spinelet is replaced by an erect 2-valved pedicellaria with bent tip, the valves rather wider at tip than at base. Superomarginal plates about 16 in each series, not well-defined, except near tip of ray; each distal plate is covered by well-spaced pointed granules, with one larger, thick, blunt spinelet on outer corner; proximally the plates are more spiniferous, with larger spinules and often one or more stout, slightly curved, pointed spines near center; in each series, from 1 to 6 plates have the entire center occupied by the enormous valvate pedicellariæ characteristic of the genus. Terminal plate small, inconspicuous, granulose. Madreporite 2.5 mm. across, rather elevated, about 5 mm. from center of disk.

Inferomarginal plates apparently a little more numerous than those of the upper series (17 to 19); they are similar, but lack the big pedicellariæ, and the presence on them of large spines is most irregular; the distalmost half dozen or so commonly have a big (relatively) conical central spine; near middle of ray there are often 2 big, flattened, bluntly pointed spines on a plate, and basally 2 or 3 such spines are commonly present; but many, perhaps most, of the inferomarginal plates carry no large spines. Actinolateral plates in regular but ill-defined series; proximally there are 4 series, but not even the one adjoining the adambulacrals reaches clear to the tip of the ray; these plates typically carry at the center a broad, flattened, truncate spine, 2 mm. or more in length, and around it 3 or 4 much smaller, sharply pointed spinelets; on many plates, however, the large spine is greatly reduced in size or is quite wanting.

Adambulacral plates with a furrow-series of 5 slender, cylindrical spinelets and a large subambulacral spine; the furrow spines may be subequal or the lateral ones may be more or less noticeably shorter; distally the number drops to 4 and then to 3; the subambulacral spine may be as large, flat, and blunt as the central spine of an actinolateral plate, but often it is much smaller, less flattened, and more pointed; besides it there are a few well-spaced, much smaller spinelets on the surface of the plate, and proximally one of these spinelets may be replaced by a big, erect, 2-jawed pedicellaria, but such pedicellariæ are by no means common. Oral plates each with 9 marginal and 2 or 3 suboral spines, of a size and arrangement comparable to those on the adjoining adambulacrals. Tube-feet in two series.

Color in life, a brilliant and well-nigh indescribable combination of green, purple, red, and white above (pl. 6, fig. 6) and light yellowish with some irregular red markings orally. The dry specimen is dull yellow with blotches and markings of dull red still evident on the upper side and here and there a deep orange-yellow spot, while the lower surface still bears traces of its red markings.

[1] *Spiniferus* = bearing spines, in reference to the spiny character of all the skeletal plates.

Holotype: M. C. Z. No. 2336; underneath a coral slab, on the southwestern reef, Mer, Murray Islands, Torres Strait, October 25, 1913.

The huge marginal pedicellariæ and the brilliant colors combine to make this perhaps the most remarkable sea-star found at Mer. It is obviously closely allied to the only species of the genus previously known, *V. striatus* of Mauritius and Hawaii. It differs from that species not only in the coloration but in the character of the dorsal surface, which shows no indication of regular reticulation and is much more uniformly covered with small spinelets. The furrow spinelets of the adambulacral armature seem to be somewhat differently proportioned and arranged, but without actual comparison of specimens it is hard to know how real this difference is. Specimens of Valvaster are so rare in museums as yet that we know nothing of the extent of diversity within a species. Nor do we know anything whatever as to the geographical distribution of these remarkable sea-stars, save that specimens have been taken at Mauritius and one has been found at the Hawaiian Islands, off the south coast of Oahu, in 14 fathoms.

PTERASTERIDÆ.

Retaster insignis.

Sladen. 1882. Jour. Linn. Soc. Zool., *16*, p. 200.—1889. *Challenger* Ast., p. 482, pl. lxxvi, figs. 3, 4; pl. lxxvii, figs. 11, 12.

This species was found in Torres Strait by the *Alert*, by the *Challenger* and by Semon, and it was therefore a great source of regret to me that we did not meet with it. Döderlein thinks it is identical with *R. cribrosus* of the East African coast, but Fisher has compared specimens of the two species and says (1919) that they seem to him to be perfectly distinct. In any case, however, since Dr. Coppinger, of the *Alert*, took specimens at Port Molle, *Retaster* seems to have extended its range through Torres Strait down the eastern coast of Queensland for some 700 miles at least. I do not believe that the supposed record from Port Jackson is reliable, as Whitelegge has not seen the species there, nor did either the *Thetis* or the *Endeavour* obtain any specimens along the coast of New South Wales. Döderlein lists *Retaster* from Samoa, thanks to a specimen in the Godeffroy Museum, but here too confirmation is needed.

OPHIUROIDEA. BRITTLE-STARS.

The ophiuran fauna of Torres Strait is exceedingly rich, but so many of the species hide themselves in the crannies of corals and of coral rock, they are easily overlooked, and general collectors are apt to pass them by. Thus the *Challenger* naturalists gathered only half a dozen species, and such zealous collectors as Coppinger and Semon did not uncover more than a small fraction of this very interesting fauna. The *Alert* collection contained 9 species, only 1 of which was taken by the *Challenger,* while Semon gathered 14 species, 3 of which were found by the *Challenger* and 5 others by the *Alert.* The only brittle-star common to all three collections is the symbiotic *Ophiomaza cacaotica,* which we also found on several occasions at Mer. Of the other 19 species known from the region in 1913 we found only 8, but we discovered 14 species new to science at the time[1] and 37 others not previously recorded from Torres Strait.

There are, then, no fewer than 71 brittle-stars now known from this restricted area, but I have no doubt many additional species will be found by the next collector interested in the group. Most of the species are found associated with coral, or under fragments on the reef-flat. Little effort has yet been made to collect mud-loving species or those living on "weedy" bottoms, and very few of these forms are as yet known. Of the 71 species, 18 or a full quarter belong to the tropicopolitan genus *Ophiothrix,* the most perplexing group in the whole class. About a third of the 18 species are ill-defined and of more or less doubtful status, and the material at hand, even taken in connection with experience on the Torres Strait reefs, does not enable me to undertake an adequate revision of the genus. The family Ophiocomidæ is represented in the Torres Strait region by 16 species, and in this case sufficient material is at hand to enable me to give a complete revision of the family. But such a revision is much less difficult and much less useful than a revision of *Ophiothrix* would be.

Unlike the sea-stars, brittle-stars are commonly more or less gregarious, and where one specimen occurs others are almost sure to be found. Of the 59 species we collected, about half were common or abundant, and half a dozen of these swarmed wherever conditions were suitable. In most cases, however, a given species occurs only in a particular habitat, and those which occur near the shoreward side of the reef-flat are wanting near the outer edge of the reef. Very few brittle-stars occurred among living corals, but the dead portions of clusters of *Seriatopora* swarmed with individuals of many common species. Every coral fragment or piece of rock large enough not to be moved about by ordinary tides is a shelter for brittle-stars, and if the shelter is large and has been undisturbed for some time, many species will be found together there. Of the brittle-stars which were found but once, it is safe to say all are small, inconspicuous species, living in the crannies of dead corals and rock fragments, and the failure to secure more specimens is as a rule due rather to their secretiveness than to their actual rarity.

[1] See H. L. Clark, 1915. Catalogue of Recent Ophiurans. Mem. M. C. Z., *25,* p. 165–376, pls. 1–20.

A few species, however, as *Ophiocoma pica* and *Ophiomastix asperula*, seem to be really rare, for in spite of their conspicuous character and of special effort being made to find them, very few individuals were found. Brittle-stars are much more active than sea-stars and are much more disposed to avoid bright light. Overturning of their shelter, or breaking up of a coral cluster, leads at once to active flight in the effort to reach another shelter. In activity of movement and ability to escape, the magnificent *Ophiomastix janualis* is *facile princeps*, and the capture of an uninjured specimen requires quickness and skill, much helped by experience.

TRICHASTERIDÆ.

Euryale aspera.

Lamarck. 1816. Anim. s. Vert., *2*, p. 538.—Döderlein. 1911. Japan. Euryalæ, p. 65, pl. 5, figs. 7, 7*a*.

This characteristic East Indian basket-fish ranges from Okinawa, in the Riu Kiu Islands (lat. 26° N.) to Double Island Point, Queensland (lat. 26° S.). The *Challenger* found it near Wednesday Island, in 8 fathoms, but we did not find it near Mer. As it is known from the Aru Islands and is not known from any point on the north coast of New Guinea or east of that island, it would seem to be one of those species which has passed through Torres Strait in the southward extension of its range. Döderlein (1911) lists it from West Australia, no doubt on the strength of Studer's (1884) record of two young specimens taken by the *Gazelle* in 50 fathoms off Dampier's Archipelago. But it must be remembered that these specimens were very young (disks, 5 to 8 mm. across) and neither specific nor generic characters are clearly indicated at such an age.

OPHIACANTHIDÆ.

Ophiacantha confusa.

Koehler. 1905. *Siboga* Oph. litt., p. 59, pl. vii, figs. 9–11.

This species was described originally from a single specimen taken in 20 fathoms at the island of Salibabu, Dutch East Indies, and I refer to it two small ophiacanthas taken from a piece of dead coral far out on the southwestern reef at Mer, October 27, 1913. Koehler's specimen had the disk, somewhat damaged, 3 mm. across and the arms 18 mm. long; the individuals from Mer are of the same size. The spinules of the disk terminate in much longer teeth in the Murray Island specimens than those shown in Koehler's figure, and the ends of the radial shields are not completely concealed. The chief difference, however, is in the basal under arm-plates which are diamond-shaped and not at all oblong, as shown in the published figure. These differences seem to me too trivial to be considered as due to anything more than "individual diversity" in the brittle-stars and the "personal equation" in the observers. In life, the specimens from Mer had the disk pale greenish and the arms banded with lighter and darker brown; the dry specimens are pale brown and whitish, with the banding of the arms barely indicated.

Ophiacantha discoidea.

Lyman. 1879. Bull. M. C. Z., *6*, p. 57, pl. xv, figs. 405–407.

(Plate 12, Figure 4.)

This is another little-known species taken by the *Challenger* in the Arafura Sea, at a depth of 49 fathoms. It was not taken by the *Siboga* and so far as I can discover has not been met with since the *Challenger* found it. We took 4 specimens with a tangle off the west reef at Mer, in 4 to 5 fathoms of water, October 7, 1913. The smallest specimen has the disk less than 2 mm. across and, of course, is not certainly identifiable. The largest (pl. 12, fig. 4) had the disk a little over 5 mm. across in life and the arms about 33 mm. long; dry, the disk is less than 5 mm. in diameter and the arms are all broken. The brown, bluish, and white coloration, so attractive in the living animal, is entirely lost in the dingy, pale brownish preserved specimens. In life, these brittle-stars were quite active, but they did not long survive their capture and transportation to the laboratory. In the largest specimen the thorns surmounting the disk stumps are fewer, longer, and themselves more thorny than in the smaller individuals. This may be a growth-change, but it is so marked that it is more probably indicative of individual diversity. This *Ophiacantha* is easily distinguished from the preceding species by the shorter, smoother, more opaque arm-spines, the larger upper-arm plates, the smaller adoral plates, and the very different disk-stumps.

AMPHIURIDÆ.

Amphiura microsoma.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 228, pl. 5, figs. 5–7.

This is a rather aberrant member of the genus, somewhat allied to *Ophionephthys*, but as only two specimens are known, little more can be said at present. They were taken from a piece of coral brought up on the tangle from 4 to 5 fathoms of water, off the northwestern reef at Mer, October 7, 1913. They lived for some hours at the laboratory and after dark it was noticed that they exhibited a remarkable degree of phosphorescence when irritated.

Amphiura septemspinosa.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 231, pl. 4, figs. 13, 14.

(Plate 13, Figure 3.)

This very pretty little brittle-star was found in a crevice of a coral fragment on the southwestern reef at Mer. The colored figure shown on plate 13 is twice natural size, but shows well the colors in life, save that the general effect is a little redder than was the ophiuran itself. While presumably this specimen was immature, specific characters are already well marked.

Amphiocnida dilatata.

Ophiocnida dilatata Koehler. 1905. *Siboga* Oph. litt., p. 30, pl. xii, figs. 2–4.
Amphiocnida dilatata H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 236.

(Plate 16, Figure 7.)

This interesting and peculiar brittle-star was previously known only from four widely scattered stations in the Sulu Archipelago, Celebes, and the Aru Islands. A single specimen was found at Mer, in a cranny in the corals of the southwestern reef October 23, 1913. The peculiar shape of the arms was noticed in life and the unusual coloration also attracted attention.

Ophionephthys octacantha.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 239, pl. 9, figs. 9, 10.

(Plate 15, Figure 3.)

The pretty coloration of this curious brittle-star has changed greatly since it was first taken. The striking blue bands on the arms have become blackish, and the brown and yellow shades have lost their brightness. The arms were very brittle in life and not one was complete when the specimen was found under a stone on the sand flat southwest of Friday Island, Torres Strait, September 13, 1913.

Amphipholis squamata.

Asterias squamata delle Chiaje. 1828. Mem. Anim. s. Vert. Napoli, *3*, p. 74.
Amphipholis squamata Verrill. 1899. Trans. Conn. Acad., *10*, p. 312.—H. L. Clark. 1904. Bull. U. S. Fish Comm., 1902, p. 560, pl. 6, figs. 33, 34; pl. 7, figs. 43, 44.

The discovery of this cosmopolitan species on the reef-flat at Mer was quite a surprise. It was not common, only four specimens being found altogether, but these are not distinguishable from specimens of the same size from Europe or the United States. The species was not previously known from the Torres Strait region, but it is known from New Zealand and the Kermadecs. Its occurrence at Mer makes one more than ever suspicious of the validity of *A. australiensis*, which I (1909*a*) described some years ago from the coast of New South Wales. There is certainly room for grave doubts in regard to the validity of several nominal species closely allied to *squamata*, and a critical study of the group needs to be made. The specimens found at Mer were discovered under rocks on both the south-eastern and southwestern reef-flats. In one case the brittle-star was on the underside of the rock and in another it was on the back of an Ophiocoma! The latter position was probably accidental, perhaps the result of the currents caused by the overturn of the rock.

Amphiodia brocki.

Amphiura brocki Döderlein. 1896. Jena. Denkschr., *8*, p. 286, pl. xv, figs. 6, 6*a*.
Amphiodia brocki H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 249.

The two specimens on which this species is based were taken by Semon, and, like all his Torres Strait material, were labeled simply "Thursday Island," but the exact locality where they were taken is not known. We found no specimens which could be considered conspecific.

Amphiodia mesopoma.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 247, pl. 6, figs. 11, 13 (*not* 12 and 14).—1918. Bull. M. C. Z., *62*, p. 287, pl. 3, fig. 7.

This is one of the few echinoderms which occur in Torres Strait and also on the southern coast of Australia. Of course, it may be found to have, like *Luidia maculata*, not only a circumaustralian distribution but a northward range throughout the East Indies. Certainly the East Indian species, *ochroleuca*, is nearly related. The only Torres Strait specimen of *mesopoma* which I have seen was taken from under a rock in a few feet of water near shore on the east coast of Badu, November 1, 1913, by my fellow collector, Mr. Frank A. Potts. It is the holotype of the species. My friend Mr. J. Gabriel, of Melbourne, has found what seems to be the same species not uncommon near Westernport, Victoria.

Amphioplus parviclypeus.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 255, pl. 7, figs. 5–8.

The holotype of this well-marked species is unique. It was taken on the underside of a coral fragment in 5 to 6 feet of water, at Badu, November 1, 1913, by Mr. Frank A. Potts.

Amphioplus relictus.

Ophiophragmus affinis Duncan. 1887. Jour. Linn. Soc. Zool., *21*, p. 89, pl. viii, figs. 4–6 (not *Amphiura affinis* Studer, 1885, which is also an *Amphioplus*).
Amphiura relicta Koehler. 1898. Bull. Sci., *31*, p. 68, pl. iv, figs. 37, 38.
Amphioplus relictus H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 256.

A single very small specimen of an *Amphioplus*, 2 mm. across the disk, was dredged by us off Goode Island, Torres Strait, in 2 to 3 fathoms on September 13, 1913. So far as can be determined from so young an individual, it seems to belong to this Indian species. Duncan's specimens were from the Mergui Archipelago, while Koehler's were from the Andaman Islands and the Ganjam coast. But the *Siboga* found the species common at a number of widely separated stations in the East Indies, and its occurrence in Torres Strait is not at all improbable.

Ophiactis delicata.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 260, pl. 11, figs. 9, 10.

It is rather curious that the unique holotype of this species was found on a comatulid (*Comanthus annulatum*) when it was taken from the sea and placed in a bucket. It is probable, therefore, that it is commensal, but although we examined scores of the comatulid, no other examples of the brittle-star were seen. Its nearest allies in the genus seem to be *O. nama* from Fiji and the Kermadecs, and *O. pteropoma* from Japan, but both these species are known only from rather deep water (191 to 610 fathoms).

There is an unfortunate error with reference to the habitat in my original account of this species. By a slip of the pen, the depth "18 fms." is inserted, whereas the comatulid on which this specimen of *Ophiactis* occurred was found far out on the southwestern reef-flat near extreme low-water mark, on October 27, the last day of collecting at Mer. Our only collecting at 18 fathoms was done two weeks earlier by a Japanese diver, when the holotype of *O. luteomaculata* was found.

Ophiactis hemiteles.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 262, pl. 10, figs. 7, 8.

(Plate 16, Figure 1.)

When this handsome brittle-star was extricated from a fragment of coral rock on the southwestern reef at Mer, October 2, 1913, it was supposed to be an Amphiura, and the correct genus was not determined until the specimen was in Cambridge. The long, tapering arms with their numerous, slender arm-spines are most unlike typical *Ophiactis*, but the single large tentacle-scale and the mouth armature are very characteristic. Unfortunately, the specimen autotomously ruptured its arms while the colored drawing was being made and the preserved specimen retains little of its original beauty. The species is an isolated one, not nearly related to any other member of the genus.

Ophiactis luteomaculata.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 263, pl. 11, figs. 7, 8.

(Plate 13, Figure 6.)

Although the holotype was found in a sponge, in 18 fathoms of water, off the northwestern reef at Mer, we found no other specimens anywhere in Torres Strait. But the *Endeavour*, 11 miles southeast of Ballina, New South Wales, in 27 to 29 fathoms, collected a fine series of sea-urchins (*Prionocidaris australis*), among the spines of which this odd little brittle-star seemed to be quite common. The smallest specimens had 6 arms and were clearly reproducing by fission, but the adults were symmetrically pentamerous like the type. The orange-colored radial shields are a good distinguishing mark for living specimens, but unfortunately the color is fugitive and is wanting in preserved material; but a dark spot or band at the middle of the larger arm-spines seems to be a persistent characteristic marking.

Ophiactis modesta.

Brock. 1888. Zeits. f. w. Zool., *47*, p. 482.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xv, figs. 5–5*b*.

This species was originally described from Amboina, but Semon took two specimens of *Ophiactis* near Thursday Island which Döderlein refers to it. We did not meet with it.

Ophiactis savignyi.

Ophiolepis savignyi Müller and Troschel. 1842. Syst. Ast., p. 95.
Ophiactis savignyi Ljungman. 1867. Öfv. Kongl. Vet.-Akad. Förh., *23*, p. 323.—Lütken. 1859. Add. ad Hist. Oph., pt. 2, pl. iii, figs. 7*a*, 7*b*.

This tropicopolitan species is common in Torres Strait, especially in red and yellow sponges. It is less common where sponges are infrequent, but at Mer it was sometimes common in the dead organ-pipe coral (*Tubipora*).

OPHIOTRICHIDÆ.

Ophiothrix belli.

Döderlein. 1896. Jena. Denkschr., *8*, p. 292, pl. xvi, figs. 14, 14*a*.

This species is based on a single specimen from Thursday Island, and as it belongs to the perplexing *longipeda* group, its validity is not unquestionable. We found no specimens to refer to it, and in the vast *Siboga* collection Koehler found none.

Ophiothrix demessa.

Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 82.—Koehler. 1905. *Siboga* Oph. litt., pl. ix, figs. 5, 6.

The discovery of this species at Mer is of no little interest, because it is essentially a Pacific species, the Hawaiian Islands being the type locality. It is known also from the Society and the Gilbert Islands, and even from the East Indies, for the *Siboga* found it at Obi Major and at the eastern end of Timor. Koehler (1907) reports specimens in the Paris Museum from the Red Sea, Madagascar, and the Seychelles.

It is rare at Mer, only two specimens being found there, and both of these were on the southeastern reef-flat under rocks. On December 10, 1913, I found a single specimen on the under side of a rock-fragment on the shore reef near Hilo, Hawaii, and my field-notes on this individual read: "Colors in life: disk gray; arms red and white banded, transversely; general effect red. Much changed in drying. Supposed to be an amphiuroid when taken; habit and habitat most un-Ophiothrix-like."

Ophiothrix dyscrita.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 271, pl. 13, fig. 3.

Although Bell (in Herdman, 1904, p. 150) considers it little less than a crime to describe a new *Ophiothrix* from only immature specimens, it seemed to me better to give a name to the individual on which this species is based than to try to discuss it without any name. It certainly is not identical with any species now known, so far as I can see, and in order that it may have its proper place in this report a name is desirable if not essential. If, when the much-to-be-desired and long-needed revision of *Ophiothrix* is made, *dyscrita* proves to be a synonym, no harm is done by the temporary use of the name. The holotype of *dyscrita* is a very small individual which was found on the same sponge with the holotype of *Ophiactis luteomaculata*, which was brought up by a Japanese diver from 18 fathoms off the northwestern reef at Mer, October 13, 1913. The color in life was pale purple above, whitish beneath. The very long, slender arms, ten times the diameter of the disk, attracted immediate attention, because they contrasted so markedly with the relatively short arms of *O. stelligera*, occurring on the same sponge.

Ophiothrix galateæ.

Lütken. 1872. Ov. Kongl. Danske Vid. Selsk. Forh., pp. 90, 108.

Koehler (1907) lists a specimen of this dubious species as from Thursday Island, but he gives no further data.

Ophiothrix hirsuta.

Müller and Troschel. 1842. Syst. Ast., p. 111.—Duncan. 1887. Jour. Linn. Soc. Zool., *21*, pl. ix, figs. 18, 19 (as *O. variabilis*).

I seriously question the validity of this species. Certainly no adequate distinction between it and *longipeda* has yet been made, and I doubt if any exists. Further study on the reefs of the East Indian region is necessary before we can decide whether *longipeda* is a protean species, different forms of which have received different specific names, or whether there really is a group of nearly allied but distinct species of which *longipeda* is a type. Specimens of *Ophiothrix* regarded as *hirsuta* have been recorded from Zanzibar and the Red Sea on the west to the Riu Kiu Islands and northwestern Australia on the east and south. At Mer, one long-armed *Ophiothrix* was taken, which I identified and have recorded (1915, Mem. M. C. Z., *25*, p. 272) as this species.

Ophiothrix liodisca.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 273, pl. 12, fig. 3.

The holotype of this well-marked species was found on the underside of a coral fragment far out on the southwestern reef at Mer, on the last day of our stay, October 27, 1913. The remarkably flat and smooth disk is a striking feature and the coloration is also notable. The pattern is well shown in the dry specimen and is more conspicuous than it was in life; the ground-color is pale olive, the distal tips of the radial shields with white markings; upper surface of arm with a narrow, median, pale-brownish stripe, bordered on each side with a broader white stripe which is bounded on the outer side with a narrow dark-olive line. The striped arms were not noted as such in the fresh specimen, my field-notes saying only: "Coloration very delicate; orange markings on upper surface of arms when seen through a lens."

Ophiothrix longipeda.

Ophiura longipeda Lamarck. 1816. Anim. s. Vert., *2*, p. 544.
Ophiothrix longipeda Müller and Troschel. 1842. Syst. Ast., p. 113.

(Plate 15, Figure 5; Plate 33, Figure 1.)

It is odd that this, one of the longest-known, commonest, and most conspicuous members of the genus, has never been figured hitherto. I have therefore thought it well to show the general appearance of a dry specimen, as photographed (pl. 33, fig. 1). The colored figure given by Herklots (1869, Echinod. peintes d'après nature, pl. 7) is so unlike any specimen of *longipeda* I have seen, either living or preserved, that the identification of his original seems to me dubious.

I first saw *longipeda* alive August 5, 1913, on the reef at Papeete, Tahiti, where it is very common; my field-notes say the colors in life were pale olive-green and brownish, and that they changed in alcohol. At Green Island, near Cairns, Queensland, large specimens similar to those at Tahiti were common, September 6, 1913. At every place where we collected in Torres Strait *longipeda* was common, living under or in the fragments of coral rock. It is extraordinary into how small a cavity the long arms can be crowded. In the largest specimen noted, the disk was 37 mm. across in life, and the arms were about 625 mm. long, but not many individuals are so large, the average size for an adult being 20 to 30 mm. across the disk with arms 400 to 500 mm. in length. The coloration of the Torres Strait specimens was fairly constant, variegated yellowish and purplish, with dark under arm-plates and upper arm-plates speckled with bluish-purple. The blue and purple shades are apt to be emphasized by alcohol, but some individuals are very distinctly purplish-blue in life. In typical specimens the arms do not show any longitudinal stripes. The amount of yellow varies a good deal in different individuals and is sometimes so great as to be very striking; one such specimen was found near the close of our stay at Mer and was drawn by Mr. Grosse (pl. 15, fig. 5).

It is very desirable that the growth-changes of this species should be worked out, but the material collected at Mer in September and October 1913 is not adequate for the purpose. The extent of individual and of geographical variation in arm-length and color also needs much more extensive study than has yet been possible. When this has been satisfactorily done, I believe *longipeda* will be regarded as the type of a genus, distinct from *Ophiothrix* proper, and containing several species. Meanwhile, the specific limits of *longipeda* itself are not at all definite. It seems to be a protean form of very extended range, since it is reported from the east coast of South Africa, northward to the Persian Gulf and eastward to the Society Islands. Oddly enough, it does not occur at the Hawaiian Islands, nor do I know of any specimens from Samoa. The northernmost locality is Kominato, Japan, and the southernmost records are from Natal, and Port Curtis, Queensland.

Ophiothrix martensi australis subsp. nov.

(Plate 15, Figure 4.)

The specimens of *O. martensi* which I found at Mer and at Thursday Island show a very distinctive type of coloration by which they are readily distinguished from specimens from the Philippine Islands (the type locality) and East Indies. With 6 Australian specimens at hand and 15 from the Philippines, the differences have been carefully weighed, and it seems desirable that the Australian form should, for the present at least, bear a subspecific name. I have accordingly selected one indicative of its geographical relationship. Excellent photographs of *australis* are given by Döderlein (1896, Jena. Denkschr., *8*, pl. XVI, figs. 13, 13*a*), based on a specimen from Thursday Island. If these photographs and the colored figure given herewith (pl. 15, fig. 4) are compared with Lyman's original figure (1874, Bull. M. C. Z., *3*, pl. IV, fig. 10), the character by which the two forms are distinguishable will be seen at a glance. In typical *martensi* there is a deep blue-purple longitudinal median line on the upper side of the arm, bordered on each side by a broader white or light-colored band or area. Judging from living specimens of *australis*, this lighter color is in life orange or orange-yellow, but all trace of yellow is lost either in alcohol or on drying. On the lower surface of the arm in typical *martensi* is a median longitudinal light stripe, presumably yellow or orange in life, of greater or less width, often more or less interrupted and broken. Now, in the southern form, the light (yellow or orange) stripes both above and below are so broken and irregular as to give a very different appearance. In typical *australis* (pl. 15, fig. 4) the two halves of each upper arm-plate are of contrasting colors; if the right half of one plate is purple or deep indigo, the left half of the same plate and the right half of each adjoining plate is orange, and vice versa. Hence we have striking alternation of purple and orange (more or less bleached in preserved material) for a greater or less distance on the arm. Similarly on the ventral surface, instead of a median line or band of yellow, we find the two halves of each plate of alternating and sharply contrasting colors. In no specimen of *australis* that I have seen is the alternation of colored plate-halves perfect; another form of alternation also occurs in which alternate, *whole* plates contrast, and all our specimens show more or less of an irregular combination of these two forms. The specimen from which Mr. Grosse's figure (pl. 15, fig. 4) was drawn is one of the most typical, but many plates are unicolor, though purple and light almost always alternate. The difference, then, between *martensi* and its sub-species *australis* may be expressed thus: in *martensi* the colors tend to a definite longitudinal arrangement, while in *australis* they tend to a transverse arrangement in which the two contrasting colors are apt to alternate on the two sides of the arm. All of the East Indian and Philippine specimens are distinctly typical *martensi*, while our 6 Australian specimens are clearly *australis*.

The *Alert* took *martensi*, according to Bell, at Port Curtis, Queensland, and Port Darwin, Northern Territory, as well as at Thursday Island. He refers to the diversity of color shown, commenting on a dark and a light form. These dark and light forms occur in both typical *martensi* and in *australis*, and are probably due simply to the extent to which the purple (or dark-colored) pigment is developed. They may perhaps be associated with age or with food.

Mr. Lyman records *martensi* as taken by the *Challenger*, "August 7, 1874," and hence somewhere among the Fiji Islands. It would be interesting to know whether these specimens are typical or whether they belong to the subspecies. To judge from Bell's comments on them in the *Alert* Report (p. 141) they are typical, but as he says nothing about the upper surface of the arms, it is not certain.

This very handsome brittle-star was rare at Mer, only 3 small specimens being found. At Thursday Island 2 large specimens with disks 10 to 12 mm. across were taken. The ground-color in life may be deep olive green or purple and the markings are orange, but in alcohol or on drying all traces of the orange disappear, green also tends to vanish, and the purple becomes more or less accentuated. In habits, *martensi* is secretive, all the specimens taken being dug out from crevices and cavities in the coral rock.

Ophiothrix melanogramma.

Bell. 1884. *Alert* Rep., p. 145.

No one seems to have met with this fine species save Bell, who, besides describing it originally from Prince of Wales Channel, Torres Strait, later (1894) listed it from northwestern Australia (36 fathoms) and from Macclesfield Bank (35 to 41 fathoms). It seems odd, in view of this distribution, that the *Siboga* failed to find the species anywhere in the East Indies. Bell has given no figures, nor does he even mention the size of the specimens he has studied.

Ophiothrix melanosticta.

Grube. 1868. Jahrsb. Schles. Ges. Vaterl. Cultur, *45*, p. 45.—Koehler. 1905. *Siboga* Oph. litt., pl. viii, figs. 4–6; pl. xiv, fig. 3.

On September 13, 1913, we dredged near Goode Island, Torres Strait, in 2 to 3 fathoms, a little brittle-star about 2.5 mm. across the disk, which is perfectly tetramerous. The colors in life were bright green and red, and the specimen was prettily variegated, but after death the shades rapidly became paler and duller, and there is little evidence now of the former beauty. The characteristic brown spots or dots are still well marked, however. The Museum of Comparative Zoölogy has a larger specimen, about 4 mm. across the disk and with arms about 20 mm. long, from Borneo, in which the green tints as well as the brown spots are still evident, but the red has entirely faded. The *Siboga* found *melanosticta* at 7 stations in the East Indies, some of the specimens having a disk diameter of 10 to 11 mm. Bell reports (1894) the species from northwestern Australia in 38 fathoms, and Koehler (1907) lists it from Port Hedland, West Australia, but it has not previously been known from Torres Strait. The type locality is China Sea, but Bell did not find it among the ophiurans from Macclesfield Bank.

Ophiothrix nereidina.

Ophiura nereidina Lamarck. 1816. Anim. s. Vert., *2*, p. 544.
Ophiothrix nereidina Müller and Troschel. 1842. Syst. Ast., p. 115.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xvi, figs. 16, 16*a*.

(Plate 15, Figures 2, 8, and 9.)

The beautiful and very characteristic coloration of this lovely brittle-star can be better appreciated from the figures given than from any detailed description. The young individuals (pl. 15, fig. 8) have the pattern of coloration on the disk (fig. 9) much more sharply defined than do older ones (fig. 2). There is relatively little color diversity in the species, the only variations I have noted being in the exact shades of red, yellow (or whiteish), and blue, and in the relative proportions of these three colors. The species is common all through the East Indies, but does not seem to occur in the Pacific. It reaches the Maldive Islands and Réunion on the west, Misaki, Japan (where Matsumoto, 1917, reports it as common) on the north, and Fraser Island, Queensland, on the south. At the Murray Islands it was common, and as it was easily recognized on the reef, I noted that far out on the southwestern reef it was often associated with comatulids. It was commonly found in and among living corals or in the crevices of large coral fragments. It is noteworthy that neither the *Alert*, the *Challenger*, nor Dr. Semon found this species in Torres Strait, nor did we find it anywhere but at the Murray Islands. It is, however, common at the Aru Islands.

Ophiothrix propinqua.

Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 83.—Koehler. 1898. Bull. Sci., *31*, pl. 3, figs. 20–22.

This species has a wide range, from Zanzibar to the Gilbert Islands, and is common all through the East Indies. It occurs at Sharks Bay, northwestern Australia. The specific characters are well-marked, but show some diversity, and there is considerable diversity in color, especially in the amount of reddish brown shown by the living animal. On the reef-flats at Mer *propinqua* was quite common, but not at all abundant. It is very secretive and is generally found concealed in some cranny or cavity of a coral-rock fragment. In life it may easily be confused with small specimens of *O. longipeda*, but it seems always to lack the purple spotting of that species, and ordinarily the arms are very much shorter.

Ophiothrix punctolimbata.

Von Martens. 1870. Arch. f. Naturg., Jhrg. 36, *1*, p. 257.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xvi, figs. 18, 18*a*.

This is a species with which I have never met, nor does Mr. Lyman seem to have ever seen specimens he could refer to it. De Loriol, Döderlein, and Koehler all think it is quite distinct from *longipeda*, but it seems to me of doubtful validity. Bell (1884) reports it from Port Curtis, Port Molle, Thursday Island, Prince of Wales Channel, and Warrior Reef, and Döderlein (1896) records a specimen taken by Semon at Thursday Island. The *Siboga* took five specimens in the East Indies, which Koehler assigns to *punctolimbata*, and Matsumoto (1917) records one Japanese specimen. More field-work and much larger series of specimens are necessary before the real status of this species and *hirsuta* can be settled.

Ophiothrix rhabdota.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 278, pl. 13, fig. 4.

(Plate 15, Figures 6 and 7.)

This species is of very doubtful validity, as it is very near *longipeda*, and it is improbable that the stripes on the arm will prove a sufficiently constant mark of distinction. We took the first specimen at Erub, September 18, 1913, but later found a number of similar individuals at Mer. The yellow stripes, so well shown in figure 7, plate 15, are an easy recognition mark fairly well kept by preserved material.

Ophiothrix rotata.

Von Martens. 1870. Arch. f. Naturg., Jhrg. 36, *1*, p. 258.

This is a species of which very little indeed is known. Zamboanga, Philippine Islands, is the type locality, but it can not be commonly or widely distributed in the Philippines, since the *Challenger* did not meet with it, nor are there any specimens in either the Semper or Griffin collections in the Museum of Comparative Zoölogy. The *Siboga* failed to find it in the East Indies, and the only records of its occurrence anywhere since it was described, that I have found, are those of Bell. In the *Alert* Report he discusses three specimens from Thursday Island, though he is not very sure of two of them, and ten years later (1894) he lists with a question mark a young specimen from Macclesfield Bank. It is perhaps important to note that whereas von Martens' type had the arms *five* times the disk diameter, the Thursday Island specimen which Bell refers "without doubt" to the same species had the arms *twelve and a half* times the disk diameter. One wonders that the validity of the identification could be "without doubt" in the face of this remarkable discrepancy, especially as the arm-spines were also noticeably different. On the whole I think *rotata* must be considered a dubious species and its occurrence in Torres Strait very uncertain.

Ophiothrix stelligera.

Lyman. 1874. Bull. M. C. Z., *3*, p. 237; pl. iii, figs. 15-20.

(Plate 16, Figure 8.)

This species ranges from Zanzibar to Fiji, and according to Koehler (1907) it extends as far south on the western coast of Australia as Koombana Bay. It is common at the Aru Islands. As even adults rarely exceed 8 mm. in disk diameter and the growth-changes are not yet worked out, it is probable that some records are erroneous. The species characters are not well-marked or very constant and confusion with other species has unquestionably occurred. Both the *Challenger* and Dr. Semon took specimens in Torres Strait, referred to *stelligera* by Lyman and Döderlein respectively. At Mer a number of examples of an *Ophiothrix* were taken which agree well with each other and fairly well with the type of *stelligera*, except in color. Rather more than half of these were found on sponges brought up by the Japanese diver from 18 fathoms off the northwestern reef, October 13, 1913. These specimens were of a pinkish color with a median white stripe on the dorsal side of each arm; a few were pale purple instead of pink. All of the other examples referred to *stelligera* were found among the coral fragments on the southwestern reef. In them the disk was reddish or yellowish (pl. 16, fig. 8) or dull greenish, and the arms were pale purple with slightly reddish spines, or dull purplish or greenish. In the dry specimens, red and pink tints are entirely lost, and pale brownish or dull purplish, light or dark, are the prevailing shades.

Ophiothrix striolata.

Grube. 1868. Jahrsb. Schles. Ges. Vaterl. Cult., *45*, p. 45.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xvii, figs. 22, 22*a*.

(Plate 15, Figure 1.)

This handsome species is well known from the East Indies, and was taken in Torres Strait by both the *Alert* and Dr. Semon. Döderlein says the latter brought many specimens from Thursday Island. Koehler (1907*a*) lists *striolata* from as far south on the West Australian coast as Fremantle. We did not find the species at Mer, but one small specimen was taken from under a stone on the sand-flat southwest of Friday Island, September 13, 1913. This individual was so prettily colored with green and brown that Mr. Grosse made a drawing of it (pl. 15, fig. 1). On being treated with formalin and corrosive sublimate and then dried, the colors underwent a remarkable change, the brown becoming purple and the green yellow. With the lapse of time these shades have altered still further and the specimen is now whitish and deep blue, as are all the other specimens of *striolata* in the Museum of Comparative Zoölogy. So far as I know, this striking difference between the colors in life and after preservation has not previously been noted; it is more marked in *striolata* than in any other *Ophiothrix* with which I am acquainted.

Another very notable and puzzling feature of this species is the presence in young specimens of a membrane on the arm-spines on the basal part of the arm, as in *Ophiopteron*. The degree to which this membrane is developed differs in different individuals; it is often very thin and easily ruptured, but it may be as thick and as complete as could be asked. I think *Ophiopteron puncto-cæruleum* Koehler, of which a cotype is in the Museum, is based on the young of *Ophiothrix striolata*, but there is not sufficient material at hand to permit a final decision. If such should be the case, the status of *Ophiopteron* and its relation to *Ophiothrix* would require a careful investigation. As usual in such cases, abundant material of all ages is urgently needed.

Ophiothrix trilineata.

Lütken. 1869. Add. ad Hist. Oph., pt. 3, pp. 58 and 100.

(Plate 16, Figures 4 to 6; Plate 33, Figures 4 and 5.)

It is a remarkable fact that this brittle-star, one of the most abundant and characteristic inhabitants of the reef-flats at Mer, was not taken in Torres Strait by the *Alert*, the *Challenger*, or Dr. Semon, nor did we find it at Thursday Island or Badu. It does not seem to occur in the Aru Islands, as Merton failed to find it there. It has not been found on any part of the Australian coast, though Bell (1894) reports it from northwestern Australia in 20 to 35 fathoms. Yet it ranges right across the Indian Ocean from Mozambique, Zanzibar and Mauritius (where it is common) to and throughout the East Indies and eastward at least as far as Samoa.

At Mer it occurred generally among living corals, and particularly in the dead basal portions of colonies of *Seriatopora*. It literally swarmed in such situations, and when these colonies were broken apart the activities of these beautiful brittle-stars were most interesting. There is much individual diversity in color, spinulation, and proportions, yet the specific characters are remarkably constant, and rare indeed is a specimen the identification of which need give any trouble. As regards the spinulation of the disk, the diversity is only in the number and the length of the spinules; these may be very few or there may be quite a number, but they are never crowded and are usually widely separated; they are sometimes rather short and sometimes very long (¼ to ½ disk diameter), but they are always slender, smooth, and acute; aside from them, there are no thorns, stumps, grains, granules, or spinules of any kind on the disk.

In color there is wonderful variety, but in the presence of 3 light stripes and 2 (or 4) very dark stripes on the upper side of each arm there is extraordinary constancy; occasionally, on the basal part of the arm, the stripes become irregular and broken and transverse markings become prominent (plate 16, fig. 4), but examination with a lens of the distal part of the arm, especially if there be a regenerating tip, reveals the characteristic stripes. There is much diversity as to the relative width of the stripes. The usual typical appearance is well shown in figure 6, plate 16, but sometimes the light stripes are much narrower than the dark ones, or, on the other hand, the median light stripe is sometimes so expanded that it occupies most of the upper surface of the arm. As a rule, the light stripes are white, cream-color, or pale yellow, but often, especially when the median stripe is greatly expanded, they become yellow or even orange. In one young specimen the whole upper surface of the basal part of each arm was bright orange. The ground-color of disk and arms is usually green of some rather deep shade, but it may be purple or blackish. The arm-spines are usually tinged with green or purple, but not rarely are bright red (pl. 16, figs. 5 and 6). Red, orange, and yellow are very fugitive colors and rarely show at all in preserved specimens. The latter are commonly deep blue, deep purple, or deep greenish, with sometimes markings of white or whitish on the disk, besides the whitish stripes on the arms. The ground-color may be light bluish, purplish, or grayish, especially in old dry specimens. The character of the disk, combined with the stripes on at least the distal part of the arm, makes the identification of even poor specimens easy.

Ophiothrix virgata.

Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 82.—Koehler. 1904. Mém. Soc. Zool. France, *17*, p. 80, figs. 36–40.

The discovery at Mer of this rare brittle-star is of no little interest, for since the holotype was described from the Gilbert Islands, the specimen collected at Amboina by Brock seems to be the only individual that has been found. Only three individuals were taken at Mer. One of these is young, with the disk not 5 mm. across, but the other two are large adults, one with the disk 9 mm. and the other 11 mm. across. The arms are in no case perfect, but seem to be 8 to 10 times the disk diameter. The field-notes on the three specimens are as follows:

"Radial shields small, bare. Yellow stripe on arm, interrupted every few plates by red transverse band (*i.e.*, every fourth or fifth plate is red). General color greenish-yellow, not bright; most under arm-plates have a small dusky spot at center.

"Radial shields bare; rest of disk thickly covered with rather stout spines; arms rather long, with a broad yellow stripe above and also below.

"Disk red-brown; arms about 8 to 9 × disk, dull olive regularly banded with darker; under a lens the radial shields are seen to be bordered with white, with a black border inside it; the yellow stripes on each surface of arm very prominent; there are yellow markings also on each side of each upper arm-plate."

In the dry specimens, the red and yellow shades have entirely disappeared and even the olive is only faintly indicated. The general coloration is simply variegated blue and white, with a conspicuous longitudinal white stripe on the arm. The affinities of *virgata* seem to be with *hirsuta*, *punctolimbata*, etc., but its specific characters appear to be constant. The specimens taken at Mer were found underneath rock fragments on the reef-flat at widely separated points.

Ophiomaza cacaotica.

Lyman. 1871. Illus. Cat. M. C. Z., No. 6, p. 9, pl. i, fig. 15.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xvii, figs. 26, 26*a*.

(Plate 16, Figure 3.)

This very interesting brittle-star was not common at Mer, only two typical specimens being taken. One of these was almost black, but was commensal with a bright-red *Comatula purpurea*, while the other corresponded very closely in color to the nearly black *Comanthus annulatum* on which it was found. A small specimen of the variety *picta*, characterized by the presence of white in the color pattern (pl. 16, fig. 3), was found on a dark specimen of *annulatum*. After watching these few specimens and those of *O. obscura*, as we saw them on the comatulids and in the laboratory, I have no doubt whatever that *Ophiomaza* is normally commensal with comatulids, is particularly adapted to the life, and does not occur apart from comatulids, except as the result of accident or possibly while passing from one to another. I doubt whether such passing occurs, however, so long as the protecting crinoid is living and healthy.

The distribution of *cacaotica* is very wide, as it is known from Zanzibar and the Gulf of Suez to New Caledonia. Bell records it (1884) from Port Molle, Queensland, and (1894) from northwestern Australia, 8 to 20 fathoms. It has been taken in Torres Strait by each of the four collecting parties that have been there. But excepting our observations at Mer, nothing seems to have been reported as to the comatulids with which it has been found.

Ophiomaza cataphracta.

Lütkenia cataphracta Brock. 1888. Zeits. f. w. Zool., *47*, p. 522.—Koehler. 1904. Mém. Soc. Zool. France, *17*, p. 114, figs. 92, 93.
Ophiomaza cataphracta H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 283.

The unique holotype of this interesting species is said to have been from Cape York, Australia.

Ophiomaza obscura.

Ophiocnemis obscura Ljungman. 1867. Öfv. Kongl. Vet.-Akad. Förh., *23*, p. 333.
Ophiomaza obscura Lyman. 1874. Bull. M. C. Z., *3*, p. 233.

(Plate 16, Figure 2.)

Three individuals of this handsome species were found on specimens of *Comanthus annulatum*, and the largest and most finely colored was chosen to illustrate the species (pl. 16, fig. 2). The other specimens were darker and duller and there were no markings.

In the dry material, the markings on the specimen figured have entirely lost their yellow color and are dirty whitish, while the ground-color no longer has a yellow tinge but is dull blackish-brown. The type locality for *obscura* is Singapore, and the only other record I have found is Bell's (1894) from northwestern Australia, 9 fathoms. There is a specimen in the Museum of Comparative Zoölogy from Port Galera, Mindanao, Philippine Islands, which is 18 mm. across the disk; the color is uniformly nearly black.

Ophiothela danæ.

Verrill. 1869. Proc. Boston Soc. Nat. Hist., *12*, p. 391.—Döderlein. 1896. Jena. Denkschr., *8*, pp. 297, 486, pl. xvii, figs. 25–25*b*; pl. xxxvii, figs. 3–3*c*.

Döderlein has referred to this species the Ophiothelas collected by Semon on gorgonians in Torres Strait, expressing himself as doubtful regarding the validity of the various 6-armed species which have been described. The question he has raised requires the careful study of more material than is at present available, but I am inclined to think the genus contains at least half a dozen valid species. Koehler (1905), however, is strongly inclined to Döderlein's view and is particularly sure that *danæ* and *isidicola* are identical, as de Loriol (1894) long ago suggested, while Matsumoto (1917) holds that there is no doubt of the identity of *danæ*, *isidicola*, and *verrilli*. Whether the specimens from Torres Strait, which Döderlein has referred to *danæ*, are really that form can not be positively settled from the photographs, but at least they do not seem to be the following species. The Fiji Islands are the type locality for *danæ;* it is also recorded, however, from the East Indies, Philippines, and southern Japan.

Ophiothela hadra.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 284, pl. 14, fig. 2.

(Plate 13, Figure 5.)

The holotype of this species was found on a sponge brought up by the Japanese diver from 18 fathoms off the northwestern coast of Mer. Its appearance in life was very markedly different (pl. 13, fig. 5) from that of the preserved specimen, as the yellow and green tints have quite disappeared; the disk is now nearly white, with several pale rose-colored blotches, and the arms are banded with dull gray and reddish.

Aside from this specimen taken at Mer, the only specimens of *hadra* known are those taken by the *Endeavour*, 11 miles southeast of Ballina, New South Wales, in 27 to 28 fathoms. These swarmed on the big spines of the sea-urchin *Prionocidaris australis*, and in their dry condition are notable for their pink and blue coloration. It is hard to believe that in life the prevailing colors should have been yellow and greenish.

Ophiophthirius actinometræ.

Döderlein. 1898. Jena. Denkschr., *8*, p. 486, pl. xxxvii, figs. 4–4*c*.

This curious little brittle-star was discovered among the cirri of *Comatula solaris* brought from Thursday Island by Semon. As we did not find *solaris* in Torres Strait, we were disappointed in not finding *Ophiophthirius*. Matsumoto's (1917) suggestion that the genus may be based only on very young specimens of *Ophiomaza* seems to me a good one and I believe that such will ultimately prove to be the case.

OPHIOCHITONIDÆ.

Ophionereis porrecta.

Lyman. 1860. Proc. Boston Soc. Nat. Hist., *7*, p. 260.—1865. Illus. Cat. M. C. Z., No. 1, p. 147, figs. 14, 15.

(Plate 12, Figure 6; Plate 33, Figures 2 and 3.)

The distribution of this fine brittle-star is very remarkable and the limits are still undetermined, but there is no doubt that the types came from the Pacific Ocean, although in the original description, after stating that the label has been lost, Mr. Lyman gives "Florida?" as the locality. Later he became convinced that the specimens were from the Pacific, and Verrill (1869) pointed out that they undoubtedly came from Hawaii. Certainly the species is common at the Hawaiian Islands. At Hilo, December 8, 1913, I took a number of specimens from under rocks on sand in shallow water; these were large adults, 10 to 15 mm. across the disk, with arms 90 to 135 mm. long; the color is very complexly variegated buff, brown, and blackish, the darker shades predominating and the arms distinctly banded; the bands, however, are neither sharply defined nor regularly spaced. There are similar but smaller specimens in the Museum of Comparative Zoölogy from Fiji, in which the ground-color is grayish rather than buff, and we also have specimens from the Philippines and one from Mauritius which, although not full grown, seem to be *porrecta.* Furthermore, we have specimens from Natal and from near East London, Cape Colony, which differ from typical *porrecta* only in the much coarser scaling and larger radial shields. It may be that this South African form should be regarded as a different species, but as very small specimens from Hawaii have a relatively coarse scaling, I hesitate at present to give them a distinctive name. More material from Mauritius and the African coast is needed before the matter can be settled. De Loriol does not list *porrecta* from Mauritius, and our specimen was originally labeled *dubia.* It must be granted that small specimens of *porrecta* and large ones of *dubia* are not always to be distinguished at a glance. Aside from the difference in disk-scaling, however, which is not always well-marked, the greater width and lesser length of both upper and under arm-plates in *porrecta* is quite distinctive. Matsumoto's (1917) figures of *porrecta* may well be compared with Savigny's (1809) of *dubia.* Matsumoto records *porrecta* from the Riu Kiu Islands and there are also reliable records from Ceylon and the Maldives. Merton, however, did not find it at the Aru Islands and it must be rare in the East Indies, for the *Siboga* found only two young specimens, which Koehler (1905) refers doubtfully to *porrecta.* It is not known from the Torres Strait region nor from anywhere on the Australian coast. It was therefore a surprise to find it not rare at Mer, where we took a number of specimens from crannies in blocks of coral rock or from the sand underneath them, on the southwestern reef. These individuals are much lighter colored (pl. 12, fig. 6) than specimens from Hawaii, as the buff tint predominates in preserved material. It will be noted that in life there was a marked greenish tinge to the disk and the variegation of the arms is made up of light brown, blackish, and white. Few specimens show any such symmetrical pattern on the disk as the one figured. Two of the specimens taken at Mer resemble those from South Africa in one noticeable particular; the arms are strongly tinged with dull purple or purplish red. This makes them look quite different from the rest, but I fail to find any other peculiarities. The tinge is not nearly so reddish as in the South African specimens and is duller.

Ophionereis semoni.

Ophiotriton semoni Döderlein. 1896. Jena. Denkschr., *8*, p. 288, pl. xv, figs. 8, 8*a*.
Ophionereis semoni Koehler. 1905. *Siboga* Oph. litt., p. 54.

In my Catalogue of Recent Ophiurans (1915*a*) I listed specimens of *Ophionereis dubia* in the Museum collection from Torres Strait and Queensland. I included also under the same name a brittle-star from Japan. Matsumoto (1917) has suggested that the Japanese specimen is not *dubia* but a young *Ophiocrases marktanneri.* This suggestion led to a reëxamination of all the material at hand supposed to be *dubia,* with the result that I think Matsumoto is correct and my specimen from Japan had best be referred to *Ophiocrases,* although the generic character is very faintly indicated. Furthermore, the specimens from Torres Strait which I had identified as *dubia* agree exactly with *O. semoni,* and I therefore concluded those two species were identical. I was further influenced to this decision by Koehler's identification as *semoni* of all those *Siboga* ophionereids which I should have called *dubia,* and by Bell's identification as *dubia* of the *Alert's* ophionereids from Torres Strait. But on critical comparison of *dubia* from Mombasa and the Red Sea with specimens from

Torres Strait and from the Philippines, I find the truth is that Döderlein's species is perfectly valid and can be readily distinguished from *dubia* by the skin-covered adorals and the shape of the arm-plates. In *semoni*, the disk-scaling is reduced to a minimum and the soft skin of the oral side not only conceals or at least obscures the outlines of the oral shields and adoral plates (even in young dried specimens), but it softens, and may even obscure the outlines of the basal under arm-plates. In *dubia*, the basal under arm-plates, oral shields, and adoral plates are well-defined and there is no evidence of a thick skin. In *semoni*, the upper arm-plates are *relatively* long and narrow, while the proximal lateral angles are approximately 60° to 70° (see Döderlein's fig. 8*a*), but in *dubia* these plates are shorter and wider and the lateral angles are about 45° to 50°. In *semoni* the under arm-plates are markedly bell-shaped, much wider distally than proximally (see Döderlein's fig. 8), while in *dubia* they have nearly parallel lateral margins. These differences seem to me ample to distinguish the two species, but they do not warrant a generic difference and therefore, like Lütken and Mortensen (1899) and Koehler (1905), I reject Döderlein's proposed genus *Ophiotriton*. The degree of development of the scales in the disk skin in *dubia* shows considerable diversity; in some dry specimens, scales are well-developed and show clearly under a lens, while in other cases they are small and hard to make out. So, too, in *semoni*, while the scales are usually so small and so embedded in the skin that they can be detected only with a microscope, in some well-preserved specimens they are more easily visible.

It is evident, then, in the light afforded by the material at hand, that in Torres Strait we have an *Ophionereis* quite distinct from the Indian Ocean species *dubia*. A specimen I took at Green Island near Cairns, Queensland, is undoubtedly *semoni*, as are specimens we collected at Friday Island and Badu. The last is a fine specimen with disk 7mm. across and arms 40 mm. long. The Torres Strait specimens are variegated with dull green and cream-color or whitish, but the one from Green Island is pale yellowish and dull light purple. In all cases the arms are distinctly banded. These brittle-stars were found under rock fragments on sand. It is notable that not a single specimen was found at Mer. Of course, the ophionereids taken by the *Alert* and listed by Bell, without comment, as *O. dubia*, are really *O. semoni*.

The range of *semoni* to the north and west is doubtful because it is evident that Koehler has not clearly distinguished it from *dubia*. In his report on the littoral ophiurans of the *Siboga* he lists *semoni* from 9 stations and makes no reference to *dubia*. But his figures (pl. VI, figs. 7, 8) show conclusively that they were made from a specimen of *dubia*. As our Philippine specimens are *dubia*, and most of the *Siboga* material is from the western and northern part of the East Indies, I am inclined to think probably the Dutch expedition did not meet with *semoni*, though the specimens from stations 282 and 301 might be that species. It is less easy to decide about the specimens Koehler has listed (1907*a*) from Sharks Bay, Western Australia, and (1910) from the Aru Islands, as *O. dubia*. There is no *a priori* reason why they may not be that species, but I feel suspicious that they are really *semoni*.

OPHIOCOMIDÆ.

The members of this family are by far the most abundant, most noticeable, and most interesting brittle-stars on the reef-flats in Torres Strait. Their large size, conspicuous coloration, and notable activity attract constant attention. All are shallow water forms, but many show an adaptation to a particular habitat that is quite marked. The family is a relatively small one, and is so well defined that a revision of its constituent members is not a great task, and, since they form about one-fifth of the ophiurans of the Torres Strait region, it is fitting that such a revision should be offered here. Members of the family occur in the West Indian region and in the Eastern Pacific, but the East Indies is its obvious home and a large percentage of its members occurs there. The family is easily recognized by the combination of a disk usually granulated but sometimes bare, flattened, stout arms with correspondingly stout arm-spines, well-developed oral papillæ and distinct clusters of dental papillæ at the point of each jaw. It approaches the Ophiodermatidæ in many ways, and the line between the two families is not a conspicuous one. Both Lyman and Lütken, the two ablest students of ophiurans in the past century, regarded the genus *Ophiarachna* as one of the Ophiocomidæ, whereas there seems no reasonable doubt now that its true place is with the Ophiodermatidæ. The absence of dental papillæ would seem to be conclusive.

With *Ophiarachna* left out of account, the Ophiocomidæ includes but 5 genera, of which *Ophiocoma* and *Ophiopsila* are nearly or quite tropicopolitan, though *Ophiocoma* is not known from the Mediterranean and *Ophiopsila* has yet to be found in the Eastern Pacific. *Ophiomastix* and *Ophiarthrum* range from Zanzibar to the Society Islands, and even to the Paumotus, but strangely enough, neither genus is yet recorded from Hawaii. *Ophiopteris* has a peculiar distribution confined to the Pacific. *Ophiopsila* differs so noticeably from the other four genera that Matsumoto (1917) makes it the basis for a separate subfamily. There are 11 species, which have recently been the subject of a revision (H. L. Clark, 1918). The subfamily Ophiocominæ needs similar treatment, and, as suggested above, the present report seems a suitable place for the publication of the results. The four genera may be distinguished from each other as follows:[1]

Key to the Genera of Ophiocominæ.

Disk covered with scales, sometimes imbedded in the skin, which bear more or less numerous granules or spinelets or both; often the scales are more or less fully hidden under the coat of granules.
- Disk covered with granules, which normally conceal the underlying scales, except often in the interbrachial arcs below;[2] no true disk spinelets; claviform arm-spines exceptional.
  - Uppermost arm-spines not evidently shortened and flattened, but often considerably enlarged .. *Ophiocoma*
  - Uppermost arm-spines on each side of each joint (and on basal part of arms in large specimens, second spine also) modified to form a flat, elliptical or circular scale .... *Ophiopteris*
- Disk with more or less evident spinelets, in some species with granules also; some upper arm-spines more or less claviform .... *Ophiomastix*

Disk covered with a smooth, naked skin, bearing neither granules nor spinelets .... *Ophiarthrum*

OPHIOCOMA.

L. Agassiz. 1835. Mem. Soc. Sci. Nat. Neûchatel, *1*, p. 192.

This is the largest and most widely distributed genus of the family, species occurring in all parts of the tropics, except only the Mediterranean Sea, into which no species has yet penetrated. It is true that *Ophiocoma nigra* (Retzius) and *Ophiocoma tumida* Müller and Troschel are both listed from the Mediterranean, but the former is one of the Ophiacanthidæ, not one of the Ophiocomidæ, and the specimen on which *tumida* is based seems to be an individual of *O. echinata* and surely did not originate in the Mediterranean. The northern limit of Ophiocoma in the Atlantic is at the Bermudas and in the Indo-Pacific region is in or near Kagoshima Gulf, Japan. Thus no species is known from above latitude 34° N. In the southern hemisphere the range is somewhat greater, reaching at least latitude 40° S., different species occurring along the South African coast, on the southern coast of Australia, and between the main islands of New Zealand. In the West Indies there are 3 species, all abundant and widely distributed; one of these, at least (*pumila*), ranges clear across the Atlantic, having been taken not only at the Cape Verdes but at the islands in the Gulf of Guinea and even on the French Kongo coast. In the Paris Museum there is a specimen of one of the other species (*echinata*) said to be from the coast of Liberia, and there is no improbability of its occurrence there. Two species occur on the west coast of Central America and Mexico; neither is known from anywhere on the South American coast, but one occurs at the Galapagos Islands. Throughout the Indo-Pacific region, from 4 to 6 species may be found wherever conditions are favorable.

[1] For genotypes, lists of species, localities, and other data see H. L. Clark, 1915, Mem. M. C. Z., *25*, p. 290–297.

[2] In specimens which have been roughly handled, the granules may be rubbed off from a large part of the disk, leaving the scales quite visible. Such specimens are often very perplexing.

No fewer than 61 specific or varietal names have been used in connection with the generic name *Ophiocoma*, but many of these were listed when the genus was not so readily recognized as at present. When proposed by Agassiz, although he mentioned only 2 species, the limits of the genus were very broad, including all brittle-stars with long, mobile arm-spines. In 1840, Müller and Troschel restricted the name to those forms with long arm-spines, in which the spines are smooth, the disk is covered with granules concealing the radial shields, there are only 2 genital slits in each interradius, and oral papillæ are present. In 1842, they recognized the presence and importance of dental papillæ and defined the genus in such terms that its natural limits are made quite clear; of the 18 species they list, however, 7 are not Ophiocomas, even according to their own diagnosis. In spite of Müller and Troschel's work, many subsequent authors ignored their delimitation of *Ophiocoma* and referred to it species which lack dental papillæ, and for this, or some equally evident reason, are not members of the genus. Including Müller and Troschel's 7 species, just referred to, some 22 brittle-stars which are not Ophiocomas have been assigned to the genus; their true position is indicated in the following list:

Ophiocoma arctica Müller and Troschel, 1842 = Ophiacantha bidentata (Retzius).
ballii Thompson, 1840 = Ophiactis ballii (Thompson).
bellis Forbes, 1839 (Ophiura bellis Fleming) = Ophiopholis aculeata (Retzius).
bidentata Müller and Troschel, 1842 = Ophiacantha bidentata (Retzius).
brachiata Forbes, 1841 = Amphiocnida brachiata (Montagu).
didelphys Wyville Thomson, 1876 = Ophiacantha vivipara Ljungman.
echinulata Forbes, 1852 = Ophiacantha bidentata (Retzius).
filiformis Forbes, 1841 = Amphiura filiformis (O. F. Müller).
goodsiri Forbes, 1841 = Ophiactis ballii (Thompson).
granulata Forbes, 1839 (Ophiura granulata Fleming = Ophiacantha sphærulata (Pennant).
isocantha Müller and Troschel, 1842 = Ophiostigma isacanthum (Say).
Ophiocoma minuta Forbes, 1839 = Ophiothrix fragilis (Abildgaard).
neglecta Forbes, 1839 (Ophiura neglecta Johnston) = Amphipholis squamata (Delle Chiaje).
nigra Müller and Troschel, 1842 (Asterias nigra Abildgaard) = Ophiacantha sphærulata (Pennant).
nillsoni Müller and Troschel, 1842 = Ophiacantha sphærulata (Pennant).
ocellata von Martens, 1867 = Ophiarachna incrassata (Lamarck).
papillosa Lyman, 1875 = Ophiopteris papillosa (Lyman).
picta Müller and Troschel, 1842 = Ophiarthrum pictum (Müller and Troschel).
punctata Forbes, 1841 = Paramphiura punctata (Forbes).
raschii G. O. Sars, 1872 = Ophiacantha raschii (G. O. Sars).
rosula Forbes, 1839 = Ophiothrix pentaphyllum (Pennant).
vivipara Wyville Thomson, 1877 = Ophiacantha vivipara Ljungman.

In addition to these 22 names, there are 21 others, which, while correctly associated with the genus *Ophiocoma*, do not seem entitled to recognition, since they refer to species which have previously received some other valid name. These are as follows, with an indication of the correct name to which they are equivalent:

Ophiocoma alternans von Martens, 1870 = scolopendrina.
brevispinosa Smith, 1876 = brevipes.
Ophiura crassispina Say, 1825 = echinata.
Ophiocoma dentata Müller and Troschel, 1842 = echinata, according to Lyman who examined the type in Berlin. The original description indicates brevipes var. insularia.
dentata Lütken, 1859 = brevipes var. variegata.
döderleini de Loriol, 1899 = brevipes var. variegata.
lineolata Müller and Troschel, 1842 = pica.
lubrica Koehler, 1898 = scolopendrina juv.
marmorata Marktanner-Turneretscher, 1887 = brevipes var. variegata.
molaris Lyman, 1861 = scolopendrina.
nigra Michelin, 1863 = erinaceus?.
Ophiocoma placentigera Lütken, 1856 = pumila.
sannio Lyman, 1861 = pica.
serpentaria Müller and Troschel, 1842 = echinata.
Ophiura squamata Lamarck, 1816, is probably based on a specimen of brevipes, but as there is some room for doubt, and the locality is given as the Atlantic Ocean, it is not permissible to use the earlier name.
Ophiocoma tartarea Lyman, 1861 = erinaceus.
tenuispina de Loriol, 1891 = brevipes var. insularia.
ternispina von Martens, 1870 = brevipes var. insularia.
tumida Müller and Troschel, 1842 = echinata.
variabilis Grube, 1857 = scolopendrina?.
valentiæ de Loriol, 1894, p. 29 = valenciæ.

There remain 18 names which designate recognizable forms of *Ophiocoma*, but how many of these are really valid species has yet to be determined, and in some cases at least can be determined only on the reefs, where the individual diversity in a definite area under identical conditions can be carefully studied. As an illustration of the usefulness of such work, I beg to call attention to the observations made at Mer on *erinaceus* and *scolopendrina*. Such study is particularly needed on the highly variable *brevipes*, of which at least 10 forms have been given names. When at Mer, I was ignorant of the great diversity shown by this species, and I collected two forms under the supposition that they were quite distinct, and later, at Hilo, Hawaii, I collected a third form, not even suspecting it was *brevipes*. Only careful observation on the reef can determine the true relation of these forms to each other, but I am using varietal names to designate them in the present report.

In attempting to draw specific lines in *Ophiocoma*, one soon discovers that the *shape* of the oral shields, upper and under arm-plates, and the arm-spines is almost worthless, for the forms assumed by these various parts is subject to extraordinary individual diversity, associated with a certain amount of growth-change. The number of tentacle-scales furnishes a character of great value, though in certain cases one is sorely puzzled to know how much weight should be attached to it. Yet I have rarely seen an *Ophiocoma* of which the true number of tentacle-scales could not be positively asserted. Some individuals of species having only *one* tentacle-scale show *two* scales on some or even on many basal arm-joints, but that *one* is the true number does not admit of question; the presence of two seems to be clearly a case of reversion. Yet it does not follow that having a single tentacle-scale is an important or even a valid specific character (see p. 128, under *schœnleinii*). The number and arrangement of the dental papillæ, the character of the granulation of the disk, and its extent orally, seem to be characters of considerable constancy and importance, while the number of arm-spines, the proportion of disk to arms, and the coloration are much less reliable.

Koehler (1907) has drawn attention to the unsatisfactory character of the line supposed to separate *Ophiocoma* from *Ophiomastix*. The character of the disk covering and the form of the upper arm-spines furnish the distinctions supposed to make one separable from the other, but a careful comparison of all the species of the two genera shows that the line has to be a very arbitrary one. Since the character of the disk covering seems to me a more fundamental feature than the form of the arm-spines, I am retaining in *Ophiocoma* the species *wendtii*, and am also including *Ophiomastix pusilla* Brock, in spite of their claviform arm-spines. Such spines indeed occur in some individuals of *scolopendrina* and other Ophiocomas.

All the various features being duly taken into account, the following key will make it possible to distinguish the 19 forms, which are here recognized by name.

Key to the Species and Varieties of Ophiocoma.

