

# Crustacea Cirripedia Thoracica: Chionelasmatoidea and Pachylasmatoidea (Balanomorpha) of New Caledonia, Vanuatu and Wallis and Futuna Islands, with a review of all currently assigned taxa

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## ABSTRACT

Balanomorph barnacles of the superfamilies Chionelasmatoidea and Pachylasmatoidea collected by various French deep-sea expeditions in the waters of New Caledonia, Vanuatu, and the Wallis and Futuna Islands are discussed. One sample from the Marianas Islands is also included. Of the 21 species reported herein, 18 are new to science, 2 are recognised as relictual, and 1 represents a northward range extension within the waters of the southwestern Pacific Ocean. In addition 4 new genera and 1 new subfamily are described. An exceptional diversity of species occurs in the subfamilies Pachylasmatinae and Hexelasmatinae of the family Pachylasmatidae. The number of new pachylasmatines described represents 46% of the known species and that of the new hexelasmatines 40%, indicating the richness of these waters. Of the 17 new species described from the waters of New Caledonia, Vanuatu, and the Wallis and Futuna Islands, 14 are considered presently to be endemic to the Vanuatu/New Caledonian region and the remaining 3 occur in a broader area which includes the Futuna and Wallis Islands region. The richest fauna occurs at the Loyalty Islands (15 species), the Norfolk Ridge (11 species) and New Caledonia (11 species). The occurrence of 2 relictual species, the chionelasmatine *Chionelasmus darwini* and the eolasmatine *Waikalasma boucheti*, in the waters of the New Caledonian region supports the hypothesis that the southwestern Pacific is a relictual area.

## RÉSUMÉ

**Crustacea Cirripedia Thoracica : Chionelasmatoidea et Pachylasmatoidea (Balanomorpha) de Nouvelle-Calédonie, du Vanuatu et des îles Wallis et Futuna, avec un examen de toutes les espèces reconnues actuellement.**

Les cirrripèdes balanomorphes des superfamilles Chionelasmatoidea et Pachylasmatoidea, récoltés par diverses expéditions françaises en eau profonde, au large de la Nouvelle-Calédonie, du Vanuatu et des îles Wallis et Futuna, sont

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JONES, D., 2000. — Crustacea Cirripedia Thoracica: Chionelasmatoidea and Pachylasmatoidea (Balanomorpha) of New Caledonia, Vanuatu and Wallis and Futuna Islands, with a review of all currently assigned taxa. In: A. CROSNIER (ed.), Résultats des Campagnes MUSORSTOM, Volume 21. *Mémoires du Muséum national d'Histoire naturelle*, **184**: 141-283. Paris ISBN 2-85653-526-7.



étudiés. Une récolte provenant des îles Mariannes est également examinée. Des 21 espèces comprises dans ce travail, 18 sont nouvelles pour la Science, deux sont considérées comme des espèces reliques et une voit son aire de répartition accrue vers le Nord. En outre, quatre nouveaux genres et une nouvelle sous-famille sont décrits. Une diversité d'espèces exceptionnelle est rencontrée dans les sous-familles Pachylasmatinae et Hexelasmatinae de la famille Pachylasmatidae. Les nouvelles pachylasmatines décrites représentent 46% des espèces connues et celles des hexelasmatines 40%, ceci montrant bien la richesse des eaux prospectées. Sur les 17 espèces décrites des eaux de la Nouvelle-Calédonie, du Vanuatu et des îles Wallis et Futuna, 14 sont considérées actuellement comme endémiques de l'ensemble Nouvelle-Calédonie et Vanuatu; les trois restantes ont été trouvées dans une zone plus étendue incluant les îles Wallis et Futuna. Les faunes les plus riches se trouvent aux îles Loyauté (15 espèces), sur la rive de Norfolk (11 espèces) et en Nouvelle-Calédonie (11 espèces également). La présence, dans les eaux de la Nouvelle-Calédonie, de deux "fossiles vivants", le chionelasmatine *Chionelasmus darwini* et l'eolasmatine *Waikalasma boucheti*, renforce l'hypothèse que le Pacifique sud-ouest est une zone refuge.

## INTRODUCTION

Since 1978 numerous specimens of balanomorph barnacles have been collected in the deep waters off Vanuatu (MUSORSTOM 8, 1994), New Caledonia, the Chesterfield and Loyalty Islands ("Vauban", 1978-79; BIOCAL, 1985; MUSORSTOM 4, 1985; LAGON, 1984-89; MUSORSTOM 5, 1986; CHALCAL 2, 1986; SMIB 2, 1986; SMIB 3, 1987; CORAIL 2, 1988; MUSORSTOM 6, 1989; SMIB 6, 1990; BERYX 2, 1992; BATHUS 2, 1993; SMIB 8, 1993; HALIPRO 2, 1996), the Wallis and Futuna Islands, Combe, Field, Tuscarora and Waterwich Banks (MUSORSTOM 7, 1992), the Norfolk Ridge (SMIB 4, 1989; SMIB 5, 1989; BATHUS 3, 1993; BATHUS 4, 1994) and the Matthew and Hunter Islands (VOLSMAR, 1989).

Information on the cruises where the samples studied here were collected can be found in RICHER DE FORGES, *et al.* (1988) for CORAIL 2; RICHER DE FORGES (1990) for "Vauban" 1978-79, BIOCAL, CHALCAL 2, MUSORSTOM 4, 5 and 6, SMIB 2, 3 and 4; RICHER DE FORGES (1991) for LAGON; RICHER DE FORGES (1993) for VOLSMAR, SMIB 5 and 6, BERYX 2; RICHER DE FORGES & MENOU (1993) for MUSORSTOM 7; RICHER DE FORGES, FALIEUX & MENOU (1996) for MUSORSTOM 8; RICHER DE FORGE & CHEVILLON (1996) for BATHUS 2, 3 and 4, SMIB 8; GRANDPERRIN *et al.* (1997) for HALIPRO 2.

Examination of these collections has yielded an exceptional diversity of thoracican cirripeds. Of particular interest are the numerous specimens that are herein assigned to the balanomorph superfamily Pachylasmatoidae, especially within the pachylasmatine genus *Pachylasma* and the hexelasmatine genus *Hexelasma*, both of which are included in the family Pachylasmatidae. These specimens are reported on herein, together with specimens from the superfamily Chionelasmatoidea. A separate paper will report on the remaining balanomorph taxa collected by the above expeditions.

The Indo-Pacific deep-sea benthos was investigated by major expeditions such as those of "Challenger" (1873-1876), "Investigator" (1884-1887), "Valdivia" (1898-1899), "Siboga" (1899-1900), "Albatross" (1907-1910) and "Galathea" (1950-52). However, none of these expeditions collected Cirripedia in the waters of Vanuatu, New Caledonia or the Wallis and Futuna Islands. The cirriped fauna of the region is known from the brief report of FISCHER (1884), who described the shallow water barnacles of New Caledonia. More recently, BUCKERIDGE (1994) provided a comprehensive account of the deep-sea Verrucomorpha from collections made by several French cruises in the New Caledonia area and the Wallis and Futuna Islands, ROSS and NEWMAN (1995) described a new *Hoekiini* from the shallow waters of New Caledonia and BUCKERIDGE (1998) described a new chionelasmatine from the Norfolk Ridge.

The present paper includes the description of 23 new taxa — 1 new subfamily, 4 new genera and 18 new species. Also included are diagnoses and discussions of the previously reported species included in the Chionelasmatoidea and the Pachylasmatoidae. Thus, *in toto*, this account covers 1 family, 2 genera, 3 species and 2 subspecies of Chionelasmatoidea and, within the Pachylasmatoidae, 1 family, 5 subfamilies, 13 genera and 50 species. My evaluation of certain species suggests some are transferred into new genera, other are re-assigned elsewhere. The diagnosis of *Tetrapachylasma* Foster, 1988 is emended to reflect the intra-specific variation now



recognised within this genus. Wall structure in the Chionelasmatoidea and the Pachylasmatoidea is discussed in relation to balanomorph wall organisation. Endemism and species diversity, and the significance of antenniformy, reproductive state and regression and/or loss of the penis are also discussed.

Informations on the types of the species mentioned in this paper are supplied where possible. When a chapter "TYPES" is missing, no information was obtained for the species considered.

**MATERIALS AND METHODS.** — Specimens were examined with the aid of microscopy and dissection. Illustrations of the shell and whole animal were made with aid of a camera lucida. Soft parts were cleared, stained and mounted following the method of JONES (1993a) and mouthparts and appendages were drawn with a camera lucida. Measurements given are all in millimeters. The terminology follows that of NEWMAN (1987), JONES (1990) and YAMAGUCHI & NEWMAN (1990).

**ABBREVIATIONS.** — Institutions are abbreviated as follows:

**AM:** Australian Museum, Sydney, New South Wales, Australia;  
**AR:** New Zealand Geological Survey Type Numbers, Auckland, New Zealand;  
**AU:** Geology Department, University of Auckland, New Zealand;  
**BMNH:** The Natural History Museum, London, U.K.;  
**GS:** New Zealand Geological Survey, Auckland, New Zealand;  
**MNHN:** Muséum national d'Histoire naturelle, Paris, France;  
**NIWA:** National Institute of Water and Atmospheric Research, Wellington, New Zealand;  
**NMNZ:** Museum of New Zealand, Wellington, New Zealand;  
**NZOI:** New Zealand Oceanographic Institute, Wellington, New Zealand;  
**SOSC:** Smithsonian Oceanographic Sorting Center, Washington, U.S.A.;  
**UMUT:** University Museum of the University of Tokyo, Japan;  
**UPIBM:** Invertebrate Museum of the Institute of Biology, College of Science, University of the Philippines;  
**USNM:** National Museum of Natural History, Washington, D.C., U.S.A.;  
**WAM:** Western Australian Museum, Perth, Western Australia;  
**YPM:** Peabody Museum of Natural History, Yale University, New Haven, CT., U.S.A.;  
**ZMC:** Zoologisk Museum, Copenhagen, Denmark;  
**ZMUA:** Zoologisch Museum, Universiteit van Amsterdam, Holland.

Within the text the following abbreviations are used: **c.a.** for caudal appendage; **C** for carina, **CL** for carinolateral, **CL<sup>1</sup>** for primary carinolateral, **CL<sup>2</sup>** for secondary carinolateral, **CI** to **CVI** for cirri I to VI; **LD** for lateral dimension; **m** for meter; **mls** for miles; **R** for rostrum, **RC** for rostro-carinal; **RL** for rostrrolateral, **rg** for range; **S** for scutum; **T** for tergum;  $\bar{x}$  for average.

In the lists of material examined the capital letters preceding the station numbers refer to the gear used: **BT** bottom trawl (large otter trawl for fishes); **CC** otter trawl (shrimps), **CH** otter trawl (fishes), **CP** beam trawl, **DE** epibenthic sledge, **DW** Waren dredge.

The acronyms for the cruises that collected the material reported on herein are as follows:

**ANZARE** = Australian and New Zealand Antarctic Research Expedition, 1913;  
**BATHUS** = the Greek Latinised name for deep;  
**BERYX** = cruises on the seamounts around New Caledonia studying stocks of the fish *Beryx*;  
**BIOCAL** = **BIO**logie en Nouvelle **CAL**édonie (a trawling cruise);  
**CHALCAL** = **CHAL**utages en Nouvelle **CAL**édonie (trawling cruises around New Caledonia);  
**CORAIL** = cruises around the Chesterfield Islands which are in the **CORAIL** (Coral) Sea;  
**HALIPRO** = **HAL**ieutique **PRO**fonde (deep fisheries);  
**LAGON** = **LAGON** de Nouvelle Calédonie (study of the benthos);  
**MUSORSTOM** = a contraction of **MUS**éum (national d'Histoire naturelle) and **ORSTOM** (**O**ffice de la **R**echerche Scientifique et **T**echnique **O**utre-Mer);  
**NAGA** = the name of a mythical sea dragon.



SMIB = Substances Marine d'Intérêt Biologique;

TUI = a New Zealand cruise of 1962 on board of the "*Tuiw*" a ship in the Royal New Zealand Navy. *Tui* is the vulgar tongue for a large passeriform bird, known also as the "Parson Bird".

"*Vauban*" = name of the ORSTOM research vessel working in New Caledonia from 1976 to 1988;

VOLSMAR = VOLcans Sous MARins (volcanoes under the sea).

TYPE SPECIES. — All holotypes of the new species are held by the MNHN and, when numbers of specimens available permit, paratypes by the WAM, the BMNH and the USNM.

REGISTRATION NUMBERS. — Due to computerisation of the WAM crustacean collection, starting from 1997, WAM crustacean registration numbers are preceded by C [e.g. WAM C 23243 for specimens of *Chionelasmus darwini* (Pilsbry, 1907) from SMIB 8: stn CP 180]. Prior to this date a different numbering system existed (e.g., WAM 261-96 for *C. darwini* from BATHUS 3: stn CP 812). MNHN registration numbers are prefixed by Ci and ZMUA registration numbers by Cirr, which refer to the respective cirriped collections. NMNZ registration numbers are prefixed by Cr and ZMC numbers by Cru, which refer to the respective crustacean collections. AM numbers prefixed by E refer to dry specimens and prefixed by P to wet (alcohol) specimens.

The samples without any registration number are kept at the Muséum national d'Histoire naturelle, Paris.

## COMBINED LIST OF STATIONS AND OF SPECIES OBTAINED PER STATION

### LAGON. New Caledonia.

Station 444. — 28.02.1985, 18°15'S, 162°59'E, 300-350 m: *Pachylasma ovatum* sp. nov.

Station 491. — 03.03.1985, 18°56'S, 163°20'E, 450 m: *Hexelasma sandaracum* sp. nov.

### BIOCAL. Loyalty Islands.

Station DW 36. — 29.08.1985, 23°09'S, 167°11'E, 650-680 m: *Hexelasma sandaracum* sp. nov.

Station DW 44. — 30.08.1985, 22°47.3'S, 167°14.3'E, 440 m: *Eutomolasma macLaughlinae* sp. nov.

Station CP 45. — 30.08.1985, 22°47'S, 167°15'E, 430-465 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma globosum* sp. nov.

Station DW 66. — 03.09.1985, 24°55'S, 168°22'E, 505-515 m: *Chionelasmus darwini* (Pilsbry), *Hexelasma persicum* sp. nov.

Station CP 67. — 03.09.1985, 24°55'S, 168°22'E, 500-510 m: *Chionelasmus darwini* (Pilsbry).

Station DW 83. — 06.09.1985, 20°35'S, 166°54'E, 460 m: *Eutomolasma orbiculatum* sp. nov.

### MUSORSTOM 4. New Caledonia.

Station DW 156. — 15.09.1985, 18°54.0'S, 163°18.8'E, 525 m: *Hexelasma aureolum* sp. nov., *H. globosum* sp. nov., *H. sandaracum* sp. nov.

Station CP 157. — 15.09.1985, 18°52.5'S, 163°16.9'E, 575 m: *Hexelasma sandaracum* sp. nov.

Station DW 159. — 15.09.1985, 18°45.9'S, 163°15.6'E, 585 m: *Hexelasma persicum* sp. nov., *H. sandaracum* sp. nov.

Station CP 167. — 16.09.1985, 18°35.8'S, 163°06.4'E, 575 m: *Hexelasma globosum* sp. nov., *H. sandaracum* sp. nov.

Station CP 169. — 17.09.1985, 18°54.3'S, 163°11.2'E, 590 m: *Hexelasma sandaracum* sp. nov.

Station CP 170. — 17.09.1985, 18°57.0'S, 163°12.6'E, 460 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma sandaracum* sp. nov.

Station CP 178. — 18.09.1985, 18°56.3'S, 163°12.9'E, 520 m: *Hexelasma sandaracum* sp. nov.

Station CP 179. — 18.09.1985, 18°56.6'S, 163°13.7'E, 475 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma persicum* sp. nov.

Station DW 183. — 18.09.1985, 19°01.8'S, 163°25.8'E, 280 m: *Eutomolasma macLaughlinae* sp. nov.



- Station CP 190. — 19.09.1985, 19°06'S, 163°29.50'E, 215 m: *Pachylasma laeviscutum* sp. nov.  
 Station CP 193. — 19.09.1985, 18°56.3'S, 163°23.2'E, 415 m: *Pachylasma ovatum* sp. nov.  
 Station CP 194. — 19.09.1985, 18°52.8'S, 163°21.7'E, 545 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 197. — 20.09.1985, 18°51.3'S, 163°21.0'E, 550 m: *Hexelasma globosum* sp. nov., *H. persicum* sp. nov., *H. sandaracum* sp. nov.  
 Station DW 215. — 28.09.1985, 22°55.7'S, 167°17.0'E, 485-520 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 221. — 29.09.1985, 22°58.60'S, 167°36.80'E, 535-560 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 222. — 30.09.1985, 22°57.6'S, 167°33.0'E, 410-440 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma persicum* sp. nov.  
 Station DW 223. — 30.09.1985, 22°57.0'S, 167°30.0'E, 545-560 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma persicum* sp. nov.  
 Station DW 229. — 30.09.1985, 22°51.5'S, 167°13.5'E, 445-460 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 230. — 30.09.1985, 22°52.5'S, 167°11.8'E, 390-420 m: *Eutomolasma macLaughlinae* sp. nov., *Pachylasma laeviscutum* sp. nov.  
 Station CP 238. — 02.10.1985, 22°13.0'S, 167°14.0'E, 500-510 m: *Chionelasmus darwini* (Pilsbry), *Hexelasma aureolum* sp. nov.

### SMIB 2. Norfolk Ridge.

- Station DW 1. — 17.09.1986, 22°53'S, 167°13'E, 438-444 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 2. — 17.09.1986, 22°55'S, 167°14'E, 438-448 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 12. — 18.09.1986, 22°53'S, 167°14'E, 445-460 m: *Eutomolasma macLaughlinae* sp. nov.

### MUSORSTOM 5. Chesterfield Islands.

- Station DW 255. — 07.10.1986, 25°15.40'S, 159°54.80'E, 280-295 m: *Tetrapachylasma arcuatum* sp. nov.  
 Station DW 301. — 12.10.1986, 22°06.90'S, 159°24.60'E, 487-610 m: *Tetrapachylasma arcuatum* sp. nov.  
 Station DW 304. — 12.10.1986, 22°10.34'S, 159°25.51'E, 385-420 m: *Tetrapachylasma arcuatum* sp. nov.  
 Station DW 338. — 15.10.1986, 19°51.6'S, 158°40.40'E, 540-580 m: *Hexelasma aureolum* sp. nov., *H. persicum* sp. nov.  
 Station DC 388. — 22.10.1986, 20°45.35'S, 160°53.69'E, 500-510 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station CP 389. — 22.10.1986, 20°44.95'S, 160°53.67'E, 500 m: *Hexelasma aureolum* sp. nov.

### CHALCAL 2. Norfolk Ridge.

- Station CC 1. — 28.10.1986, 24°54.96'S, 168°21.91'E, 500 m: *Chionelasmus darwini* (Pilsbry).  
 Station CC 2. — 28.10.1986, 24°55.48'S, 168°21.29'E, 500 m: *Chionelasmus darwini* (Pilsbry).  
 Station CH 4. — 27.10.1986, 24°44.31'S, 168°09.32'E, 253 m: *Tetrapachylasma arcuatum* sp. nov.  
 Station CH 9. — 31.10.1986, 23°15.64'S, 168°03.06'E, 300 m: *Hexelasma persicum* sp. nov.  
 Station CP 21. — 28.10.1986, 24°54.00'S, 168°21.61'E, 500 m: *Chionelasmus darwini* (Pilsbry).  
 Station DW 72. — 28.10.1986, 24°54.5'S, 168°22.3'E, 527 m: *Hexelasma aureolum* sp. nov.  
 Station DW 74. — 29.10.1986, 24°40.36'S, 168°38.39'E, 650 m: *Chionelasmus darwini* (Pilsbry).  
 Station DW 75. — 29.10.1986, 24°39.31'S, 168°39.67'E, 600 m: *Chionelasmus darwini* (Pilsbry).  
 Station DW 76. — 30.10.1986, 23°40.50'S, 167°45.20'E, 470 m: *Chionelasmus darwini* (Pilsbry), *Hexelasma aureolum* sp. nov.  
 Station DW 77. — 30.10.1986, 23°38.35'S, 167°42.68'E, 435 m: *Chionelasmus darwini* (Pilsbry).

### SMIB 3. Norfolk Ridge.

- Station DW 5. — 21.05.1987, 24°55'S, 168°22'E, 502-512 m: *Hexelasma aureolum* sp. nov.  
 Station DW 21. — 24.05.1987, 22°59'S, 167°19'E, 525 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 22. — 24.05.1987, 23°03'S, 167°19'E, 503 m: *Eutomolasma macLaughlinae* sp. nov.  
 Station DW 24. — 24.05.1987, 22°59'S, 167°19'E, 525 m: *Chionelasmus darwini* (Pilsbry), *Eutomolasma macLaughlinae* sp. nov.



Station DW 25. — 24.05.1987, 22°56'S, 167°16'E, 437 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 27. — 24.05.1987, 22°55'S, 167°16'E, 457 m: *Eutomolasma macLaughlinae* sp. nov.

#### CORAIL 2. **Chesterfield Islands.**

Station DE 16. — 21.07.1988, 20°47.75'S, 160°55.87'E, 500 m: *Hexelasma aureolum* sp. nov.

Station CP 17. — 21.09.1988, 20°48.14'S, 160°57.14'E, 500 m: *Hexelasma aureolum* sp. nov.

#### MUSORSTOM 6. **Loyalty Islands/Loyalty Ridge.**

Station DW 400. — 14.02.1989, 20°42.18'S, 167°00.40'E, 270 m: *Hexelasma foratum* sp. nov.

Station CP 401. — 14.02.1989, 20°42.15'S, 167°00.35'E, 270 m: *Pachylasma bacum* sp. nov., *Hexelasma sandaracum* sp. nov.

Station DW 407. — 15.02.1989, 20°40.70'S, 167°06.60'E, 360 m: *Tetrapachylasma arcuatum* sp. nov.

Station DW 421. — 16.02.1989, 20°26.27'S, 166°40.17'E, 245 m: *Microlasma fragile* sp. nov.

Station DW 422. — 16.02.1989, 20°26.20'S, 166°40.31'E, 257 m: *Hexelasma aureolum* sp. nov.

Station DW 424. — 17.02.1989, 20°24.30'S, 166°24.70'E, 599 m: *Hexelasma sandaracum* sp. nov.

Station DW 451. — 20.02.1989, 20°59.00'S, 167°24.50'E, 330 m: *Hexelasma foratum* sp. nov.

Station DW 460. — 20.02.1989, 21°01.70'S, 167°31.45'E, 420 m: *Metlasma crassum* sp. nov., *Hexelasma aureolum* sp. nov.

Station CP 465. — 21.02.1989, 21°03.55'S, 167°32.55'E, 480 m: *Eutomolasma macLaughlinae* sp. nov.

Station CP 466. — 21.02.1989, 21°05.25'S, 167°32.2'E, 540 m: *Eutomolasma macLaughlinae* sp. nov.

Station CP 467. — 21.02.1989, 21°05.13'S, 167°32.11'E, 575 m: *Eutomolasma macLaughlinae* sp. nov.

Station CC 470. — 21.02.1989, 21°04.40'S, 167°33.20'E, 560 m: *Hexelasma sandaracum* sp. nov.

Station CP 471. — 22.02.1989, 21°08.00'S, 167°54.10'E, 460 m: *Tetrapachylasma arcuatum* sp. nov., *Hexelasma sandaracum* sp. nov.

Station DW 472. — 22.02.1989, 21°08.60'S, 167°54.70'E, 300 m: *Tetrapachylasma arcuatum* sp. nov., *Hexelasma flavidum* sp. nov.

Station DW 476. — 22.02.1989, 21°09.36'S, 167°56.40'E, 300 m: *Metlasma crassum* sp. nov., *Hexelasma aureolum* sp. nov.

Station DW 478. — 22.02.1989, 21°08.96'S, 167°54.28'E, 400 m: *Eurylasma angustum* sp. nov., *Tetrapachylasma arcuatum* sp. nov., *Metlasma crassum* sp. nov., *Hexelasma aureolum* sp. nov., *H. persicum* sp. nov.

Station DW 479. — 22.02.1989, 21°09.13'S, 167°54.95'E, 310 m: *Metlasma crassum* sp. nov.

Station DW 483. — 23.02.1989, 21°19.80'S, 167°47.80'E, 600 m: *Hexelasma sandaracum* sp. nov.

Station DW 486. — 23.02.1989, 20°21.40'S, 167°47.65'E, 370 m: *Hexelasma globosum* sp. nov.

#### SMIB 4. **Norfolk Ridge.**

Station DW 44. — 08.03.1989, 24°46.0'S, 168°08.2'E, 300 m: *Hexelasma sandaracum* sp. nov.

Station DW 55. — 09.03.1989, 23°21.4'S, 168°04.5'E, 260 m: *Chionelasmus darwini* (Pilsbry), *Eutomolasma orbiculatum* sp. nov.

Station DW 58. — 09.03.1989, 22°59.8'S, 167°24.2'E, 560 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 60. — 10.03.1989, 22°00.1'S, 167°21.6'E, 535 m: *Hexelasma sandaracum* sp. nov.

Station DW 61. — 10.03.1989, 22°59.9'S, 167°22.8'E, 550 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma aureolum* sp. nov.