A. Disk granules nearly or quite spherical and of more or less uniform size.
  B. Claviform spines when present, uppermost of series.
    C. Disk granulation rather coarse, 9 to 64 granules per square millimeter, covering only part, and often a very small part, of oral interbrachial areas.
      D. Tentacle-scales 2 (distally there is usually only 1, and individual pores proximally may have but 1).
        E. Granulation coarse, 9 to 36 per square millimeter; adoral plates small at sides of oral shields; arm-spines 4 or 5; coloration black or blackish, or some combination of blackish and whitish.
          F. Oral shields square or oblong with rounded corners as wide proximally as distally; under arm-plates not noticeably wider than long, often longer than wide, especially basally; granulation moderately coarse 25 to 36 per square millimeter; uppermost arm-spines often short and swollen; West Indian................ *echinata*
          FF. Oral shields wider distally than proximally, often markedly so; under arm-plates usually much wider than long; granulation coarser, often only 9 to 16 granules per square millimeter; uppermost arm-spines rarely short and swollen; Indo-Pacific.

Coloration varied but not often very dark orally; under arm-plates, at least proximally, with more or less whitish; arms long, 4.5 to 7.5 times disk diameter .... *scolopendrina*
Coloration nearly or quite uniformly black; arms 4 to 5 times disk diameter *erinaceus*
EE. Granulation finer, 36 to 64 granules per square millimeter; coloration without white or whitish; arm-spines 5 or 6.
About 49 to 64 granules per square millimeter; adoral plates small; coloration very fine, variegated brown and yellow; arm-spines not noticeably flattened or curved .... *pica*
About 36 granules per square millimeter; adoral plates very large, nearly or quite meeting proximal to oral shield; coloration neither conspicuous nor variegated; arm-spines more or less flat, truncate, slightly curved dorso-ventrally and rather delicate.......... *canaliculata*
DD. Tentacle-scale single, though there are often 2 on basal pores and even as far out as the fiftieth segment 2 may occur.
E. No claviform upper arm-spines, though swollen ones may occur.
F. Tentacles red; granulation of disk coarse, about 16 granules per square millimeter; under arm-plates markedly wider than long; uppermost arm-spines long and slender, often equal to *five* segments.......... *riisei*
FF. Tentacles not red; granulation of disk finer, 16 to 36 granules per square millimeter; uppermost arm-spines rarely equal to *four* segments.
Coloration grayish black, often more or less variegated with whitish; size very large, up to 40 mm. disk diameter; tentacle-scales commonly 2 on basal pores .... *æthiops*
Coloration uniformly rich brown-black; no whitish; disk diameter rarely exceeds 22 mm.; tentacle-scales rarely 2 except on the first 1 to 3 pores.. *schœnleinii*
EE. Some upper arm-spines more or less markedly claviform.......... *wendtii*
CC. Disk granulation very fine, 64 to 100 granules per square millimeter, covering oral interbrachial areas.
D. Coloration variegated.
Prevailing colors green or greenish, and white or pale yellowish.......... *brevipes*
Prevailing tints gray or blackish or brownish, and whitish or pale brown.. *brevipes* var. *variegata*
DD. Coloration uniformly deep brownish black.
Jaws very short; oral plates greatly reduced; arm-spines 3 to 5 but often 6, moderately long.......... *brevipes* var. *insularia*
Jaws long with evident oral plates; arm-spines 5, exceedingly long (5 to 6 mm.) and slender.......... *brevipes* var. *longispina*
BB. Claviform spines few, 1 or 2 on each side near base of arm, not uppermost, but next to uppermost of a series.......... *pusilla*
AA. Disk granules, some or all, at least near disk-margin, higher than thick, becoming more or less markedly spiniform.
B. Tentacle-scales single.
C. Arms long, 6 to 10 times disk diameter.
Arm-spines 4 or 5, uppermost or next, longest; under arm-plates with light areas distally but these are rarely large and continuous enough to form a median light stripe *pumila*
Arm-spines, 5 to 7, the third or fourth longest; a median light stripe on under surface of arm almost always well marked.......... *alexandri*
CC. Arms relatively short, 4 to 5.5 times disk diameter.
Arms 5; disk granules low and thick, except near disk-margin; size large, disk diameter 20 mm. and more.......... *valenciæ*
Arms 6; disk granules more or less spiniform; size small, about 5 mm. in diameter.. *parva*
BB. Tentacle-scales 2; arms 5, not much more than three times disk diameter; color chocolate-brown *bollonsi*

As one examines the above key and takes into consideration the geographical distribution of the different species and varieties, one is struck by the clear evidence of differentiation going on within the genus, tending to form three distinct groups, which may some day be regarded as genera. One of these, which may be called the *brevipes* group, extends across the Indo-Pacific region from Eastern Africa to Hawaii and Easter Island. It is easily recognized by the fine, close granulation of the disk which covers also the oral interbrachial areas, and the presence of two tentacle-scales. The other two, which may be called the *pumila* group, known by a light coloration, commonly brown or green, and the more or less spiniform granules, and the *scolopendrina* group, recognized by spherical granules, more or less bare oral interbrachial areas, and dark or variegated coloration, occur not only in the Indo-Pacific region, but in the Panamic and West Indian regions as well, some even extending to Western Africa. In each of the three geographical areas there seems to be going on a similar specific evolution, affording an interesting illustration of parallel differentiation. In the West Indian region this differentiation has reached its most definite results; here we have 3 well-marked species, one (*pumila*) in the *pumila* group and two (*echinata* and *riisei*) in the *scolopendrina* group. There is no present tendency towards any intergradation of these species; any West Indian *Ophiocoma* can be referred at once and without difficulty to its proper species. In other words, specific evolution in *Ophiocoma* in the West Indies has attained definite and clear-cut results. The same is true in the Panamic region, where, however, only two species are involved—*alexandri* of the *pumila* group and *æthiops* of the *scolopendrina* group; the latter is the more interesting, for, while it possesses the general appearance and coloration of the West Indian *echinata*, it has nearly lost one of the two tentacle-scales, as the West Indian *riisei* has done, and meanwhile it has become much the largest species of the genus.

When we turn to the Indo-Pacific region we find that specific differentiation is much less perfect and there are numerous forms whose phylogenetic significance is as yet very obscure. This is least true in the *pumila* group, of which but two[1] forms are involved—one of these is *valenciæ* of the East African region, much like *alexandri* of the Panamic region, but with short arms, and the other is *parva* of the southern tropical Pacific islands, which has retained the 6 arms of young *pumila*, the species to which it is most closely allied. In the *brevipes* group, differentiation has gone on very markedly in color, size, and proportions, and to some degree in arm-spines and mouth-parts, but nothing fixed seems to have been reached. Hence we have a perplexing series of forms which look very unlike each other, but which are bound together by numerous intergradations. It is quite possible that each of the four forms herein recognized by name is an incipient species, but the evidence is very dubious at present. In the *scolopendrina* group there is clearly a differentiation similar to that which has taken place in the West Indies, by which we should have a more or less variegated species with 2 tentacle-scales, and a uniformly black species with a single tentacle-scale. But as yet there are many connecting links left, and hence we find variegated individuals with 2 tentacle-scales, which we call *scolopendrina*, variegated or dark individuals with 1 tentacle-scale (and claviform upper arm-spines), which are called *wendtii*, black forms with 2 tentacle-scales, known as *erinaceus*, and other black specimens with a single tentacle-scale which have been named *schœnleinii*. An isolated and well-marked species (*canaliculata*) has become differentiated on the southern coast of Australia, but nowhere in the Indo-Pacific region is there a well-defined indisputable species of the *scolopendrina* group.

As Matsumoto (1917) has pointed out, *brevipes* is apparently the most primitive member of *Ophiocoma*. From it, the *scolopendrina* group has been differentiated by the tendency to loss of disk granulation, associated with increase of size of granules and an increasing number and more definite arrangement of the dental papillæ. Further specialization leads to such species as *riisei* and *schœnleinii*, in which a tentacle-scale has been lost and the color has become uniformly black. The evolution of the *pumila* group seems to have been along a somewhat different line. Here the color has tended to become lighter, and green is an evident feature of young individuals and of recently regenerated arms. Now the color green is known in the genus otherwise only in *brevipes*, a fact which suggests that the *pumila* group has originated directly from *brevipes* and not, as one might infer from the long arms and certain other features, from *scolopendrina*. If this is the case, differentiation has gone as far as in *riisei* in fixing a single tentacle-scale and a distinct color-pattern, while in the character of the disk-granulation it has gone much further. As

[1] I am leaving *bollonsi* out of account, as I have never seen an example of the species, and while it has granules which "become spiniform," it has 2 tentacle-scales and a uniformly dark coloration which precludes the idea of its having any close genetic connection with the *pumila* group.

alexandri has more numerous arm-spines than *pumila*, much longer arms than *valenciæ*, as highly specialized a disk-covering as either, and in addition a well-fixed color-mark on the oral surface, it seems fair to consider it the most highly specialized member of the genus.

In regard to the type species of *Ophiocoma*, there is room for disagreement. In 1865, Lyman definitely designated "*O. scolopendrina* Agass." as the type. But there is no such species anywhere in literature as "*O. scolopendrina* Agass.," and therefore, in 1915, I named "*Ophiura echinata* Lamarck 1816" as genotype, saying: "Type determined by the fact that Agassiz mentions but two species and *echinata* alone is identifiable." A careful examination of Agassiz's statement when instituting the genus shows that he gives as the constituent species "*O. squamata* Ag. (*Ophiura squam.* Lam.)—*O. echinata* Ag. (*Ophiura echin.* Lam.) etc." Since *squamata* is not certainly identifiable, it would seem that *echinata* is obviously the type of the genus but clearly Lyman interpreted the "etc." of Agassiz's statement to include all the rest of Lamarck's species of *Ophiura* to which the diagnosis of *Ophiocoma* as given by Agassiz applied, and he accordingly, for some reason best known to himself, selected *scolopendrina*. As there is no obvious reason why he should not have done so, his designation stands and my later choice of *echinata* seems to be superfluous. Fortunately, *scolopendrina* and *echinata* are so very closely allied that it is only with great care that they can be distinguished. Many specimens would be almost indistinguishable were the locality whence they came not known. It is therefore of no importance which is regarded as the genotype.

Ophiocoma echinata.

Ophiura echinata Lamarck. 1816. Anim. s. Vert., *2*, p. 543.
Ophiura crassispina Say. 1825. Jour. Acad. Nat. Sci. Phila., *5*, p. 147.
Ophiocoma echinata Agassiz. 1835. Mém. Soc. Sci. Nat. Neûchatel, *1*, p. 192.
Ophiocoma serpentaria Müller and Troschel. 1842. Sys. Ast., p. 98.
Ophiocoma dentata Müller and Troschel. 1842. Sys. Ast., p. 99.
Ophiocoma tumida Müller and Troschel. 1842. Sys. Ast., p. 100.
Ophiocoma crassispina Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 142, pl. iv, figs. 7*a*–7*d*.

This is one of the commonest brittle-stars of the West Indies, occurring from Bermuda to "Aspinwall" (Colon) and Brazil, in shallow water, wherever conditions are at all suitable for any echinoderms. A specimen in the Paris Museum is said to be from Liberia, and it is quite possible that the species occurs on both sides of the Atlantic. It reaches a large size, a specimen in the Museum of Comparative Zoölogy measuring 30 mm. across the disk. The color is ordinarily more or less uniformly black, but it is very common to find specimens with the disk variegated with white or even wholly whitish. The arms, particularly near the tips and in young specimens, are apt to be banded with light and dark shades. The oral shields are unusually constant in shape in this species, and are quite characteristic; they are usually longer than wide, but even if wider than long, the inner end is as wide as the outer. The uppermost arm-spines are often short and thick or even swollen, but they are not claviform, and not rarely they are quite slender. While easily distinguished from the other West Indian and the Panamic Ophiocomas, *echinata* is surprisingly near the common Indo-Pacific *scolopendrina*, from which it can only be certainly distinguished by the comparison of all the characters.

Ophiocoma scolopendrina.

Ophiura scolopendrina Lamarck. 1816. Anim. s. Vert., *2*, p. 544.
Ophiocoma scolopendrina Müller and Troschel. 1842. Sys. Ast., p. 101.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 293, pl. 14, figs. 10, 11.
? *Ophiocoma variabilis* Grube. 1857. Arch. f. Naturg., Jhrg. 23, *1*, p. 342.
Ophiocoma molaris Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 79.
Ophiocoma alternans von Martens. 1870. Arch. f. Naturg., Jhrg. 36, *1*, p. 251.
Ophiocoma lubrica Koehler. 1898. Bull. Sci., *31*, p. 76, pl. iii, figs. 23, 24.

(Plate 13, Figure 9.)

This very common and widely distributed *Ophiocoma* ranges from the Cape of Good Hope and the Arabian Gulf on the west to Hawaii and the Paumotu Islands on the east.

It reaches Kagoshima Gulf, Japan, on the north, and extends southward on the Australian coast to Sharks Bay on the west and Port Molle on the east. Full-grown adults are 25 to 30 mm. across the disk with arms 5 to 7.5 times as much; a very typical specimen 25 mm. across the disk has arms 195 mm. long. The coloration is ordinarily variegated with dark and light shades; the colors are rarely clear enough to be called black and white, but are commonly dark gray or brown and dirty whitish, dull yellow, or pale brown. In young specimens, however, the colors are clearer and the upper arm-spines may have a rosy tint which is sometimes very distinct in life (pl. 13, fig. 9), but is entirely lost in preserved material. Large specimens with uniformly dark disks (nearly or quite black) and with the arms sometimes correspondingly dark are by no means rare, but in all such cases the oral shields and the under arm-plates, at least the basal ones, are light, with or without darker markings.

At Mer *scolopendrina* is very common, but it occupies a restricted and peculiar habitat near high-water mark, where the bottom is composed of a furrowed and creviced rock, the slightly sloping surface of which is relatively free from sand and from both animal and plant life. During the period of low water there is little indication of anything living in this region, but as the tide comes in and the water washes over the surface, one sees slender processes projecting everywhere out of the rock crevices, and as the water becomes 2 or 3 inches deep the whole surface is alive with these swaying projections. Examination shows them to be the arms of Ophiocomas, all of the same species and all extending further out from the rock as the water increases in depth. Further examination shows that these arms are in groups of three, the body and the other two arms of each brittle-star remaining firmly anchored in the crevice. It is not clear whether the actions are associated with feeding or not, but it does seem indisputable that they are associated with respiration, the tentacles on the swaying arms being very fully distended. With the fall of the tide, the brittle-stars retract all the arms into the crevice, and it is astonishing into how small a space an individual 20 mm. across the disk can pack its five arms, each 140 to 150 mm. long. It was a difficult matter to collect specimens which were actually in the unbroken rock, but occasionally large fragments were broken off and lay on the rock surface undisturbed by the ordinary tidal movements. Under these fragments numbers of Ophiocomas were to be found, and these were usually *O. scolopendrina.* It was not uncommon to find *brevipes* var. *variegata* in such a situation, but I never saw that species show the reaction to the incoming tide so characteristic of *scolopendrina.* Further out on the reef-flat only very young specimens of *scolopendrina* were found, and these were quite uncommon.

The complete separation of habitat between *scolopendrina* and *erinaceus* (see p. 127), their quite unlike habits, and the perfectly distinct coloration, satisfy me that at Mer they represent two well-differentiated species. None of the Murray Island *scolopendrinas* have a uniform color, and all of them have relatively long arms, so that there is no evident intergradation with *erinaceus.* Of course, very young specimens, 8 mm. and less across the disk, have not the specific characters well marked and hence can not be certainly identified. Most of these occurred in the habitat of *erinaceus,* and hence all may be of that species, but I am inclined to think that when the larvæ of *scolopendrina* first settle down and undergo their metamorphosis they do so in the corals where *erinaceus* lives, and only as they mature do they pass shoreward to the crevices which the adults inhabit. On the other hand, it is possible that just as *echinata* and *riisei,* in the West Indies, have breeding-periods two months or more apart, so *scolopendrina* and *erinaceus* at Mer are physiologically isolated from each other, and if that is the case all the young Ophiocomas we found are probably *erinaceus.*

Ophiocoma erinaceus.

Ophiocoma erinaceus Müller and Troschel. 1842. Sys. Ast., p. 98.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 291, pl. 15, figs. 5, 6.
Ophiocoma tartarea Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 78.
? *Ophiocoma nigra*, Michelin. 1863. Maillard's Réunion, Annex A, p. 2.

This perplexing form has a range nearly coincident with that of *scolopendrina*, and its true relation to that species has been the subject of much difference of opinion. Lyman regarded the two as distinct, saying that *erinaceus* can be distinguished by its large, central disk scales. Personally, I do not find this supposed difference in disk-scales a tangible and constant feature. De Loriol (1894) has given an excellent summary of the characters of *erinaceus*, which he considers quite distinct from *scolopendrina*. Koehler, on the other hand, as the result of his extended studies, concludes that there is no constant difference between the two forms. Matsumoto (1917) is decidedly of the same opinion and says emphatically: "There is no doubt that *O. scolopendrina*, *schœnleinii*, and *erinaceus* are conspecific." Reef collecting at Mer has led me to a different conclusion, and my critical study of all the material in the Museum of Comparative Zoölogy leads me to believe that both *erinaceus* and *schœnleinii* are at least incipient species. As I find little practical difficulty in separating mixed lots of Ophiocomas into these various species, I think it desirable for the present to retain the different names.

The largest specimen of *erinaceus* which I have seen is 28 mm. across the disk and has arms 140 mm. long. In another specimen, 16 mm. in disk-diameter, the arms are only 70 mm. long. The coloration shows little diversity, but it is interesting to note that some specimens from Mer have the tentacles *red*, as in *riisei*, whereas they are usually black. A specimen from Hilo also has red tentacles and the general color is red-brown, instead of black, with the arms distally banded with light and dark red-brown. This specimen has more granules than usual orally. A specimen from Ponape has 2 or 3 short radiating light lines on disk at base of each arm and the lower, basal arm-spines are light with a dark longitudinal stripe.

At Mer we found *erinaceus* very common in the *Pocillopora*, *Acropora*, and *Seriatopora* zone, 600 to 1,200 feet from high-water mark. It lived among the coral branches and only occasionally was it to be found on the sand under rock fragments. It is a much more active species than *scolopendrina*, and when the coral in which an individual was sheltered was broken up, the Ophiocomas quickly sought concealment. The color in life is very black, but in young specimens the tips of the arms may be banded, and on the oral side of the arms transverse white lines are not infrequent distally, even in large specimens. As already mentioned, some individuals had the tentacles bright orange-red, and one of these is further remarkable for having the radial shields, though small, bare, and distinct—a very unusual condition for an *Ophiocoma*.

Ophiocoma pica.

Ophiocoma pica Müller and Troschel. 1842. Sys. Ast., p. 101.
Ophiocoma lineolata Müller and Troschel. 1842. Sys. Ast., p. 102.
Ophiocoma sannio Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 81.

(Plate 13, Figure 8.)

This is not only the handsomest, but it is the least variable member of the genus. The arms are always short and rather stout, seldom much over four times the disk-diameter and often only three and a half times. The largest specimen in the Museum of Comparative Zoölogy is 23 mm. across the disk and has arms 80 mm. long. The disk granulation is finer than in most Ophiocomas, but still evidently coarser than in *brevipes*. It extends only a short distance onto the oral surface. The arm-spines are 5 or 6 in each series proximally and seem quite crowded; distally there are but 4. There is little variation in form of the arm-plates and oral shields. The oral papillæ are usually only 3 or 4 on a side, but the dental papillæ are numerous and crowded, sometimes more than 20. The coloration, rich brown with almost golden-yellow markings, is remarkably constant and makes the species very easy to recognize. The geographical range extends from Zanzibar and the Red Sea to the Paumotus and Hawaiian Islands, but there is no evidence of its reaching southern Japan on the north or continental Australia on the south. At Mer, *pica* was one of the rarest brittle-stars, and only 4 specimens were found. All were taken far out on the reef-flat, among the living corals, in such situations as *O. erinaceus* frequented.

Ophiocoma canaliculata.

Lütken. 1869. Add. ad Hist. Oph., pt. 3, p. 46, 99.—Koehler. 1904. Mém. Soc. Zool. France, *17*, p. 75, figs. 30–32.

Few members of the family are as rare or as little-known as this isolated form, occurring in Bass Strait and on the southern coast of Victoria. My friend, Mr. J. Gabriel, who has sent me many echinoderms from that region, has secured but 1 specimen in the past 7 or 8 years, although he feels sure that 10 or 12 years ago it was quite common at a spot which has been spoiled as a collecting-ground by certain harbor improvements. The species is a very distinct one, quite different from any other member of the genus, particularly in the form of the arm-spines and the large adoral plates. Nothing is known of the colors in life, but the dry specimen before me is light brown, with a distinctly green tinge on the disk, and with the arms quite reddish.

Ophiocoma riisei.

Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 141, 143, pl. iv, figs. 6*a*–6*d*.

This well-defined West Indian species ranges from Bermuda to Brazil, but it has not yet been found in the eastern Atlantic. It reaches a large size. The biggest one I have seen measures 32 mm. across the disk and has arms 160 mm. long. While the general impression, especially in life, is that the color is uniformly black, careful examination of dried specimens often reveals some evidence of a color-pattern on the disk, and in young specimens this may be quite marked, and the arms are evidently banded, at least distally, with light and dark red-brown. The rust-red tentacles are a very constant and convenient specific character. Perhaps the most remarkable feature of this species is the late stage at which the granules of the disk appear; a specimen 5 mm. across will usually have no granules whatever, and this is true of one dry specimen at hand, 8 mm. across. Of course such specimens do not seem to be Ophiocomas and are sure to give difficulty in identification.

Ophiocoma æthiops.

Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 141, 145.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 291, pl. 13, figs. 6, 7.

This is the Panamic representative of *echinata* and *scolopendrina*, distinguished from them easily by the single tentacle-scale; the basal pores, even far out beyond the disk, may have two, but there is never any doubt that one is the typical number. The coloration is much like that of *echinata*, black or black marked, variegated, or banded with whitish. In size, *æthiops* is the largest of Ophiocomas. The biggest specimen in the Museum of Comparative Zoölogy is 40 mm. across the disk and has arms 240 mm. long and 6 mm. wide. Of course Bell's (1887) record of *æthiops* from the Andaman Islands is based on a misidentification. Perhaps the specimen or specimens concerned were the form for which Koehler has revived Müller and Troschel's name *wendtii* (*q.v.*).

Ophiocoma schœnleinii.

Müller and Troschel. 1842. Sys. Ast., p. 99.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 293, pl. 15, figs. 1, 2.

The status of this species admits of much discussion. Its resemblance to *erinaceus* is so obvious and striking that Matsumoto considers them unquestionably identical. No one seems to have noticed that there is an equally close resemblance to the West Indian *riisei*. Indeed, *schœnleinii* can always be distinguished from *erinaceus* by the single tentacle-scale, but that feature it has in common with *riisei*. Small specimens of *riisei* can be selected which are exceedingly difficult to distinguish from *schœnleinii*. The species are, however, unquestionably distinct: *schœnleinii* is uniformly black, with black tentacles, has no indication of a color-pattern or of light and dark banding on arms (white bands may be present near tips), and lacks the rusty-red tentacles and general reddish oral tinge of *riisei;* the arms average somewhat shorter, and the uppermost arm-spines are shorter and stouter; moreover, in *schœnleinii*, young specimens have the disk fully covered with granules at an age when *riisei* is still bare.

Relatively little is yet known as to the distribution of *schœnleinii*, as it has not usually been distinguished from *erinaceus*. There are specimens in the Museum of Comparative Zoölogy from Amboina, Fiji, and Samoa. Matsumoto reports it from Formosa and the Riu Kiu Islands. I took a specimen at Green Island near Cairns, northern Queensland, and the only other *Ophiocoma* seen there was *brevipes*, which was very common. At Mer, *schœnleinii* was rather common, 18 specimens being taken, but unfortunately it was not distinguished from *erinaceus* until after we left the island. It occurred with that species among the living coral, but my field-notes give no hint as to any peculiarities of habits or habitat, a fact which makes me very dubious as to its validity as a species. But until the question can be looked into on the reefs, it will do no harm to recognize by name this form with a single tentacle-scale. The largest example of *schœnleinii* seen is 22 mm. across the disk and has arms only 80 mm. long; but another, 20 mm. in disk-diameter, has arms 100 mm. long.

Ophiocoma wendtii.

Müller and Troschel. 1842. Sys. Ast., p. 99.—Koehler. 1907. Bull. Sci., *41*, p. 327, pl. xiii, fig. 38.

The only brittle-star I have seen which can be referred to this peculiar form is from Zanzibar and has long been catalogued as *Ophiomastix asperula;* it is listed as such by me in my Catalogue of Recent Ophiurans (1915). It is in poor condition, but comparison with indubitable specimens of *asperula* shows it is not that species, while the disk covering is clearly that of an *Ophiocoma*. The claviform upper arm-spines are conspicuous, but since the form of the upper arm-spines is exceedingly variable in most Ophiocomas, one hesitates to put much trust in that character alone, especially as it is not well marked in the specimen of *wendtii* Koehler (1905) describes from near Batavia. In the possession of these claviform upper arm-spines *wendtii* is a perplexing link with *Ophiomastix*, as Koehler has suggested. With this character constant, the species would probably be always recognizable. Without it, it is hard to see how *wendtii* is to be distinguished from *æthiops*, unless the color-pattern shown in Koehler's figure (1907) and well marked in the specimen before me proves a constant feature. Koehler records this puzzling form from Fernando Veloso, the Seychelles, near Batavia, New Ireland, and Fiji.

Ophiocoma brevipes.

Ophiocoma brevipes Peters. 1851. Monatsb. K. Preus. Akad. Wiss. Berlin, p. 465.
Ophiocoma brevispinosa E. A. Smith. 1876. Ann. Mag. Nat. Hist. (4), *18*, p. 40.

(Plate 13, Figure 7; Plate 34, Figures 3 and 4.)

Ophiocomas with a finely granulated disk, the granulation covering the interbrachial areas of the oral side, furnish a most perplexing problem, the correct solution of which awaits careful study on the reefs. If one is willing to ignore size, color, and character of arm-spines, as well as the arm-length and the form of arm-plates and oral shields, one may unite all the varied forms under the single name *brevipes*. But even a little experience on the reefs makes one dissatisfied with such an arrangement, and temporarily varietal names may be used for the more obvious forms. Further study will probably show that one or more of these is not in any sense a natural group and should have no distinctive name, while on the other hand it is quite possible that at least one is really a distinct species. There is no doubt that the form to which Peters first gave the name *brevipes* is the relatively small (15 to 18 mm. across the disk) variety, in which the arms are only 3.5 to 4.5 times the disk-diameter; there are 5 to 7 arm-spines on the basal joints, and there is more or less green or greenish in the light coloration. This typical form occurs all through the Indo-Pacific region from Zanzibar to Hawaii, north to southern Japan, and south to Green Island, Queensland. At Mer it was rather common on the northeastern reef-flat on the sand under coral fragments. In life the lower surface has often a distinctly reddish tinge.

Ophiocoma brevipes var. variegata.

Ophiocoma variegata E. A. Smith. 1876. Ann. Mag. Nat. Hist. (4), *18*, p. 39.—1879. Philos Trans., *168*, p. 565, pl. li, figs. 1–1c.
Ophiocoma dentata Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 165 (non Müller and Troschel).
Ophiocoma marmorata Marktanner-Turneretscher. 1887. Ann. K. K. Natur. Hofmus. Wien, *2*, p. 303, pl. xii, figs. 16, 17.
Ophiocoma döderleini de Loriol. 1899. Mém. Soc. Phys. Hist. Nat. Genève, *33*, pt. 2, No. 1, p. 30, pl. iii, fig. 2.

This is the large, variegated form of *brevipes*, lacking green in the coloration, and having the arms a little longer relatively, often five times the disk-diameter. Adult specimens are 20 to 25 mm. across the disk. There is great diversity in the color-pattern, the basal shades of which are blackish, gray, brown, and dirty white; the most striking forms are those with the disk handsomely reticulated (*dentata* Lütken) and with the disk regularly sprinkled with small blackish spots (*döderleini* de Loriol). The arms are commonly more or less distinctly banded with light and dark shades. Specimens before me with a greenish tinge seem to connect this form with typical *brevipes*, but I shall not be surprised if each form proves to be a valid species. At Mer *variegata* is very common, especially on the southeastern flat. One specimen was taken which seemed to be a true albino, as it was uniformly whitish; unfortunately it became stained in the preserving fluid and is now a dingy brownish rather than white. This form of *brevipes* occurred at Mer, oftentimes near high-water mark in the zone where *scolopendrina* occurred, but it was not by any means confined to that region. We found it common at Erub, and it also occurred at Green Island, near Cairns. There are specimens in the Museum of Comparative Zoölogy from Lord Howe Island, from Zanzibar, from Mauritius, and from the Pelew Islands. Some very young *brevipes* from the Hawaiian Islands may be *variegata*, but it is not unlikely they are the young of var. *insularia*.

Ophiocoma brevipes var. insularia.

Ophiocoma insularia Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 80.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 291, pl. 15, figs. 3, 4.
Ophiocoma ternispina von Martens. 1870. Arch. f. Naturg., Jhrg. 36, *1*, p. 252.
Ophiocoma tenuispina (*err. typ.*) de Loriol. 1894. Mém. Soc. Phys. Hist. Nat. Genève, *32*, pt. 1, No. 3, p. 27.

This is a well-marked form bearing much the same relation to var. *variegata* that *erinaceus* does to *scolopendrina*. It is characteristic of the Pacific region, for while von Martens' type of *ternispina* was from Flores and there is a typical specimen of *insularia* in the Museum of Comparative Zoölogy from Tanegashima, Japan, all the other specimens I have seen are from Hawaii, the Society Islands, and Easter Island. It seems to be the only Ophiocoma occurring so far to the southeast as Easter Island, excepting only the following closely related variety, *longispina*. In size, *insularia* becomes the largest of the *brevipes* group, a specimen from Hawaii measuring 32 mm. across the disk. The uniformly blackish color and the presence of only *three* rather long and slender arm-spines beyond the basal joints of the arms make the recognition of *insularia* easy. We did not meet with it in the Torres Strait region. Specimens from Easter Island are lighter colored than usual and tend to have banded arms.

Ophiocoma brevipes var. longispina.

Ophiocoma insularia var. *longispina* H. L. Clark. 1917. Bull. M. C. Z., *61*, p. 441.

This variety is based on a single specimen from Easter Island and may represent only an extremely divergent individual of *insularia*. But the arm-spines are 5 to 6 mm. long, equaling 4 or 5 arm-segments, and there may be as many as 5 on the basal arm-joints. The jaws are much longer and with more evident oral plates than in typical *insularia*.

Ophiocoma pusilla.

Ophiomastix pusilla Brock. 1888. Zeit. f. w. Zool., *47*, p. 499.—Koehler. 1905. *Siboga* Oph. Litt., p. 65; pl. vi, figs. 9, 10; pl. xiii, fig. 3.

The close, uniform coat of granules which covers the disk seems to me to necessitate putting this species in *Ophiocoma*. Not having seen a specimen, I can not pass on its validity, but it must be noted that all known specimens are very small and it is possible that they are only the young of a much larger form, perhaps some ophiocomid already known. As yet *pusilla* has been found certainly only at Amboina, where Brock says he secured many specimens. Semon, however, failed to find it there.

Ophiocoma pumila.

Ophiocoma pumila Lütken. 1856. Vid. Med., p. 13.—1859. Add. ad Hist. Oph., pt. 2, p. 146, pl. iv, figs. 5*a*–5*d*.
Ophiocoma placentigera Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 147.

This familiar and easily recognized species occurs not only throughout the West Indian region from Bermuda to Tobago, but also is found at the Cape Verde Islands and on the west coast of Africa. The most notable facts in its life-history are that in its early stages, after the adult form is assumed, there are 6 arms, and reproduction by fission occurs as in *Ophiactis savignyi*, and further, the coloration at that stage is green and white, as in the Ophiactis. For these reasons the young Ophiocomas closely resemble the Ophiactis and may be easily mistaken for it, since they inhabit very similar places, such as the algæ around the sides of a rock partly buried in the sand. The adult *O. pumila* retain the habit of secreting themselves among and under algæ, quite unlike the other West Indian Ophiocomas. The green coloration is replaced by yellowish-brown in the adult, except at the tips of the arms or on regenerating parts. There is rarely any evidence of a continuous light line on the under side of the arm, but each under arm-plate has 1 to 3 light areas along its distal margin. The disk-diameter rarely exceeds 15 mm., but the arms may be ten times as long.

Ophiocoma alexandri.

Lyman. 1860. Proc. Boston Soc. Nat. Hist., *7*, p. 256.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 291, pl. 16, figs. 5, 6.

This is the west-coast representative of *pumila*, known from Cape St. Lucas to the Pearl Islands, Panama. It has not yet been found at the Galapagos. It reaches a larger size than *pumila*, with disk 15 to 20 mm. across and arms 150 to 200 mm. long. Nothing is recorded as to color in life, but to judge from museum material, it would seem to be very much like that of *pumila*. It is not known whether the young have 6 arms, but it is highly probable that they have.

Ophiocoma valenciæ.

Ophiocoma valenciæ Müller and Troschel. 1842. Sys. Ast., p. 102.—H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 293, pl. 16, figs. 7, 8.
Ophiocoma valentiæ de Loriol. 1893. Mém. Soc. Phys. Hist. Nat. Genève, *32*, pt. 1, No. 3, p. 29.

This species, closely related as it is to *pumila* and *alexandri*, seems to be confined to the east coast of Africa, from Mozambique to the Red Sea, and the Mascarene Islands. Bell (1902) records it as common throughout the Maldive Islands, but this seems to be the extreme eastern limit of its range. It is slightly larger than its allies, reaching a disk-diameter of 23 mm., but the arms are much shorter, rarely more than 5 or 5.5 times the disk. Nothing is known of the color in life or the early growth-stages.

Ophiocoma parva.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 292, pl. 14, figs. 8, 9.

(Plate 13, Figure 4.)

This interesting little species so closely resembles the young of *pumila* that it is only by actual comparison of specimens of the same size that they are to be distinguished. The disk in *parva* is more closely covered and the disk-granules are less spiniform, the arm-spines are shorter and stouter, and the arm-plates, both upper and under, are shorter and wider. It is curious that no specimens with a disk-diameter exceeding 5 mm. were found, for it seems probable that these are the young of a larger, 5-armed species. At Mer, *parva* was fairly common in just such situations as *pumila* inhabits in the West Indies, and was generally found associated with *Ophiactis savignyi*, just as *pumila* is.

Ophiocoma bollonsi.

Farquhar. 1908. Trans. N. Z. Inst., *40*, p. 108.

This species is known only from the original specimen taken in 16 fathoms between Stephen Island and the mainland, New Zealand. It is apparently most nearly related to *canaliculata*, with which species it has several important characters in common, notably the large adoral plates. As Farquhar says the disk granules become spiniform at the disk-margin orally, it has seemed necessary in preparing the artificial key to put it in the *pumila* section of the genus, but, as already said, it has no special affinity for these forms.

OPHIOPTERIS.

E. A. Smith. 1877. Ann. Mag. Nat. Hist. (4), *19*, p. 306.

This genus is remarkable, not only for the peculiar and characteristic upper arm-spines, but for the distribution of the species, one of which occurs only in New Zealand and the other only on the coast of southern California. Neither species is at all common and nothing is known of habits or growth-changes. The two are very closely allied, and, in the absence of more abundant material, it is difficult to determine what the essential differences are, yet there is little doubt that they are quite distinct.

Key to the Species of Ophiopteris.

Color black or very dark brown, more or less reddish orally; arm-plates, especially the upper, not very markedly wider than long; uppermost arm-spine *nearly circular*.............................. *antipodum*

Color brown, often more or less variegated and arms distinctly banded; arm-plates markedly wider than long; uppermost arm-spines somewhat more elongated.. *papillosa*

Ophiopteris antipodum.

E. A. Smith. 1877. Ann. Mag. Nat. Hist. (4), *19*, p. 306, pl. xv.

This is the New Zealand species and both of the specimens in the Museum of Comparative Zoölogy are from Island Bay, near Wellington. But Mr. Farquhar writes me that it is very rare, even there, and he has very seldom met with it. The larger of our two specimens is about 15 mm. across the disk.

Ophiopteris papillosa.

Ophiocoma papillosa Lyman. 1875. Illus. Cat. M. C. Z., No. 8, pt. 2, p. 11.
Ophiopteris papillosa McClendon. 1909. Univ. Cal. Publ., Zool., *6*, p. 49, pl. v, figs. 28, 29.

This species ranges from Monterey to San Diego, from the shore out to at least 30 fathoms, but it is by no means common. McClendon gives "Lower California" as a locality, but this is probably quoted from Lyman (1882) "Lower California: 22 fms.," and Mr. Lyman means the lower or southern part of the State of California, as his material was from 5 miles south of Santa Barbara. I can find no record for Lower California proper. McClendon's largest specimen was 11 mm. across the disk. In his description he says the disk is covered with "short, cylindrical stumps," but the nearly spherical granules hardly warrant that description, even when highly magnified.

There is an interesting possibility that *O. antipodum* and *papillosa* do not represent a natural genus, but that the former is a specialized form derived from a southern Ophiocoma, perhaps *erinaceus*, while *papillosa* is derived from *æthiops*. If this were to be the case, the remarkable geographical distribution of *Ophiopteris* would be explained, and we should have an extraordinary case of convergent evolution. A careful study of the growth-stages in the two species of *Ophiopteris* would probably reveal the truth.

OPHIOMASTIX.

Müller and Troschel. 1842. Sys. Ast., pp. 84 and 107.

Although so closely allied to *Ophiocoma* that a perfectly sharp line can not be drawn between the two groups, this genus is remarkable for the distinctness of its component species and for the constancy of color as a specific character. Typical species of *Ophiomastix* are easily distinguished from typical Ophiocomas by the absence of granules and the presence of spinelets on the disk, and by the possession of conspicuous claviform arm-spines. But unfortunately there are several species of the genus which have a coating of disk-granules, and while low, conical spinelets are also present, some individuals of *mixta*, *elegans*, and *asperula* are not easily separated from the *pumila* group of *Ophiocoma* by the character of the disk-covering alone. Actual comparison of specimens makes the distinction evident enough, but it is difficult to put it into words. On the other hand, *claviform* arm-spines are often wanting, especially in young individuals of *Ophiomastix*, while they are conspicuous in typical *Ophiocoma wendtii* and may occur in other species of that genus.

It is a remarkable fact that each of the 13 species of *Ophiomastix* described since the genus, based on a single species, was named in 1842, seems to be valid, and there are no synonyms to be assigned to any one of the species, except the most peculiar *flaccida*, which was first described by Lyman in 1874, and in 1878 was redescribed by Smith as a new species, type of a new subgenus. Smith recognized the close relationship of his specimen to Lyman's, but thought certain differences warranted their separation. These differences were due, however, to condition of the specimens and are not at all constant. Nevertheless, *flaccida* is an aberrant Ophiomastix, and Smith's suggestion of a new subgenus for it is a very natural one, if subgenera are to be recognized. In no other case has a writer described a species of *Ophiomastix* which does not seem to be valid, but, as already pointed out (p. 122), the form which Brock (1888) called *Ophiomastix pusilla* is better treated as an Ophiocoma.

One reason why there are not more misidentifications of the species of *Ophiomastix* is undoubtedly found in the fact that the pattern of coloration is very constant in each species of the genus, and even the shades of color show relatively little diversity. This is so different from the condition found in *Ophiocoma* that it furnishes a very striking proof of the fact that the value of color and color-pattern as taxonomic characters can only be determined by actual study of the genus or species concerned and can not safely be assumed on any *a priori* ground.

The growth changes in *Ophiomastix* are as yet but little known. The few very small specimens at hand suggest that the specific characters are assumed rather slowly. Individuals under 10 mm. disk-diameter have the upper and under arm-plates longer than wide and very different in shape from that found in adults of the same species. The adoral plates and oral shields are also very different from the adults in very young specimens, and the latter may lack claviform arm-spines and even disk spinelets. It is therefore difficult to identify certainly very small specimens, unless they are actually taken with adults.

The genus *Ophiomastix* has its center of abundance in the East Indian region. The *Siboga* took 7 species, and we found 7 species at Mer, 5 being common. Only one species occurs on the east coast of Africa, and is otherwise known only from Madagascar and the Maldives. No species is recorded from Mauritius. One species occurs at Ceylon, 3 are listed from the Philippines, 3 from the Riu Kiu Islands (one extending northward to Tokyo Bay), 3 from Fiji, and 1 from the Paumotus, but none are yet recorded from the Hawaiian Islands. It is most remarkable that the genus, while so common at Mer, is quite unknown from the mainland coast of Australia and from the Thursday Island region.

Brock (1888) gave special attention to *Ophiomastix* and published two important tables of the species, one based on the claviform spines and the other on the disk-covering. In neither, however, does he make sufficient allowance for individual diversity or for growth-changes. It is hoped that the following key will prove more elastic.

Key to the Species of Ophiomastix.

A. Tentacle-scales present.
  B. Disk covered with granules, some of which are elongated into spinelets; the gradation between granules and spinelets may be obvious or the latter may be abruptly distinct; arms relatively short, about 5 times disk-diameter.
    C. Tentacle-scale single, except often on basal pores; colors black (or dark gray) and white (or whitish) .... *asperula*
    CC. Tentacle-scales 2.
      Color in life uniformly deep red; preserved specimens are orange, yellow, cream-color, brownish, or grayish, without markings .... *mixta*
      Colors, brown variegated with lighter; arm-spines ringed with light and dark .... *elegans*
  BB. Disk bare but with more or less numerous, scattered spinelets, and sometimes a few coarse granules.
    C. Tentacle-scales 2.
      D. Arms long, 7 to 12 times disk-diameter.
        E. Disk-spines rather blunt, not acicular, white, usually more or less clearly banded with dark brown .... *annulosa*
        EE. Disk spines very sharp, more or less acicular, unicolor and never banded.
          General coloration black and deep yellow; arm-spines black and not banded; oral shields with margins barely marked with yellow .... *janualis*
          General coloration dark brown and whitish; arm-spines, at least proximally, more or less distinctly banded; oral shields with broad whitish margins .... *lütkeni*
      DD. Arms short, about 5 times disk-diameter.
        Upper arm-plates broadly fan-shaped, distal half and distal half of side arm-plates white or whitish; proximal halves very dark brown .... *caryophyllata*
        Upper arm-plates broadly diamond-shaped (twice as wide as long) uniformly light gray or fawn color in marked contrast to dark side arm-plates .... *corallicola*
    CC. Tentacle-scale single, except often on basal pores.
      D. Arm-spines commonly 4, sometimes 5, often only 3 on alternate segments.
        E. Claviform spines short and very stout; disk handsomely marked with irregular blackish lines .... *venosa*
        EE. Claviform spines slightly developed or wanting; disk not marked with black.
          Disk with conspicuous characteristic white markings; arms banded .... *variabilis*
          Disk without markings and arms not banded .... *ornata*
      DD. Arm-spines alternating 3 and 2 .... *bispinosa*
AA. Tentacle-scales wanting; no granules but some scattered spinelets on disk; arm-spines 3 and 2 .. *flaccida*

Ophiomastix asperula.

Lütken. 1869. Add. ad Hist. Op h., pt. 3, p. 43.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xv, figs. 9, 9*a*.—Koehler. 1905. *Siboga* Oph. Litt., pl. vi, figs. 11, 12.

(Plate 14, Figure 1.)

Although the colors are not bright, this is a very handsome brittle-star. It is quite *Ophiocoma*-like and may easily be confused with *Ophiocoma wendtii* at first glance. Indeed, the specimen in the Museum of Comparative Zoölogy from Zanzibar, supposed to be an *asperula* (see H. L. Clark, 1915), proves, on critical examination, to be *Ophiocoma wendtii* and not an Ophiomastix. It is in poor condition and for many years has borne the label

"*Ophiomastix asperula?*." As a matter of fact, *asperula* is not known from the Indian Ocean; the type locality is Fiji, and the only other places from which it is known are Amboina, where it seems to be common, and the little island of Kaniungan Ketjil, on the eastern coast of Borneo, where the *Siboga* took one specimen. At Mer *asperula* is rare and only three specimens were found; all occurred under coral fragments on the southeastern reef-flat. The largest is 20 mm. across the disk, and has arms 90 mm. long; it is thus considerably larger than any other specimen recorded.

Ophiomastix mixta.

Lütken. 1869. Add. ad Hist. Oph., pt. 3, p. 42.—Matsumoto. 1917. Japan. Oph., p. 348, fig. 97.

(Plate 14, Figure 2.)

The handsome claret-red color[1] of this fine species is very fugacious and leaches out in fresh water and in every preserving fluid which I tried; after death it even leaches out in salt water. It was impossible to preserve the color, even in dried specimens, for any length of time. Those which retain the most color become orange, but even that shade fades and nearly all preserved specimens are yellowish, pale brownish, or nearly white. In size, *mixta* ranks among the smallest members of the genus. Matsumoto (1917) gives a figure of a specimen 20 mm. across the disk, but the largest specimen I have seen is 16 mm. in disk-diameter and has the arms about 64 mm. long. In most specimens the arms are approximately 5 times the diameter of the disk. Brock (1888) says the specimens he found at Amboina were all small, and few of those we found at Mer are more than 12 mm. across the disk.

The covering of granules shows more or less diversity in different individuals, but the growth-changes are not remarkable, for very small specimens do not have the disk-covering like an Ophiocoma. In some adults the granule-coat is quite like an Ophiocoma, except near and at the margin, but in others the spinelets are sufficiently long and numerous to indicate clearly an Ophiomastix. The claviform spines are lacking in most young specimens, but they are frequently, if not always, well-developed in adults. Koehler (1905) is certainly mistaken in thinking that the presence of claviform spines shows that the specimen is not *mixta*.

The type-localities of *mixta* are Fiji and Samoa. Brock (1888) found it common at Amboina. Bell (1899) records it from the Loyalty Islands, and Koehler (1905) from the northern point of Timor. It seems to be common at Misaki, Japan, but it is not yet known from the Philippines. At Mer it is fairly common in the dead portions of colonies of *Porites*, *Pocillopora*, *Acropora*, and *Seriatopora* on the southeastern reef-flat. It also occurred occasionally under rock fragments. There is certainly no obvious correlation between the color and the environment.

Ophiomastix elegans.

Brock. 1888. Zeit. f. w. Zool., *47*, p. 500.

This species is unfortunately known only from the holotype taken by Brock at Amboina. While allied to *mixta*, it is evidently quite a distinct species.

Ophiomastix annulosa.

Ophiura annulosa Lamarck. 1816. Anim. s. Vert., *2*, p. 543.
Ophiomastix annulosa Müller and Troschel. 1842. Syst. Ast., p. 107.—Döderlein. 1896. Jena. Denkschr., *8*, pl. xvi, fig. 11.

(Plate 14, Figure 6.)

This is one of the large species of *Ophiomastix*, having the disk 25 to 30 mm. across and arms about eight times as long as that. The claviform spines are numerous and usually

[1] The fine speckling with black, seen with a lens in figure 2, plate 14, is not present on the brittle-star itself, but is a device adopted by the lithographer for deepening the red color where necessary. The banding of the arms with gray, which is always present distally to a greater or less degree, is poorly indicated in the figure.

very conspicuous. The species has a wide range from Minikoi and Ceylon on the west to Pinnacle Island, Riu Kiu Islands on the north, and the Solomon and Loyalty Islands on the southeast. It is common all through the East Indies, especially at Amboina. At Mer, *annulosa* is one of the commonest brittle-stars. The coloration is very characteristic, but occasional albinos occur which are a nearly uniform cream-color; in some of these the distal portions of the arms have the usual red, white, and black shades. Specimens under 10 mm. in disk-diameter are not so red as adults, the arm-plates are very different, and the claviform spines are wanting; when only 5 mm. across the disk, there are no specific characters like those of the adult, except the whitish disk-spines, and these are not numerous. Unlike some other members of the genus, *annulosa* does not often occur among the living corals, but is most abundant under rocks and coral slabs. It is very active, and as soon as its sheltering rock is overturned it moves rapidly to a new shelter.

Kent (1893, Great Barrier Reef, p. 121, pl. XI, fig. 11) records *Ophiomastix annulosa* from the Cairncross Islands (on the coast of Queensland and just south of the Torres Strait region). His description indicates that he had a sea-star of some sort in hand, but his figure is more like a brittle-star. Neither the form nor colors are those of an Ophiomastix, nor is there any indication of the claviform spines. Nevertheless, there is no other brittle-star any more like his figure than *annulosa*, and it is not at all improbable that the species has reached the Cairncross Islands. It does seem strange, however, that none of the naturalists of the *Challenger* or the *Alert*, nor Dr. Semon, nor our own party, found even one specimen of this very common species in the vicinity of Thursday Island or Badu or the Cape York peninsula.

Ophiomastix janualis.

Lyman. 1871. Illus. Cat. M. C. Z., No. 6, p. 14, pl. i, figs. 13, 14.

(Plate 14, Figure 5.)

The holotype of this species is so youthful that it is difficult to assert just how the adult would appear, but, after comparison with the material obtained at Mer, I have not hesitated to call the Murray Island specimens *janualis*. Yet Lyman's specimen was supposed to come from the coast of Bolivia! No ophiocomid is known from the western coast of South America, and if an Ophiomastix should be found there the relation to the Murray Island form would require reinvestigation. The differences between *janualis* and *lütkeni* seem to be mainly in the coloration, and yet they are so marked it is very unlikely the two forms are identical.

The only known locality for *janualis* is Mer,[1] where we found it fairly common among *Porites*, *Pocillopora*, and *Acropora*, well out on the southeastern reef-flat. It never seemed to occur under rocks or coral slabs. It is one of the most active ophiurans I have ever seen, and it is no simple matter to capture a specimen uninjured. The largest specimen, 28 mm. in disk-diameter, damaged all of its arms, but other specimens show that the arms are nine or ten times as long as the disk is wide. There is practically no diversity in color, except that the amount of yellow along the margins of the oral shields and arm-plates is a trifle greater in some specimens than in others.

Ophiomastix lütkeni.

Pfeffer. 1900. Abh. Senckenb. Nat. Ges., *25*, p. 83.—H. L. Clark. 1915. Mem. M. C. Z., *25*, pl. 16, figs. 3, 4.

This species is very similar in proportions and form, and in the disk-covering, to *janualis*, but the pattern and shades of coloring are very different. Careful examination of material in the Museum of Comparative Zoölogy from the Philippine Islands shows that two specimens supposed to be *janualis* are really *lütkeni*. One of these is a *Challenger* specimen, originally called *caryophyllata* and afterwards *janualis*. The other is a later

[1] For specimens from the Philippine Islands listed as *janualis*, see *lütkeni*.

acquisition, in poor condition, with only the basal portion of the arms, and is catalogued as *janualis.* Both these specimens have the coloration of *lütkeni* and must be regarded as such. This discovery that *janualis* is not known from the Philippines and that Mer is the only definite locality for that species raises some annoying questions. The holotype of *janualis* was collected by Captain Putnam and was supposed to be from Bolivia (Mejillones). It seems to me sure that it did not come from that country, and I have suggested (1915) that it came from Hongkong; but if it came from Hongkong it is more likely to be the young of the Philippine species than of the one from Mer. In that case, the name *lütkeni* would become a synonym of *janualis* and the Murray Island Ophiomastix would need a new name. But unfortunately the holotype of *janualis* is so much smaller than any specimens of *lütkeni* or of the species from Mer available to me, I can not decide to which it is nearer (the coloration is very indistinct); and moreover, the doubt about the locality always confronts us. I see no better course, therefore, than to continue calling the Murray Island form *janualis* and the species from Ternate, the Philippines, and the Riu Kiu Islands, *lütkeni.*

Ophiomastix caryophyllata.

Lütken. 1869. Add. ad Hist. Oph., pt. 3, p. 43.—Döderlein. 1896. Jena. Denksehr., *8*, pl. xv, figs. 10, 10*a*.

(Plate 14, Figure 4; Plate 36, Figure 10.)

The type locality for this species is the Fiji Islands, but it has been taken several times at Amboina, the *Siboga* took it off the east coast of Borneo and at Saleyer, and Koehler (1907) records specimens in the Paris Museum from the Sulu Archipelago and New Caledonia. At Mer it was quite common in the dead portions of coral colonies on the southeastern reef-flat. It does not reach a very large size, 19 mm. across the disk and arms, about five times as long being the maximum. The disk is quite thickly covered with spinules.

The coloration is very constant in the Murray Island specimens, but it is either more variable elsewhere or other species have been confused with *caryophyllata*, for both Brock and Koehler refer to specimens which are very different in color from any *caryophyllata* I have seen. My identification of the specimens from Mer is based on comparison with a specimen in the Museum of Comparative Zoölogy from Fiji, received from the Godeffroy Museum, bearing the name of this species and agreeing well with Lütken's description. Brock (1888) says his specimens from Amboina agreed well with Lütken's in color, yet further on he says the color is "Goldgelb und Purpur," whereas Lütken gives the colors as dark brown and light brown. Koehler (1905) says that two of the *Siboga* specimens were almost black, a coloration suggestive of *lütkeni* or *janualis.* In preserved specimens dark brown and light brown, or brownish-white, are the shades, as Lütken says. In life, the colors were to my eyes bright brown and silvery gray, but to my artist, Mr. Grosse, the brown seemed reddish-purple, as shown in plate 14, figure 4. The bands of light and dark color on the arms are of approximately equal width; the dark does not predominate as in the figure given.

In specimens with the disk under 10 mm. in diameter the claviform spines appear to be wanting or may just be indicated, but in the full-grown adults they are numerous and conspicuous both by size and dark color.

Ophiomastix corallicola.

H. L. Clark. 1915. Mem. M. C. Z., *25*, p. 294, pl. 16, figs. 1, 2.

(Plate 14, Figure 3; Plate 36, Figure 11.)

This is one of the characteristic animals of the southeastern reef-flat at Mer. It occurs with other species of *Ophiomastix*, especially *caryophyllata*, in the colonies of *Porites*, *Pocillopora*, *Acropora*, and *Seriatopora*, and is rarely found on the sand, either among the corals or under rocks. It is very active, and climbs about rapidly (for an echinoderm) between the branches of the coral colonies. Although so similar to *caryophyllata*, it is perfectly distinct from that species, the form of the upper arm-plates (pl. 36, fig. 11) and the very different color-pattern preventing any confusion of the two. The largest specimen seen is 18 mm. across the disk.

Ophiomastix venosa.

Peters. 1851. Monatsb. K.-Preuss. Akad. Wiss. Berlin, p. 464.—Koehler. 1904. Mém. Soc. Zool. France, *17*, p. 73, figs. 28, 29.

The geographical isolation of this species on the eastern coast of Africa is notable. It has been recorded from Mozambique, Zanzibar, and Madagascar. Bell asserts (1902) that it is common in the Maldives, but as it is not known from Mauritius or the Seychelles, it seems to me its occurrence at the Maldives requires confirmation. It is the heaviest species of the genus, 30 mm. across the disk when adult, with arms about 150 mm. long, noticeably stout and with relatively short, thick spines. The disk spinules are few, sometimes occurring only at the disk-margin; they are short, thick, and blunt.

Ophiomastix variabilis.

Koehler. 1905. *Siboga* Oph. Litt., p. 69, pl. vi, fig. 16; pl. xvi, figs. 3, 4.

This species is known only from the *Siboga* specimens, which were taken at four widely separated stations in the Dutch East Indies. They show great diversity in disk-spinulation, but agree in the characteristic light markings about the radial shields. The largest specimens are only 6 to 7 mm. across the disk, with arms 40 to 45 mm. long, so it is evident that adult material will throw new light on the status of the species.

Ophiomastix ornata.

Koehler. 1905. *Siboga* Oph. Litt., p. 71, pl. vi, figs. 13, 14.

The unique holotype of this species was taken on Borneo Bank by the *Siboga*. It is only 9 mm. across the disk and all the arms are broken. Adult material is therefore needed even more than in the case of *variabilis*.

Ophiomastix bispinosa.

H. L. Clark. 1917. Bull. M. C. Z., *61*, p. 442, pl. 2, figs. 1, 2.

This is another inadequately known species, of particular interest because of its being the easternmost representative of the genus. The unique holotype, only 5 mm. in disk-diameter, with arms 40 to 45 mm. long, was taken at Makemo in the Paumotus.

Ophiomastix flaccida.

Ophiomastix flaccida Lyman. 1874. Bull. M. C. Z., *3*, p. 226, pl. vi, figs. 14, 15.
Acantharachna mirabilis Smith. 1878. Jour. Linn. Soc. Zool., *13*, p. 335, pl. xviii, figs. 1–6.

(Plate 13, Figure 2.)

I should not have dared identify with this species the little brittle-star found at Mer, October 8, 1913, and figured on plate 13, had I not had for comparison a small paratype from the Philippine Islands. The Murray Island individual was scarcely 4 mm. across the disk and had arms only about 18 mm. long. The disk was bluish with some orange-red lines, the arms yellow with dark-green marks along the sides and the arm-spines white. There are no disk spinelets, but on each arm are a number of claviform spines, and as there are no tentacle-scales I am satisfied that the individual is a very young *flaccida*. The species is otherwise known from the Philippine Islands, many stations in the Dutch East Indies, and the island of Salawatti, New Guinea. Studer (1883) says the species lives on sponges and is purplish-red in life. The largest specimen in the Museum of Comparative

Zoölogy is 18 mm. across the disk. The single individual collected at Mer was found on the underside of a rock-fragment on the southeastern reef-flat. It is not unlikely that further knowledge of the habits and morphology of this species will justify the recognition for it of Smith's genus *Acantharachna*.

OPHIARTHRUM.

Peters. 1851. Monatsb. K.-Preuss. Akad. Wiss. Berlin, p. 463.

Like *Ophiomastix*, this genus is so easily recognized and the specific limits within it are so well defined, there are no synonyms and no wrongly assigned species to cause confusion. Only three species have been described, and each of these is valid. The genus may be regarded as a specialized offshoot of *Ophiocoma*, with a deficiently calcified disk, only 1 tentacle-scale and 3 or 4 arm-spines. It has a very wide range from Mozambique and Zanzibar to the Society Islands. It is not known, however, from the Hawaiian group as yet. The three species are not morphologically very different from each other, and the form of the plates of either arms or oral frame afford no very distinctive characters; but the coloration is an unfailing means of distinguishing the species, for while it is not by any means constant within narrow limits, each species is entirely different from the others.

Key to the Species of Ophiarthrum.

Arm spines light, spotted or ringed with dusky.
 Disk very dark, at least at center; no yellow; no median dark line on upper side of finely speckled arms . . *elegans*
 Disk beautifully marked in life with white, yellow[1] and gray; arms with a more or less distinct median dark line on upper side . . . . *pictum*
Arm-spines, and arms, uniformly grayish-brown; disk black . . . . *lymani*

Ophiarthrum elegans.

Peters. 1851. Monatsb. K.-Preuss. Akad. Wiss. Berlin, p. 464.—Koehler. 1898. Bull. Sci., *31*, pl. iii, figs. 25, 26.

(Plate 13, Figure 1.)

The centrally dark and peripherally light disk make this species easy to recognize, but there is great diversity in the colors of the living animals. Those found at Tahiti on August 5, 1913, had the disk deep chocolate-brown and the arms were banded with that shade and with deep brick-red; but these colors were much changed in alcohol. At Green Island, Queensland, where *elegans* is very common, none of the individuals showed any trace of red and the disk was dark brown with a purple tinge. At Mer the general coloration was very deep purple and greenish-white; there was great individual diversity in the amount of light color on the disk, but many had the arrangement of dark and light areas more or less as in the specimen figured (pl. 13, fig. 1).

The distribution of this species is notable, as it is one of the few members of the family occurring in the neighborhood of Thursday Island. We found it common, but oddly enough it was not taken by the earlier collectors. Its known range extends from Mozambique and Zanzibar eastward to the Society Islands, and from Green Island, Queensland, northward to the Riu Kiu Islands. It occurs under rocks and coral fragments on the reef-flats, like an Ophiocoma, and is moderately active when its shelter is disturbed. It is rather more delicate than an Ophiocoma and the surface of the disk seems to disintegrate or rub off very easily if the specimen remains long in a crowded collecting bucket. It was not easy at Mer to get specimens back to the laboratory in an uninjured condition.

The largest specimen of *elegans* that I have seen is from Samoa. It is 23 mm. across the disk and is further notable for having *six* arms, a very unusual freak. De Loriol (1893) says the arms are 9 times the disk-diameter, but in those which I have measured the proportion is 5.5 to 8 to 1.

[1] In preserved specimens, which are often quite brown, the yellow shades fade and may disappear or become brown, and the white becomes dingy.

Ophiarthrum pictum.

Ophiocoma picta Müller and Troschel. 1842. Sys. Ast., p. 102.
Ophiarthrum pictum Lyman. 1874. Bull. M. C. Z., *3*, p. 225, pl. vii, figs. 2–4.

(Plate 12, Figure 1.)

This is unquestionably one of the most beautiful of brittle-stars, though its beauty is quite different from that of *Ophiarachna incrassata*. In the present species, the colors are light and in life many of the tints are very delicate; few if any remain unchanged in preservation. As shown in the figure (pl. 12, fig. 1), white, pearl-gray, and yellow are the principal colors, but a darker shade of gray forms a more or less complete median longitudinal stripe on the upper side of the arm. There is considerable individual diversity in the color-pattern of the disk, but the 5 white interradial areas with their curious yellow marks are generally very distinct. The white is often distinctly tinted with blue. The largest specimen I have seen is 30 mm. across the disk, and specimens 20 to 25 mm. across are common; the arms are 5.5 to 8 times the disk-diameter.

This species has a much more restricted range than the preceding. The type locality is Java, and it has not been found west of that island. It is common at Amboina and is known also from several other stations in the Dutch East Indies, from the Philippines, from Timor, and New Guinea, and from the Pelew Islands. At Mer we found *pictum* fairly common on the southeastern reef-flat, where it lives under rock and coral fragments. Like *elegans*, it is a moderately active and rather delicate brittle-star, but it stood handling and transportation to the laboratory rather better than the smaller species.

Ophiarthrum lymani.

De Loriol. 1894. Mém. Soc. Phys. Hist. Nat. Genève, *32*, pt. 1, No. 3, p. 34, pl. xxiv, figs. 2–2*d*.

This is one of the endemic echinoderms of Mauritius, known only from de Loriol's account. It is about the same size as *elegans*, but has relatively shorter arms, as these are only a trifle more than five times the disk-diameter. The coloration is the obviously distinguishing species character. One can not determine from de Loriol's account whether he had more than a single specimen.

OPHIODERMATIDÆ.

Ophiarachna incrassata.

Ophiura incrassata Lamarck. 1816. Anim. s. Vert., *2*, p. 542.
Ophiarachna incrassata Müller and Troschel. 1842. Syst. Ast., p. 104.—Herklots. 1869. Échinod. peintes d'après Nature, pl. vi (colored).

(Plate 34, Figures 1 and 2.)

The type locality of this superb ophiuran is unknown, but Müller and Troschel give Java as its home. It has been recorded from Zanzibar, Darros Island, and Ceylon on the west and from the Caroline and Fiji Islands on the east; on the north it reaches the Riu Kiu and Bonin Islands, while on the south Green Island, Queensland, seems to be the limit of range. It occurs throughout the Torres Strait region, being common at Badu, Erub, and Mer. It is the largest known simple-armed ophiuran, mature specimens having the disk 40 to 50 mm. across. The largest specimen I have seen is 57 mm. in disk-diameter. The arms are rather short and stout, 3.5 to 4 times the width of the disk. The coloration is as remarkable as the size and would scarcely be guessed at from preserved specimens. The ground-color is a brilliant grass-green, upon which are white spots encircled with black, and occasional black spots and markings; the arm-spines, particularly the lower ones, are handsomely annulated with black and white. All in all, *incrassata* is one of the handsomest, if not actually the most beautiful, of all brittle-stars. Unfortunately, the green is very fugacious, and preserved specimens, no matter how carefully or by what method prepared, rarely retain even a hint of it. It is replaced by a pale brown or dirty yellow which may fade to light yellow or nearly white.

At Mer this species is very common under large rock-fragments and coral slabs on the southeastern reef-flat. It acts very much like an Ophioderma and reminds one in its notably active movements of the large West Indian *Ophioderma cinerea*. One very unusual freak was collected, having 6 arms; the supernumerary arm, instead of being in the same plane as the other 5, is directly below one of them; all 6 are of approximately equal size. There are only 5 normal jaws, but the oral frame is obviously affected by the growth of the extra arm.

Pectinura arenosa.

Lyman. 1879. Bull. M. C. Z., *6*, p. 48, pl. xiv, figs. 392–394.

We did not meet with this species in Torres Strait, but Semon took a specimen near Thursday Island. It was originally described from specimens taken by the *Challenger* in Bass Strait. Koehler records a specimen taken by the *Investigator* off Point de Galle, Ceylon, while the *Siboga* took specimens at half a dozen stations in the Dutch East Indies. It is noteworthy that neither the *Thetis* nor the *Endeavour* met with the species on the southeastern and southern coasts of Australia.

Pectinura yoldii.

Ophiopeza yoldii Lütken. 1856. Vid. Med., p. 9.—1859. Add. ad Hist. Oph., pt. 2, pl. i, fig. 9.
Pectinura yoldii H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 119.

The type locality of this species is unknown, but it was probably in the East Indies, as the range is now known to be from New South Wales northward to Sumatra and the Philippines. We did not meet with *yoldii* in the Torres Strait region, but Semon took it near Thursday Island, and the *Alert* secured it at several stations on the Queensland coast, as well as in Torres Strait. It is also known from the Aru Islands.

Ophiopezella spinosa.

Ophiarachna spinosa Ljungman. 1867. Öfv. Kongl. Vet.-Akad. Förh., *23*, p. 305.
Ophiopezella spinosa Lyman. 1882. *Challenger* Oph., p. 17.
Ophiopezella lütkeni de Loriol. 1893. Rev. Suisse Zool., *1*, p. 392, pl. xiii, figs. 1–1*e*.

(Plate 12, Figure 2.)

This species, which ranges from the Philippines to the Society Islands, extends southward to the Torres Strait region, where we found it at both Friday Island and Mer. It was taken only once by the *Siboga*, but this was probably due to its secretive habits, for it is an inactive little species, occurring in the sand under rocks and slabs. The specimens taken at Mer were found on the southeastern reef-flat.

Ophiochasma stellatum.

Ophiarachna stellata Ljungman. 1867. Öfv. Kongl. Vet.-Akad. Förh., *23*, p. 305.
Ophiopinax stellatus Bell. 1884. *Alert* Rept., p. 136, pl. viii, fig. C.
Ophiochasma stellatum H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 121.

We did not meet with this handsome brittle-star in the Torres Strait region, but the *Alert* took it there, according to Bell. Its known range is from Port Molle and Port Denison, Queensland, northward to the Gulf of Siam, but it is remarkable that the *Siboga* failed to meet with it.

Ophiarachnella gorgonia.

Ophiarachna gorgonia Müller and Troschel. 1842. Sys. Ast., p. 105.
Ophiarachnella gorgonia H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 123.

(Plate 12, Figure 5; Plate 35, Figures 4 and 5.)

This pretty brittle-star was common at Mer and showed little diversity in color or size. The larger specimens, with disk 10 to 15 mm. across, are duller in color than the young. The specific limits of *gorgonia* are, however, as yet very badly drawn, and more extended observations on living material are necessary before positive conclusions can be reached. In 1909, I believed the species a highly variable one and concluded that the names *marmorata* Lyman, *ramsayi* Bell, *stearnsii* Ives, and *venusta* de Loriol were all synonyms of *gorgonia*. But further study of the material, after my visit to Torres Strait in 1913, led me to restore (1915) *marmorata* and *ramsayi* to the ranks of valid species, and here the matter must be left for the present. Unfortunately, the geographical range of the green-and-white form, occurring at Mer and at Amboina, can not be determined from data at hand. Specimens believed to be true *gorgonia* are known from the east coast of Africa to Fiji and Samoa, and from Queensland to Japan. At Mer the specimens were all rather small and the disk-granulation is coarse. They occurred all around the island under stones on sandy bottom, even up to near high-water mark. We found no specimens near Thursday Island, and it is noteworthy that none of the earlier expeditions to Torres Strait found any. Yet I found at Green Island, near Cairns, Queensland, two specimens identical with those afterward taken at Mer.

Ophiarachnella infernalis.

Ophiarachna infernalis Müller and Troschel. 1842. Sys. Ast., p. 105.
Pectinura infernalis Koehler. 1905. *Siboga* Oph. Litt., p. 7, pl. i, figs. 1–3.
Ophiarachnella infernalis H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 124.

This species ranges from Zanzibar to the Pelew Islands and from Torres Strait to southern Japan. Dr. Coppinger, of the *Alert*, took it at Port Molle, Thursday Island, Prince of Wales Channel, and Port Darwin. We found it common at Erub and at Mer, under stones on sandy bottoms. The rather dingy coloration is unattractive, and there is nothing else about the species that calls for special comment. Dr. Koehler writes me that he is confident I am wrong in considering his species *similis* identical with *infernalis*. As I have no indubitable specimens of *similis*, I refrain from further discussion of the question at present.

Ophiarachnella septemspinosa.

Ophiarachna septemspinosa Müller and Troschel. 1842. Sys. Ast., p. 105.
Pectinura septemspinosa Döderlein. 1889. Zool. Jahrb., Syst., *3*, pl. xxxii, figs. 4a–4c.
Ophiarachnella septemspinosa H. L. Clark. 1909. Bull. M. C. Z., *52*, p. 126.

(Plate 12, Figure 7.)

This fine species, adults of which may be as much as 36 mm. across the disk, is known from Zanzibar to the Fiji Islands, but it is not yet reported from the Philippines, nor was it hitherto known from Australia. We found it rather uncommon at the Murray Islands, the first specimen being taken from under a rock-fragment on the reef-flat on the south side of Weier. It is a large, active brittle-star, appearing much like one of the West Indian Ophiodermas. The colors in life (pl. 12, fig. 7) are very handsome, but the green is fugacious and disappears in preserved specimens.

OPHIOLEPIDIDÆ.

Ophiura kinbergi.

Ophiura (vel *Ophioglypha*) *kinbergi* Ljungman. 1866. Öfv. Kongl. Vet.-Akad. Förh., *23*, p. 166.
Ophiura kinbergi H. L. Clark. 1911. Bull. 75 U. S. Nat. Mus., p. 37, fig. 9.

(Plate 12, Figure 3.)

This pretty little species has a notable and interesting north-and-south range, occurring as it does at Port Philip, Victoria, and in the Sea of Japan at latitude 38° 16′ N. Its east-and-west range is rather narrow, for while it reaches Calcutta and Ceylon on the west, it has not yet been recorded from further east than the Philippines and the eastern coast of Australia. At Mer we found only two specimens and these were both small. They were taken with the tangle, in 4 to 5 fathoms, off the northwestern reef, in company with *Ophiacantha discoidea*. The colors in life (pl. 12, fig. 3) are very delicate and fugacious; so preserved specimens do not show them clearly, if at all.

Ophiolepis cincta.

Müller and Troschel. 1842. Sys. Ast., p. 90.—Lütken. 1859. Add. ad Hist. Oph., pt. 2, p. 101, pl. ii, figs. 6*a*, 6*b*.

This is a typical Indo-Pacific species, ranging from Mozambique to the Red Sea on the west, through the East Indian region, northward to Japan, southward to New South Wales, and eastward to the Society Islands. The *Challenger* found it in Torres Strait, and we took two nearly white specimens from under stones in sand at Thursday Island. We also found *cincta* at Badu, and at Mer it was quite common under rocks in sand, but all of the specimens found were small. No adults were seen. Lyman has given (1865, pl. II, fig. 4) a very good colored figure of the adult under the name *Ophiolepis garretti*. The young are much less handsomely colored.

Ophiolepis superba.

Ophiura annulosa de Blainville. 1834. Man. Act., p. 244 (non Lamarck, 1816).
Ophiolepis annulosa Lütken. 1859. Add. ad Hist. Oph., pt. 2, pl. ii, figs. 5*a*, 5*b*.
Ophiolepis superba H. L. Clark. 1915*a*. Spolia Zeylanica, *10*, p. 89.

We found this very noticeable brittle-star both at Erub and Mer, under stones on sandy bottoms. It was taken by the *Challenger* in Torres Strait and by the *Alert* at Clairmont, just south of the Torres Strait region, and at Port Darwin to the west. The known range is from Zanzibar to the Marshall Islands on the east, to the Riu Kiu Islands on the north, and to Turtle Island, West Australia, on the south. There is considerable diversity in the amount of black (or deep rich purple, in life) present in proportion to the deep buff, and occasionally specimens with no black at all occur. Herklots (1869, pl. IV, fig. 2) has given a very good colored figure of a specimen from Java.

Ophioplocus imbricatus.

Ophiolepis imbricata Müller and Troschel. 1842. Sys. Ast., p. 93.
Ophioplocus imbricatus Lyman. 1861. Proc. Boston Soc. Nat. Hist., *8*, p. 76, footnote.—Herklots. 1869. Échinod. peintes d'après Nature, pl. v, fig. 1.

(Plate 12, Figure 8; Plate 35, Figures 1 to 3.)

Although this is also a wide-ranging Indo-Pacific species, it has not yet been found east of the Gilbert Islands. Yet a closely allied species occurs on the coast of California. It extends northward to the Riu Kiu Islands, but on the Japanese coast is replaced by a third species. Southward it reaches Shark Bay, West Australia, and the Murray Islands, but it is not known from the Thursday Island region nor from the Aru Islands. On the southern coast of Australia and in New Zealand waters are other members of the genus. At both Erub and Mer *imbricatus* is common, under rocks and coral fragments on the sand. Most individuals are light colored, one might say "sandy" (pl. 12, fig. 8), but one specimen found at Mer was so very different it was supposed to be another species. The disk was deep yellow, heavily marbled with dark, dusky olive (pl. 35, fig. 3). Comparison with material from the East Indies shows, however, that this diversity of color has little significance, as it intergrades with the unmarked condition through numerous connecting links.

ECHINOIDEA. SEA-URCHINS.

The echini are, in the Torres Strait region, the least notable of the five classes of echinoderms; neither in number of individuals nor of species are they remarkable. Nearly all are well-known forms and few call for extended comment. The *Challenger* collection contained 8 species, while Dr. Coppinger of the *Alert* brought home a dozen. Semon took 8, of which 2 were not taken by either of the earlier expeditions. We found 14 species at Mer and took 7 others in the vicinity of Thursday Island. It is remarkable that only 6 of these 21 were taken by the earlier collectors, while they took 12 species with which we did not meet. It is rather peculiar that they all found *Prionocidaris bispinosa, Temnotrema bothryoides,* and *Laganum decagonale* in the vicinity of Thursday Island, while we saw none of them anywhere in the Torres Strait region. The only echinoid common to all four collections is the characteristically Australian spatangoid *Breynia.*

There are thus only 33 echini known from the restricted region under consideration, and it is not likely this number will be greatly increased by further collecting, although dredging and the use of tangles may result in some novelties. Not a dozen of the species are really common; fully as many are actually rare and unlikely to be found. Most of the species are to be found under large coral slabs or rock-fragments, or in their crevices, but the clypeastroids occur only on sandy bottoms, while the spatangoids may be found in sandy mud. None of the species except the Echinometra seem to be gregarious, but both *Centrechinus* and *Echinothrix* are sometimes found several together around and under the sheltering rock. *Echinometra* may occur in scores among rock-fragments where conditions are favorable. Both *Centrechinus* and *Echinothrix* are unpleasant creatures to touch when alive, as the exceedingly long, sharp, and mobile spines are poisonous and inflict a very painful wound, for which time seems to be the only alleviant. All of these disagreeable echini are handsome animals, especially when seen in bright sunlight, and *Echinothrix calamaris* is perhaps the most beautiful of sea-urchins. Another notable species is *Tripneustes gratilla,* in which the contrasts between the purple test, orange spines, and black-and-white pedicels are very striking. As *Tripneustes* lives out on the open reef-flat when adult, not seeking the shelter of rocks, it is one of the conspicuous animals on such areas.

CIDARIDÆ.

Prionocidaris bispinosa.

Cidarites bispinosa Lamarck. 1816. Anim. s. Vert., *3,* p. 57.
Phyllacanthus annulifera A. Agassiz. 1872. Rev. Ech., pt. 1, p. 150.
Leiocidaris bispinosa Döderlein. 1903. Jena. Denkschr., *8,* p. 695, pl. lviii, figs. 5–11*a*.
Prionocidaris bispinosa Döderlein. 1911. Abh. Senckenb. Naturf. Ges., *34,* p. 240.

The nomenclature of this very variable species has been much confused, but at last it seems to be agreed that Lamarck's name *bispinosa* is really based on the present form. One of the few disappointments of my Australian trip was our failure to meet with this species. The *Challenger,* the *Alert,* and Dr. Semon all took specimens in the Torres Strait region, and I confidently expected to get a good series. The geographical range of *bispinosa* extends throughout the East Indies from China and the Gulf of Siam to Queensland, Sharks Bay, West Australia, and even to New Britain (Bell). It is not a large urchin, the test measuring 30 to 50 mm. in diameter in adults. The primaries are either smooth or thorny and the smooth reddish or purplish collar is unspotted.

Prionocidaris verticillata.

Cidarites verticillata Lamarck. 1816. Anim. s. Vert., *3*, p. 56.
Phyllacanthus verticillata A. Agassiz. 1873. Rev. Ech., pl. i*f*, fig. 3.
Prionocidaris verticillata Döderlein. 1911. Abh. Senckenb. Naturf. Ges., *34*, p. 243.

The *Challenger* took a specimen of this cidarid near Wednesday Island in 8 fathoms, but neither the *Alert* nor Semon found it, nor were we so fortunate as to meet with it. It has a very wide range, from Mozambique to Samoa northward to the Riu Kiu Islands and south to Torres Strait, but it is apparently not common anywhere and good series for study are still desiderata. It does not reach a large size (disk-diameter up to 40 mm.), but nothing is known of the growth-stages or of the degree of diversity which individuals may show.

Phyllacanthus imperialis.

Cidarites imperialis Lamarck. 1816. Anim. s. Vert., *3*, p. 54.
Phyllacanthus imperialis Brandt. 1835. Prodrome, p. 268.—A. Agassiz. 1873. Rev. Ech., pl. i*f*, figs. 2, 6. 7.

This fine cidarid ranges from Zanzibar and the Red Sea to and throughout the East Indies, southward to the Loyalty Islands, and along the east coast of Australia to Port Jackson. There is more or less diversity in the length and thickness of the spines, but material is not yet sufficiently abundant anywhere to enable us to decide whether the varieties which have been proposed and named are really of genetic significance.

At Mer this species was not often met with, but it was not rare in its own particular habitat, which proved to be below low-water mark at the outer margin of the reef, a region where collecting is most difficult. The discovery of this habitat came about thus: We were anxious to secure specimens of *Heterocentrotus* and sought the aid of one of the most intelligent natives. A sea-urchin of some sort was shown him and then it was explained we wanted some animals like that, only with very big, thick spines, and a sketch was drawn to make sure he understood. He responded readily that he knew where to find them, so he was given a bucket and sent off, with the promise of sixpence apiece for all he could bring home. When he returned the bucket was nearly filled with *Phyllacanthus imperialis*, which he had secured off the northwestern reef by diving! He was quite disappointed that these were not the urchins desired. Other, but smaller, specimens were found on both the southeastern and southwestern reef-flats, under rocks near the reef-margin but above low-water mark.

CENTRECHINIDÆ.

It is unfortunate that the familiar name for this family, Diadematidæ, must be abandoned, but since there seems no doubt that *Centrechinus* must replace *Diadema*, the family name must also be altered.

Centrechinus savignyi.

Diadema savignyi Michelin. 1845. Rev. Mag. Zool., p. 15.

(Plate 17, Figures 1 and 2.)

This species is very much more common at Mer than the following, but it is by no means abundant. It is easily distinguished by the blue lines, *not spots*, on the dorsal side, the claret-colored oral region, and the entire absence of white. There is often a purplish-red tinge to the whole animal, and this may become very marked in preserved specimens. I suspect that Saville Kent's (1893) figure (chr. pl. xi, fig. 12) of *Diadema setosa*, said to be natural color, is based on *savignyi*, but as it shows white and blue spots, it is more representative of *setosus*. His account of *setosa* shows that he did not think of there being two species, and it seems to me obvious that he has confused them in his colored figure as well as in the text. If not, his specimen of *setosus* was exceptionally light-colored. Mortensen lists *savignyi* from Zanzibar, but says it does not occur in the Gulf of Siam. The *Albatross* found it at Easter Island, which indicates the greatest possible range for an Indo-Pacific species, considerably more than 14,000 miles east and west.

Centrechinus setosus.

Echinometra setosa Leske. 1778. Add. ad Klein, p. 36.
Diadema setosa Gray. 1825. Ann. Phil., *10*, p. 4.
Centrechinus setosus Jackson. 1912. Phyl. Ech., p. 28.

(Plate 17, Figures 3 and 4.)[1]

The genus *Centrechinus* is a perplexing one, because in Museum specimens the species resemble each other so closely it is difficult to detect constant differences. But observations in the West Indies and in Torres Strait have satisfied me that there are important specific differences in color, and, when these are properly known, the separation of the species will not be so difficult. At Mer two species of *Centrechinus* occur, and they are so unlike in color that any one can distinguish them at a glance, and neither is like the West Indian form. One of the Torres Strait species is characterized by white markings, five spots, dorsally in the interradii (pl. 17, fig. 3) and the whole oral region (pl. 17, fig. 4). Further distinguishing characters are found in series of blue spots bordering the dorsal interambulacra near the ambitus, but converging and forming a single line between the white spot and the periproct, and in the bright-orange anal region (pl. 17, fig. 3). Comparison with good museum material shows that this is the species common at Amboina, the type-locality for *setosus*, and I do not hesitate to identify it with Leske's species. It was the first *Centrechinus* we met with in Torres Strait, a large specimen being found at Prince of Wales Island. We subsequently met with it at Erub and Mer, but it was not nearly so common as the next species (*savignyi*). The two species did not occur actually together, but both were found at various points all over the southeastern reef-flat. Even in small specimens of *setosus* the white spots are evident. There is some diversity in the ground-color of the animal, for while adults appear to be perfectly black, they often have a purplish tinge, and young specimens are purplish or brownish with banded spines.

It is not possible to discuss the distribution of *setosus* with much profit, for most records published hitherto confuse all the Indo-Pacific species of the genus under one name. We know that the present species occurs on the Queensland coast at Palm Islands, and I found a Centrechinus at Green Island, but did not note the species. Amboina is certainly the home of *setosus*, and Mortensen (1904) describes specimens from the Gulf of Siam. He adds that he has seen specimens from Zanzibar and from Tahiti, so there is little doubt that it occurs throughout the Indo-Pacific region.

Echinothrix calamaris.

Echinus calamaris Pallas. 1774. Spic. Zool., *1*, fasc. 10, p. 31.
Echinothrix calamaris Peters. 1853. Monatsb. Akad. Berlin, p. 484.—Döderlein. 1903. Jena. Denkschr., *8*, pl. lix, fig. 9; pl. lxiii, fig. 6.

This fine sea-urchin has a typical Indo-Pacific distribution from Mozambique and the Red Sea to the Hawaiian and Society Islands, and even further southeastward to the Paumotus. It does not seem to have been recorded from the Australian coast, and I did not see it at Green Island. But at Mer it is by no means rare. Several specimens were

[1] In order to make the plan of coloration perfectly obvious, I suggested to Mr. Grosse that he leave out the spines in drawing *Centrechinus* and show only the test with its characteristic color-pattern. The result is very satisfactory, except that the illustrations do not look like *Centrechinus*! And the somewhat hemispherical test becomes too flat when printed so black.

found under large rock-fragments on the southeastern reef-flat, often in company with *Centrechinus*. The beautifully banded, black-and-white, quill-like spines, with the yellow-green ambulacral primaries, combine to make this an exceptionally handsome echinoid.

Echinothrix diadema.

Echinus diadema Linné. 1758. Sys. Nat., p. 664.
Echinothrix turcarum A. Agassiz. 1873. Rev. Ech., pl. iiia, fig. 3.
Echinothrix diadema Lovén. 1887. Ech. Linn., p. 137.

This very black sea-urchin has essentially the same range as the preceding and, like it, has not been hitherto known from Australian seas. At Mer it was fairly common on the southeastern reef-flat. The large specimens were notable for having the ambulacral spines rusty-red instead of brown or black. In smaller specimens the interambulacral primaries were often more or less distinctly banded as in *calamaris*, but were never as clearly marked as in that species. Observations made at Mer lead me to think it possible that the two forms are not distinct species, but that we have here an illustration of a dimorphic species such as are well known to occur among birds. In other words, if the development of a single lot of eggs from an Echinothrix could be followed through, we should find that some became *calamaris* and some *diadema*. It is much to be hoped that some day such an experiment may be carried through to completion.

STOMOPNEUSTIDÆ.

Stomopneustes variolaris.

Echinus variolaris Lamarck. 1816. Anim. s. Vert., *3*, p. 47.
Stomopneustes variolaris Agassiz. 1841. Mon. d'Ech.: Obs. Prog. Rec. Hist. Nat. Ech., p. 7.

This species is reported from all coasts of the Indian Ocean, except only northern and western Australia. There is a record also from Samoa, but this needs to be confirmed, as it is an old one and there is no other Pacific record, so far as I know. Tenison-Woods (1880) describes a species of *Stomopneustes* from the east coast of Australia, but this is now generally agreed to be identical with *variolaris*. He found his specimens at Trinity Bay, latitude about 16° S., but he believes the species also occurs at Port Denison, latitude 20.° On the other hand, *Stomopneustes* is not known from Thursday Island or vicinity, or from the Aru Islands, or from the northwestern side of the continent. At Mer we found only a single small specimen, under a rock on the southwestern reef. Tenison-Wood says the species is very secretive and difficult to find, so it may be that its absence from many places is apparent rather than real.

ECHINIDÆ.

Lytechinus verruculatus.

Psammechinus verruculatus Lütken. 1864. Vid. Med., p. 166.
Echinus verruculatus de Loriol. 1884. Mém. Soc. Phys. Hist. Nat. Genève, *28*, No. 8, p. 21; pl. iii, figs. 3*a*–3*e*.
Echinus angulosus Bell. 1884. *Alert* Rep., p. 121.
Lytechinus verruculatus H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, p. 253.

It is with little doubt that I include this species among the echinoderms of Torres Strait. The reason for doing so is that Bell (*l. c.*) records *Echinus angulosus* for Thursday Island and Prince of Wales Channel. I am certain that this is a misidentification; *angulosus* is a South African species and its occurrence in Torres Strait is highly improbable if not utterly impossible. On the other hand, *angulosus* has often been confused with *verruculatus*, and as the latter occurs at the Aru Islands, and, moreover, a specimen was taken by me at Green Island, near Cairns, it seems to me very probable that the *Alert* specimens are this widely distributed Indo-Pacific species. Unfortunately, we failed to find *verruculatus* in the Torres Strait region.

Nudechinus darnleyensis.

Echinus darnleyensis J. E. Tenison-Woods. 1878. Proc. Linn. Soc. N. S. W., *2*, p. 167.
Nudechinus darnleyensis H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, p. 277.

It was a great disappointment to me that although we were three days at Darnley Island (Erub), we found no small echini there, nor did we meet with this species anywhere else. The localities from which the type material came are given as "Darnley Island and Cape Grenville" (northern Queensland) "10–20 fms." Bell (1884) says the *Alert* took small echini at Thursday Island and in Prince of Wales Channel which he refers to this species provisionally. I believe it is not known from elsewhere, the small echini collected by the *Siboga*, identified by de Meijere as *darnleyensis*, apparently representing two different species (according to Mortensen, 1904).

Tripneustes gratilla.

Echinus gratilla Linné. 1758. Sys. Nat., ed. 10, p. 664.
Tripneustes gratilla Lovén. 1887. Ech. Linn., p. 77.

(Plate 17, Figure 6.)

From Mozambique to the Red Sea on the west to Hawaii, Clarion Island, and the Paumotus on the east, this big, conspicuous, and common sea-urchin ranges. It is very common at Mer, and I found one specimen at Green Island, Queensland. It is recorded by Whitelegge (1889) as "very rare" in Port Jackson, doubtless the extreme southern limit of its range. On the west coast of Australia it occurs as far south as Sharks Bay. It has not yet been reported from the Thursday Island region nor from the Aru Islands.

At Mer, *gratilla* occupies the same habitat and shows the same habits as its congener, *esculentus*, does in the West Indies, preferring open, more or less grassy bottoms when adult, but living in concealment under and among rocks when young. The color of *gratilla* (pl. 17, fig. 6) is much more striking than is that of *esculentus*, and also more variable. As a rule the test is dark, commonly rich blue-purple, the spines white, and the pedicels white with more or less black basally. This was the color of the individuals seen at Tahiti, but the specimen found at Green Island had the spines tipped with deep orange. Among the individuals seen at Mer the orange-color was generally strongly developed, the spines being commonly wholly orange, but sometimes there was orange at the spine-tips only, and now and then it was wholly wanting. It is a very fugitive color and I found no method of preparation that would serve to save it. Some individuals of *gratilla* reach a large size; the largest I have measured is 145 mm. in diameter.

TEMNOPLEURIDÆ.

Temnopleurus toreumaticus.

Cidaris toreumatica Leske. 1778. Add. ad Klein, p. 155.
Temnopleurus toreumaticus L. Agassiz. 1841. Mon. d'Ech.: Obs. Prog. Rec. Hist. Nat. Ech., p. 7.

This species has a rather unusual distribution, occurring from the Persian Gulf to southern Japan, including the Maldive Islands and Ceylon, and southward through the East Indies to northern Australia. It also occurs at Delagoa Bay, South Africa, though it is not yet known between that point and the Persian Gulf. Döderlein records it from the Aru Islands and Bell says the *Alert* took it in Prince of Wales Channel, Torres Strait, and at Port Denison, Queensland. We did not meet with *Temnopleurus* at any place where we collected.

Salmacis belli.

Salmacis sphæroides var. *belli* Döderlein. 1903. Jena. Denkschr., *8*, p. 718, pl. lxiv, figs. 1–1c.
Salmacis belli Mortensen. 1904. Siam. Ech., pp. 68, 72.

This is a characteristic species of northern Australia, and I regret very much that we failed to meet with it. It was first taken by the *Challenger* in Torres Strait and subsequently by the *Alert* at Port Molle, Queensland, but the former specimens were identified originally as *S. rarispina* and the latter as *S. bicolor*. They were subsequently examined by Mortensen and found to be *belli*. Semon also found the form near Thursday Island, and Döderlein based his supposedly new variety of *sphæroides* on Semon's material. He later agreed with Mortensen that *belli* is entitled to rank as a distinct species.

Salmacis dussumieri.

Agassiz and Desor. 1846. Cat. Rais. Éch., p. 359 (55).—Döderlein. 1903. Jena. Denkschr., *8*, pl. lxiii, figs. 5–5c.

The inclusion of this species in the present list is due to Mortensen's (1904) statement that one of the small specimens of *Salmacis* taken by the *Challenger* at her Station 186 (Torres Strait) is *dussumieri*. He also says that *dussumieri* was taken by the *Alert* at Port Denison, Queensland, and identified by Bell as *S. sulcata*. The known range of *dussumieri* is from Mozambique to southern Japan and eastern Australia. Whitelegge (1889) lists it from Port Jackson, but I doubt if it occurs so far south. The specimens taken on the coast of New South Wales by the *Endeavour* which look like *dussumieri* appear to be a distinct species, *oligopora*.

Salmacis virgulata alexandri.

Salmacis alexandri Bell. 1884. *Alert* Rep., p. 118.
Salmacis virgulata var. *alexandri* Döderlein. 1903. Jena. Denkschr., *8*, p. 712, pl. lxii, figs. 1, 3–7.
Salmacis virgulata alexandri Döderlein. 1914. Ech. Südwest. Aust., p. 454.

Although typical examples of *alexandri* are easily distinguished from typical *virgulata*, there is no doubt that the two forms intergrade along the northeastern coast of Australia. True *virgulata* has been taken as far south as southern Queensland, while we found at Badu, on an eel-grass bottom, a small but typical specimen of *alexandri*, the form really characteristic of the coast of New South Wales. We did not find a *Salmacis* at the Murray Islands.

Temnotrema bothryoides.

Temnopleurus bothryoides Agassiz and Desor. 1846. Cat. Rais. Éch., p. 360 (56).
Pleurechinus bothryoides Döderlein. 1903. Jena. Denkschr., *8*, p. 706, pl. lxi, figs. 1, 2.
Temnotrema bothryoides H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, p. 318.
Temnotrema decorum Döderlein. 1914. Ech. Südwest Aust., p. 459.

Although Torres Strait seems to be the particular home of this little sea-urchin and the *Challenger*, the *Alert*, and Semon all found it there, we failed to meet with it, much to my regret, as I have never yet seen a specimen. The *Siboga* took it at the Aru Islands, and Döderlein (1914) records it from Sharks Bay, West Australia. There is no occasion for abandoning the specific name *bothryoides*, as Döderlein (1914) does. He apparently fails to consider that the use of a specific name in one genus does not invalidate its use in another. Agassiz had a right to call a sea-urchin *Temnopleurus bothryoides* even though Leske had called something else *Cidaris bothryoides*, and Agassiz's specific name persists, no matter how frequently it is shifted from one genus to another. Döderlein's proposed substitute name is thus a pure synonym.

Temnotrema maculata.

Pleurechinus maculatus Mortensen. 1904. Siam. Ech., p. 89, pl. i, figs. 4, 14.
Temnotrema maculata H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, p. 318.

Mortensen (*l. c.*) states that he has seen specimens of this species brought from Torres Strait by Haddon, and that it also occurs at Hongkong, on Macclesfield Bank, and at five *Siboga* stations in the East Indies. He suggests that it may be only a form of *bothryoides*, but as I have seen neither species I have no opinion on the point to express. It would be interesting to know if Haddon secured his specimens at Mer, where he spent some weeks.

Temnotrema sculpta.

Temnotrema sculpta A. Agassiz. 1863. Proc. Acad. Nat. Sci. Phila., p. 358.
Pleurechinus variegatus Mortensen. 1904. Siam. Ech., p. 84, pl. i, figs. 5, 6, 8, 19; pl. ii, fig. 6.

(Plate 17, Figure 5.)

It was a pleasant surprise to find this pretty little urchin in a cranny of a coral fragment on the southwest reef at Mer, October 21, 1913. It was particularly noted because it was the only little echinoid which we found during our stay at the island. I believe this is the first record for the species south of the equator. Comparison with specimens from Japan shows there is considerable variation in the amount of red at the base of the spines; in some individuals it is scarcely noticeable and is chiefly to be seen on the oral spines; in others it is evident on all the larger spines; and in some cases the whole basal half of the spine, especially near the mouth, is red. In all cases the banding of the spines is more or less distinct. In the Murray Island specimen, which is 8 mm. in diameter, the red is present only on the spines near the mouth and is not extensive there.

STRONGYLOCENTROTIDÆ.

Echinostrephus molare.

Echinus molaris de Blainville. 1825. Dict. Sci. Nat., *37*, p. 88.
Echinostrephus molare A. Agassiz. 1872. Rev. Ech., pt. 1, p. 119.—H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, pl. 105, figs. 10, 11.

This remarkable sea-urchin ranges from southeastern Africa to Japan and to the Murray Islands. How much further eastward the distribution extends is not yet known, but in the Gilbert, Hawaiian, and Society Islands, *molare* is replaced by the allied species *aciculatum.* There seems to be no good figure extant of *molare* as it appears in life, but the photograph of *aciculatum* given in "Hawaiian and other Pacific Echini" (H. L. Clark, 1912, pl. 105, fig. 9) answers perfectly well, for in the condition and from the point of view shown the two species are indistinguishable. At Mer, *molare* was fairly common on the southwestern reef, but its habits are such that it would easily be overlooked in ordinary reef-collecting, and even when detected it is very difficult to get the specimen, for of all sea-urchins, *Echinostrephus* is without doubt *the* rock-borer. No one who has seen the smooth, cylindrical holes, often 75 to 100 mm. or more in depth, in which the urchin fits like a piston in its cylinder, can doubt that the animal is itself the maker of its home. How the work is done I can not presume to say, but one may guess that the teeth and oral spines, aided perhaps by an acid secretion, are the tools used. Apparently when undisturbed the urchin rests near the top of the hole, perhaps the abactinal surface is slightly extruded, but when the rock is struck or some similar stimulus given, the animal drops to the bottom of the cavity. We found it impossible to get them out of their holes by means of a hooked wire or any process of pulling; the animal permits itself to be pulled to pieces before it relaxes the spines enough to be drawn out. The only whole specimens we procured were those whose burrows were in rocks small enough to be lifted and carried ashore. Such rocks could be broken up and the sea-urchins thus have their homes removed from around them.

ECHINOMETRIDÆ.

Parasalenia gratiosa.

A. Agassiz. 1863. Bull. Mus. Comp. Zoöl., *1*, p. 22.—1873. Rev. Ech., pl. iii*d*, figs. 1, 2.

From Zanzibar to the Red Sea, north to Japan, south to New Caledonia, and east to the Paumotus extends the range of *Parasalenia*, but whether one species or two occur in this vast area is yet uncertain, though the indications are strong that there is only one. The genus is not yet known from Hawaii.

One specimen was found at Green Island, Queensland, one at Erub, and three at Mer. These are all typical of *gratiosa* in every particular, and none of them showed in life, or have now, any trace of red in the coloration. All but the smallest are unicolor, nearly or quite black in life, save for the conspicuously white milled rings on the primary spines. In the dry specimens the primary spines are dull olive-green, either light or dark; the milled rings are no longer white, but are buff or cream-color. In the specimen from Erub the small spines around the peristome are more or less distinctly banded, and in the one from Green Island, which is very small (length of test only 6 mm.), even the primaries are banded distally. The largest specimen has the test about 32 mm. long, 27 mm. wide, and 17 mm. high; the primary spines at ambitus are 25 mm. long. This seems to be much the largest specimen of *Parasalenia* as yet recorded. It is further remarkable in that oculars I and II are in contact with the periproct, just as in *Gymnechinus*, a condition hitherto unknown in the Echinometridæ.

Echinometra mathæi.

Echinus mathæi de Blainville. 1825. Dict. Sci. Nat., *37*, p. 94.
Echinometra mathæi de Blainville. 1830. Dict. Sci. Nat., *60*, p. 206.

This is probably the commonest sea-urchin in the world, as it ranges throughout the full extent of the vast Indo-Pacific region and is more or less gregarious in its habits. Wherever local conditions permit it is abundant. And yet I have failed to find published a really satisfactory figure!

At both Erub and Mer, *mathæi* was exceedingly common, and very variable in both color and form. Particularly on the southeastern reef-flat at Mer did it abound, and special efforts were made there to correlate color or form or both to details of habitat, but all such attempts were in vain.

Heterocentrotus mamillatus.

Echinus mamillatus Linné. 1758. Sys. Nat., ed. 10, p. 667.
Heterocentrotus mamillatus Brandt. 1835. Prod. Desc. Anim., p. 266 (66).—H. L. Clark. 1912. Mem. Mus. Comp. Zoöl., *34*, pls. 115–117.

It is interesting to find this species of *Heteroeentrotus* at Mer, because previous evidence indicated that it is the more northern form and that if a member of the genus occurred in Torres Strait, which was hardly to be expected, it would prove to be *trigonarius*. Although only two specimens were found, both are *mamillatus*, and show no notable peculiarities. One was brought to the laboratory by a native boy, and the other was found on the eastern reef-flat under a large rock-fragment.

ARACHNOIDIDÆ.

Arachnoides placenta.

Echinus placenta Linné. 1758. Sys. Nat., ed. 10, p. 666.
Arachnoides placenta Agassiz. 1841. Mon. Ech.: Mon. Scut., p. 94, pl. 21, figs. 35–42.

Döderlein (1903) lists this species from Thursday Island, and there are records in the "Revision of the Echini" from Cape York and Torres Strait. There are specimens in the Museum of Comparative Zoölogy from Samoa, New Zealand, Port Mackay, and Port Denison, Queensland, Lombok, the Philippines, and Singapore. Bell (1899) lists it from New Britain, and Sluiter (1895*a*) records specimens from Timor and Java. There is no other echinoderm with this distribution.

LAGANIDÆ.

Laganum decagonale.

Scutella decagonalis de Blainville. 1827. Dict. Sci. Nat., *48*, p. 229.
Laganum decagonum Agassiz. 1841. Mon. Ech.: Mon. Scut., p. 112, pl. 23, figs. 16–20.
Laganum decagonale Bell. 1884. *Alert* Rep., p. 122.

Although the three previous expeditions to Torres Strait collected laganids which A. Agassiz, Bell, and Döderlein refer to this species, we did not meet with it at any point.

Its general geographical distribution is still uncertain, owing to the ease with which it is confused with other species. Unfortunately, the fine photographs in the "Revision of the Echini" (pl. XIIIe, figs. 8 to 10), said to be this species, are apparently *Peronella lesueuri*. Owing to this fact, I suspect the records of *decagonale* from Torres Strait really refer to *P. lesueuri*, which is common there. Döderlein (1914) has himself stated that the specimens from Torres Strait and the Aru Islands, which he called *decagonale*, are really *lesueuri*.

Laganum depressum.

Agassiz. 1841. Mon. Éch.: Mon. Scut., p. 110, pl. 23, figs. 1–7.

This species was taken by both the *Challenger* and the *Alert* in the Torres Strait region (Prince of Wales Channel), but we did not meet with it. It has a widespread distribution in the Pacific Ocean and occurs in the East Indies, the Philippines, and on the coast of Ceylon. Its occurrence on the coast of Africa needs confirmation.

Peronella lesueuri.

Laganum lesueuri Agassiz. 1841. Mon. Éch.: Mon. Scut., p. 116, pl. 24, figs. 3–6.
Peronella lesueuri A. Agassiz. 1872. Rev. Ech., pt. 1, p. 148.

We found this fine laganid at Friday Island and later it proved to be abundant at Badu, but we saw no indications of its occurrence at the Murray Islands. It occurs on the southern coast of Queensland and on the coast of West Australia as far south as Fremantle at least. It is common in the Aru Islands and northward through the East Indies to Hongkong and southern Japan. It is not known as yet from the Pacific Ocean proper.

Peronella orbicularis.

Echinodiscus orbicularis Leske. 1778. Add. ad Klein, p. 144.
Laganum orbiculare Agassiz. 1841. Mon. Éch.: Mon. Scut., p. 120, pl. 22, figs. 16–20.
Peronella orbicularis A. Agassiz. 1872. Rev. Ech., pt. 1, p. 149.

This is another laganid whose distribution is very imperfectly known because it has been so often confused with other species. It is known certainly from the Persian Gulf, the East Indies, the Philippines, and Torres Strait. The *Challenger* took it at the last-named place, but when the "Report on the Echini" was published, the specimens were not separated out from the large number of laganids listed as *Peronella decagonalis*, and hence *orbicularis* does not figure in that Report. On the extensive sand-flat southwest of Friday Island we found three bare tests of this species, but we did not meet with living specimens.

FIBULARIIDÆ.

Fibularia volva.

Agassiz and Desor. 1847. Cat. Rais. Éch., p. 142.

(Plate 35, Figures 6 to 9.)

On a small beach on the eastern side of Badu many bare and bleached tests of young Breynias occurred, November 1, 1913, and among them half a dozen tests of a Fibularia were also found. On account of the form and the character of the petals, I felt no hesitation in referring them to *volva* until Dr. Mortensen called my attention to the matter of madreporic pores, when, to my astonishment, I found there are a number of such pores present instead of one, as in typical *volva*. As I had previously considered the presence of a single madreporic pore one of the *family* characters in the Fibulariidæ, these Torres Strait specimens are rather disconcerting. As they are not in any too good condition, however, I have decided to list them under *volva* with the mere statement that they probably represent an undescribed species. Photographs are given (pl. 35, figs. 6 to 9) of one of the largest merely to show the form of the test and the relative sizes of the peristome and periproct. According to Bell, the *Alert* took *volva* in Prince of Wales Channel.

SCUTELLIDÆ.

Echinodiscus tenuissimus.

Lobophora tenuissima Agassiz and Desor. 1847. Cat. Rais. Éch., p. 136.
Echinodiscus tenuissimus Gray. 1855. Cat. Rec. Ech., pt. 1, p. 20.
Echinodiscus auritus var. *tenuissima* Döderlein. 1903. Jena. Denkschr., *8*, p. 723, pl. lxv, figs. 4–5.

This is a well-marked form occurring in the East Indian region from Japan to New Guinea. Semon took it near Thursday Island, but Döderlein, who gives admirable photographs of two of the specimens, considers them unworthy of specific rank and places them as a variety of *auritus*. While a large series of specimens may justify such a decision, the material I have examined has convinced me that *auritus* and *tenuissimus* are quite distinct.

ECHINONEIDÆ.

Echinoneus cyclostomus.

Leske. 1778. Add. ad Klein, p. 109.—Westergren. 1911. Mem. Mus. Comp. Zoöl., *39*, pls. 1–5.

This common tropicopolitan species was fairly abundant on the southeastern flat at Mer, occupying the same sort of habitat and revealing the same habits as in the West Indies. Buried in the sand under rock-fragments, it would usually escape notice if the sand were not sifted or otherwise disturbed. Occasionally a small specimen is found clinging to the under surface of the rock-fragment near its margin. The coloration in life of the Murray Island *Echinoneus* ranged from pale brownish cream-color to deep red, generally light red, with the tube-feet red, just like West Indian specimens. The *Alert* took a very small specimen of *Echinoneus* in Prince of Wales Channel.

HEMIASTERIDÆ.

Schizaster lacunosus.

Echinus lacunosus Linné. 1758. Sys. Nat., ed. 10, p. 665.
Schizaster japonicus A. Agassiz. 1882. *Challenger* Ech., pl. xxxvi, figs. 8–13.
Schizaster lacunosus Lovén. 1887. Ech. Linn., p. 168.

The *Challenger* took this spatangoid just west of Torres Strait at station 188, so that its occurrence there is not surprising, but it was unexpected to find it on so unlikely a spot as the Madge Reefs, Thursday Island. No doubt, however, the single bare test found there, September 15, 1913, was originally washed up from a muddy bottom somewhere in the vicinity. The species seems to be most common in the waters of southern Japan, and Thursday Island would seem to be the extreme southern limit of its range.

SPATANGIDÆ.

Brissus latecarinatus.

Spatangus brissus var. *latecarinatus* Leske. 1778. Add. ad Klein, pp. xx, 185.
Brissus carinatus A. Agassiz. 1873. Rev. Ech., pl. xxi *a*, figs. 1–3.
Brissus latecarinatus H. L. Clark. 1917. Mem. Mus. Comp. Zoöl., *46*, p. 219.

This species has a notable range, as it is common at Mauritius and also at Panama and on the Mexican coast. It is also well known from numerous intervening localities, including the Gilbert, Samoan, Hawaiian, and Society Islands. And still it has not yet been recorded from the east coast of Africa! We found it common at Erub, in the sand on the reef-flat along the south side of the island, but at Mer only two bare tests of small individuals were found. It is not easy to understand this, for there was no obvious difference in local conditions. Whitelegge (1889) includes this species in the fauna of Port Jackson, and Ramsay (1885) says it is common on the coasts of eastern and southern Australia. Tenison-Woods (1880) goes even further and says it is "common in all *extra-tropical* Australia" (italics mine). If there has been no mistake in identification, this indicates an extraordinary range for a tropical species. But there have been no specimens of *Brissus* in any of the three large collections I have examined from southern and eastern Australia.

Breynia australasiæ.

Spatangus australasiæ Leach. 1815. Zool. Misc., *2*, p. 68.
Breynia australasiæ Gray. 1855. Cat. Rec. Ech., pt. 1, p. 46.—A. Agassiz. 1873. Rev. Ech., pl. xv*a*, figs. 7–9.

This is one of the most typical of Australian echinoderms, for it occurs along the whole northern coast and extends its range southward to Port Jackson on the east and to Fremantle on the west. It is also common at Lord Howe Island and at the Aru Islands. It seems to extend westward as far as Flores. At Thursday Island, Friday Island, and Badu it is very common, and every collector in Torres Strait has taken it; indeed, it is the only echinoid of which that can be said. We saw no traces of it at Erub or Mer, and it probably does not occur at those islands.

Lovenia elongata.

Spatangus elongatus Gray. 1845. Eyre Voy., *1*, p. 436.
Lovenia elongata Gray. 1851. Ann. Mag. Nat. Hist. (2), *7*, p. 131.—A. Agassiz. 1873. Rev. Ech., pl. xix *c*, figs. 1–4.

This fine spatangoid ranges from Zanzibar to southern Japan and Australia. Ramsay (1885) says it is rare at Port Jackson but "less rare on the South Coast," which is, to say the least, unexpected for a tropical species. The *Alert* took specimens in Torres Strait, and we found part of a bare test at Friday Island. A related but quite different species (*camarata*) was taken by the *Challenger* at station 188, just west of Torres Strait, in 28 fathoms. No Lovenias were seen at Erub or Mer.

HOLOTHURIOIDEA. SEA-CUCUMBERS. BÊCHE-DE-MER.

Holothurians form not only a conspicuous but a most important part of the Torres Strait marine fauna, for many of the species are collected, cooked, and dried for export to China under the French name bêche-de-mer or the Malay term trepang. Thus prepared they are most uninviting-looking objects, but they are regarded by the Chinese as a very desirable article of diet. Alive and exhibiting their natural colors and form, many holothurians are really beautiful objects, but it must be granted that the majority are unattractive and often repulsive. Elongated, sometimes worm-like, they show no external obvious resemblance to the other classes of echinoderms, and no one unfamiliar with their anatomy would think of the really close relationship. The identification of the numerous species is not easy, as it must be based finally on the calcareous particles of the skin, and many of the obvious external characters are so subject to growth-changes and individual diversity that a large proportion of the specimens taken are perplexing even to one familiar with the group. Added to this is the fact that specimens must be preserved in fluid (commonly alcohol) and in the preserved condition size, color, and proportions are altered, often to such a degree that one can hardly believe the changes possible. We are still so ignorant of growth-changes and of the limits of individual diversity, even in the best-known species, that many forms now recognized by name may prove merely nominal, while in other cases it seems probable that two or more species are now concealed under a single name. As a result of these difficulties, many identifications of holothurians are open to serious doubt, and this is particularly true of the East Indian and Australian species. Hence one can not feel confidence in the records from many localities, and the actual distribution of very few species is known with any degree of reliability.

The *Challenger* took only 4 species of holothurians in the Torres Strait region, and as these were identified by Théel, perhaps the best systematist who has specialized on holothurians, one feels very sure of the species. According to Bell, the *Alert* brought home 9 species of holothurians from the region, none of which was taken by the *Challenger*. But his supposedly new *Actinocucumis difficilis* is probably identical with *A. typica*, which was collected by the *Challenger*. Semon gathered 10 species during his stay at Thursday Island, none of which was found by the earlier collectors. I was more fortunate than my predecessors, for during our stay I secured 52 species, of which only 7 had been previously taken, 3 by the *Alert* and 4 by Semon. There are thus 68 species included in the present report, but unfortunately very few of them are sufficiently well known to make them of much service in the discussion of questions of distribution.

Holothurians are found in a great variety of situations, but, excepting the largest species, which lie quietly or move about sluggishly on sandy or grassy bottoms, they seek shelter either through burial in sand or sandy mud, or by crowding themselves into the crannies and cavities of coral-rock fragments or of the dead portions of coral colonies. Occasionally they live on the under side of rock fragments or on the sand beneath such rocks. While not truly gregarious, some species are often represented by 4 or 5 individuals under one shelter, and species which live in the open not uncommonly occur by dozens on a relatively small area. As sluggish as sea-urchins, and absolutely without means of escape, holothurians are the easiest of echinoderms to capture. They have no means of defense except the very sticky Cuvierian organs of a few species and these organs are harmless, statements to the effect that they are poisonous or irritating to the touch being absolutely wrong. Their sliminess and stickiness are unpleasant, but perfectly harmless, at least to human beings.

Most holothurians are quite sensitive to staleness of the water in which they are placed, and many species, especially in the genera *Stichopus* and *Holothuria*, tend to disintegrate as the freshness of the water is lost. Whether this is due to lack of oxygen or to excess of Co_2, or to some other factor, has never been determined. The process begins by the softening and sloughing off of bits of the epidermis. These areas rapidly increase in extent and the underlying tissues of the body-wall begin to assume a mucilaginous consistency, until at last the body-form is lost and the whole animal is a shapeless mass of semisolid slime. The same process often goes on if the animal is simply laid on a rock out of water. This sensitiveness to the condition of the water necessitates care in collecting specimens; the buckets in which they are placed must not be overcrowded and the holothurians should be killed as soon as may be. Since they are very contractile, and in particular retract their tentacles completely when disturbed or handled, good specimens can, as a rule, be secured only by narcotizing before killing. Holothurians are very susceptible to Epsom salts ($MgSO_4$) and relax more or less completely after a time when placed in a saturated solution thereof. Some species of Cucumariidæ will not re-expand the tentacles, even when narcotized, but by carefully exerted pressure and suitable manipulation, those organs can usually be forced out into a relatively extended condition.

BÊCHE-DE-MER.

One of the practical results that it was hoped to secure from the study of Torres Strait holothurians was the accurate identification of the species used for bêche-de-mer. It was thought possible that specimens secured from the dealers, given the right treatment in the laboratory, might be identifiable. Such proved to be the case, but unfortunately it immediately appeared that trade names have little relation to specific characters, and several species may appear under a single trade name, or the reverse may be true, several trade names being applied to a single species. It was noted that different men applied the trade names in different ways, and I was unable to determine whether this was due to lack of knowledge or to a general looseness in the use of the trade names. The various trade forms that were secured are as follows, the scientific name of the species concerned being given in connection with it. All belong to the family Holothuriidæ.

"Good Fish":

Prickly-red fish, *Thelenota ananas*. Mammy fish, *Actinopyga nobilis*. Teat fish, *A. nobilis*. Red fish, *A. mauritiana*. Black fish, *A. miliaris*.

"Cheap Fish":

Stone fish, *Actinopyga lecanora*. Sand fish, *Holothuria marmorata*, *H. scabra*. Chalky fish, *H. marmorata*. Curry fish, *H. scabra*, *Stichopus variegatus?*. Lolly fish, *H. atra*. Tiger fish, *H. argus*.

In a list of the different kinds of bêche-de-mer exported from Thursday Island, given to me by the late Dr. J. R. Tosh, then of Erub, there are, in addition to the above 11 names, the following, of which I did not succeed in getting specimens, and I therefore have little idea to what species of holothurians they refer: Mainland or deep-water black "fish"; White chalky "fish"; White speckled "fish"; Leather "fish"; Waterbag.

It is of course necessary that any holothurian, to be of use as bêche-de-mer, must be of considerable size, and the larger the individual is, the more probable that it will make a satisfactory preparation. Yet it is true that not all large holothurians will make bêche-de-mer, and in Torres Strait *Stichopus chloronotus* and *Holothuria coluber*, although large and common, seem to be entirely ignored. Examination of a considerable amount of bêche-de-mer ready for shipment shows that size, hardness, color, presence or absence of projections ("prickles" and "teats"), and the character of the surface, whether rough or smooth, are the commercial tests chiefly applied. Naturally these are in a general way correlated with characters which serve to distinguish species, but where specific differences are revealed only in the calcareous particles of the body-wall, in the arrangement of papillæ and pedicels, in the size, number, or form of tentacles, or in the natural color, it is not strange that they are entirely lost in the preparation of the bêche-de-mer. Hence it is not remarkable that both *H. scabra* and *H. marmorata* may become "sand fish" in the market. On the other hand, since size, the development of tubercles and projections, and the amount of calcareous matter in the body-wall increase with age and are also subject to much individual diversity, it is natural that some specimens of *Actinopyga nobilis* are called "mammy fish" and some "teat fish," or that *H. scabra* may be either "sand" or "curry fish."

W. Saville-Kent, in his remarkable book on the Great Barrier Reef of Australia (1893), has given a rather extended account of the bêche-de-mer fisheries of tropical Australia, and has many illustrations of the holothurians concerned. His identifications are based on spirit specimens named for him by Bell at the British Museum. This attempt to connect the commercial and scientific names of the species of bêche-de-mer, through the efforts of two different workers, has not resulted happily, and it is important therefore to revise here, in the present connection, the list of holothurians given by Kent. (See next page.)

The discrepancies which may be noted between Kent's account and the data secured by me in 1913 are easily explained as the result of changes produced by 25 years of further exploitation of the fisheries and the lack of accuracy and consistency among the fishermen and dealers from whom our information was secured. There can be little question that the matter of the artificial breeding of the more important species of bêche-de-mer should be investigated and that the protection and development of the fishery in a scientific and systematic way should be taken up by the government. A few thousand dollars invested annually for 10 years would probably result in a very great increase in the financial returns from the industry and in making it a permanent source of income to the country. An export tax of a penny a pound or even half that amount, would yield a fund sufficient for the purpose.

Kent's list of Holothurians revised.

Kent's name.	Correct name.	Remarks.
1. Stichopus variegatus	Thelenota ananas	This, we are all agreed, is the "prickly-red fish." The excellent photograph given by Kent is unmistakable.
2. Stichopus chloronotus	Stichopus chloronotus.	
3. Stichopus lutea n. sp.	Stichopus variegatus? probably	This may be *S. horrens*?
4. Actinopyga lecanora	Actinopyga lecanora	The commercial "stone fish."
5 Actinopyga obesa	Actinopyga mauritiana?	"Red fish." *A. obesa*, does not occur in Australia.
6. Actinopyga mauritiana	Actinopyga mauritiana?	
7. Actinopyga echinites	Actinopyga echinites?	
8. Actinopyga polymorpha n. sp.	Actinopyga miliaris	"Black fish."
9. Holothuria mammifera n. sp.	Actinopyga nobilis	"Teat fish," "mammy fish." Although Kent says there are no anal teeth, his figure (pl. XXXIV) certainly indicates *A. nobilis*. His statement that it is the most valuable of the commercial species is further proof that *nobilis* is the holothurian concerned.
10. Holothuria marmorata n. sp.	Holothuria marmorata?	Kent says his *marmorata* is a "n. sp." but the name *H. marmorata* dates from Jaeger, 1833. I can not determine positively whether Kent's species is the same as Jaeger's or not, but it seems to be an Actinopyga, as he calls it a "teat-fish."
11. Holothuria fusco-cinorea	Holothuria fusco-cinerea.	
12. Holothuria edulis	Holothuria edulis?	Kent says "nearly pure white beneath," while *edulis* is bright rose-red ventrally in life. The red, however, is lost quickly in alcohol.
13. Holothuria impatiens	Holothuria impatiens?	Kent says, "closely resembling *edulis*," but I see little resemblance!
14. Holothuria argus	Holothuria argus	"Leopard, spotted, or tiger fish" are the names commonly in use.
15. Holothuria vagabunda	Holothuria atra?	Adult.
16. Holothuria sanguinolenta	Holothuria atra	Half-grown.
17. Holothuria atra	Holothuria impatiens?	Characterized by the abundant Cuvierian tubes. These are wanting in *atra*.
18. Holothuria coluber	Holothuria coluber.	
19. Holothuria vitiensis	Holothuria pervicax?	As *pervicax* is very common at Mer and emits great quantities of Cuvierian tubes, I feel quite sure of this identification.
20. Holothuria botellus	Holothuria impatiens	This is a very dubious identification based on Kent's description of the color, which accords well with certain specimens of *impatiens* found at Mer. But Kent says it does not emit "Cuvierian filaments," while *impatiens* has those organs well developed.

SYNAPTIDÆ.

Euapta godeffroyi.

Synapta godeffroyi Semper. 1868. Holothurien, p. 231; pl. XXXIX, fig. 13.
Euapta godeffroyi Östergren. 1898. Öfv. K. Vet.-Akad. Forh., *55*, p. 113.

This species was found near Thursday Island by Semon, and we took one specimen at Mer. This individual was supposed to be a small *Synapta maculata* until the calcareous particles were examined. It was found under a stone on the southeastern reef-flat. The species is known from Mauritius to the Hawaiian Islands.

Opheodesoma glabra.

Synapta glabra Semper. 1868. Holothurien, p. 12, pl. ii; pl. iv, fig. 8.
Opheodesoma glabra Fisher. 1907. Hawaiian Hol., p. 723.

Semon took two specimens of this synaptid near Thursday Island, but we did not meet with it. It is known from a number of stations in the East Indian region and also from Fiji.

Opheodesoma grisea.

Synapta grisea Semper. 1868. Holothurien, p. 11, pl. iv, figs. 6, 7.
Ophcodesoma grisea Fisher. 1907. Hawaiian Hol., p. 723.

This species, like *Euapta godeffroyi*, bears a close superficial resemblance to *Synapta maculata*, and the five specimens we found on the southeastern reef-flat at Mer were supposed to be that species until the calcareous particles were examined. Sluiter (1894) reports that the specimens Semon took near Thursday Island were "ganz, gleichmassig weiss," and designates them as a variety *alba*. It seems to me possible, however, that they had bleached after preservation, and it will be proper to ignore the variety until specimens white in life are met with. There are many records of *grisea* in the East Indian region and several for northern Australia, but it is not yet known from the western Indian Ocean, nor from any of the Pacific islands. The record given in my Apodous Holothurians (1908, p. 75) of "Samoa" is due to a typographical error for Samau.

Polylectana kefersteinii.

Synapta kefersteinii Selenka. 1867. Zeit. f. w. Zool., *17*, p. 360, pl. xx, figs. 120, 121.
Polyplectana kefersteinii H. L. Clark. 1908.[1] Apod. Hol., pp. 16, 77.

This fine synaptid is common at the Hawaiian Islands, where I collected specimens both at Lahaina, Maui, and at Hilo, Hawaii, in December 1913. Thence it ranges westward to the Red Sea and southward to Tahiti (where I took a specimen, August 5, 1913), Samoa, and the Murray Islands. At Mer three specimens were found on the southeastern reef-flat, among dead stag-horn corals. In life they were dark brown dorsally and lighter beneath; each digit of the tentacles had a median dark streak.

The growth-changes of *kefersteinii* are very interesting, particularly as shown in the number of tentacles, but unfortunately they are as yet very imperfectly known. Ludwig (1888) reports 11 specimens from Amboina, of which one had only 15 tentacles, six had 20, one had 22, two had 26, and one 27, but he says nothing about the size of these individuals, so it is impossible to determine whether there is any definite correlation between size (or age) and the number of tentacles. The material in the Museum of Comparative Zoölogy, however, throws some light on the matter and indicates that the full number of tentacles is not developed until the animal is well grown. Of 22 specimens available, from Samoa, Tahiti, Mer, and the Hawaiian Islands, one has 16 tentacles, two have 18, two have 20, and one has 21; these are all small specimens, about 50 to 100 mm. long in their alcoholic condition. There are three individuals of small or moderate size with 22 tentacles, four about half-grown with 23, one, also half-grown, with 24, seven (from more than half-grown to very large) with 25, and one big one has 26. The correlation between size and number of tentacles is by no means exact, for the smallest specimen has 20 tentacles and the largest 25. This largest specimen is about 300 mm. long and 15 to 18 mm. in diameter, in the preserved condition, which would indicate a length in life of probably more than 600 mm. Many of the specimens with fewer than 25 tentacles have one or more of them smaller than the others, sometimes merely a little bud with no evident branches.

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[1] The date on the title-page is 1907, but the actual date of publication was January 1908.

Synapta maculata.

Holothuria maculata Chamisso and Eysenhardt. 1821. Nov. Act. Akad. Germ., *10*, p. 352.
Synapta maculata Jäger. 1833. De Holoth., p. 15.—H. L. Clark. 1908. Apod. Hol., p. 78, pl. i; pl. iv, figs. 17-19, 26.

This giant synaptid, common and widely distributed from the eastern coast of Africa to the Society Islands, reaching southern Japan (Riu Kiu Islands) on the north and Queensland on the south, was not rare on the southeastern reef-flat at Mer, where specimens 3 feet long or more were occasionally seen. At Papeete, Tahiti, no specimens were found on the reef, but along shore, in front of the town, several were seen. One of these measured about 125 cm. in length and 35 to 40 mm. in diameter. It was dark gray, longitudinally striped with deep brown. The other specimens were lighter, more yellow-brown, with dark stripes.

Like all synaptids, *maculata* is very sluggish in all its movements, except the ceaseless bending and twisting of the tentacles. It frequently occurs unsheltered on grassy bottoms, but it is more commonly found, often several individuals together, under rock fragments on the reef-flat. There is considerable diversity of color and in life some specimens show more or less yellow. The calcareous particles are very constant and very distinctive. The published figures of the anchors are somewhat misleading, for the vertex is usually smooth and rounded, and when the minute knobs are present on either side they are so very small that they do not affect the contour of the curve.

Synaptula indivisa.

Synapta indivisa Semper. 1868. Holothurien, p. 13, pl. iv, fig. 1.
Synaptula indivisa H. L. Clark. 1908. Apod. Hol., p. 83.

Semon secured near Thursday Island a single synaptid which Sluiter (1894) refers to this little-known species, but unfortunately he gives no data in regard to it. It seems to me quite possible that *indivisa* is only the young of *nigra*, as is suggested by the calcareous particles.

Synaptula nigra.

Synapta nigra Semper. 1868. Holothurien, p. 12, pl. iv, fig. 9.
Synaptula nigra H. L. Clark. 1908. Apod. Hol., p. 81.

This species was originally found in the Philippines, and subsequently on the shores of the Red Sea. Lampert (1885) reports it from Australia, but with no definite locality. On the southeastern reef-flat at Mer we found half a dozen individuals. They were uniformly purplish-brown, darkest above.

Synaptula recta.

Synapta recta Semper. 1868. Holothurien, p. 14, pl. iv, figs. 2, 3.
Synaptula recta H. L. Clark. 1908. Apod. Hol., p. 84.

On September 13, 1913, we found this species common on the sandflat southwest of Friday Island, where we took nine specimens 200 to 300 mm. long and 8 to 12 mm. in diameter. Eight of them were brown, more or less mottled or variegated with whitish; some individuals had so little mottling they were almost uniformly deep brown, while others had the white markings very abundant. One specimen was markedly different from the others and was supposed to be a different species, until critically examined in the laboratory. It was whitish, mottled with purple; on the ventral surface, posteriorly, the purple mottlings form a double stripe along each longitudinal muscle; anteriorly the purple pigment is more abundant and the general effect is a purple ground-color with transverse blotches of white. We did not find *recta* at Mer, but it is known from China Strait, eastern New Guinea, from many stations in the East Indian region, from Ceylon, and from the Gulf of Aden. There is a fine large specimen in the Museum of Comparative Zoölogy collection from Ponape, Caroline Islands.

Leptosynapta latipatina [1] sp. nov.

(Plate 36, Figure 12.)

Anterior end, including tentacles, calcareous ring, polian vessel, etc., wanting. Calcareous particles, anchors, plates and miliary granules as in other members of the genus, but essentially alike at both ends of the animal and quite uniform in size and proportions.

Anchors (pl. 36, fig. 12*a*) 0.135 to 0.168 mm. long, averaging about 0.150; the vertex is flattened, and the flukes bend down rather abruptly, tending to be parallel with the shaft; the width across the flukes at their tips is about 0.060 mm. and their length is about one-fourth that of the anchor as a whole; the flukes are often smooth, but when fully developed have 3 to 5 small teeth near the tip; the stock is uniformly convex and rather coarsely toothed distally, but nearly straight next to the shaft.

Plates (pl. 36, fig. 12*b*) broadly oval, 0.122 to 0.126 mm. long, averaging about 0.125; they are about 0.090 mm. wide where broadest, just distal to middle. They have the usual large, toothed and small, smooth perforations; the bridge seems to be a little higher and less fused with the plate itself than in some related species, but on the whole there is little that is distinctive about the plates.

Miliary granules (pl. 36, fig. 12*c*) are confined to the longitudinal muscles where they are fairly numerous. They are 0.015 to 0.030 mm. long and for the most part C-shaped with thickened ends, but they vary greatly in relative length and thickness of the different parts; at one extreme are nearly straight rods with enlarged and perforated ends (sometimes several perforations in each end), while at the other are doughnut-shaped bodies, apparently formed by the union of the two ends of the C. Rarely they are more or less branched.

Color.—In life, translucent white, with numerous minute spots of pinkish; in alcohol, pale pink with numerous minute spots of reddish. Examination under the microscope shows that the spots are very small verrucæ crowded with pigment; of course, the number per square millimeter and the relative position of these verrucæ depend upon the amount of contraction of the body-wall, and therefore the animal is most deeply colored where most contracted and palest where most relaxed.

The larger of the two fragments on which this species is based is, in alcohol, about 80 mm. long and 3 to 4 mm. in diameter. In life the animal was evidently more than 100 mm. long and relatively slender; my field-notes say "4 inches" but this obviously applies only to the portion collected; how much is lacking is unknown.

Holotype, M. C. Z. No. 990; in sand, under a rock fragment, on flat southwest of Friday Island, Torres Strait.

When this specimen was taken, it was supposed to be complete but with the tentacles fully contracted. Later examination in the laboratory revealed its damaged condition and it was my hope and expectation that further collecting where it was found would furnish perfect individuals. But a sudden change in our plans took us out to the Murray Islands, and I never again set foot on the sand flat southwest of Friday Island.

This synaptid is clearly very near to both *inhærens* and *dolabrifera*, especially the latter. Joshua (1914) says, in connection with the Australian species: "There is no doubt in my mind that if *dolabrifera* was collected at a locality north of the equator, it would be identified without hesitation as *inhærens*." Probably a superficial examination would lead to such a blunder, but any careful study shows such well-marked and constant differences in the form of the anchors and plates and the calcareous particles of the longitudinal muscles, in the number of polian vesicles, and in the calcareous ring, that there is no reason to doubt their specific distinctness. There are numerous genera, not only of holothurians

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[1] *Latus* = broad + *patina* = a small plate, in reference to the relatively wide anchor-plates.

but of many higher animals, where, if we choose to ignore details and overlook slight differences, all the species can be united under a single specific name, with disastrous results to the study of the evolution of species and their distribution.

Comparison of the present Torres Strait *Leptosynapta* with the Australian species shows at once that its anchors and plates are only about two-thirds as large as those of *dolabrifera*, while the anchors have a different form, the vertex being more curved and the arms longer, more slender, and more nearly parallel with the shaft. (Compare figs. 12*a* and 13, pl. 36.) There are differences in the plates, too, the most noticeable being that in *latipatina* the bridge seems to be less fused with the plate. The miliary granules are much alike in the two species and quite different from those of *inhærens*. I have no doubt that good material showing tentacles, calcareous ring, etc., will show that the recognition of *latipatina* as distinct from both *inhærens* and *dolabrifera* is amply justified.

Protankyra similis.

Synapta similis Semper. 1868. Holothurien, p. 10, pl. iii, fig. 2; pl. iv, fig. 14.
Protankyra similis Östergren. 1898. Öfv. K. Vet.-Akad. Forh., *55*, p. 117.

This Philippine species is included here on the strength of a headless fragment taken by Semon near Thursday Island, which Sluiter (1894) decided from the calcareous particles belongs to *similis*. This species is otherwise not known from outside the Philippines. It is important to note that Semper seems to have made a mistake in giving 10 as the number of tentacles, for the cotype in the Museum of Comparative Zoölogy, received from him, and a second specimen, apparently of the same lot, have 12 tentacles each. This necessitates a change in my key to the genus (1908), as *similis* is there set off by itself as the only *Protankyra* with 10 tentacles. It really belongs in the section of the key with *insolens* and *benedeni*, but is distinguishable from those species at once by the accessory calcareous particles, which are short straight rods, forked at each end, an unusual and very characteristic form.

Protankyra verrilli.

Synapta verrilli Théel. 1886. *Challenger* Hol., p. 12, pl. i, fig. 1.
Protankyra verrilli Östergren. 1898. Öfv. K. Vet.-Akad. Forh., *55*, p. 117.

The two specimens on which this species is based were taken by the *Challenger* near Cape York in 8 fathoms. So far as I know, it has not been met with since.

Chiridota rigida.

Semper. 1868. Holothurien, p. 18, pl. iii, fig. 3; pl. v, figs. 3, 13.

This widespread representative of a perplexing genus was originally described from the Philippines. What seems to be the same thing occurs at various points in the East Indies, at Rotuma, at the Hawaiian Islands, at the eastern end of New Guinea, and at the Murray Islands. The single specimen we found at Mer was discovered by my colleague, F. A. Potts, while he was digging for worms among the eel-grass roots in the sandy mud of the northwestern reef-flat. It is a small individual, less than 40 mm. long in life, pale reddish, with few, scattered wheel papillæ. The habitat of this specimen was so unlike that whence Semper's and Fisher's specimens were taken (soft, sandy bottom of tide-pools on coral reefs) that I thought it might prove to be something distinct from *rigida*, but I have not found any way by which it can be distinguished from Philippine or Hawaiian material of the same size. In the Philippines, *rigida* grows to a considerable size; some specimens in the Museum of Comparative Zoölogy, from Bantayan Reef, Cebu, must have been 125 mm. long, and possibly more, in life.

Trochodota maculata[1] sp. nov.

(Plate 36, Figures 14 to 21.)

Length (in alcohol) 26 mm.; diameter scarcely 2 mm. Tentacles 10, 1 to 2 mm. long (pl. 36, fig. 14), with 4 or 5 digits on each side; digits very slender, with a thin epithelium and characteristic calcareous particles. Neither a polian vesicle nor a madreporic canal was found. Ciliated funnels (pl. 36, figs. 15, 16) numerous. Calcareous ring of 10 pieces (pl. 36, fig. 17) enlarged at base of each tentacle. Calcareous particles in the body-wall of two kinds, wheels and sigmoid bodies. Wheels (pl. 36, fig. 18) 0.050 to 0.100 mm. across, but mostly 0.070 to 0.080 mm.; inner margin not uniformly serrate, but with relatively few teeth in groups. Sigmoid bodies (pl. 36, figs. 19, 20) 0.066 to 0.077 mm. long, chiefly in little groups of 5 to 10 forming minute papillæ, but also scattered singly. Calcareous rods of tentacles (pl. 36, fig. 21) about 0.045 mm. long, with branching ends. Color (in life) pale pink with numerous minute spots of a darker shade, much as in *Leptosynapta latipatina;* the resemblance is so close the two species are easily confused, until either the tentacles or calcareous particles are examined. In its preserved condition *T. maculata* is bright brown, covered with minute papillæ, each of which is tipped with bright brown-red; much brown-red is scattered as pigment-granules, in the skin.