Station DW 62. — 10.03.1989, 23°00.4'S, 167°21.8'E, 540 m: *Hexelasma sandaracum* sp. nov.

Station DW 63. — 10.03.1989, 22°58.7'S, 167°21.1'E, 520 m: *Hexelasma sandaracum* sp. nov.

Station DW 64. — 10.03.1989, 22°55.3'S, 167°16.4'E, 460 m: *Eutomolasma macLaughlinae* sp. nov., *Hexelasma sandaracum* sp. nov.

Station DW 65. — 10.03.1989, 22°55.3'S, 167°14.5'E, 420 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 68. — 10.03.1989, 22°55.0'S, 167°16.0'E, 440 m: *Eutomolasma macLaughlinae* sp. nov., *E. orbiculatum* sp. nov.



**VOLSMAR. New Hebrides Arc.**

Station DW 16. — 03.06.1989, 22°25.1'S, 171°40.7'E, 500 m: *Tetrapachylasma arcuatum* sp. nov., *Metalasma crassum* sp. nov., *Hexelasma foratum* sp. nov.

**SMIB 5. Norfolk Ridge.**

Station DW 71. — 07.09.1989, 23°41.3'S, 168°00.7'E, 265 m: *Eurylasma pyramidale* sp. nov.

Station DW 75. — 07.09.1989, 23°40.9'S, 168°00.8'E, 270 m: *Eurylasma pyramidale* sp. nov.

Station DW 85. — 13.09.1989, 22°20.0'S, 163°42.9'E, 260 m: *Pachylasma laeviscutum* sp. nov.

Station DW 87. — 13.09.1989, 22°18.7'S, 168°41.3'E, 370 m: *Tetrapachylasma arcuatum* sp. nov., *Hexelasma flavidum* sp. nov.

Station DW 88. — 13.09.1989, 22°18.6'S, 168°40.2'E, 350 m: *Pachylasma laeviscutum* sp. nov.

Station DW 93. — 13.09.1989, 22°20.0'S, 168°42.3'E, 255 m: *Eurylasma pyramidale* sp. nov., *Tetrapachylasma arcuatum* sp. nov., *Hexelasma flavidum* sp. nov.

Station DW 94. — 13.09.1989, 22°19.6'S, 168°42.8'E, 275 m: *Eurylasma pyramidale* sp. nov., *Hexelasma persicum* sp. nov.

Station DW 101. — 14.09.1989, 23°21.2'S, 168°04.9'E, 270 m: *Eurylasma pyramidale* sp. nov.

**BERYX 2. New Caledonia.**

Station DW 34. — 19.10.1992, 23°33'S, 167°17'E, 560-570 m: *Hexelasma sandaracum* sp. nov.

Station DW 35. — 19.10.1992, 23°33'S, 167°16'E, 550-570 m: *Hexelasma sandaracum* sp. nov.

Station DW 38. — 19.10.1992, 23°38'S, 167°39'E, 550-690 m: *Hexelasma sandaracum* sp. nov.

Station CP 46. — 20.10.1992, 23°42'S, 168°01'E, 300-350 m: *Hexelasma persicum* sp. nov.

**MUSORSTOM 7. Wallis and Futuna Islands, Combe, Field, Tuscarora and Waterwich Banks.**

Station CP 505. — 11.05.1992, 14°19'S, 178°04'W, 245-400 m: *Eutomolasma macLaughlinae* sp. nov.

Station CP 508. — 11.05.1992, 14°20'S, 178°06'W, 245-440 m: *Pachylasma laeviscutum* sp. nov.

Station CP 515. — 12.05.1992, 14°13'S, 178°10'W, 224-252 m: *Pachylasma laeviscutum* sp. nov.

Station DW 522. — 13.05.1992, 13°11'S, 176°15'W, 650-765 m: *Hexelasma sandaracum* sp. nov.

Station DW 537. — 16.05.1992, 12°30'S, 176°41'W, 325-400 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 539. — 17.05.1992, 12°27'S, 177°27'W, 700 m: *Hexelasma sandaracum* sp. nov.

Station DW 547. — 17.05.1992, 14°20'S, 178°06'W, 455 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 559. — 19.05.1992, 11°48'S, 178°19'W, 547-552 m: *Hexelasma sandaracum* sp. nov.

Station DW 582. — 22.05.1992, 13°10'S, 176°14'W, 360 m: *Hexelasma sandaracum* sp. nov.

Station DW 586. — 22.05.1992, 13°11'S, 178°11'W, 510-600 m: *Hexelasma sandaracum* sp. nov.

Station CP 622. — 28.05.1992, 12°34'S, 178°11'W, 1280-1300 m: *Hexelasma persicum* sp. nov.

**SMIB 8. New Caledonia.**

Station DW 150. — 27.01.1993, 24°54.3'S, 168°22.2'E, 519-530 m: *Hexelasma aureolum* sp. nov.

Station DW 167. — 29.01.1993, 23°38.1'S, 168°43.1'E, 430-452 m: *Eutomolasma macLaughlinae* sp. nov.

Station CP 180. — 30.01.1993, 23°47.7'S, 168°18.1'E, 425-460 m: *Chionelasmus darwini* (Pilsbry), *Hexelasma persicum* sp. nov.

Station DW 185. — 31.01.1993, 23°16'S, 168°04.3'E, 305-355 m: *Hexelasma persicum* sp. nov.

Station DW 189. — 31.01.1993, 23°17.6'S, 168°05.5'E, 400-402 m: *Hexelasma sandaracum* sp. nov.

Station DW 193. — 01.02.1993, 22°58.7'S, 168°20.1'E, 500-508 m: *Hexelasma persicum* sp. nov.

Station DW 194. — 01.02.1993, 22°59.6'S, 168°22.5'E, 491 m: *Hexelasma persicum* sp. nov.

Station DW 197. — 01.02.1993, 22°51.3'S, 168°12.5'E, 414-436 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 198. — 01.02.1993, 22°51.6'S, 167°12.4'E, 414-430 m: *Eutomolasma macLaughlinae* sp. nov.

Station DW 199. — 01.02.1993, 22°51.6'S, 168°12.22'E, 408-410 m: *Eutomolasma macLaughlinae* sp. nov.



**BATHUS 2. New Caledonia.**

- Station DW 718. — 11.05.1993, 22°46.70'S, 167°14.45'E, 430-436 m: *Eutomolasma maclaughlinae* sp. nov.  
 Station DW 719. — 11.05.1993, 22°47.57'S, 167°14.58'E, 444-455 m: *Eutomolasma maclaughlinae* sp. nov.  
 Station DW 720. — 11.05.1993, 22°51.62'S, 167°16.40'E, 530-541 m: *Eutomolasma maclaughlinae* sp. nov.  
 Station DW 729. — 12.05.1993, 22°52.42'S, 167°11.90'E, 400 m: *Eutomolasma maclaughlinae* sp. nov.,  
*Hexelasma sandaracum* sp. nov.  
 Station DW 738. — 13.05.1993, 23°02.09'S, 166°56.61'E, 588-647 m: *Eutomolasma maclaughlinae* sp. nov.

**BATHUS 3. Norfolk Ridge, Loyalty Ridge.**

- Station DW 778. — 24.11.1993, 24°43'S, 170°07'E, 750-760 m: *Waikalasma boucheti* Buckeridge.  
 Station CP 805. — 27.11.1993, 23°41'S, 168°01'E, 278-310 m: *Eurylasma pyramidale* sp. nov.  
 Station DW 809. — 27.11.1993, 23°39'S, 167°59'E, 650-730 m: *Hexelasma aureolum* sp. nov.  
 Station DW 811. — 28.11.1993, 23°41'S, 168°15'E, 383-408 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 812. — 28.11.1993, 23°43.38'S, 168°15.98'E, 391-440 m: *Chionelasmus darwini* (Pilsbry).  
 Station CP 815. — 28.11.1993, 23°47'S, 168°16'E, 460-470 m: *Chionelasmus darwini* (Pilsbry), *Eurylasma ferulum* sp. nov.  
 Station DW 818. — 28.11.1993, 23°44'S, 168°16'E, 394-401 m: *Hexelasma persicum* sp. nov.  
 Station DW 819. — 28.11.1993, 23°45'S, 168°16'E, 478-486 m: *Hexelasma aureolum* sp. nov.  
 Station CH 820. — 28.11.1993, 23°43'S, 168°16'E, 405-411 m: *Hexelasma persicum* sp. nov.  
 Station DW 829. — 29.11.1993, 23°21'S, 168°02'E, 386-390 m: *Eutomolasma maclaughlinae* sp. nov.  
 Station DW 830. — 29.11.1993, 23°20'S, 168°01'E, 361-365 m: *Hexelasma persicum* sp. nov., *Eurylasma pyramidale* sp. nov.  
 Station CP 833. — 30.11.1993, 23°03'S, 168°58'E, 441-444 m: *Eutomolasma maclaughlinae* sp. nov.

**BATHUS 4. New Caledonia, Norfolk Ridge.**

- Station CP 909. — 14.08.1994, 18°57.64'S, 163°10.30'E, 516-558 m: *Eutomolasma maclaughlinae* sp. nov.  
 Station CP 910. — 05.08.1994, 16°69.32'S, 163°08.47'E, 560-608 m: *Hexelasma flavidum* sp. nov.,  
*H. sandaracum* sp. nov.  
 Station CP 911. — 05.08.1994, 18°58'S, 163°09'E, 558-566 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 914. — 05.08.1994, 18°48.79'S, 163°15.23'E, 600-616 m: *Pachylasma ovatum* sp. nov.  
 Station DW 916. — 05.08.1994, 18°53.30'S, 163°19.55'E, 600-616 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 923. — 06.08.1994, 18°51.51'S, 163°24.17'E, 470-502 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 924. — 07.08.1994, 18°54.85'S, 163°24.34'E, 344-360 m: *Pachylasma ovatum* sp. nov.  
 Station DW 927. — 07.08.1994, 18°55.48'S, 163°22.11'E, 452-444 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 928. — 07.08.1994, 18°55'S, 163°24'E, 420-452 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 929. — 07.08.1994, 18°51.55'S, 163°23.27'E, 502-516 m: *Hexelasma persicum* sp. nov.,  
*H. sandaracum* sp. nov.  
 Station DW 932. — 08.08.1994, 19°07.91'S, 163°29.38'E, 170-190 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 951. — 10.08.1994, 20°31.44'S, 164°54.97'E, 960 m: *Hexelasma sandaracum* sp. nov.

**MUSORSTOM 8. Vanuatu.**

- Station CP 962. — 21.09.1994, 20°19.70'S, 169°49.02'E, 370-400 m: *Pachylasma laeviscutum* sp. nov.  
 Station CP 963. — 21.09.1994, 20°20.10'S, 169°49.08'E, 400-440 m: *Pachylasma laeviscutum* sp. nov.,  
*Tetrapachylasma arcuatum* sp. nov.  
 Station DW 967. — 21.09.1994, 20°19.45'S, 169°52.87'E, 295-334 m: *Eurylasma angustum* sp. nov.  
 Station CP 972. — 22.09.1994, 19°21.94'S, 169°28.07'E, 487-507 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 973. — 22.09.1994, 19°21.30'S, 169°27.03'E, 460-480 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 974. — 22.09.1994, 19°21.51'S, 169°28.26'E, 492-520 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 978. — 22.09.1994, 19°22.62'S, 169°27.11'E, 413-408 m: *Hexelasma sandaracum* sp. nov.



- Station DW 988. — 23.09.1994, 19°16.04'S, 169°24.12'E, 372-466 m: *Pachylasma laeviscutum* sp. nov.  
 Station DW 989. — 23.09.1994, 19°13.92'S, 169°20.25'E, 650-669 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1026. — 28.09.1994, 17°50.35'S, 168°39.33'E, 437-504 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1027. — 28.09.1994, 17°53.05'S, 168°39.35'E, 550-571 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1045. — 30.09.1994, 15°57.63'S, 166°38.43'E, 459-488 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 1046. — 30.09.1994, 16°53.62'S, 168°11.08'E, 461-480 m: *Hexelasma sandaracum* sp. nov.  
 Station DW 1060. — 02.10.1994, 16°13.82'S, 167°20.80'E, 375-397 m: *Eurylasma angustum* sp. nov.  
 Station DW 1062. — 02.10.1994, 16°14.82'S, 167°18.64'E, 619-658 m: *Bathylasma alearum* sp. nov.  
 Station DW 1067. — 02.10.1994, 16°16.78'S, 167°21.52'E, 344-366 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1080. — 05.09.1994, 15°57.30'S, 167°27.73'E, 799-850 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1083. — 05.10.1994, 15°51.91'S, 167°19.42'E, 397-439 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1086. — 05.10.1994, 15°36.58'S, 167°16.32'E, 182-215 m: *Pachylasma bacum* sp. nov.  
 Station CP 1114. — 08.10.1994, 14°52.39'S, 167°03.40'E, 647 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1125. — 10.10.1994, 15°57.63'S, 166°38.43'E, 1160-1220 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1127. — 10.10.1994, 15°58.86'S, 166°37.82'E, 1052-1058 m: *Hexelasma sandaracum* sp. nov.  
 Station CP 1131. — 11.10.1994, 15°38.41'S, 167°03.52'E, 140-175 m: *Pachylasma laeviscutum* sp. nov.  
 Station CP 1136. — 11.10.1994, 15°40.62'S, 167°01.60'E, 398-400 m: *Hexelasma sandaracum* sp. nov.

#### HALIPRO 2. New Caledonia.

- Station BT 49. — 16.11.1996, 25°23.66'S, 168°19.62'E, 605-628 m: *Chionelasmus darwini* (Pilsbry).  
 Station BT 70. — 20.11.1996, 24°42.96'S, 168°08.17'E, 226-238 m: *Tetrapachylasma arcuatum* sp. nov.  
 Station BT 71. — 20.11.1996, 24°50.12'S, 168°09.97'E, 820-1220 m: *Tetrapachylasma arcuatum* sp. nov.

### LIST OF SPECIES DESCRIBED OR DISCUSSED HEREIN

† = fossil species

#### CHIONELASMATOIDEA

##### Family CHIONELASMATIDAE

##### Genus *EOCHIONELASMUS*

*Eochionelasmus ohtai* Yamaguchi, 1990

##### Genus *CHIONELASMUS*

*Chionelasmus crosnieri* Buckeridge, 1998

*Chionelasmus darwini* (Pilsbry, 1907)

*Chionelasmus darwini darwini* (Pilsbry, 1907)

*Chionelasmus darwini cantelli* Yamaguchi, 1998

##### Subfamily PACHYLASMATINAE

##### Genus *EUTOMOLASMA* gen. nov.

*Eutomolasma chinense* (Pilsbry, 1912)

*Eutomolasma japonicum* (Hiro, 1933)

*Eutomolasma macLaughlinae* sp. nov.

*Eutomolasma orbiculatum* sp. nov.

##### Genus *MICROLASMA* gen. nov.

*Microlasma arwetergum* (Rosell, 1991)

*Microlasma crinoidophilum* (Pilsbry, 1911)

*Microlasma fragile* sp. nov.

*Microlasma ochriderma* (Foster, 1981)

#### PACHYLASMATOIDEA

##### Family PACHYLASMATIDAE

##### Subfamily EOLASMATINAE

##### Genus *EOLASMA*

†*Eolasma maxwelli* Buckeridge, 1983

†*Eolasma rugosa* Buckeridge, 1985

##### Genus *WAIKALASMA*

*Waikalasma boucheti* Buckeridge, 1996

†*Waikalasma juneae* Buckeridge, 1983

##### Genus *PACHYLASMA*

*Pachylasma bacum* sp. nov.

*Pachylasma darwinianum* (Pilsbry, 1912)

*Pachylasma ecaudatum* Hiro, 1939

*Pachylasma giganteum* (Philippi, 1836)

*Pachylasma integrirostrum* Broch, 1931

*Pachylasma laeviscutum* sp. nov.

*Pachylasma ovatum* sp. nov.

*Pachylasma scutistriata* Broch, 1922



Genus **EURLASMA** gen. nov.*Eurylasma angustum* sp. nov.*Eurylasma ferulum* sp. nov.*Eurylasma pyramidale* sp. nov.Genus **TETRAPACHYLASMA***Tetrapachylasma arcuatum* sp. nov.*Tetrapachylasma aurantiacum* (Darwin, 1854)*Tetrapachylasma ferrugomaculosa* (Jones, 1993)*Tetrapachylasma ornatum* sp. nov.*Tetrapachylasma trigonum* Foster, 1988

## Subfamily METALASMATINAE subfam. nov.

Genus **METALASMA** gen. nov.*Metalasma crassum* sp. nov.

## Subfamily BATHYLASMATINAE

Genus **BATHYLASMA***Bathylasma alearum* (Foster, 1978)†*Bathylasma aucklandicum* (Hector, 1888)*Bathylasma corolliforme* (Hoek, 1883)*Bathylasma hirsutum* (Hoek, 1883)Genus **MESOLASMA***Mesolasma fosteri* (Newman & Ross, 1971)Genus **TETRACHAELASMA***Tetrachaelasma southwardi* Newman & Ross, 1971Genus **TESSARELASMA**†*Tessarelasma pilsbryi* Withers, 1936

## Subfamily HEXELASMATINAE

Genus **HEXELASMA***Hexelasma americanum* Pilsbry, 1916*Hexelasma arafurae* Hoek, 1913*Hexelasma aureolum* sp. nov.*Hexelasma brintoni* (Newman & Ross, 1971)*Hexelasma callistoderma* Pilsbry, 1911*Hexelasma flavidum* sp. nov.*Hexelasma foratum* sp. nov.*Hexelasma globosum* sp. nov.*Hexelasma gracilis* Foster, 1981*Hexelasma leptoderma* Newman & Ross, 1971*Hexelasma nolearia* (Foster, 1978)*Hexelasma persicum* sp. nov.*Hexelasma sandaracum* sp. nov.*Hexelasma triderma* Newman & Ross, 1971*Hexelasma velutinum* Hoek, 1913

## WALL ORGANISATION IN THE BALANOMORPHA

In the systematics of balanomorph barnacles the number of wall plates and the manner in which they articulate or coalesce to one another are of major importance. In early balanomorphs the wall was surrounded by one or more whorls of smaller imbricating plates that protect the suture between the base of the primary wall and the substratum, and the lower portion of the sutures between the wall plates (BUCKERIDGE & NEWMAN, 1992; NEWMAN, 1993). In most Tertiary forms the imbricating plates are lost and significant concomitant changes appear in the structure of the compartments themselves (e.g., the development of alae and radii), the number of wall plates and in the way these articulate or coalesce with one another.

The phylogeny of the balanomorphs indicates that various plates have been added to the wall, with 8 being the maximum complement in a few surviving early forms. This is repeated in their ontogeny to a remarkable extent. However, the general pattern is one of reduction, from 8-plated forms to 6-plated forms, of which some derived forms independently went to 4 plates.

Although the 4 plates seen in derived forms have evolved through reduction by elimination or coalescence, current concepts on the evolution, ontogeny and homologies of the wall plates in balanomorphs indicate that 4 plates are the basic number (ROSS & NEWMAN, 1996). Since DARWIN (1854) the primitive 8-plated wall in balanomorphs such as *Catophragmus* s. l., *Pachylasma*, *Octomeris* and *Chelonibia* has been considered to consist of R-RL-L-CL-C with CL overlapping C and underlapped by L. The 6-plated balanomorph wall (R-L-CL-C) was considered to be a reduction from 8 plates, due to the development of a tripartite or compound rostrum (RL+R+RL). Early in the ontogeny of all balanomorph barnacles, however, the wall consists of only 4 plates, R, L, and C (DARWIN, 1854; GLENNER & HØEG, 1993). YAMAGUCHI & NEWMAN (1990) consider this 4-plated wall to have also been the case in balanomorph phylogeny and these and subsequent authors have provided evidence that the so-called "median-latus" (L) is actually the CL, as L was incorporated into the operculum and subsequently lost (YAMAGUCHI & NEWMAN, 1990; BUCKERIDGE & NEWMAN, 1992; NEWMAN, 1993). Therefore, the basic balanomorph wall should be designated R-CL-C (rather than R-L-C) with CL overlapping C and R.



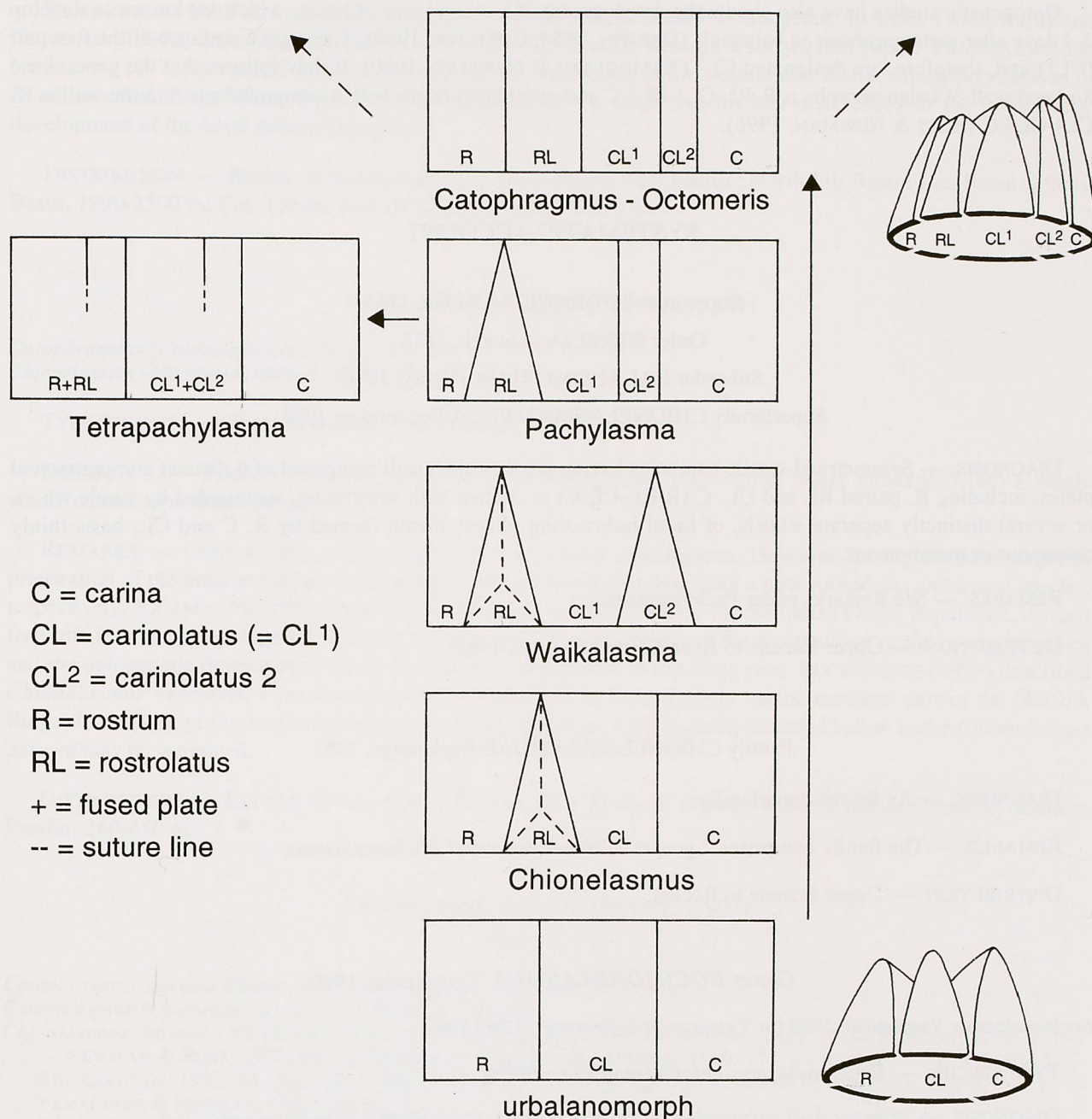


FIG. 1. — Schematic representation of wall organization in selected genera of lower Balanomorpha, viewed from right side (basal whorls of imbricating plates, where present, not shown). These reflect grades of wall construction rather than a strict phylogeny, but the polarity indicated by arrows reflects the general evolution of the balanomorph wall. Proceeding from the bottom, the urbalanomorph wall of four plates in which CL overlaps R and C (imbricating plates were present, radii absent). *Chionelasmus*, in which RL, derived from an imbricating plate, has been added to protect the R/L suture, upper portion of RL not incorporated into sheath and lower portion not fully incorporated into wall (imbricating plates present). *Waikalasma*, in which CL<sup>2</sup> has been added by replication of CL<sup>1</sup> rather than by transfert from the imbricating whorls; CL<sup>2</sup> but not RL enter the sheath. *Pachylasma*, in which RL and CL<sup>2</sup> are incorporated into wall but RL is not yet incorporated into sheath (imbricating plates absent in Recent forms). *Tetrapachylasma*, in which RL fuses with R to form compound rostrum (RL+R+RL), and CL<sup>2</sup> fuses with CL<sup>1</sup>. *Catophragmus-Octomeris* (imbricating plates lost in latter), in which RL is incorporated into sheath. [From ROSS & NEWMAN, 1996, fig. 2 (part), reproduced with the permission of Dr Arthur HUMES, Editor, Journal of Crustacean Biology].



Ontogenetic studies have also shown the development of a second pair of latera, which are known to develop 3-4 days after metamorphosis in balanoids (DARWIN, 1854; COSTLOW, 1965). These are a replicate of the first pair (CL<sup>1</sup>) and, therefore, are designated CL<sup>2</sup> (YAMAGUCHI & NEWMAN, 1990). It thus follows that the generalised 8-plated wall of balanomorphs is R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C and in 6-plated forms with a compound rostrum the wall is R-CL<sup>1</sup>-CL<sup>2</sup>-C (ROSS & NEWMAN, 1996).