Holotype, M. C. Z. No. 991; from under a rock-fragment, southeastern reef-flat, Mer, Murray Islands, Torres Strait.

This little holothurian represents a very well-marked species, most nearly allied to *allani* of the southern coast of Australia. Only the single specimen was found at Mer, and it is possible that it is immature, as the genital organs are quite inconspicuous.

GENERAL REMARKS ON THE CHIRIDOTINÆ.

Since the publication (January 1908) of my revision of the Apodous Holothurians, a number of papers have appeared in which the genera and species of Chiridotinæ are discussed. While much light has been thrown on certain obscure points, some of the writing has been at best unconstructive criticism, and it seems desirable to gather together here the positive results and summarize our present knowledge of the subfamily.

A paper on New Zealand holothurians by Dendy and Hindle (1907), a supplementary paper by Professor Dendy (1908), and a paper on the holothurians of the subantarctic islands of New Zealand (1909) by the same writer have contributed greatly to our knowledge of the Chiridotinæ of that part of the world. Unfortunately, however, Professor Dendy takes an extremely conservative position, saying:

> "The study of these New Zealand species makes it perfectly clear to my mind that the presence or absence of wheels and sigmata, and the arrangement of the wheels (in papillæ or scattered) cannot reasonably be used as the main basis for a generic classification of the subfamily."

He accordingly rejects all genera except *Chiridota* (which he elects to spell Chirodota) and *Rhabdomolgus*, which he insists on putting in the Chiridotinæ, entirely ignoring the characters of the genus and its type-species, with which the New Zealand species he calls a *Rhabdomolgus* has little in common. Of the real Chiridotinæ, described by Dendy and Hindle (1907) or by Dendy alone (1909), *gigas* is a true *Chiridota* and adds another species to that already perplexing genus, while *benhami* is clearly a *Trochodota* as I understand that genus, and *geminifera* seems to represent the group to which I gave the name *Scoliodota* (1908). These two species will be discussed further in a subsequent paragraph.

A second writer, Mr. E. C. Joshua, has made some very valuable observations on the Chiridotinæ of the coast of Victoria and South Australia. He described first (1912) a new

[1] *Maculatus* = spotted, in reference to the coloration.

form from Port Philip as *Tæniogyrus allani*. His excellent photomicrograph of a bit of the skin shows that the holothurian is not a Tæniogyrus but a Trochodota. In 1914, recognizing this fact, Mr. Joshua rejects the former genus altogether, saying that in his opinion "the genus *qua* genus never had any real existence, Semper's language in dealing with it conveys little more than the suggestion for a genus." Obviously Mr. Joshua is laboring under two difficulties; first, he had not seen a specimen of true *Tæniogyrus*, and second, either he has not seen Semper's original statement or he fails to appreciate it. For Semper (1868, p. 23), after suggesting that perhaps Stimpson's specimens were immature, says very clearly that if they were sexually mature (and subsequent material proves that they were) the species is not a Chiridota, but is best treated as the type of a new genus, *Tæniogyrus*. As he had no specimens, this was a perfectly legitimate, if not altogether commendable, action on his part, and I do not see on what ground one can reject the genus, unless he follows Dendy's extremely conservative course and accepts only the genus *Chiridota* for all Chiridotinæ with any sort of spicules. Fortunately, Mr. Joshua does not take this regrettable position, but recognizes the essential difference between species having the sigmoid bodies and those which lack them. In his second paper (1914) Joshua discusses *Trochodota allani* and describes a notable new *Trochodoat* which he calls *roebucki*. Mr. Joshua has been so good as not only to donate to the Museum of Comparative Zoölogy alcoholic specimens of both these species, but he has also most generously sent us a series of very finely prepared mounts, in balsam, for microscopical study. It has therefore been very easy to compare his species with each other and with the other members of the genus, as well as with two species of *Tæniogyrus*. Both of the Victorian Trochodotas are, of course, perfectly valid, as Mr. Joshua's descriptions and figures fully show.

In view of Dendy's and Joshua's papers, I have again gone over all the available material of Chiridotinæ (excepting *Chiridota* and *Polycheira*) to see whether a better and more natural grouping of the genera than that given in my "Apodous Holothurians" (1908) might not be possible, to meet the criticisms of my colleagues. I find, however, that I must maintain *Tæniogyrus*, and I can not for a moment allow that *Rhabdomolgus* is one of the Chiridotinæ, or that *R. novæ-zealandiæ* is a Rhabdomolgus at all. Dendy himself considers it a modified Chiridota, while *Rhabdomolgus* is a specialized synaptid. In my opinion, *Rhabdomolgus novæ-zealandiæ* might be treated as perhaps an Achiridota not very nearly allied to *Achiridota inermis* (Fisher), but there is a serious objection to this course. All the evidence indicates that the New Zealand species is derived from *Trochodota* by the loss of (1) the wheels, and (2) the sigmoid bodies, while the Hawaiian deep-water species is almost certainly derived from a deep-water Chiridota of the North Pacific. Therefore, to place the New Zealand and Hawaiian species in the same genus destroys the very purpose of our best systematic work (*i.e.*, to show genetic relationships), and I therefore agree fully with Becher (1909) in placing the New Zealand chiridotid in a new genus (*Kolostoneura*) by itself. Becher has discussed its peculiarities amply, so they need not be considered further here. Emphasis may, however, be placed on the fact that the new genus bears the same relation to *Trochodota* that *Achiridota* does to *Chiridota* and *Anapta* to *Synapta*.

From Japan have come three papers by Mr. Hiroshi Ohshima which have thrown much light on the Japanese species of the genera here under discussion. The first of these papers (1913) is unfortunately in Japanese, but there is a brief summary of important points in German, a good plate of photomicrographs, and four text figures illustrating the calcareous particles of *Scoliodota japonica*. These figures show at once that *Scoliodota* is a pure synonym of *Trochodota*, unless one chooses to doubt whether Ohshima really had the same holothurian as von Marenzeller. This seems to me highly improbable, and I therefore abandon my genus *Scoliodota*, which was monotypic when established.

There remains, nevertheless, a New Zealand holothurian, *Chiridota geminifera* Dendy and Hindle, which has the essential character of *Scoliodota*, namely, the entire absence of wheels. This now lacks a generic name, as I consider it would be unfortunate to modify the definitions of either *Trochodota* or *Toxodora* in order to include it. But it is obviously closely related to the former. It must be remembered, however, that *geminifera* is based on only a single small specimen, 25 mm. long, collected some years ago and damaged by acid alcohol. Both the small size of the sigmoid bodies (0.050 mm.) and the absence of wheels might indicate immaturity, and it seems to me better to consider the type of *geminifera* as an aberrant individual of *dunedinensis* which has retained immature characters beyond the normal extent [1] than to make it the type of a new genus. Until more material is secured, therefore, I shall consider *C. geminifera* as a synonym of *T. dunedinensis*.

In connection with the abandonment of *Scoliodota* and the dubious status of *Chiridota geminifera*, attention may well be called to the possibility that the specimens taken near Port Jackson by the *Challenger*, and referred by Théel to von Marenzeller's Japanese species, really represent a chiridotid which normally entirely lacks wheels. Here again additional and undamaged material is necessary in order that the truth may be ascertained, but from the size, the number of digits on the tentacles, and the size of the sigmoid bodies, it seems almost certain that the Australian and Japanese forms are not identical.

Ohshima's second paper (1914) contains a good account in English of the synaptids of Japan, but it lacks illustrations, and certain details with reference to the wheels in *Trochodota* are not made clear in his descriptions. This is unfortunate, as the character of the wheels seems to be of fundamental importance in distinguishing species in this genus. The third paper (1915) deals with holothurians from the northwestern Pacific and adds a species of *Tæniogyrus* and one of *Toxodora* to those already known.

As a result of these publications and my renewed study of the group, I venture to give a corrected key to the genera of this subfamily and to the species of its component genera (except *Chiridota* and *Polycheira*), believing that these will prove of service to future workers.

Key to the Genera of Chiridotinæ.[2]

A. No sigmoid bodies; wheels present, collected in little papillæ.
  B. Tentacles 12 (10 to 14); ciliated funnels single and scattered .... *Chiridota*
  BB. Tentacles 18 (16 to 20); ciliated funnels collected into stalked clusters .... *Polycheira*
AA. Sigmoid bodies present, or if absent, wheels are also wanting, and all deposits may be wanting.
  B. Wheels present; sigmoid bodies conspicuous.
    C. Wheels gathered into sharply defined papillæ .... *Tæniogyrus*
    CC. Wheels not gathered in papillæ, scattered in the skin, often numerous enough to be crowded into ill-defined heaps, sometimes so scattered as to be easily overlooked .... *Trochodota*
  BB. Wheels wanting; sigmoid bodies wanting.
    C. Deposits in form of minute curved rods scattered throughout skin .... *Toxodora*
    CC. Deposits wanting in body-wall.
      D. Tentacles 12 .... *Achiridota*
      DD. Tentacles 10 .... *Kolostoneura*

Key to the Species of Tæniogyrus.

A. Tentacles 12; polian vessels several; sigmoid bodies not in well-defined groups.
  Polian vessels 6 or 7; wheels 0.042 to 0.130 mm. in diameter; sigmoid bodies 0.170 to 0.210 mm. long with greatest width, from tip of hook to back of shaft, about equal to length, and with inrolled end divided into a few short, pointed branches; rods in tentacles 0.170 mm. long; southern South America,[3] littoral .... *contortus* (Ludwig), 1874

[1] There is of course the obvious possibility that the absence of wheels is due to their having been dissolved by the acid alcohol, which has merely damaged the sigmoid bodies.

[2] This key as originally published in my Apodous Holothurians contains an unfortunate misprint, which indicates that there is no difference between *Chiridota* and *Polycheira* in the character of the ciliated funnels.

[3] Specimens from Kerguelen need a critical reëxamination. The three specimens taken by the *Siboga* in the Java Sea, called *Sigmodota contorta*, also need a careful reëxamination. They are more likely *dubius* than *contortus*, but very likely neither.

Key to the Species of Tæniogyrus—Continued.

Polian vessels 10; wheels 0.090 to 0.175 mm.; sigmoid bodies 0.185 to 0.230 mm. long, with greatest width only two-fifths as much and with inrolled end undivided; tentacle rods unknown; Hawaiian Islands, 220 to 257 fathoms .... *dubius*[1] sp. nov.

AA. Tentacles 10; polian vessel single.

Sigmoid bodies in groups, at least dorsally, about 0.130 mm. long, forming papillæ when body-wall is contracted; coast of southeastern Australia; littoral............. *australianus* (Stimpson), 1856

Sigmoid bodies not in groups, but scattered in the body wall, more numerous ventrally; Japan, 55 to 120 fathoms.. *cidaridis* (Ohshima), 1915

Key to the Species of Trochodota.[2]

A. Wheels with inner margin of rim uniformly serrated.

B. Tentacle-rods simple, ends more or less forked or branched.

C. Tentacles with 8 (4 pairs) or more digits.

D. Inner margin of rim of wheels finely serrate (about 100 teeth); wheels 0.100 to 0.160 mm. across; sigmoid bodies 0.090 to 0.120 mm. long; tentacle-rods 0.050 to 0.060 mm.; New Zealand...*dunedinensis* (Parker), 1881

DD. Inner margin of rim of wheels coarsely serrate or crenulate (about 35 to 55 teeth); wheels 0.050 to 0.070 mm. across.

Inner margin of wheel-rim with about 35 to 40 blunt, rounded teeth; Auckland Islands. *benhami* (Dendy), 1909

Inner margin of wheel-rim with about 50 to 55 bluntly pointed teeth; Japan. *japonica* (von Marenzeller), 1881

CC. Tentacles with 4 or 6 (2 or 3 pairs) digits.

D. Digits 6; wheels 0.037 to 0.105 mm.; sigmoid bodies 0.080 to 0.095 mm.; Japan......*rosea* (Ohshima), 1914

DD. Digits only 4.

Inner margin of wheel-rim with about 50 teeth; wheels 0.060 to 0.080 mm.; sigmoid bodies 0.085 mm., with no hook at thickened distal end; Mediterranean Sea.. *venusta* (Semon), 1887

Inner margin of wheel-rims with 60 to 80 teeth; wheels 0.035 to 0.100 mm.; sigmoid bodies 0.120 to 0.180 mm., with a conspicuous hook at distal end; Victoria......*roebucki* Joshua, 1914

BB. Tentacle-rods long C-shaped, not branched at ends but with 6 to 10 projections on convex side; Japan .... *diasema*[3] sp. nov.

AA. Wheels with inner margin of rim not uniformly serrated but teeth present in well-separated groups.

B. Sigmoid bodies not in heaps or groups, but well scattered in body-wall; teeth of wheel-rim in six groups of about 7 each.

Digits 6; wheels 0.154 to 0.182 mm. across; sigmoid bodies 0.125 to 0.150 mm.; tentacle-rods branched at ends only, 0.076 to 0.087 mm. long; Falkland Islands and southern South America.. *purpurea* (Lesson), 1830

Digits 8 to 10; wheels 0.033 to 0.150 mm.; sigmoid bodies 0.120 to 0.130 mm.; tentacle-rods with projections on sides, 0.050 to 0.065 mm.; Victoria and South Australia..*allani* (Joshua), 1912

BB. Sigmoid bodies chiefly in little heaps or groups; few teeth on wheel-rim; 8 to 10 digits; sigmoid bodies 0.066 to 0.077 mm.; tentacle-rods branched at ends only, about 0.045 mm. long; Murray Islands..*maculata* sp. nov. (see above)

Key to the Species of Toxodora.

Size small, 30 mm. in length; color reddish brown; digits numerous, 10 to 16; off southeastern coast of New England.. *ferruginea* Verrill, 1882

Size large, 145 mm. in length; color purplish gray; digits few, about three pairs; Suruga Gulf, Japan. *pacifica* Ohshima, 1915

ACHIRIDOTA.

This genus still contains only the type-species from the Hawaiian Islands described as *Anapta inermis* by Fisher. The stout calcareous ring, each piece of which has a prominent anterior tooth, is an excellent character.

[1] Described and figured by Fisher (1907, p. 735, pl. LXXXII, fig. 2) as "*Tæniogyrus*, species." It seems to me sufficiently different from *contortus* to warrant giving it a name.

[2] It is almost impossible to make an accurate key to the species of this genus without reëxamination of several species. In his description of *benhami* Dendy fails to say whether the sigmoid bodies are scattered or in groups, and one does not know whether the number of teeth on the inner margin of the wheel, as shown in his figure, is exact or not. So in the descriptions of *rosea*, of the Japanese form which he identifies as *dunedinensis* but which I am here naming *diasema*, and of *Scoliodota japonica* Ohshima leaves out certain details which must be known before this key can be made reliable. None of these four species is accessible to me, but each seems to be valid.

[3] *διάσημος = distinct*, in reference to the clear difference between it and *dunedinensis*, the New Zealand species to which Ohshima (1914, p. 478) referred the holotype of *diasema*.

KOLOSTONEURA.

Genotype: *Rhabdomolgus novæ-zealandiæ* Dendy and Hindle. Monotypic.

As suggested above (p. 165), *Rhabdomolgus novæ-zealandiæ* Dendy and Hindle has little in common with *Rhabdomolgus ruber*, except the number of tentacles and the absence of calcareous particles in the body-wall. The tentacles show beyond question that it is one of the Chiridotinæ, while it is equally sure that *R. ruber* is a true synaptid. Under such conditions it is obvious that the New Zealand species must either be placed in *Achiridota* or become the type of a new genus. The number of tentacles suggests a near relationship to *Trochodota*, while the character of the calcareous ring is very different from that of *Achiridota*, and it seems that a phylogenetic classification is more nearly secured by the establishment of the new genus. This step has already been taken by Becher (1909).

CUCUMARIIDÆ.

Cucumaria semperi.

Bell. 1884. *Alert* Rep., p. 147, pl. ix, fig. A.

The localities given for this species are Port Denison and "Torres Straits." Vaney (1912) records it from the Aru Islands, but unfortunately without a word of comment. We found no Cucumarias anywhere in Torres Strait.

Thyone buccalis.

Stimpson. 1856. Proc. Acad. Nat. Sci. Phila., 7, p. 386.

The type locality for this Thyone is Port Jackson, but it has been taken at several stations along the Queensland coast, and its occurrence in Torres Strait is therefore not strange. We found a single specimen under a rock on the flat southwest of Friday Island, September 13, 1913. The color in life is dull purple.

Thyone okeni.

Bell. 1884. *Alert* Rep., p. 149, pl. ix, fig. D.

Oddly enough, the type locality for this holothurian is also Port Jackson, but, unlike the preceding species, it does not seem to have been met with since the original description. It is therefore a matter of considerable interest that we took on Madge Reef, near Thursday Island, an excellent example of *okeni*. It was found closely attached by the pedicels to the under side of a rock-fragment; the pedicels, not thus used, held most tenaciously to sand-grains, bits of shell, etc., quite effectively concealing the whole animal. The color in life was brownish, the pedicels with a distinctly reddish tint. The change of shape in preservation is very striking; in life, the dorso-ventral diameter of the body was 0.40 of the body-length, and both mouth and anus were close to the dorsal side; after preservation, the body became a nearly cylindrical tube whose diameter is scarcely 0.15 of the length; the mouth and anus are terminal.

Thyone papuensis.

Thyone fusus var. *papuensis* Théel. 1886. *Challenger* Rep., p. 92, pl. vii, fig. 1.

A single specimen of this Thyone was taken by the *Challenger* in 8 fathoms in Torres Strait. It is rather odd that of three Thyones known to have been taken in Torres Strait, each represents a distinct species. Théel considered the *Challenger* Thyone as so nearly identical with the Scandinavian species *fusus* that he gives it only a varietal name, but the differences he points out seem to me sufficient to warrant its recognition as a species, especially since *fusus* is not known from any other place in the Indo-Pacific region. Pearson (1903) has reported *papuensis* from Ceylon.

Thyone sacellus.

Stolus sacellus Selenka. 1867. Zeit. f. w. Zool., *17*, p. 355, pl. xx, figs. 115, 116.
Thyone sacella von Marenzeller. 1881. Verh. Zool.-bot. Ges. Wien, *31*, p. 134.

With that brevity which always gives him so much satisfaction, but which is often a source of exasperation to others, Bell (1884) lists this Indian Ocean species from Torres Strait without a word of comment. Théel (1886) thinks that *sacellus* is identical with Stimpson's *buccalis*, and if that is so, Bell's identification needs no emendation. If the two species are distinct, however, it is probable that the specimen Bell calls *sacellus* is really *buccalis*.

Phyllophorus proteus.

Bell. 1884. *Alert* Rep., p. 150, pl. ix, figs. F, F′.

As this species does not seem to have been met with since the original description, I am glad to be able to give some additional facts about it, based on a type-specimen in the Museum of Comparative Zoölogy received from the British Museum in 1907. The specimen is in excellent condition, about 30 mm. long and 15 mm. in diameter; the anterior end is strongly introverted, and it is easily estimated that in life the extended animal was probably 60 mm. or more in length and 10 to 12 mm. thick. The tentacles are 20 in number and arranged in the manner typical for the genus (see Ohshima, 1912). The calcareous ring is not as given by Bell, for unfortunately he has apparently described and figured it upside down; if his figure be inverted, the form of the anterior parts of both radial and interradial pieces is well given, but he has not accurately represented the posterior margin, where in reality the interradial piece is somewhat concave but has no posterior prolongations, while each radial piece has on either side a slender tapering extension, as long as the width of the ring. The calcareous particles of the body-wall are as figured by Bell, but most unfortunately he apparently saw the characteristic tables only from the inner side or else he observed only incomplete ones; for his figure of a "four-sided, four-chambered body" shows the lower surface of the disk of a table or a surface on which the spire is wanting; in all cases seen by me there is a more or less developed spire of 2 to 4 short rods, terminating in 3 to 6 coarse, sharp teeth; these spires are relatively low, not as high as the width of the plate; the tables are fairly abundant in the body-wall, but nowhere crowded; they are lacking in the introvert and in the wall of extended pedicels. Rosettes are abundant in the wall of the introvert and of the pedicels and base of the tentacles, as well as in the body-wall itself; everywhere they are more or less collected into heaps, forming little white spots when seen under a lens. Terminal plates of pedicels well developed, but supporting rods are very rare; those seen were relatively wide, with a double series of perforations. Tentacles, especially at tips of branches, with numerous, very slender supporting rods, slightly branched at the ends, commonly flattened and perforated there.

This is a well-marked species, the validity of which is not affected by the idiosyncrasies of Bell's account. It was collected by Dr. Coppinger at Port Molle, Clairmont Island, Thursday Island, and "Alert Island, 7 fms."

Phyllophorus schmeltzii.

Thyonidium schmeltzii Ludwig. 1874. Arb. Zool.-zoot. Inst. Würzburg, *2*, p. 94, pl. vi, fig. 20.
Phyllophorus schmeltzii Ludwig. 1892. Bronn's Thierreich, *2*, abt. 3, p. 347.

On the last day of our stay at Mer, an exceptionally low tide made accessible the extreme outer part of the southwestern reef-flat, and a good many interesting echinoderms were collected. Among them is this little holothurian, of which 14 specimens were found among the dead portions of staghorn corals. They were uniformly dark brown in life, not the dull purplish or blackish of *Pseudocucumis africana*, which they resemble in size. They are unlike that species, too, in their habitat, not seeking the shelter of rock cavities and crevices as that species does. The type-locality for *schmeltzii* is Bowen, but Dr. Coppinger took it at Warrior Reef in Torres Strait, Théel (1886) records it from the Pelew Islands, and the *Siboga* took it at two and perhaps three stations in the East Indies. The locality "Gulf of St. Vincent," for a specimen in the Museum Godeffroy, seems to me improbable and needs confirmation.

Pseudocucumis aciculus.

Cucumaria acicula Semper. 1868. Holothurien, p. 54, pl. xv, fig. 11.
Pseudocucumis acicula Ludwig. 1874. Arb. Zool-zoot. Inst. Würzburg, *2*, p. 90.

(Plate 19, Figure 4.)

This really notable holothurian was fairly common at Mer, and a specimen was also taken at Weier, but few were so brilliantly colored as the one figured. Most individuals were brown-orange or orange-brown or blackish, the depth of shade apparently depending upon the amount of dark-brown pigment in the skin; the tentacles seem to be quite generally variegated with whitish. The largest individuals are 80 to 100 mm. long when fully extended, but shrink to little more than half that length when contracted. All of the individuals seen were found on the under side of rock-fragments on the reef-flats. The species was originally described from Fiji, but it is also known from Tonga, Ceram, Amboina, the Andaman Islands, and Mauritius. There is a specimen in the Museum of Comparative Zoölogy from Port Galera, Mindoro, Philippine Islands.

Pseudocucumis africanus.

Cucumaria africana Semper. 1868. Holothurien, p. 53, pl. xv, fig. 16.
Orcula cucumiformis Semper. 1868. Holothurien, p. 244.
Pseudocucumis theeli Ludwig. 1887. Sitz. K. Preus. Akad. Wiss. Berlin, *54*, p. 1236, pl. xv, figs. 12-16.
Pseudocucumis africana Ludwig. 1888. Zool. Jahrb., *3*, p. 815.

On the afternoon of the day we landed at Thursday Island, September 10, 1913, a stroll along the shore at the west end of the island yielded a few small black holothurians, living deep in the crevices and crannies of the rock, whence it was hard to dislodge them in an uninjured condition. Later in the month, the same species was met with at Erub and at Mer on the under side of rock-fragments. These specimens were dull purplish in color with nearly black tentacles. Subsequent investigation has shown that all these little sea-cucumbers are *Pseudocucumis africanus*, a species long known from Mozambique, Mauritius, the Seychelles, the Mergui Archipelago, southern Japan, and many stations in the East Indies. The general appearance is well brought out in Ohshima's figure (1912, pl. 1, fig. 4). The big, rough, calcareous plates are very characteristic, so that the species is easy to identify, even when the tentacles are strongly contracted. Lampert (1896, p. 61) has pointed out that the calcareous plates in *Orcula cucumiformis* Semper, the type locality for which is Cape York, are identical with those of *Pseudocucumis africanus*. In view of what we now know regarding the development and arrangement of the tentacles in *Pseudocucumis*, I think it is safe to consider *cucumiformis* a synonym of *africanus*.

Pseudocucumis eurystichus [1] sp. nov.

(Plate 37, Figures 9 to 19.)

Length 27 mm.; diameter 11 mm.; in life, extended, the length was about 50 mm. and the diameter 8 or 9. Body somewhat pentagonal in cross-section. Tentacles strongly contracted and difficult to make out, apparently 18, 9 or 10 of which are large. Pedicels confined to ambulacra but in very broad series; in each dorsal ambulacrum there are 5 rows and in the ventral there are 6 or 7; pedicels relatively large and crowded. Calcareous ring high, but the anterior projections, which are as long on the interradial pieces as on the

[1] εὐρύς = *broad* + στίχος = *row* or *rank*, in reference to the very broad series of pedicels.

radial, are more than half the height; interradial projections sharply pointed, radial blunt; interradial pieces slightly concave behind; radial pieces with short but distinct posterior prolongations. Polian vessels 4. Madreporic canal single. Genital tubules somewhat branched, in a large tuft, each side of the mesentery, near middle of body.

Calcareous particles consist of tables, supporting rods, and terminal plates. In the tentacles are numerous supporting rods, 0.075 to 0.130 mm. long, usually slender and unbranched, enlarged and perforated at each end; the smaller ones, however, are often deeply forked at one or both ends, the tips being perforated. In the pedicels there are no supporting rods, but tables are plentiful and the terminal plates are well developed. In the body-wall itself tables are plentiful; they consist of a more or less asymmetrical disk, 0.047 to 0.094 mm. long, the width one-half to five-sixths as much, perforated with four large holes and often with four (or even more) small marginal holes; the spire consists of only two rods, the height of which about equals the disk-length.

Color in life dull purplish, the broad rows of pedicels pale red; in alcohol, the body-wall is dull purple, but the pedicels are dirty white.

Holotype: M. C. Z. No. 1004; under a stone on the flat southwest of Friday Island, Torres Strait, September 13, 1913.

Only a single specimen of this easily recognized holothurian was discovered. The broad series of pedicels and the characteristic tables are very distinctive.

Actinocucumis difficilis.

Bell. 1884. *Alert* Rep., p. 148, pl. ix, fig. C.

The type locality for this species is Albany Island, Torres Strait, and I believe it has not been met with since its original discovery. There is no doubt it is very close to the following species, but there is no *a priori* reason why there may not be two species of *Actinocucumis* in Torres Strait, even though we failed, as did Semon, to find *any* representative of the genus there. If the figures given by Ludwig and by Bell, to show the form of the calcareous plates in the body-wall, can be relied on (and they seem well drawn), the two writers were not working with specimens of one species.

Actinocucumis typicus.

Ludwig. 1874. Arb. Zool-zoot. Inst. Würzburg, *2*, p. 91; pl. vii, fig. 24.

The type locality for this rare species is Bowen, Queensland, but it is recorded also from Amoy and Ceylon. The *Challenger* took a single specimen at her station 186, which was in 8 fathoms of water, Torres Strait.

Pentacta challengeri.

Colochirus challengeri Théel. 1886. *Challenger* Hol., p. 80, pl. vi, fig. 11; pl. xiv, figs. 1, 2.

Three specimens of this Pentacta were taken by the *Challenger* in Torres Strait, in 8 fathoms, and the *Siboga* collected a single specimen near Pulu Jedan at the northeastern corner of the Aru Islands. The species is not otherwise known.

The generic name *Pentacta* was proposed by Goldfuss in 1820 with only *Actinia doliolum* Pallas from the Cape of Good Hope as its constituent species. This holothurian was long lost to science, but in 1887 Ludwig recorded it from Angra Pequena Bay and showed that it was identical with an Australian species he had previously described under the name *Colochirus australis*. Curiously enough, however, Ludwig retains the generic name *Colochirus*, dating from 1846, whereas it is obvious that if *doliolum* is recognizable as a species, it must be the type of *Pentacta* and hence *Colochirus* is a synonym of that genus.

Pentacta cucumis.

Colochirus cucumis Semper. 1868. Holothurien, p. 58, pl. xiii, fig. 17; pl. xiv, fig. 16.

Sluiter (1894) records a single specimen of this species taken by Semon near Thursday Island. It was originally described from the Philippines, but has since been recorded from several stations in the East Indies, and also from Japan (Théel, 1886).

Pentacta tuberculosus.

Holothuria tuberculosa Quoy and Gaimard. 1833. Voy. *Astrolabe*, *4*, p. 131.
Colochirus anceps Semper. 1868. Holothurien, p. 57, pl. xii, fig. 1; pl. xiii, fig. 15.
Colochirus tuberculosus Semper. 1868. Holothurien, p. 239.

In life this is a very noticeable holothurian, the red of the ambulacra contrasting strongly with the yellow of the interradii; both colors are, sometimes at least, more brilliant than in Semper's figure. Unfortunately, these fine colors are very fugitive, and, as Bell (1884) has pointed out, alcoholic specimens range in color from grayish-white or brownish-yellow to nearly black. On the sand-flat southwest of Friday Island two specimens of *tuberculosus* were found by us, September 13, 1913. One was about 75, the other about 100 mm. long. We did not find the species at the Murray Islands, but it is known from a number of stations on the Australian coast, as far south as Port Jackson, and the *Alert* took it in Torres Strait. Vaney (1912) lists it from the Aru Islands, and it is found thence northward to Amoy, Hongkong, and southern Japan, yet the *Siboga* did not meet with it. It is also known from Guam, and Quoy and Gaimard are supposed to have taken it at the Tonga Islands. There are specimens in the Museum of Comparative Zoölogy from Bowen Strait, on the northern coast of Australia, between Croker Island and Coburg Peninsula.

Pentacta trimorpha[1] sp. nov.

(Plate 37, Figures 1 to 8.)

Length of alcoholic specimen, 10 mm.; diameter about 2.75 mm. Body quite distinctly quadrangular, the ventral surface, occupied by the three ambulacra, somewhat wider than the dorsal side, occupied by the mid-dorsal interambulacrum and with the dorsal ambulacra forming its boundaries. Body-wall very firm and almost brittle from the abundance of calcareous deposits. Ambulacra extended anteriorly into triangular "valves" which could apparently close over the withdrawn tentacles. Pedicels, ventrally, relatively large, distinct, in a rather crowded and irregular double series in each ambulacrum; dorsally, smaller and so fully contracted that both number and position are obscured. There are no evident dorsal papillæ, but the sides and back of the animal are uneven and "lumpy." Tentacles 10, the two ventral ones not half as large as the others. Calcareous ring (pl. 37, fig. 1) low, with no posterior prolongations; each piece is concave behind and has a conspicuous anterior point; on the radial pieces this anterior prolongation is truncate and is wider than the pointed prolongation of the interradial pieces.

Calcareous particles of the body-wall very numerous in three fairly distinct layers; the innermost is made up of heavy lenticular bodies (pl. 37, fig. 5) nearly a millimeter long, with the width one-half to three-fourths as much, composed of a coarse calcareous network with minute interspaces; the middle layer is made up of heavy knobbed plates, 0.050 to 0.100 mm. long, each with 4 to 6 or more perforations (pl. 37, fig. 7); the outer layer consists of pretty little, oblong plates (pl. 37, fig. 6), 0.050 to 0.060 mm. in diameter, each with 4 major perforations and 4 minor ones at the corners; the outer surface is provided with conical knobs, but the projections of the inner surface are much more rounded; the plates are not perfectly flat, but are a trifle concave (pl. 37, fig. 8); if much more so, they would be like the "baskets" of *Thyone;* few of the plates are symmetrically developed. Pedicels with large supporting rods (pl. 37, fig. 4), about 0.160 mm. long and

[1] τρίμορφα = three-formed, in reference to the three kinds of calcareous particles in the body-wall.

0.040 mm. wide, and heavy terminal plates. Tentacles with big supporting rods (pl. 37, fig. 3), 0.400 mm. long by 0.050 wide, in the main stem and very numerous smaller rods in the branches; in the ultimate branchlets the rods (pl. 37, fig. 2) are about 0.040 mm. long and scarcely 0.002 mm. wide; besides the rods the basal part of the tentacles contains numerous rosette-like, perforated plates only 0.030 to 0.040 mm. across.

Color in life, dull purplish-brown; in alcohol, very pale brown, the tentacles much darker yellowish-brown.

Holotype: M. C. Z. No. 997, from under surface of a rock-fragment, southeastern reef-flat, Mer, Murray Islands, Torres Strait.

This little holothurian was not distinguished from *Pseudocucumis aciculatus* when it was found, as its color and habitat were like those of some small specimens of that species. Of course, the more careful examination with the microscope soon showed the great differences. While it is not impossible that this individual may prove to be a young one of some previously known species, or even identical with Ludwig's little species (*minuta*) from Bowen, Queensland, the calcareous particles seem to be quite distinctive, and it has seemed wiser to record it under a new name. The genus *Pentacta* very much needs critical revision, and a careful study of growth-changes in the calcareous deposits of the body-wall will probably show that too many species are now recognized. The corresponding changes in the character and distribution of the ambulacral appendages and interambulacral papillæ are also much in need of critical study.

HOLOTHURIIDÆ.

Labidodemas semperianum.

Selenka. 1867. Zeit. f. w. Zool., *17*, p. 309, pl. xvii, figs. 1-3.

Although Selenka gives "Sandwich Islands" as the type locality for this interesting holothurian, his types in the Museum of Comparative Zoölogy are from the Society Islands. While it is possible that the specimens in the Museum Godeffroy are from the Hawaiian group, there are no other records from there, and I think "Sandwich Islands" is a slip of the pen. I agree with Sluiter (1901) that *selenkianum* Semper and *dubiosum* Ludwig are synonyms of Selenka's name. But I can not feel that Sluiter's *L. egestosum* is a valid species, for I think the *entire* absence of calcareous matter demonstrates that the formalin in which the specimen was preserved was the cause of its peculiarities. The fact that other holothurians in the same receptacle were not decalcified proves nothing, as it is unlikely all were put in at the same time, and moreover formalin acts to different degrees on different specimens under apparently similar conditions. If *egestosum*, therefore, is a Labidodemas and not a young Holothuria, it must, I think, be considered identical with *semperianum*, which was also found on the reef at Saleyer.

This species occurs at Tahiti, at the Fiji Islands, at half a dozen stations in the East Indies, and at the Andaman Islands. I took a small specimen, about 50 mm. long, "pellucid white" in color, on the reef at Papeete, Tahiti, August 5, 1913. At Mer, three specimens were found buried in the sand, under rocks, on the southeastern reef-flat. They were 200 to 250 mm. long in life, and about 25 mm. in diameter. The color was a delicate translucent pink and the papillæ and pedicels were notably long. Of course, the preserved specimens are much smaller and more opaque.

Holothuria altimensis[1] sp. nov.

(Plate 37, Figures 20 to 29.)

Length 20 mm.; diameter about 7 mm.; body somewhat depressed, the distinct ventral surface flattened. Tentacles 20, well extended and somewhat rigid from the abun-

[1] *Altus* = high + *mensa* = a table, in reference to the very high spires with which the tables are provided.

dance of calcareous rods. Pedicels relatively large, not numerous or crowded, confined to ventral surface, but not in distinct series there. Dorsal surface well covered with large (but much contracted) papillæ, not arranged in definite series. Calcareous ring (pl. 37, fig. 20) moderately developed, not peculiar; radial pieces higher than interradial, the anterior prolongation wide and deeply notched; prolongation of interradial pieces triangular, pointed. Polian vessel single, very long, and slender. Madreporic canal single, small, free, more or less coiled, not whitish but purplish. Genital organs quite undeveloped. Anal opening rather large, not guarded by teeth or calcified papillæ. No Cuvier's organs.

Calcareous particles in body-wall so abundant that the epidermis is almost brittle, of two kinds, buttons and tables; the latter again are of two quite distinct sorts. Ordinary tables are abundant, and have the disk (pl. 37, fig. 27) nearly circular, or squarish with rounded corners, 0.050 to 0.075 mm. across, perforated by a central and 8 peripheral holes; the central hole is only a little larger than the others. Spires (pl. 37, fig. 25) about as high as disks are wide, with 2 to 4 cross-beams; the form of the spire shows considerable diversity, ranging from slender and smooth with relatively few small thorns at truncated tip to stout and rough, with numerous thorns covering the rounded distal half (pl. 37, fig. 26). The second type of table is much larger and markedly different; only 3 were seen and these were from the sides of the body; the disk (pl. 37, fig. 22) is about 0.130 mm. across and consists of 4 wide, radiating, flattened rods, lying at right angles to each other, the distal tips expanded and perforated by several well-marked holes; the spire (pl. 37, fig. 23) is equal to only about one-half the disk diameter and is rather slender and smooth, except at tip, where it is finely thorny. Buttons (pl. 37, figs. 28, 29) very numerous, 0.050 to 0.090 mm. long, the width about 0.60 of the length; most of them are about 0.075 by 0.045 mm.; there are commonly three pairs of subequal holes and the calcareous material between them is about as wide as the narrowest hole; some buttons are bigger and have 10 to 12 holes, but they are asymmetrical and obviously abnormal. Pedicels with heavy, wide, more or less strongly curved supporting rods (pl. 37, fig. 24), perforated at both ends and at the expanded middle; they intergrade with the buttons. Terminal plates present. Tentacle rods (pl. 37, fig. 21) very numerous; those in the stalk of the tentacle are large, up to 0.400 mm. long, and nearly straight, while those near the tips of the branches are very much smaller, 0.050 to 0.060 mm. long, and strongly curved; the rods may be smooth or rough, but they are not perforated even at the ends. Color brown; tips of pedicels and branches of tentacles deep yellow.

Holotype: M. C. Z. No. 1009; from under side of a rock-fragment, southeastern reef-flat, Mer, Murray Islands, Torres Strait.

When this little holothurian was collected it was supposed to be a small *Actinopyga parvula*, and hence no particular attention was paid to it at the time. Later examination showed that it is a *Holothuria* and quite different from any of the species (such as *difficilis*, *monacaria*, *leucospilota*) which it superficially resembles. The calcareous particles are sufficiently distinctive to prevent confusion with these or any other species.

Holothuria arenicola.

Semper. 1868. Holothurien, p. 81, pl. xx; pl. xxx, figs. 13*a*, *b*.

This widespread Indo-Pacific holothurian was quite common at Mer, on the southeastern reef-flat. It always occurs buried in the sand, under rock-fragments. The tentacles are relatively small and not very extensile; they are completely retracted when the animal is first dug out of the sand, and it is not easy then to tell which is the oral end. There are no Cuvier's organs, a rather noticeable fact on the reef-flat, where several holothurians of about the same size (150 to 300 mm. long) are conspicuous users of those unpleasant means of defense. The living animal, as noted at Mer, is white or whitish, with few, scattered, brown-red spots or small blotches, essentially as shown in Semper's figure.

I do not believe the records of *arenicola* from Surinam and Bahia are trustworthy, but apparently the species does occur at the Galapagos Islands and at Cocos Island, Mexico, as well as at Hawaii and Tahiti. Several recent writers have revived Brandt's name *maculata* for this species, but even if we grant that Brandt's *maculata* is identical with *arenicola*, his name can not be used, as it is antedated by *H. maculata* of Chamisso and Eysenhardt, as Fisher (1907) has pointed out.

Holothuria argus.

Bohadschia argus Jaeger. 1833. De Hol., p. 19, pl. 2, figs. 1, 1*b*.
Holothuria argus Semper. 1868. Holothurien, p. 80, pl. xxx, figs. 11*a*, *b*.

This is one of the most conspicuous and unmistakable members of the genus. It has a wide range, from the Seychelles to Tahiti, north to the Riu Kius and south at least to Cooktown, Queensland, and probably much further. It is not recorded from the Thursday Island region, but we found it not uncommon at Mer on the southeastern reef-flat. Kent (1893) has given an excellent figure of *argus*, in connection with a full account of its relation to the Australian bêche-de-mer industry. He calls it "leopard" or "spotted fish," a more appropriate name than "tiger-fish," the name given to me as in use in the Torres Strait region. I can not altogether suppress the suspicion that the name "tiger-fish" originated in a mistake of someone who had heard the name "leopard-fish" and on endeavoring subsequently to recall it got no nearer than "tiger!"

Holothuria atra.

Jaeger. 1833. De Hol., p. 22.—Semper. 1868. Holothurien, pl. xxvi.

This widespread and perplexing species has been exhaustively studied by C. L. Edwards (1908), and the distinction between it and *H. floridana* has been brought out well. But a careful study of growth-changes and of individual diversity associated with habitat is still greatly needed. It is not at all improbable that at least two distinct species are still confused under the name *atra*. Oddly enough, in spite of its being one of the commonest of Indo-Pacific holothurians, *atra* has not hitherto been recorded from Torres Strait, though Kent (1893) lists it from the Barrier Reef. We found it common at Madge Reef, Thursday Island, at Friday Island, at Erub, and at Mer. We had previously noted it as common at Tahiti, very abundant at Rarotonga, Cook Islands, and common at Green Island, Queensland.

At Mer, one of the native fishermen brought me two very large and very black holothurians, which he called "lolly-fish" and which he said were found only in deep water (2 to 3 fathoms or more) outside the reef. He said they made very valuable bêche-de-mer. So far as I can see from the examination of spicules, these "lolly-fish" are only very large individuals of *atra*, yet the shallow-water specimens were considered worthless by the fishermen. I can only account for this on the ground that as *atra* reaches maturity it leaves the reef-flat and passes into deeper water, where the body-wall becomes thicker and harder, and the full size (450 to 600 mm. in length) is attained, making the animal suitable for bêche-de-mer. Specimens 200 to 300 mm. long are not black in life when examined closely, but deep chestnut-brown or occasionally red-brown. This is only noticeable when the skin is stretched. These reef-flat specimens often become more or less fully covered with sand or sediment, attached to the body-wall apparently by mucus. This coat may be continuous, but it often flakes off in patches, and it is usually better developed dorsally than ventrally. Cuvier's organs seem to be quite wanting.

Holothuria axiologa[1] sp. nov.

(Plate 38, Figures 1 to 13.)

Length in life about 600 mm.; width about 100 mm., and vertical thickness about 75 mm. Body somewhat depressed with ventral surface flattened, everywhere well covered with the small pedicels, which are quite uniformly distributed and show no serial arrangement. No tubercles and no papillæ. Mouth oral in position, surrounded by 20 large tentacles. Calcareous ring massive but not peculiar; radial pieces much larger than interradial. Polian vessels 2, each with a number of branches. Madreporic canal single. No indication of teeth or calcified papillæ at anus. No Cuvier's organs.

Calcareous particles of body-wall of two kinds, tables and fenestrated eggs, oblongs and buttons; those of the dorsal side are more open and delicate than the stouter ones of the ventral surface. Tables (pl. 38, figs. 3–8) fairly numerous but not crowded, very diversified, hardly two exactly alike; most complete tables have a disk 0.030 to 0.060 mm. across with a large central hole (divided by the table-legs into 4) and a peripheral series of 10 to 12 holes; few tables have the peripheral holes in any number, the disk consisting of a simple ring with projecting teeth on its outer margin (the distal elongation and fusing of these teeth form the peripheral holes); spire of 4 rods and 1 cross-beam, 0.030 to 0.050 mm. high, with numerous (28 to 40) teeth around top and down on distal part of sides; top of spire 0.020 to 0.035 mm. in diameter. Fenestrated bodies (pl. 38, figs. 9–11) egg-shaped or more oblong, 0.050 to 0.075 mm. in length and 0.020 to 0.030 mm. in diameter, hardly two exactly alike and few perfectly symmetrical; with the buttons (pl. 38, figs. 12, 13), they are densely crowded in the dermis below the tables. Pedicels with very few, widely branched supporting rods (pl. 38, fig. 2), about 0.100 mm. long; in place of the rods are more or less incomplete fenestrated bodies; terminal plates well developed. Tentacle-rods (pl. 38, fig. 1) not crowded, straight or curved, even C-shaped, 0.050 to 0.200 mm., not perforated either at middle or near ends, but usually somewhat prickly, at least at the tips. Color in life, yellowish brown dorsally with dark-brown pedicels, whitish with yellow pedicels ventrally and on sides where the shades merge. There is little change in alcohol, except the loss of any really yellow tints.

Holotype: M. C. Z. No. 1015; in 3 to 5 meters off northwestern reef, Mer, Murray Islands, Torres Strait, October 25, 1913.

This fine big holothurian was the source of some dispute between the two native fishermen who brought it to me; one maintained it was a "curry-fish" (usually *H. scabra*), but the other said it was a "white-fish," a form of bêche-de-mer of which I failed to get a sample. It is certainly not *H. scabra* nor very closely allied to that species, nor can I find any other to which it is any nearer. The specimen was brought in towards the end of our stay at Mer, when the available supply of alcohol was nearly exhausted. It was therefore not practicable to preserve so huge a holothurian, and hence I was obliged to throw away a large part of it, retaining only the anterior and posterior ends.

Holothuria coluber.

Semper. 1868. Holothurien, p. 90, pl. xxviii; pl. xxx, figs. 28*a*, *b*.

This fine species is very common at Mer, and we also saw it at Erub and at Thursday Island. It was originally described from the Philippines and has apparently been met with since only by Saville Kent, who found it common on the inshore reefs of tropical Queensland, and by the *Siboga*, whose collectors took a single specimen on Borneo Bank. Kent (1893) gives an excellent photograph and also a colored figure, and his statements regarding occurrence, habits, and worthlessness for bêche-de-mer are fully confirmed by

[1] ἀξιόλογος = *remarkable*, of obvious application to this notable species.

my observations in Torres Strait. Semper says Cuvier's organs are present, but neither Kent nor I have found them. There is evidently some diversity in the color of the tentacles and pedicels, none of the specimens seen by me having them nearly so yellow as in Kent's figure, or as would accord with Semper's expression "hellgelb." At Mer, according to my notes, the color in life is black, with tentacles and pedicels whitish or yellowish; the contrast between the light tentacles and black body is very striking, and is emphasized by the occurrence in the same habitat of *H. atra*, whose tentacles are always very dark. In adult specimens of *coluber*, 500 to 600 mm. long, the body-wall is firm and rather thick, and it is hard to understand why it should not make satisfactory bêche-de-mer.

Holothuria cumulus[1] sp. nov.

(Plate 38, Figures 14 to 19*a*.)

Length in life about 50 mm.; diameter about 10. Body more or less cylindrical, with a thin but rather firm body-wall. Tentacles 20. Pedicels relatively few, scattered all over both dorsal and ventral surfaces, with no indication of serial arrangement. Calcareous ring rather low; interradial pieces more than twice as wide as high, with a sharp median anterior projection; radial pieces very much stouter with a conspicuous, wide, rounded anterior projection. No polian vessel was found. Madreporic canal single, small, free. No indication of anal teeth or calcified papillæ. No Cuvier's organs.

Calcareous particles, tables, and buttons. Tables (pl. 38, figs. 15–18) form a single close layer all over body-surface; disk about 0.080 mm. in diameter, with a quadripartite central hole and a peripheral circle of 8 to 11 large holes and often half a dozen smaller perforations outside of them; but there are not two well-defined circles even on the largest disks; spire not quite equal to disk-diameter, rather stout, of 4 rods and 2 (or rarely 3) cross-bars; top, about 0.020 mm. square, covered with numerous teeth. Buttons (pl. 38, figs. 19, 19*a*) 0.040 to 0.090 mm. long, the width one-third to one-half length, variable in form, number of perforations, and completeness of development; not scattered, but collected in very distinct heaps or rings, which are well distributed over the body but are not abundant; few buttons have the typical three pairs of perforations symmetrically developed, and many, if not most, buttons have 4 to 6 pairs of holes; holes relatively small as compared with calcareous part of button. Pedicels with terminal plates, and not very numerous supporting rods; latter are curved, enlarged, and perforated at the ends. Tentacle-rods (pl. 38, fig. 14) straight or curved, pointed at ends, without perforations, and not thorny. Color in life whitish, with pedicels yellow; alcohol has made little change, save that the general tint is more gray and indistinct brown spots and blotches can be seen on the dorsal side.

Holotype: M. C. Z. No. 1019; from under surface of a rock-fragment, on south-eastern reef-flat, Mer, Murray Islands, Torres Strait.

This is probably a young individual, but the diversity and arrangement of the buttons are quite distinctive and I can not refer it to any species hitherto described. It is not impossible that it is a young *pardalis*, but the character of the tables makes that quite unlikely. It does not seem probable that the accumulation of the buttons in heaps is a youthful character, and it is therefore not likely that we are dealing with the young of some previously known species with scattered buttons. Certainly *cumulus* does not resemble at all any other holothurian taken at Mer. But there is in the Museum of Comparative Zoölogy collection a still smaller specimen, supposed to be from Hilo, Hawaii, in which the calcareous particles are suggestive of *cumulus*. This individual is not in very good condition and its identification is uncertain, but it indicates the possibility of *cumulus* being a widely distributed Pacific species.

[1] *Cumulus* = a little heap, in reference to the distribution of the buttons.

Holothuria edulis.

Lesson. 1830. Cent. Zool., p. 125, pl. xlvi, fig. 2.

(Plate 19, Figure 1.)

The handsome coloration of this species led to its being one of the first holothurians taken to Europe from the East Indian region. It ranges from Mozambique and Zanzibar to the Caroline Islands and Fiji, north to the Riu Kiu Islands and south to tropical Queensland. We took it at Erub and it was common at Mer. The largest specimen seen was about 400 mm. long. Semper (1868) lays special emphasis on the occurrence of papillæ, not pedicels, on the dorsal surface. So far as I could see on living specimens, the dorsal appendages were like the ventral, and I should call them all "pedicels," and this well illustrates the worthlessness of the distinction between pedicels and papillæ as a taxonomic character. At Mer this holothurian was found under rocks on the reef rather below the lowest tide-marks.

Holothuria fuscocinerea.

Jaeger. 1833. De Hol., p. 22.—Semper. 1868. Holothurien, p. 88; pl. xxvii; pl. xxx, figs. 22*a*, *b*.

This is not a very well defined species, in spite of Semper's beautiful figure, and it is quite probable that *H. curiosa* Ludwig is identical with it. We took two holothurians at Mer, quite unlike in general appearance, which seem to be *fuscocinerea*, and a fine specimen was taken at Thursday Island on October 30, 1913, after our stay at Mer. Kent (1893) records the species from the Barrier Reef, and it is also listed from Ceylon, the Philippines, Celebes, Japan, and Samoa. But Mitsukuri (1912) does not include it among Japanese holothurians, and the *Siboga* failed to take the species in the East Indies. A comparison of Kent's description with Semper's figure is a tangible indication of how hazy the specific limits are.

Holothuria hypamma[1] sp. nov.

(Plate 38, Figures 20 to 24.)

Length 165 mm. (in life, about 250 mm.); diameter 35 mm. Body rather depressed, thickest near middle and tapering towards both ends. Tentacles 20, very short, the whole oral region being relatively quite small. Pedicels rather small, more or less numerous; only a few scattered on middle of ventral surface, and they are nearly wanting in mid-dorsal region; sometimes, but not always, the ventral surface is sharply set off from dorsal by an imaginary line along the sides, just below which the pedicels are more crowded than elsewhere; dorsal pedicels sometimes enlarged and papilliform, but mostly like ventral, except more tapering; the differences are distinguishable in life, but are very insignificant in preserved material. No anal teeth or conspicuous anal papillæ. Calcareous ring notably asymmetrical, the dorsal side, especially the two radial pieces, being very much stouter and better developed than the ventral; dorsal radial pieces about as high as wide, the anterior corners rounded, and the margin between them notched. Polian vessel single, long. Madreporic canal single, very small, only the tip free. No Cuvier's organs.

Calcareous deposits excessively numerous, so that the body-wall is hard, in two principal forms, tables and buttons. Tables (pl. 38, figs. 21–23) in a crowded outer layer, so stout and spiny or warty that they are well-nigh spherical, even distorted; disk-diameter about 0.070 to 0.080 mm.; height of spire somewhat less, but its diameter at top, which is thickly covered with stout teeth, about 0.040 mm.; lower surface of disk not flat as usual, but more or less markedly convex; upper side of disk and base of spire with many knobs and tubercles. Buttons (pl. 38, fig. 24) so crowded that there are about 9,000 to each cubic millimeter of skin; they typically have 3 pairs of holes and 12 spherical knobs on each surface, but very few are symmetrically developed; they range in length

[1] ὑπό = under + ἄμμος = sand, in reference to the manner of life.

from 0.050 to 0.100 mm., while the width is about half as much. Supporting rods of pedicels (pl. 38, fig. 20) not very abundant, but large, flat, branched, and perforated at the ends; terminal plates present. Supporting rods of tentacles not very abundant, nearly straight, rough or spiny at tips. Color in life white, with or without a brown tinge and two series of dark blotches on dorsal surface; sometimes with numerous small blackish spots; in alcohol the white becomes yellowish or brownish; tentacles pale yellowish or brownish; pedicels tipped with yellow. Surface of body commonly more or less covered with sand-grains, concealing the true color; these are apparently held by a cement-like mucus which does not release them readily even after death.

Holotype: M. C. Z. No. 1029; from under a rock-fragment, on southeastern reef-flat, Mer, Murray Islands, Torres Strait.

This holothurian is fairly common at Mer, and I also took a specimen at Green Island, Queensland, and at Hilo, Hawaii. A specimen from Port Galera, Mindoro, Philippine Islands, is in the Museum of Comparative Zoölogy. What seems to be the same species is common in the West Indies, and specimens are in the Museum of Comparative Zoölogy from Bermuda, Jamaica, and Tobago; but these West Indian specimens may perhaps represent a closely allied species. Whether allied or identical, the West Indian specimens, like those from Mer, were found buried in the sand under rock-fragments. They apparently live a very sedentary and usually subterranean life. Occasionally individuals are found closely attached to the under surface of rock-fragments where these are well buried in sand.

It is somewhat remarkable that so common and widespread a holothurian has not hitherto been described, but it has not been wholly overlooked, for specimens of *hypamma* occur in the type material of *Stichopus rigidus* Selenka in the Museum of Comparative Zoölogy. This species has long been considered a *Holothuria* rather than a *Stichopus.* It is superficially much like *hypamma,* but is easily distinguished by the buttons having 5 to 8 pairs of holes and the tables being small, with a peripheral circle of holes in a smooth disk, and having 8 supporting rods. Selenka obviously confused the two species, as he describes the tables of *rigida* but the buttons of *hypamma.* The name *rigida* is to be restricted to the form with distinct tables, and buttons having 5 to 8 pairs of holes. The type locality is the Society Islands.

Holothuria immobilis.

Semper. 1868. Holothurien, p. 90, pl. xxix; pl. xxx, figs. 27*a*, *b*.

Although this fine species is recorded from Mauritius, the Philippines, and Samoa, it is very little known. It was therefore an unexpected pleasure to find it at Mer, though we secured only a single specimen, found on the southeastern reef-flat. It agrees very well with Semper's description.

Holothuria impatiens.

Fistularia impatiens Forskål. 1775. Desc. Anim., p. 121, pl. xxxix, fig. B.
Holothuria impatiens Gmelin. 1788. Linn. Syst. Nat., ed. 13, p. 3142.

(Plate 19, Figures 3 and 5.)

Of all holothurians this is, I believe, the most perplexing to the systematist, for it displays a diversity of color most unusual in a holothurian, and there is also a lack of constancy in the development and distribution of papillæ that causes trouble. Moreover, it appears to have a tropicopolitan range, although there are considerable regions where it has not yet been taken. No critical comparative study has been made as yet of the calcareous particles in specimens from widely separated areas, nor is anything known of the growth-changes in the species. It is not at all improbable, therefore, that several perfectly distinct species are now united under the name *impatiens.*

Throughout the Torres Strait region, *impatiens* (*sens. lat.*) is one of the commonest holothurians, occurring under rock-fragments and in dead coral wherever local conditions permit. The specimens collected fall into the following groups, which are easily distinguished (with one exception) by color alone, but I have not as yet discovered any correlated character or characters which are reliable.[1]

(1) *H. impatiens*, typical (pl. 19, fig. 5). This is the usual variegated form, the coloration of which is most diversified; the ground-color is gray (with or without a purple cast) or brown, and either black or white or both may occur in blotches or bands; the papillæ are brown or yellowish, often with light tips, or they may be the same color as that part of the animal from which they arise. Forskål's figure shows what his description indicates, that he had this variety as the basis of his species. In some individuals from Mer the papillæ are all yellow, in handsome contrast with the purplish-brown background. I have been inclined to designate these by a varietal name, but as they intergrade with ordinary specimens, I have decided not to do so.

(2) *H. impatiens* var. *concolor*. Holotype, M. C. Z. No. 1039. This form is a uniformly purplish-gray; the exact shade varies from light to dark, but there is not much diversity; the papillæ are the same color as the body itself. Specimens of this form are often smaller than typical *impatiens*, and the papillæ seem relatively smaller still. The West Indian holothurians referred to *impatiens* are nearest this variety.

(3) *H. impatiens* var. *pulchra* (pl. 19, fig. 3). Holotype, M. C. Z. No. 1043. This is a very conspicuous variety, with the body-wall yellow (often with a greenish tinge) and the papillæ brown (often with a purple tinge). It is strikingly different from the preceding forms and contrasts especially with the extreme *impatiens* which has yellow papillæ.

(4) *H. impatiens* var. *lutea*. Holotype, M. C. Z. No. 1041. In this form the papillæ and body-wall alike are a uniform yellow, having a slightly brownish tint. Only a single specimen was seen, and that was found under a stone on the southeastern reef-flat at Mer.

It may seem a needless multiplication of names to designate each of these varieties in this way, but in future discussions of the species it will be a convenience to have some simple means of indicating such well-marked forms, and I am not at all sure that one or more of them may not prove to be valid species.

All these holothurians as seen at Mer agreed in the cylindrical body, showing no clear difference between dorsal and ventral surfaces, but uniformly covered with rather well spaced, large papillæ, and without distinct pedicels. They all have 20 light-colored tentacles and conspicuously well developed, white, very viscid Cuvier's organs. They grow to a large size, at least up to 400 mm. in length. They are somewhat gregarious, three or four specimens often occurring under the same shelter.

Holothuria leucospilota.

Stichopus (*Gymnochirota*) *leucospilota* Brandt. 1835. Prod. desc. Anim., p. 251.

Holothuria vagabunda Selenka. 1867. Zeit. f. w. Zool., *17*, p. 334, pl. xix, figs. 75, 76.—Semper. 1868. Holothurien, p. 81, pl. xxi.

Holothuria leucospilota Ludwig. 1881. Zeit. f. w. Zool., *35*, p. 595.

Although Ludwig does not use the combination of generic and specific names here credited to him, either in this place or in subsequent publications, he demonstrates beyond doubt the identity of Brandt's and Selenka's species and indicates that *Holothuria leucospilota* is the proper name to use. It is regrettable to abandon so familiar a name as *vagabunda*, but there seems to be no reason whatever for not using the much older name. The species has very distinctive calcareous tables, which make its identification relatively easy as compared with most members of the genus. The distribution is throughout the Indo-

[1] I hope at some future time to make a thorough study of all the *impatiens* material I can obtain and determine positively the significance of the unusual diversity.

Pacific region from Natal to the Red Sea on the west to the Hawaiian and Society Islands in the east; northward the species reaches 34° 20′ on the eastern coast of Japan (Kozu Island), while its southern limit is still uncertain. It occurs at Bowen and is listed from Rockhampton, but as this city is 43 miles from the ocean, the vicinity of Keppel Bay is probably meant, and it is not at all unlikely that *leucospilota* occurs there. Lampert's record from "Adelaide" can hardly refer to the South Australian capital, while the record from "Peru" of course means the island in the Pacific and not the South American country. Kent's (1893) statements regarding the size and color indicate a mistaken identification of his Barrier Reef material, though no doubt he found *leucospilota* along the Queensland coast.

At Mer we found this species fairly common on the lower surface of rock-fragments. The color is usually brown, as shown in Semper's figure, but becomes very dark in old individuals and is light, tending to purplish, in small ones. In many individuals the dorsal papillæ are numerous, long, and slender, in considerable contrast to the shorter, stouter pedicels of the ventral side. Cuvier's organs are slender and white in life, and it is probable that any color they may have in preserved specimens is artificial.

Holothuria marmorata.

Bohadschia marmorata Jaeger. 1833. De Hol., p. 18, pl. 3, fig. 9.
Holothuria marmorata Semper. 1868. Holothurien, p. 79, pl. xxx, fig. 10.

This fine big holothurian was common on the reef-flat at Mer, the largest specimens fully 400 mm. long by 100 mm. wide. The body-wall is firm and there are very numerous small pedicels. The color is yellow-brown, pale ventrally (sometimes nearly white) and dark dorsally; the pedicels are noticeably darker than the adjacent body-wall. Often there are blotches of a lighter or a darker shade dorsally. Cuvier's organs are well developed. The species ranges from Mauritius to Fiji, and north to the Riu Kiu Islands. How far south it ranges is unknown, for it is not certain that Kent's (1893) "*marmorata*" from the Barrier Reef is the present species.

Holothuria modesta.

Ludwig. 1874. Arb. Zool.-zoot. Inst. Würzburg, *2*, p. 106, pl. vii, fig. 26.

This little-known species was originally described from Cape York, but the account is very brief and neither size nor color of the unique holotype is mentioned. Bell (1884) records a single specimen from Torres Strait, with a question mark and without any information. Lampert (1885) lists three specimens from Kosseir, on the Red Sea, but as the largest was only 10 mm. long it is obvious that their identification is open to very serious doubt. Sluiter (1901) lists a specimen from Macassar and one from Saleyer, but gives no information whatever about them.

At Friday Island, and a few days later at Erub, we found holothurians which seem to be this species, but at Mer not a single specimen was found. Those seen at Erub were 100 to 125 mm. long, dull gray, with yellow tentacles and pedicels. My notes comment on the "very short" tentacles and say that the species was "rather common under stones."

Holothuria monocaria.

Lesson. 1830. Cent. Zool., p. 225, pl. 78.

This well-known Indo-Pacific species was taken by Semon at Thursday Island, and we found it common at Mer. It also occurred at Green Island, Queensland. Mitsukuri reports it as abundant at Misaki, Japan, and says it attains a length of more than 500 mm. there. I found it common at Hilo, Hawaii, but neither there nor at Mer did I see individuals anywhere nearly 500 mm. long. At Mer it always occurred on the under side of rock-fragments.

Holothuria pardalis.

Selenka. 1867. Zeit. f. w. Zool., *17*, p. 336, pl. xix, fig. 85.

This common species was also taken by Semon near Thursday Island, while we found it at Friday Island, Erub, and Mer, and even at Green Island, Queensland. It has a very wide range, from Zanzibar to Cocos Island, Mexico, and from Japan to Port Mackay, Queensland. It occurs in sand under rock-fragments. Bell (1884) records one specimen of *H. lineata* from Thursday Island and also, "with considerable doubt," a single specimen of *H. peregrina* from the same place. It seems to be generally agreed now that these two supposed species are simply forms of *pardalis*.

Holothuria pervicax.

Selenka. 1867. Zeit. f. w. Zool., *17*, p. 327, pl. xviii, fig. 54.

(Plate 19, Figure 2.)

This is another of the widespread Indo-Pacific holothurians, known from the Red Sea and Zanzibar to Tahiti and Hawaii and northward to Misaki, Japan. We found a number of specimens at Erub, and at Mer it is one of the commonest holothurians. It is found under rocks and coral fragments. The largest specimens are upwards of 300 mm. in length. The thick white Cuvier's organs are normally very well developed but are sometimes scanty.

Holothuria remollescens.

Lampert. 1885. Die Seewalzen, p. 242, figs. 8, 9, 22.

We found at Mer, on the under side of a rock-fragment, a dull purplish-gray holothurian, about 135 mm. in length, which seems to represent this little-known species, originally described from the Red Sea and since recorded only once, a single small specimen from Grand Coco Island.

Holothuria rugosa.

Ludwig. 1874. Arb. Zool-zoot. Inst. Würzburg, *2*, p. 110, pl. vii, figs. 33*a–c*.

This is another little-known species, of which we found one specimen at Mer. The type locality is Samoa, and the species has also been reported from the Andaman Islands, the Pelew Islands, Rotuma, New Britain, and Waigeu. The single individual taken at Mer was buried in sand under a rock-fragment on the southeastern reef-flat.

Holothuria scabra.

Jaeger. 1833. De Hol., p. 23.—Semper. 1868. Holothurien, pl. xix.

This big species ranges along the whole East African coast from Port Natal to the Red Sea and thence eastward to the Caroline and Fiji Islands; on the north it reaches the Riu Kiu Islands and on the south Torres Strait. It is widely used for bêche-de-mer, some individuals making "curry-fish," while others only rank as "sand-fish." Saville Kent (1893) does not mention *scabra*, and it is possible that it does not occur along the Great Barrier Reef. We did not find it at Mer, but we took two specimens on the sand-flat southwest of Friday Island. One of these was about 375 mm. long and 100 mm. thick; "white below; pale gray above finely speckled with blackish, most thickly along the mid-dorsal line; dorsal pedicels blackish." The other specimen was smaller; "white below; cream-color blotched with brown above; dorsal pedicels tipped with brown." These descriptions, when compared with Semper's figure and Mitsukuri's (1912) color notes, show that in the matter of its patterns and shades, *scabra* is quite variable.

Holothuria subverta[1] sp. nov.

(Plate 38, Figures 25 to 32.)

Length about 100 mm.; breadth 23 mm.; vertical diameter about 12 mm. Body notably depressed, widest posterior to middle and narrowed towards each end, well covered with papillæ and pedicels; no hard-and-fast line can be drawn between these two sorts of appendages as occurring in *subverta;* true pedicels (simple cylindrical, truncate outgrowths) are relatively rare, but true papillæ (elongatedly conical, pointed outgrowths) are also rare; most of the appendages are conical for the basal half and cylindrical and truncate distally; ventrally they are mostly about 2 mm. long, in 8 to 10 irregular series, the outermost series on each side being situated on the well-marked margin between the dorsal and ventral surfaces; among these longer papillæ-pedicels are scattered a few small pedicels which lack the conical base; dorsally the appendages are smaller (as a rule), more numerous and much less evidently in series; many are more pointed distally; the ventral surface is quite clean, but the dorsal surface seems to have much fine dirt adherent to it. Tentacles 20, small and very short. Calcareous ring rather stout; radial pieces deeply forked anteriorly, about 2 mm. high by 1.75 mm. wide; interradial pieces much smaller, with an anterior pointed projection, 1.2 mm. wide, 0.70 mm. high at the sides, and 1 mm. at the center; neither radial nor interradial pieces are markedly concave posteriorly. Polian vessels 2, 7 to 8 mm. long. Madreporic canal single, free, 7 to 8 mm. long. Cuvier's organs very well developed, forming a compact tuft of thick whitish tubules at the base of the respiratory tree.

Calcareous particles in tentacles, papillæ, and body-wall exceedingly numerous, and while they are easily grouped as supporting rods, buttons, and tables, they are very variable indeed. Tables 0.035 to 0.100 mm. across the disk, with spires 0.040 to 0.140 mm. high and 0.025 to 0.030 mm. square at top; disk (pl. 38, fig. 27) squarish, with smooth margins, a large central hole and about 8 marginal perforations, of which the 4 corner ones are smaller than the 4 which lie between them; spire (pl. 38, fig. 26) with 1 to 6 cross-bars, but usually with several; only a few small, stumpy tables (pl. 38, fig. 30) have but a single cross-bar; the tables form a single layer all over the animal; they are lower and more stumpy dorsally than ventrally, and are highest (pl. 38, fig. 29) and most slender in the papillæ. Buttons 0.030 to 0.080 mm. long, with the width half as much or less; typically there are 3 pairs of perforations of approximately equal size (pl. 38, fig. 31), but sometimes the pair at each end of the button is greatly reduced, leaving a large perforation on each side at the middle of the button, and 2 little round holes near each end; on the other hand, buttons occur with small holes at each end in addition to the usual 6 large perforations (pl. 38, fig. 32); buttons smooth or knobbed, but usually with 12 to 16 knobs on each surface; sometimes on the smallest plates only 2 distinct knobs are present on each side, these being at the ends of the bar separating the median pair of perforations; ventrally there are few knobs on the buttons, commonly none along the margins, but the dorsal buttons are usually very fully knobbed. Supporting rods of pedicels (pl. 38, fig. 25), typically about 0.150 mm. long, expanded and with 1 to 4 perforations at each end, and also expanded at the middle with 1 or 2 relatively large perforations there, on each side of the long axis; such rods intergrade, however, especially near base of pedicels, with the true buttons. Supporting rods of tentacles simply smooth, slightly curved rods, with the ends neither expanded nor branched; they are 0.075 to 0.125 mm. long. Terminal plates well developed in pedicels, while at the tips of some of the more pointed dorsal papillæ are minute, reticulated spheres, one sphere to each papilla, apparently a modified terminal plate. Color dull gray, brownish dorsally because of dirt; pedicel-papillæ white or whitish, ventrally contrasting evidently with the ground-color but dorsally obscured by dirt; tentacles very light.

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[1]*Subvertus* = upside-down, in reference to the ease with which the lower surface may be mistaken for the upper.

Holotype: M. C. Z. No. 1062; on under side of rock, reef-flat, Mer, Murray Islands, Torres Strait. F. A. Potts, collector.

This is unquestionably the most remarkable holothurian we found at Mer, and it is to be regretted that only a single one was seen. The dorsal surface looks so much like the ventral, and *vice versa*, that it is difficult to believe one's eyes when dissection shows the attachment of the dorsal mesentery, the position of the madreporic canal, etc. The mouth, too, indicates the ventral surface, as it is not terminal but evidently on the lower side. The animal was exceedingly sluggish, and as it failed to eject any Cuvier's organs when handled they were supposed to be wanting; but dissection shows them well developed. I know of no species to which *subverta* is closely related, and it will probably become the type of a separate genus when *Holothuria* is finally broken up into its component parts.

THELENOTA[1] Brandt.

Large aspidochirote holothurians, with well-marked difference between dorsal and ventral surfaces; dorsal with papillæ and pedicels; ventral with very numerous pedicels; on neither surface is there any indication of longitudinal series. Calcareous particles of body-wall of two kinds; innumerable minute oval granules 0.002 to 0.004 mm. long and dichotomously branched rods; the latter are not sufficiently numerous to form a distinct layer, but occur external to most of the granules.

Genotype: *Trepang ananas* Jaeger.

The discovery at Mer of a holothurian, as large as *ananas* and with very similar calcareous deposits, but otherwise very different, led me to make a special study of the two species. I have for some time been convinced that our classification of the pedate holothurians needs complete revision, the calcareous particles of the body-wall being given far greater weight than hitherto as a primary indicator of relationship, and much less weight being given to attempted distinctions between pedicels and papillæ, or to the arrangement of these appendages of the body-wall. Pearson (1914) has made a beginning at splitting up the old heterogeneous group *Holothuria*, but he lays more weight on the form of the calcareous ring, on the anal teeth, and on the ambulacral appendages than I am willing to allow them, and not nearly so much weight as I believe justly rests on the calcareous spicules. The five subgenera he proposes do not seem to me natural groups, and as he unfortunately fails to designate any genotypes, he has not helped very much in the elucidation of the subject. As he did not touch *Stichopus*, the present genus did not come within his field.

The character of the calcareous deposits, quite different from any otherwise known in the family, seems to me sufficient reason for the recognition of this genus, but the large size and the arrangement of the ambulacral appendages give further warrant for such action. There are, however, two points with reference to the morphology of *Thelenota* which I greatly regret to have to leave undetermined. The first and more important is the number of tufts of gonads. All the museum material available to me is eviscerated, and I failed to investigate the point when fresh material was available at Mer. The holotype of *T. anax* shows the base of a tuft on the left side of the mesentery, but there does not seem to be any on the right. I was accordingly inclined to put the species in *Holothuria* until I examined the calcareous spicules. The best specimen of *T. ananas* in the Museum of Comparative Zoölogy has the base of a large gonad on the left side and a noticeably smaller one on the right. Selenka (1867) says there are 2 gonads and Semper (1868) considers that feature a character of the genus *Stichopus*, and accordingly shifts *ananas* to the genus where subsequent writers have left it. But I can not discover that any one has confirmed Selenka's statement. It seems to me unlikely that *ananas* normally has 2 gonads like *Stichopus*, and

[1] The derivation of this name (θηλή = nipple + νῶτον = back) is evident. It is very appropriate to the type-species, but much less so to the new one from Mer.

anax only 1 like *Holothuria;* but even if that prove to be the case, I should not consider it ground for generic separation. The other point which I must leave for future investigators to determine is the normal number of tentacles. It is probable, of course, that there are 20, but I have not found that number indisputably present in even one specimen, and in the available material the number present is apparently only 16 to 18, and in one case 19.

In regard to the name of the genus, a word of explanation is necessary, as I expected to use Jaeger's (1833) name *Trepang,* in spite of its objectionable un-Latinized form. But Jaeger includes in the genus four species, *edulis, ananas, impatiens,* and *peruviana,* and says, after remarking that the genus is dubious anyway, that *ananas* is probably a true Holothuria, while *impatiens* and *peruviana* might perhaps be known as Synaptas. Hence *edulis* must be recognized as the type of *Trepang,* as it is the only species indubitably referred to the genus by the original author thereof. Brandt (1835) undertook to classify holothurians in far more numerous genera, subgenera, and sections than knowledge of the group at that time warranted and with not very happy results. But many of his proposed names will have to be used, and we shall be fortunate if all prove to be as appropriate and satisfactory as *Thelenota.*

Besides the two species here included in the genus, Selenka's species *Mülleria formosa* very possibly belongs in *Thelenota.* As Mitsukuri (1912) has pointed out, were it not for the presence of anal teeth, one would not hesitate to identify *formosa* with *ananas,* but Selenka particularly mentions them, saying they have the upper surface granulated. It should be noted, too, that Selenka says rib-like, curved supporting rods occur in all the pedicels, whereas there are no supporting rods in the pedicels of either *ananas* or *anax.* Finally, it may be mentioned that Selenka's figure of a forked rod of *M. formosa* (1867, pl. xvii, fig. 19*b*) is not exactly like the rods of either *ananas* or *anax,* but is more like those of the latter. Under the circumstances it seems to me we must retain *formosa* as a valid species, characterized especially by the presence of anal teeth and supporting rods in the pedicels, until the type in the Museum Godeffroy is re-examined and Selenka is shown to be wrong, or until young individuals of *ananas* are shown to have, at least sometimes, anal teeth and supporting rods.

Thelenota ananas.

Trepang ananas Jaeger. 1833. De Hol., p. 24, pl. 3, fig. 1.
Holothuria (*Thelenota*) *ananas* Brandt. 1835. Prod. Descr. Anim., p. 253.
Stichopus ananas Semper. 1868. Holothurien, p. 75.—Sluiter. 1901. *Siboga* Holos., p. 30, pl. ii, fig. 1.—Mitsukuri. 1912. Act. Holos., p. 150, text-fig. 25.

(Plate 18, Figure 3.)

This, the largest of holothurians, is not uncommon at the Barrier Reef, 4 miles east of Mer, but it is in such demand for bêche-de-mer that it is pretty nearly exterminated in the shallow water around the islands. All that we saw were in water over a fathom deep and could only be gotten by diving for them. The largest specimen I measured was not quite 750 mm. long, 115 mm. wide, and about 85 mm. high. Kent (1893) says they grow to be "three or four feet" long, and while that is not incredible, accurate measurements of such giants would be desirable. When Kent wrote, the bêche-de-mer prepared from *ananas* was not in high favor, though it had been, earlier, the most prized of all. In 1913 it was regarded as the most valuable of all the Torres Strait varieties, the best quality being priced at about 75 cents a pound. It is known to the trade as "prickly red-fish," and is unmistakable not only because of its large size but because the dorsal papillæ dry up into, and persist as, hard, sharp projections, which are very characteristic. The best figure of *ananas* extant is Kent's (1893, pl. xxxv, fig. B) photograph, unfortunately labeled (after Bell's identification) as *Stichopus variegatus,* as Sluiter (1901) and Mitsukuri (1912) have already pointed out. Sluiter's colored figure of what is probably the smallest known specimen is of great interest. Mitsukuri's figures of the calcareous ring and spicules are very good indeed, admirably showing the proportions of the dichotomously branched rods. His remarks on *Mülleria formosa* Selenka are also of great importance.

This big holothurian is characteristic of the western and southern Pacific, Java on the west and Okinawa on the north being the known limits on that side; on the east it reaches the Marshall Islands, and on the southeast the Society Islands, as is shown by specimens in the Museum of Comparative Zoölogy. How far to the south it occurs on the Barrier Reef is not known. Its absence from the Indian Ocean west of Java is striking.

While we were at Mer, Dr. E. N. Harvey dissected a fresh specimen of *ananas* and made the interesting discovery that the epithelium covering practically all the internal organs, particularly the gonads, is colored with a red pigment, which becomes purple in the presence of alkalies. He accordingly made use of tissues from fresh specimens of this holothurian in experiments he was making on the permeability of living tissues by acids.

Thelenota anax[1] sp. nov.

(Plate 18, Figure 3.)

Length in life, 725 mm.; now, in alcohol, about 425 mm.; width about 100 mm. and height 80 to 85 mm. Body-wall thick, especially dorsally. Ventral surface densely covered with pedicels, with no indication of longitudinal series. Dorsal surface also well covered by ambulacral appendages, but these are for the most part more papilliform than those of the ventral side; most of these papillæ are quite small, but along each side and scattered rather sparingly over the back are larger papillæ, which may be as much as 6 to 8 mm. high and 8 to 10 mm. in diameter at base (in life); in the preserved specimen they can be detected only with difficulty. The form and distribution of the ambulacral appendages, as well as their size and color at the anterior end of the body, are well brought out in the figure (pl. 18, fig. 3). There are no anal teeth, nor are there any papillæ about the anus to suggest them. Tentacles 16 or more; 16 can be counted, but they are in poor condition and I have little doubt 20 is the normal number. Calcareous ring only moderately heavy, not peculiar; dorsal side higher (wider) than ventral; radial pieces larger than interradial and their posterior margin more deeply concave, but the differences are not very great. Polian vessels, madreporic canals, and the very long tentacle ampullæ are so inextricably tangled with parts of gonad and respiratory-trees that nothing certain could be made out as to their number. Lining of body-cavity a deep brownish-red, as in *ananas*, indicating that the same "indicator" pigment is present in this species.

Calcareous spicules of body-wall of two sorts, similar to those of *ananas*. The minute oval grains are excessively numerous and form a fairly continuous layer, not very thick, all over the body; a rough estimate indicates there are not fewer than 160 billion of them if the layer averages one-fourth of a millimeter in thickness! Most of the grains are about 0.002 mm. long, the width a very little less, but a considerable number are noticeably larger; the largest measured was about 0.005 mm. long. Just outside the granules lie the dichotomously branched rods; they seem to be a little more numerous ventrally than dorsally, but they do not form a definite layer and are seldom abundant enough anywhere for the ends to overlap; the length "over all" is 0.040 to 0.100 mm. They are, as in *ananas*, of two quite distinct kinds, slender and stout. The slender ones have the original rod (where the entire length is about 0.100 mm.) about 0.012 mm. long and 0.004 mm. thick; the primary branches are about 0.016 mm. long and 0.003 mm. thick; the secondary branches are nearly as long and a little more slender; and the tertiary branches are about 0.008 mm. long, fine and acute. The tertiary branches usually have 1 to 3 long, con-

[1] ἄναξ = a prince or chief, in reference to the large size and fine appearance of this notable holothurian.

spicuous, acute thorns on the side; if the secondary branches do not divide they bear 1 to 4 such thorns, and indeed these thorns may occur anywhere on the rods. Of course, few rods are perfectly symmetrical, and it is rare indeed to find two alike, but, as a rule, the primary branches are longer than the original rod; tertiary branches are present, and there are at least some conspicuous, slender thorns. The stout rods are usually about 0.050 mm. long, with the original rod about 0.009 by 0.005 mm., the primary branches about the same or a little longer and the secondary branches a little shorter and very acute. Thorns are frequently developed, but tertiary branches rarely occur. There seem to be no connecting-links between stout and slender rods, and the latter are very much more numerous, perhaps 25 to 1. Here and there I have found the slender rods with a rough, warty, or corroded surface, but I believe these are artifacts. Pedicels, when fully developed, with a very finely reticulate terminal plate but with no supporting rods; a few of the dichotomously branched rods may be elongated at right angles to the axis of the pedicel and have a few anastomosed branches, but such are infrequent and inconspicuous. Tentacles without supporting rods, but with a small number of widely scattered plates, 0.050 to 0.075 mm. across formed by anastomosis of the branches of the branched rods. Much more numerous, but not particularly abundant, are little rods, about 0.060 mm. long, which may be bent, curved, or straight and smooth or rough at the tips. Color, in life, white, blue, brown, and yellow, as shown in plate 18, figure 3; the ventral side was pure white, the back pale blue, the large papillæ whitish at base, yellow distally, and dark brown at tip; dorsally the pedicels were brown, usually with darker tips, but ventrally they were white with dark or light brown or yellow tips. Tentacles bright brown. In alcohol, all blue and yellow shades have disappeared and the animal is now yellow-brown above, whitish below, everywhere more or less thickly speckled with the deep brown tips of the pedicels. Tentacles dingy yellow-brown.

Holotype: M. C. Z. No. 1068; off the northwestern reef, in several fathoms, Mer, Murray Islands, Torres Strait.

This very fine holothurian was brought to the laboratory by one of the native fishermen, who got it by diving. He called it an "amber-fish," but I have failed to find any such name used for bêche-de-mer in the Torres Strait region. The species was evidently not a novelty to the natives, who spoke of it as a "prickly-fish" and as one of the most desirable kinds. We saw no other specimens at Mer, nor did we find it at the Barrier Reef, where *ananas* was not uncommon. The differences from *ananas*, in color and in form of dorsal papillæ, are so striking (*cf.* pl. 18, figs. 2 and 3) it is hard to believe the two species are really congeneric; but the resemblances in calcareous particles and in internal organization are even more remarkable.

Stichopus chloronotus.

Brandt. 1835. Prod. Descr. Anim., p. 250.—Selenka. 1867. Zeit. f. w. Zool., *17*, p. 315, pl. xvii, figs. 20-24; pl. xviii, fig. 25.

(Plate 18, Figure 2.)

This is one of the commonest and most easily recognized of Torres Strait holothurians, the form and color being characteristic and showing little diversity. We saw it at Thursday Island and at Erub, as well as at the Murray Islands. It lives in the open, on flats covered with "eel-grass" (*Posidonia*) and is never found under rocks or among corals. The largest specimen seen was only a little more than 300 mm. long. The color is always deep green; in bright sunshine the green is very obvious even in the darkest specimens, but in poor light many of the larger specimens look almost black; the distal portion of the big dorsal papillæ *is* blackish, with the extreme tip brown-orange; tentacles ashy with the stalks whitish; pedicels dark ashy. Mitsukuri (1912) says the specimen he collected at Amami-Oshima was "deep black with a bluish tinge, the tips of some papillæ being ochre-yellow." It will be interesting to learn whether further observations confirm the presence of a *blue* rather than a green color in the Riu Kiu form of *chloronotus*. It may be desirable, if this is the case, to recognize a northern subspecies. Kent's (1893) description agrees well with the specimens I saw, and his colored figure is much nearer to nature than any other of those which he gives illustrating echinoderms. As he says, this species is, for some reason, commercially worthless, the consistency of the body-wall not permitting its preservation as bêche-de-mer. It would be interesting to know if there is a notable *chemical* difference between the body-wall of this Stichopus and that of *Thelenota ananas* (one of the most valuable bêche-de-mers), or whether the difference is purely physical. The geographical range of *chloronotus* is extensive, from Mozambique to the Hawaiian Islands; yet it is not known from Tahiti, nor can I find a record from the Red Sea. Kent (1893) says it extends southward on the Queensland coast to the "central Barrier region," and Mitsukuri (1912) records it from Amami-Oshima, in the northern Riu Kius. At Mer, *chloronotus* is often accompanied by a commensal annelid, a species of *Gastrolepidia*, whose color corresponds exactly with that of its host and whose form enables it to retain its position even against a considerable effort to detach it. Whether this worm is *G. clavigera*, which occurs on *Holothuria atra* in the Maldives, or whether it is an undescribed species I do not know. A crude colored figure of it is given by Kent (1893).

Stichopus horrens.

Selenka. 1867. Zeit. f. w. Zool., *17*, p. 316, pl. xviii, figs. 27–29.
Stichopus godeffroyi var. *b* Semper. 1868. Holothurien, p. 246.
Stichopus tropicalis Fisher. 1906. Proc. U. S. Nat. Mus., *32*, p. 676, pl. lxx, figs. 1–1*i*.

(Plate 18, Figure 4.)

This seems to be a species characteristic of the Pacific, for it is unknown west of the Philippines. At Mer and at Erub, *horrens* was common under rocks on the reef-flats. My field-notes describe it as "very irregular and soft, almost repulsive; variegated color." The length of the living specimens was 150 to 300 mm. At Papeete, Tahiti, August 5, 1913, I found a small Stichopus about 35 mm. long, under a rock-fragment, which is probably a young *horrens*. In life it was pellucid, almost transparent, showing very little color of any sort.

The color in adult *horrens* is apparently rather variable, for Fisher says that at the Hawaiian Islands it is dark olive-green mottled with deep brownish-green; at Mer there is usually little indication of green, the browns, white, gray, and blackish combining to give an indescribable diversity. One specimen at Mer is, however, described in my field-notes as "olive-green of 2 or 3 shades, mottled," which is practically identical with the color at Honolulu.

Fisher records this Stichopus from the Friendly, Samoan, Fiji, Pelew, and Philippine Islands, as well as from Honolulu and Puako Bay, Hawaii. We found it at Friday Island as well as at Mer, and I also found it common at Lahaina and at Hilo, Hawaii.

Stichopus variegatus.

Semper. 1868. Holothurien, p. 73, pl. xvi; pl. xvii; pl. xxx, figs. 1, 6.

This huge holothurian rivals the species of *Thelenota* in size, for Semper gives the measurements of one he saw as 3 feet long and 8 inches in diameter. For the most part, however, specimens of *variegatus* are much smaller than this, usually 300 to 400 mm. long and 75 to 100 mm. thick. The color is very diversified. My field-notes at Mer give the following descriptions of different individuals: (1) Deep yellow with an olive cast, spotted with dark olive, not thickly; tentacles light yellowish. (2) Yellow-brown with deep olive lines running diagonally. (3) Blackish; dull yellow-olive above and around mouth, and faint indications of a similar shade at small scattered places on back.

This species is fairly common at Mer, and what seems to be the same thing was also found at Badu. The geographical range of the species is great, from the Red Sea and Zanzibar on the west to the Caroline and Samoan Islands on the east; it is reported from southern Japan (Izu). Bell (1884) lists it from Port Molle, but as he identified *Thelenota ananas* (Jaeger) for Saville Kent (1893) as *Stichopus variegatus*, it is obvious this record can not be trusted.

On October 13, 1913, a Japanese diver brought up from 18 fathoms off the northwestern reef at Mer a holothurian over 700 mm. long and 125 mm. thick, which our Murray Island fishermen said was a "curry-fish." This proved to be a specimen of *variegatus*, but none of the bêche-de-mer sold as curry-fish, which I examined, were specimens of *Stichopus*.

Actinopyga echinites.

Mülleria echinites Jaeger. 1833. De Hol., p. 17.—Semper. 1868. Holothurien, pl. xxx, fig. 8.
Actinopyga echinites Saville Kent. 1893. Great Barrier Reef, p. 236.

This species ranges from Zanzibar to Fiji, north to the Riu Kiu Islands and south to Port Denison, Queensland. Semon took it near Thursday Island, but we did not meet with it at any point. There are specimens in the Museum of Comparative Zoölogy from Ponape, Caroline Islands, and Tongoa, New Hebrides. Bêche-de-mer fishermen call this "red-fish," as they do *A. mauritiana*.

Actinopyga lecanora.

Mülleria lecanora Jaeger. 1833. De Hol., p. 18, pl. ii, figs. 2, 2*b*.—Semper. 1868. Holothurien, pl. xxx, fig. 7.
Actinopyga lecanora Bronn. 1860. Das Thierreich, *1*, pl. xlv, explanation of figs. 10, 11.[1]

This is the "stone-fish" of bêche-de-mer fishermen in Torres Strait and is common throughout the region. We found it several times at the Murray Islands, generally on the under surface of large rock-fragments. The range of the species is from Mauritius to Tongatabu, north to the Riu Kiu Islands, south to the Great Barrier Reef.

Actinopyga lubrica.

Mülleria lubrica Sluiter. 1894. Jena. Denkschr., *8*, p. 104.

This curious species is based on two specimens only 42 mm. long taken by Semon near Thursday Island. The calcareous particles (aborted tables only) are absolutely unique in the genus. The species has not been met with since first described.

Actinopyga mauritiana.

Holothuria mauritiana Quoy and Gaimard. 1833. Voy. *Astrolabe*, *4*, p. 138.
Actinopyga mauritiana Bell. 1887. Sci. Trans. Roy. Dublin Soc., (2), *3*, p. 653, pl. xxxix, fig. 1.—Fisher. 1907. Proc. U. S. Nat. Mus., *32*, p. 648, pl. lxvii, figs. 1–1*d*.

This species is easily confused in life with *A. lecanora*, and though the bêche-de-mer fishermen call it "red-fish," I think their line of division between red-fish and stone-fish would not coincide with the line between *lecanora* and *mauritiana*. At Mer, *mauritiana* seems to be less common than *lecanora*, but Kent (1893) considers the latter rare on Queensland shores and the former "abundant." Pearson (1914) considers *mauritiana* the commonest member of the genus. It certainly has the most extensive geographical range—Mozambique to the Red Sea on the west, Hawaii, the Marquesas and the Paumotus on the east, the Riu Kius on the north, and Fiji on the south. Fisher's account (1907) of the species as it occurs at Hawaii is very complete and satisfactory.

[1] The usual quotation of "p. 403" for this combination of *Actinopyga* and *lecanora* is a mistake. *Actinopyga* is proposed as a substitute for *Mülleria* on p. 403, but it is not used in combination with *lecanora* until the figures of the latter appear on pl. XLV.

Actinopyga miliaris.

Holothuria miliaris Quoy and Gaimard. 1833. Voy. *Astrolabe*, *4*, p. 137.
Actinopyga miliaris Bell. 1887. Sci. Trans. Roy. Dublin Soc. (2), *3*, p. 653, pl. xl, fig. 1.

This is the "black-fish" of the bêche-de-mer fishermen, and was called by Kent (1893) *Actinopyga polymorpha.* He says it occurs on the reefs near low water-mark and is of high commercial value. It seems to be rare at Mer, as we found only a single specimen. That one is peculiar in having *six* anal teeth; the sixth, however, is smaller than the others and is quite near to one of them; there are only 5 longitudinal muscles, and there is no other evidence of any tendency to hexamerous symmetry. This specimen was found clinging to the underside of a rock-fragment on the reef-flat and when collected was almost globular, with a diameter of about 100 mm. The color seemed nearly black. When narcotized with magnesium sulphate it relaxed and became more than 200 mm. long and about 60 mm. wide in the middle. The color was then seen to be deep brown. The range of *miliaris* is from Mozambique and the Red Sea to the Riu Kiu, Caroline, and Tonga Islands.

Actinopyga nobilis.

Mülleria nobilis Selenka. 1867. Zeit. f. w. Zool., *17*, p. 313, pl. xvii, figs. 13-15.
Actinopyga nobilis Fisher. 1907. Proc. U. S. Nat. Mus., *32*, p. 647.

This is the "teat-fish" or "mammy-fish" of the Torres Strait region and ranks second only to "prickly red" in the market. It ranges from Natal to the Red Sea on the African coast and thence to the Hawaiian and Fiji Islands. How far south it goes on the Australian coast is unknown. Kent (1893) gives a good photograph (pl. xxxiv, fig. 3) of a typical, somewhat contracted specimen, but as he overlooked the anal teeth, he called it by the appropriate but unnecessary name *Holothuria mammifera.* At Mer this species was rare, and it is probably so around all the inhabited islands, where its commercial value is a serious handicap in the struggle for existence. Pearson (1914) proposes to separate this species and *parvula* from *Actinopyga* in a genus, *Argiodia.* As I am very much in doubt about the status of *parvula,* I prefer not to use *Argiodia* at present, but I think with *nobilis* as the type it will ultimately be a useful genus. Unfortunately, Pearson fails to designate any type and, still worse, does not include either *nobilis* Selenka or *maculata* Brandt in the genus as first diagnosed and published. But he does include as his first species (and apparently in each of his five subgenera he intends the first species named to be regarded as the type) *Argiodia maculata* (Selenka). As there is no such holothurian, it is obvious (and is shown in his next paper) that this is a slip of the pen for *Argiodia maculata* (Brandt), which is the equivalent of *Mülleria nobilis* Selenka, and I hereby designate this species as the type of *Argiodia.* The name *Argiodia* would seem to be a pure synonym of *Microthele* Brandt and will therefore have to give way to the latter, which is fortunately very appropriate, at least to *nobilis.*

Mitsukuri (1912), under the doubly erroneous name *Mülleria maculata,* gives with important figures a very good account of this species as he has studied it in the Riu Kiu Islands. It is 60 years since Bronn first pointed out that the name Mülleria could not be used for a holothurian. No one (save Verrill in 1867) paid any attention to his clear statement and his new name, *Actinopyga,* until Bell in 1887 took up the name and rightly demanded its use. Fisher (1907) and Pearson (1914) have followed him, but Sluiter (1894 and 1901), Koehler and Vaney (1908), and Mitsukuri (1912) have persisted in this no longer excusable error. As for the specific name *maculata,* it has already been pointed out by other authors (Fisher, 1907, p. 664, for example) that *Holothuria maculata* Chamisso and Eysenhardt, 1821, preëmpted that name; hence Brandt's *Holothuria maculata* is a homonym which is necessarily rejected and under article 36 of the International Code can not be revived.

Actinopyga parvula.

Mülleria parvula Selenka. 1867. Zeit. f. w. Zool., *17*, p. 314, pl. xvii, figs. 17, 18.
Actinopyga parvula Verrill. 1867. Trans. Conn. Acad., *1*, pt. 2, p. 347.—Fisher. 1907. Proc. U. S. Nat. Mus., *32*, p. 645, pl. lxvii, figs. 2–2*g*.

This species was originally described from specimens from Florida, the largest of which was 50 mm. long, but Lampert (1885) records without comment specimens from Kosseir on the Red Sea, the Seychelles, and Amboina. Théel (1886) suggested its possible occurrence in the Pacific, referring to a specimen 30 mm. long, from Samoa, in the Stockholm Museum. Bedford (1899) records specimens from Funafuti, and Fisher (1907) gives an excellent account of 13 specimens from Hawaii. There are specimens in the Museum of Comparative Zoölogy from the Tortugas, Florida, the Bahamas, Jamaica, Tobago, the Murray Islands, the Kermadec Islands (recorded by Benham, 1911), and Hawaii.

One very notable feature of all known specimens is their small size and apparent immaturity. Another remarkable feature is the close resemblance to *Holothuria captiva* of the West Indies, and to *H. difficilis* of the Indo-Pacific region. It seems very probable that *parvula* is either the young of a large species, whose calcareous particles undergo an extraordinary change with growth, or that it is not phylogenetically an *Actinopyga* at all, but is a *Holothuria* which has attained calcareous teeth about the anus independently, and is most nearly related to *H. captiva.* Indeed, the resemblance to *captiva* is one of the things which most need investigation. This resemblance is specially emphasized by Benham's (1911) observations on specimens from the Kermadecs, which seem to show regeneration of the posterior half of the body, taken in connection with Crozier's (1914, p. 8) observations on *H. captiva* at Bermuda.

This species was not rare at Mer, specimens being found on both sides of the island. They occur clinging tightly to the under side of rock-fragments. When touched, they eject copious white Cuvier's organs. The color above is uniformly brown, and beneath is yellowish. Few exceed 30 to 40 mm. in length. In all these particulars, as well as in the calcareous particles of the body-wall, the resemblance to *Holothuria captiva* is very striking.

Part II.

COMPOSITION AND ORIGIN OF THE ECHINODERM FAUNA OF THE TORRES STRAIT REGION AND QUEENSLAND.

In view of our still relatively slight knowledge of the echinoderm fauna of Torres Strait, it would seem to be somewhat presumptuous to undertake its analysis critically in search of light on its origin, but the data which we now have are surprisingly suggestive and fully warrant an effort to understand and interpret them. In order to appreciate this rich and varied fauna, we must include in our survey the echinoderms known from the surrounding region. The entire area to be considered may for convenience be divided quite naturally into the following areas.

1. The coast of northern and western Australia, from Melville Bay on the east to Sharks Bay on the west. Unfortunately, nothing whatever is known of the echinoderms of the Gulf of Carpentaria.
2. The island of Rotti and the southern coast of Timor, a region still very imperfectly known. The knowledge we have is due almost wholly to the splendid work of the *Siboga*.
3. The Arafura Sea, the Aru Islands, and less naturally the Kei Islands. The Tenimber Islands are an important part of this area, but unfortunately they were not visited by the *Siboga* and nothing is known of their marine fauna.
4. The northern coast of New Guinea from Humboldt Bay eastward (and the southern coast as far west as the Fly River delta may be included, too, if one wishes, since its echinoderms are quite unknown); New Britain and its neighbors; the Solomon and Loyalty Islands, the New Hebrides, and New Caledonia—all that vast area which forms a sort of western limit to the southern half of the tropical Pacific Ocean. Practically nothing is known of the echinoderms of most of this region.
5. Fiji and Samoa, typical tropical Pacific islands, whose echinoderms are still very imperfectly known, but which nevertheless may not be ignored in considering the Australian fauna.
6. The Murray Islands and vicinity, including Erub (Darnley Island) and even Warrior Reef still further west. This is the northern end of the Great Barrier Reef region.
7. Thursday Island and vicinity, including Torres Strait proper, and extending from Albany Passage on the south to Mabuag (Jervis Island) on the north. The southern coast of New Guinea from the Fly River delta westward may be included here, but nothing whatever is known of its echinoderms.
8. The coast of Queensland from Albany Passage southward, including the off-lying islands and reefs.
9. The coast of Australia south of Queensland.

It is of course quite unnecessary to take into account all the echinoderms known from each of these areas. Obviously a species known only from Fiji, or New Britain, or even Queensland or West Australia, is of little or no direct value in studying the Torres Strait fauna. In compiling the following list of species to be considered, it has seemed best therefore, in order that the list should not be too long, to exclude all species not occurring in the Torres Strait region which are known from only one place. Some species are included, however, which occur at only one place in the region under consideration, if they are known from the regions to the north or east. All species of the Torres Strait region are included in the table, even when known from but a single specimen, as it seems desirable to consider them in contrasting the eastern and western halves of that region. It is also desirable that this table should include all the known echinoderms of Torres Strait. It is not to be denied that the inclusion or rejection of species in the table is more or less arbitrary, but I have endeavored to include all species which would throw

Tabulated List of Echinoderms of Torres Strait and Surrounding Areas.[1]

Name.	Western and northwestern Australia.	Southern side of Timor, & Rotti.	Arafura Sea, Aru and Kei Islands.	Northern coast of New Guinea, New Britain, New Hebrides, Solomon and Loyalty Islands, and New Caledonia.	Fiji & Samoa.	Murray Islands and vicinity.	Thursday Island and vicinity.	Coast of Queensland.	Coast of New South Wales or Victoria.
Crinoidea.									
Comatella maculata (P. H. C.)				×		×		×	
nigra (P. H. C.)		×				×			
stelligera (P. H. C.)					×	×		×	×
Capillaster multiradiata (L.)	×	×	×			×		×	
Comatula etheridgei A. H. C.	×		×						
pectinata (L.)	×	×	×			×	×	×	×
purpurea (J. Müll.)	×	×	×	×		×	×		
rotalaria Lam'k.	×		×				×	×	
solaris Lam'k.	×					×	×	×	
Comaster belli (P. H. C.)	×						×		
multifida (J. Müll.)	×						×		
novæguineæ (J. Müll.)	×				×		×	×	
Comanthus alternans (P. H. C.)						×		×	
annulata (Bell)	×		×	×	×	×	×	×	
bennetti (J. Müll.)		×		×				×	
briareus (Bell)	×	×	×					×	
callipepla H. L. C.						×			
luteofusca H. L. C.					×	×			
parvicirra (J. Müll.)	×	×	×	×	×	×	×	×	
samoana A. H. C.		×		×	×	×			
schlegelii P. H. C.		×		×		×		×	
Zygometra elegans (Bell)	×						×	×	
microdiscus (Bell)	×		×				×	×	
punctata (A. H. C.)	×		×					×	
Heterometra crenulata (P. H. C.)	×		×				×	×	
delicata H. L. C.							×		
nematodon (Hartlaub)			×					×	
Amphimetra discoidea (A. H. C.)	×		×				×	×	
jaquinoti (J. Müll.)	×							×	
Stephanometra callipecha (H. L. C.)						×			
indica (E. A. Smith)		×	×				×		
monacantha (Hartl.)				×	×	×			
stypacantha H. L. C.						×			
Lamprometra brachypecha H. L. C.					×	×			
gyges (Bell)	×			×		×	×	×	
protecta (Ltk.)		×		×	×				
Oligometra anisa H. L. C.						×			
carpenteri (Bell)	×		×				×	×	
Oligometrides adeonæ (Lam'k.)	×		×				×	×	
Colobometra perspinosa (P. H. C.)				×				×	×
Tropiometra afra (Hartlaub)	×					×		×	
Dorometra nana (Hartlaub)			×			×			
Asteroidea.									
Astropecten granulatus M. & T.			×				×		
polyacanthus M. & T.	×		×	×	×				×
zebra Sladen	×					×	×		
Archaster angulatus M. & T.	×			×	×				
typicus M. & T.	×		×	×	×			×	
Luidia forficifera Sladen			×				×		×
maculata M. & T.	×		×				×	×	×
Iconaster longimanus (Möbius)	×		×				×	×	
Goniodiscaster coppingeri (Bell)							×	×	
pleyadella (Lam'k.)							×		
Ogmaster capella (M. & T.)								×	
Stellaster incei Gray	×		×	×			×	×	×
princeps Sladen							×		
Anthenea tuberculosa Gray	×			×			×	×	

[1] The omission of color varieties from this list results in only 241 forms being recorded here from the Torres Strait region instead of 246, the total number mentioned on p. 10.

Tabulated List of Echinoderms of Torres Strait and Surrounding Areas—continued.

Name	Western and northwestern Australia.	Southern side of Timor, & Rotti.	Arafura Sea, Aru and Kei Islands.	Northern coast of New Guinea, New Britain, New Hebrides, Solomon and Loyalty Islands, and New Caledonia.	Fiji & Samoa.	Murray Islands and vicinity.	Thursday Island and vicinity.	Coast of Queensland.	Coast of New South Wales or Victoria.
Asteroidea—continued.									
Oreaster gracilis Ltk	×		×			×	×	×	
nodosus (L.)	×		×	×		×	×	×	
Culcita novæguineæ M. & T	×			×	×	×			
Asterope carinifera (Lam'k.)		×		×	×	×		×	
Habroporina pulchella H. L. C						×			
Fromia elegans H. L. C						×			
milleporella (Lam'k.)				×	×	×			
monilis Perrier			×	×	×				
Nardoa mollis de Loriol				×		×			
novæcaledoniæ (Perr.)	×			×		×		×	
pauciforis (von Mart.)						×		×	
rosea H. L. C						×			
tuberculata Gray	×	×		×					
Ferdina ocellata H. L. C						×			
Linckia guildingii Gray					×			×	
lævigata (L.)		×	×	×	×	×		×	
multifora (Lam'k.)				×	×				
Bunaster uniserialis H. L. C						×			
Leiaster speciosus von Mart					×	×			
Ophidiaster granifer Ltk					×	×		×	
lioderma H. L. C						×			
squameus Fisher						×			
Tamaria pusilla (M. & T.)[1]				×	×				
tuberifera (Sladen)							×		
Hacelia helicosticha (Sladen)	×		×				×		
Nepanthia brevis Perrier	×						×		
Asterina anomala H. L. C						×			
burtonii Gray				×		×			
exigua (Lam'k.)				×		×			×
nuda H. L. C						×			
Echinaster luzonicus (Gray)	×	×	×	×	×	×	×	×	
Mithrodia clavigera (Lam'k.)				×	×				
Acanthaster planci (L.)				×	×	×			
Metrodira subulata Gray	×		×				×	×	
Valvaster spinifera H. L. C						×			
Retaster insignis Sladen							×	×	
Ophiuroidea.									
Euryale aspera Lam'k	×		×				×	×	
Ophiacantha confusa Koeh						×			
discoidea Lym			×			×			
Amphiura microsoma H. L. C						×			
septemspinosa H. L. C						×			
Amphiocnida dilatata (Koeh.)			×			×			
Ophionephthys octacantha H. L. C							×		
Amphipholis squamata (Del. Ch.)	×				×	×			×
Amphiodia broeki (Död.)							×		
mesopoma H. L. C							×		×
Amphioplus parviclypeus H. L. C							×		
relictus (Koeh.)							×		
Ophiactis delicata H. L. C						×			
hemiteles H. L. C						×			
luteomaculata H. L. C						×			×
modesta Brock							×		
savignyi M. & T	×	×	×	×	×	×	×		×
Ophiothrix belli Död							×		
demessa Lym					×	×			
dyscrita H. L. C						×			
galateæ Ltk							×		

[1] I have ignored in this list, *Tamaria fusca* (Bell's *Linckia megaloplax* in part at least = this) for while it occurs on the coast of northwestern Australia, Bell's identifications leave us badly confused as to its real distribution.

Tabulated List of Echinoderms of Torres Strait and Surrounding Areas—continued.

Name	Western and northwestern Australia.	Southern side of Timor, & Rotti.	Arafura Sea, Aru and Kei Islands.	Northern coast of New Guinea, New Britain, New Hebrides, Solomon and Loyalty Islands, and New Caledonia.	Fiji & Samoa.	Murray Islands and vicinity.	Thursday Island and vicinity.	Coast of Queensland.	Coast of New South Wales or Victoria.
Ophiuroidea—continued.									
Ophiothrix hirsuta M. & T.						×			
liodisca H. L. C.						×			
longipeda Lam'k.	×		×	×	×	×	×	×	
martensi australis H. L. C.	?		?			×	×	×	
melanogramma Bell	×						×		
melanosticta Grube	×		×				×		
nereidina Lam'k.		×	×			×		×	
propinqua Lym.	×	×			×	×			
punctolimbata v. Mart.		×	×				×	×	
purpurea v. Mart.		×	×	×					
rhabdota H. L. C.						×			
stelligera Lym.	×	×	×		×	×	×		
striolata Grube	×						×		
trilineata Ltk.	×	×			×	×			
virgata Lym.						×			
Ophiomaza cacaotica Lym.	×	×		×		×	×	×	
cataphracta (Brock)							×		
obscura (Ljn.)	×					×			
Ophiothela danae Verr.	×	×	×		×		×		
hadra H. L. C.						×			×
Ophiophthirius actinometræ Död.							×		
Ophionereis dubia (M. & T.)	?		?		×				
porrecta Lym.		?			×	×			
semoni Död.		×					×	×	
Ophiocoma brevipes Peters	×	×		×	×	×		×	
var. variegata E. A. S.						×		×	
erinaceus M. & T.				×	×	×			
parva H. L. C.						×			
pica M. & T.		×	×	×	×	×			
schoenleinii M. & T.						×		×	
scolopendrina Lam'k.	×	×		×	×	×		×	
wendtii M. & T.	×			×	×				
Ophiomastix annulosa (Lam'k.)				×		×			
asperula Ltk.					×	×			
caryophyllata Ltk.				×	×	×			
corallicola H. L. C.						×			
flaccida Lym.				×		×			
janualis Lym.						×			
mixta Ltk.		×		×	×	×			
Ophiarthrum elegans Peters				×	×	×	×	×	
pictum (M. & T.)				×		×			
Ophiarachna incrassata (Lam'k.)		×		×	×	×		×	
Pectinura arenosa Lym.							×		×
yoldii (Ltk.)	×		×				×	×	×
Ophiopezella spinosa (Ljn.)					×	×	×		
Ophiochasma stellatum (Ljn.)							×	×	
Ophiarachnella gorgonia (M. & T.)	×			×	×	×		×	
infernalis (M. & T.)	×	×	×	×		×	×	×	
megaloplax (Bell)	×							×	
septemspinosa (M. & T.)		×			×	×			
Ophiura kinbergi (Ljn.)		×	×			×			×
Ophiolepis cincta M. & T.			×		×	×	×		×
superba H. L. C.	×	×		×		×	×	×	×
Ophioplocus imbricatus (M. & T.)	×			×		×			
Echinoidea.									
Eucidaris metularia (Lam'k.)		×	×	×	×				
Prionocidaris bispinosa (Lam'k.)	×		×	×			×	×	
verticillata (Lam'k.)		×			×		×		
Phyllacanthus imperialis (Lam'k.)			×	×		×			×
Centrechinus savignyi (Mich.)				×		×			

Tabulated List of Echinoderms of Torres Strait and Surrounding Areas—continued.

Name	Western and northwestern Australia.	Southern side of Timor, & Rotti.	Arafura Sea, Aru and Kei Islands.	Northern coast of New Guinea, New Britain, New Hebrides, Solomon and Loyalty Islands, and New Caledonia.	Fiji & Samoa.	Murray Islands and vicinity.	Thursday Island and vicinity.	Coast of Queensland.	Coast of New South Wales or Victoria.
Echinoidea—continued.									
Centrechinus setosus (Leske.)		×			×	×	×	×	
Echinothrix calamaris (Pal.)		×	×	×	×	×			
diadema (L.)					×	×			
Astropyga radiata (Leske)			×	×				×	
Stomopneustes variolaris (Lam'k.)				×	×	×		×	
Lytechinus verruculatus (Ltk.)			×		×		×	×	
Nudechinus darnleyensis (Woods)	×					×	×	×	
Toxopneustes pileolus (Lam'k.)		×	×		×				
Tripneustes gratilla (L.)	×	×	×		×	×		×	×
Temnopleurus toreumaticus (Leske)			×	×			×	×	
Salmacis belli Död			×				×	×	
dussumieri Ag. & Des							×	×	
sphaeroides (L.)	×							×	×
virgulata Ag. & Des								×	
virgulata alexandri Bell	×		×				×	×	×
Temnotrema bothryoides (Ag.)	×	×	×				×		
sculpta A. Ag.						×			
Mespilia globulus (L.)				×	×				
Echinostrephus molare (Bl.)						×			
Parasalenia gratiosa A. Ag.		×		×	×	×		×	
Echinometra mathaei (Bl.)	×	×		×	×	×	×	×	
oblonga (Bl.)	×		×	×	×				
Heterocentrotus mammillatus (L.)	×	×				×			
trigonarius (Lam'k.)				×	×				
Clypeaster humilis (Leske)				×				×	
Arachnoides placenta (L.)			×	×	×		×	×	
Laganum depressum Agass.		×	×	×	×		×		
laganum (Leske)			×	×					×
Peronella lesueuri (Agass.)	×	×	×				×	×	
orbicularis (Leske)	×						×		
Fibularia volva Agass. & Des.	×		×				×	×	
Echinocyamus crispus Maz.		×	×						
Echinodiscus tenuissimus (Agass. & Des.)				×			×		
Echinoneus cyclostomus Leske		×			×	×	×		
Oligopodia epigonus (von Mart.)		×	×						
Schizaster lacunosus (L.)			×				×		
Brissopsis luzonica (Gray)		×	×	×					
Metalia spatagus (L.)			×		×				
sternalis (Lam'k.)				×	×			×	
Brissus latecarinatus (Leske)					×	×			×
Maretia ovata (Leske)				×				×	×
Breynia australasiæ (Leach.)	×	×	×				×	×	
Lovenia elongata (Gray)		×	×				×		×
subcarinata (Gray)		×	×						
Echinocardium cordatum (Penn.)	×							×	×
Holothurioidea.									
Euapta godeffroyi (Semper)					×	×	×		
Opheodesoma glabra (Semper)					×		×		
grisea (Semper)		×				×	×	×	
serpentina (J. Müll.)			×	×					
Polyplectana kefersteinii (Sel.)					×	×			
Synapta maculata (Ch. & Eys.)		×		×	×	×		×	
Synaptula indivisa (Semper)		×					×		
nigra (Semper)						×			
recta (Semper)	×	×		×			×		
reticulata (Semper)			×	×					
Leptosynapta latipatina H. L. C.							×		
oöplax (v. Mar.)			×	×					
Protankyra similis (Semper)							×		
verrilli (Théel)							×		

Tabulated List of Echinoderms of Torres Strait and Surrounding Areas—continued.

Name	Western and northwestern Australia.	Southern side of Timor, & Rotti.	Arafura Sea, Aru and Kei Islands.	Northern coast of New Guinea, New Britain, New Hebrides, Solomon and Loyalty Islands, and New Caledonia.	Fiji & Samoa.	Murray Islands and vicinity.	Thursday Island and vicinity.	Coast of Queensland.	Coast of New South Wales or Victoria.
Holothurioidea—continued.									
Chiridota rigida Semper			×	×		×			
Polycheira rufescens (Br.)		×		×	×				
Trochodota maculata H. L. C.						×			
Cucumaria semperi Bell							×	×	
Thyone buccalis Stimpson							×	×	×
mirabilis Ludwig	×		×					×	
okeni Bell							×		×
papuensis Théel							×		
sacellus (Sel.)	×		×				×		
Phyllophorus proteus Bell							×	×	
schmeltzii (Ludw.)						×		×	
Pseudocucumis aciculus (Semper)					×	×			
africanus (Semper)	×	×		×		×	×		
eurystichus H. L. C.							×		
Actinocucumis difficilis Bell							×		
typicus Ludwig	×						×	×	
Pentacta challengeri (Théel)			×				×		
cucumis (Semper)							×		
doliolum (Pallas)	×		×					×	×
trimorpha H. L. C.						×			
tuberculosa (Q. & G.)	×		×				×	×	×
Labidodemas semperianum Sel		×			×	×			
Holothuria altimensis H. L. C.						×			
arenicola Semper		×		×	×	×			
argus (Jaeger)		×			×	×		×	
atra Jaeger	×	×	×	×	×	×	×	×	
axiologa H. L. C.						×			
cinerascens (Br.)				×	×				
coluber Semper						×	×	×	
cumulus H. L. C.						×			
difficilis Semper				×	×				
edulis Lesson				×	×	×		×	
fuscocinerea Jaeger	×				×	×	×	×	
graeffei Semper		×			×				
hypamma H. L. C.						×		×	
immobilis Semper					×	×			
impatiens (Forskål)	×	×		×	×	×	×		
leucospilota (Br.)	×	×		×	×	×		×	
marmorata (Jaeger)		×			×	×			
modesta Ludw	×					×	×		
monocaria Lesson		×	×	×	×	×	×	×	
pardalis Sel		×		×	×	×	×	×	
pervicax Sel		×			×	×			
remollescens Lampert						×			
rugosa Ludwig				×	×	×			
scabra Jaeger		×			×		×		
subverta H. L. C.						×			
tenuissima Semper		×			×				
vitiensis Semper				×	×				
Stichopus chloronotus Br.		×	×	×	×	×	×	×	
horrens Sel					×	×	×		
variegatus Semper	×	×	×		×	×	×		
Thelenota ananas (Jaeger)				×	×	×		×	
anax H. L. C.						×			
Actinopyga echinites (Jaeger)	×			×	×		×	×	
lecanora (Jaeger)		×		×		×	×	×	
lubrica (Sluiter)							×		
mauritiana (Q. & G.)				×	×	×	×	×	
miliaris (Q. & G.)	×			×	×	×	×	×	
nobilis (Sel.)	×	×		×	×	×			
parvula (Sel.)					×	×			

light on the problems under consideration, and at the same time to avoid including those non-Australian forms which would be of no service. After careful sifting, I find 290 species, one subspecies (in *Salmacis*) and one variety (in *Ophiocoma*) which must be taken into account in analyzing the Torres Strait fauna. Of these, 239 species, the 1 subspecies and the 1 variety make up that fauna, while the remaining 51 occur only on the coast of Queensland (17) or only to the west, north, or east of Torres Strait (33). It may be stated at once that probably many and perhaps all of the 17 Queensland species will be found ultimately in the Torres Strait region, and the same may be true of many of the 33 other species. Their apparent absence is due very probably to our imperfect knowledge.

THE QUESTION OF A SOUTHERN ELEMENT.

On examining this list, one is at once struck with the paucity of southern forms. There are surprisingly few species found in the Torres Strait region which occur south of Queensland, and nearly all of these are obviously tropical forms which have extended their range to Port Jackson. There are 9 species (*Asterina exigua, Amphiodia mesopoma, Ophiactis luteomaculata, Ophiothela hadra, Pectinura arenosa, Laganum laganum, Thyone buccalis, Thyone okeni, Pentacta doliolum*) which admit of a different interpretation but examination of their ranges gives little support to the view that they represent a southern fauna. Not one of the eight genera is characteristically Australian, nor is there one confined to the southern hemisphere. The holothurian *Pentacta doliolum* was originally described from the Cape of Good Hope, but it is recorded from a number of East Indian stations, and apparently occurs all around Australia. It must be granted, however, that its specific characters are not well worked out and the various records are not of uniform reliability. The other holothurians, the two Thyones, are known only from the eastern coast of Australia and might be considered southern species which have extended their range to Torres Strait, but as more than half the known species of *Thyone* occur north of the equator and the nearest relative of these forms is an East Indian species (*sacellus*), that would seem to be an unnatural explanation of their distribution. The occurrence of *Laganum laganum* as far south as Tasmania is remarkable, but it is a common species in the East Indian region and is in no real sense a southern form. The brittle-star *Pectinura arenosa* was originally taken in Bass Strait, but seems to have a distribution corresponding to that of *Laganum laganum*, and the genus is certainly not a southern one. The other three brittle-stars in the list are too little known to use as the basis of any argument, but in view of the fact that both *Ophiactis* and *Amphiodia* are common tropical genera, it is difficult to believe that these species are indicative of a southern element in the Torres Strait fauna or on the Queensland coast. The sea-star *Asterina exigua* has a distribution which quite warrants the belief that it represents a southern fauna, but unfortunately for this view, the genus is essentially a tropical one, and since *exigua* is recorded from Java, the Moluccas, and the Philippines, it is not at all necessary to consider it a southern form. This absence of a southern or even a characteristically Australian element in the Queensland and Torres Strait fauna is somewhat disconcerting, for it brings out the fact that the echinoderms give no support to the theory of Neumayr that in Jurassic times and subsequently there existed a "Gulf of Queensland," which, as Hedley (1909) has expressed it, "offered a refuge to old forms of life." Of course, the absence of evidence in a single group does not count heavily against positive evidence given by other groups, but it is certainly noteworthy that the echinoderm fauna of Queensland does not even suggest the former existence of a "Gulf of Queensland."

THE EASTERN AND WESTERN ELEMENTS.

In contrast to this negative evidence regarding the "Gulf of Queensland," there is positive evidence of a striking sort that the fauna of the eastern coast of Australia is made up from two distinct elements, and much light is thrown upon these and their relative importance by a critical study of the Torres Strait fauna. Examination of the tabulated list given above shows that there is a considerable number of species which are of little or no value for such a study. First of all are the species which are known from only a single locality, often from only one or a few specimens. There are 44 of these, shown in list 1.

LIST 1.—*Species of very restricted range.*

Comanthus callipepla.
Heterometra delicata.
Stephanometra callipecha.
stypacantha.
Oligometra anisa.
Stellaster princeps.*
Habroporina pulchella.
Fromia elegans.
Nardoa rosea.
Ferdina ocellata.
Bunaster uniserialis.
Ophidiaster lioderma.
Tamaria tuberifera.*
Asterina anomala.
nuda.
Valvasterias spinifera.
Amphiura microsoma.
septemspinosa.
Ophionephthys octacantha.
Amphiodia brocki.*
Amphioplus parviclypeus.
Ophiactis delicata.
Ophiactis hemiteles.
Ophiothrix belli.*
dyscrita.
liodisca.
rhabdota.
Ophiomaza cataphracta.*
Ophiophthirius actinometræ.*
Ophiocoma parva.
Ophiomastix corallicola.
janualis.
Leptosynapta latipatina.
Protankyra verrilli.*
Trochodota maculata.
Thyone papuensis.*
Pseudocucumis eurystichus.
Pentacta trimorpha.
Holothuria altimensis.
axiologa.
cumulus.
subverta.
Thelenota anax.
Actinopyga lubrica.*

The nine species indicated by an asterisk were taken by the *Challenger,* the *Alert,* Dr. Semon, or some other collector prior to 1913. The remainder are all known only from Mer, except *Heterometra delicata, Ophionephthys octacantha, Amphioplus parviclypeus,* and *Leptosynapta latipatina,* which we collected only in the Thursday Island region.

Another group which is of little use in the present study is made up of those species which have such a wide distribution that their occurrence is to be expected almost anywhere in the central part of the Indo-Pacific region. A few species have an even wider distribution and are tropicopolitan or even cosmopolitan. This group contains 38 species, which appear in list 2.

In list 2, species occurring at the Murray Islands are indicated by an asterisk, while those which are not known from any part of the Torres Strait region or Australian coast are indicated by a dagger. It will be noted at once that every species on the list comes under one or the other head. In other words, not a single member of this group of widespread species occurs anywhere on the mainland coast of Australia or in the Thursday Island region unless it also occurs at the Murray Islands. The significance of this fact will be referred to subsequently, in connection with the interpretation of all the data.

List 2.—*Species of very wide range.*

Comanthus annulata.*	Toxopneustes pileolus.†	Holothuria atra.*
parvicirra.*	Mespilia globulus.†	cinerascens.†
Lamprometra protecta.†	Echinometra mathæi.*	difficilis.†
Fromia monilis.†	Heterocentrotus trigonarius.†	græffei.†
Linckia multifora.†	Echinoneus cyclostomus.*	impatiens.*
Tamaria pusilla.†	Oligopodia epigonus.†	leucospilota.*
Echinaster luzonicus.*	Metalia spatagus.†	monocaria.*
Mithrodia clavigera.†	Brissopsis luzonica.†	pardalis.*
Amphipholis squamata.*	Lovenia subcarinata.†	tenuissima.†
Ophiactis savignyi.*	Opheodesoma serpentina.†	vitiensis.†
Ophiothrix longipeda.*	Synaptula reticulata.†	Stichopus chloronotus.*
purpurea.†	Leptosynapta oöplax.†	Actinopyga mauritiana.*
Eucidaris metularia.†	Polycheira rufescens.†	

Still a third group, whose value in distributional study is small, is made up of species which are known from more than one place, generally from two or more widely separated areas, but which are of such rarity or of such indefinite and uncertain range that we lack the data for determining even their approximate distribution. A few species are also included here which have an extended range outside the area under discussion, but are only known from a single isolated record within it. Altogether there seem to be 29 species which must be placed here. (See list 3.)

List 3.—*Species of imperfectly known range.*

Heterometra nematodon.	Ophiactis luteomaculata.*	Synaptula nigra.
Colobometra perspinosa.	modesta.	Protankyra similis.
Astropecten granulatus.	Ophiomaza obscura.	Cucumaria semperi.
Archaster angulatus.	Ophionereis dubia.	Pentacta challengeri.
Goniodiscaster coppingeri.	Ophiocoma wendtii.	cucumis.
pleyadella.	Ophiarachnella megaloplax.	Actinocucumis difficilis.
Linckia guildingii.	Prionocidaris verticillata.	Holothuria hypamma.
Retaster insignis.	Clypeaster humilis.	remollescens
Amphiodia mesopoma.*	Echinocyamus crispus.	Actinopyga parvula.
Amphioplus relictus.	Synaptula indivisa.	

This is really a very heterogeneous list. Only 5 occurred at Mer, and of the other 24 I have seen but 3 in life. Several of the species are of doubtful authenticity, and some of the records are based on young or imperfect specimens, the identification of which is open to doubt. All in all, this list is the least useful or significant of any of those into which the tabulated list is subdivided. The two species marked with an asterisk are among the forms mentioned as having a possible southern affiliation.

There remain, then, 181 forms concerning the range of which we have sufficient knowledge to justify us in undertaking to group them according to their distribution. Of these, about one-third appear to occur along the whole northern coast of Australia, or at any rate are known from the eastern coast of northern Queensland as well as from the coast of northern West Australia. There is a possibility that the Gulf of Carpentaria is really "an impassable gulf" and that no species of echinoderm ranges along the entire northern coast of the continent with even approximate continuity; but since there is no good reason for believing this to be the case, I have included in the following list all species known from both the eastern and western coasts of tropical Australia which have not already been given in lists 1 to 3. There are 64 such forms shown in list 4.

List 4.—*Species of Tropical Australian range.*

Capillaster multiradiata.
Comatula pectinata.*
    purpurea.*
    rotalaria.
    solaris.*
Comaster belli.
    multifida.
    novæguineæ.
Comanthus briareus.
Zygometra elegans.
    microdisca.
    punctata.
Heterometra crenulata.
Amphimetra discoidea.
    jaquinoti.
Stephanometra indica.
Lamprometra gyges.*
Oligometra carpenteri.
Oligometrides adeonæ.
Tropiometra afra.*
Astropecten zebra.*
Archaster typicus.
Luidia maculata.
Iconaster longimanus.
Stellaster incei.
Anthenea tuberculosa.
Oreaster gracilis.
    nodosus.*
Hacelia helicosticha.
Nepanthia brevis.
Metrodira subulata.
Ophiothrix galateæ.
    hirsuta.*
    martensi australis.*
    melanogramma.
    melanosticta.
    punctolimbata.
    stelligera.*
    striolata.
Ophiomaza cacaotica.*
Ophiothela danæ.
Pectinura yoldii.
Ophiarachnella infernalis.*
Ophiolepis superba.*
Prionocidaris bispinosa.
Nudechinus darnleyensis.*
Tripneustes gratilla.*
Salmacis sphæroides.
    virgulata alexandri.
Temnotrema bothryoides.
Breynia australasiæ.
Echinocardium cordatum.
Synapta recta.
Thyone mirabilis.
    sacellus.
Pseudocucumis africanus.*
Actinocucumis typicus.
Pentacta doliolum.
    tuberculosa.
Holothuria fuscocinerea.*
Holothuria modesta.*
Stichopus variegatus.*
Actinopyga echinites.
    miliaris.*

The forms occurring in the Murray Islands area are indicated in the above list by asterisks, and it is surprising to find that there are only 20 of these. Moreover, only half a dozen of the 20 are at all common at Mer, and 4 we did not meet with there at all. It is perhaps of some significance that only 5 of the 20 species occur at Fiji or Samoa. Only 8 of the 20 are known from the eastern end of New Guinea or the islands east and north thereof. It seems reasonable, therefore, to suppose that most of these 20 species in question have reached the Murray Islands region from the west through Torres Strait and are comparatively recent arrivals there. This conclusion is less likely to be true, however, for the most widely distributed species, such as *Tripneustes gratilla.*

Somewhat larger than the Australian group of species which is so poorly represented at Mer is what may be called the Barrier Reef group, which forms about half of the Murray Islands fauna and extends southward along the coast of Queensland, often to Port Curtis and occasionally to New South Wales. This group contains 73 species, as shown in list 5.

Examination of this list reveals a very noteworthy fact, namely, that whereas 70 of the 73 species are known to occur in the East Indian region, *not one* is known from the vicinity of Thursday Island and only 7 are found either at the Aru or Kei Islands or in the Arafura Sea. Moreover, 40 of the forms listed have been recorded from the eastern New Guinea-New Caledonia area and 61 from the islands of the tropical Pacific west of latitude 160° E. There is no doubt that imperfect exploration of the New Guinea-New Caledonia area is the reason why fewer of the species are known there than from the islands further east. There are 4 species among the 73 which we did not find at Mer, but it is quite likely they occur there; they are indicated in the list by asterisks. All are wide-ranging East Indian and Pacific species and are not in any particular (except apparent absence from the Murray Island region) separable from the other 69 species.

List 5.—*Species of the Barrier Reef Area.*

Comatella maculata.
stelligera.
Comanthus alternans.
bennetti.*
luteofusca.
samoana.
schlegelii.
Stephanometra monacantha.
Lamprometra brachypecha.
Dorometra nana.
Astropecten polyacanthus.*
Culcita novæguineæ.
Asterope carinifera.
Fromia milleporella.
Nardoa mollis.
novæcaledoniæ.
pauciforis.
Linckia lævigata.
Leiaster speciosus.
Ophidiaster granifer.
squameus.
Asterina burtonii.
exigua.
Acanthaster planci.
Ophiacantha confusa.
Ophiacantha discoidea.
Ophiothrix demessa.
propinqua.
trilineata.
Ophiothrix virgata.
Ophionereis porrecta.
Ophiocoma brevipes
var. variegata.
erinaceus.
pica.
schœnleinii.
scolopendrina.
Ophiomastix annulosa.
asperula.
caryophyllata.
flaccida.
mixta.
Ophiarthrum pictum.
Ophiarachna incrassata.
Ophiarachnella gorgonia.
septemspinosa.
Ophioplocus imbricatus.
Phyllacanthus imperialis.
Centrechinus savignyi.
Echinothrix calamaris.
Echinothrix diadema.
Stomopneustes variolaris.
Echinostrephus molare.
Parasalenia gratiosa.
Heterocentrotus mamillatus.
Metalia sternalis.*
Brissus latecarinatus.
Maretia ovata.*
Polypleetana kefersteinii.
Synapta maculata.
Chiridota rigida.
Phyllophorus schmeltzii.
Pseudocucumis aciculus.
Labidodemas semperianum.
Holothuria arenicola.
argus.
edulis.
immobilis.
marmorata.
pervicax.
rugosa.
Thelenota ananas.
Actinopyga nobilis.

Since this Barrier Reef group is so wholly absent from the Thursday Island region, the question naturally arises whether there is a group of East Indian species occurring in that region and absent (as a rule) from Mer. List 6, of 33 forms, shows that there is such a Thursday Island group, and its composition is of considerable interest.

List 6.—*Species of the Thursday Island Area.*

Comatella nigra.*
Luidia forficifera.
Ogmaster capella.
Euryale aspera.
Amphiocnida dilatata.*
Ophiothrix nereidina.*
Ophionereis semoni.
Pectinura arenosa.
Ophiochasma stellatum.
Ophiura kinbergi.*
Ophiolepis cincta.*
Centrechinus setosus.*
Astropyga radiata.
Lytechinus verruculatus.
Temnopleurus toreumaticus.
Salmacis belli.
dussumieri.
virgulata.
Temnotrema sculpta.*
Arachnoides placenta.
Laganum depressum.
laganum.
Peronella lesueuri.
orbicularis.
Fibularia volva.
Echinodiscus tenuissimus.
Schizaster lacunosus.
Lovenia elongata.
Opheodesoma glabra.
grisea.*
Holothuria coluber.*
scabra.
Actinopyga lecanora.*

This group is not so sharply defined as is the Barrier Reef group, and it includes a number of species which might perhaps with equal justice go in one of the other lists. There are 10 species that occur at Mer (indicated by asterisks), but like the Murray Island species in list 4 they seem to have reached that region from the west, not from the east. It is true that *Ophiolepis cincta* and *Centrechinus setosus* occur in the Pacific, but neither is known from the New Guinea-New Caledonia region, while they do occur in the region northwest from Torres Strait. There are 10 species in list 6 which are not yet actually known from the Thursday Island region (5 of these are among the 10 occurring at Mer), but as all of these 10 occur on each side of the region and do not occur in the Pacific, there is little reason to doubt their occurrence in the strait. Only 5 species in this list occur in the New Guinea-New Caledonia region, and only 7 occur in the Pacific further to the east, and none of these widespread forms occur at Mer, except the *Ophiolepis* and *Centrechinus* already mentioned and *Actinopyga lecanora*. On the other hand, 30 of the 33 forms here listed are East Indian species, and 25 of them extend their range southward along the eastern coast of Australia, often to southern Queensland and in a few cases to Victoria (*Ophiura kinbergi*) and Tasmania (*Laganum laganum*). It seems indisputable, therefore, that this Thursday Island group has had a different history from the larger Barrier Reef group already discussed.

There still remain eleven echinoderms whose distribution is such that it has seemed better not to include them in the foregoing lists. First there are three holothurians (*Thyone buccalis* and *T. okeni*, *Phyllophorus proteus*) and a little brittle-star (*Ophiothela hadra*) which are known from only a few specimens, taken at widely separated stations along the coast of eastern Australia. The holothurians are very possible endemic species of the Queensland coast. The brittle-star is a member of a difficult genus, and its specific identity is in need of elucidation. Perhaps these four species might well have been included in list 3. A second group, composed of three species (*Comatula etheridgei*, *Nardoa tuberculata*, *Echinometra oblonga*) occurs on the coast of northwestern Australia and northward to the Aru Islands or further, but not in the Torres Strait region. The comatulid, however, may be only the young of *C. rotalaria;* the sea-star is a species easily liable to misidentification, and the sea-urchin is of the same sort. Hence the trio may well be ignored until more is definitely known about their occurrence on the northern coast of Australia. Finally, the four remaining species, two brittle-stars (*Ophiarthrum elegans*, *Ophiopezella spinosa*) and two holothurians (*Euapta godeffroyi*, *Stichopus horrens*), are peculiar in that all occur in the tropical Pacific, also at Mer, and in the Thursday Island region, but not any further to the west. Apparently these four species belong to the Barrier Reef fauna, but they have pushed their way into Torres Strait from the east.

The grouping of our 292 echinoderms in the above lists brings out clearly the fact that the littoral fauna of tropical Queensland is composed of two very distinct elements, the larger of which has come in from the east, the smaller from the northwest through Torres Strait. If we turn once more to Hedley's (1910) discussion of the "Gulf of Queensland" and the subsequent opening of Torres Strait, we find it suggested that when "continued subsidence to the east at last burst through the Melanesian plateau, a flood of active competitors must have swept in from the open Pacific. This reached the Queensland coast either by creeping along the land round the Papuan Gulf or by direct, usually larval, transit across the Coral Sea. With the opening of Torres Strait and the consequent outgoing current, the Queensland fauna was spread along North Australia to the Moluccas." Three hypotheses are involved in these sentences, probably suggested, or at any rate supported, by Hedley's splendid studies on Australian Mollusca: (1) That there was an early

Queensland littoral fauna with a characteristic facies; (2) that the influx of Pacific forms from the east reached and came into competition with this early fauna; and (3) that the opening of Torres Strait led to a movement of this Queensland fauna northward and westward to the Moluccas and West Australia.