## SYSTEMATIC ACCOUNT

Superorder THORACICA Darwin, 1854

Order SESSILIA Lamarck, 1818

Suborder BALANOMORPHA Pilsbry, 1916

Superfamily CHIONELASMATOIDEA Buckeridge, 1983

DIAGNOSIS. — Symmetrical sessile barnacles having primary shell wall composed of 6 distinct compartmental plates, including R, paired RL and CL, C (R-RL-CL-C) in contact with substratum, surrounded by single whorl, or several distinctly separate whorls, of basal imbricating plates; sheath formed by R, C and CL; basis thinly calcareous or membranous.

REMARKS. — See Remarks under Pachylasmatoidea.

DISTRIBUTION. — Upper Eocene to Recent (BUCKERIDGE, 1983).

Family CHIONELASMATIDAE Buckeridge, 1983

DIAGNOSIS. — As for the superfamily.

REMARKS. — The family comprises 2 genera, *Chionelasmus* and *Eochionelasmus*.

DISTRIBUTION. — Upper Eocene to Recent.

Genus *EOCHIONELASMUS* Yamaguchi, 1990

*Eochionelasmus* Yamaguchi, 1990 (in YAMAGUCHI & NEWMAN, 1990: 136).

TYPE SPECIES. — *Eochionelasmus ohtai* Yamaguchi, 1990.

DIAGNOSIS. — Primary wall surrounded by several distinct, basal whorls of monomorphic imbricating plates; caudal appendages present.

TYPES of *Eochionelasmus ohtai*. — *Holotype*: UMUT cat. no. RA-18631; Japan/French KAIYO 87 Cruise (Site B of station 4), North Fiji Basin, Southwest Pacific, 16°59.4'N, 173°54.9'E, 1990 m; 28.12.1987; holotype and paratypes attached to one another and to the ferro-manganese-coated, glassy crust of pillow basalt, temperature anomaly +0.1 to +0.2°C above an ambient of +2.2°C.

*Paratypes*: UMUT cat. no. RA-18632, UMUT RA-18633, UMUT RA-18634 (juvenile); USNM 221862; BMNH 1989.47; MNHN Ci 2110; all locations as for holotype.

*Holotype depository*: UMUT.

*Paratypes depository*: UMUT, USNM, BMNH, MNHN.



REMARKS. — Until recently only 1 species, *E. ohtai*, was attributed to this genus. In 1997 YAMAGUCHI and NEWMAN (1997a) described *E. paquensis* from the East Pacific Rise. In a subsequent paper, YAMAGUCHI and NEWMAN (1997b) proposed *E. ohtai manusensis* for the Manus Basin population, distinct from populations of *E. ohtai ohtai* in the North Fiji and Lau Basins, based on small but distinct differences in the ontogenetic development of the basal imbricating plates.

DISTRIBUTION. — Recent, from hydrothermal vents. South-west Pacific; North Fiji Basin; Lau Basin; Manus Basin, 1990-2500 m; East Pacific Rise, N of Easter Island, 2578 m.

### Genus *CHIONELASMUS* Pilsbry, 1911

*Catophragmus* (*Chionelasmus*) Pilsbry, 1911: 82.

*Chionelasmus* - NILSSON-CANTELL, 1928: 445.

TYPE SPECIES. — *Chionelasmus darwini* (Pilsbry, 1907).

DIAGNOSIS. — Primary wall surrounded by basal, trimorphic, imbricating plates condensed into a single whorl; caudal appendages present.

REMARKS. — Until recently, only 1 species was attributed to this genus. However, during the final stages of preparation of the present manuscript, 2 papers were published that described a new subspecies and a new species, respectively. YAMAGUCHI (1998) proposed *Chionelasmus darwini cantelli* for the Indian Ocean population, distinct from the Hawaiian population of *Chionelasmus darwini darwini*, based on the morphology of the opercular plates and the ontogenetic development of the basal imbricating plates. In the same year, BUCKERIDGE (1998) described *Chionelasmus crosnieri*, a facultative coral-dwelling species from a guyot on the northern part of the Norfolk Ridge. In the light of these recent publications, re-examination of the material included below under *Chionelasmus darwini* may be warranted.

DISTRIBUTION. — Eocene, Tonga; Upper Eocene, New Zealand; Recent, western Indian Ocean to northern Pacific; 260-650 m.

### *Chionelasmus darwini* (Pilsbry, 1907)

Figs 2-3, 4 a

*Catophragmus darwini* Pilsbry, 1907: 188, fig. 4, pl. 5 figs 1-8; 1916: 335.

*Catophragmus* (*Chionelasmus*) *darwini* - PILSBRY, 1911: 82.

*Chionelasmus darwini* - NILSSON-CANTELL, 1928: 445, figs 1-2; 1938: 14. — POPE, 1965: 10. — GORDON, 1970: 9, 105. — NEWMAN & ROSS, 1976: 40, frontispiece. — STANLEY & NEWMAN, 1980: 177. — FOSTER, 1981: 352, fig. 3. — BUCKERIDGE, 1983: 61, fig. 46. — HUI & MOYSE, 1984: 91, fig. 1. — NEWMAN, 1987: 23, figs 4, 5A, 6. — YAMAGUCHI & NEWMAN, 1990: 148, fig. 8.

MATERIAL EXAMINED. — **New Caledonia.** MUSORSTOM 4: stn CP 238, 500-510 m: 1 specimen.

SMIB 8: stn CP 180, 425-460 m: several specimens (WAM C 23243).

HALIPRO 2: stn BT 49, 605-628 m: several specimens attached to gorgonian.

**Loyalty Islands.** BIOCAL: stn DW 66, 505-515 m: 1 specimen. — Stn CP 67, 500-510 m: several specimens.

**Norfolk Ridge.** CHALCAL 2: stn CC 1, 500 m: 1 specimen. — Stn CC 2, 500 m: 1 specimen. — Stn CP 21, 500 m: 1 specimen. — Stn DW 74, 650 m: 1 specimen. — Stn DW 75, 600 m: 1 specimen. — Stn DW 76, 470 m: 4 specimens. — Stn DW 77, 435 m: 2 specimens.

SMIB 3: stn DW 24, 535 m: 1 specimen, attached to sponge.

SMIB 4: stn DW 55, 260 m: 1 specimen.

BATHUS 3: stn CP 812, 391-440 m: many specimens, attached to coral rubble (WAM 261-96). — Stn CP 815, 460-470 m: many specimens, attached to coral rubble (MNHN-Ci 2694). Drawn.



TYPES. — *Syntypes*: (from incomplete specimens) USNM 32407 [hard parts], USNM 32408 [soft parts]; "Albatross" station 3998, near Kauai, Hawaiian Is, 417-430 m.

*Syntypes depository*: USNM (material is missing).

DIAGNOSIS. — Wall consisting of 6 white, porcellanous plates, without radii. R with alae. S without adductor ridge; S and T with strongly developed articular ridges. Caudal appendages multi-articulate, 8-12 segments.

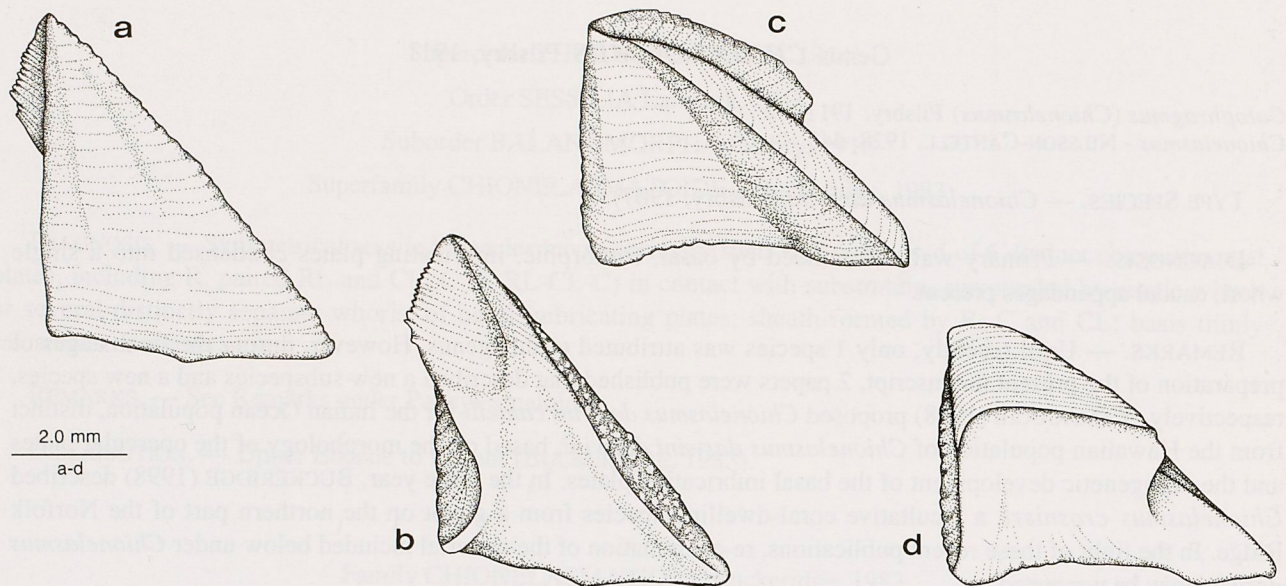


FIG. 2. — *Chionelasmus darwini* (Pilsbry, 1907). Specimen from BATHUS 3, stn CP 815 (MNHN-Ci 2694): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view.

SUPPLEMENTARY DESCRIPTION. — Measurements of 10 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height
rg	3.8-13.3	2.3-13.8	1.5-13.6
$\bar{x}$	9.3	7.5	6.3

Cirrus I shortest, rami unequal. Cirrus II resembling cirrus III more than cirrus I. Cirrus III unmodified, similar to cirri IV-VI. Chaetotaxy ctenopod. Cirral formula as follows:

		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	10, 13	18, 19	20, 25	19+, 25	22, 26	25, 25	12
Ci 2694	right	9, 11	12, 13	9+, 20	18, 20	24, 26	25, 25	8

REMARKS. — This species was collected previously from the western Indian Ocean and from the southwestern and northern Pacific Ocean. The present specimens from the waters of New Caledonia expand the distribution of the species in the south-western Pacific Ocean and extend the depth range to between 260 and 650 m. The well preserved specimens in the present collection agree in general with previous descriptions of *C. darwini* from the Hawaiian Islands (PILSBRY, 1907) and Rodriguez Island (NILSSON-CANTELL, 1928). However, some variation exists in the form of the mandible. The material examined herein shows the pectinated inferior angle of



the mandible bifid on the right side, but roundly molariform on the left side. In addition, both mandibles lack the 2 small additional teeth between teeth 1 and 2 which were illustrated by NILSSON-CANTELL (1928). These differences may reflect intra-specific variation.

**DISTRIBUTION.** — Western Indian Ocean, south-western to northern Pacific Ocean: Rodriguez Island (9.5 mls N, 4.0 mls W of Port Mathurin), western Indian Ocean, 527 m; Kermadec Islands, south-west Pacific Ocean (30°34'S, 178°30'W), 501 m; Hawaiian Islands, north Pacific Ocean, 417-430 m. Now also known from New Caledonia, 425-510 m, the Loyalty Islands, 500-515 m and Norfolk Ridge, 260-650 m.

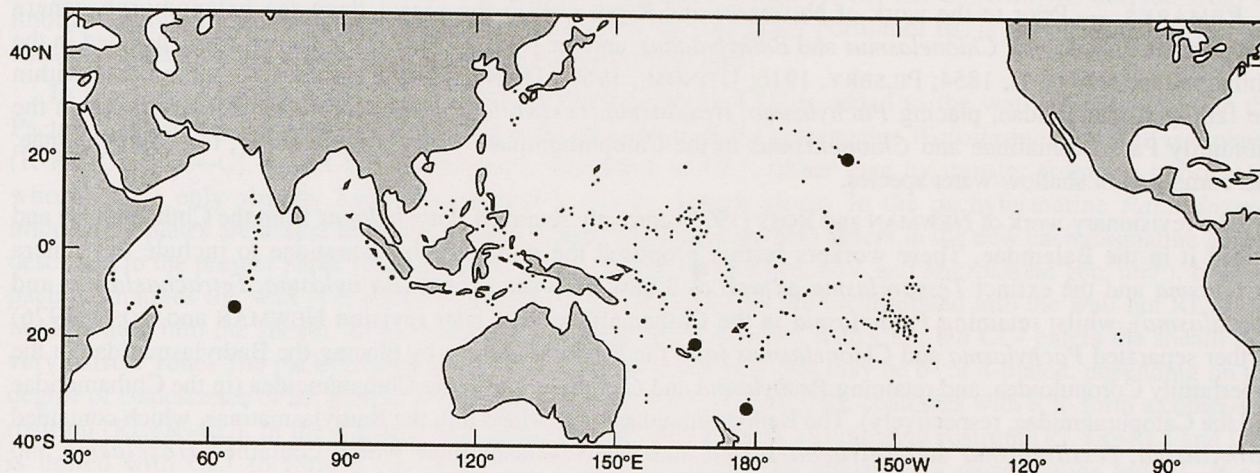


FIG. 3. — *Chionelasmus darwini* (Pilsbry, 1907). Distribution map (depth 260-650m).

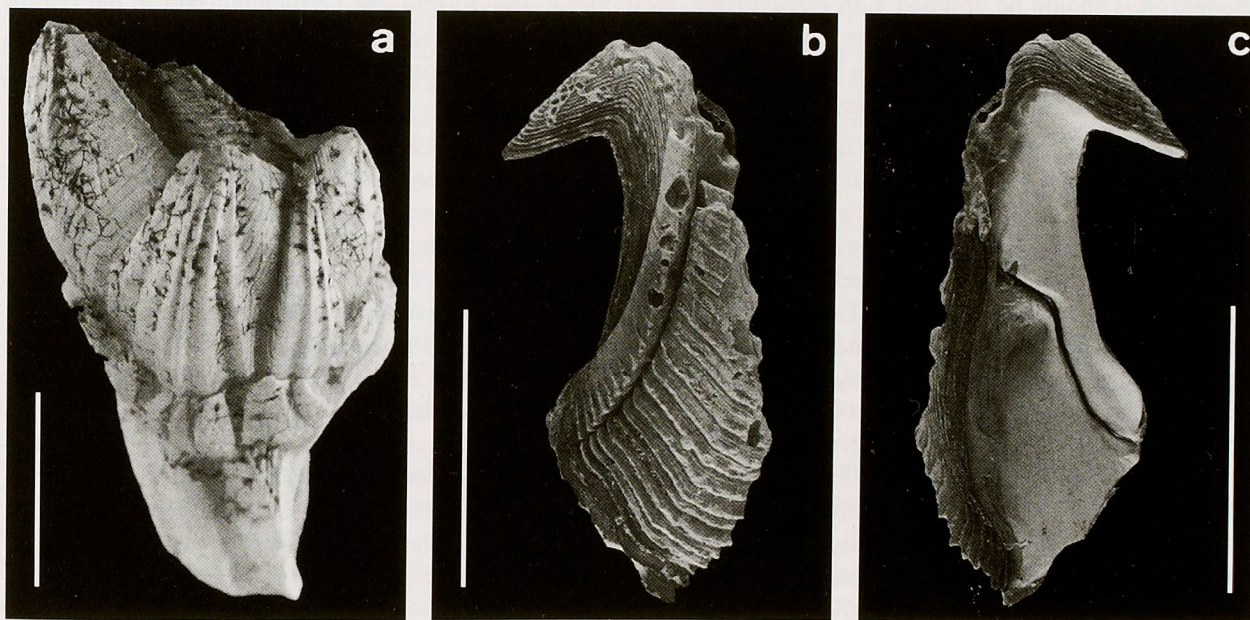


FIG. 4. — **a**, *Chionelasmus darwini* (Pilsbry, 1907). Specimen from BATHUS 3, stn CP 812 (WAM 261-96): lateral view.

FIG. 4. — **b-c**, *Waikalasma boucheti* Buckeridge, 1996. Specimen (incomplete) from BATHUS 3, stn DW 778 (MNHN-Ci 2410): opercular plates articulated together; **b**, external view; **c**, internal view. Scales = 0.5 cm for **a**; 1 cm for **b-c**.



TYPES. — *Syntypes*: (from incomplete specimens) USNM 32407 [hard parts], USNM 32408 [soft parts]; "Albatross" station 3998, near Kauai, Hawaiian Is, 417-430 m.

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DIAGNOSIS. — Wall consisting of 6 white, porcellanous plates, without radii. R with alae. S without adductor ridge; S and T with strongly developed articular ridges. Caudal appendages multi-articulate, 8-12 segments.

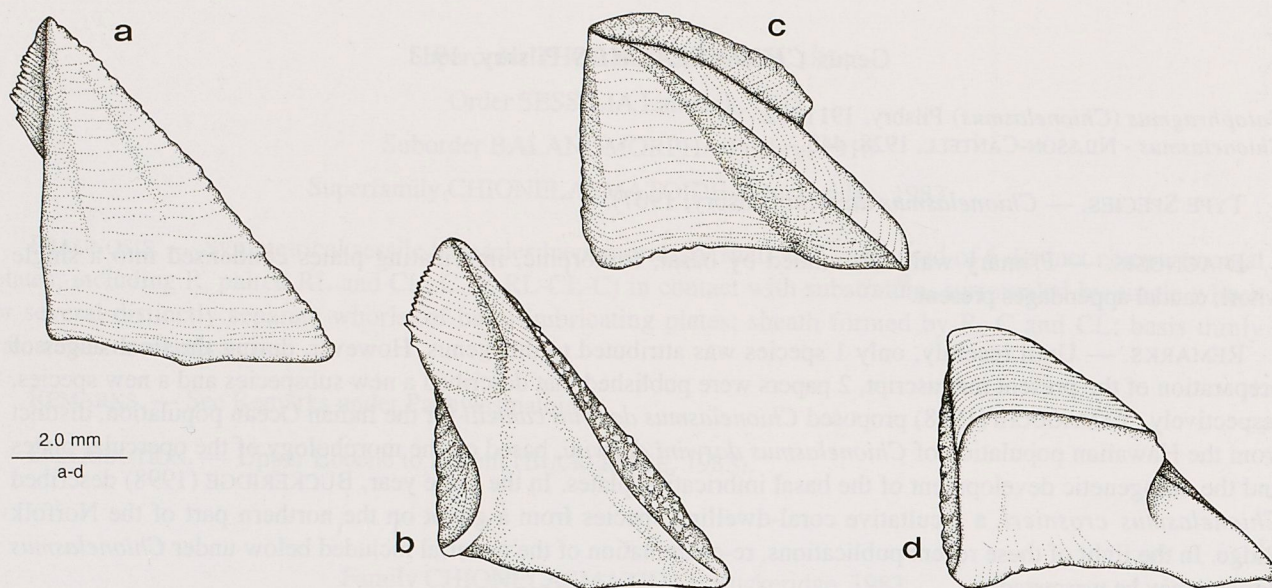


FIG. 2. — *Chionelasmus darwini* (Pilsbry, 1907). Specimen from BATHUS 3, stn CP 815 (MNHN-Ci 2694): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view.

SUPPLEMENTARY DESCRIPTION. — Measurements of 10 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height
rg	3.8-13.3	2.3-13.8	1.5-13.6
$\bar{x}$	9.3	7.5	6.3

Cirrus I shortest, rami unequal. Cirrus II resembling cirrus III more than cirrus I. Cirrus III unmodified, similar to cirri IV-VI. Chaetotaxy ctenopod. Cirral formula as follows:

		C I	C II	C III	C IV	C V	C VI	c. a.
MNHN-Ci 2694	left	10, 13	18, 19	20, 25	19+, 25	22, 26	25, 25	12
	right	9, 11	12, 13	9+, 20	18, 20	24, 26	25, 25	8

REMARKS. — This species was collected previously from the western Indian Ocean and from the southwestern and northern Pacific Ocean. The present specimens from the waters of New Caledonia expand the distribution of the species in the south-western Pacific Ocean and extend the depth range to between 260 and 650 m. The well preserved specimens in the present collection agree in general with previous descriptions of *C. darwini* from the Hawaiian Islands (PILSBRY, 1907) and Rodriguez Island (NILSSON-CANTELL, 1928). However, some variation exists in the form of the mandible. The material examined herein shows the pectinated inferior angle of



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**DISTRIBUTION.** — Western Indian Ocean, south-western to northern Pacific Ocean: Rodriguez Island (9.5 mls N, 4.0 mls W of Port Mathurin), western Indian Ocean, 527 m; Kermadec Islands, south-west Pacific Ocean (30°34'S, 178°30'W), 501 m; Hawaiian Islands, north Pacific Ocean, 417-430 m. Now also known from New Caledonia, 425-510 m, the Loyalty Islands, 500-515 m and Norfolk Ridge, 260-650 m.

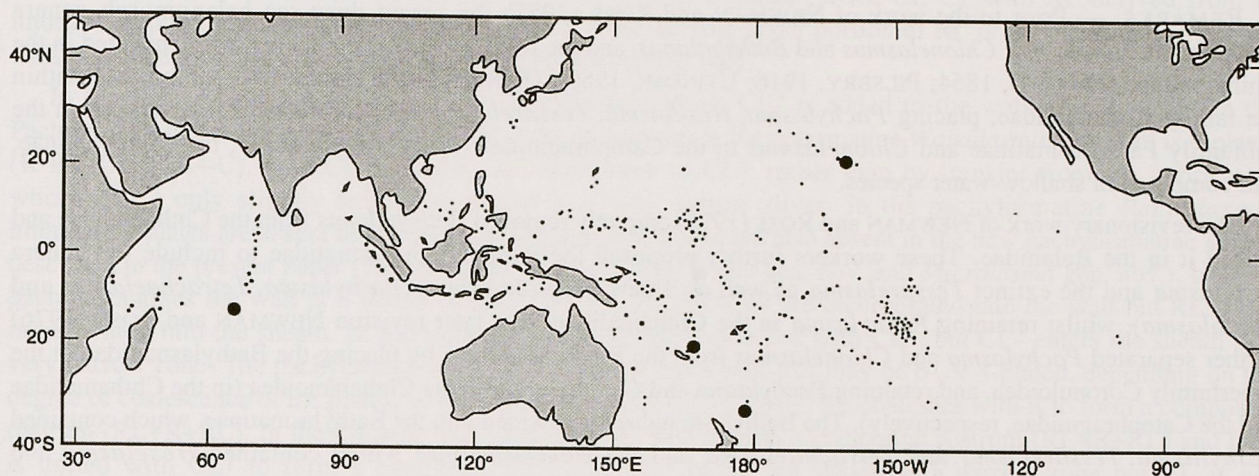


FIG. 3. — *Chionelasmus darwini* (Pilsbry, 1907). Distribution map (depth 260-650m).

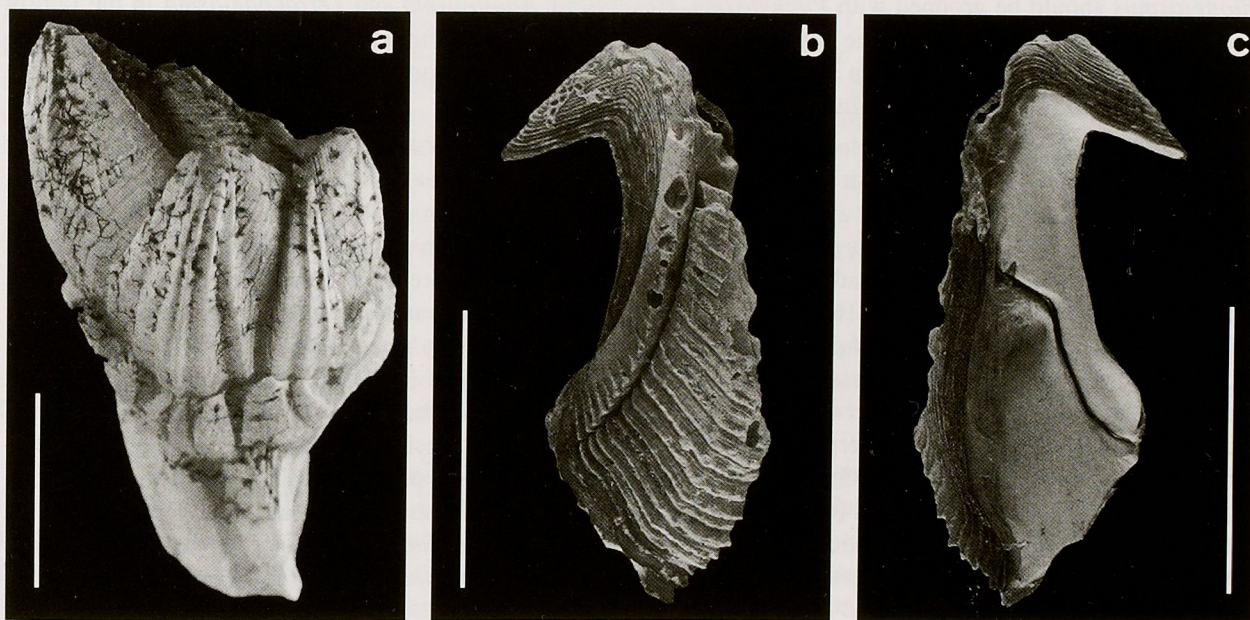


FIG. 4. — **a**, *Chionelasmus darwini* (Pilsbry, 1907). Specimen from BATHUS 3, stn CP 812 (WAM 261-96): lateral view.