THE GULF OF QUEENSLAND HYPOTHESIS.

As regards the first of these hypotheses, we have already seen (p. 198) that the echinoderms offer no evidence in support of it. There is a very distinct Australian echinoderm fauna, but it occurs primarily on the southeastern and southern coasts of the continent, and the further north one goes on the Queensland coast the less it is to be found. Apparently none of it reaches the Torres Strait region, nor is there any reason to believe it ever extended any further north than it does to-day. If, therefore, a Jurassic Gulf of Queensland existed, it is evident that it had a very scanty echinoderm fauna, if any. Even the great gulf (now the Coral Sea) postulated by Hedley as existing at the close of the Mesozoic seems to have lacked echinoderms. If this conclusion is erroneous, they were apparently overwhelmed by the influx from the Pacific, when the ridge of which the Solomons are the remains was finally broken through, for that the hypothesis of this influx is supported by the present study of Torres Strait echinoderms admits of little doubt.

THE PACIFIC INFLUX HYPOTHESIS.

Of course the influx of Pacific echinoderms was not a sudden inrush following a catastrophic alteration of the Solomons ridge. On the contrary, it was evidently a slow introduction of species abundant in the East Indies and western Pacific, which gradually extended their range southwestward into the slowly deepening bays and channels which have finally separated the islands of the Solomon and Bismarck Archipelagoes. We have as yet no clue as to just where the first connection between the Pacific and the Coral Sea of to-day was located, but there seems little doubt that it was between the Solomons and the New Hebrides. Along its northwestern coast the ancestors of the present echinoderm fauna of the Queensland coast pushed their way. Among these early immigrants were comatulids of the genera *Comatella* and *Comatula*, sea-stars of the genera *Astropecten* and *Asterina*, brittle-stars of the genera *Ophiactis*, *Ophiothrix*, and *Pectinura*, sea-urchins of the genera *Phyllacanthus*, *Tripneustes*, *Brissus*, and *Maretia*, and holothurians of the genera *Leptosynapta* and *Thyone*. All these genera have reached New South Wales and all are characteristic of the western Pacific. In some cases endemic species have developed on the Australian coast, but in others the forms from even as far south as New South Wales are not yet to be distinguished from those of the Pacific.

The great group of echinoderms given above in list 5 and designated "the Barrier Reef group," are the present representatives of the element in the Queensland fauna originating with the Pacific influx. A detailed study of that group is fully warranted by some of the really important facts which it reveals.

The 10 comatulids represent 5 genera, all of which range from the western Indian Ocean to the western Pacific, with their center in the East Indian region. All except *Comanthus alternans* are known from New Britain, New Caledonia, or the Loyalty Islands, or from the Pacific Islands farther east, while 5 are not known from the region west and northwest of Torres Strait. It is quite possible that *alternans* does not belong in this Barrier Reef group, since it is not yet known from the western Pacific, but I have ventured to put it here because of its absence from Australia, except at Port Molle and Mer, and its occurrence at Mer only in relatively deep water (18 fathoms) outside the reef.

The 14 sea-stars represent 10 genera, all of which are widespread in the Indo-Pacific region. Of these, however, *Astropecten* alone has been taken in the western half of the Torres Strait region. *Culcita* and *Nardoa* are recorded from northwestern Australia, but it seems very probable that they reached that region with the retreating southern coast of the Banda Sea, past Timor, where *Asterope* also occurs. It is particularly noteworthy that half of the 10 genera belong to the Ophidiasteridæ, and all of these are common at the Fiji-Tonga-Samoan group of islands. 9 of these 14 sea-stars are not known from west of the Murray Island region, unless it be north of Timor, or in the western part of the Indian Ocean. The most striking evidence afforded by the sea-stars, however, in support of the Pacific origin of the Barrier Reef group of echinoderms is offered by *Nardoa*, which is a very characteristic New Caledonian genus. At Mer, 4 well-marked species (one endemic) occur, and 2 of these are found at Green Island far down on the coast of Queensland, but the genus is quite unknown in the western half of the Torres Strait region, in the Arafura Sea, or at the Aru Islands. Of course, it is not at all unlikely that one or more species will be found somewhere in this extensive area, but such a discovery would not invalidate at all the claim that *Nardoa* has reached the Barrier Reef region directly from the Pacific and not from the west. The genus *Ophidiaster* clearly has a similar history, for while 3 species (one endemic) are found at Mer, and one of these is found at Green Island, none is known from elsewhere on the Australian coast, from the Arafura Sea, or the Aru Islands. On the other hand, one of the Murray Island Ophidiasters was originally described from Tonga and another from the Hawaiian Islands.

The 23 brittle-stars represent but 9 genera, and 4 of these are tropicopolitan or more or less cosmopolitan. Nevertheless, there is strong evidence that most, if not all, of these 23 species reached the Torres Strait region from the east. The Ophiacanthas are too little known and too liable to misidentification to be of any importance, but the 4 species of *Ophiothrix* are characteristically Pacific forms and while they occur in the East Indies and even as far west as the African coast, they are quite unknown in the Thursday Island region, Arafura Sea, and Aru Islands. They are not yet known from the Queensland coast, and if they prove to be consistently absent there, which is hardly probable, they must be regarded as among the later arrivals from the Pacific. The occurrence of *Ophionereis porrecta*, a brittle-star common at the Hawaiian Islands and elsewhere in the Pacific, on the reef-flat at Mer, contrasts markedly with its absence from the Thursday Island region, the Arafura Sea, and the Aru Islands, where *Ophionereis semoni* is a characteristic form. The distribution of *Ophiarachnella septemspinosa* is similar to that of *Ophionereis porrecta*. But the family Ophiocomidæ supplies the strongest evidence offered by brittle-stars in support of the eastern origin of the Barrier Reef group. While 15 species and one well-marked variety of ophiocomids occur at Mer, and 12 of these are known from farther east (3 are at present apparently endemic), only a single species (*Ophiarthrum elegans*) is known from the Thursday Island area, only one (*Ophiocoma pica*) from the Kei Islands, and only 3 (*Ophiocoma brevipes, scolopendrina,* and *wendtii*) from northwestern Australia. In view of the abundance of these brittle-stars at the Murray Islands, their large size, conspicuous appearance, and active habits, it is incredible that their apparent absence from the Thursday Island region is due to superficial collecting there. Five forms were found at Green Island, and at least one other is known from the Queensland coast, but we are still very much in the dark as to how far southward along the Barrier Reef these fine ophiurans have extended their range. The occurrence of *Ophiarthrum elegans* in the Thursday Island region can easily be accounted for as a local westward extension of range from the Barrier Reef, and its absence from the Arafura Sea and the adjoining regions northward and westward confirms this view. The occurrence of *Ophiocoma pica* at the Kei Islands and along the coast of Timor, considered in the light of its absence from the Aru Islands and Arafura Sea, is unquestionably due to a southern movement from the East Indies. In the case of *O. scolopendrina* and *wendtii,* such a movement has continued across the Sahul Bank to northwestern Australia.

Most of the 11 echini included in the Barrier Reef group occur to the west of Torres Strait, and hence do not offer very satisfactory evidence concerning their origin. Of the others, *Echinostrephus* is so secretive a form that its apparent absence from any area may easily be due only to its having been overlooked. *Stomopneustes* is also secretive, but its large size makes it much less likely to be overlooked, and its entire absence from the region west of the Murray Islands, taken in connection with its occurrence at Samoa and on the Queensland coast, indicates its Pacific origin. The three spatangoids, *Metalia, Brissus,* and *Maretia,* have a distribution like that of *Stomopneustes,* although *Brissus* alone was met with at Mer. Both *Brissus* and *Maretia* extend their range as far as Port Jackson, which would suggest that they were among the first echinoderms to reach the Australian coast after the connection with the Pacific was established.

There are 15 holothurians in the Barrier Reef group, and each (excepting half a dozen species of *Holothuria*) represents a different genus, but 8 species occur west of Torres Strait, and hence their place of origin is not indisputable. The other 7 occur in the East Indies, but 6 of them are common in the Pacific. A typical example of the group is *Polyplectana kefersteinii,* which occurs at Hawaii as well as at many of the more western islands. Apparently none of the holothurians from the Pacific influx has yet reached Port Jackson, and only 5 are listed from the Queensland coast. But *Leptosynapta dolabrifera,* the endemic species of southeastern Australia, is undoubtedly the descendant of a leptosynaptid which was an early arrival from the Pacific.

We find, then, that in what is here called the Barrier Reef group of echinoderms, there are at least 40 species, more than half the group, whose distribution in the Torres Strait region and along the Queensland coast, so far as known, necessitates the belief that they have come directly from the Pacific past what is now the eastern end of New Guinea.

In the light of this very convincing evidence, it is possible to find confirmatory data in some of the other lists given above. In list 1 there are several species which, although endemic, are of interest because of their relationships. Among the comatulids the two species of *Stephanometra* represent a group particularly characteristic of the region extending southeastward from the Philippines to Fiji via New Britain and the Solomons, and their occurrence at Mer at once suggests an eastern origin. Of the sea-stars, *Fromia elegans* and *Nardoa rosea* belong to genera which, as already shown, very probably have come in from the New Caledonian region, while the nearest relative of the Murray Islands *Ferdina* is the species occurring at Fiji. The only brittle-stars in list 1 which have any particular significance are the species of *Ophiomastix;* indeed, only *O. corallicola,* obviously very near the Fijian *O. caryophyllata*, throws any light on original sources. Of the holothurians, *Thelenota anax*, while a very distinct species, is clearly a very near relative of *T. ananas*, and this big "prickly fish" seems to belong to the Pacific influx.

Turning now to list 2, it may be recalled that every species on this list which occurs on the Australian coast or in the Thursday Island region is found at Mer. This is quite what would be expected if the members of this group of widespread species reached Australia from the Pacific via the eastern end of New Guinea, but if any considerable number of them reached the Queensland coast via Torres Strait there would almost certainly be some which did not become established at Mer. Of the 38 species in list 2, 31 are known from Fiji or Samoa, and 3 others probably occur at one or both of those groups, since they are known from other Pacific islands. Of the 4 remaining species, *Oligopodia epigonus* is a very rare echinoid of whose distribution we as yet know very little, *Ophiothrix purpurea* alone seems to be an East Indian species, while the 2 holothurians, *Opheodesoma serpentina* and *Synaptula reticulata*, are very imperfectly known and very probably occur in the Pacific. The indications, therefore, that the echinoderms of list 2 are a Pacific group which has reached Australia from the west are certainly considerable.

Little need be said of list 3 but that some of the species in it seem to have reached Australia with the Pacific influx. Thus *Colobometra perspinosa* is known from the Moluccas, Island of Jobi on the northern side of New Guinea, Queensland, Port Jackson, and Lord Howe Island; the last locality, located as it is on the east side of the Thomson Deep, is almost conclusive proof of the route of this comatulid around eastern New Guinea. The nearly cosmopolitan *Linckia guildingii* is not known from the southern Moluccas or New Guinea, but it occurs at Samoa, Tonga, and Tahiti, and on the coast of Queensland. None of the brittle-stars are sufficiently well known to throw any light on distributional questions, and the 3 echini do not appear to have been associated with any Pacific influx. Of the holothurians, *Actinopyga parvula* is quite unknown from the southern Moluccas and New Guinea, but does occur at Hawaii and Samoa, and I think it has reached Mer from that direction.

The characteristically Australian fauna of list 4 does not afford any evidence in support of a Pacific influx. Apparently it has come in along either side, or, perhaps better, along *both* sides of the Arafura Sea. Among the 20 comatulids, only a single species is known from either Fiji or Samoa, and only 1 or perhaps 2 others occur on the shores of eastern New Guinea or the islands to the east and southeast; but 9 of the species are East Indian, and all of the others find their nearest relatives in that region. The sea-stars tell the same story, only one of the 11 occurring at Fiji or Samoa, 6 being found in the East Indies, and all the others having their nearest relatives there. So, too, of the 13 brittle-stars only 2 occur at Fiji or Samoa, 8 or 9 occur through the East Indies, and the remaining 2 or 3 are certainly very nearly related to East Indian forms. There are only 8 echini to be considered; of these only *Tripneustes* is found at Fiji or Samoa, and only 1 or 2 are as yet known to be East Indian species, but the affinities of the others are so unmistakably East Indian as to admit of no discussion. Of the dozen holothurians, 4 occur at Fiji or Samoa, but these and all the others, except *Actinocucumis typicus*, are East Indian species. Thus, out of 64 characteristically Australian species, only 9 are found at Fiji, but about 36 occur more or less generally in the East Indies and all the remainder have unmistakable East Indian relationships. It is of particular interest and perhaps importance to note that apparently about one-third of this group are more or less peculiar to Australia or to Australia and the Aru Islands, and while their nearest relatives are East Indian, they have become specifically distinct from those forms.

The 34 species of list 6 are as distinctly East Indian as those of list 4, for while 7 are known from either Fiji or Samoa, 30 species are characteristically East Indian and the other 4 find their nearest relatives there. The distribution of some of the species in this list is peculiar, notably that of *Arachnoides placenta*, which occurs in New Zealand as well as along the Malay Peninsula. It is one of the very few echinoderms of the Torres Strait region which occur in New Zealand waters. Its distribution is best explained as follows: Originating in the East Indian region, it extended southward to the Moluccas and southeastward to Fiji and finally to New Zealand; later, with the opening of Torres Strait, it has extended down the eastern coast of tropical Queensland; it may have reached New Zealand via the New Caledonian ridge, but as it is not yet recorded from New Caledonia, it seems more likely that it arrived via Fiji.

THE USE OF TORRES STRAIT AS A MIGRATION ROUTE.

Turning now to Hedley's third hypothesis, that the breaking through of Torres Strait led to a movement westward and northward of a Queensland coastal fauna, we are confronted at once with the difficulty of securing evidence, since there is no characteristic Queensland echinoderm fauna, save what has apparently been derived from the Pacific. Nevertheless, it is conceivable that after the opening of Torres Strait the Pacific influx of echinoderms moved westward as well as southward. If it moved northwestward to the Moluccas and rejoined the Indo-Pacific fauna, the circuit of New Guinea would be complete and all evidence as to the westward movements of the Pacific fauna would be obliterated. If, however, certain species moved along the northern coast of Australia, their absence from Timor and the Aru and Kei Islands might be indicative of their history. Were it not for the Fly River delta, it would be absurd to expect any difference between the echinoderm faunas on the northern and southern shores of western Torres Strait and the Arafura Sea, but the presence of that delta undoubtedly put a stop to any westward movement of the Pacific influx of echinoderms along the southern coast of New Guinea. Hence such a movement might occur, confined to the northern coast of Australia. When, however, we study the distribution table (p. 192), we find there are relatively few species which occur on the northwestern and northern coasts of Australia, west of Torres Strait, which are also found in the Fijian or Samoan regions, and of these not half a dozen are lacking from the northern side of the Arafura Sea. There seems to be, therefore, no adequate evidence that the opening of Torres Strait has resulted in any movement of echinoderms westward or northwestward. The Pacific influx seems to have been turned almost wholly southwestward and southward by some influence, probably the fresh-water drainage of southern New Guinea, which has given rise to the Fly River and its delta. As a result of this, the opening of Torres Strait has made little difference, if any, to the echinoderm fauna west of it. Its influence on the Murray Islands region to the east has been somewhat more evident, as 40 of the 156 species occurring there seem to have reached the islands from the west.

In contrast, then, with the results obtained by Hedley from his study of the molluscan fauna, this study of the echinoderms of the Torres Strait region gives no evidence in support of either the hypothesis that there was an ancient "Gulf of Queensland" with a characteristic marine fauna, or the hypothesis that with the opening of Torres Strait the marine fauna of the Queensland coast passed westward and northward to the southern Moluccas. This absence of evidence in favor of these hypotheses may be accounted for by the interesting hypothesis that there were no echinoderms in the old Gulf of Queensland, but that echinoderms first reached eastern Australia with the Pacific influx. Whether or not the evidence afforded by the fossil echinoderms of Australia gives support to this theory is a matter worthy of investigation. In no better way can the probability of the hypothesis be established, or perhaps its absurdity be shown. But the evidence from fossils may not be discussed here.

The hypothesis of Hedley, that the connection of the Pacific with the Coral Sea by the depression of the Solomon Ridge brought a great influx of species to the Australian coast, is amply demonstrated by the Torres Strait echinoderm fauna, and this hypothesis may perhaps be now regarded as a reasonable conclusion.

THE TRIPLE ORIGIN OF THE COASTAL FAUNA OF TROPICAL AUSTRALIA.

Aside from the light which these studies have thrown on the hypotheses of Hedley, they have made fairly clear the triple origin of the echinoderm fauna of tropical Australia. Of course, in one sense, this fauna is a unit derived from a single source. It is essentially an Indo-Pacific fauna and there is little doubt that

that fauna originated in the East Indies; but in a different sense the tropical Australian fauna is the result of three independent movements, and hence we may fairly refer to its triple origin.

1. The Original Fauna: The evidence at hand indicates that the first Australian echinoderms occurred on the northern coast of the continent, and apparently at a time when there were few, perhaps no, echinoderms on the eastern coast. Without going into the question of the topography of what we now call the East Indies, as they existed during Mesozoic and early Tertiary times, there is little reason to doubt that while New Guinea and Australia were still united as one land-mass, a bay of the Indian Ocean lay to the northwest of what is now Torres Strait, its southern limit being the then northern boundary of Australia. Bathymetrical charts seem to indicate that this bay occupied what is now the Banda Sea, and that with the passage of time its shores have steadily receded southward and eastward, and by a final eastward extension, union with the Coral Sea through Torres Strait was effected. The echinoderms occupying the southeastern shores of this bay or sea formed the first echinoderm fauna of Australia, undoubtedly East Indian in its origin and Indo-Pacific in its composition. It still forms a considerable part of the fauna of northern Australia west of the Gulf of Carpentaria, and is largely the source of the fauna of tropical West Australia. Most of its components passed into the Torres Strait region and many, ultimately, clear through to the Barrier Reef and southward along the Queensland coast, but a few have merely held their ground and remain to show what this early fauna was like. The following may be mentioned as some of the characteristic species of this fauna.

Comatula etheridgei.[1]	Nepanthia brevis.	Heterocentrotus mamillatus.
Nardoa tuberculata.	Ophiothrix melanosticta.	Peronella orbicularis.
Hacelia helicosticha.	Ophiothrix striolata.	Pseudocucumis africanus.
	Ophioplocus imbricatus.	

It is obvious, from the unsatisfactory nature of this list, that few of the species occurring in the original fauna have failed to follow the extending shore-lines as Torres Strait opened. Probably *Ophioplocus* and *Heterocentrotus* have failed to pass through Torres Strait at all, and their occurrence at Mer is due to the Pacific influx. If this is the case, they are admirable representatives of the first Australian fauna. It may perhaps be worthy of note that they are both highly specialized, but very widespread forms.

2. The Pacific Influx: This has been so fully discussed in the preceding pages that little need be said here about it. From it has come a very large part of the fauna, not only of the Murray Islands and Barrier Reef, but of the coast of tropical Queensland as well. It is impossible to say just how many Australian species or their ancestors reached the continent by this route, but careful examination of the "Tabulated List" (p. 192) suggests that more than 125 of the 210 or more Barrier Reef and Queensland echinoderms may have done so, and almost certainly not fewer than 80 did. It does not seem necessary to offer here a list of these,

[1] If this prove to be the young of *C. rotalaria*, it will not seriously affect the propriety of placing it here, for it is highly probable that *C. rotalaria* is one of the original Australian species which have extended their range through Torres Strait.

since it would be in large part a repetition of list 5. Probably many of the ancestral forms of what are now endemic species came in from the Pacific, and hence the influx from that region is at least indirectly responsible for these characteristically Australian species. That so large a number of endemic forms occur in the Torres Strait region and on the coast of eastern Australia might perhaps be construed as further evidence that the Pacific influx entered a virgin territory in which echinoderms were previously unknown and which hence gave particularly good opportunities for speciation.

3. The East Indian Influx: As is indicated by list 6, the opening of Torres Strait led to a migration of East Indian forms through the strait and down the eastern coast of the continent. Comparison of list 6 with the tabulated list as a whole (p. 192) shows that there are many other species (for the most part included in lists 1 to 4) which may have come to the Queensland coast via Torres Strait, but in regard to which the data are still too imperfect to enable us to determine the migration route. On the other hand, as stated above (p. 207), it is not impossible that some of the forms on list 6 did not reach the Torres Strait region from the west, but from the east. Where the present range practically surrounds New Guinea, it is exceedingly difficult, if not impossible, to determine the migration route. The following 10 species may be cited as typical of the East Indian influx, but the distance they have moved along the Queensland coast and their relative abundance there reveal great inequalities:

Luidia forficifera.	Pectinura arenosa.	Salmacis virgulata.
Ogmaster capella.	Ophiochasma stellatum.	Laganum laganum.
Euryale aspera.	Ophiura kinbergi.	Holothuria coluber.
	Temnopleurus toreumaticus.	

SUMMARY.

1. There are 240 species of echinoderms (with 1 subspecies and 1 variety) in the Torres Strait fauna, while 50 other species occur nearby and must be considered in any analysis of that fauna. Many, perhaps all, of these 50 species will probably be found somewhere in the Torres Strait region, and there is little doubt that enough other species will also be found to bring the total for the region to over 300 forms.

2. There is no evidence that any of this large fauna has come from the south.

3. Hence there is no evidence, afforded by echinoderms, in support of the hypothesis of a Mesozoic Gulf of Queensland, having a characteristic marine fauna. If such a gulf existed, it apparently lacked echinoderms.

4. Nearly 20 per cent of the Torres Strait fauna is, so far as our present knowledge goes, endemic.

5. Of the 292 forms considered, 38 are so wide-ranging that their occurrence in the Torres Strait region seems to have little significance, but it is noteworthy that not a single one of these 38 forms occurs anywhere on the coast of Australia or in the Thursday Island region, unless it also occurs at the Murray Islands.

6. There are 28 of the 292 forms regarding which our knowledge is too imperfect to permit their use in discussing questions of distribution.

7. There seems to be a tropical Australian fauna of 64 species, known from both the northeastern and northwestern coasts of the continent. It is quite possible that this fauna comprises two distinct elements and is not a homogeneous group. Until, however, collecting in the Arafura Sea, the Gulf of Carpentaria, and along the Arnhem Peninsula has been undertaken, its composition can not be discussed profitably.

8. The Barrier Reef fauna, as revealed by its occurrence at the Murray Islands, is a very distinct group, comprising one-fourth of all the 292 forms under consideration. It is quite wanting from the Thursday Island region. Nearly all the species occur in the East Indies, while more than 60 are already known from the islands of the Pacific.

9. The Barrier Reef fauna is replaced in the Thursday Island region by a group of some 34 species which seem to have come from the west. A few of them have extended their range to the Barrier Reef.

10. The Barrier Reef fauna seems to furnish strong evidence that Hedley's theory as to the original connection between the Pacific Ocean and the head of the "Gulf of Queensland" (*i. e.*, what is now the Coral Sea) resulting from the sinking of the Solomon Islands ridge, is correct, and that this was followed by an influx of Pacific species to the eastern side of the Australian continent.

11. Detailed analysis of the Barrier Reef fauna shows it to be the direct result of this "Pacific Influx," and a similar analysis of other groups of species confirms the reality and importance of this "Influx" in the formation of the echinoderm fauna of eastern Australia.

12. The study of the echinoderm fauna of tropical Australia west of the Barrier Reef area leads to the conclusion that it originated in the main from the East Indies with the gradual southward and eastward retreat of the shores of what is now the Banda Sea. This retreat finally resulted in the Arafura Sea and the opening of Torres Strait.

13. The opening of Torres Strait led to the eastward and southward extension of this East Indian fauna, some representatives reaching the Murray Islands and Barrier Reef to the east, and others reaching Port Jackson, and even Tasmania or Victoria, on the south.

14. The evidence is entirely lacking at present for deciding whether the Gulf of Carpentaria causes a break in the continuity of the tropical Australian fauna. It is quite possible that the echinoderms of northeastern Australia are the result of migration along the eastern shores of the extending Arafura Sea, while those of northwestern Australia are the forms which long ago occupied the southern coasts of what is now the Banda Sea, and have been drawn southwestward with the retreat of the Australian coast-line.

15. There is no satisfactory evidence of any migration of echinoderms westward through Torres Strait, though it is not impossible that some species from the "Pacific influx" have followed the northern coast of the continent westward. Knowledge of the echinoderm fauna of the Gulf of Carpentaria is essential for determining this point.

CONCLUSIONS.

When the composition of the rich echinoderm fauna of Torres Strait is carefully examined, its origin is indicated with surprising clearness, and the physiographical history of northern Australia is illuminated to a greater degree than might have been expected. During Mesozoic times, the eastern coast of Queensland possessed either no echinoderm fauna or so scanty a one that there are no survivors to-day. The northern coast of the western part of the continent possessed a fauna essentially East Indian in its composition. The depression of land areas in the region east of New Guinea led finally to the connection of what is now the Coral Sea with the Pacific between the Solomon Islands and the New Hebrides, and this connection has become more and more extensive with the passage of time, until the contours of the present day have been reached.[1] At the same time, the coast-line of tropical Australia has retreated westward and the Great Barrier Reef has been formed. With these physiographical changes came an influx of echinoderms from the Pacific, following the northwestern coast-line of the new straits and seas and giving rise finally to the rich echinoderm fauna of the Murray Island region and the Barrier Reef, and to some extent to that of southern Queensland and New South Wales.

The changes taking place to the northwest of the Coral Sea and to the southeast of the Banda Sea finally led to the formation of Torres Strait with the result that the East Indian fauna now had direct access to the northeastern coast of Australia, and many of its echinoderms migrated eastward and southward to mingle on the Queensland coast with the species of the Pacific influx. The striking differences, even at the present day, between the echinoderms of the Thursday Island region and those of the Murray Islands suggest that the East Indian fauna reached the vicinity of Thursday Island, occupying the Arafura Sea and western end of Torres Strait before the connection with the Coral Sea was established and has not as yet been greatly affected by the completion of the Strait. On the other hand, a considerable number of its component echinoderms have reached the Murray Islands and the Barrier Reef, adding much to the richness of the fauna of that region. The echinoderm fauna of the eastern coast of Australia is thus made up from the mingling of the Pacific influx around eastern New Guinea with the East Indian influx via Torres Strait, the former apparently being the more important of the two. Whether the fauna of southern Australia and Tasmania has developed from this mingled stream, or whether a new source is concerned in its formation, are questions of the greatest interest, but quite outside the scope of the present report.

[1] It is not intended to even imply that there has been a consistent and continuous sinking of this area since the Mesozoic. There may have been several periods of elevation alternating with periods of depression. That question simply does not concern us in the present report.

BIBLIOGRAPHY.[1]

AGASSIZ, A. 1863. Synopsis of the Echinoids collected * * * on the North Pacific Exploring Expedition. Proc. Acad. Nat. Sci. Phila., pp. 352–360.

———. 1863a. List of Echinoderms sent * * * in exchange, etc. Bull. M. C. Z., **1**, pp. 17–28.

———. 1872–74. Revision of the Echini.

———. 1877. North American starfishes. Mem. M. C. Z., **5**, No. 1.

———. 1881. *Challenger* Echini.

AGASSIZ, L. 1835. Prodrome d'une Monographie des Radiaires ou Échinodermes. Mem. Soc. Sci. Nat. Neuchâtel, **1**, pp. 168–199.

———. 1841. Monographies d'Échinodermes. 2me Livr., pp. 1–20.

——— and E. DESOR. 1846, 1847. Catalogue Raisonné * * * des Échinodermes. Ann. Sci. Nat. (2), **6**, pp. 305–374; **7**, pp. 129–168; **8**, pp. 1–35, 355–380.

BECHER, S. 1909. Die systematische Stellung des Rhabdomolgus novaezealandiæ. Arch. Zool. Exp. (5), **1**, notes et revues, No. 2, pp. XXXIII–XLIII.

BEDFORD, F. P. 1899. Report on Holothurians collected * * * at Funafuti and Rotuma. Proc. Zool. Soc. London f. 1898, pp. 834–848.

———. 1900. On Echinoderms from Singapore and Malacca. Proc. Zool. Soc. London f. 1900, pp. 271–299.

BELL, F. J. 1882. Descriptions of new or rare species of Asteroidea, etc. Proc. Zool. Soc. London f. 1882, pp. 121–124.

———. 1882a. An attempt to apply a method * * * to * * * Comatulidæ, etc. Proc. Zool. Soc. London f. 1882, pp. 530–536.

———. 1884. *Alert* Echinoderms.

———. 1884a. The species of Oreaster. Proc. Zool. Soc. London f. 1884, pp. 57–87.

———. 1887. Report on a collection of Echinoderms from the Andaman Islands. Proc. Zool. Soc. London f. 1887, pp. 139–145.

———. 1887a. The Echinoderm fauna of the Island of Ceylon. Trans. Roy. Dublin Soc., **3**, pp. 643–658.

———. 1894. On the Echinoderms collected by the *Penguin* and *Egeria*. Proc. Zool. Soc. London f. 1894, pp. 392–412.

———. 1899. Echinoderms other than Holothurians. Willey's Zool. Res., **2**, pp. 133–140.

———. 1902. The Actinogonidiate Echinoderms of the Maldive and Laccadive Islands. Gardner's Fauna and Geog. Mald. and Laccad. Arch., **1**, pt. 3, pp. 223–233.

———. 1903. Report on a collection of Echinoderms from the neighborhood of Zanzibar. Am. Mag. Nat. Hist. (7), **12**, pp. 244–248.

BELL, F. J. 1909. Report on the Echinoderma * * * in the western parts of the Indian Ocean. Trans. Linn. Soc. London (2), Zool., **13**, pt. 1, No. 2, pp. 17–22.

BENHAM, W. B. 1911. Stellerids and Echinids from the Kermadec Islands. Trans. N. Z. Inst., **43**, pp. 140–163.

BLAINVILLE, H. M. D. DE. 1825. Oursin. Dict. Sci. Nat., **37**, pp. 59–98.

———. 1827. Scutelle. Dict. Sci. Nat., **48**, pp. 222–229.

———. 1830. Zoophytes. Dict. Sci. Nat., **60**, pp. 1–546.

———. 1834. Manual d'Actinologie ou Zoophytologie.

BRANDT, J. F. 1835. Prodromus descriptionis animalium ab H. Mertensio observatorium.

BROCK, J. 1888. Die Ophiuriden-fauna des indischen Archipels. Zeit. f. w. Zool., **47**, pp. 465–539.

BRONN, H. G. 1860. Klassen und Ordnungen der Strahlthiere (Actinozoa). Klass. und Ord. d. Thierreiches, **2**.

BROWN, R. N. RUDMOSE. 1910. Echinoidea and Asteroidea from the Mergui Archipelago, etc. Proc. Roy. Phys. Soc. Edinburgh, **18**, pp. 21–35.

See also Simpson and Brown, 1910.

CARPENTER, P. H. 1881. The Comatulæ of the Leyden Museum. Notes Leyden Mus., **3**, pp. 173–217.

———. 1882. Description of new or little known Comatulæ. Jour. Linn. Soc. Zool., **16**, pp. 487–526.

———. 1888. *Challenger* Comatulids.

CHAMISSO, A., and C. G. EYSENHARDT. 1821. De Animalibus * * * duce Ottone de Kotzebue * * * observatis. Nov. Act. Akad. Germ., **10**, pp. 345–374.

CHIAJE, S. DELLA. 1828. Memoire sulla storia e notomia degli animali senza vertebre del regno di Napoli, **3**.

CLARK, A. H. 1907. New genera of Recent free Crinoids. Smiths. Misc. Coll., **50**, pp. 343–364.

———. 1908. Preliminary notice of * * * Recent Crinoids from the Philippine Islands. Smiths. Misc. Co l., **52**, pp. 199–234.

———. 1908a. New genera of unstalked Crinoids. Proc. Biol. Soc. Wash., **21**, pp. 125–136.

———. 1908b. The Crinoid genus Comatula Lamarck, etc. Proc. U. S. Nat. Mus., **33**, pp. 683–688.

———. 1909. On a collection of Crinoids from the Copenhagen Museum. Vid. Med., pp. 115–194.

———. 1909a. The type of the genus Comaster. Proc. Biol. Soc. Wash., **22**, p. 87.

———. 1909b. A revision of the Crinoid families Thalassometridæ and Himerometridæ. Proc. Biol. Soc. Wash., **22**, pp. 1–22.

[1] Publications to which reference has been made in this Report.

Clark, A. H. 1909c. Five new species of Recent unstalked Crinoids. Proc. U. S. Nat. Mus., **37**, pp. 29–34.

———. 1910. On the type-specimen of the Crinoid described by Müller as *Alecto purpurea*. Proc. Biol. Soc. Wash., **23**, pp. 95–98.

———. 1911. Recent Crinoids of Australia. Mem. Australian Mus., **4**, pp. 706–804.

———. 1912. The Crinoids of the Indian Ocean. Echinoderma of the Indian Museum, pt. 7.

———. 1913. Notes on the Recent Crinoids in the British Museum. Smiths. Misc. Coll., **61**, No. 15, pp. 1–89.

———. 1913a. A revision of the Crinoid family Mariametridæ. Proc. Biol. Soc. Wash., **26**, pp. 141–144.

———. 1918. The unstalked Crinoids of the *Siboga* Expedition. *Siboga* Reports, Livr. LXXXIII.

Clark, H. L. 1904. The Echinoderms of the Woods Hole Region. Bull. U. S. Fish Comm. f. 1902, pp. 545–576.

———. 1908. The Apodous Holothurians. Smiths. Contr. Knowl., **35**, No. 1723.

———. 1909. Notes on some Australian and Indo-Pacific Echinoderms. Bull. M. C. Z. **52**, pp. 107–136.

———. 1909a. *Thetis* Echinoderms. Mem. Australian Mus., **4**, pp. 519–564.

———. 1910. The Echinoderms of Peru. Bull. M. C. Z., **52**, pp. 319–358.

———. 1911. North Pacific Ophiurans. Bull. 75 U. S. Nat. Mus., pp. i–xvi, 1–302.

———. 1912. Hawaiian and other Pacific Echini. Pt. 4. Mem. M. C. Z., **34**, pp. 205–383.

———. 1914. The Echinoderms of the West Australian Museum. Rec. W. A. Mus., **1**, pp. 132–173.

———. 1915. The Comatulids of Torres Strait. Carnegie Inst. Wash., Pub. No. 212, pp. 97–125.

———. 1915a. Catalogue of Recent Ophiurans. Mem. M. C. Z., **25**, pp. 163–376.

———. 1915b. Echinoderms of Ceylon. Spolia Zeylanica, **10**, pp. 83–102.

———. 1916. Sea-lilies, starfishes, brittle-stars, and sea-urchins. *Endeavour* Biol. Res., **4**, pp. 1–123.

———. 1917. *Albatross* Ophiuroidea. Bull. M. C. Z., **61**, pp. 427–453.

———. 1917a. Hawaiian and other Pacific Echini. Pt. 6. Mem. M. C. Z., **46**, pp. 81–283.

———. 1918. Brittle-stars, new and old. Bull. M. C. Z., **62**, pp. 265–338.

Crozier, W. J. 1914. The orientation of a Holothurian by light. Amer. Jour. Physiol., **36**, pp. 8–20.

Dendy, A. 1908. Note on the spicules of *Chirodota geminifera* Dendy and Hindle. Jour. Linn. Soc., Zool., **30**, p. 251.

———. 1909. On a small collection of Holothurians from the Auckland Islands. Subantarctic Is. of N. Z., Art. 8, pp. 146–154.

Dendy, A., and E. Hindle. 1907. Some additions to our knowledge of the New Zealand Holothurians. Jour. Linn. Soc., Zool., **30**, pp. 95–125.

Döderlein, L. 1889. Echinodermen von Ceylon. Zool. Jahrb., **3**, pp. 821–846.

———. 1896. Semon's Ophiuroidea and Asteroidea. Jena. Denkschr., **8**, pp. 277–322.

———. 1898. Semon's Crinoidea and epizoic Ophiuroidea. Jena. Denkschr., **8**, pp. 473–488.

———. 1903. Semon's Echinoidea. Jena. Denkschr., **8**, pp. 683–726.

———. 1910. Asteroidea, Ophiuroidea, Echinoidea. Schultze's Zool.-Anthrop. Ergebn. Forschungsr. Südafrika, **4**, pp. 245–258.

———. 1911. Ueber Japanische und andere Euryalæ Abh. Math.-Phys. Kl., K. Bayern. Akad. Wiss. Suppl. Bd. **II**, Abh. 5, pp. 1–123.

———. 1911a. Ueber Echinoidea von den Aru-Inseln. Abh. Senckenb. Naturf. Ges., **34**, pp. 237–248.

———. 1914. Echinoidea. Fauna Südwest-Australiens, **4**, pp. 445–492.

Dujardin, F., et H. Hupé. 1862. Histoire Naturelle des Zoophytes Échinodermes.

Duncan, P. M. 1887. On the Ophiuridæ of the Mergui Archipelago. Jour. Linn. Soc. Zool., **21**, pp. 85–106.

Edwards, C. L. 1908. Variation, development, and growth, * * * in Holothuria atra. Biometrika, **6**, pp. 236–301.

Farquhar, H. 1908. Description of a new Ophiuroid. Trans. N. Z. Inst., **40**, p. 108.

Filhol, H. 1885. Mission à l'île Campbell, **3**, pt. 2. Recherches Zoologiques, etc. Echinodermes, pp. 572, 573.

Fisher, W. K. 1906. The starfishes of the Hawaiian Islands. Bull. U. S. Fish Comm. f. 1903, pt. 3, pp. 987–1130.

———. 1907. The Holothurians of the Hawaiian Islands. Proc. U. S. Nat. Mus., **32**, pp. 637–744.

———. 1911. Asteroidea of the North Pacific. Pt. I. Bull. 76 U. S. Nat. Mus., pp. i–vi, 1–419.

———. 1913. New starfishes from the Philippine Islands, Celebes, and Moluccas. Proc. U. S. Nat. Mus., **46**, pp. 201–224.

———. 1917. New starfishes from the Philippines and Celebes. Proc. Biol. Soc. Wash., **30**, pp. 89–94.

———. 1919. Starfishes of the Philippine seas and adjacent waters. Bull. 100 U. S. Nat. Mus., pp. i–xi, 1–546.

Forbes, E. 1839. On the Asteriadæ of the Irish Sea. Mem. Wernerian Soc., **8**, pt. 1, pp. 114–129.

———. 1841. A history of British Starfishes, etc.

———. 1852. Appendix to Sutherland's Voyage in Baffin's Bay, etc., **2**.

Forskål, P. 1775. Descriptiones Animalium quae in itinere orientali osservavit.

Gasco, F. 1876. Descrizione di alcuni Echinodermi, etc. Rend. Reale Acad. Sci. Fis. e Mat. Napoli, **15**, fasc. 2.

GMELIN, J. F. 1788. Linnaei Syst. Nat. Editio 13.
GOLDFUSS, G. A. 1820. Handbuch der Zoologie.
GOTO, S. 1914. A descriptive monograph of Japanese Asteroidea. Pt. 1. Jour. Coll. Sci. Tokyo, **29**, pp. 1-808.
GRAY, J. E. 1825. An attempt to divide the Echinida or Sea-eggs into natural families. Ann. Phil., **26**, pp. 423-431.
———. 1840. A synopsis of the genera and species of the class Hypostoma. Ann. Mag. Nat. Hist., **6**, 175-184, 275-290.
———. 1845. Description of two new invertebrate animals from Australia. Eyre's Jour. * * * of Discovery, etc., **1**, pp. 435-436.
———. 1847. Descriptions of some new genera and species of Asteriadæ. Proc. Zool. Soc. London f. 1847, pp. 72-83. Also in Ann. Mag. Nat. Hist.
———. 1851. Description of some new genera and species of Spatangidæ in the British Museum. Ann. Mag. Nat. Hist. (2), **7**, pp. 130-144.
———. 1855. Catalogue of the Recent Echinida in the British Museum.
———. 1866. Synopsis of the species of Starfishes.
GREEF, R. 1872. Ueber einige auf den canarischen Inseln (Lanzarote) aufgefundene Seesterne. Sitz.-ber. Ges. Bef. Naturw. Marburg, pp. 102-106.
———. 1882. Echinodermen beobachtet auf eine Reise nach der Guinea-Insel São Thomé. Zool. Anz., **5** pp. 114-120; 135-139; 156-159. (Reprints paged 1-15.)
GRUBE, A. E. 1857. Beschreibungen neues oder weniger bekanntes Seesterne und Seeigel. Nova Acta Akad. Germ., **27**, pp. 1-50.
———. 1857*a*. Diagnosen einiger neuen Echinodermen. Arch. f. Naturg. **23**, pt. 1, pp. 340-344.
———. 1864. Die Insel Lussin und ihre Meeresfauna.
———. 1868. Ueber einige seltenere oder neue Ophiuriden. Jahresb. Schles. Ges. Vaterl. Cultur, **45**, pp. 44, 45.
HARTLAUB, C. 1890. Beitrag zur Kenntnis der Comatuliden-fauna des Indischen Archipels. Nach. Ges. Göttingen, No. 5, pp. 168-187.
———. 1891. *Same title.* Nova Acta Akad. Germ., **58**, pp. 1-120.
HARVEY, E. N. 1915. Report of researches conducted at Murray Island, Torres Strait, etc. Carnegie Inst. Wash., Year Book No. 13, pp. 204-207.
HEDLEY, C. 1909. Rep. 12th Meet. Austral. Assoc. Adv. Sci., pp. 329-371.
HERDMAN, W. A., and J. B. 1904. Report on the Echinoderma. Rep. Ceylon Pearl Oys. Fish., pt. 2, pp. 137-150.
HERKLOTS, J. A. 1869. Échinodermes, peintes d'après Nature, etc.
IVES, J. E. 1891. Echinoderms and Arthropods from Japan. Proc. Acad. Nat. Sci. Phila., pp. 210-223.
JACKSON, R. T. 1912. Phylogeny of the Echini. Mem. Boston Soc. Nat. Hist., **7**, pp. 1-491.
JAEGER, G. F. 1833. De Holothuriis.
JOSHUA, E. C. 1912. On a new Holothurian of the genus *Taeniogyrus* found in Port Philip Bay. Proc. Roy. Soc. Victoria, n. s., **25**, pp. 79-81.
———. 1914. Victorian Holothurioidea. Proc. Roy. Soc. Victoria, n. s., **27**, pp. 1-11.
KENT, W. SAVILLE. 1893. The Great Barrier Reef of Australia.
KOEHLER, R. 1895. Catalogue raisonné des Échinoderms recueillis par Korotnev aux îles de la Sonde. Mem. Soc. Zool. France, **8**, pp. 374-423.
———. 1898. *Investigator* Ophiurans: Littoral. Bull. Sci., **31**, pp. 54-124.
———. 1904. Ophiures nouvelles ou peu connues. Mem. Soc. Zool. France, **17**, pp. 54-119.
———. 1905. *Siboga* Ophiurans: Littoral. *Siboga* Reports Livr. XXI.
———. 1907. Revision de la Collection des Ophiures du Museum d'Histoire Naturelle, Paris. Bull. Sci., **41**, pp. 279-351.
———. 1907*a*. Ophiuroidea. Fauna Südwest-Australiens, **1**, pp. 241-254.
———. 1909. *Investigator* Deep Sea Asteroidea.
———. 1910. Astéries et Ophiures des îles Aru et Kei. Abh. Senckenb. Naturf. Ges., **33**, pp. 265-295.
———. 1910*a*. *Investigator* Shallow Water Asteroidea.
KOEHLER, R. and C. VANEY. 1908. *Investigator* Littoral Holothurioidea.
LAMARCK, J. B. P. 1816. Histoire Naturelle des Animaux sans Vertèbres.
LAMPERT, K. 1885. Die Seewalzen.
LEACH, W. E. 1815. Zoological Miscellany, vol. 2.
LESKE, N. G. 1778. Additamenta ad Klein.
LESSON, R. P. 1830. Centurie Zoologique, etc.
LINCK, J. H. 1733. De stellis marinis.
LINNE, C. 1758. Systema Naturæ. Ed. X.
LJUNGMAN, A. V. 1866. Om några nya Arter af Ophiurider. Öf. K. Vet. Akad. Förh., **23**, pp. 163-166.
LORIOL, P. DE. 1884. L'Ile Maurice Èchinides. Mem. Soc. Phys. Hist. Nat. Genève, **28**, No. 8, pp. 1-64.
———. 1885. L'Ile Maurice Stellerides. Mem. Soc. Phys. Hist. Nat. Genève, **29**, No. **4**, pp. 1-84.
———. 1891. Notes pour servir a l'étude des Échinodermes. Mem. Soc. Phys. Hist. Nat. Genève, Suppl. vol., No. 8 pp. 1-31.
———. 1894. L'Ile Maurice Ophiurides et Astrophytides. Mem. Soc. Phys. Hist. Nat. Genève, **32**, pt. 1, No. 3, pp. 1-64.
———. 1899. Notes pour servir a l'étude des Échinodermes, VII. Mem. Soc. Phys. Hist. Nat. Genève, **33**, pt. 2, No. 1, pp. 1-34.
———. 1900. Notes pour servir a l'étude des Échinodermes, VIII. Rev. Suisse Zool., **8**, pp. 55-96.
LOVEN, S. 1887. On the species of Echinoidea described by Linnæus. Bih. K. Svenska Vet. Akad. Handl., **13**, Afd. 4, No. 5, pp. 1-185.

LUDWIG, H. 1874. Beiträge zur Kenntnis der Holothurien. Arb. Zool.-Zoot. Inst. Würzburg, **2**, pp. 77–118.

———. 1881. Revision der Mertens-Brandtschen Holothurien. Zeit. f. w. Zool., **35**, pp. 575–599.

———. 1887. Drei Mittheilungen über alte und neue Holothurienarten. Sitz. K. Preus. Akad. Wiss. Berlin, **54**, pp. 1217–1244.

———. 1888. Die von J. Brock im Indischen Archipel gesammelten Holothurien. Zool. Jahrb., **3**, pp. 805–822.

———. 1892. Die Seewalzen. Bronn's Thierreichs, **2**, Abt. 3, buch 1.

———. 1897. Die Seesterne des Mittelmeeres. Fauna Stat. Neap., **24**, pp. i–x, 1–496.

———. 1899. Echinodermen des Sansibargebietes. Abh. Senckenb. Nat. Ges., **21**, pp. 537–563.

LÜTKEN, C. 1856. Bidrag til Kundskab om Slangestjernerne. Vid. Med., pp. 1–26.

———. 1859. Bidrag til Kundskab om de ved Kysterne af Mellem- og Syd-America levende arter af Söstjerner. Vid. Med., pp. 25–96.

———. 1864. Kritiske Bemaerkninger om forskjellige Söstjerner (Asterider), etc. Vid. Med., pp. 123–169.

———. 1869. Add. ad Hist. Oph., pt. 3. K. Dansk. Vid. Selsk. Skrifter. R. 5, naturvid og math. afd., **8**, pp. 19–100.

———. 1871. Fortsatte kritiske og beskrivende Bidrag til Kundskab om Söstjernerne (Asteriderne). Vid. Med., pp. 227–304.

———. 1872. Ophiuridarum novarum vel minus cognitarum Descriptiones Nonnullae. Ov. Kongl. Danske Vid. Selsk. Forh., pp. 75–158.

LÜTKEN, C., and TH. MORTENSEN. 1899. *Albatross* Panamic Ophiuridæ. Mem. M. C. Z., **32**, pp. 93–208.

LYMAN, TH. 1860. Descriptions of new Ophiuridæ, etc. Proc. Boston Soc. Nat. Hist., **7**, pp. 193–204; 252–262.

———. 1861. *Same title and journal*, **8**, pp. 75–86.

———. 1865. Ophiuridæ and Astrophytidæ. Illus. Cat. M. C. Z., No. 1, pp. 1–200.

———. 1871. Suppl. to Ophiuridæ and Astrophytidæ. Illus. Cat. M. C. Z., No. 6, pp. 1–17.

———. 1874. Ophiuridæ and Astrophytidæ, old and new. Bull. M. C. Z., **3**, pp. 211–272.

———. 1875. Ophiuridæ and Astrophytidæ. Illus. Cat. M. C. Z., No. 8, pt. 2, pp. 1–34.

———. 1879. *Challenger* Ophiuridæ and Astrophytidæ. Bull. M. C. Z., **6**, pp. 17–83.

———. 1882. *Challenger* Ophiurans.

MCCLENDON, J. F. 1909. The Ophiurans of the San Diego Region. Univ. of Calif. Publ., Zool., **6**, pp. 33–64.

MARENZELLER, E. VON. 1881. Neue Holothurien von Japan und China. Verh. Zool.-Bot. Ges. Wien, pp. 121–140.

MARKTANNER-TURNERETSCHER, G. 1887. Beeshreibungen neuer Ophiuriden, etc. Ann. k. k. Naturh. Hofmuseums, **2**, pp. 291–316.

MARTENS, E. VON. 1865. Ueber ostasiatische Echinodermen. Arch. f. Naturg. **31**, (1), pp. 345–360.

———. 1866. *Same title and journal*, **32**, (1), pp. 57–88; 133–189.

———. 1867. *Same title and journal*, **33**, (1), pp. 106–119.

———. 1869. Seesterne und Seeigel: Dencken's Reisen., **3**, pp.123–134.

———. 1870. Die Ophiuriden des Indischen Oceans. Arch. f. Naturg., **36**, (1), pp. 244–262.

MATSUMOTO, H. 1917. A monograph of Japanese Ophiuroidea. Jour. Coll. Sci. Tokyo, **38**, art. 2, pp. 1–408.

MICHELIN, H. 1844. Description de quatre Echinides et Stellerides nouvelles. Rev. Zool., **1**, p. 173.

———. 1845. Zoophytes, Echinodermes et Stellerides (de l'île Maurice). Mag. Zool. **7**, pp. 173–199 (or 1–27).

———. 1863. Echinides et Stellerides. Maillard's "Reunion," Ann. A, pp. 1–7.

MITSUKURI, K. 1912. Studies on Actinopodous Holothurioidea. Jour. Coll. Sci. Tokyo, **29**, Art. 2, pp. 1–284.

MÖBIUS, K. 1859. Neue Seesterne des Hamburger und Kieler Museums.

MONKS, S. P. 1904. Variability and autotomy of Phataria. Proc. Acad. Nat. Sci. Phila., **56**, pp. 596–600.

MORTENSEN, TH. 1904. Echinoidea. D. Kgl. Dan. Vid. Seksk. Skr., **7**, Naturv. og Math. Afd. I, **1**, pp. 1–124.

MÜLLER, J. 1841. Ueber die Gattungen und Arten der Comatulen. Arch. f. Naturg. **7**, pp. 139–148.

———. 1843. Neue Beiträge zur Kenntnis der Arten der Comatulen. Arch. f. Naturg. **9**, pp. 131–136.

MULLER, J., and F. TROSCHEL. 1840. Monatsb. Akad. Wiss. Berlin, April, p. 104.

———. 1842. System der Asteriden.

NARDO, J. D. 1834. De Asteriis. Oken's Isis, **7**, pp. 716, 717.

OHSHIMA, H. 1912. On the System of Phyllophorinæ, etc. Ann. Zool. Jap., **8**, pp. 53–96.

———. 1913. Synaptiden von Misaki. Zool. Mag., **25**, pp. 253–266 (in Japanese).

———. 1914. The Synaptidæ of Japan. Ann. Zool. Jap., **8**, pp. 467–482.

———. 1915. Report on the Holothurians collected by the * * * *Albatross*, etc. Proc. U. S. Nat. Mus., **48**, pp. 213–291.

ORBIGNY, A. D'. 1839. Echinodermes: Webb and Berthelot's Voy. aux Îles Canaries, pp. 148–149.

ÖSTERGREN, H. 1898. Das System der Synaptiden. Ofv. Ak. Forh., **55**, pp. 111–120.

PALLAS, P. S. 1774. Spicilegia Zoologica, fasc. 10.

PARKER, T. J. 1881. On a new Holothurian, etc. Trans. N. Z. Inst., **13**, p. 418.

PEARSON, J. 1903. Report on the Holothurioidea. Rep. Ceylon Pearl Oys. Fish., Suppl. Rep., No. V, pp. 182–208.

———. 1914. Notes on the Holothurioidea of the Indian Ocean. Spolia Zeylanica, **9**, pp. 173–190.

PERRIER, E. 1869. Recherches sur les Pédicellaires et les Ambulacres des Astéries et des Oursins. Ann. Sci. Nat. (5), **12**, pp. 197–304.

———. 1875. Revision de la Collection de Stellérides du Museum d'histoire naturelle de Paris. Arch. Zool. Exp., **4**, p. 265–450.

———. 1876. *Same title and journal*, **5**, pp. 1–104; 209–304.

(These papers on the sea-stars of the Paris Museum were subsequently issued as a booklet with new pagination and with the date 1875.)

———. 1881. Description sommaire des espèces nouvelles d'Asteries. Bull. M. C. Z., **9**, pp. 1–31.

———. 1884. Mémoire sur les Étoiles de Mer * * * des Antilles, etc. Nouv. Arch. Mus. Hist. Nat. Paris (2), **6**, pp. 127–276.

———. 1894. *Travailleur* et *Talisman* Stellérides.

PETERS, W. 1851. Uebersicht der * * * von Mossambique eingesammelten Ophiuren, etc. Monatsb. K. Akad. Wiss. Berlin, pp. 463–466.

———. 1852. Uebersicht der Seesterne von Mossambique. Monatsb. K. Akad. Wiss. Berlin, pp. 177, 178.

———. 1853. Ueber die an der Küste von Mossambique beobachteten Seeigel, etc. Monatsb. K. Akad. Wiss. Berlin, p. 484.

PFEFFER, G. 1896. Ostafrikanische Echiniden, Asteriden und Ophiuriden, etc. Mitt. Mus. Hamburg, **13**, pp. 43–48.

———. 1900. Echinodermen von Ternate: Kukenthal's Forschungsreise. Abh. Senckenb. Ges., **25**, pp. 81–86.

QUOY, J. R. C., and P. GAIMARD. 1833. Voyage de l'*Astrolabe*. Zoologie, **4**.

RAMSAY, E. P. 1885. Catalogue of the Echinodermata of the Australian Museum. Pt. 1. Echini, pp. 1–54.

REICHENSPERGER, A. 1914. Ungestielte Crinoideen der Aru- und Kei-Inseln. Abh. Senckenb. Ges., **35**, pp. 79–108.

RUSSO, A. 1894. Echinodermi raccolti nel Mar Rosso, etc. Boll. Soc. Napoli, **7**, pp. 159–163.

SARS, G. O. 1872. Nye Echinodermer fra den Norske Kyst. Forh. Vid. Selsk. Christiana f. 1871, pp. 1–31.

SAVIGNY, J. C. DE. 1809. Iconographie des Echinodermes, Polypes et Zoophytes de l'Egypte.

SAY, T. 1825. On the species of the Linnean genus *Asterias* inhabiting the coast of the United States. Jour. Acad. Nat. Sci. Phila., **5**, pp. 141–154.

SELENKA, E. 1867. Beiträge zur Anatomie und Systematik der Holothurien. Zeit. f. w. Zool., **17**, pp. 291–374.

SEMON, R. 1887. Beiträge zur Naturgeschichte der Synaptiden des Mittelmeeres. Mitt. Zool. Stat. Neapel, **7**, pp. 272–300.

SEMPER, C. 1868. Reisen im Archipel der Philippinen. Pt. 2. Wiss. Res. **1**, Holothurien.

SIMPSON, J. C., and R. N. R. BROWN. 1910. Asteroidea of Portuguese East Africa collected by Jas. C. Simpson, M.A., B.Sc. (1907–08). Proc. Roy. Soc. Edinburgh, **18**, pp. 45–60.

SLADEN, W. P. 1878. On the Asteroidea and Echinoidea of the Korean Seas. Jour. Linn. Soc. Zool., **14**, pp. 424–445.

———. 1882. *Challenger* Pterasteridæ. Jour. Linn. Soc. Zool., **16**, pp. 189–246.

———. 1883. *Challenger* Astropectinidæ. Jour. Linn. Soc. Zool., **17**, pp. 214–269.

———. 1889. *Challenger* Asteroidea.

SLUITER, C. PH. 1889. Die Evertebraten aus der Sammlung des K. Nat. Ver. in Nied.-Ind. in Batavia. Nat. Tijd. v. Nederl. Ind. (8), **9**, pp. 285–313.

———. 1894. Semon's Holothurioidea. Jena. Denkschr. **5**, pp. 101–106.

———. 1895. Die Asteriden-Sammlung des Museums zu Amsterdam. Bijdr. Dierk., **17**, pp. 49–64.

———. 1895*a*. Die Echiniden-Sammlung des Museums zu Amsterdam. Bijdr. Dierk., **17**, pp. 65–74.

———. 1901. *Siboga* Holothurians. *Siboga* Rep. Livr. XLIV.

SMITH, E. A. 1876. Descriptions of two new species of *Ophiocoma*. Ann. Mag. Nat. Hist. (4), **18**, pp. 39, 40.

———. 1877. Description of a new form of Ophiuridæ from New Zealand. Ann. Mag. Nat. Hist. (4), **19**, pp. 305–308.

———. 1878. Description of *Acantharachna mirabilis*, a new form of Ophiuridæ. Jour. Linn. Soc. Zool., **13**, pp. 335–337.

STIMPSON, W. 1856. Descriptions of some new marine invertebrata. Proc. Acad. Nat. Sci. Phila., **7**, pp. 386, 387.

STUDER, TH. 1883. Uebersicht ueber die Ophiuriden * * * *Gazelle*, etc. Abh. K. Akad. Wiss. Berlin f. 1882, pp. 1–37.

———. 1884. *Gazelle* Asteriden und Euryaliden. Abh. K. Akad. Wiss. Berlin, pp. 1–64.

SÜSSBACH, S., and A. BRECKNER. 1910. Die Seeigel, Seesterne und Schlangensterne der Nord- und Ost-See. Wiss. Meer. Komm. deutsch.-Meer. N.P., **12**, pp. 169–300.

TENISON-WOODS, J. E. 1878. The Echini of Australia. Proc. Linn. Soc. N. S. W., **2**, pp. 145–176.

———. 1880. On some new Australian Echini. Proc. Linn. Soc. N. S. W., **4**, pp. 282–291.

THÉEL, H. 1886. *Challenger* Holothurians. Pt. 2.

THOMPSON, W. 1840. Contributions towards a knowledge of the Mollusca * * * of Ireland, with descriptions of * * * invertebrates. Ann. Mag. Nat. Hist., **5**, pp. 84–102.

THOMSON, C. WYVILLE. 1876. Notice of some peculiarities in the mode of propagation of certain Echinoderms, etc. Jour. Linn. Soc. Zool., **13**, pp. 55–79.

———. 1877. Voyage of the *Challenger:* The Atlantic. 2 vols.

VANEY, C. 1912. Holothurien der Aru-Inseln. Abh. Senckenb. Ges., **34**, pp. 289–291.

Verrill, A. E. 1867. Notes on the Radiata in the Museum of Yale College, etc. Trans. Conn. Acad., **1**, pp. 247–351.

———. 1869. On new and imperfectly known Echinoderms and Corals. Proc. Boston Soc. Nat. Hist., **12**, pp. 381–396.

———. 1871. Additional observations on Echinoderms chiefly from the Pacific Coast of America. Trans. Conn. Acad., **1**, pp. 568–593.

———. 1882. Notice of the remarkable marine fauna, etc. Amer. Jour. Sci. (3) **23**, pp. 216–222.

———. 1899. North American Ophiuroidea. Trans. Conn. Acad., **10**, pt. 2, pp. 301–386.

Verrill, A. E. 1914. Monograph of the shallow water Star-fishes of the North Pacific Coast, etc. Harriman Alaska Series, **14**.

———. 1915. Report on the Starfishes of the West Indies, Florida and Brazil. Univ. of Iowa Bull., Lab. Nat. Hist., **7**, pp. 1–232.

Westergren, A. M. 1911. Echinoneus and Micropetalon. Mem. M. C. Z., **39**, pp. 35–68.

Whitelegge, T. 1889. List of the marine and freshwater invertebrate fauna of Port Jackson and the neighborhood. Jour. Proc. Roy. Soc. N. S. W., **23**, pp. 163–323.

EXPLANATION OF PLATES.

PLATE 1.

FIG. 1. *Comanthus callipepla;* holotype; Mer; entire animal seen from oral side.
2. *Comanthus annulata;* bit of one arm near middle, seen from oral side.
3. *Comatula pectinata;* tip of an arm.
4. *Lamprometra gyges;* oral surface of one arm.
5. *Comanthus parvicirra;* oral surface of one arm.
6. *Comanthus annulata* var. *xantha;* aboral surface of one arm with the bases of two others.
7. *Comanthus parvicirra;* aboral surface of one arm.
8. *Comanthus annulata;* oral surface of one arm.
9. *Stephanometra callipecha;* oral surface of one arm.
10. *Oligometra anisa;* oral surface of one arm.

All figures natural size.

PLATE 2.

FIG. 1. *Lamprometra brachypecha;* paratype; Mer; oral surface.
2. *Comatella stelligera,* green form; Mer; the eight lower arms of figure are not completed, thus avoiding confusion with upper arms of fig. 1; they are complete and normal in original specimen.

Both figures natural size.

PLATE 3.

FIG. 1. *Comatella maculata;* Mer; oral surface.
2. *Comatula pectinata* juv.; Mer; red form; oral surface.
3. *Comanthus annulata* juv.; Mer; an unusual blue form; oral surface.

All figures natural size.

PLATE 4.

FIG. 1. *Oligometra anisa;* paratype; Mer; adult, purplish form; oral surface.
2. *Habroporina pulchella;* paratype; Mer; smaller specimen, aboral surface.
3. *Oligometra anisa* juv.; paratype; brown form; oral surface.

All figures natural size.

PLATE 5.

FIG. 1. *Culcita novæguineæ* juv.; Erub; aboral surface.
2. *Asterope carinifera* adult; Mer; aboral surface.

Both figures natural size.

PLATE 6.

FIG. 1. *Anthenea tuberculosa* juv.; Thursday Island; aboral surface.
2. *Asterina burtonii* juv.; Mer; aboral surface.
3. *Nepanthia brevis;* Thursday Island; oral surface of one radius.
4. *Nepanthia brevis;* Thursday Island; aboral surface.
5. *Ferdina ocellata;* holotype; Mer; aboral surface; all arms represented as normal.
6. *Valvaster spiniferus;* holotype; Mer; aboral surface.

All figures natural size.

PLATE 7.

FIG. 1. *Ophidiaster granifer;* Erub; aboral surface.
2. *Bunaster uniserialis;* holotype; Mer; aboral surface.
3. *Fromia elegans;* holotype; Mer; aboral surface.
4. *Fromia milleporella;* Mer; oral surface of one radius.
5. *Fromia milleporella;* Mer; aboral surface.
6. *Asterina exigua;* large pentamerous specimen; Erub; aboral surface.
7. *Asterina exigua;* small, hexamerous specimen; Erub; aboral surface.
8. *Asterina anomala;* 8-armed holotype, somewhat idealized by omission of one arm and equalization of others; Mer; aboral surface.

All figures natural size, except fig. 2 which is × 2, and fig. 8 which is × 1.5.

PLATE 8.

FIG. 1. *Tamaria tuberifera;* Badu; aboral surface.
2. *Ophidiaster squameus;* Mer; aboral surface.

Both figures natural size.

PLATE 9.

FIG. 1. *Linckia lævigata* juv.; Mer; aboral surface.
2. *Linckia lævigata,* adult; Mer; aboral surface.

Both figures natural size.

PLATE 10.

FIG. 1. *Nardoa rosea;* holotype, somewhat idealized by equalization of arms; Mer; aboral surface.
2. *Echinaster luzonicus;* Thursday Island; aboral surface.
3. *Echinaster luzonicus;* arm of a very dark-colored specimen, aboral surface.
4. *Echinaster luzonicus;* uncolored sketch of very unusual, aberrant ray, having budding ray on each side; oral surface.

All figures natural size.

PLATE 11.

Leiaster speciosus; aboral surface. Nat. size.

PLATE 12.

FIG. 1. *Ophiarthrum pictum;* Mer; disk and base of one arm; aboral surface.
2. *Ophiopezella spinosa* juv.; Mer; aboral surface.
3. *Ophiura kinbergi* juv.; Mer; aboral surface.
4. *Ophiacantha discoidea;* Mer; aboral surface.
5. *Ophiarachnella gorgonia;* Mer; aboral surface.
6. *Ophionereis porrecta;* Mer; disk and one arm; aboral surface.
7. *Ophiarachnella septemspinosa;* Mer; disk and one arm; aboral surface.
8. *Ophioplocus imbricatus;* Mer; disk and one arm; aboral surface.

All figures natural size.

PLATE 13.

FIG. 1. *Ophiarthrum elegans;* Mer; disk and one arm; aboral surface.
2. *Ophiomastix flaccida* juv.; Mer; aboral surface.
3. *Amphiura septemspinosa;* holotype; Mer; aboral surface.
4. *Ophiocoma parva;* paratype; Mer; aboral surface.
5. *Ophiothela hadra;* holotype; Mer; aboral surface.
6. *Ophiactis luteomaculata;* holotype; Mer; aboral surface.
7. *Ophiocoma brevipes;* Mer; disk and one arm; aboral surface.
8. *Ophiocoma pica;* Mer; disk and one arm; aboral surface.
9. *Ophiocoma scolopendrina* juv.; Mer; aboral surface.

All figures natural size.

PLATE 14.

FIG. 1. *Ophiomastix asperula.*
2. *Ophiomastix mixta.*
3. *Ophiomastix corallicola;* paratype.
4. *Ophiomastix caryophyllata.*
5. *Ophiomastix janualis.*
6. *Ophiomastix annulosa.*

Each figure represents aboral surface of disk and one arm of an adult specimen from Mer. Nat. size.

PLATE 15.

FIG. 1. *Ophiothrix striolata* juv.; Friday Island; aboral surface.
2. *Ophiothrix nereidina;* Mer; disk and one arm; aboral surface.
3. *Ophionephthys octacantha;* holotype; Friday Island; all arms are broken; aboral surface.
4. *Ophiothrix martensi australis;* paratype; Madge Reef, Thursday Island; disk and one arm; aboral surface.
5. *Ophiothrix longipeda,* yellow form; Mer; disk and one arm; aboral surface.
6. *Ophiothrix rhabdota;* paratype; Mer; disk and one arm; aboral surface.
7. *Ophiothrix rhabdota;* paratype; Mer; bit of arm, much enlarged to show the three longitudinal yellow stripes; aboral surface.
8. *Ophiothrix nereidina* juv.; Mer; aboral surface.
9. *Ophiothrix nereidina* juv.; Mer; disk and base of one arm enlarged to show beautiful mosaic pattern; aboral surface.

All figures natural size except 7 and 9 which are enlarged about eight times.

PLATE 16.

FIG. 1. *Ophiactis hemiteles;* holotype; Mer; aboral surface.
2. *Ophiomaza obscura;* Mer; aboral surface.
3. *Ophiomaza cacaotica* var. *picta;* Mer; aboral surface.
4. *Ophiothrix trilineata;* Mer; aberrant coloration; aboral surface.
5. *Ophiothrix trilineata;* Mer; typical coloration; aboral surface.
6. *Ophiothrix trilineata;* Mer; bit of arm enlarged to show trilineate coloration; aboral surface.
7. *Amphiocnida dilatata;* Mer; aboral surface.
8. *Ophiothrix stelligera* juv.; Mer; aboral surface.

All figures natural size, except fig. 6, which is × 10.

PLATE 17.

FIG. 1. *Centrechinus savignyi;* Mer; aboral surface of test, spines and tubercles being entirely omitted, so as not to obscure the characteristic color-pattern.
2. *Centrechinus savignyi;* Mer; oral surface of test without tubercles or spines.
3. *Centrechinus setosum;* Mer; aboral surface of test without tubercles or spines.
4. *Centrechinus setosum;* Mer; oral surface of test without tubercles or spines.
5. *Temnotrema sculpta;* Mer; aboral surface.
6. *Tripneustes gratilla;* Mer; aboral surface.

All figures natural size, except fig. 5, which is × 2.5.

PLATE 18.

FIG. 1. *Stichopus chloronotus;* Mer; side view of anterior end.
2. *Thelenota ananas;* Mer; dorsal view of posterior end.
3. *Thelenota anax;* holotype; Mer; side view of anterior end.
4. *Stichopus horrens;* Mer; dorsal view of anterior end.

All figures natural size.

PLATE 19.

FIG. 1. *Holothuria pervicax;* Mer; dorsal view.
2. *Pseudocucumis aciculata;* Mer; dorsal view.
3. *Holothuria impatiens* var. *pulchra,* juv.; Mer; dorsal view.
4. *Holothuria edulis;* Erub; side view.
5. *Holothuria impatiens;* Mer; dorsal view of anterior end.

All figures natural size.

PLATE 20.

FIG. 1. *Comanthus alternans;* Mer; calyx and part of two rays; aboral surface.
2. *Comanthus luteofusca;* holotype; Mer; aboral surface.
3. *Comanthus luteofusca;* holotype; Mer; oral surface.
4. *Comanthus samoana;* Mer; aboral surface.

All figures natural size.

PLATE 21.

FIG. 1. *Oligometra anisa;* Mer; side view of specimen from which fig. 10, pl. 1, was drawn.
2. *Oligometra anisa;* holotype; Mer; aboral surface.
3. *Oligometra anisa;* holotype; Mer; oral surface.
4. *Lamprometra gyges;* Mabuag; aboral surface.
5. *Lamprometra gyges;* Mabuag; oral surface.
6. *Heterometra delicata;* holotype; Friday Island; aboral surface.

All figures natural size, except fig. 6, which is slightly enlarged.

PLATE 22.

FIG. 1. *Lamprometra brachypecha;* holotype; Mer; oral surface.
2. *Lamprometra brachypecha;* holotype; Mer; aboral surface.
3. *Lamprometra gyges;* Marshall Islands; side view.
4. *Stephanometra stypacantha;* holotype; Mer; aboral surface.

All figures natural size except fig. 3 which is somewhat enlarged.

PLATE 23.

FIG. 1. *Goniodiscaster coppingeri;* Adolphus Island; aboral surface.
2. *Goniodiscaster coppingeri;* Adolphus Island; oral surface.
3. *Asterina nuda;* holotype; Weier; aboral surface.
4. *Asterina nuda;* holotype; Weier; oral surface.
5. *Asterina anomala;* paratypes; Mer; aboral surface.

All figures natural size.

PLATE 24.

FIG. 1. *Oreaster nodosus;* Jappen Island, New Guinea; aboral surface.
2. *Habroporina pulchella;* holotype; Mer; aboral surface.
3. *Habroporina pulchella;* holotype; Mer; oral surface.

Fig. 1 is not quite natural size, while figs. 2 and 3 are × 2.5.

PLATE 25. *Oreaster nodosus.*

FIG. 1. Side view of specimen shown on pl. 24, fig. 1.
2. Aboral view of larger specimen with more complex dorsal spines; Jappen Island, New Guinea.

Fig. 1 is about 0.9 nat. size, while fig. 2 is about 0.8.

PLATE 26.

FIG. 1. *Linckia lævigata;* Mer; aboral surface.
2. *Asterina anomala;* paratype; Mer; aboral surface.
3. *Asterina anomala;* paratype; Mer; oral surface.
4. *Habroporina pulchella;* holotype; Mer; aboral surface.
5. *Habroporina pulchella;* holotype; Mer; oral surface.

Fig. 1, nat. size; figs. 2 and 3, ×2.5; figs. 4 and 5, nat. size.

PLATE 27.

FIG. 1. *Leiaster speciosus;* Mer; aboral surface.
2. *Leiaster speciosus;* Mer; oral surface.
3. *Ophidiaster lioderma;* holotype; Mer; aboral surface.
4. *Ophidiaster lioderma;* holotype; Mer; oral surface.

All figures natural size.

PLATE 28.

FIG. 1. *Tamaria fusca;* Holothuria Bank, northwestern Australia; aboral surface.
2. *Tamaria fusca;* Holothuria Bank, northwestern Australia; oral surface.
3. *Nardoa variolata;* Zanzibar; aboral surface.
4. *Nardoa variolata;* Zanzibar; oral surface.

Figs. 1 and 2 about 2.5, figs. 3 and 4 about 0.9, nat. size.

PLATE 29.

FIG. 1. *Nardoa rosea;* holotype; Mer; aboral surface.
2. *Nardoa rosea;* holotype; Mer; oral surface.
3. *Ophidiaster granifer;* Erub; aboral surface.
4. *Ophidiaster granifer;* Erub; oral surface.
5. *Fromia elegans;* holotype; Mer; aboral surface.
6. *Fromia elegans;* holotype; Mer; oral surface.

All figures natural size.

PLATE 30. *Leiaster brevispinus.*
FIG. 1. Aboral surface of holotype; Hawaiian Islands.
2. Oral surface of holotype; Hawaiian Islands.
Both figures natural size.

PLATE 31.
FIG. 1. *Ferdina ocellata;* holotype; Mer; aboral surface.
2. *Ferdina ocellata;* holotype; Mer; oral surface.
3. *Fromia hadracantha;* holotype; Philippine Islands; aboral surface.
4. *Fromia hadracantha;* holotype; Philippine Islands; oral surface.
5. *Fromia pacifica;* holotype; Hawaiian Islands; aboral surface.
6. *Fromia pacifica;* holotype; Hawaiian Islands; oral surface.
7. *Tamaria lithosora;* holotype; Zanzibar; aboral surface.
8. *Tamaria lithosora;* holotype; Zanzibar; oral surface.
All figures natural size.

PLATE 32. *Hacelia superba.*
FIG. 1. Oral surface of holotype; off Barbados, 100 fms.
2. Aboral surface of holotype; off Barbados, 100 fms.
Both figures natural size.

PLATE 33.
FIG. 1. *Ophiothrix longipeda;* Suva, Fiji; aboral surface.
2. *Ophionereis porrecta;* Mer; aboral surface.
3. *Ophionereis porrecta;* Mer; oral surface.
4. *Ophiothrix trilineata;* Mer; typical coloration; aboral surface.
5. *Ophiothrix trilineata;* Mer; aberrant coloration; aboral surface.
Fig. 1 about ¾ nat. size. All other figures, natural size.

PLATE 34.
FIG. 1. *Ophiarachna incrassata;* Mer; aboral surface.
2. *Ophiarachna incrassata;* Mer; oral surface.
3. *Ophiocoma brevipes;* Mer; aboral surface.
4. *Ophiocoma brevipes;* Mer; oral surface.
All figures natural size.

PLATE 35.
FIG. 1. *Ophioplocus imbricatus;* Mer; aboral surface.
2. *Ophioplocus imbricatus;* Mer; oral surface.
3. *Ophioplocus imbricatus;* Mer; aboral surface of specimen with heavily marked disk.
4. *Ophiarachnella gorgonia;* Mer; aboral surface.
5. *Ophiarachnella gorgonia;* Mer; oral surface.
6. *Fibularia volva?;* Badu; aboral surface.
7. *Fibularia volva?;* Badu; oral surface.
8. *Fibularia volva?;* Badu; side view.
9. *Fibularia volva?;* Badu; interior view of oral half of test.

PLATE 36.
FIG. 1. *Oligometra anisa;* structural details. *a*, Cirrus. *b*, p_1. *c*, p_2. *d*, p_3. *e*, p_4. Fig. 1*a* is ×4; the others are ×3.
2. *Stephanometra callipecha;* structural details. Letters as under fig. 1; all figures ×3.
3. *Stephanometra stypacantha;* structural details. Letters as under fig. 1; all figures ×3.
4. *Heterometra delicata;* structural details. Letters as under fig. 1, with *f*, basal part of arm. Fig. 4*f* is ×3; the others are ×5.
5. *Bunaster uniserialis;* holotype; oral view of basal part of arm, ×9.
6. *Bunaster uniserialis;* holotype; aboral view of basal part of arm, ×9.
7. *Bunaster uniserialis;* a single pedicellaria and its surroundings, ×95.
8. *Valvaster spiniferus;* holotype; Mer; three adambulacral plates, showing diversity of armature, ×10.
9. *Valvaster spiniferus;* holotype; Mer; bit of aboral margin of arm, showing two of the huge pedicellariæ, ×3.
10. *Ophiomastix caryophyllata;* Mer; three upper arm-plates, ×5.
11. *Ophiomastix corallicola;* Mer; three upper arm-plates, ×5.
12. *Leptosynapta latipatina;* holotype; Friday Island. *a*, Anchor, ×200. *b*, Anchor-plate, ×200. *c*, Miliary particles, ×450.
13. *Leptosynapta dolabrifera;* Port Jackson, N. S. W.; anchor, ×200.
14–21. *Trochodota maculata;* holotype; Mer.
14. A tentacle, ×35.
15. An excretory funnel, ×400.
16. Inner face of distal half of excretory funnel, ×400.
17. Piece of calcareous ring, ×35.
18. Wheel, ×450.
19, 20. Sigmoid bodies, ×450.
21. Tentacle-rods, ×450.

PLATE 37.

FIGS. 1– 8. *Pentacta trimorpha;* holotype; Mer.
1. Radial and interradial pieces of calcareous ring, ×10.
2, 3. Tentacle-rods, ×450.
4. Supporting rod from pedicels, ×450.
5. Large calcareous plate from deep in skin, ×40.
6. Calcareous "basket" from epidermis, ×450.
7. Knobbed button from dermis, ×50.
8. "Basket," seen from the side, ×450.

9–19. *Pseudocucumis eurystichus;* holotype; Friday Island.
9. Interradial and radial pieces of calcareous ring, ×5.
10–12. Tentacle-rods, ×450.
13. Side view of table from base of pedicel, ×450.
14. Simple disk of table from pedicel, ×450.
15. More developed disk of table from pedicel, ×450
16 Side view of spire of table from body-wall, ×450
17–19 Disks of tables from body-wall, ×450

20–29. *Holothuria altimensis;* holotype; Mer.
20. Radial and interradial pieces of calcareous ring, ×10.
21. Tentacle-rods, ×450.
22. Disk of table from body-wall, ×450.
23. Spire of table from body-wall, ×450.
24. Supporting rods of pedicels, ×450.
25. Side view of spire of ordinary table, ×450.
26. Top of spire of ordinary table, seen from above, ×450.
27. Disk of ordinary table, ×450.
28. Typical button, ×450.
29. Atypical buttons, ×450.

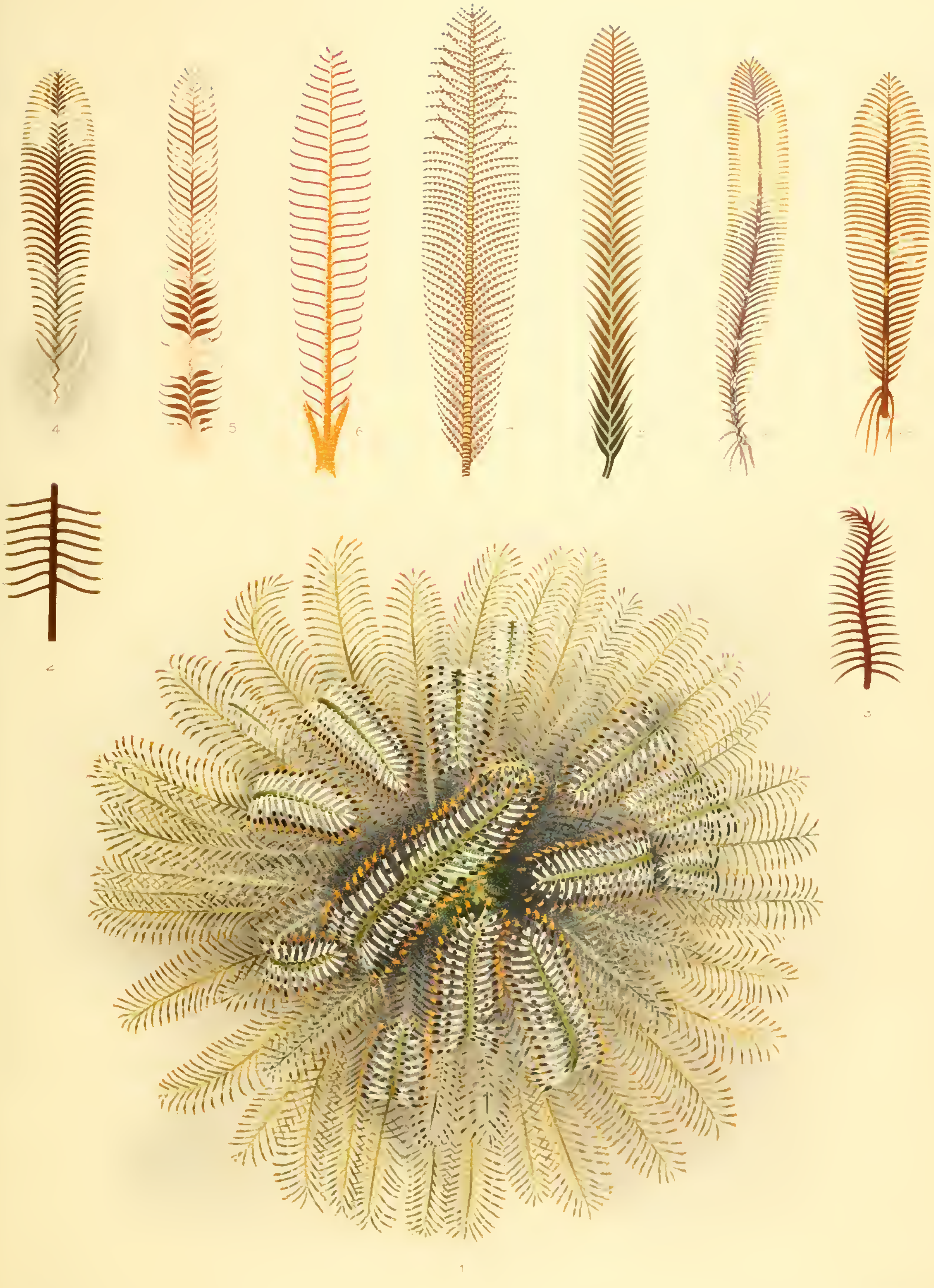
PLATE 38.

FIGS. 1–13. *Holothuria axiologa;* holotype; Mer.
1. Tentacle-rods, ×450.
2. Supporting rod of dorsal pedicel, ×450.
3. Typical disk of table, ×450.
4. Side view of spire of table, ×450.
5. Top of spire seen from above, ×450.
6. Simpler disk of table, ×450.
7. Simpler spire in side view, ×450.
8. Top of simpler spire seen from above, ×450.
9. Long, slender, fenestrated ellipse, ×450.
10. Heavier ellipse, ×450.
11. Ellipse intermediate between an ellipse and a button, ×450.
12. Knobbed button, ×450.
13. Knobbed button, seen from the side, ×450.

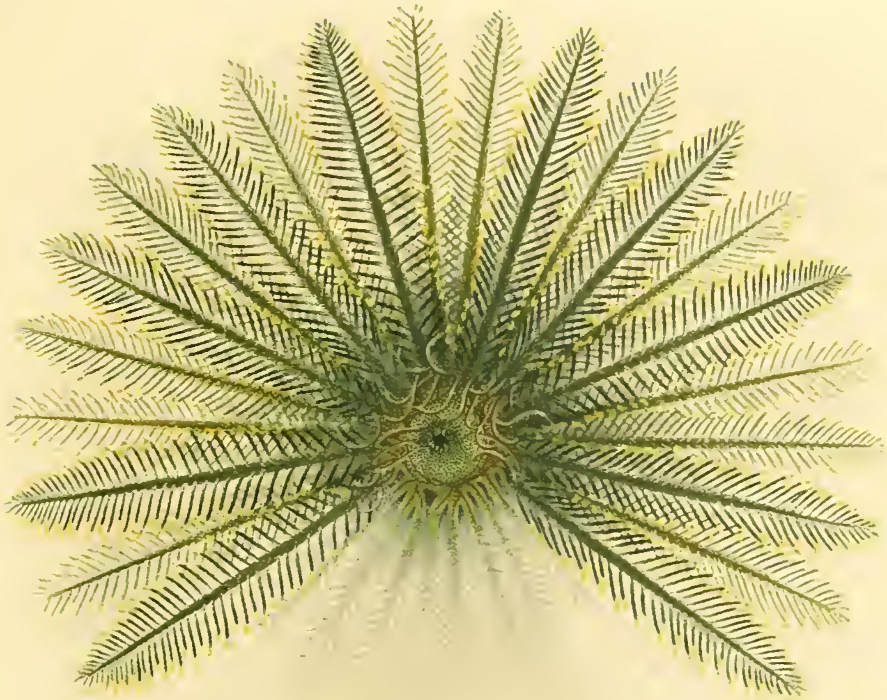
14–19*a*. *Holothuria cumulus;* holotype; Mer.
14. Tentacle-rods, ×450.
15. Side view of spire of table, ×450.
16. Disk of table, ×450.
17. Disk of larger table, ×450.
18. Top of spire seen from above, ×450.
19. Typical buttons, ×450.
19*a*. Larger button, ×450.

20–24. *Holothuria hypamma;* holotype; Mer.
20. Supporting rod of pedicel, ×95.
21. Disk of table seen from below, ×450.
22. Side view of table, ×450.
23. Top of spire seen from above, ×450.
24. Button, ×450.

25–32. *Holothuria subverta;* holotype; Mer.
25. Supporting rod of pedicel, somewhat idealized, ×450.
26. Side view of typical table, ×450.
27. Disk of typical table, ×450.
28. Top of spire of typical table seen from above, ×450.
29. Side view of extremely slender spire, ×450.
30. Side view of very stout table from dorsal body-wall, ×450.
31. Typical button, ×450.
32. Larger, smooth, ventral button, ×450.



ECHINODERMS FROM TORRES STRAITS



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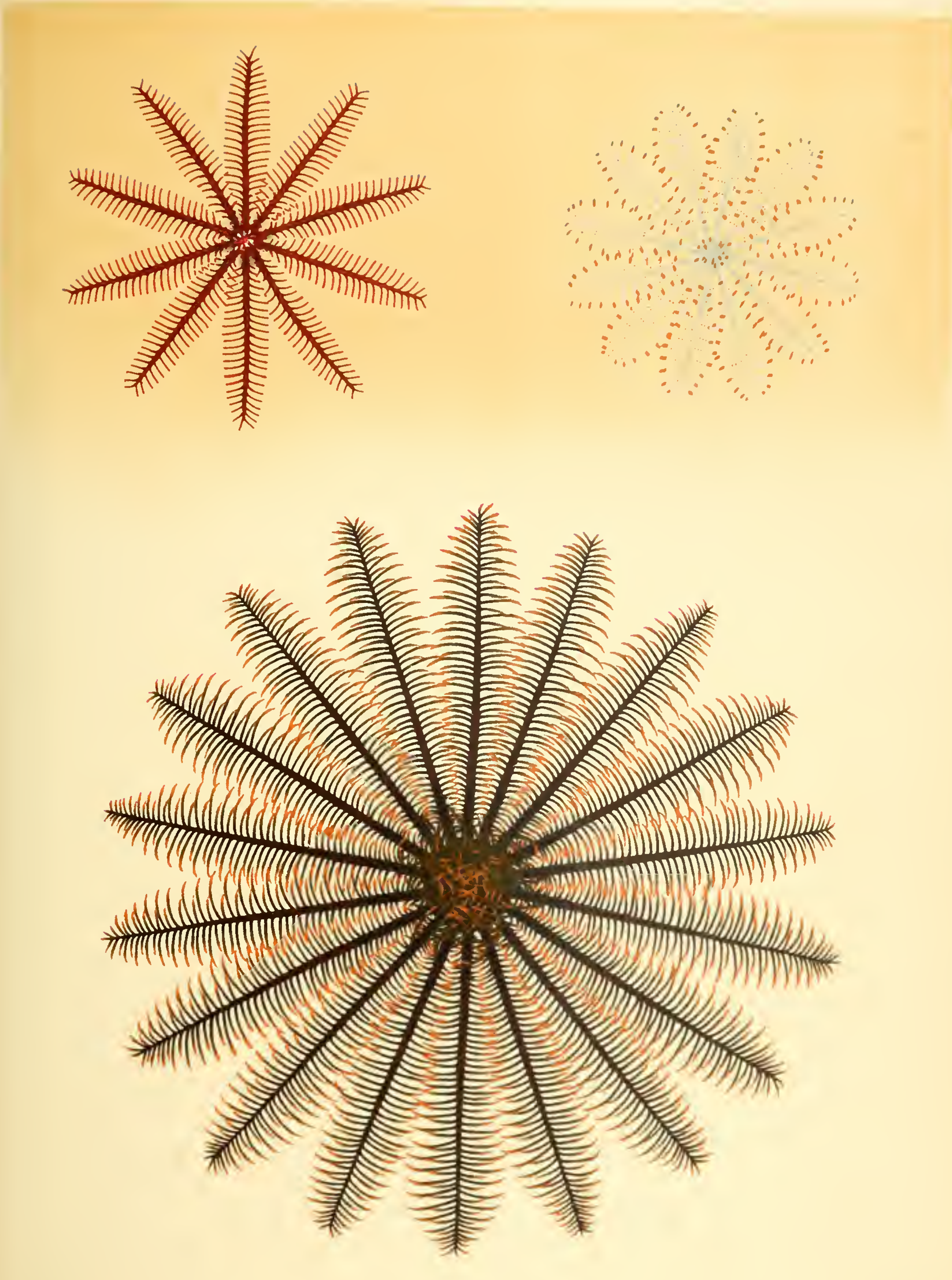

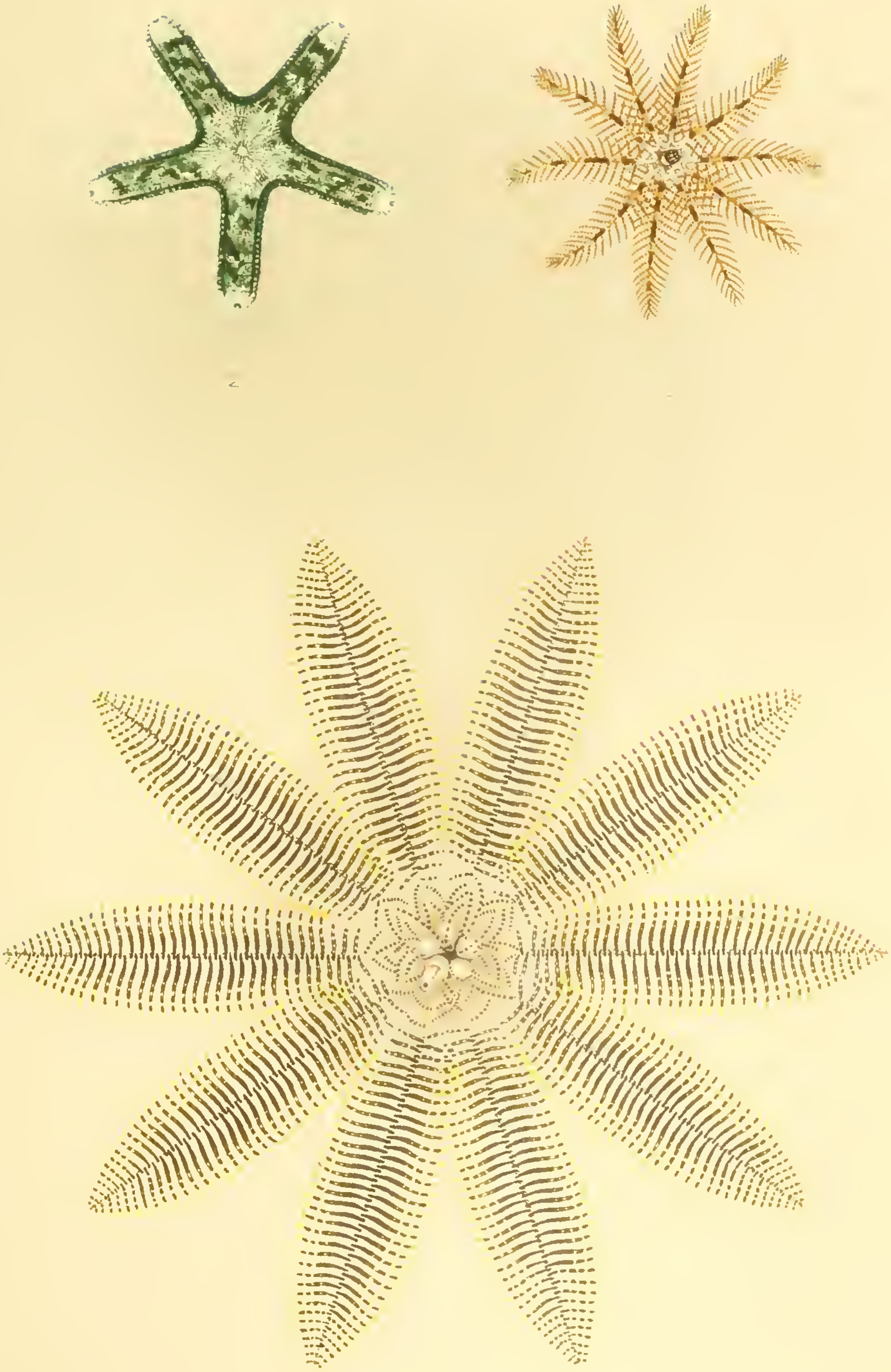

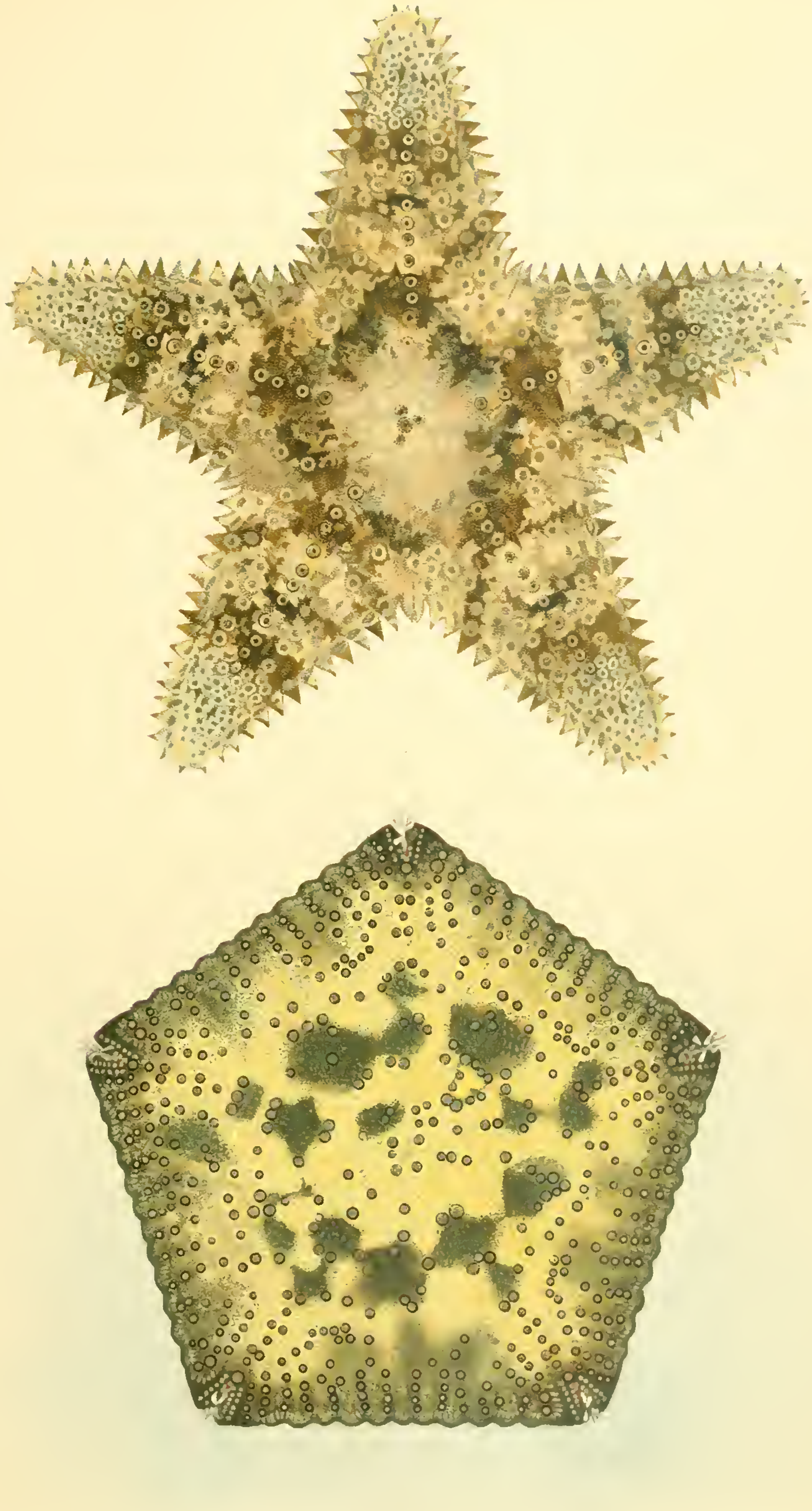

GROSSE Dr


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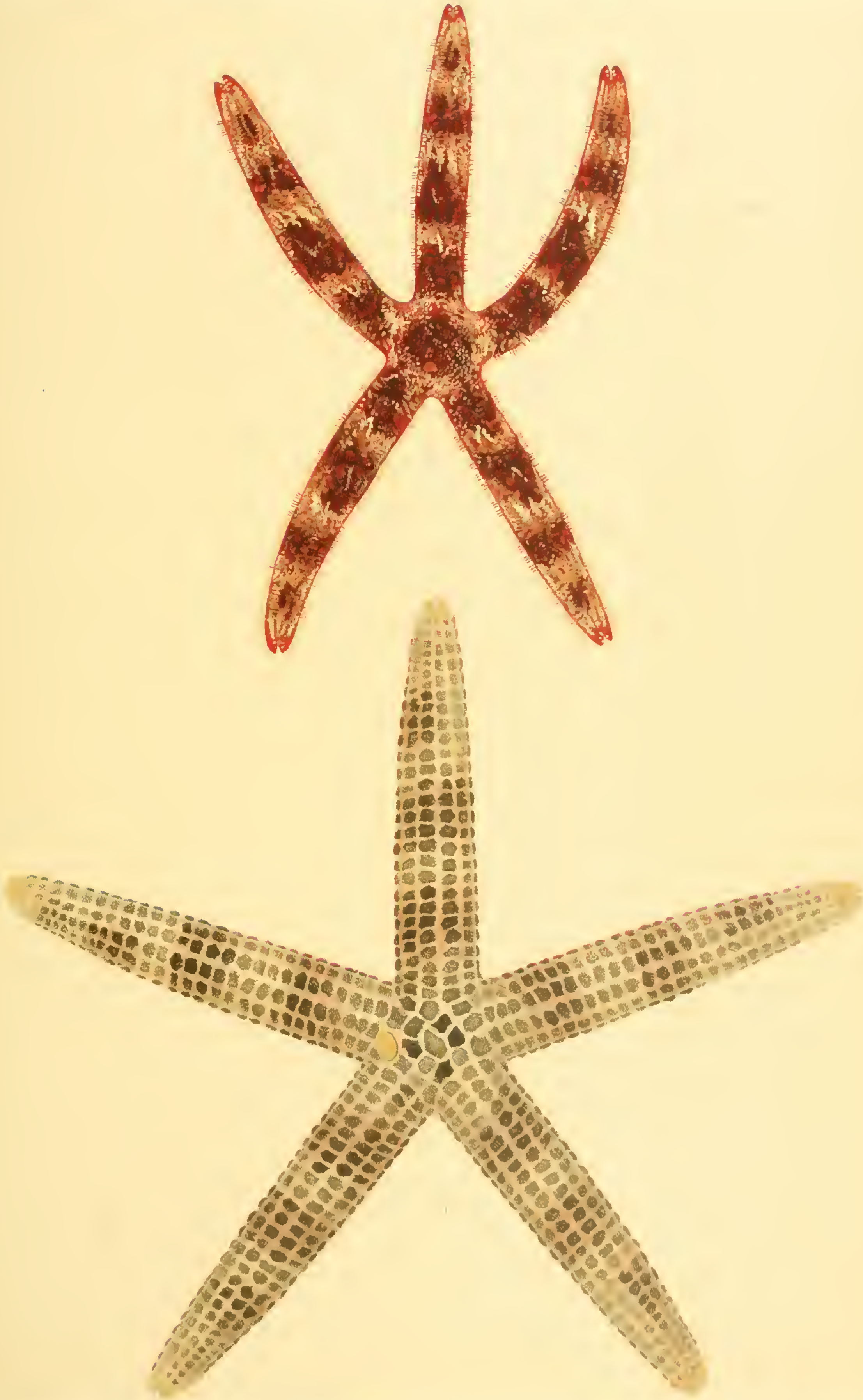
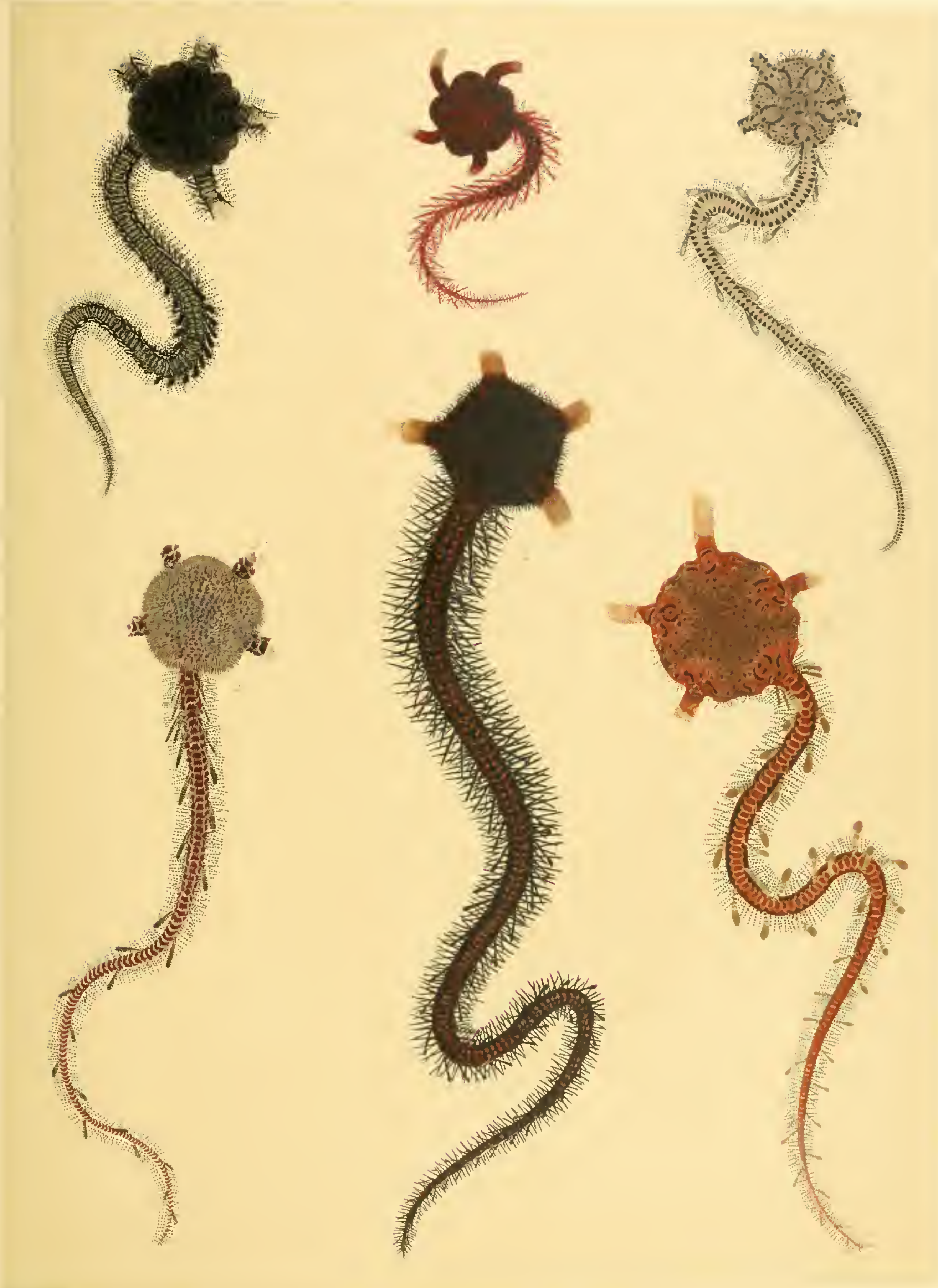
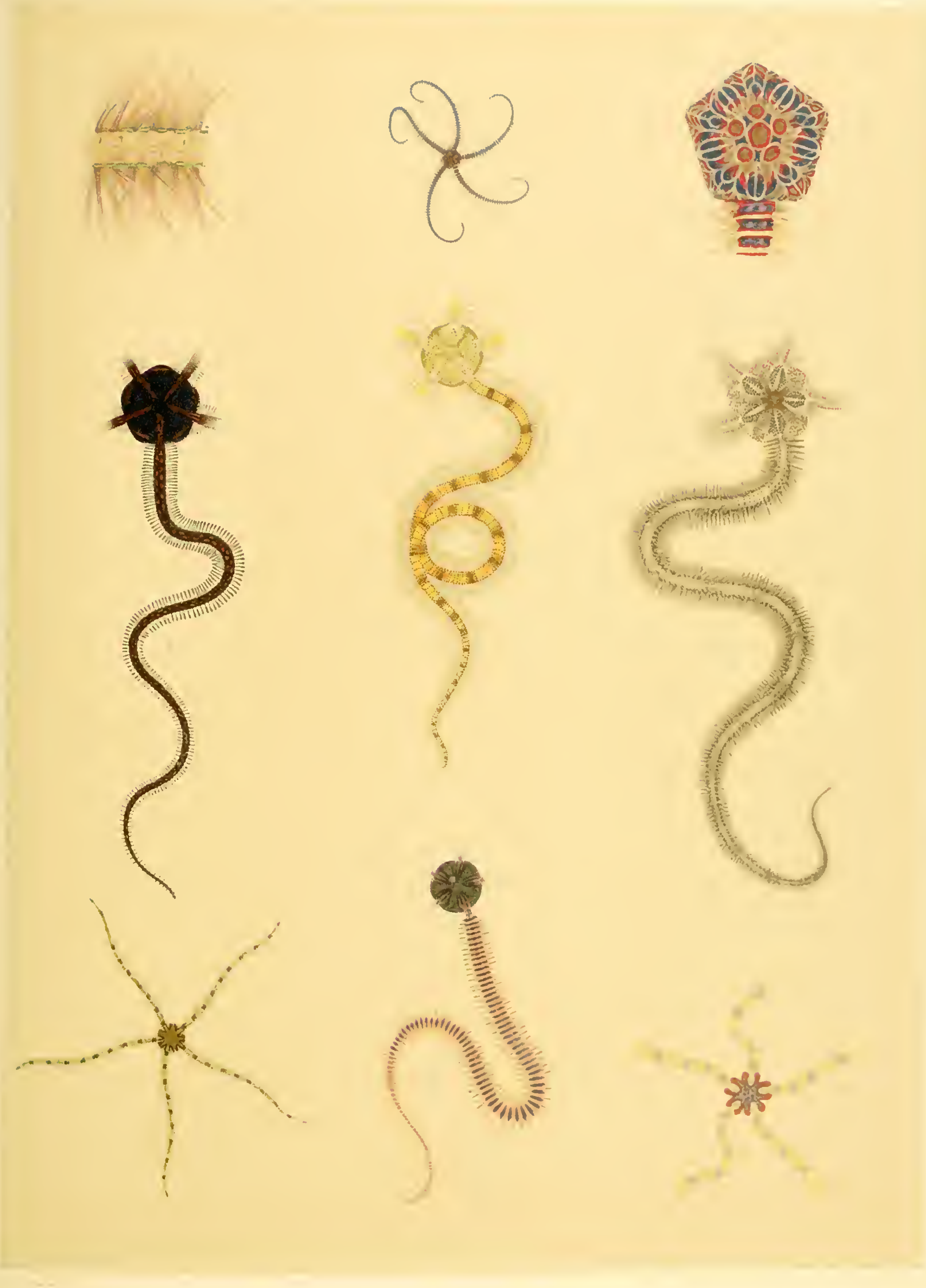
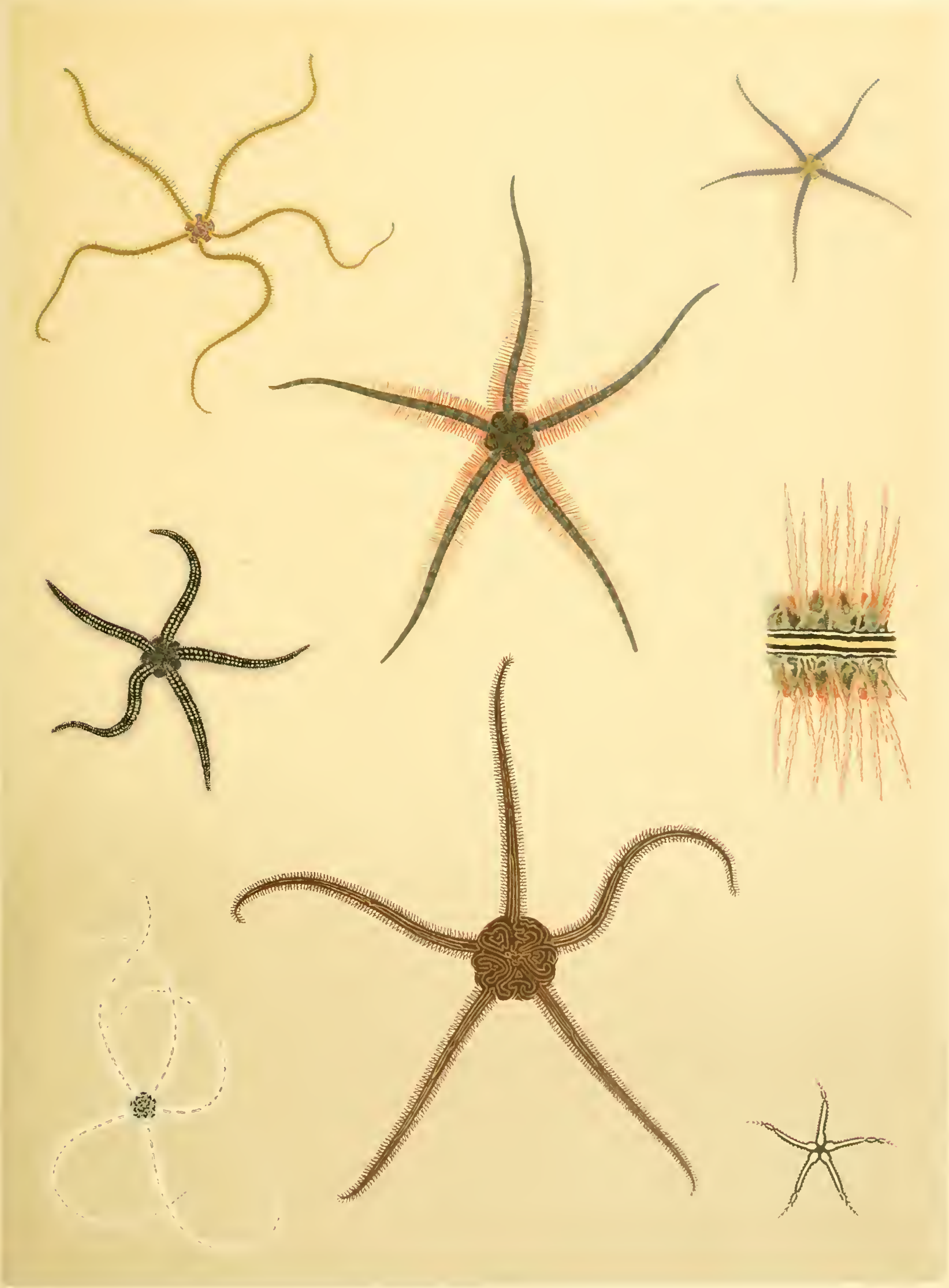
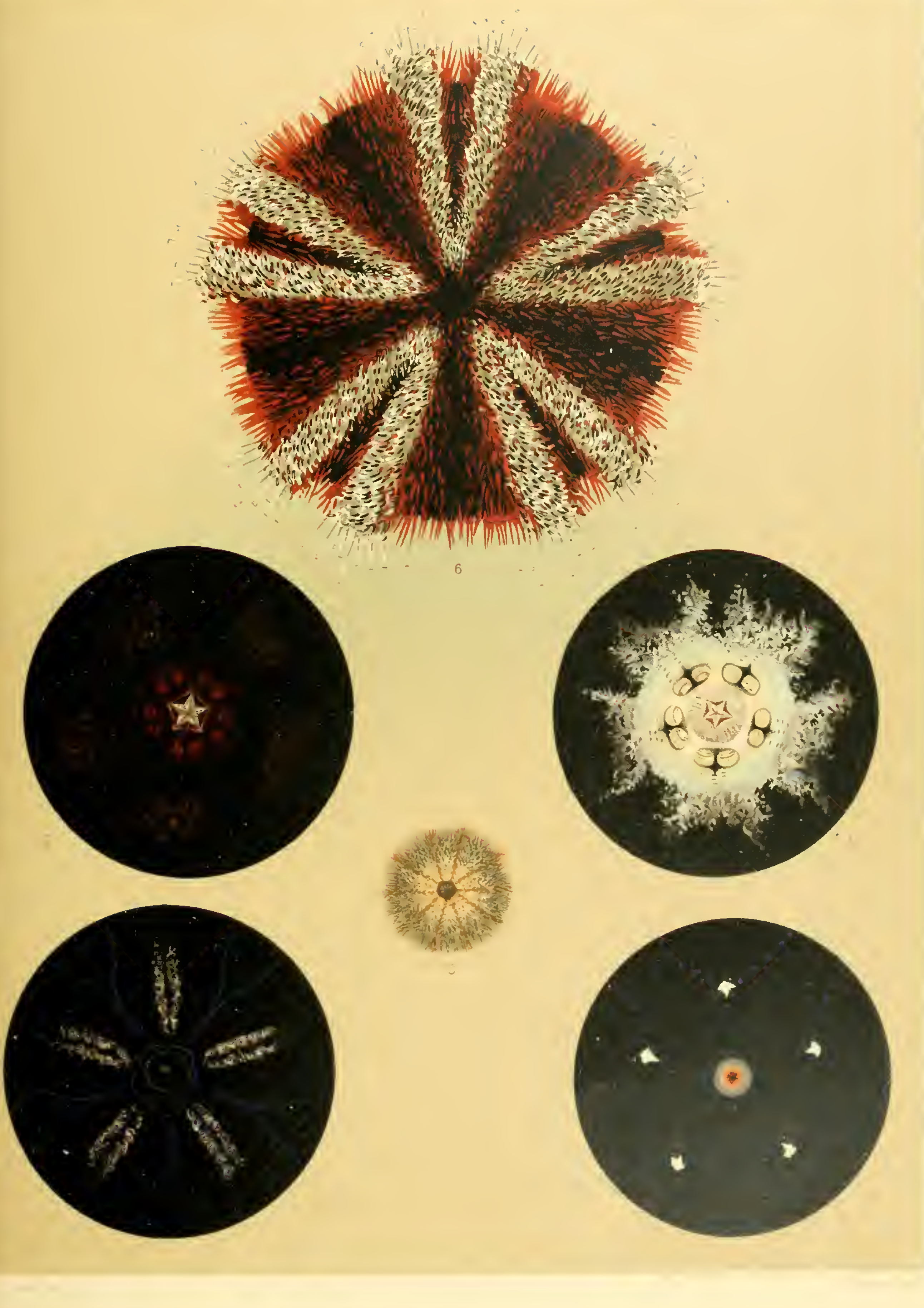


ECHINODERMS FROM TORRES STRAITS









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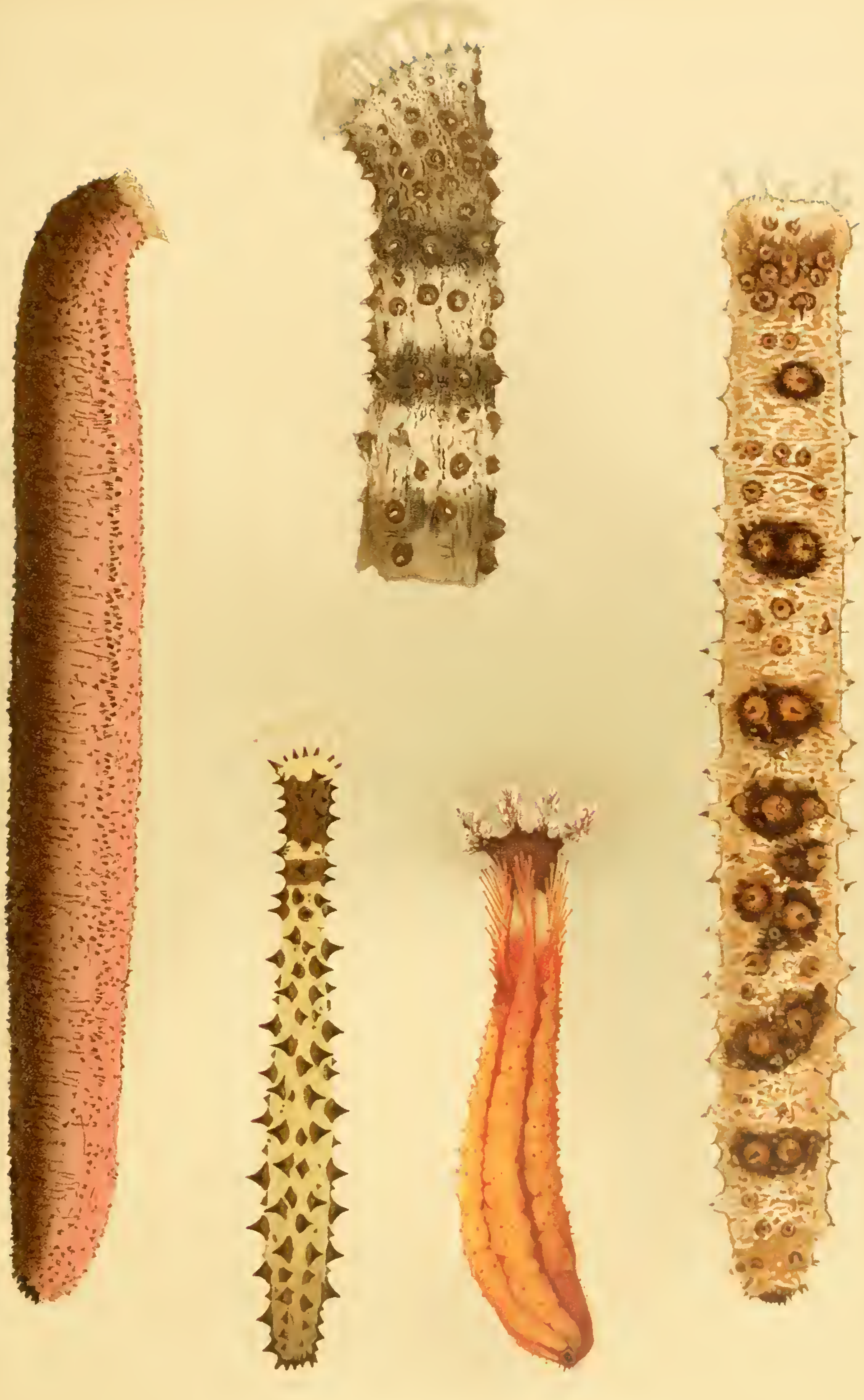
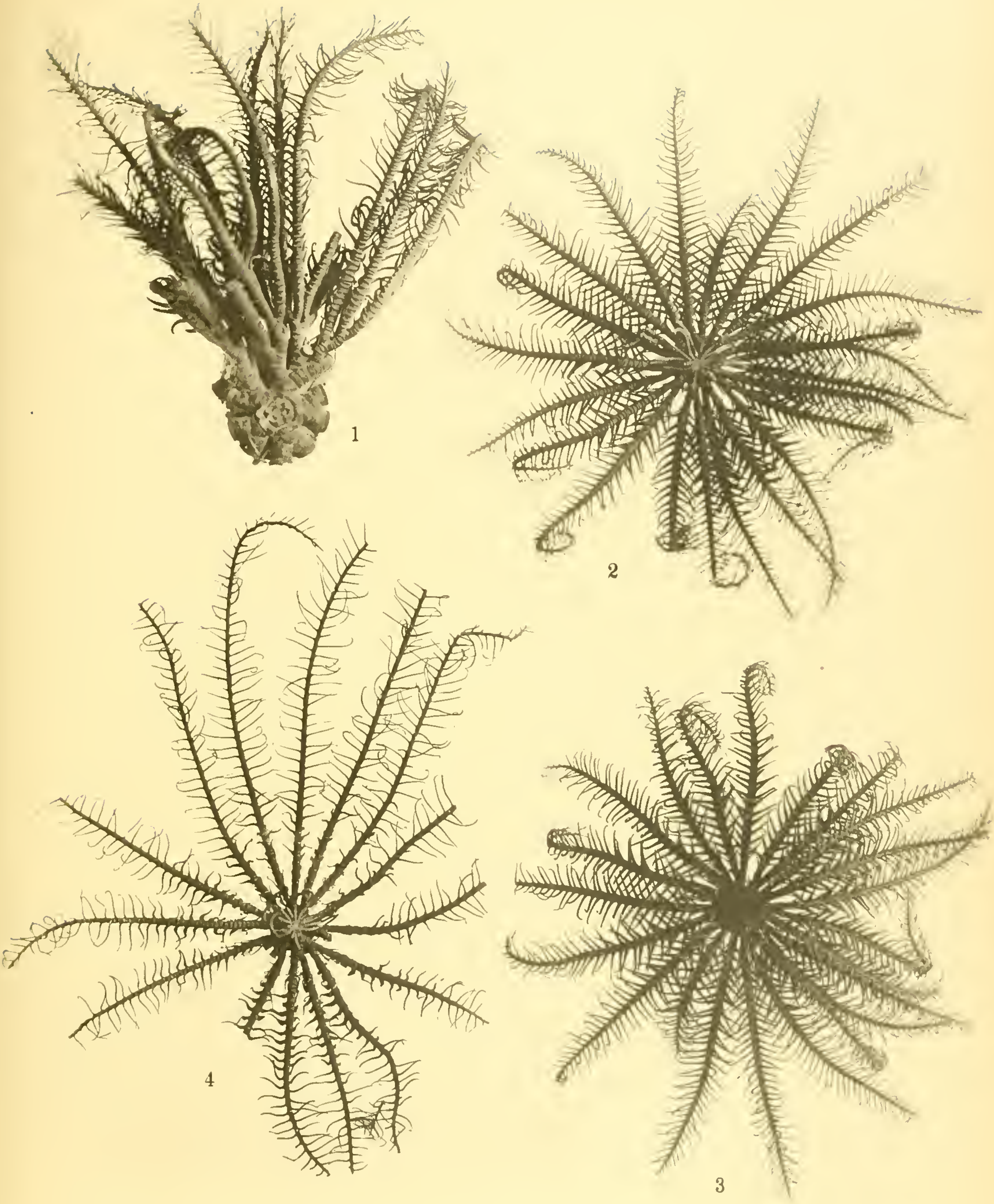
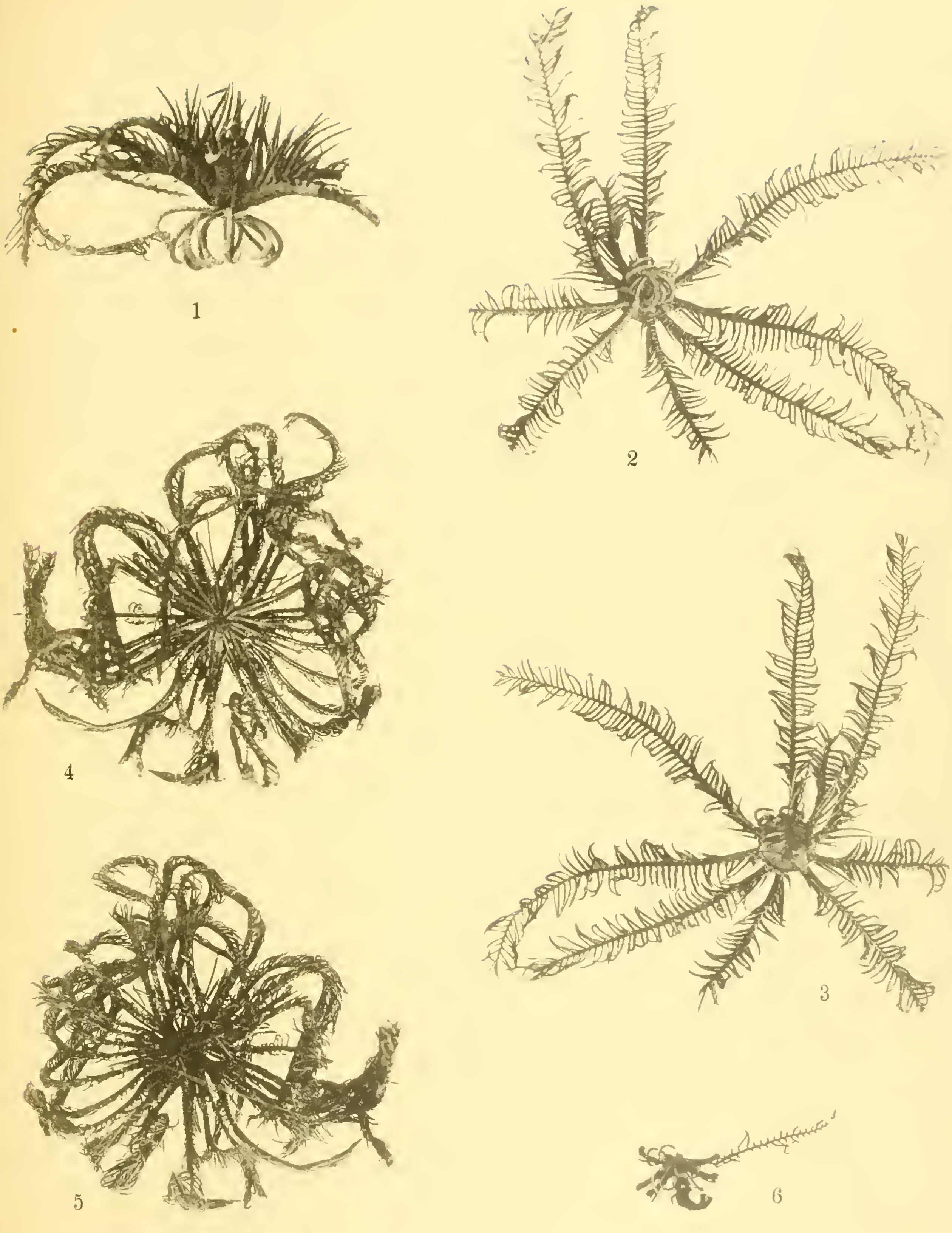
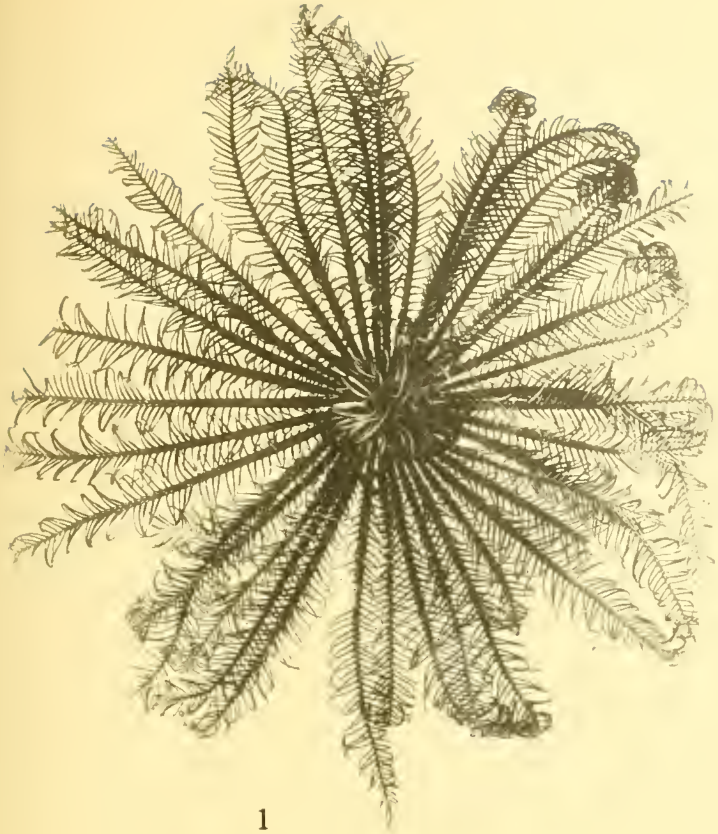




1. Comanthus alternans, calyx and part of two rays; aboral surface. X 1
2. Comanthus luteofusca, holotype, aboral surface. X 1.
3. Comanthus luteofusca, holotype, oral surface X 1
4. Comanthus samoana, aboral surface. X 1



1. Oligometra anisa, side view. Original from which fig. 10, plate 1, was drawn. X 1
2. Oligometra anisa, holotype, aboral surface. X 1.
3. Oligometra anisa, holotype, oral surface. X 1.
4. Lamprometra gyges, aboral surface. X 1.
5. Lamprometra gyges, oral surface. X 1.
6. Heterometra delicata, holotype, aboral surface. Slightly enlarged. X 1.



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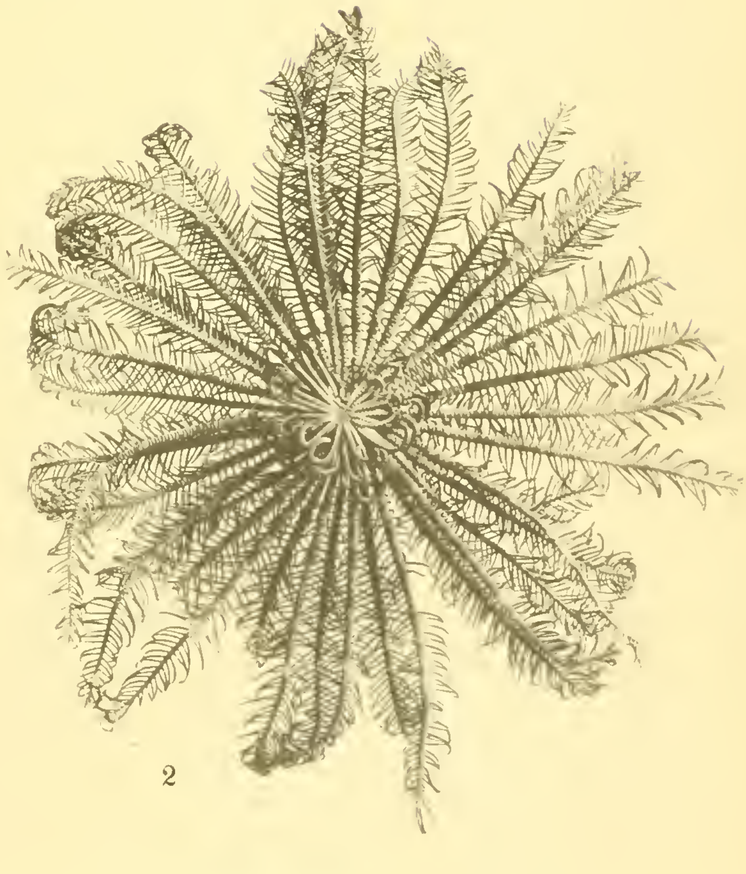

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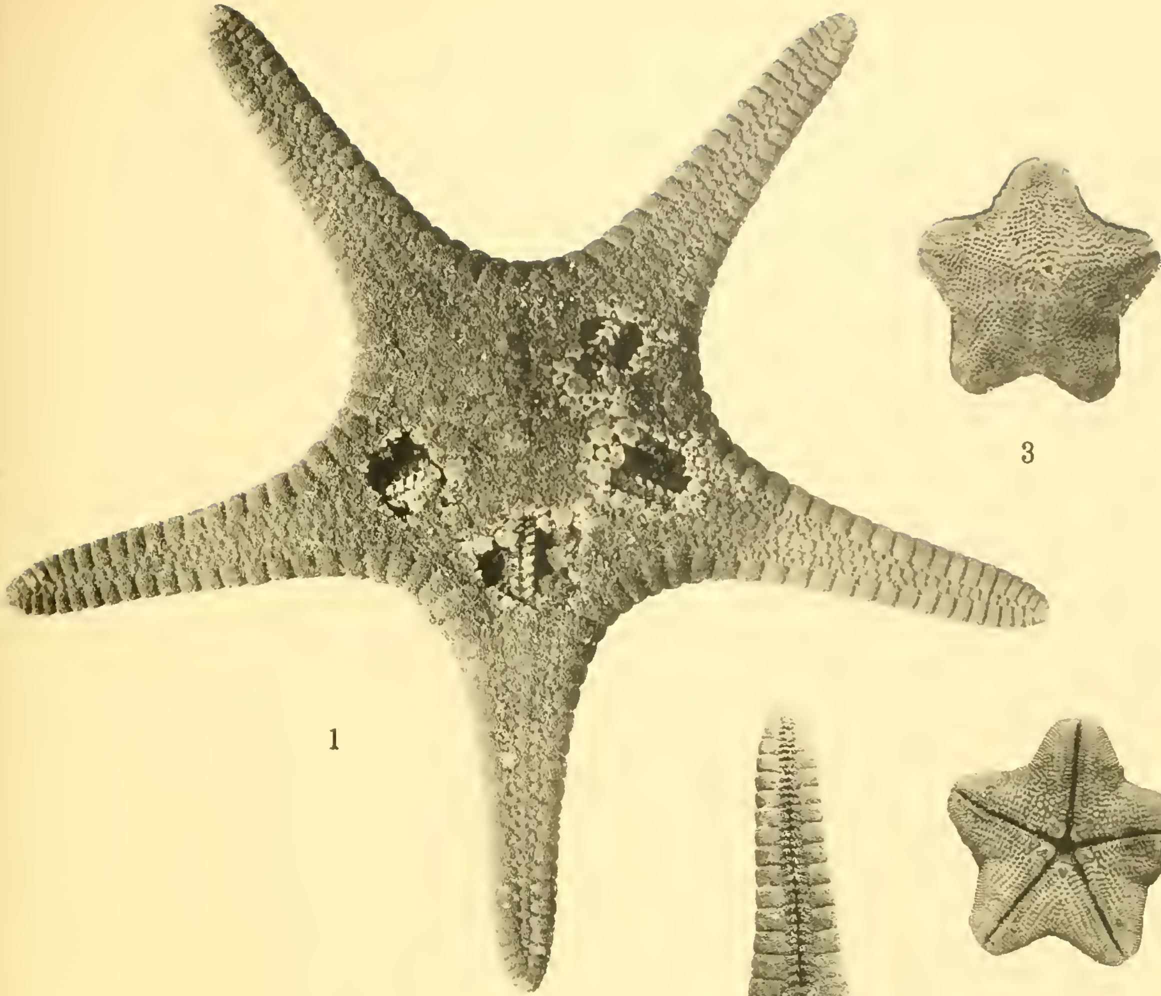
1. Lamprometra brachypecha, holotype, oral surface. × 1.
2. Lamprometra brachypecha, holotype, aboral surface. × 1.
3. Lamprometra gyges, side view. Somewhat enlarged.
4. Stephanometra stypacantha, holotype, aboral surface. × 1.