FIG. 4. — **b-c**, *Waikalasma boucheti* Buckeridge, 1996. Specimen (incomplete) from BATHUS 3, stn DW 778 (MNHN-Ci 2410): opercular plates articulated together; **b**, external view; **c**, internal view. Scales = 0.5 cm for **a**; 1 cm for **b-c**.



Superfamily PACHYLASMATOIDEA Utinomi, 1968 (emend.)

DIAGNOSIS. — Wall composed of 8 distinct compartmental plates (R, paired RL, CL<sup>1</sup> and CL<sup>2</sup>, and C), without (excepting *Waikalasma*) extra whorls of basal imbricating plates; rostrum compound, RL not entering sheath; parietes solid; radii, when present, solid; basis commonly membranous, or if calcareous solid, and not forming complex inter-digitations with wall.

DISTRIBUTION. — Paleocene to Recent; cosmopolitan (BUCKERIDGE, 1983).

REMARKS. — Prior to the work of NEWMAN and ROSS (1971) the extant deep-sea balanomorph genera *Pachylasma*, *Hexelasma*, *Chionelasmus* and *Bathybalanus*, and the fossil genus *Tessarelasma*, were included in the Chthamalidae (DARWIN, 1854; PILSBRY, 1916; UTINOMI, 1968). UTINOMI (1968) included 3 subfamilies within the family Chthamalidae, placing *Pachylasma*, *Hexelasma*, *Tessarelasma* and, curiously, *Bathybalanus* in the subfamily Pachylasmatinae and *Chionelasmus* in the Catophragminae. The third subfamily, the Chthamalinae, was composed of shallow-water species.

The revisionary work of NEWMAN and ROSS (1971) correctly removed *Bathybalanus* from the Chthamalidae and placed it in the Balanidae. These workers further proposed the family Bathylasmatidae to include the genera *Hexelasma* and the extinct *Tessarelasma* as well as 3 new deep-sea genera (*Bathylasma*, *Tetrachaelasma* and *Aptolasma*), whilst retaining *Pachylasma* in the Chthamalidae. In a later revision NEWMAN and ROSS (1976) further separated *Pachylasma* and *Chionelasmus* from the Bathylasmatidae by placing the Bathylasmatidae in the superfamily Coronuloidea, and retaining *Pachylasma* and *Chionelasmus* in the Chthalamoidea (in the Chthamalidae and the Catophragmidae, respectively). The Bathylasmatidae was divided into the Bathylasmatinae, which contained *Bathylasma*, *Tessarelasma* and *Tetrachaelasma* and the Hexelasmatinae which contained *Hexelasma* and *Aptolasma*.

FOSTER (1978) maintained that *Pachylasma* and *Hexelasma* were closely related, as had been noted previously by PILSBRY (1916). Furthermore, basing his conclusions upon shell construction, FOSTER (1978) proposed that *Chionelasmus* should be grouped with *Pachylasma*, *Hexelasma*, *Aptolasma* and *Tetrachaelasma* in the family Pachylasmatidae, as distinct from the Chthamalidae which contained *Chthamalus*, *Catophragmus*, *Octomeris*, *Tetrachthalamus* and *Chamaesipho*. In a further revision, FOSTER (1981) synonymised *Aptolasma* with *Hexelasma* and transferred *Bathylasma* and *Mesolasma* to the Pachylasmatidae.

The superfamilial rank Pachylasmatoidea was proposed by BUCKERIDGE (1983) for the families Pachylasmatidae and Tetracitidae, but the latter was later assigned to the Tetracitoidea (NEWMAN, 1993). Within the Pachylasmatidae 5 subfamilies were recognised, i.e. Chionelasmatinae, Pachylasmatinae, Eolasmatinae, Bathylasmatinae and Hexelasmatinae. BUCKERIDGE (1983) noted that both *Chionelasmus* and *Pachylasma* had weakly articulated plates without radii and, in this respect, showed more in common with *Hexelasma* and *Bathylasma* than the Chthamalidae. He also commented that the hexelasmatines and the living bathylasmatines (i.e. *Hexelasma*, *Bathylasma*, *Tetrachaelasma*) had a more specialised body morphology than *Chionelasmus* and *Pachylasma*, as they did not possess caudal appendages. BUCKERIDGE (1983) suggested that *Pachylasma* represented an intermediate stage between an 8-plated and extra whorled balanomorph and the 6-plated, single whorled Hexelasmatinae and, furthermore, that *Chionelasmus* was a plesiomorphic living balanomorph. His phylogenetic tree (BUCKERIDGE, 1983) showed *Pachydiadema* as the most primitive balanomorph and, on p. 21, he derived *Chionelasmus* "... perhaps [evolving] directly from *Pachydiadema*". BUCKERIDGE, however, based his ideas on the now-considered false notion of NEWMAN (pers. comm.) that *Chionelasmus* possibly changed from 8- to 6-plated during ontogeny (as suggested by NEWMAN 1987). *Chionelasmus* became the "most primitive living balanomorph" in the works of YAMAGUCHI and NEWMAN (1990) and BUCKERIDGE and NEWMAN (1992). In 1990, what is now considered the most primitive living member of the suborder Balanomorpha, *Eochionelasmus*, was described from the North Fiji Basin (YAMAGUCHI & NEWMAN, 1990). NEWMAN (1987) proposed the superfamilial rank Chionelasmatoidae to embrace the Chionelasmatidae and *Chionelasmus* and *Eochionelasmus*.

YAMAGUCHI and NEWMAN (1990) and NEWMAN and YAMAGUCHI (1995) proposed a new hypothesis concerning the evolution of the 8-plated balanomorph wall, based on evidence concerning the organisation of the



shell of *Eochionelasmus* and *Neobrachylepas*, the ontogeny of the shell wall of *Chionelasmus* and the ontogeny of *Balanus* s.l. This evidence suggested that the true (median) lateral plate is replaced by the CL plate in the balanomorphs, and that an additional, secondary CL plate (CL<sup>2</sup>) is added by replication in advanced balanomorphs. In the light of these findings, BUCKERIDGE and NEWMAN (1992) reinterpreted the structure of the wall of the fossil eolasmatine *Waikalasma juneae*, proposing that *Waikalasma* was amongst the most plesiomorphic of balanomorph barnacles and not merely an evolutionary offshoot. Subsequently, BUCKERIDGE (1996) described an extant species of *Waikalasma*, the first living representative of the eolasmatines.

In the lower balanomorphs (i.e. the Chionelasmatoidea) imbricating plates are present, as either a basal whorl (*Chionelasmus*) or whorls (*Eochionelasmus*). The wall is 6-plated (R-RL-CL-C), with RL derived from an imbricating plate which is added to protect the R/CL suture. The upper portion of RL is not incorporated into the sheath and the lower portion is not fully incorporated into the wall.

In the higher balanomorphs (e.g., the Pachylasmatoidea), CL<sup>2</sup> is added to the wall structure. Within the Pachylasmatidae, two whorls of imbricating plates are present in the eolasmatine *Waikalasma*. The wall is 8-plated (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C), with CL<sup>2</sup> added by the replication of CL<sup>1</sup>, rather than by transfer from the imbricating whorls. CL<sup>2</sup> only slightly enters the sheath as a very narrow sliver. In the pachylasmatine *Pachylasma*, imbricating plates are absent in Recent forms. Imbricating plates are also absent in the new pachylasmatine genera described in the present paper (*Eutomolasma* gen. nov., *Eurylasma* gen. nov. and *Microlasma* gen. nov.). In these pachylasmatines the wall is 6-plated (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL and CL<sup>2</sup> are incorporated into the wall but RL is not incorporated into the sheath. In *Eurylasma* CL<sup>2</sup> is partially coalesced with CL<sup>1</sup>, but CL<sup>2</sup> enters the sheath as a very narrow zone. The pachylasmatine *Tetrapachylasma* has a wall that may be 6- or 4-plated, depending on the degree of coalescence of the plates. In the 6-plated form (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL coalesces with R to form a compound rostrum (RL+R+RL). In the 4-plated wall (R-CL-C), RL and R form a compound rostrum (RL+R+RL) and CL<sup>2</sup> is united with CL<sup>1</sup> to form a compound CL plate. CL<sup>2</sup> enters the sheath as a narrow zone but RL is not incorporated into the sheath (except in *T. ornatum* sp. nov.).

Imbricating plates are absent in the new subfamily Metalasmatinae described herein, and in the Bathylasmatinae and the Hexelasmatinae. In the Metalasmatinae, the Hexelasmatinae and the bathylasmatines *Bathylasma*, *Mesolasma* and *Tessarelasma*, the wall is 6-plated (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL and CL<sup>2</sup> are incorporated into the wall but RL is not incorporated into the sheath. The bathylasmatine *Tetrachaelasma* has a 4-plated wall (R-CL-C), due to the absence of CL<sup>2</sup>. Thus in the Pachylasmatoidea the RL does not enter the sheath (with the exception of the tetrapachylasmatid *T. ornatum*, which shows the incipient inclusion of RL into the sheath).

#### Family PACHYLASMATIDAE Utinomi, 1968 (emend.)

##### Tables 1-2

DIAGNOSIS. — Wall composed of 8 distinct, calcareous plates (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C); adults externally with 8, 6 or 4 plates differentiated; diametric growth of shell effected by alar growth of R (when distinct), CL<sup>1</sup> and CL<sup>2</sup>, and C; radii absent; sutural edges not complexly interlocked.

REMARKS. — Within the Pachylasmatidae 5 subfamilies were recognised by BUCKERIDGE (1983), i.e. Chionelasmatinae, Pachylasmatinae, Eolasmatinae, Bathylasmatinae and Hexelasmatinae. NEWMAN (1987) later proposed the Chionelasmatoidea, containing the Chionelasmatidae. A new pachylasmatid subfamily, the Metalasmatinae, is defined and described herein. The chionelasmatooids possess caudal appendages and, in the pachylasmatooids, the metalasmatines and pachylasmatines, but these structures are absent in the eolasmatines, bathylasmatines and hexelasmatines.

Adult pachylasmatooids have a variety of shell plate patterns when viewed externally, i.e. 8, 6 or 4 plates. The 8-plated adult pattern is represented by R, paired RL, paired CL<sup>1</sup> and CL<sup>2</sup>, and C (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C). This pattern occurs in the eolasmatines. In the 6-plated adult pattern there is a compound rostral plate, paired CL<sup>1</sup> and CL<sup>2</sup>, and C (R-CL<sup>1</sup>-CL<sup>2</sup>-C). The compound rostral plate may have the rostral suture between R and RL visible



TABLE 1. — Pachylasmatidae: characters of the subfamilies.

	no. plates		imbricating plates		R and RL	CL <sup>1</sup> and CL <sup>2</sup>	alar growth ridges	alar welting
	ext.	int.	+	-				
EOLASMATINAE	8	8	+	-	separate	separate	parallel to inferior alar margin	absent
PACHYLASMATINAE	6	8		-	compound	separate	parallel to inferior alar margin	absent
	6	6		-	compound	separate		
	4	6		-	compound	partially coalesced		
	4	4		-	compound	coalesced		
METALASMATINAE subfam. nov.	6	6		-	compound	separate	sinuously parallel to inferior alar margin	absent; superior alar margin of C thickened in distal 1/2; CL <sup>1</sup> and CL <sup>2</sup> thickened in distal 1/3
BATHYLASMATINAE	6	6		-	compound	separate	diverging from inferior alar margin	narrow
	4	4		-	compound			
HEXELASMATINAE	6	6		-	compound	separate	parallel or diverging from inferior alar margin	narrow to moderate

ext. = external; int. = internal; + = present; - = absent or not applicable.

TABLE 2. — Pachylasmatidae: characters of the subfamilies (continued).

	parietal growth ridge	opercular plates	basis	chitin in parietal plates	c.a.	mandible
EOLASMATINAE	low; lacking small setae	T artic. ridge prom. S artic. ridge not proj.	membranous	absent	absent	tridentoid
PACHYLASMATINAE	low; lacking small setae	T artic. ridge varies from not proj. to proj. S artic. ridge varies from not proj. to proj.	membranous, or membranous/calcareous, or calcareous	absent	present, sometimes reduced/vestigial	tridentoid
METALASMATINAE subfam. nov.	prom., with small setae	T artic. ridge proj. S artic. ridge proj.	membranous	present	present	tridentoid
BATHYLASMATINAE	prom., with small setae	T artic. ridge varies from not proj. to proj. S artic. ridge proj.	membranous or calcareous	absent	absent	quadridentoid
HEXELASMATINAE	prom., with small setae	T artic. ridge not proj. S artic. ridge not proj.	calcareous, sometimes membranous centrally	present	absent	quadridentoid

artic. = articular; c.a. = caudal appendage; proj. = projecting; prom. = prominent.

(occasionally obscure) externally and internally; internally a total of 8 plates is differentiated since R and RL still retain their integrity. Rostral sutures are absent when the coalescence of R and the paired RL is complete; internally a total of 6 plates is differentiated. In the 6-plated adult pattern, CL<sup>1</sup> and CL<sup>2</sup> may be distinct entities, or partially coalesced, but in the latter condition CL<sup>2</sup> still retains a discrete, reduced ala and the suture line is visible internally and externally. The 6-plated pattern occurs in the subfamily Metalasmatinae described herein and in the hexelasmatines, some pachylasmatines (*Eutomolasma* gen. nov., *Microlasma* gen. nov., *Eurylasma* gen. nov.,



*Pachylasma*) and some bathylasmatines (*Bathylasma*, *Mesolasma*). In the 4-plated adult pattern CL<sup>2</sup> may never develop — this condition is seen in some bathylasmatines (*Tetrachaelasma*, *Tessarelasma*).

However, whilst the shell wall pattern is regarded as "fixed" at either 8, 6 or 4 plates for the majority of pachylasmatoid genera (e.g., 8 for *Waikalasma*, 6 for *Pachylasma*, 4 for *Tetrachaelasma*), one genus (*Tetrapachylasma*) exhibits a "variable" pattern, where adult populations contain individuals with 6 or 4 plates. In the 6-plated individuals there is a compound rostral plate, and CL<sup>1</sup> and CL<sup>2</sup> can be separate or show degrees of coalescence. In the 4-plated individuals CL<sup>1</sup> and CL<sup>2</sup> are coalesced, there is a compound rostral plate, and a C.

DISTRIBUTION. — Upper Eocene to Recent; cosmopolitan. All living species inhabit shallow to deep waters.

### Key to the Subfamilies of the Family PACHYLASMATIDAE

Tables 1-2

1. Primary shell wall of adult externally 8-plated; R and RL plates separate; with or without extra whorls of basal imbricating plates ..... **EOLASMATINAE**  
 — Primary shell wall of adult externally 6- or 4-plated; R and RL forming a compound rostral plate; without extra whorls of basal imbricating plates ..... **2**
2. Alar welting absent; caudal appendages present, sometimes reduced or vestigial; mandible tridentoid ..... **3**  
 — Alar welting present; caudal appendages absent; mandible quadridentoid ..... **4**
3. Chitinous rods or lamina absent in wall plates; horizontal growth ridges low, lacking small setae; superior alar margins of C, CL<sup>2</sup> and CL<sup>1</sup> not thickened distally ..... **PACHYLASMATINAE**  
 — Chitinous rods or lamina present in wall plates; horizontal growth ridges prominent, with small setae; superior alar margins of C, CL<sup>2</sup> and CL<sup>1</sup> thickened distally ..... **METALASMATINAE** subfam. nov.
4. Chitinous tubes or lamina absent in wall plates; articular ridge of S prominent ..... **BATHYLASMATINAE**  
 — Chitinous tubes or lamina present in wall plates; articular ridge of S not prominent ..... **HEXELASMATINAE**

#### Subfamily EOLASMATINAE Buckeridge, 1983

Tables 1-2

DIAGNOSIS. — Primary wall with 8 solid calcareous compartmental plates (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C); with or without whorls of imbricating plates; basis membranous.

TYPE GENUS. — *Eolasma* Buckeridge, 1983.

DISTRIBUTION. — Upper Paleocene to Lower Miocene: New Zealand, Australia. Recent: South-west Pacific (off Vanuatu and off the Loyalty Ridge), 700-850 m.

REMARKS. — Presently the Eolasmatinae contains 2 genera, *Eolasma* and *Waikalasma*. *Eolasma*, and hence the type genus of the eolasmatines, is based on a handful of disarticulated plates, which may or may not be from the same species. Thus, there is no guarantee that the genus is 8-plated. Intact specimens of *Eolasma*, as yet unknown, would indicate whether *Waikalasma*, which is 8-plated and which has additional whorls of basal imbricating plates, is related to *Eolasma* or whether *Waikalasma* belongs elsewhere, and not in this subfamily.



Genus **WAIKALASMA** Buckeridge, 1983

*Waikalasma* Buckeridge, 1983: 64.

DIAGNOSIS. — Wall with 8 solid, weakly articulated, calcareous compartmental plates including narrow R, paired RL, CL<sup>1</sup> and CL<sup>2</sup>, and wide C; alae well developed, particularly on C, barely inset from paries; radii absent; 4 whorls of imbricating plates present; basis membranous; caudal appendages absent.

TYPE SPECIES. — *Waikalasma juneae* Buckeridge, 1983.

FOSSIL SPECIES. — *Waikalasma juneae* Buckeridge, 1983.

RECENT SPECIES. — *Waikalasma boucheti* Buckeridge, 1996.

TYPES OF *Waikalasma juneae*. — *Holotype*: AU 5622 R13/f7078; A 131, articulated shell with all eight compartments present but in varying stages of decortication, from the Waikawua Formation (Otaian), collected by J. and J. BUCKERIDGE.

*Paratypes*: from AU 5622, A 132 carina; from AU 6849, A 133 carina; from AU 5622, A 134 incomplete rostrum.

*Holotype and paratype depository*: AU.

DISTRIBUTION. — Lower Miocene to Recent. Oceania.

REMARKS. — Until recently the genus contained a single fossil species, *W. juneae*. However, the first known living representative of the Eolasmatinae, *W. boucheti* Buckeridge, has recently been described from the seas off Vanuatu, in the south-western Pacific Ocean (BUCKERIDGE, 1996). In the present report an incomplete specimen collected from the Loyalty Ridge is also attributed to *W. boucheti*.

***Waikalasma boucheti*** Buckeridge, 1996

Figs 4 b-c, 5-7

*Waikalasma boucheti* Buckeridge, 1996: 449.

MATERIAL EXAMINED. — **Loyalty Ridge**. BATHUS 3: stn DW 778, 750-760 m: 1 specimen (incomplete) (MNHN-Ci 2410). Drawn.

TYPES. — *Holotype*: MNHN-Ci 2428; Vanuatu, MUSORSTOM 8, stn CP 1080, 15°57.4'N, 167°27'E, 799-850 m; 05.10.1994.

*Paratype*: MNHN-Ci 2506; Vanuatu, MUSORSTOM 8, stn DW 1113, 14°53'N, 167°06'E, 700-736 m; 08.10.1994.

*Holotype and paratype depository*: MNHN.

DIAGNOSIS. — *Waikalasma* with 2 or more whorls of large imbricating plates, inner whorl with total of 8 plates; S triangular, very elongate, with long, low articular ridge, adductor muscle scar weak, central; T narrow, inverted 'V' shaped, basal margin deeply excavated, spur at basi-scutal angle.

SUPPLEMENTARY DESCRIPTION. — Incomplete specimen consisting of C, paired opercular plates and soft body; R, CL<sup>1</sup> and CL<sup>2</sup> not recovered. C solid, large; external growth ridges regular, low, giving plate smooth appearance, faint indications of 2 (?) weak longitudinal ribs; C height 13.7; plate sloping inward gently toward orifice, apex slightly spout-like, retroverted; alae triangular, large, placed approximately at right angle to paries, basal outline rectangular, basal widths of alae and paries equal, alar growth ridges sinuously paralleling inferior alar margin, alar welting absent; internally sheath covering 2/3 height of valve, inner surface of C below sheath smooth; base of C slightly inflected inward, with lamina of chitin close to inner surface. Basis unknown. S triangular; elongate, height more than twice width, externally with many spaced, regular, growth ridges; articular ridge barely



projecting; internally adductor muscle scar slightly above middle of valve; depressor muscle scars indistinct. T narrow, height 6 times width; "boomerang" shape due to deep indentation of basal margin; externally well spaced, regular, growth ridges; articular ridge projecting; internally tergal muscle crests lacking. Internal articular junction between opercular plates sinusoidal. Color of preserved material dirty cream, with some brown markings.

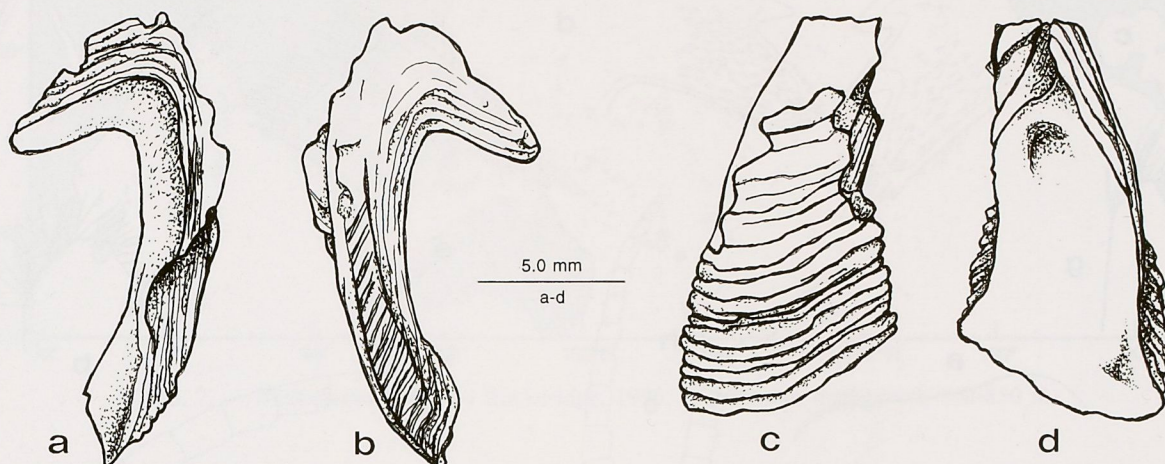


FIG. 5. — *Waikalasma boucheti* Buckeridge, 1996. Specimen (incomplete) from BATHUS 3, stn DW 778 (MNHN-Ci 2410): a, T, internal view; b, T, external view; c, S, external view; d, S, internal view.

Labrum with shallow medial depression, numerous small teeth (approximately 47) across margin. Mandibular palp ovate; dense setae terminally. Mandible with 3 teeth, tooth 1 largest, slightly separated from teeth 2 and 3; upper margins of 2 and 3 smooth; inferior angle 1/3 length of margin, bluntly molariform, sharply dentate. Maxillule with 1-2 pairs of long, stout setae at upper angle; slight notch indicated 1/3 length down cutting margin, dense spines on either side of notch, 7-9 pairs of smaller spines above notch, 7-9 pairs of larger setae below notch; inferior angle small, straight, not protuberant, with 5-6 pairs of small setae. Maxilla wide; lobes indistinct; long serrulate setae terminally.

Cirrus I with rami subequal; anterior ramus slightly longer and wider than posterior; both rami thickly setose, setae finely serrulate distally. Cirrus II similar to cirrus III, longer than cirrus I; rami subequal; both rami with proximal segments setose, setae simple or serrulate, both rami with distal segments tending toward antenniformy, segments becoming oblong. Cirrus III with rami subequal, segments becoming oblong distally; posterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 4 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 2-4 pairs of setae on anterior faces, distal 2 pairs of setae longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-Ci 2410	left	11, 12	21, 18+	23, 23	28, 27	15+, 24+	31, 18+	absent
	right	11, 13	20, 5+	22, 27	31, 32	33, 32	31, 32	absent

Caudal appendages absent. Penis less than height of basal segment of pedicel of cirrus VI; annulated; naked; without tufts of long setae distally.

REMARKS. — Externally there are faint indications of 2, possibly 3, weakly developed longitudinal ribs on the C. Although no basal whorls of imbricating plates were found associated with the incomplete specimen, the "chitinous lamina" in the slightly inwardly inflected base of C may be all that remains of the infolded, basal portion of the imbricating plates, as described in *W. boucheti* (BUCKERIDGE, pers. comm.), and thus the presence of imbricating plates may be inferred.



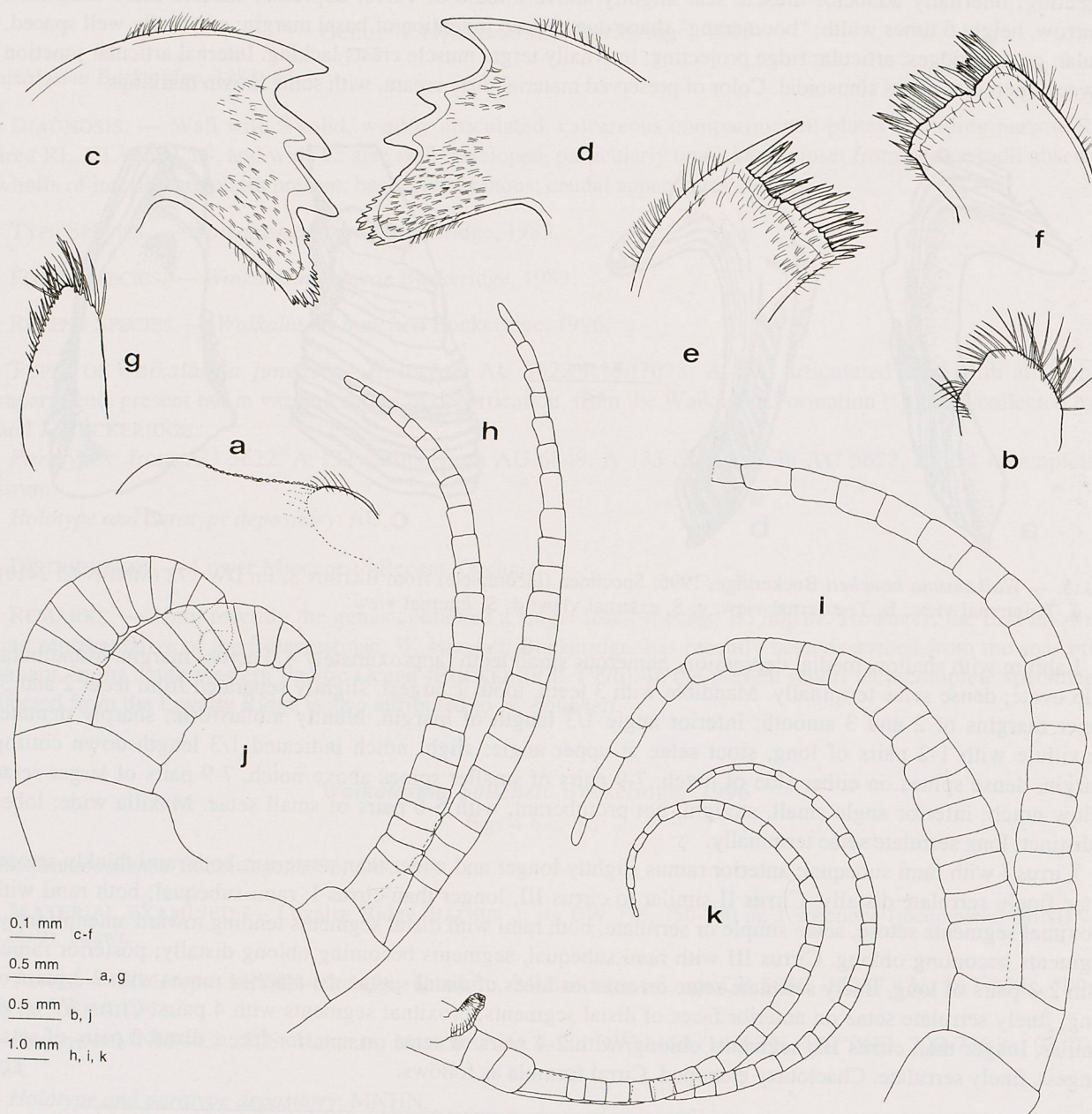


FIG. 6. — *Waikalasma boucheti* Buckeridge, 1996. Specimen (incomplete) from BATHUS 3, stn DW 778 (MNHN-Ci 2410): **a**, labrum; **b**, maxilla; **c**, right mandible; **d**, left mandible; **e**, right maxillule; **f**, left maxillule; **g**, mandibular palp; **h**, cirrus III; **i**, cirrus II; **j**, cirrus I; **k**, cirrus VI.

There are some variations in the soft part morphology of the present material compared to the specimen described from off Vanuatu by BUCKERIDGE (1996). The inferior angle of the mandible is large ( $1/3$  the length of the cutting margin), bluntly molariform and sharply dentate; the maxillule has a slight notch  $1/3$  the distance down the cutting margin, with dense spines on either side; the labrum has an extremely shallow medial depression with numerous conical small teeth along the crest; cirrus I is much shorter than cirrus II and the proximal segments of both rami of cirrus I are much broader and narrower than the corresponding segments in cirrus II. The totality of these differences would suggest that we are dealing with 2 distinct species. However, the paucity of complete specimens precludes further discussion.



DISTRIBUTION. — Vanuatu (700-850 m); Loyalty Ridge (750-760 m).

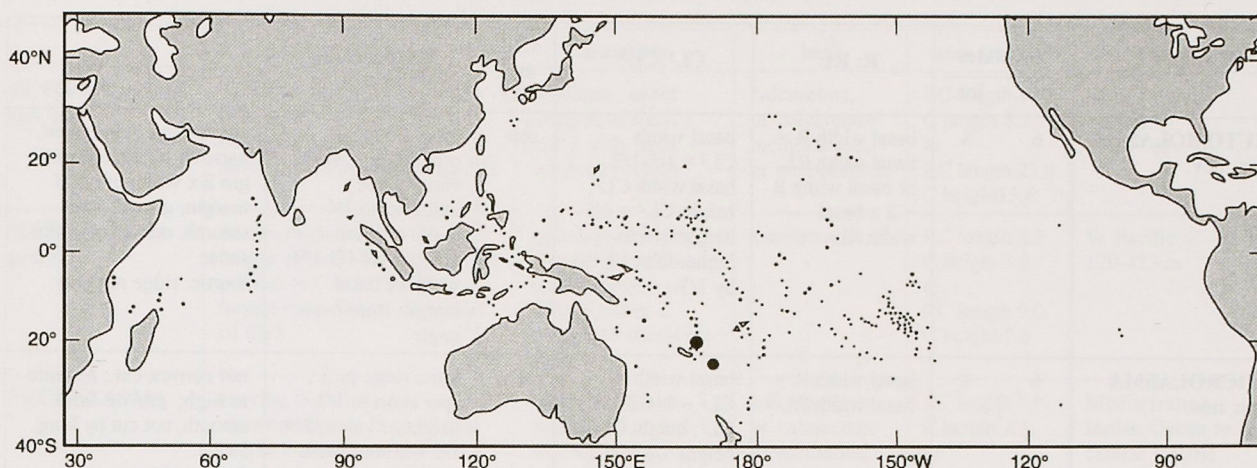


FIG. 7. — *Waikalasma boucheti* Buckeridge, 1996. Distribution map (depth 700-850 m).

### Genus *EOLASMA* Buckeridge, 1983

*Eolasma* Buckeridge, 1983: 62.

DIAGNOSIS. — Shell with 8 solid calcareous compartmental plates (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C); external alar growth ridges parallel inferior alar margin; T with prominent articular ridge, S with articular ridge weakly elevated; basis membranous.

TYPE SPECIES. — *Eolasma maxwelli* Buckeridge, 1983.

FOSSIL SPECIES. — *Eolasma maxwelli* Buckeridge, 1983; *Eolasma rugosa* Buckeridge, 1985.

TYPES OF *Eolasma maxwelli*. — *Holotype*: GS11463 L35/F7537, AR 852 scutum [= number 5 on slide]; Eyre River Sands (Waipawan to Mangaorapan), White's Creek, collected by P. A. MAXWELL.

*Paratypes*: AR 853-864 twelve scuta; AR 865-871 seven terga; AR 872-874 three rostrilatera; AR 875-876 two carinae or rostra; AR 877-878 two carinolatera; AR 879-880 two latera; all same locality as holotype.

*Holotype and paratype depository*: New Zealand Geological Survey, Lower Hutt, New Zealand.

DISTRIBUTION. — Late Paleocene to early Eocene: New Zealand; Early Miocene: Victoria, Australia.

REMARKS. — BUCKERIDGE (1983) considered that the distinct alae and the lack of extra whorls of imbricating plates surrounding the primary shell wall make *Eolasma* more derived than *Waikalasma*.

### Subfamily PACHYLASMATINAE Utinomi, 1968 (emend.)

#### Tables 1-4

DIAGNOSIS. — Wall not surrounded by whorl(s) of imbricating plates. Adult externally with 6 or 4 solid compartmental plates. Parietes with chitin absent; horizontal growth ridges low, lacking small setae. External alar growth ridges parallel to inferior alar margin, alar welting absent. Opercular plates with articular ridges varying from projecting to not projecting. Basis membranous or calcareous. Mandible tridentoid. Caudal appendages present, sometimes reduced or vestigial.

DISTRIBUTION. — Paleocene to Recent; Western Pacific, Africa, Mediterranean.



TABLE 3. — Pachylasmatidae: characters of the genera.

	no. plates		R: RL	CL <sup>1</sup> :CL <sup>2</sup>	CL <sup>1</sup> and CL <sup>2</sup>	T artic. ridge and spur	S
	ext.	int.					
<b>EUTOMOLASMA</b> gen. nov.	6	8	basal width R = basal width RL, or basal width R = 2 x basal width RL	basal width CL <sup>2</sup> = 1/5-1/2 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = 4/5 height CL <sup>1</sup> to higher than CL <sup>1</sup> by 1/3	sep.	artic. ridge not proj. to proj.; spur varies from indistinct to 1/4 width of basal margin, set 1/5-1/9 width of basal margin from b-s angle	convex ext.; elongated, narrow; occludent mar- gin 2 x width of basal margin; growth lines smooth, not cut by long. striae. S artic. ridge not proj.
<b>MICROLASMA</b> gen. nov.	6	8	basal width R = basal width RL	basal width CL <sup>2</sup> = 1/4-2/3 CL <sup>1</sup> ; height CL <sup>2</sup> = height CL <sup>1</sup> or CL <sup>2</sup> shorter than CL <sup>1</sup> by 1/5	sep.	artic. ridge proj.; spur short to 1/2 height of valve, 2/9- 1/2 width of basal margin, set from 1/8-1/10 width of basal margin from b-s angle	not convex ext.; as wide as high; growth lines smooth, not cut by long. striae. S artic. ridge proj.
<b>PACHYLASMA</b>	6 6	8 6	basal width R = basal width RL n.a.	basal width CL <sup>2</sup> = basal width CL <sup>1</sup> ; or basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = height CL <sup>1</sup>	sep.	artic. ridge barely proj. to proj.; spur absent, indistinct, or short; 2/5-1/3 width of basal margin; set from 1/5-1/10 length of basal margin to at b-s angle	length of S basal margin 1/2 or >1/2 length of occludent margin; growth lines smooth, or convoluted, often cut by numerous long. striae. S artic. ridge varying from not proj. to proj.
<b>EURLASMA</b> gen. nov.	6 6	8 6	basal width RL = 3 x basal width R, or basal width RL = 6 x basal width R n.a.	basal width CL <sup>2</sup> = 1/2-9/10 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = 3/4- 9/10 height CL <sup>1</sup>	part. fus.	artic. ridge not proj.; spur indistinct, 1/2-2/3 width of basal margin, not separated from b-s margin	subpyramidal or pyrami- dal form; concave ext.; length of basal margin 2/5-5/12 length of occlu- dent margin; growth lines convoluted, may be cut by long. striae. S artic. ridge not or bare- ly proj.
<b>TETRAPACHY- LASMA</b>	6 6 4 4	8 6 6 4	basal width R = basal width RL n.a. n.a. n.a.	basal width CL <sup>2</sup> = 1/2 to equal basal width CL <sup>1</sup> ; height CL <sup>2</sup> = height CL <sup>1</sup>	part. fus. or fus.	artic. ridge proj.; spur indistinct or short, 1/3-1/2 width of basal margin; set at or at distance of 1/7-1/12 length basal margin from b-s angle	length of basal margin 1/2-7/10 length of occludent margin; growth lines sinuous or convoluted, often cut by 14-8 long. striae. S artic. ridge proj. or not proj.

artic. = articular; b-s = basi-scutal; ext. = external; fus. = fused; int. = internal; long. = longitudinal; n.a. = not applicable; part. fus. = partly fused; proj. = projecting; sep. = separate.

REMARKS. — BUCKERIDGE (1983) considered that this subfamily was represented by a single genus, *Pachylasma*, containing 12 species, of which 3 were fossil. Prior to the present study 3 more extant species of *Pachylasma* were described (FOSTER, 1981; ROSELL, 1981; JONES, 1993b). A second pachylasmatine genus, *Tetrapachylasma*, was described by FOSTER (1988). Herein I describe 3 new genera within the Pachylasmatinae (*Eutomolasma* gen. nov., *Eurlasma* gen. nov. and *Microlasma* gen. nov.) together with 11 new species. The diagnosis of *Tetrapachylasma* Foster, 1988 is emended to reflect the infra-specific variation now recognised within this genus.



TABLE 4. — Pachylasmatidae: characters of the genera (continued).

	caudal appendage	mandible	basis	size (max.)	distribution/depth
<b>EUTOMOLASMA</b> gen. nov.	11-17 segments; from longer than pedicel of CVI by 1/4 height of pedicel of CVI to > twice height of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with weak subsidiary cusps	calcareous, or calcareous/membranous, or membranous	RC length 10.5 C height 8.2 to RC length 23.0 C height 13.6	W to central Pacific; 55-647 m
<b>MICROLASMA</b> gen. nov.	6-9 segments; from < than 1/2 height of basal segment of pedicel of CVI to slightly longer than height of pedicel of CVI	tridentate; margins of teeth smooth or upper margins of teeth 3 and/or 2 often with subsidiary cusps	membranous	RC length 5.3 C height 3.0 to RC length 9.0 C height 7.0	W Pacific; 120-423 m
<b>PACHYLASMA</b>	varying from absent, or uniaarticulate, to 19 segments; height from minute to 1/3 > length of pedicel of CVI	tridentate; upper margins of teeth 2 and/or 3 smooth or with subsidiary cusps	calcareous, or calcareous/membranous, or membranous	RC length 7.0 C height 2.5 to RC length 30.0 C height 30.5	Mediterranean; Indian Ocean to central Pacific Ocean; 104-616 m
<b>EURLASMA</b> gen. nov.	5-13 segments; from 1/2 height of distal segment of pedicel of CVI to longer than height of pedicel of CVI by 1/4	tridentate; upper margins of teeth 2 and 3 often with subsidiary cusps	calcareous	RC length 9.7 C height 7.5 to RC length 15.0 C height 10.6	Loyalty Is, Vanuatu, Norfolk Ridge; 255-470 m
<b>TETRAPACHYLASMA</b>	short (length of basal segment of pedicel of CVI) to long (twice length of pedicel of CVI)	tridentate; upper margins of teeth 2 and 3 with subsidiary cusps; sometimes subsidiary cusps in angle between teeth 1 and 2	calcareous or calcareous/membranous	RC length 6.0 C height 2.5 to RC length 24.0 C height 7.0	W Pacific, W Australia; 3-610 m

The material examined herein indicates that some species have a fixed pattern of 6 wall plates in the adult, whilst others exhibit a variable pattern of either 6 or 4. The species which have a fixed pattern fall into 4 species groups. Given the other consistent morphological similarities exhibited by these groups of taxa, 3 can be considered justifiably as genera — i.e. *Eutomolasma* gen. nov., *Eurylasma* gen. nov. and *Microlasma* gen. nov. However the fourth group, *Pachylasma*, must be considered to be a grouping whose resolution has yet to be determined. The affinities of the various species included in this genus are still unclear and, until further specimens are collected and information on ontogenetic development and intra-specific variation assembled, it will be difficult to resolve the relationships of the various taxa.

Adults of *Eurylasma* gen. nov., *Eutomolasma* gen. nov., *Microlasma* gen. nov. and *Pachylasma* have a fixed pattern of 6-plates (compound rostral plate, paired CL<sup>1</sup> and CL<sup>2</sup>, and C). In *Eutomolasma*, *Microlasma* and *Pachylasma*, CL<sup>1</sup> and CL<sup>2</sup> are separate entities. These plates are coalesced to a certain degree in *Eurylasma*, but the ala of CL<sup>2</sup> is still evident, albeit reduced - thus the adult is still regarded as 6-plated.

One genus, *Tetrapachylasma*, is herein regarded as having a variable wall pattern. Within this genus CL<sup>1</sup> and CL<sup>2</sup> may be separate entities, or coalesced to a certain degree, but the reduced ala of CL<sup>2</sup> is still evident. Both of these conditions represent a 6-plated shell (compound rostral plate, paired CL<sup>1</sup> and CL<sup>2</sup>, and C). However, CL<sup>1</sup> and CL<sup>2</sup> can be totally coalesced, in which case the shell is regarded as 4-plated — i.e. compound rostral plate, paired CL plates (coalesced CL<sup>1</sup> and CL<sup>2</sup>) and C. Both the 4- and the 6-plated condition occur within populations of the same species. No instances have been recorded of a 5-plated condition (i.e. CL<sup>1</sup> and CL<sup>2</sup> totally coalesced on one side only). Thus, the adult shell pattern of this genus is considered to be a variable pattern of either 4 or 6 parietal plates. Ontogenetic evidence has revealed that *Tetrapachylasma arcuatum* sp. nov. and 2 species which were included previously within *Pachylasma* (i.e. *P. aurantiacum* Darwin, 1854 and *P. ferrugomaculosa* Jones, 1993b)



may have either 4 or 6 plates in the adult. Similarities in the form of the wall plates, the opercular plates and body morphology suggest these species, along with *T. ornatum* sp. nov., can be included with *T. trigonum* Foster, 1988 to form a generic grouping.

### Key to the genera of PACHYLASMATINAE

Tables 3-4

1. Adults with CL<sup>1</sup> and CL<sup>2</sup> partially coalesced (CL<sup>2</sup> retaining small ala) or coalesced (ala of CL<sup>2</sup> absent); rostral plate compound, sutures obscure or visible, basal width of R equal to or smaller (1/3 or 1/6 basal width) than basal width of RL ..... **2**  
 — Adults with CL<sup>1</sup> and CL<sup>2</sup> separate; rostral plate compound, sutures obscure or visible, basal width of R equal to or wider (twice basal width) than basal width of RL ..... **3**
2. Rostral plate compound, sutures obscure or visible, basal width of R smaller (1/3 or 1/6 basal width) than basal width of RL; S concave, sub-pyramidal or pyramidal, due to angled basal margin; articular ridge of T not projecting ..... **EURLASMA** gen. nov.  
 — Rostral plate compound, sutures obscure or visible, basal width of R equal to basal width of RL; S not concave, not sub-pyramidal or pyramidal, basal margin straight; articular ridge of T projecting ..... **TETRAPACHYLASMA**
3. Rostral plate compound, sutures visible, basal width of R equal to or wider (twice basal width) than basal width of RL; growth ridges of S even, smooth, not cut by longitudinal striae; basal width of CL<sup>2</sup> smaller (1/5-2/3 basal width) than basal width of CL<sup>1</sup> ..... **4**  
 — Rostral plate compound, sutures obscure or visible, basal width of R equal to basal width of RL; growth ridges of S convoluted, cut by longitudinal striae; basal width of CL<sup>2</sup> equal to basal width of CL<sup>1</sup> ..... **PACHYLASMA**
4. Basal width of R equal to or wider (twice basal width) than basal width of RL; S convex externally, elongated and narrow; S articular ridge not projecting; caudal appendages long (from 1/4 longer than pedicel of cirrus VI to more than twice height of pedicel of cirrus VI), 11-17 segments; basal width of CL<sup>2</sup> 1/5-1/2 basal width of CL<sup>1</sup> ..... **EUTOMOLASMA** gen. nov.  
 — Basal width of R equal to basal width of RL; S not convex externally, S as wide as high; S articular ridge projecting; caudal appendages short (from less than 1/2 height of basal segment of pedicel of cirrus VI to slightly longer than height of pedicel of cirrus VI), 6-9 segments; basal width of CL<sup>2</sup> 1/4-2/3 basal width of CL<sup>1</sup> ..... **MICROLASMA** gen. nov.

### Genus **EUTOMOLASMA** gen. nov.

Fig. 8; Tables 3-6

DIAGNOSIS. — Symmetrical shell form, orifice large. Adult with fixed shell-plate pattern of 6 parietal plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C). Rostral plate compound, sutures visible, basal width of R equal to or twice basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate. S convex externally; elongated, narrow; with smooth, even, transverse growth ridges, not cut by longitudinal striae. Caudal appendages longer than pedicel of cirrus VI by 1/4 to at least twice height of pedicel of cirrus VI; 11-17 segments.

TYPE SPECIES. — *Eutomolasma chinense* (Pilsbry, 1912).

RECENT SPECIES. — *Eutomolasma chinense* (Pilsbry, 1912); *E. japonicum* (Hiro, 1933); *E. macLaughlinae* sp. nov.; *E. orbiculatum* sp. nov.



TABLES 5 and 6. — *Eutomolasma* gen. nov.: characters of the species

	no. plates ext. int.	R:RL	CL <sup>1</sup> :CL <sup>2</sup>	T	basis
<i>E. chinense</i> (Pilsbry, 1912)	6 8	R = RL	separate; CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	articular ridge not proj.; spur extremely short, wide; ext. with no long. ridge	calcareous thin centrally
<i>E. japonicum</i> (Hiro, 1933)	6 8	R = RL	separate; CL <sup>2</sup> = < 1/2 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = 8/9 height CL <sup>1</sup>	articular ridge slightly proj.; spur indistinct, set at 1/8 width of basal margin from b-s angle; ext. with long. ridge close to S margin; 6-7 muscle crests proj. below basal margin	membranous or partly calcareous
<i>E. macLaughlinae</i> sp. nov.	6 8	R = 2 x RL	separate; CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = heigher than CL <sup>1</sup> by 1/3	articular ridge scarcely proj.; spur short, basally rounded, 1/8 width basal margin; set at distance of 1/10 width basal margin from b-s angle; ext. with 2 long., parallel ridges, 1 on each side of spur; 7-9 muscle crests, extending well beyond basal margin	membranous
<i>E. orbiculatum</i> sp. nov.	6 8	R = RL	separate; CL <sup>2</sup> = 1/4-1/5 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = 4/5 height CL <sup>1</sup>	articular ridge strongly proj.; spur indistinct, 1/4 width basal margin; set 1/5 width basal margin from b-s angle; ext. with long. ridge close to S margin; 15-18 small muscle crests, extending just beyond basal margin	membranous

b-s = basi-scutal; ext. = external; int. = internal; long. = longitudinal; proj. = projecting.

	S shape	S growth lines	caudal appendage	mandible	size (max.)	distribution	depth
<i>E. chinense</i> (Pilsbry, 1912)	convex ext.; S occludent margin 2.5 x length of basal margin; artic. ridge low	smooth, even, transverse, not cut by long. striae	unknown	unknown	RC length 16.5 C height 13.6	S China Sea	380 m
<i>E. japonicum</i> (Hiro, 1933)	feebly convex ext.; S occludent margin > 2 x S basal margin; S artic. ridge not projecting	smooth, even, transverse, not cut by long. striae	13-14 segs; 2 x length of pedicel of CVI	tridentate; upper margins of teeth 2 & 3 with subsidiary cusps	RC length 21.0 R height 11.0	SW Japan	55-364 m
<i>E. macLaughlinae</i> sp. nov.	feebly convex ext.; S basal margin 7/15 S occlu- dent margin; S artic. ridge not projecting	smooth, even, transverse, not cut by long. striae	11-17 segs, at least 2 x length of pedicel of CVI	tridentate; upper margins of teeth 2 & 3 with subsidiary cusps	RC length 10.5 C height 8.2	Lord Howe Ridge New Caledonia Loyalty Islands Norfolk Ridge Futuna Island Combe Bank Waterwich Bank	500-510 m 280-647 m 430-575 m 420-560 m 245-400 m 455 m 325-400 m
<i>E. orbiculatum</i> sp. nov.	convex ext.; S basal margin 1/2 S occludent margin; S artic. ridge not projecting	smooth, even, transverse, not cut by long. striae	14-15 segs; longer than pedicel of CVI by 1/4 length of pedicel of CVI	tridentate; upper margins of teeth 2 & 3 with weak subsidiary cusps	RC length 23.0 CH 9.6	Loyalty Islands Norfolk Ridge	460 m 260-440 m

artic. = articular; b-s = basi-scutal; ext. = external; long. = longitudinal; max. = maximum; segs = segments.



REMARKS. — The symmetrical shell form and the large orifice, the externally convex, elongated and narrow S with smooth S growth ridges and the long caudal appendages (11-17 segments) distinguish this genus. Other distinguishing characters are listed in Tables 3-6. The species included herein are moderate (maximum: RC length 10.5, C height 8.2) to large (maximum: RC length 23.0, LD 29.9, C height 9.6, R height 9.0) in size and occur in association with gastropods, echinoderms, brachiopods, balanomorph and scalpellid barnacles, coral and pumice.

ETYMOLOGY. — From the Greek *eutomos*, "regular", in reference to the symmetrical form of the shells of the species in this genus.

DISTRIBUTION. — Western to central Pacific, 55-647 m: Loyalty Islands, Norfolk Ridge, 260-460 m (*E. orbiculatum*); Lord Howe Ridge, New Caledonia, Loyalty Islands, Norfolk Ridge, Futuna Island, Combe Bank, Waterwich Bank, 245-647 m (*E. macLaughlinae*); South China Sea, 380 m (*E. chinense*); SW Japan, 55-364 m (*E. japonicum*).