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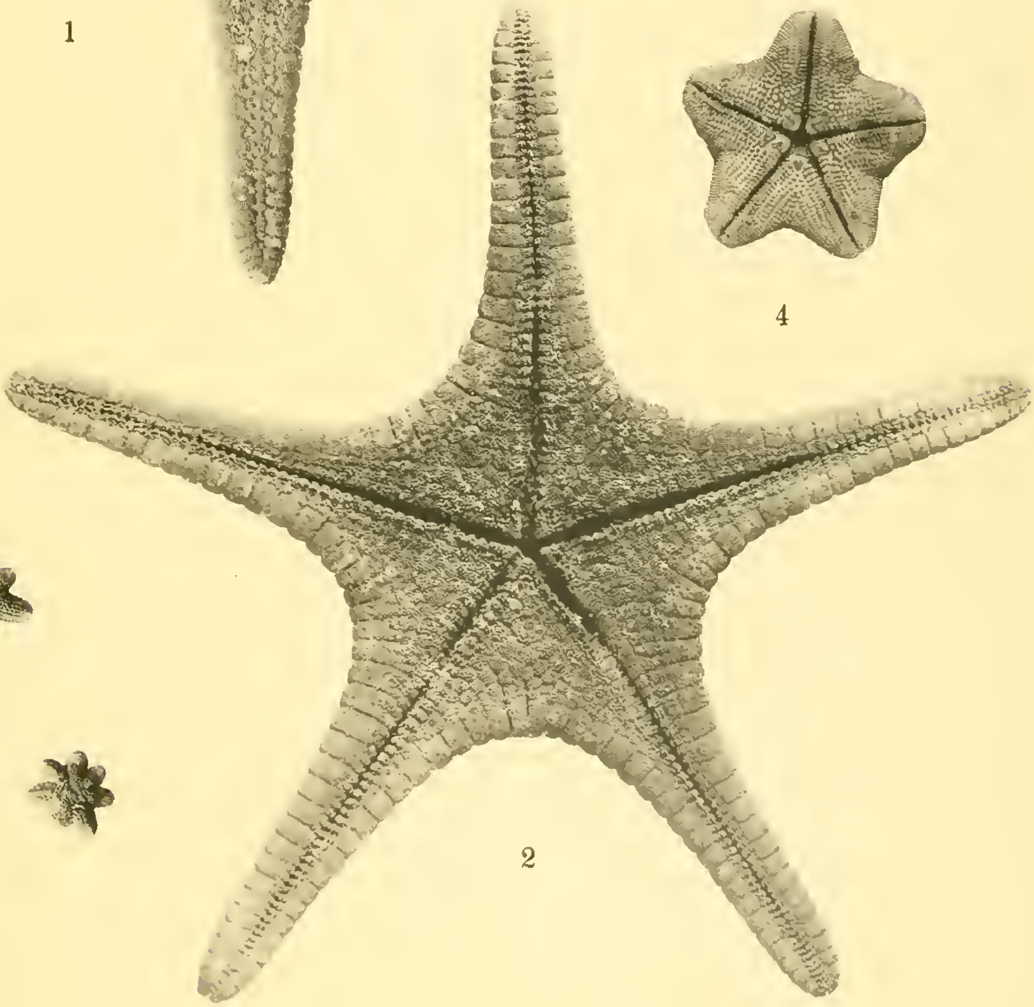

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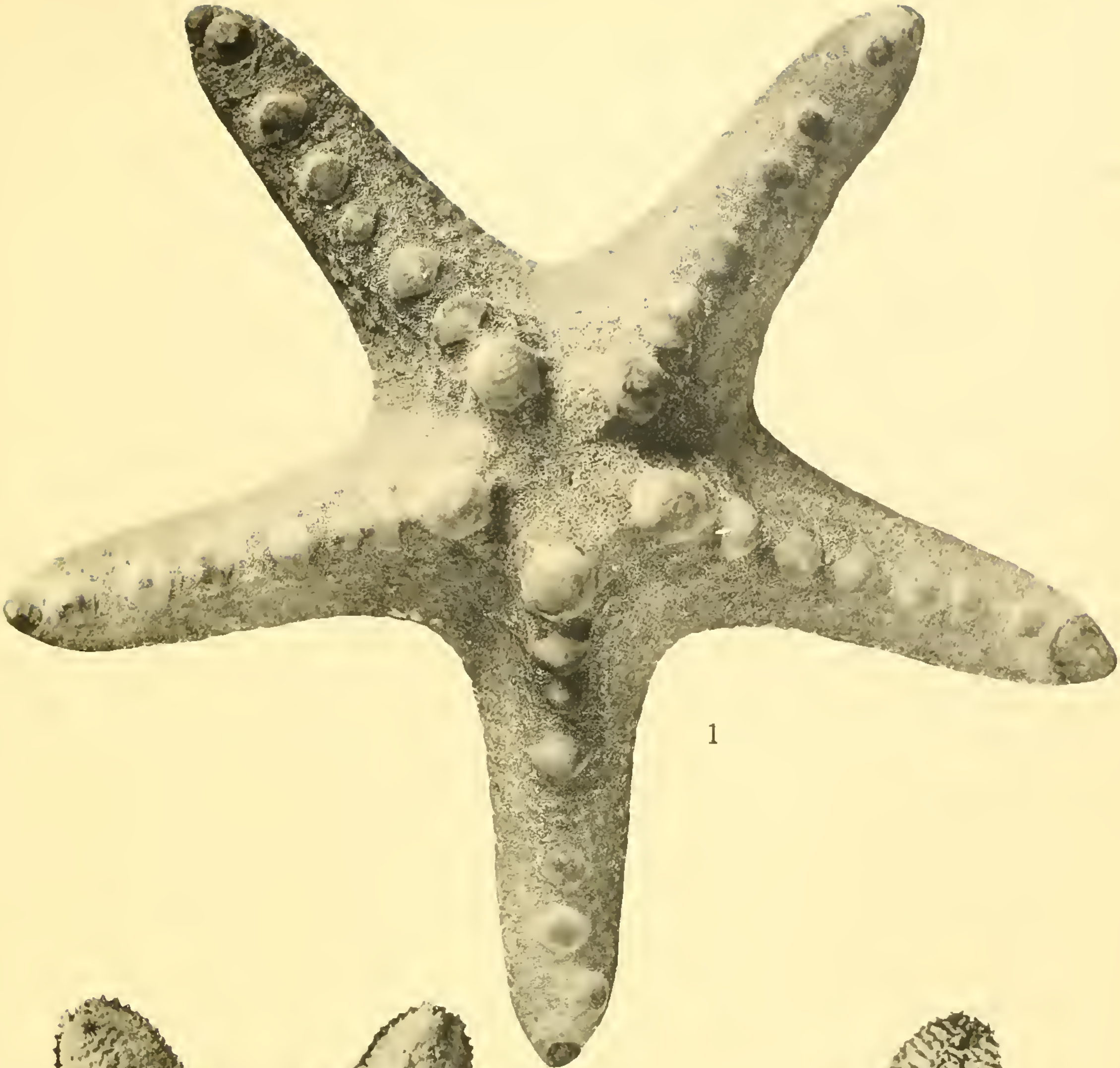
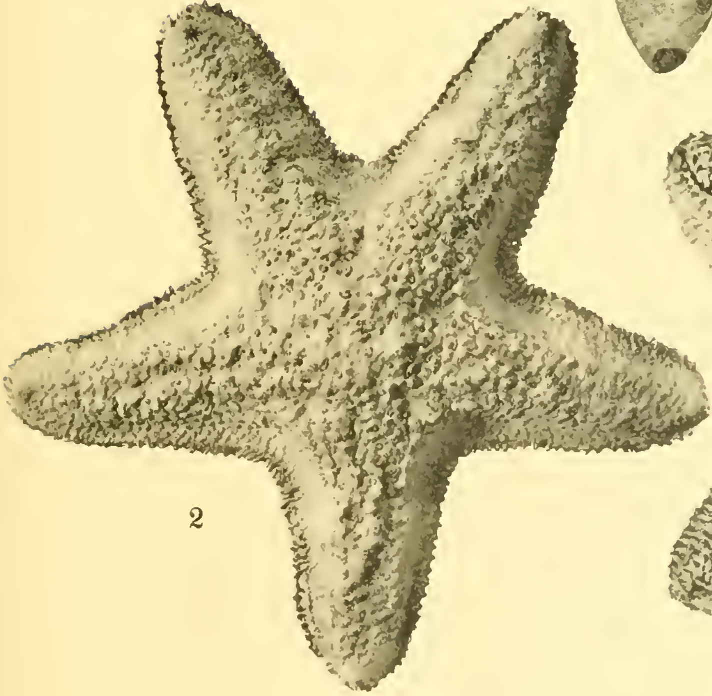
5

1. Goniodiscaster coppingeri, aboral surface. X 1.
2. Goniodiscaster coppingeri, oral surface. X 1.
3. Asterina nuda, holotype, aboral surface. X 1.
4. Asterina nuda, holotype, oral surface. X 1.
5. Asterina anomala, paratypes, aboral surface. X 1.



1



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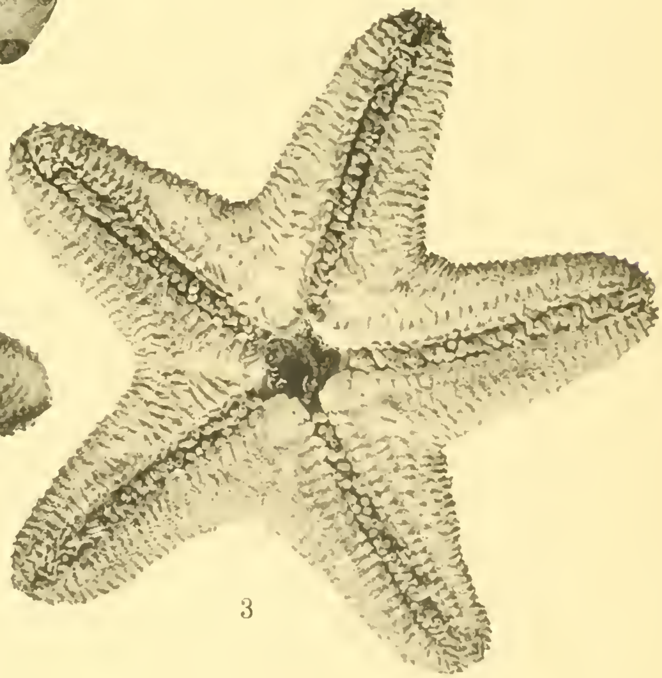
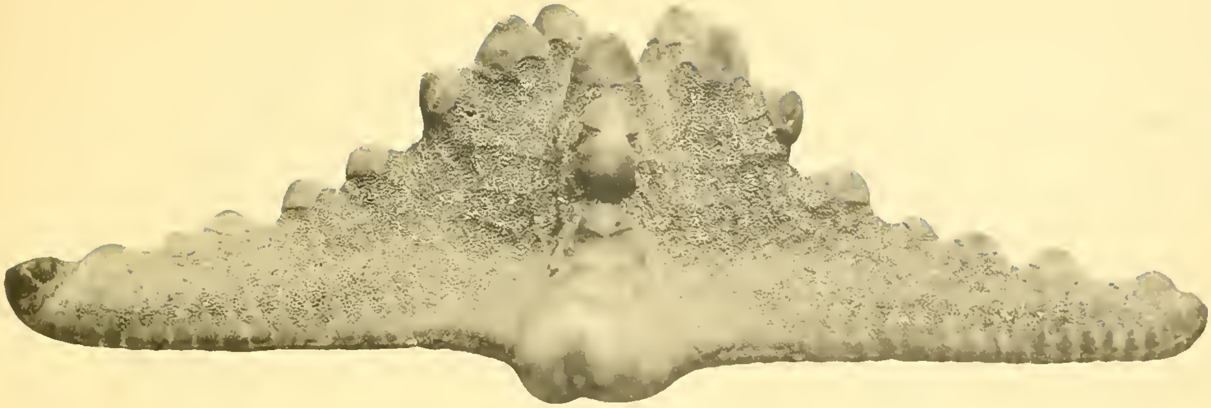


3

1. Oreaster nodosus, aboral surface. Not quite nat. size.
2. Habroporina pulchella, holotype, aboral surface. X 2.5.
3. Habroporina pulchella, holotype, oral surface. X 2.5.



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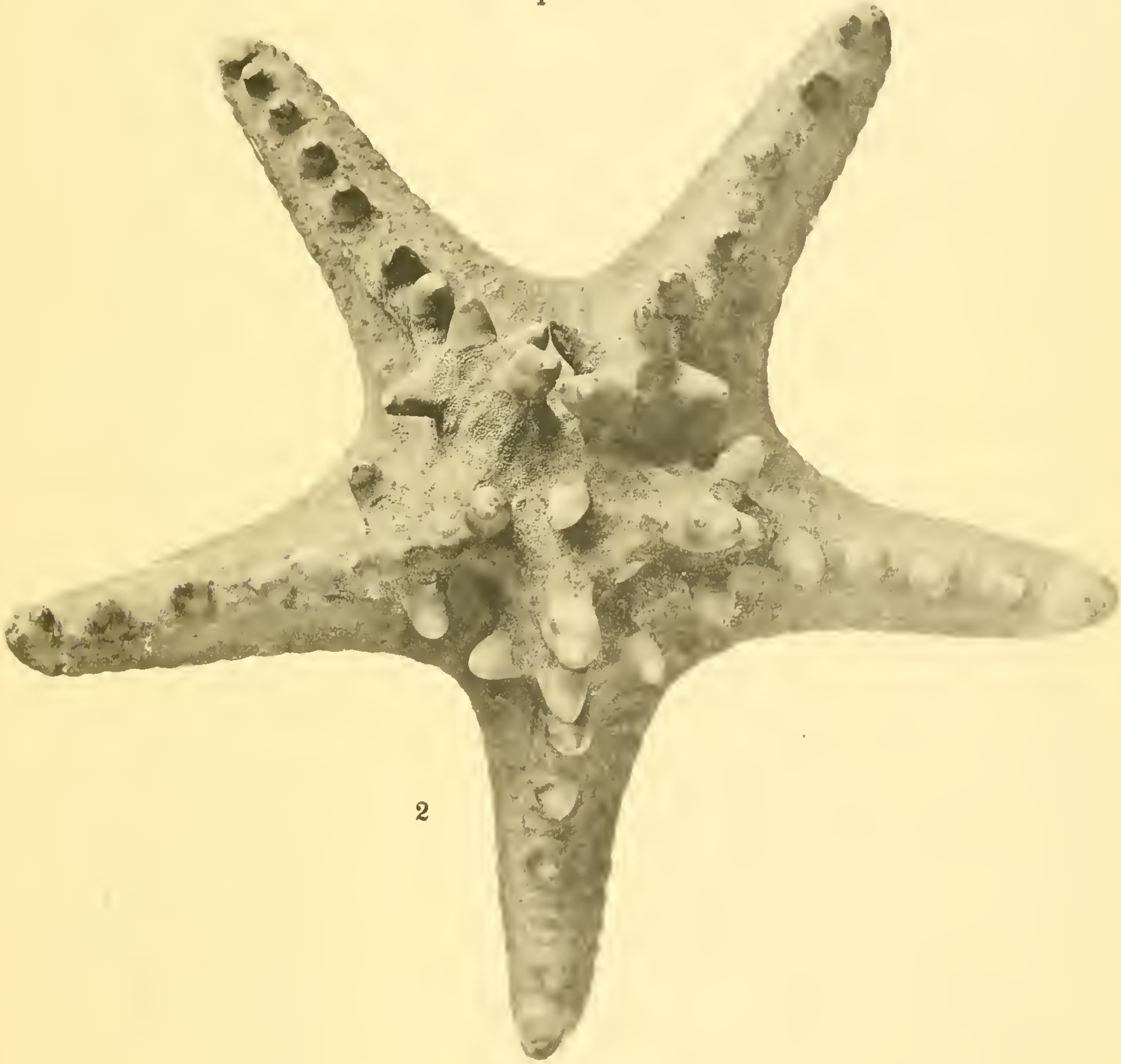
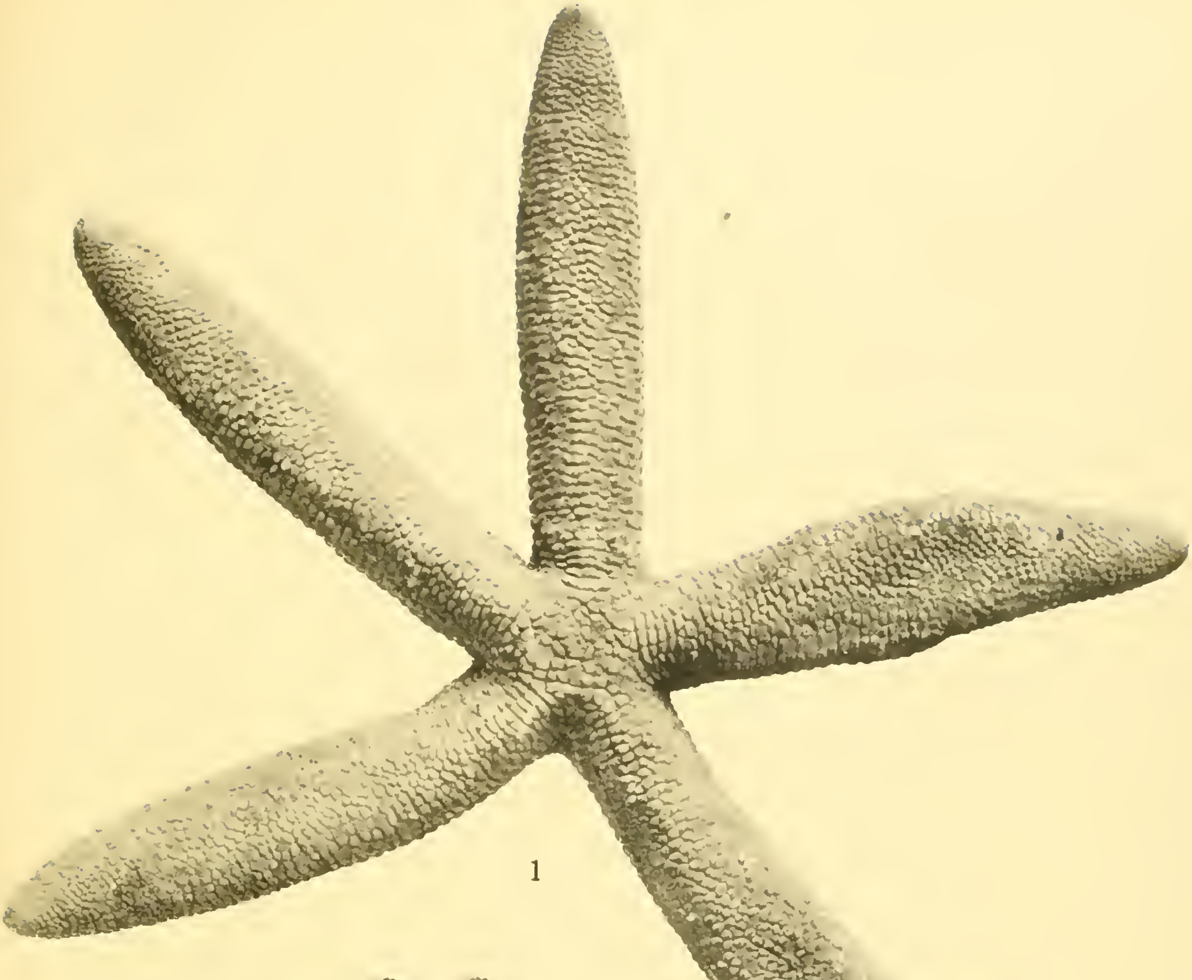


2

1. Oreaster nodosus, side view of specimen shown on pl. 24, fig. 1. X 0.9.
2. Oreaster nodosus, aboral view of a larger specimen with more complex dorsal spines. X 0.8.



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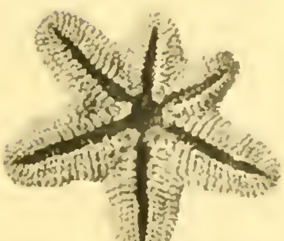

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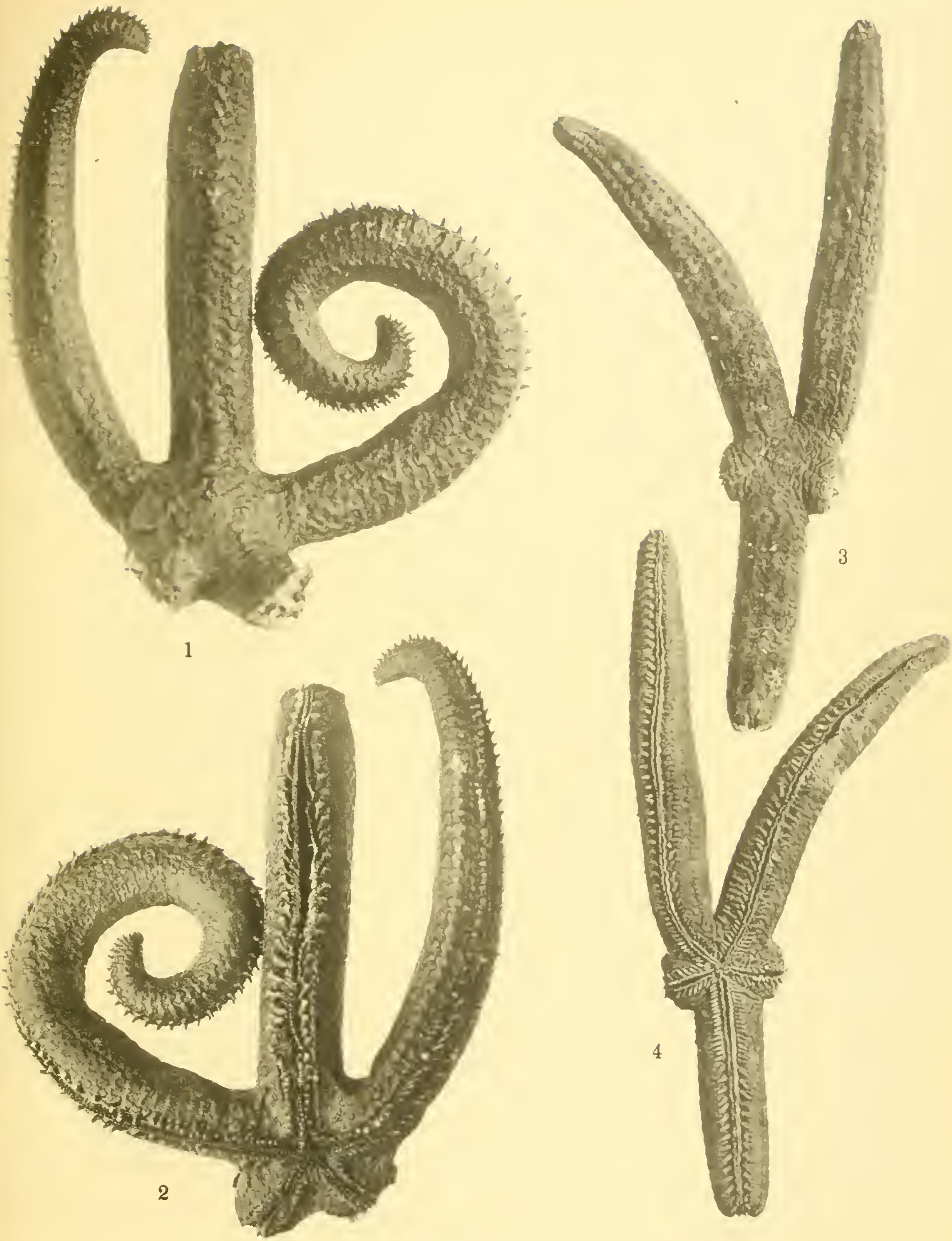
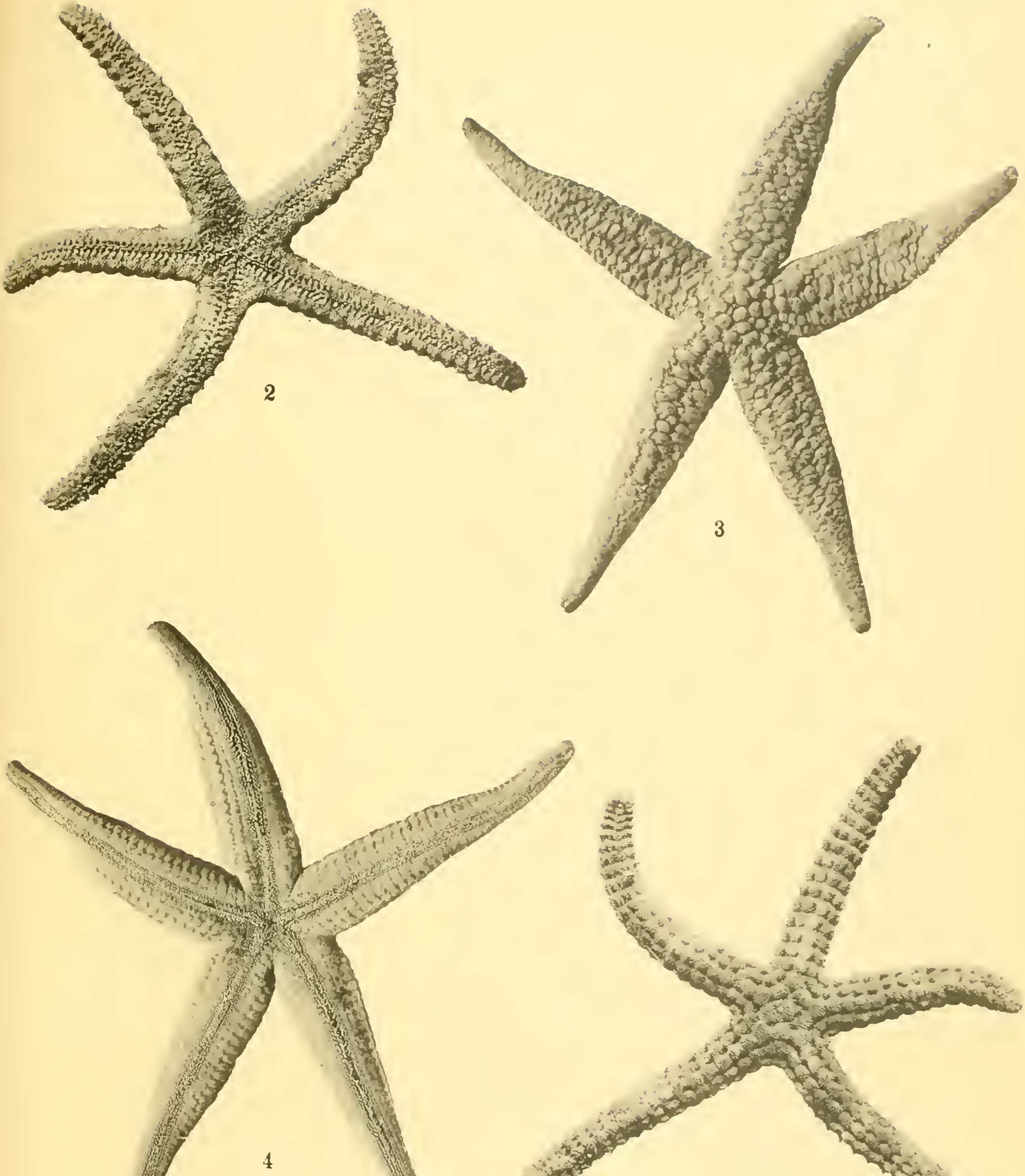
1. Linckia laevigata, aboral surface. X 1.

2. Asterina anomala, paratype, aboral surface. X 2.5.
3. Asterina anomala, paratype, oral surface. X 2.5.

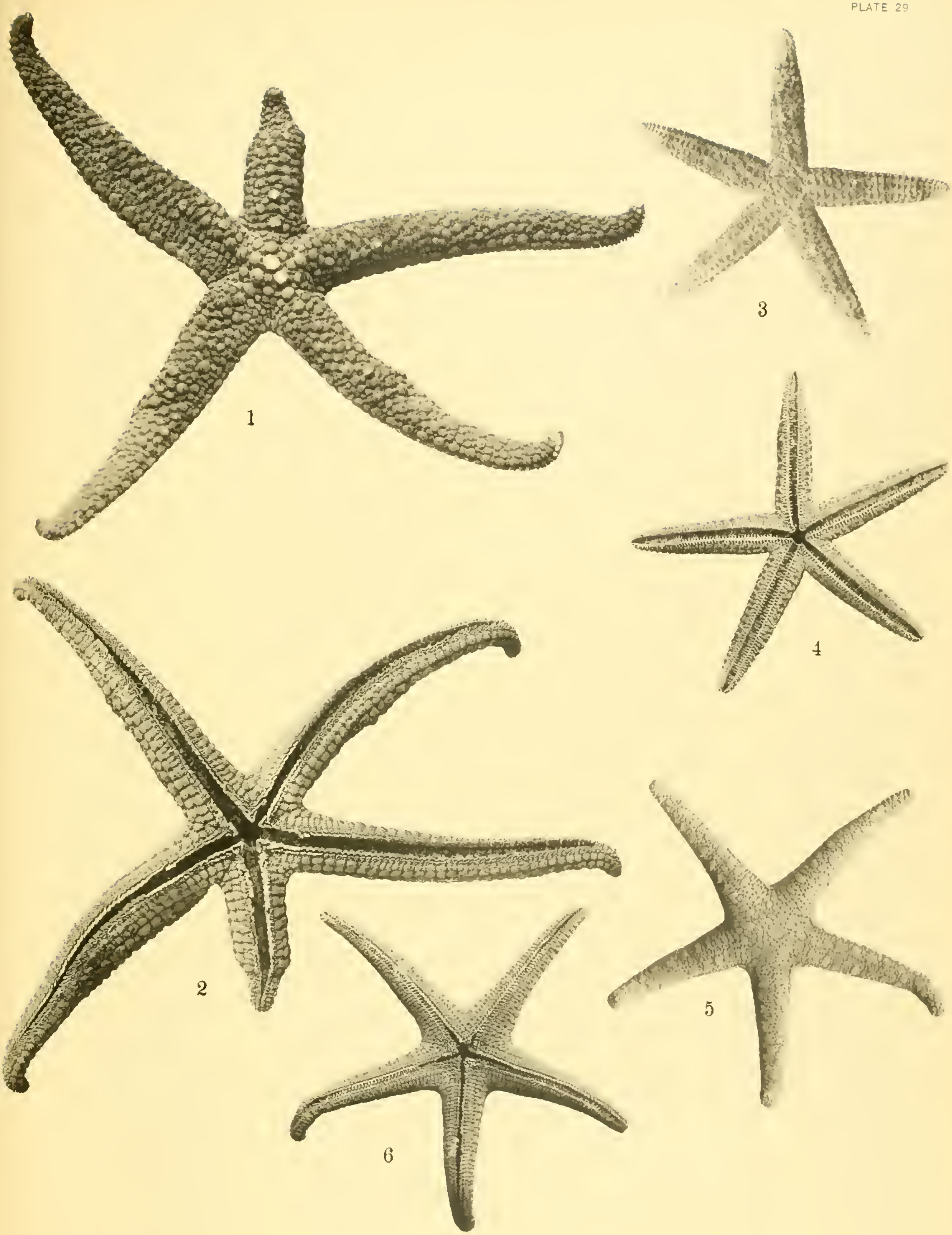
4. Habroporina pulchella, holotype, aboral surface. X 1.
5. Habroporina pulchella, holotype, oral surface. X 1.



1. Leiaster speciosus, aboral surface. X 1.
2. Leiaster speciosus, oral surface. X 1.
3. Ophidiaster liodema, holotype, aboral surface. X 1.
4. Ophidiaster liodema, holotype, oral surface. X 1.

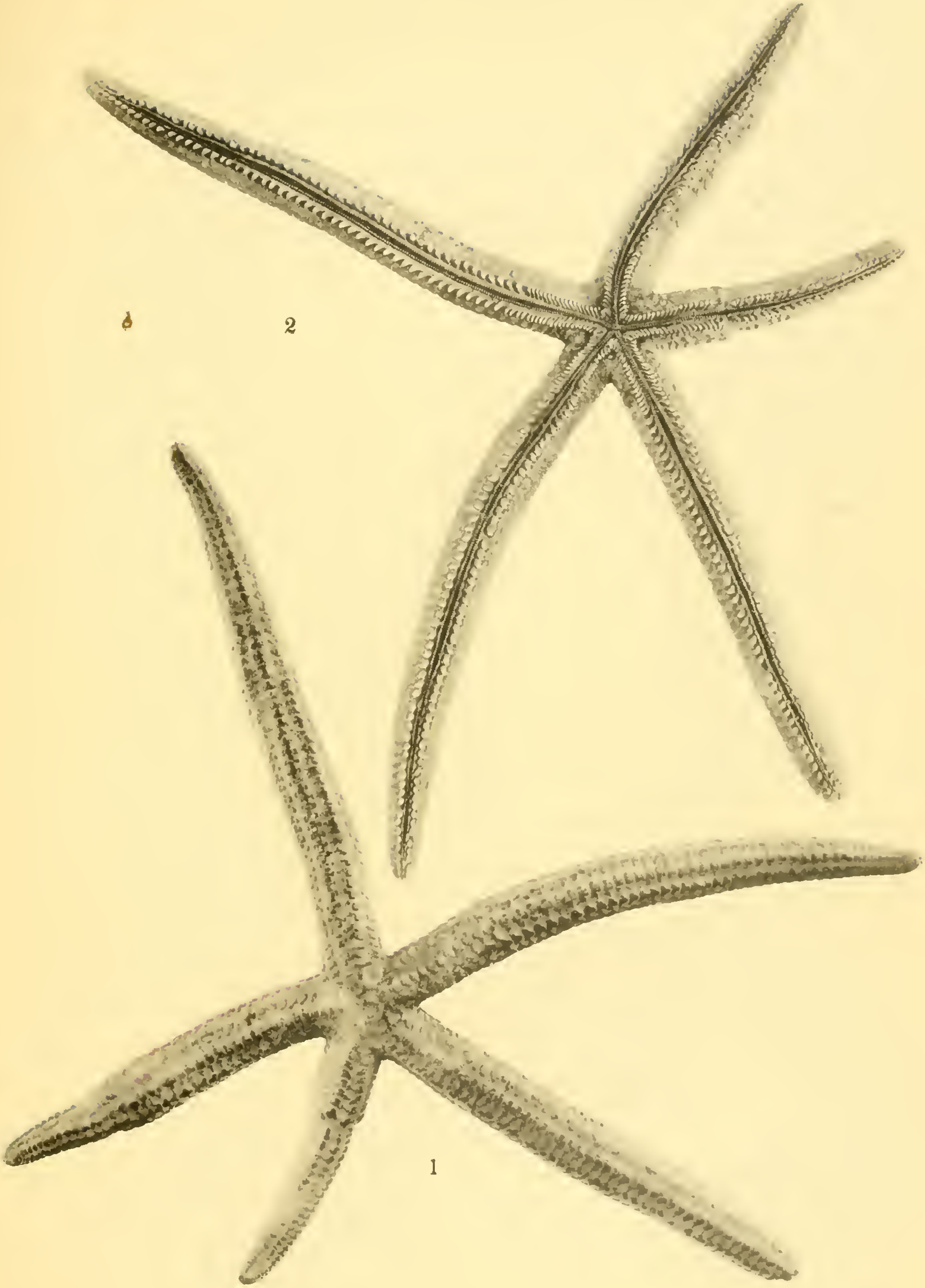


1. Tamaria fusca, aboral surface. X 2.5.
2. Tamaria fusca, oral surface. X 2.5.
3. Nardoa variolata, aboral surface. X 0.9.
4. Nardoa variolata, oral surface. X 0.9.

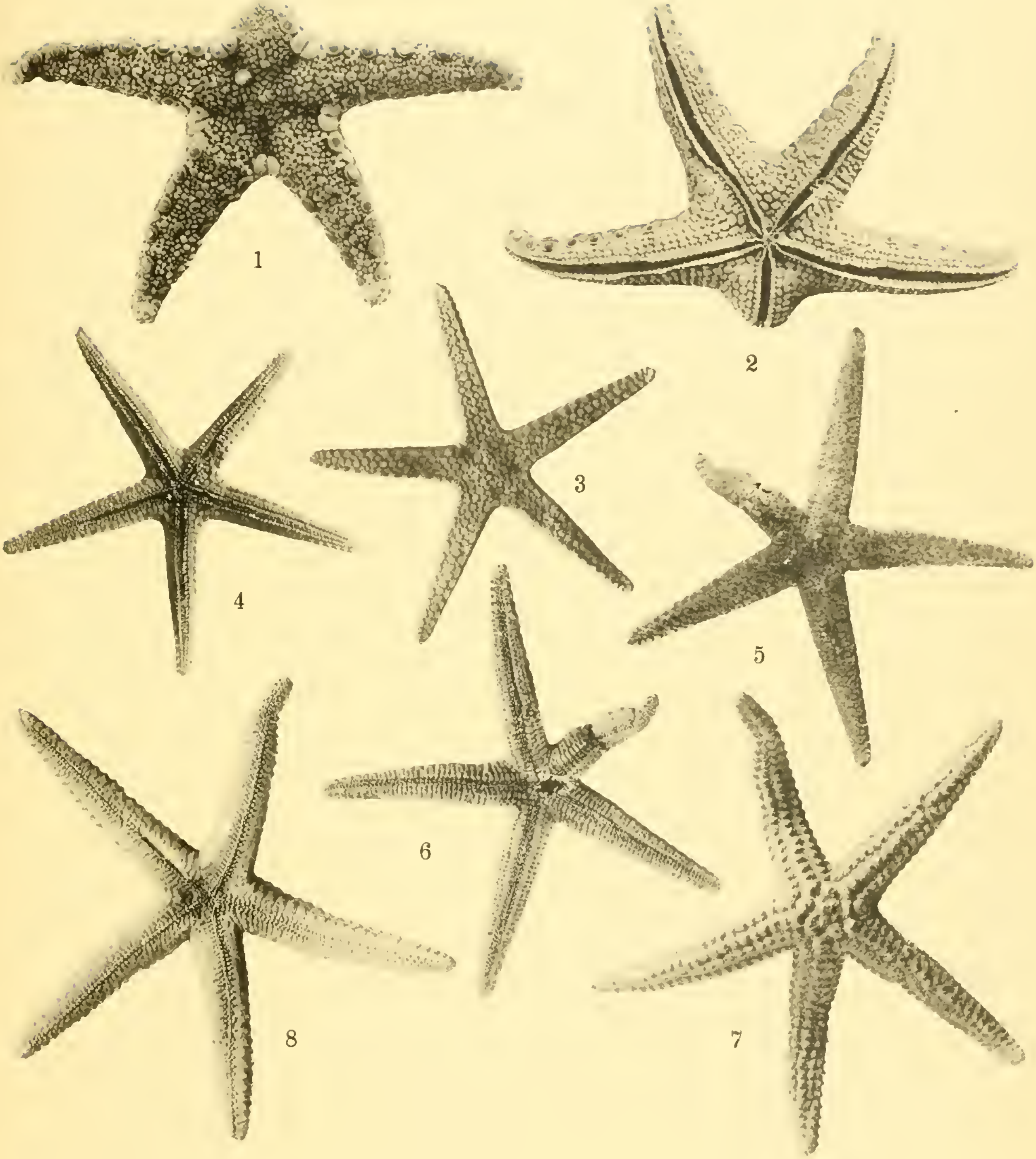


1. Nardoa rosea, holotype, aboral surface. X 1.
2. Nardoa rosea, holotype, oral surface. X 1.
3. Ophidiaster granifer, aboral surface. X 1.
4. Ophidiaster granifer, oral surface. X 1.
5. Fromia elegans, holotype, aboral surface. X 1.
6. Fromia elegans, holotype, oral surface. X 1.

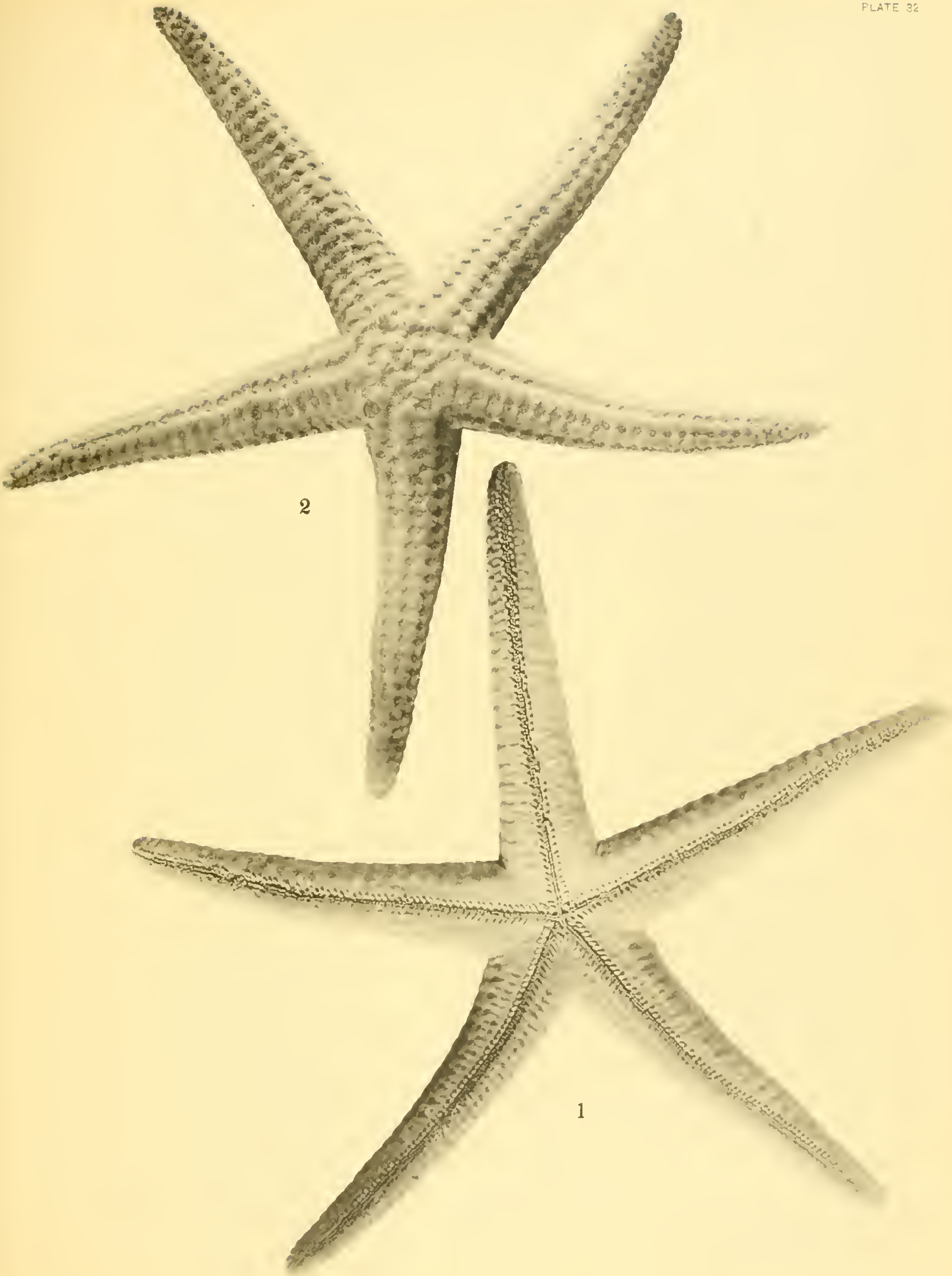
PLATE 30



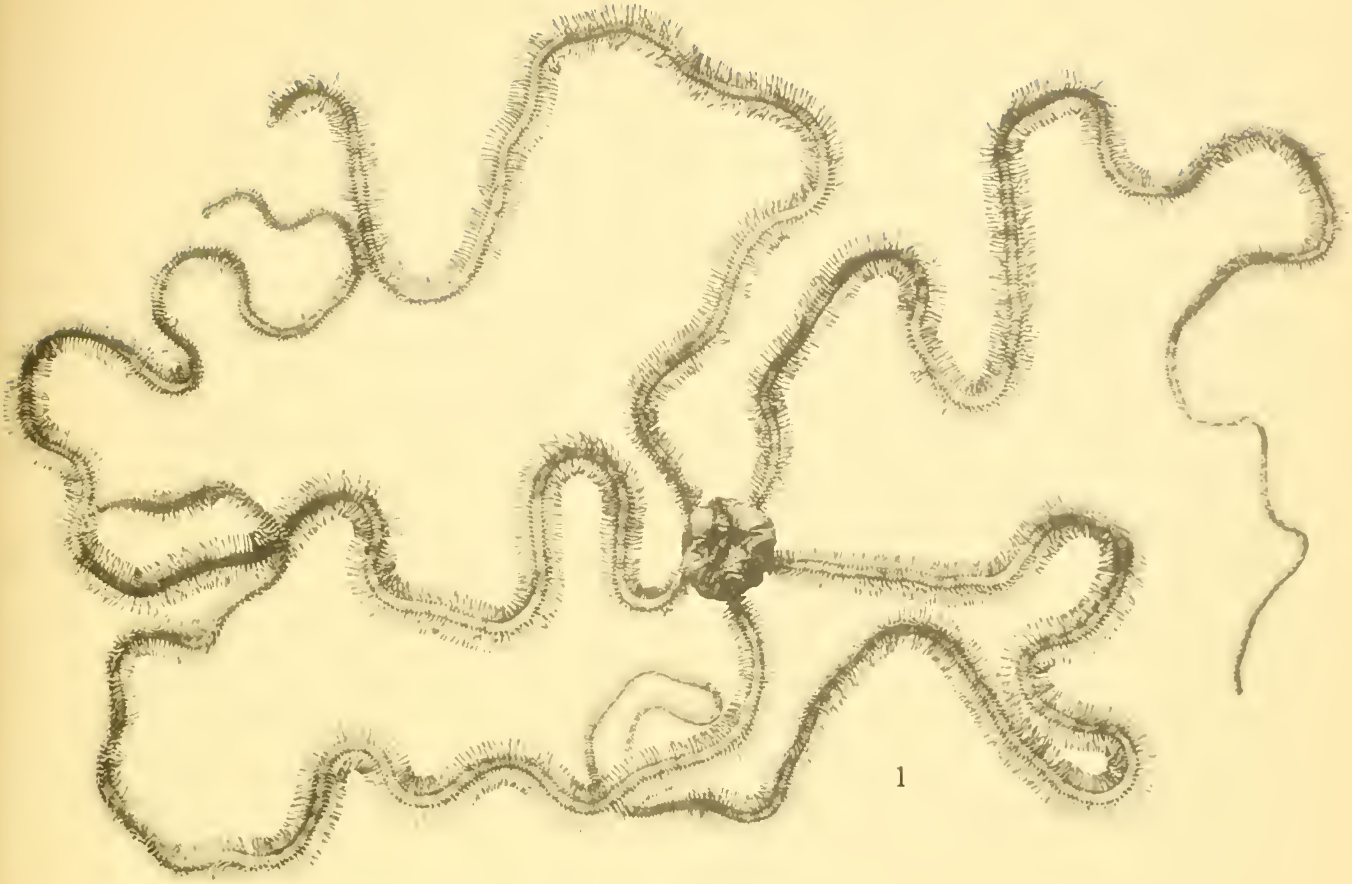
1. Leiaster brevispinus, holotype, aboral surface. X 1.
2. Leiaster brevispinus, holotype, oral surface. X 1.



1. Ferdina ocellata, holotype, aboral surface. X 1.
2. Ferdina ocellata, holotype, oral surface. X 1.
3. Fromia hadracantha, holotype, aboral surface. X 1.
4. Fromia hadracantha, holotype, oral surface. X 1.
5. Fromia pacifica, holotype, aboral surface. X 1.
6. Fromia pacifica, holotype, oral surface. X 1.
7. Tamaria lithosora, holotype, aboral surface. X 1
8. Tamaria lithosora, holotype, oral surface. X 1.



1. Hacelia superba, holotype, oral surface. X 1.
2. Hacelia superba, holotype, aboral surface. X 1.



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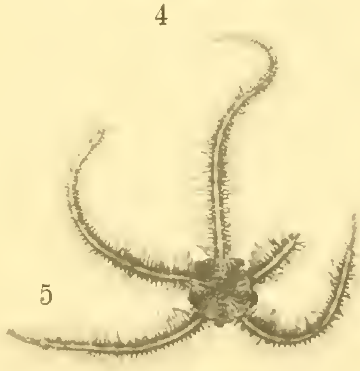

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3

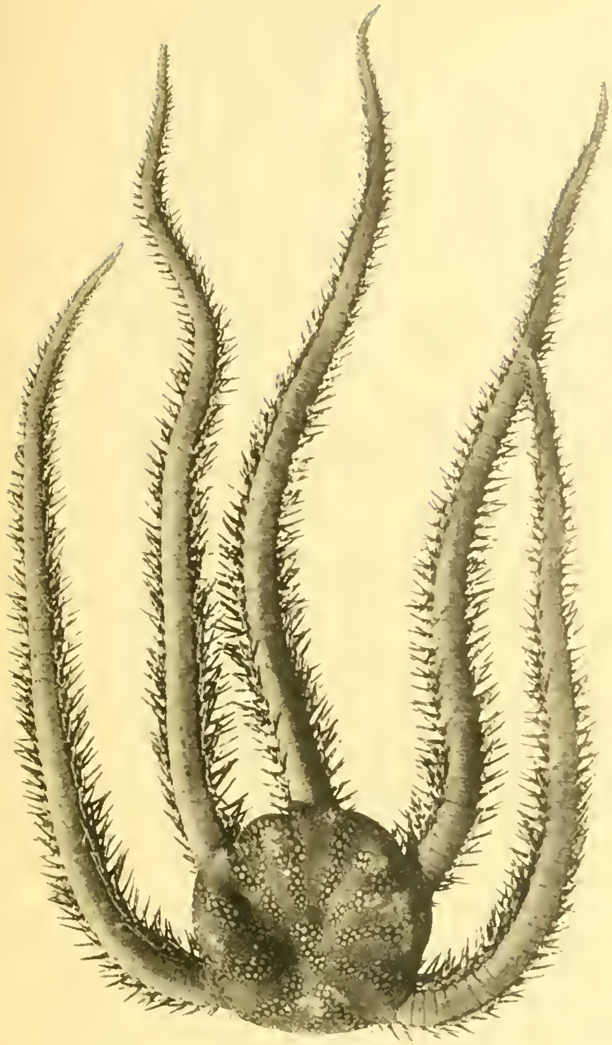
1. Ophiothrix longipeda, aboral surface. X 0.75.

2. Ophionereis porrecta, aboral surface. X 1.

3. Ophionereis porrecta, oral surface. X 1.

4. Ophiothrix trilineata, aboral surface. X 1.

5. Ophiothrix trilineata, aboral surface. X 1.



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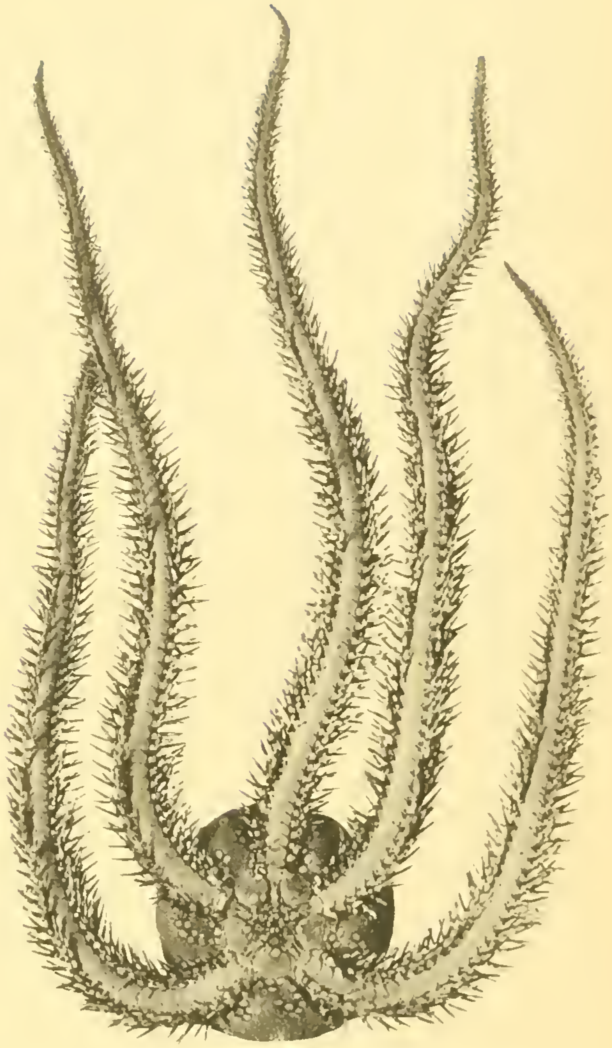

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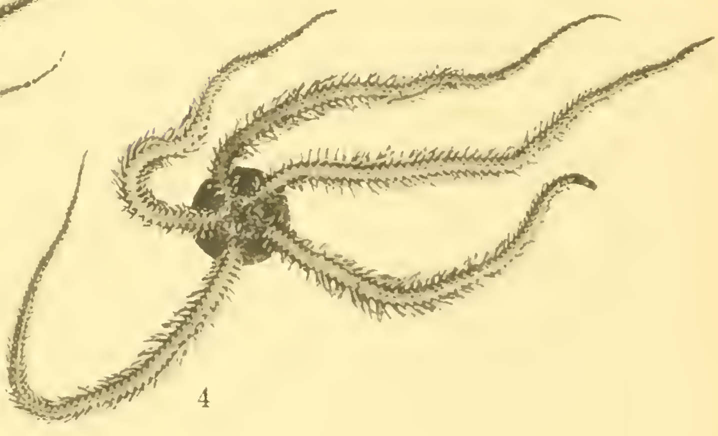

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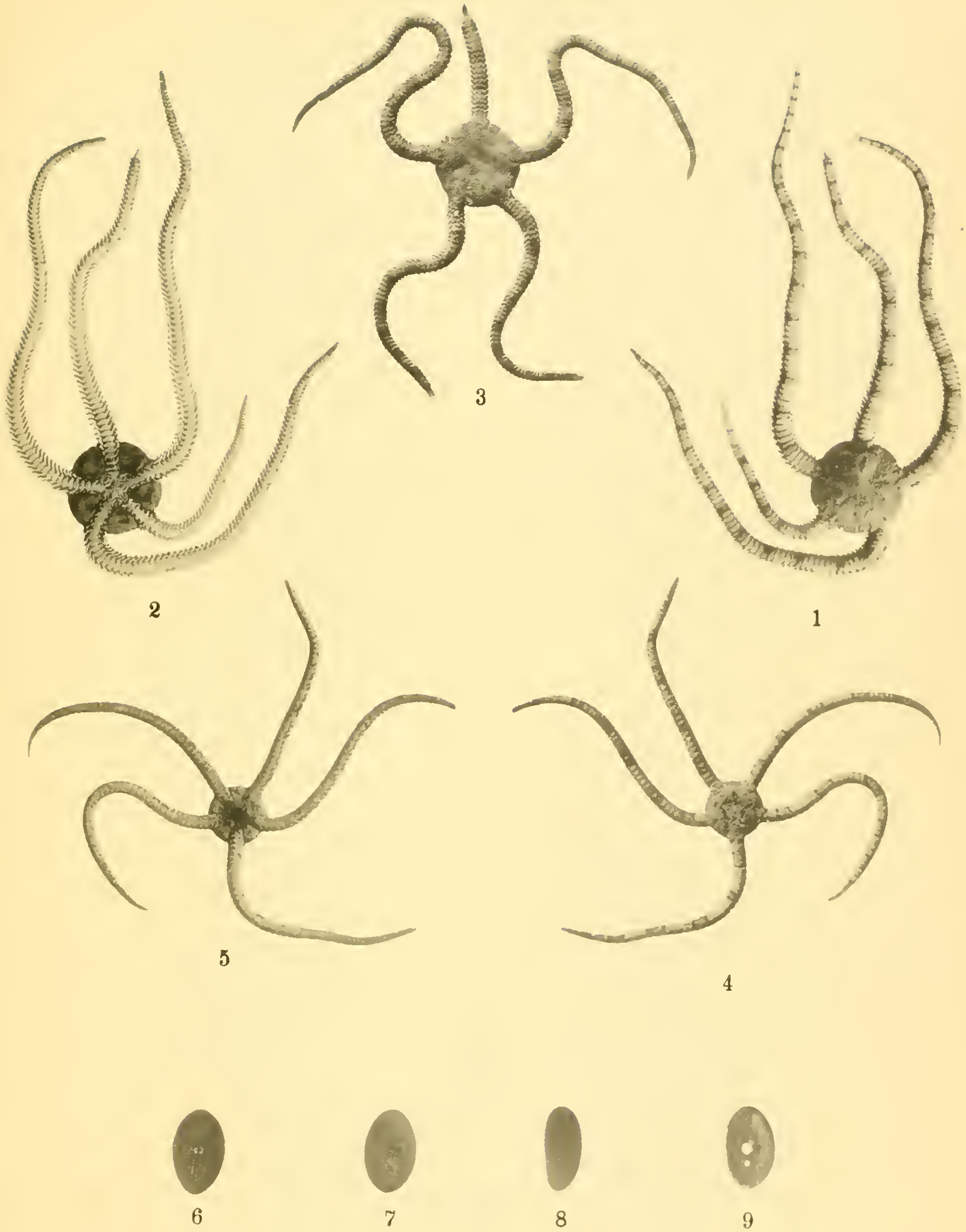
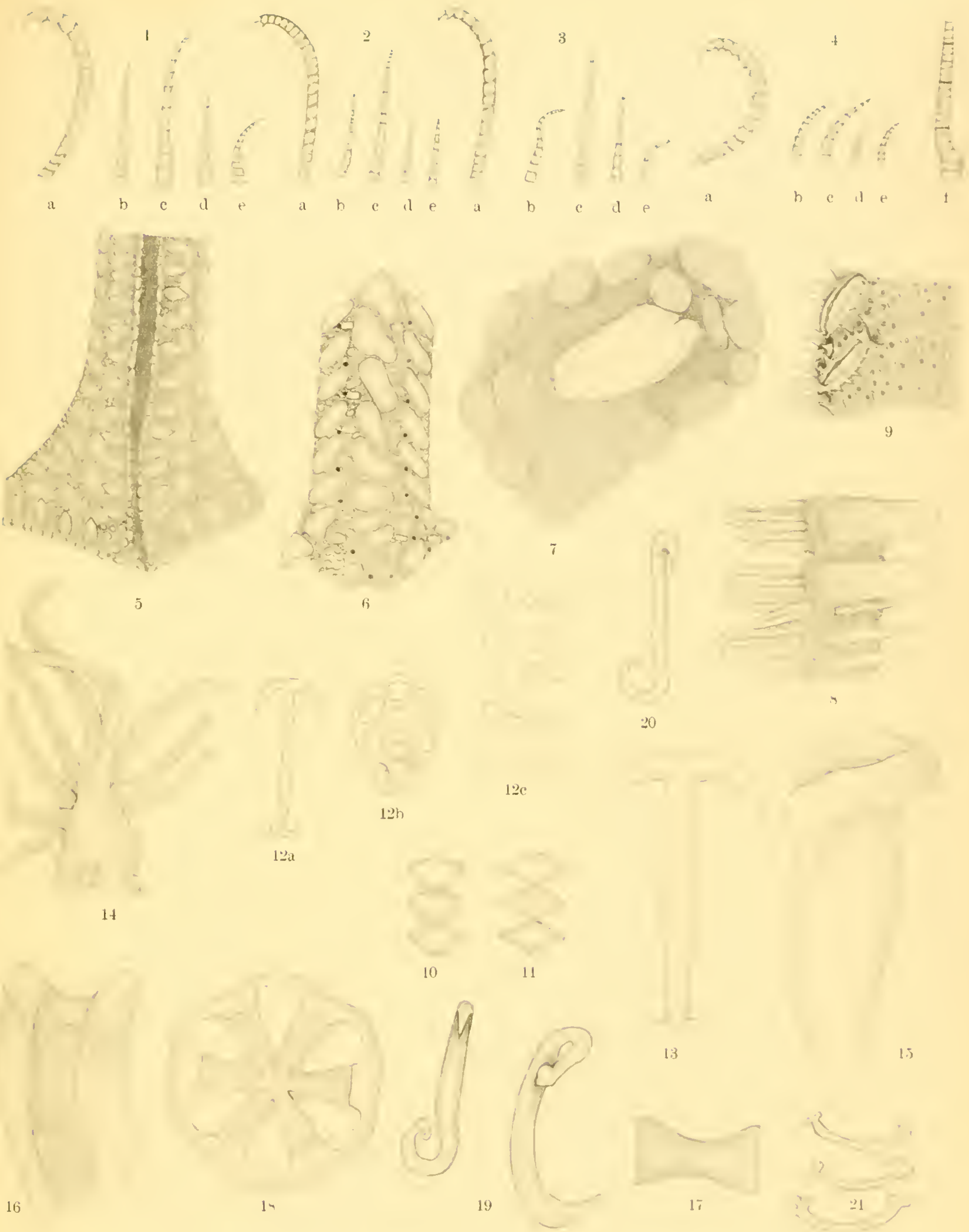
1. Ophiarachna incrassata, aboral surface. X 1.
2. Ophiarachna incrassata, oral surface. X 1.
3. Ophiocoma brevipes, aboral surface. X 1.
4. Ophiocoma brevipes, oral surface. X 1

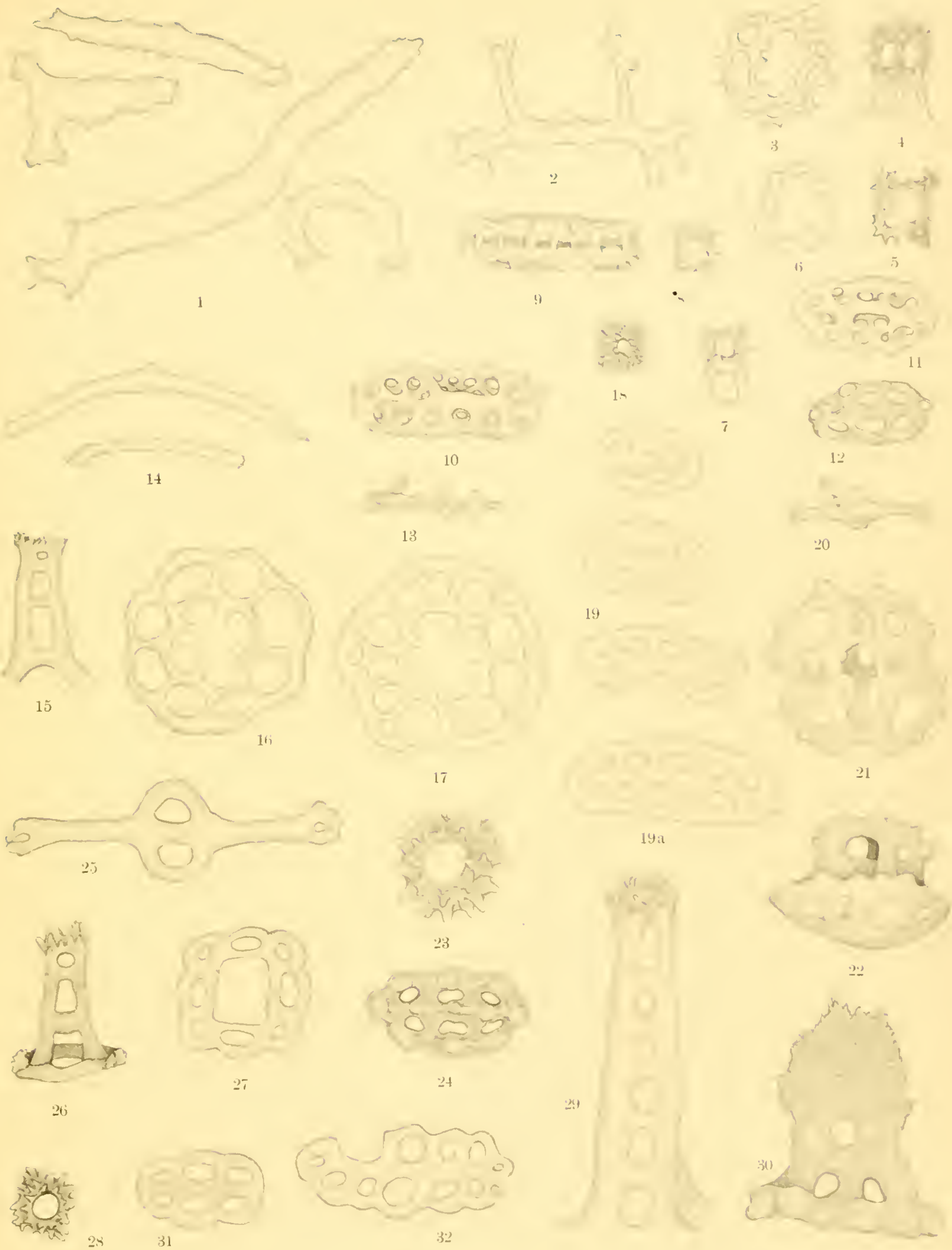


1. Ophioplocus imbricatus, aboral surface. X 1.
2. Ophioplocus imbricatus, oral surface. X 1.
3. Ophioplocus imbricatus, aboral surface of specimen with heavily marked disk. X 1.
4. Ophiarachnella gorgonia, aboral surface. X 1.
5. Ophiarachnella gorgonia, oral surface. X 1.
6. Fibularia volva (?), aboral surface. X 1.
7. Fibularia volva (?), oral surface. X 1.
8. Fibularia volva (?), side view. X 1.
9. Fibularia volva (?), interior view of oral half of test. X 1.



ECHINODERMS FROM TORRES STRAITS.

ECHINODERMS FROM TORRES STRAITS.



ECHINODERMS FROM TORRES STRAITS.