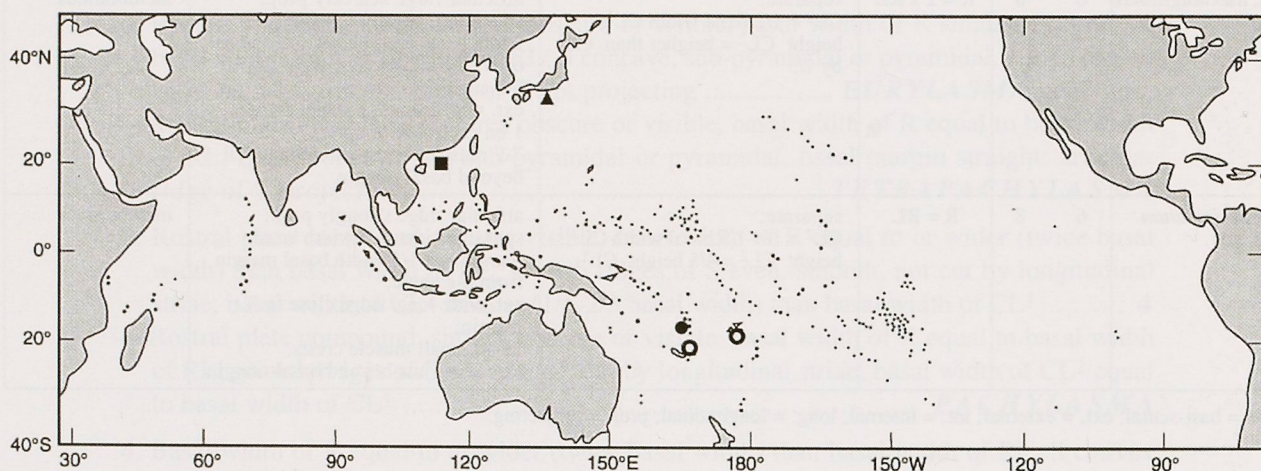


FIG. 8. — *EUTOMOLASMA* gen. nov. Distribution map: ■, *E. chinense* (380 m); ▲, *E. japonicum* (55-364 m); ●, *E. orbiculatum* (260-460 m); ○, *E. macLaughlinae* (245-647 m).

***Eutomolasma chinense* (Pilsbry, 1912)**

Fig. 8; Tables 5-6

*Pachylasma chinense* Pilsbry, 1912: 293; 1916: 329. — NEWMAN & ROSS, 1976: 40.

TYPES. — *Holotype*: USNM Cat. No. 43471; "Albatross", stn 5301, China Sea, near Hong Kong, 20°37'N, 115°43'E, 380 m, on scutum of a living *Scalpellum stearnsii* Pilsbry; mouthparts and caudal appendages on slide, shell and opercular plates separate.

*Holotype depository*: USNM (shell and opercular plates have not been located).

DIAGNOSIS. — Orifice piriform, toothed. Parietal plates thin, covered with thin, yellowish epicuticle. Basal width of R equal to basal width of RL, R separated from RL by sutures, inconspicuous externally, conspicuous internally. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Superior alar margins arched, finely serrate. S convex externally. T externally with longitudinal depression absent; articular ridge of T not projecting beyond articular margin; T spur short, wide.

REMARKS. — *Eutomolasma chinense* is a moderate sized species (maximum: RC length 16.5, C height 13.6), characterised by the equal basal widths of R and RL, the basal width of CL<sup>2</sup> being 1/2 the basal width of CL<sup>1</sup>, and the S being externally convex.



The calcareous rather than membranous basis, the inconspicuous rather than conspicuous external sutures of the rostral plate, the basal width of CL<sup>2</sup> being 1/2 the basal width of CL<sup>1</sup>, rather than less than 1/2 the basal width of CL<sup>1</sup>; the alae being arched rather than parallel to the basis, the short and wide, rather than indistinct, tergal spur; the absence rather than presence of a longitudinal ridge externally on the T, close to the S margin; and the thin parietal plates, white with pink apices and covered with a yellowish epicuticle, rather than glossy pink plates, distinguish *E. chinense* from *E. japonicum*. The differences between *E. macLaughlinae* sp. nov. and *E. chinense* are listed under *E. macLaughlinae*, and between *E. orbiculatum* sp. nov. and *E. chinense* are listed under *E. orbiculatum*.

DISTRIBUTION. — South China Sea, 380 m.

*Eutomolasma japonicum* (Hiro, 1933)

Fig. 8; Tables 5-6

*Pachylasma japonicum* Hiro, 1933: 65; 1937: 430. — NEWMAN & ROSS, 1976: 40. — ROSELL, 1991: 37.

TYPES. — Syntypes: SMBL Type; station 303, off Toi-saki, Hiuga-nada, 31°16'00"N, 131°33'15"E, 364 m, 12.06.1928, bottom sand; 7 specimens attached to broken shells of *Clypeaster japonicus* Döderlein, together with *Scalpellum laccadivicum* Annandale.

Syntypes depository: SMBL (specimens have not been located).

DIAGNOSIS. — Form rounded oval from above. Parietal plates with numerous, smooth, regular growth ridges. Basal width of R equal to basal width of RL; rostral sutures visible externally. Basal width of CL<sup>2</sup> less than 1/2 basal width of CL<sup>1</sup>. Alae broad, triangular, distinctly striped verically, summits almost parallel to basal margins. S elongate, triangular, externally feebly convex; articular ridge not projecting. T triangular, externally longitudinal ridge set close to S margin; articular ridge slightly projecting; 6-7 muscle crests projecting beyond basal margin; T spur indistinct.

REMARKS. — The slightly projecting tergal articular ridge, the 6-7 tergal muscle crests projecting beyond the tergal basal margin and the externally feebly convex S characterise *E. japonicum*. Differences between *E. japonicum* and *E. chinense* are listed under *E. chinense*, between *E. japonicum* and *E. macLaughlinae* sp. nov. under *E. macLaughlinae*, and between *E. japonicum* and *E. orbiculatum* sp. nov. under *E. orbiculatum*. *Eutomolasma japonicum* is a large species (maximum: RC length 21.0, R height 11.0).

DISTRIBUTION. — SW Japan, 55-364 m.

*Eutomolasma macLaughlinae* sp. nov.

Figs 8-11; Tables 5-6

MATERIAL EXAMINED. — **Chesterfield Islands.** MUSORSTOM 5: stn DC 388, 500-510 m: 2 specimens, attached to coral.

**New Caledonia.** "Vauban": 12.04.1978: 8 specimens, some attached to shell of gastropod.

MUSORSTOM 4: stn CP 170, 460 m: 1 specimen. — Stn CP 179, 475 m: 1 specimen. — Stn CP 179, 475 m: 5 specimens, on pumice and shells of gastropod. — Stn DW 183, 280 m: 1 specimen, on *Chirona (Striatobalanus) amaryllis* (Darwin, 1854), latter attached to a sponge. — Stn CP 215, 485-520 m: 2 specimens. — Stn DW 221, 535-560 m: 1 specimen. — Stn DW 222, 410-440 m: 5 specimens. — Stn DW 223, 545-560 m: many specimens. — Stn DW 229, 445-460 m: many specimens, some attached to gastropod shell (MNHN-Ci 2695). Drawn; 1 specimen (MNHN-Ci 2391); 9 specimens, attached to gastropod shell (WAM C 23244); many specimens, attached to gastropod shells (WAM 251-96). — Stn DW 230, 390-420 m: 3 specimens.

SMIB 8: stn DW 167, 430-452 m: 1 specimen (WAM C 23245). — Stn DW 197, 414-436 m: 4 specimens. — Stn DW 198, 414-430 m: several specimens. — Stn DW 199, 408-410 m: 1 specimen, attached to gastropod.

BATHUS 2: stn DW 718, 430-436 m: several specimens, attached to brachiopod shells and echinoderm tests (WAM C 23246). — Stn DW 719, 444-455 m: many specimens (1 ovigerous), attached to gastropod shells and echinoderm



tests (WAM C 23247). — Stn DW 720, 530-541 m: 2 specimens (WAM C 23248); many specimens. — Stn DW 729, 400 m: many specimens. — Stn DW 738, 588-647 m: 1 specimen, attached to gastropod; 1 specimen.

BATHUS 4: stn CP 909, 516-558 m: 2 specimens, attached to shells of gastropods.

**Loyalty Islands.** BIOCAL: stn DW 44, 440 m: many specimens, attached to shells of gastropods and test of echinoderm. — Stn CP 45, 430-465 m: 17 specimens (6 juveniles), attached to fragment of test of echinoderm and shells of gastropods.

MUSORSTOM 6: stn CP 465, 480 m: 1 specimen, attached to fragment of echinoderm test. — Stn CP 466, 540 m: 2 specimens, attached to gastropods (USNM); 2 specimens. — Stn CP 467, 575 m: many specimens, some attached to shells of gastropods.

**Norfolk Ridge.** SMIB 2: stn DW 1, 438-444 m: several specimens on gastropod shell. — Stn DW 2, 438-448 m: 1 specimen (BMNH). — Stn DW 12, 445-460 m: 1 specimen, attached to shell of gastropod.

SMIB 3: stn DW 21, 525 m: 2 specimens. — Stn DW 22, 503 m: 12 specimens. — Stn DW 24, 525 m: 1 specimen; 1 specimen (broken). — Stn DW 25, 437 m: 3 specimens. — Stn DW 27, 457 m: 1 specimen.

SMIB 4: stn DW 58, 560 m: 11 specimens. — Stn DW 61, 550 m: 1 specimen. — Stn DW 64, 460 m: several specimens on gastropod shell. — Stn DW 65, 420 m: many specimens attached to gastropod shells. — Stn DW 68, 440 m: 3 specimens, attached to gastropod shells.

BATHUS 3: stn DW 829, 386-390 m: 1 specimen, attached to shell of gastropod (MNHN-Ci 2392). — Stn CP 833, 441-444 m: 11 specimens, attached to fragments of echinoderm test and shell of gastropod.

**Futuna Island.** MUSORSTOM 7: stn CP 505, 245-400 m: 1 specimen, attached to fragment of shell of gastropod.

**Combe Bank.** MUSORSTOM 7: stn DW 547, 455 m: 1 specimen.

**Waterwich Bank.** MUSORSTOM 7: stn DW 537, 325-400 m: 1 specimen, attached to shell of gastropod.

**TYPES.** — *Holotype*: MNHN-Ci 2391 (MUSORSTOM 4, stn DW 229).

*Paratypes*: BMNH (SMIB 2, stn DW 2). — MNHN-Ci 2392 (BATHUS 3, stn DW 829). — MNHN-Ci 2695 (MUSORSTOM 4, stn DW 229). Drawn. — USNM (MUSORSTOM 6, stn CP 466). — WAM 251-96 (MUSORSTOM 4, stn DW 229).

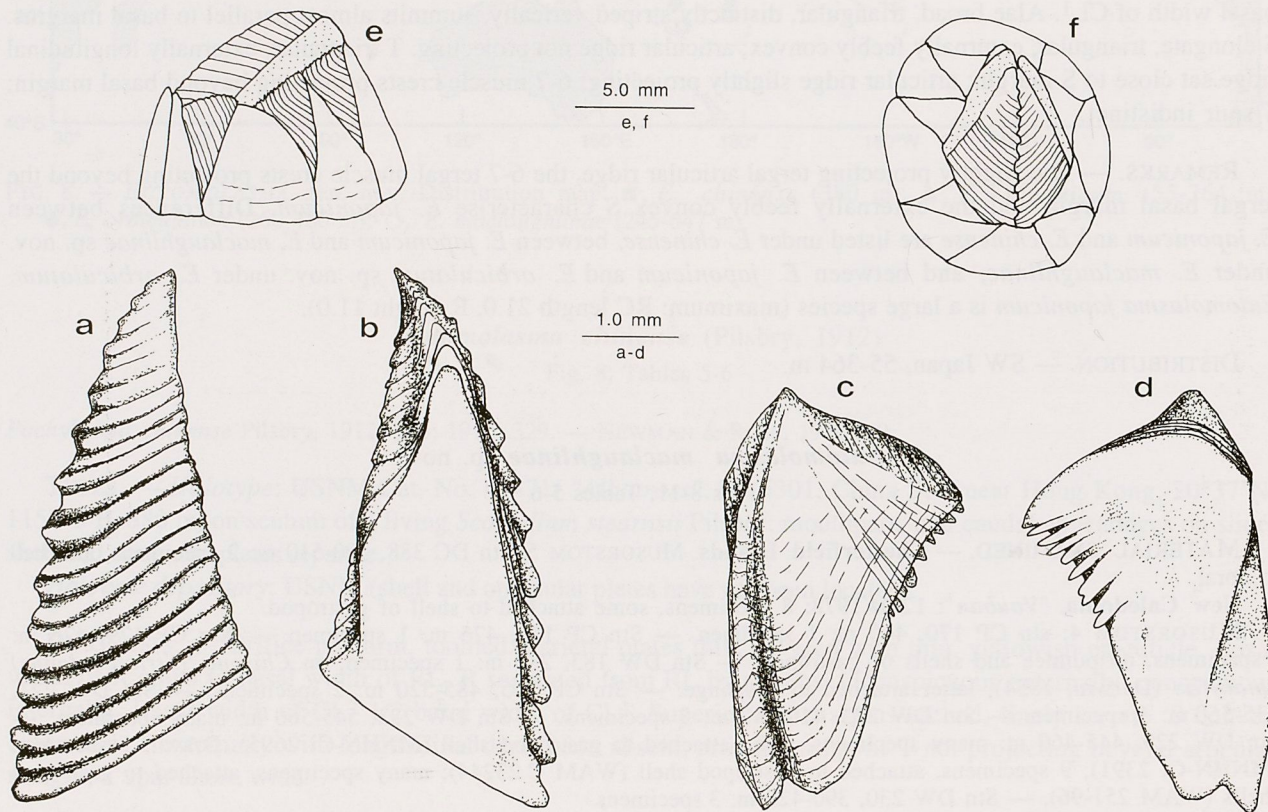


FIG. 9. — *Eutomolasma macLaughlinae* sp. nov. Paratype from MUSORSTOM 4, stn DW 229 (MNHN-Ci 2695): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view; e, whole animal, lateral view; f, whole animal, from above.



**DIAGNOSIS.** — Form rounded oval from above; orifice smooth, large, diamond-shape. Basal width of R twice basal width of RL; rostral sutures visible externally. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Superior alar margin subparallel to basal margin, finely serrate. S elongate triangle, feebly convex externally. Articular ridge of T scarcely projecting; externally with 1 parallel, longitudinal ridge on each side of spur; 7-9 muscle crests extending beyond basal margin; T spur short.

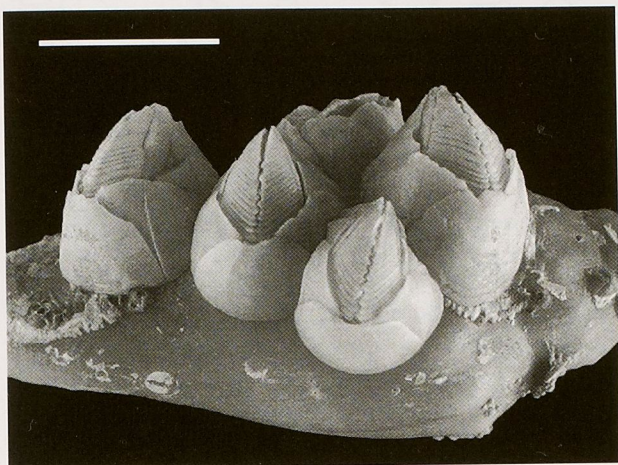


FIG. 10. — *Eutomolasma macLaughlinae* sp. nov. Paratypes from MUSORSTOM 4, stn DW 229 (WAM 251-96): oblique lateral view. Scale = 1cm.

**DESCRIPTION.** — Shell moderate sized (maximum: RC length 10.5, C height 8.2). Parietal plates with growth ridges barely visible, irregular, most developed on rostral plate. Rostral plate convex; basal width twice basal width of CL<sup>1</sup>, height subequal to height of C; sutures between R and RL visible externally and internally. CL<sup>1</sup> and CL<sup>2</sup> separate; basal width of CL<sup>1</sup> subequal to basal width of R, twice width of CL<sup>2</sup>. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>; CL<sup>2</sup> higher than CL<sup>1</sup> by 1/3. Height of C equal to or slightly higher than R, basal width equal to that of CL<sup>1</sup>; apex sloping inward to orifice, not retroverted and spout-like. Alae of C, CL<sup>1</sup> and CL<sup>2</sup> subequal, broad, triangular; alar growth ridges regular, parallel to inferior alar margin. Basis membranous; flat. Opercular plates orientated from sub-parallel to basis to angle of 40° to basis. S elongate triangle, basal margin 7/15

length of occludent margin; apex acute; externally feebly convex, growth ridges regular, smooth, not cut by longitudinal striae; internally adductor muscle and lateral depressor muscle pits absent; articular furrow narrow; articular ridge long, extending 3/4 length of valve, not projecting beyond articular margin; adductor ridge indistinct. T similar size to S, sub-triangular; externally with fine growth ridges, fine longitudinal striations in carinal area, 2 parallel, longitudinal ridges, 1 either side of spur; internally with 7-9 distinct muscle attachment crests extending beyond basal margin; articular margin convex; articular ridge long, barely projecting beyond articular margin; articular furrow wide; spur short, rounded, 1/9 width of basal margin, set at its own width from basi-scutal angle. Color of parietal plates peachy orange, C and CL<sup>2</sup> deeper orange; shell sometimes pale ochre-orange or dirty cream color; opercular plates lemon yellow; eggs orange. Measurements of 10 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height	R height
rg	7.7-10.5	7.2-11.0	3.8-8.2	4.7-8.2
$\bar{x}$	9.0	8.6	5.5	6.0

Labrum with shallow medial depression; small teeth present at edges of depression, teeth absent from central area. Mandibular palp club-shaped; dense, serrate setae terminally. Mandible with 3 teeth, tooth 1 largest, separated from teeth 2 and 3; upper margins of 2 and 3 with subsidiary cusps; inferior angle molariform, dentate. Maxillule with 1 pair of long, stout setae at upper angle; notch below upper angle 1/4 length of cutting margin, with 5-6 pairs of smaller setae; straight cutting margin below with 5-7 pairs of longer, stout setae; inferior angle slightly sinuous, with 5-6 pairs of smaller setae. Maxilla as wide as high, with long serrulate setae terminally.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior ramus barely protuberant anteriorly; both rami with segments moderately setose. Cirrus II longer than cirrus I; rami subequal, anterior ramus shorter than posterior; proximal segments of anterior ramus slightly protuberant anteriorly; distal segments of posterior ramus antenniform; all segments with dense, simple setae, some finely serrulate setae



distally. Cirrus III longer than cirrus II, rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of more distal segments, proximal segments with 8 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4 pairs of setae on anterior faces, distal 2 pairs longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN	left	12, 8	14, 15	16, 18	22, 25	27, 27	28, 28	11+
Ci 2695	right	11, 8	14, 14	17, 19	15+, 25	27, 29	29, 28	17

Caudal appendages at least twice length of pedicel of cirrus VI; 11-17 segments; sparse circlet of long, fine setae apically and at distal borders of segments, setal length equal to segmental length. Penis subequal to cirrus VI; annulated, sparsely setose, with sparse circlet of long setae distally. Eggs large, 0.5 x 0.4 mm.

REMARKS. — *Eutomolasma maclaughlinae* sp. nov. differs from all other members of the genus by the large size of the R (basal width twice the basal width of RL); by CL<sup>2</sup> being higher, not shorter, than CL<sup>1</sup>; and by T possessing 2 external longitudinal ridges, 1 each side of the spur. It is further separated from *E. chinense* by the membranous rather than calcareous basis, by the rostral plate sutures being visible externally rather than being inconspicuous, by the absence of an epicuticle, rather than a thin, yellowish epicuticle covering the parietal plates; and by the color of the parietal plates (peachy orange or pale ochre/orange to dirty cream rather than white tinted with pink apically).

The new species is similar to *E. orbiculatum* sp. nov. as both species have a convex tergal articular margin (more pronounced in *E. orbiculatum*), but *E. maclaughlinae* may be separated from *E. orbiculatum* as follows: by its smaller size (maximum: RC length 10.5, RC length 23.0, respectively), by the basal width of CL<sup>2</sup> being 1/2 that of CL<sup>1</sup> rather than 1/4-1/5; by the T articular ridge scarcely projecting, rather than extending well beyond the articular margin; by the length of the caudal appendages (at least twice the height of the pedicel of cirrus VI rather than longer than the pedicel of cirrus VI by 1/4); and by the dentition of the labrum (small teeth present at the edges of the median depression, rather than absent).

*Eutomolasma japonicum* differs from *E. maclaughlinae* sp. nov. in C being the shortest of all the plates (rather than equal to or higher than R), by the basal width of R being equal to, rather than twice, the basal width of RL; by the basal width of CL<sup>2</sup> being less than 1/2 that of CL<sup>1</sup>, rather than 1/2; by the height of CL<sup>2</sup> being 8/9 the height of CL<sup>1</sup> rather than higher than CL<sup>1</sup> by 1/3; by the T spur being indistinct rather than short and rounded; and by the color (glossy pink parietal plates, fading toward a whitish R, rather than peachy orange or pale ochre/orange).

ETYMOLOGY. — Named in honour of my friend and colleague Dr Patsy A. McLAUGHLIN, in recognition of her contributions to cirripedology, and who first noted this species on mollusc shells inhabited by hermit crabs.

DISTRIBUTION. — Chesterfield Islands, 500-510 m; New Caledonia, 280-647 m; Loyalty Islands, 430-575 m; Norfolk Ridge, 386-560 m; Futuna Island, 245-400 m; Combe Bank, 455 m; Waterwich Bank, 325-400 m.

*Eutomolasma orbiculatum* sp. nov.

Figs 8, 12-14; Tables 5-6

MATERIAL EXAMINED. — **Loyalty Islands.** BIOCAL: stn DW 83, 460 m: 3 specimens (MNHN-Ci 2393, Ci 2696). Drawn.

**Norfolk Ridge.** SMIB 4: stn DW 55, 260 m: 13 specimens (ontogenetic series), attached to *Petrotrochus caledonicus* Bouchet & Métivier (WAM 252-96). — Stn DW 68, 440 m: 1 specimen (MNHN-Ci 2394).



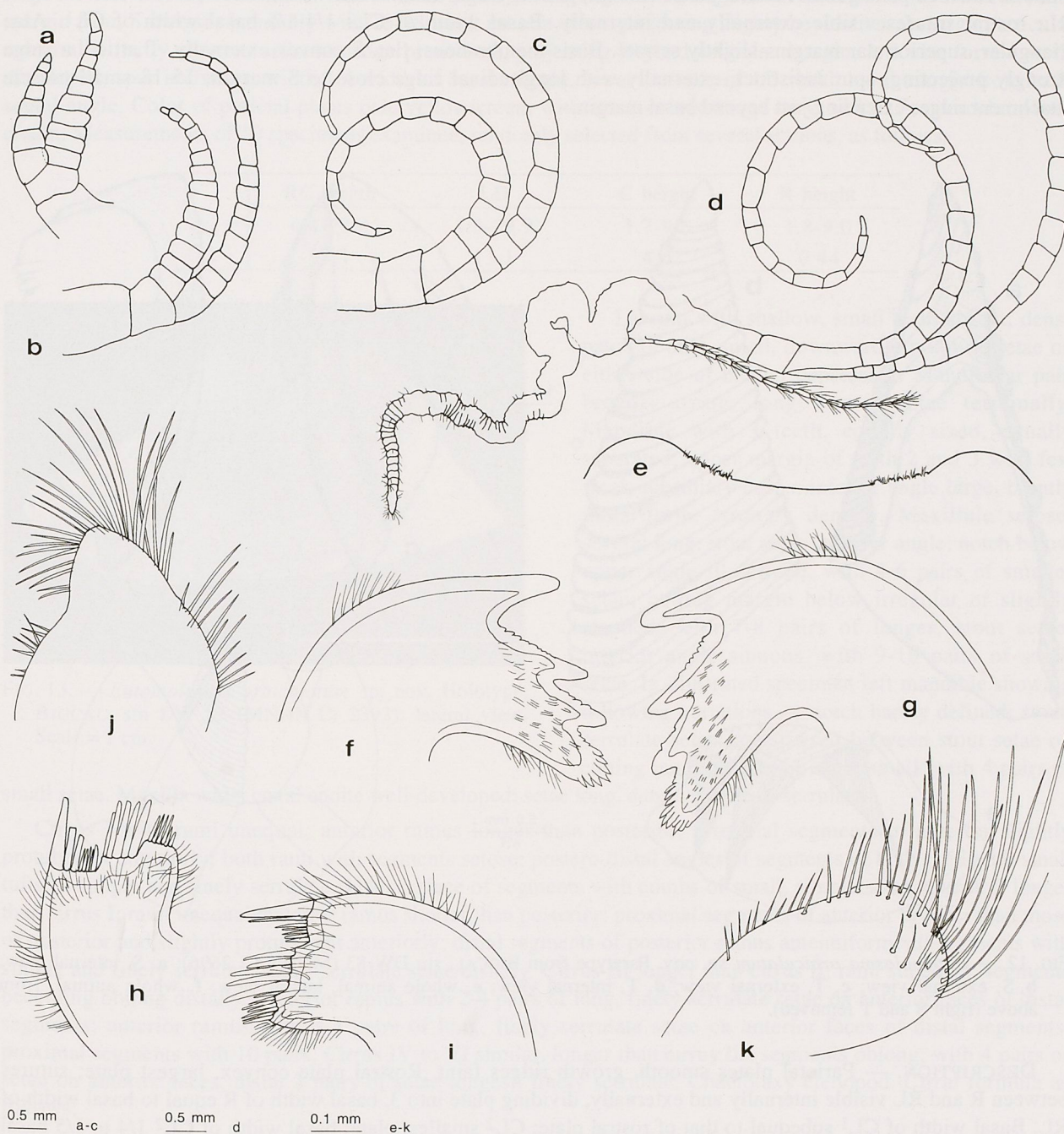


FIG. 11. — *Eutomolasma macLaughlinae* sp. nov. Paratype from MUSORSTOM 4, stn DW 229 (MNHN-Ci 2695): **a**, cirrus I; **b**, cirrus II; **c**, cirrus III; **d**, cirrus VI, penis and caudal appendage; **e**, labrum; **f**, right mandible; **g**, left mandible; **h**, right maxillule; **i**, left maxillule; **j**, maxilla; **k**, mandibular palp.

TYPES. — *Holotype*: MNHN-Ci 2393 (BIOCAL, stn DW 83).

*Paratypes*: MNHN-Ci 2394 (SMIB 4, stn DW 68). — MNHN-Ci 2696 (BIOCAL, stn DW 83). Drawn. — WAM 252-96 (SMIB 4, stn DW 55).



DIAGNOSIS. — Shell large (maximum: RC length 23.0, C height 9.6); basal circumference subcircular. Orifice smooth, rounded pentagonal. Parietal plates smooth, growth ridges faint. Basal width of R equal to basal width of RL; rostral sutures visible externally and internally. Basal width of CL<sup>2</sup> 1/4-1/5 basal width of CL<sup>1</sup>. Alae triangular, superior alar margins slightly serrate. Basis membranous; flat. S convex externally. T articular ridge strongly projecting; spur indistinct; externally with longitudinal ridge close to S margin; 15-18 small muscle attachment ridges extending just beyond basal margin.

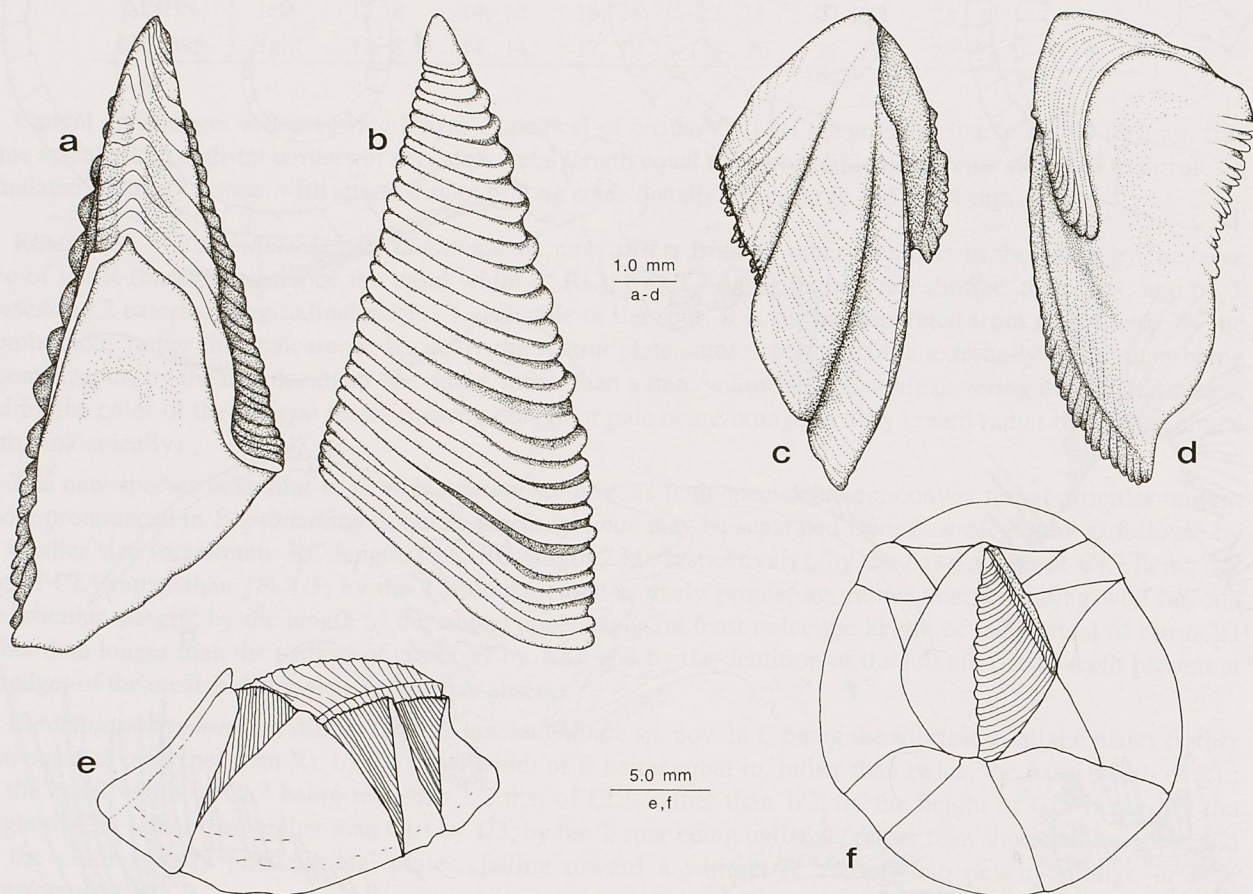


FIG. 12. — *Eutomolasma orbiculatum* sp. nov. Paratype from BIOCAL, stn DW 83 (MNHN-Ci 2696): **a**, S, internal view; **b**, S, external view; **c**, T, external view; **d**, T, internal view; **e**, whole animal, lateral view; **f**, whole animal, from above (right S and T removed).

DESCRIPTION. — Parietal plates smooth, growth ridges faint. Rostral plate convex, largest plate; sutures between R and RL visible internally and externally, dividing plate into 3, basal width of R equal to basal width of RL. Basal width of CL<sup>1</sup> subequal to that of rostral plate; CL<sup>2</sup> smallest plate; basal width of CL<sup>2</sup> 1/4 to 1/5 basal width of CL<sup>1</sup>; height of CL<sup>2</sup> 4/5 height of CL<sup>1</sup>. C convex; narrower than CL<sup>1</sup> and rostral plate, wider than CL<sup>2</sup>; shorter than or subequal to height of R. Alae triangular, those of CL<sup>1</sup> widest, alae of CL<sup>2</sup> 2/3 width of alae of CL<sup>1</sup>, alae of C 1/3 width of alae of CL<sup>1</sup>; superior alar margins slightly serrate; alar growth ridges parallel to inferior alar margin, faintly marked. Basis membranous; flat. Orifice large, roundly pentagonal; not toothed. Opercular plates lodged sub-parallel to basis. S convex externally, elongate triangle, occludent margin twice length of basal margin; apex acute; externally with regular, smooth, transverse growth ridges not cut by longitudinal striae; internally adductor muscle pit faint, at slightly less than 1/2 height of valve; lateral depressor muscle pit absent; articular furrow narrow, shallow; articular ridge extending 3/4 length of valve, not projecting beyond



articular margin; adductor ridge absent. T 2/3 size of S; externally growth ridges faint, except in area of articular ridge (visible when whole animal viewed from above), with longitudinal ridge set at distance of 1/5 width of basal margin from S margin; internally with 15-18 weak muscle crests projecting slightly beyond basal margin; articular margin distinctly convex; articular ridge prominent, projecting beyond articular margin; articular furrow well-developed; spur indistinct, width 1/4 width of basal margin, set at distance of 1/5 width basal margin from basiscutal angle. Color of parietal plates pale yellow/cream with some ochre/orange on C and CL<sup>2</sup>; opercular plates cream. Measurements of 10 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height	R height
rg	4.4-23.0	4.3-29.9	1.7-9.6	1.8-9.0
$\bar{x}$	12.1	13.1	4.6	0.44

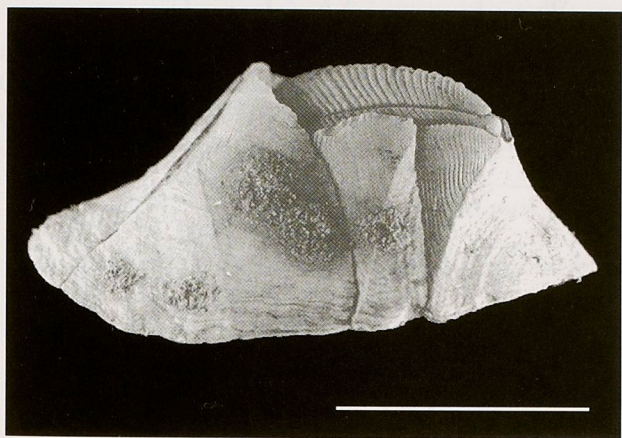


FIG. 13. — *Eutomolasma orbiculatum* sp. nov. Holotype, BIOCAL, stn DW 83 (MNHN-Ci 2393): lateral view. Scale = 1 cm.

Labrum with shallow, small teeth absent; dense patch of stiff, small, downwardly pointing setae on either side of medial depression. Mandibular palp broadly ovate; long serrate setae terminally. Mandible with 3 teeth, equally sized, equally separated; upper margin of teeth 2 and 3 with few weak subsidiary cusps; inferior angle large, bluntly molariform, strongly dentate. Maxillule setose; several long, stout setae at upper angle; notch below upper angle ill-defined, with 4-6 pairs of smaller setae; cutting margin below irregular or slightly stepped, with 7-8 pairs of longer, stout setae; inferior angle sinuous, with 9-10 pairs of small setae. In illustrated specimen left mandible showing following variations — notch barely defined; stout, serrulate setae interspersed between stout setae on cutting margin; inferior angle small, with 4 pairs of

small setae. Maxilla wide, coxal endite well-developed; setae long, dense, simple or serrulate.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior slightly protuberant anteriorly; both rami with segments setose; postero-distal angles of segments of both rami with small tufts of simple and finely serrulate setae, surface of segments with combs of small, simple setae. Cirrus II longer than cirrus I; rami unequal, anterior ramus shorter than posterior; proximal segments of anterior broader than those of posterior and slightly protuberant anteriorly; distal segments of posterior ramus antenniform; all segments with simple and finely serrulate setae, serrulate setae distally. Cirrus III longer than cirrus II; rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 10 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4 pairs of setae on anterior faces, distal 2 pairs of setae longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN	left	13, 11	12, 18	19, 21	20, 28	27, 27	28, 29	14
Ci 2696	right	13, 10	15, 15	18, 20	22, 25	29, 27	28, 28	15

Caudal appendages longer than pedicel of cirrus VI by 1/4 length of pedicel of cirrus VI; 14-15 segments; sparse, long, fine setae apically and around distal margins of segments. Penis 1/4 length of cirrus VI; finely annulated; sparsely setose, with circlet of dense long setae distally.



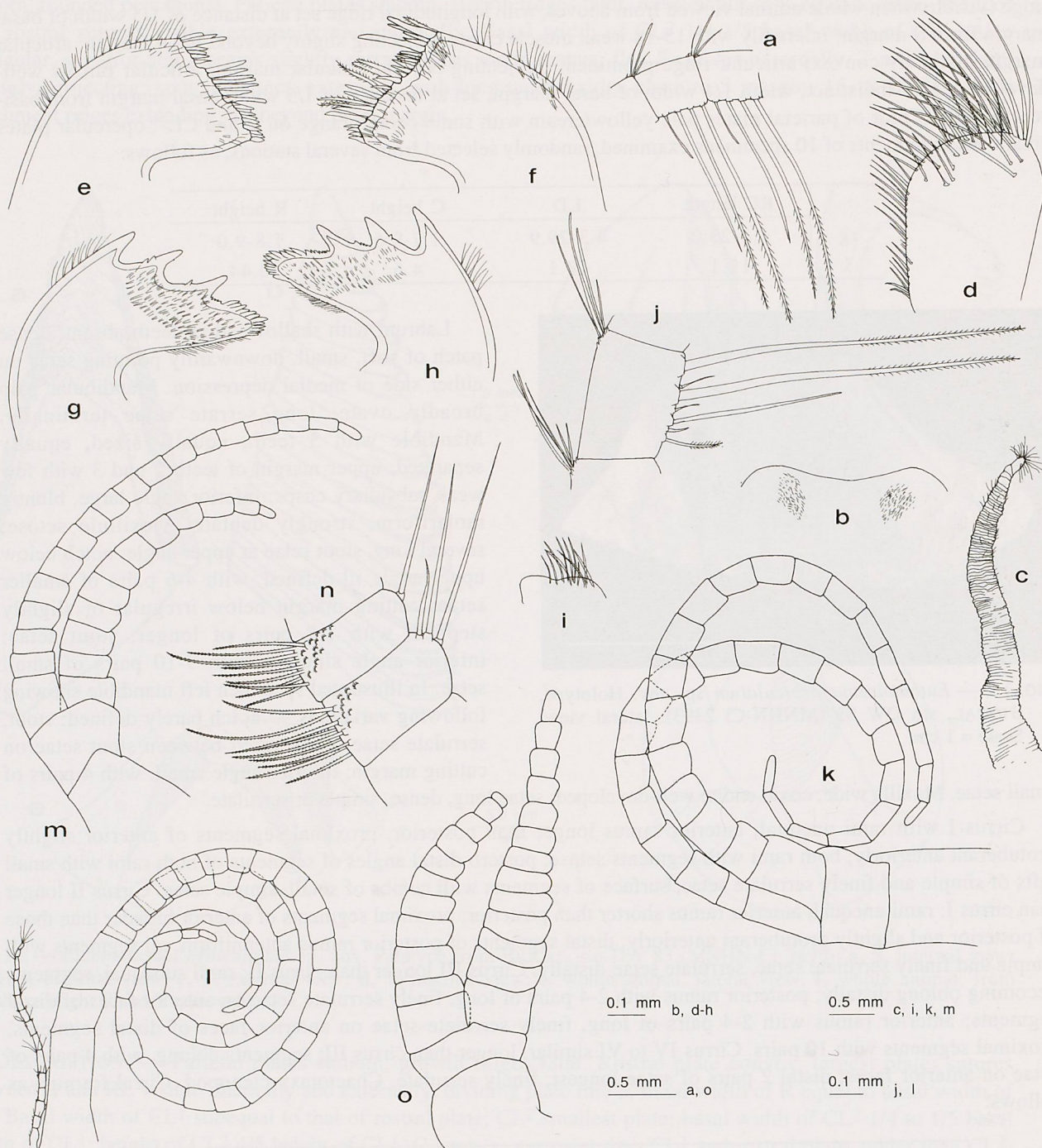


FIG. 14. — *Eutomolasma orbiculatum* sp. nov. Paratype from BIOCAL, stn DW 83 (MNHN-Ci 2696): a, cirrus VI, posterior ramus, median segment; b, labrum; c, penis; d, mandibular palp; e, right maxillule; f, left maxillule; g, right mandible; h, left mandible; i, maxilla; j, cirrus III, posterior ramus, median segment; k, cirrus III; l, cirrus VI and caudal appendage; m, cirrus II; n, cirrus I, posterior ramus, median segments; o, cirrus I.

REMARKS. — The strongly projecting tergal articular ridge, the 15-18 weak muscle crests projecting slightly beyond the tergal basal margin and the externally convex S characterise *Eutomolasma orbiculatum* sp. nov.



The species is similar to *E. japonicum*, but may be distinguished from that species by the narrow secondary CL<sup>2</sup>, whose basal width is 1/4-1/5, rather than less than 1/2, the basal width of CL<sup>1</sup>; by the basis being totally membranous rather than calcareous at the edges and membranous centrally; by features of the S, which in *E. orbiculatum* is convex externally, with the basal margin 1/2 the length of the occludent margin, and feebly convex, with the basal margin less than 1/2 the length of the occludent margin in *E. japonicum*; by the T having a convex articular margin and a prominent articular ridge extending well beyond the articular margin (*E. orbiculatum*) rather than a straight articular margin and a scarcely projecting articular ridge (*E. japonicum*); by the relative lengths of the caudal appendages, being longer than the pedicel of cirrus VI by 1/4 the height of the pedicel of cirrus VI (14-15 segments) rather than twice the height of the pedicel of cirrus VI (13-14 segments); and by the color - parietal plates pale yellow-cream with some ochre-orange (*E. orbiculatum*), rather than glossy pink (*E. japonicum*). The new species differs from *E. macLaughlinae* sp. nov. in size, in the overall shell form and in the soft part morphology (see remarks under *E. macLaughlinae*).

*Eutomolasma orbiculatum* sp. nov. may be distinguished from *E. chinense* by the rostral sutures being visible externally and internally, rather than inconspicuous; by the basal width of CL<sup>2</sup> being 1/4-1/5 the basal width of CL<sup>1</sup> rather than 1/2 the basal width of CL<sup>1</sup>; by the membranous rather than calcareous basis; by the tergal articular ridge strongly projecting, rather than not projecting; and by the color of the parietal plates — pale yellow/cream with some ochre/orange, rather than white with pink apices and covered with a yellowish epicuticle.

ETYMOLOGY. — From the Latin *orbiculatum*, "circular", in reference to the circular circumference of the shell.

DISTRIBUTION. — Loyalty Islands, 460 m; Norfolk Ridge, 260-440 m.

#### Genus *MICROLASMA* gen. nov.

Fig. 15; Tables 3-4, 7-8

DIAGNOSIS. — Adult with fixed shell pattern of 6 weakly articulated, thin parietal plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C). Rostral plate compound, sutures visible, basal widths of R and RL subequal. CL<sup>1</sup> and CL<sup>2</sup> separate. S externally flat, as wide as high, with smooth, even transverse growth ridges, not cut by longitudinal striae. Caudal appendage length ranging from less than height of basal segment of pedicel of cirrus VI to slightly longer than pedicel of cirrus VI, 6-9 segments.

TYPE SPECIES. — *Microlasma fragile* sp. nov.

RECENT SPECIES. — *Microlasma arwetergum* (Rosell, 1991); *M. crinoidophilum* (Pilsbry, 1911); *M. fragile* sp. nov.; *M. ochriderma* (Foster, 1981).

REMARKS. — *Microlasma* gen. nov. is similar to *Eutomolasma* gen. nov. as both have an adult fixed wall pattern of 6 plates, a compound rostral plate with visible sutures and CL<sup>1</sup> and CL<sup>2</sup> as separate entities. However, the genera may be distinguished by characters of the S and the caudal appendages. The S of *Microlasma* is as wide as high and is flattened, that of *Eutomolasma* is elongated, narrow and convex externally. The caudal appendages of *Microlasma* are 6-9 segmented and small, ranging from less than the height of the proximal segment of the pedicel of cirrus VI to just longer than the pedicel of cirrus VI, whereas those of *Eutomolasma* are 11-17 segmented and long (longer than the pedicel of cirrus VI by 1/4 the height of the pedicel of cirrus VI, to at least twice the height of the pedicel of cirrus VI). Other distinguishing characters are listed in Tables 3, 4, 7 and 8.

The species included within *Microlasma* gen. nov. are relatively small (maximum: RC length 9.0, LD 6.2, C height 7.0, R height 2.6). Ovigerous specimens of *M. arwetergum* have an RC length of 4.2 and those of *M. fragile* sp. nov. 5.3. The species occur in association with animal substrates — e.g., *M. arwetergum* and *M. crinoidophilum* with crinoids, *M. ochriderma* with gorgonians, and *M. fragile* with gorgonians and sponges, but further records may show these associations to be purely facultative.



TABLES 7 and 8: *Microlasma* gen. nov: characters of the species

	no. plates ext. int.	R:RL	CL <sup>1</sup> : CL <sup>2</sup>	T	basis
<i>M. arwetergum</i> (Rosell, 1991)	6 8	R = RL	separate; CL <sup>2</sup> = 1/4 basal width CL <sup>1</sup> ; CL <sup>2</sup> sharply tapering; CL <sup>2</sup> shorter than CL <sup>1</sup> by 1/5	artic. ridge projecting, broad; unique arrow shape, spur 1/2 height of valve, 2/9 width of basal margin; set at 1/9 length of basal margin from b-s scutal angle; 3-5 muscle crests proj. from basal margin	membranous
<i>M. crinoidophilum</i> (Pilsbry, 1911)	6 8	R = RL	separate; CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup> ; CL <sup>2</sup> sharply tapering; CL <sup>2</sup> shorter than CL <sup>1</sup> by 1/5	artic. ridge projecting; spur short, 2/5 width of basal margin; set at 1/10 length of basal margin from b-s scutal angle; 5-6 muscle crests proj. from basal margin; ext. with long. depression running along S border	membranous
<i>M. fragile</i> sp. nov.	6 8	R = RL	separate; CL <sup>2</sup> = 1/2-1/3 basal width CL <sup>1</sup> ; height CL <sup>2</sup> = height CL <sup>1</sup>	artic. ridge projecting; spur 1/2 height of valve, roundly truncate, 1/5 width of basal margin; set at 1/8 length of basal margin from b-s angle; 6-8 muscle crests proj. from basal margin	membranous
<i>M. ochriderma</i> (Foster, 1981)	6 8	R = RL	separate; CL <sup>2</sup> = 2/3 basal width CL <sup>1</sup> ; CL <sup>2</sup> = height CL <sup>1</sup>	artic. ridge projecting; spur short, 1/2 width of basal margin; set at 1/10 length of basal margin from b-s angle; 5-7 muscle crests proj. from basal margin	membranous

artic. = articular; b-s = basi-scutal; ext. = external; int. = internal; proj. = projecting.

	S shape	S growth lines	c.a.	mandible	size (max.)	distribution	depth
<i>M. arwetergum</i> (Rosell, 1991)	S transversely elongated; basal margin 5/7 length of occludent margin; artic. ridge proj.	smooth, even, transverse, not cut by long. striae	7-9 segments; slightly longer than pedicel of CVI	tridentate; upper margins of teeth 3 and/or 2 with small subsidiary cusps	RC length 5.0, ovigerous at RC length 4.2	Philippines	120-123 m
<i>M. crinoidophilum</i> (Pilsbry, 1911)	S width = 1/2 S length; basal margin 2/3 length of occludent margin; artic. ridge proj.	smooth, even, transverse, not cut by long. striae	8 segments; < 1/2 height of basal segment of pedicel of CVI	tridentate; upper margins of teeth 3 and/or 2 often with small subsidiary cusps	RC length 9.0 C height 7.0	E China Sea, Japan	274-400 m
<i>M. fragile</i> sp. nov.	S as wide as high; basal margin 7/10 length of occludent margin; artic. ridge proj.	smooth, even, transverse, not cut by long. striae	6-7 segments; slightly longer than basal segment of pedicel of CVI	tridentate; upper and lower margins of teeth smooth	RC length 5.3 C height 3.0, ovigerous at RC length 5.3	Loyalty Is	245 m
<i>M. ochriderma</i> (Foster, 1981)	S as wide as high; basal margin 2/3 length of occludent margin; artic. ridge proj.	smooth, even, transverse, cut by few faint, long. striae	7 segments; = to height of basal segment of pedicel of CVI	tridentate; upper margins of teeth smooth; teeth sharp, curved	RC length 7.8	Norfolk I.	392-423 m

artic. = articular; c.a. = caudal appendage; long. = longitudinal; max. = maximum; proj. = projecting.

ETYMOLOGY. — From the Greek *mikros*, "small", in reference to the small size of the species which constitute this genus.



DISTRIBUTION. — Western Pacific Ocean. East China Sea, Japan, 274-400 m (*M. crinoidophilum*); Philippines, 120-123 m (*M. arwetergum*); Norfolk I., 392-423 m (*M. ochriderma*); Loyalty Islands, 245 m (*M. fragile*).

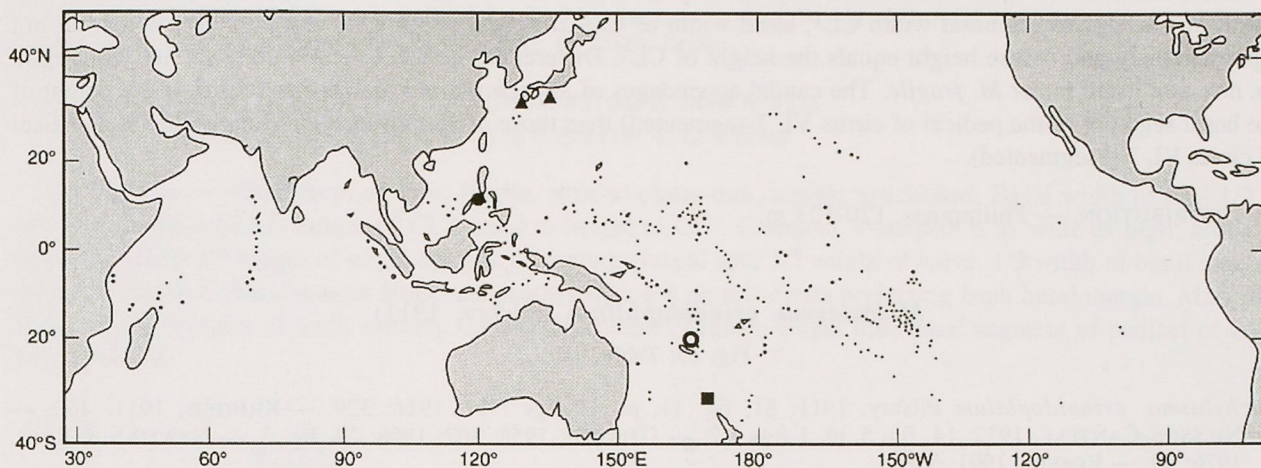


FIG. 15. — *MICROLASMA* gen. nov. Distribution map: ▲, *M. crinoidophilum* (274-400 m); ●, *M. arwetergum* (120-123 m); ○, *M. fragile* (245 m); ■, *M. ochriderma* (392-423 m).

***Microlasma arwetergum* (Rosell, 1991)**

Fig. 15; Tables 7-8

*Pachylasma arwetergum* Rosell, 1991: 35, figs 6 j-k, 8 f-h, 9 a-f.

MATERIAL EXAMINED. — **Philippines.** MUSORSTOM 3: stn 124, 12°02.6'N, 121°35.3'E, 120-123 m: holotype (MNHN-Ci 2103).

TYPES. — *Holotype*: MNHN Ci 2103; Philippines, MUSORSTOM 3, stn 124, 12°02.6'N, 121°35.3'E, 120-123 m; attached to cirri of crinoids, with *Heteralepas cornuta* (Darwin, 1851).

*Paratypes*: MNHN Ci 2104; Philippines, MUSORSTOM 3: stn 124, 12°02.6'N, 121°35.3'E, 120-123 m. — UPIBM Crust. Coll. No. 372; Philippines, MUSORSTOM 3: stn 124, 12°02.6'N, 121°35.3'E, 120-123 m.

*Holotype depository*: MNHN.

*Paratypes depository*: MNHN, UPIBM.

DIAGNOSIS. — Shell conical, more or less elongated along rostrocarinal axis. CL<sup>2</sup> sharply tapering, apex so narrow that apex of CL<sup>1</sup> almost touches C; basal width of CL<sup>2</sup> 1/4 basal width of CL<sup>1</sup>; CL<sup>2</sup> shorter than CL<sup>1</sup> by 1/5. C deeply concave, almost V-shaped. S transversely elongated towards basiocludent angle; S basal margin 5/7 length of ocludent margin, S articular ridge projecting. T smaller than S, arrow-shaped; long spur 1/2 height of valve, width 2/9 width of basal margin, set at distance of 1/9 length of basal margin from basi-scutal angle; 3-5 muscle crests projecting beyond basal margin. Mandible with 3 teeth, upper margin of tooth 3 and/or 2 with small subsidiary cusps. Caudal appendages slightly longer than pedicel of cirrus VI, 7-9 segments.

REMARKS. — This species (maximum RC basal diameter 5.0; ovigerous specimens RC length 4.2) is distinguished from all others in the genus by the unique, arrow-shape of the T, produced by the long T spur and a deep incision on the tergal basal margin, and by the pinkish-brown color of the parietal plates. *Microlasma arwetergum* resembles *M. crinoidophilum*, as both species have small, sharply tapering CL<sup>2</sup> (1/4 the basal width and 1/2 the basal width of CL<sup>1</sup>, respectively), the apices of which are shorter than the apices of CL<sup>1</sup>. The caudal appendages of *M. arwetergum* are 7-9 segmented and are longer than the pedicel of cirrus VI,



whilst those of *M. crinoidophilum* are 8-segmented and not as long as the basal segment of the pedicel of cirrus VI. *Microlasma arwetergum* is a smaller species than *M. crinoidophilum* (maximum RC length 5.0, 9.0, respectively).

*Microlasma arwetergum* differs from *M. fragile* sp. nov. and *M. ochriderma* as both the latter have CL<sup>2</sup> (basal width of CL<sup>2</sup> 1/2 to 1/3 basal width CL<sup>1</sup>, basal width of CL<sup>2</sup> 2/3 basal width CL<sup>1</sup>, respectively) which do not taper narrowly and whose height equals the height of CL<sup>1</sup>. Differences between *M. arwetergum* and *M. fragile* sp. nov. are listed under *M. fragile*. The caudal appendages of *M. ochriderma* are shorter (equal to the height of the basal segment of the pedicel of cirrus VI, 7-segmented) than those of *M. arwetergum* (longer than the pedicel of cirrus VI, 7-9 segmented).

DISTRIBUTION. — Philippines, 120-123 m.

***Microlasma crinoidophilum* (Pilsbry, 1911)**

Fig. 15; Tables 7-8

*Pachylasma crinoidophilum* Pilsbry, 1911: 81, fig. 11, pl. 17 figs 1-11; 1916: 329. — KRÜGER, 1911: 460. — NILSSON-CANTELL, 1932: 14, fig. 5, pl. 1 figs 1-2. — UTINOMI, 1958: 307; 1968: 24, fig. 3. — NEWMAN & ROSS, 1976: 40. — ROSELL, 1991: 37.

MATERIAL EXAMINED. — **Japan**. "Albatross": stn 4934: off Sala Misaki, Kagoshima Gulf, 274-400 m, 16.08.1906: holotype (USNM 3867).

TYPES. — *Holotype*: USNM 38675; Japan, "Albatross": stn 4934, off Sala Misaki, Kagoshima Gulf, 274-400 m, 16.08.1906; dry (1 lot) and wet (1 lot).

*Holotype depository*: USNM.

DIAGNOSIS. — Shell basal contour oblong. C and CL<sup>1</sup> largest plates; CL<sup>2</sup> shorter than CL<sup>1</sup> by 1/5, apices of former tapering abruptly, so that alae of CL<sup>1</sup> almost touch alae of C; basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. C vertical, other parietal plates sloping inward. S width equal to 1/2 S length, S basal margin 2/3 width of occludent margin, articular ridge projecting. T externally with longitudinal depression running along S border; spur short, 2/5 width of basal margin, set at distance of 1/10 length of basal margin from basi-scutal angle; 5-6 muscle crests projecting from basal margin. Mandible with 3 teeth, upper margins of teeth 3 and 2 often with small subsidiary cusps, inferior angle dentate. Caudal appendages less than 1/2 height of basal segment of pedicel of cirrus VI, 8 segments.

REMARKS. — The species is small (maximum: RC length 9.0, C height 7.0). Differences between *M. crinoidophilum* and *M. arwetergum*, and between *M. crinoidophilum* and *M. fragilis* sp. nov., are listed under *M. arwetergum* and *M. fragilis* sp. nov., respectively.

*Microlasma crinoidophilum* differs from *M. ochriderma* in the form of CL<sup>2</sup>. In *M. crinoidophilum* CL<sup>2</sup> is sharply tapering and shorter than CL<sup>1</sup> by 1/5, whereas in *M. ochriderma* CL<sup>2</sup> and CL<sup>1</sup> are equal in height, and the apex of CL<sup>2</sup> does not taper narrowly. The basal width of CL<sup>2</sup> is 1/2 the basal width of CL<sup>1</sup> in *M. crinoidophilum* whereas it is 2/3 the basal width of CL<sup>1</sup> in *M. ochriderma*. The T of *M. crinoidophilum* has a longitudinal depression running along the S border and the tergal spur is 2/5 the width of the basal margin, whilst the T of *M. ochriderma* has no longitudinal depression and the tergal spur is 1/2 the width of the basal margin. The caudal appendages of *M. crinoidophilum* are 8-segmented and are less than 1/2 the height of the basal segment of the pedicel of cirrus VI, whilst those of *M. ochriderma* are 7 segmented and equal to the height of the basal segment of the pedicel of cirrus VI. The mandibular teeth of *M. ochriderma* are curved and smooth, whereas those of *M. crinoidophilum* are not curved and the upper margins of teeth 2 and 3 may have small subsidiary cusps.

DISTRIBUTION. — East China Sea, Japan, 274-400 m.



*Microlasma fragile* sp. nov.

Figs 15-18; Tables 7-8

MATERIAL EXAMINED. — **Loyalty Islands.** MUSORSTOM 6: stn DW 421, 245 m: 3 specimens, ovigerous (large orange eggs), attached to sponge (MNHN-Ci 2395, Ci 2396). Drawn.

TYPES. — *Holotype*: MNHN-Ci 2395 (MUSORSTOM 6, stn DW 421).

*Paratypes*: MNHN-Ci 2396 (MUSORSTOM 6, stn DW 421). Drawn.

DIAGNOSIS. — Shell form upright; fragile, parietal plates thin, weakly articulated. Basal width of CL<sup>2</sup> 1/2 to 1/3 basal width of CL<sup>1</sup>; height of CL<sup>2</sup> equal to height of CL<sup>1</sup>. C almost V-shaped. S as wide as high; articular ridge extending 2/3 length of tergal margin, projecting. Tergal spur 1/2 height of valve, 1/5 width of basal margin, set at 1/8 length of basal margin from basi-scutal angle; 6-8 muscle crests projecting from basal margin. Mandible with 3 teeth, margins of teeth smooth. Caudal appendages slightly longer than basal segment of pedicel of CVI, 6-7 segmented.

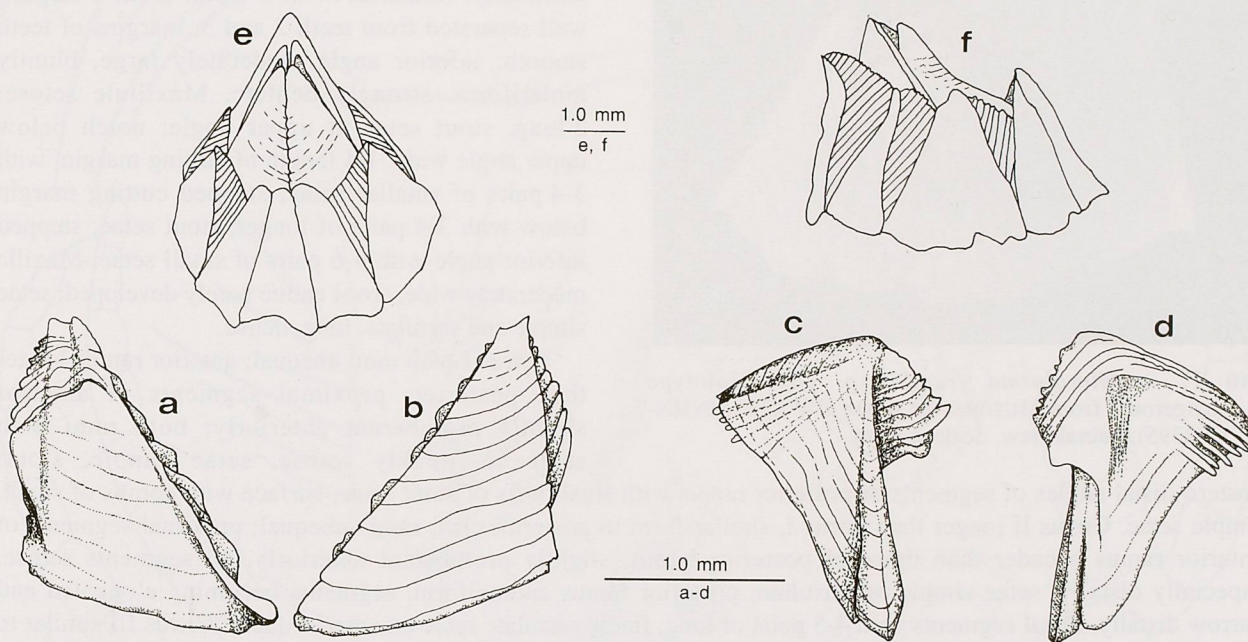


FIG. 16. — *Microlasma fragile* sp. nov. Paratype (ovigerous) from MUSORSTOM 6, stn DW 421 (MNHN-Ci 2396): a, S, internal view; b, S, external view; c, T, external view; d, T, internal view; e, whole animal, from above; f, whole animal, lateral view.

DESCRIPTION. — Size small (maximum: RC length 5.3, C height 3.0). Shell form upright, rostral plate and CL<sup>1</sup> sloping in toward orifice, apex of CL<sup>2</sup> pointing toward C. Parietal plates thin, fragile, weakly articulated; growth ridges fine, irregular, marked by minute setae. Rostral plate broad, convex; sutures between R and RL visible internally and externally, dividing plate into 3 subequal parts. CL<sup>1</sup> and CL<sup>2</sup> separate; CL<sup>1</sup> as broad as R. C deeply concave, apex spout-like, retroverted; higher than and subequal to width of R. Alae wide, those of C widest, those of CL<sup>1</sup> and CL<sup>2</sup> subequal, 1/2 width of carinal ala; superior alar margins finely serrate; alar growth ridges parallel to inferior alar margin. Basis membranous; flat. Orifice large, pentagonal, toothed. Opercular plates placed approximately 30° to basis. S flat, thin; triangular, as wide as high, basal margin 7/10 length of occludent margin; externally with well-spaced, even growth ridges, not convoluted or sinuous, not cut by longitudinal striae; internally adductor muscle and lateral depressor muscle pits absent; articular furrow narrow; articular ridge



extending 2/3 length of valve, projecting well beyond articular margin; adductor ridge absent. T thin; sub-triangular, smaller than S by 1/4; externally growth ridges fine, some longitudinal striations in carinal area; internally with 6-8 fine muscle crests projecting beyond basal margin; articular ridge prominent, extending well beyond articular margin; articular furrow well-developed; spur roundly truncate, length 1/2 length of basal margin, set at distance of 1/8 length of basal margin from basi-scutal angle, width 1/5 length of basal margin. Color of parietal and opercular plates orange-ochre; eggs orange. Measurements of 3 specimens measured as follows:

	RC length	LD	C height	R height
<i>Holotype</i> : MNHN-Ci 2395	4.5	3.7	1.7	1.6
<i>Paratypes</i> : MNHN-Ci 2396	5.3	4.2	3.0	2.6
"	4.8	3.9	2.2	1.9

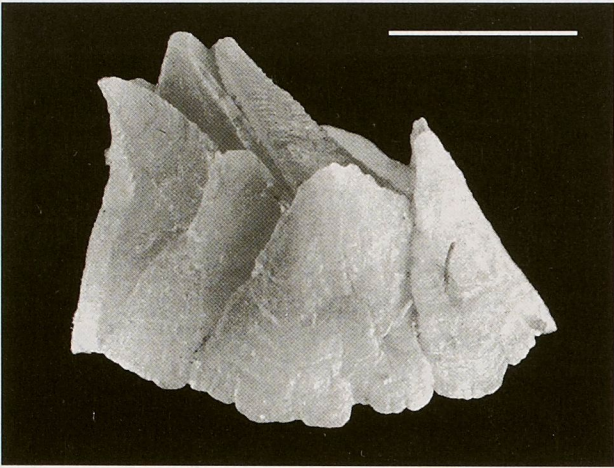


FIG. 17. — *Microlasma fragile* sp. nov. Holotype (ovigerous) from MUSORSTOM 6, stn DW 421 (MNHN-Ci 2395); lateral view. Scale = 1 cm.

Labrum with shallow medial depression, with regular row of small, spaced teeth, some bidentate. Mandibular palp oblong, narrow; long, serrate setae terminally. Mandible with 3 teeth, tooth 1 largest, well separated from teeth 2 and 3; margins of teeth smooth; inferior angle moderately large, bluntly molariform, strongly dentate. Maxillule setose; 2 long, stout setae at upper angle; notch below upper angle wide, 1/4 length of cutting margin, with 3-4 pairs of smaller setae; stepped cutting margin below with 3-4 pairs of longer, stout setae; stepped inferior angle with 4-6 pairs of small setae. Maxilla moderately wide, coxal endite barely developed; setae simple and serrulate, long, dense.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior slightly protuberant anteriorly; both rami with segments thickly setose, setae simple, stout;

postero-distal angles of segments of posterior ramus with small tufts of stout setae, surface with combs of small, simple setae. Cirrus II longer than cirrus I, similar form to posterior cirri; rami subequal; proximal segments of anterior ramus broader than those of posterior ramus, slightly protuberant anteriorly, all segments setose, especially distally, setae simple or serrulate; posterior ramus antenniform, segments becoming elongated and narrow distally, distal segments with 4-5 pairs of long, finely serrulate setae on anterior faces. Cirrus III similar to cirri IV-VI; rami subequal, segments becoming oblong distally; posterior ramus with 2-5 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces distal segments, proximal segments with 5 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 5 pairs of setae on anterior faces, distal 2 pairs longest. Cirral formula as follows:

<i>Paratype</i> :		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	8, 6	8, 10	15, 18	17, 22	20, 22	21, 22	6
Ci 2396	right	13, 11	9, 9	14, 17	22, 23	24, 21	22, 23	7

Caudal appendages slightly longer than basal segment of pedicel of CVI, 6-7 segmented; sparse circlet of long setae terminally; long setae around distal segmental margins, setal length equal to or longer than segmental length. Penis subequal to length of cirrus VI; annulated; sparsely setose distally; circlet of long setae terminally. Eggs large, rounded, 0.40 x 0.42 mm.



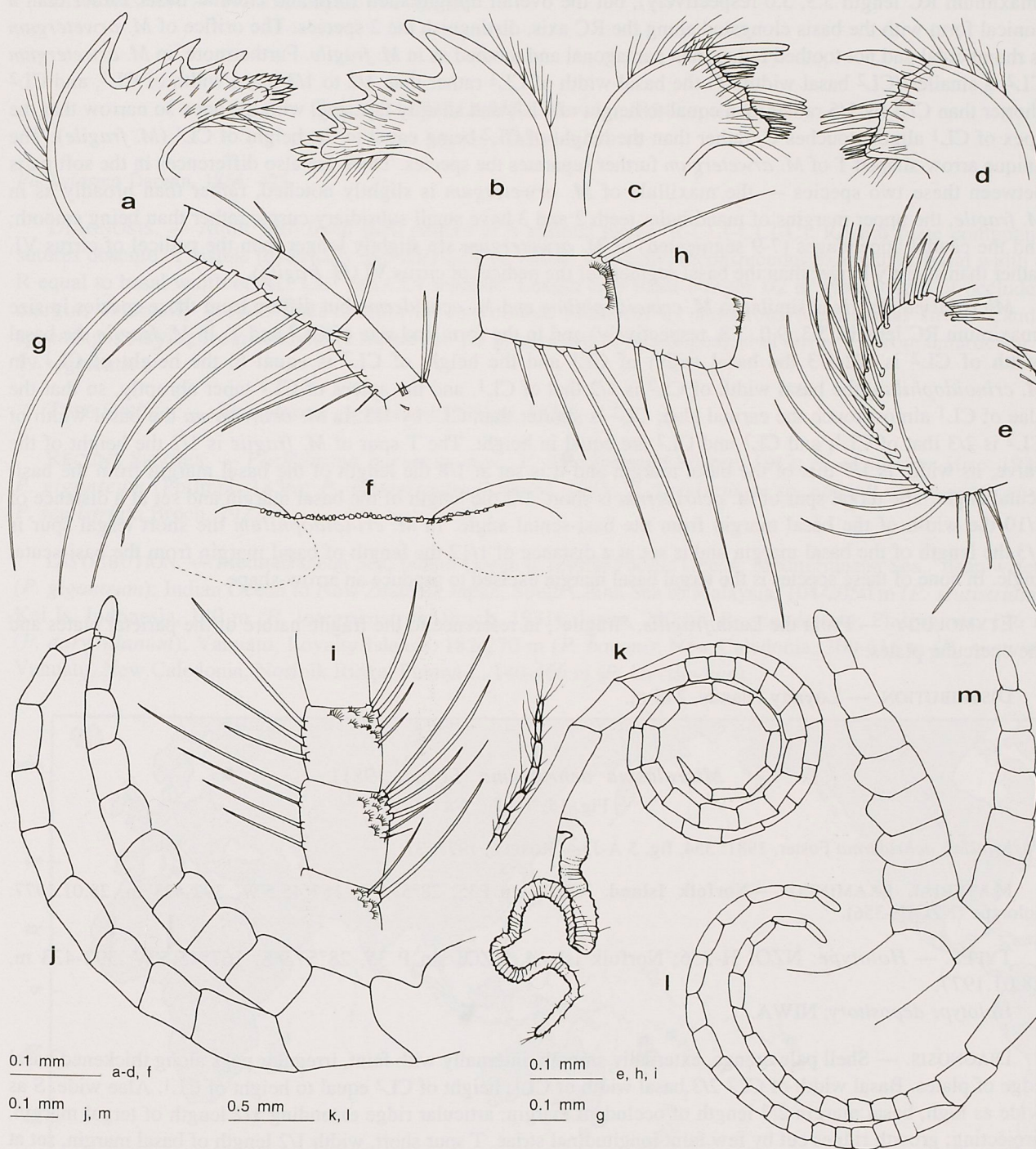


FIG. 18. — *Microlasma fragile* sp. nov. Paratype (ovigerous) from MUSORSTOM 6, stn DW 421 (MNHN-Ci 2396): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, maxilla; **f**, labrum; **g**, cirrus III, posterior ramus, median segments; **h**, cirrus II, posterior ramus, median segments; **i**, cirrus I, posterior ramus, median segments; **j**, cirrus II; **k**, cirrus VI, caudal appendage and penis; **l**, cirrus III; **m**, cirrus I.

REMARKS. — *Microlasma fragile* sp. nov. may be distinguished from other members of the genus by its fragile, thin, weakly articulated parietal plates. The size of *M. fragile* is similar to that of *M. arwetergum*



(maximum RC length 5.3, 5.0 respectively), but the overall upright shell form and circular basis, rather than a conical form with the basis elongated along the RC axis, distinguish the 2 species. The orifice of *M. arwetergum* is rhomboidal and not toothed rather than pentagonal and toothed as in *M. fragile*. Furthermore, in *M. arwetergum* CL<sup>2</sup> is smaller (CL<sup>2</sup> basal width 1/4 the basal width of CL<sup>1</sup> rather than 1/2 to 1/3 basal width of CL<sup>1</sup>, and CL<sup>2</sup> shorter than CL<sup>1</sup> by 1/5 rather than equal to height of CL<sup>1</sup>) and sharply tapering, with the apex so narrow that the apex of CL<sup>1</sup> almost touches C, rather than the height of CL<sup>2</sup> being equal to the height of CL<sup>1</sup> (*M. fragile*). The unique arrow-shaped T of *M. arwetergum* further separates the species. There are also differences in the soft parts between these two species — the maxillule of *M. arwetergum* is slightly notched, rather than broadly as in *M. fragile*, the upper margins of mandibular teeth 2 and 3 have small subsidiary cusps, rather than being smooth; and the caudal appendages (7-9 segmented) of *M. arwetergum* are slightly longer than the pedicel of cirrus VI, rather than slightly longer than the basal segment of the pedicel of cirrus VI (*M. fragile*).

*Microlasma fragile* is similar to *M. crinoidophilum* and *M. ochriderma* but differs from those species in size (maximum RC lengths 5.3, 9.0, 7.8, respectively) and in the form and size of CL<sup>2</sup> and T. In *M. fragile* the basal width of CL<sup>2</sup> is 1/2-1/3 the basal width of CL<sup>1</sup> and the height of CL<sup>2</sup> is equal to the height of CL<sup>1</sup>. In *M. crinoidophilum* the basal width of CL<sup>2</sup> is 1/2 that of CL<sup>1</sup>, and the apices of CL<sup>2</sup> taper abruptly, so that the alae of CL<sup>1</sup> almost touch the carinal alae; CL<sup>2</sup> is shorter than CL<sup>1</sup> by 1/5. In *M. ochriderma* the basal width of CL<sup>2</sup> is 2/3 that of CL<sup>1</sup>, and CL<sup>1</sup> and CL<sup>2</sup> are equal in height. The T spur of *M. fragile* is 1/2 the height of the valve, its width is 1/5 that of the basal margin and it is set at 1/8 the length of the basal margin from the basi-scutal angle. The tergal spur of *M. ochriderma* is short, 1/2 the length of the basal margin and set at a distance of 1/10 the width of the basal margin from the basi-scutal angle. In *M. crinoidophilum* the short tergal spur is 1/3 the length of the basal margin and is set at a distance of 1/12 the length of basal margin from the basi-scutal angle. In none of these species is the tergal basal margin excised to produce an arrow-shape.

ETYMOLOGY. — From the Latin *fragilis*, "fragile", in reference to the fragile nature of the parietal plates and the opercular plates.

DISTRIBUTION. — Loyalty Islands, 245 m.

*Microlasma ochriderma* (Foster, 1981)

Fig. 15; Tables 7-8

*Pachylasma ochriderma* Foster, 1981: 354, fig. 5 A-J. — ROSELL, 1991: 37.

MATERIAL EXAMINED. — **Norfolk Island**. NZOI: stn P35, 28°57.9'S, 167°45.5'W, 392-423 m, 28.01.1977: holotype (NZOIH-356).

TYPES. — *Holotype*: NZOI H-356; Norfolk Island, NZOI stn P 35, 28°57.9'S, 167°45.5'W, 392-423 m, 28.01.1977.

*Holotype depository*: NIWA.

DIAGNOSIS. — Shell pale orange, externally smooth, internally with faint, irregular pegs along thickened basal edge of plates. Basal width of CL<sup>2</sup> 2/3 basal width of CL<sup>1</sup>; height of CL<sup>2</sup> equal to height of CL<sup>1</sup>. Alae wide. S as wide as high, basal margin 2/3 length of occludent margin; articular ridge extending 1/2 length of tergal margin, projecting; growth ridges cut by few faint longitudinal striae. T spur short, width 1/2 length of basal margin, set at distance of 1/10 length of basal margin from basi-scutal angle; 5-7 muscle crests projecting from basal margin. Mandible with 3 sharp, curved teeth, margins smooth. Caudal appendages as long as basal segment of pedicel of cirrus VI, 7 segments.

REMARKS. — The species (RC length 7.8) is distinguished by the dimensions and the manner of articulation of the opercular plates, and by the orange color of the shell plates. Differences between *M. ochriderma* and *M. arwetergum* are listed under *M. arwetergum*, between *M. ochriderma* and *M. crinoidophilum* under *M. crinoidophilum*, and between *M. ochriderma* and *M. fragile* under *M. fragile*.



DISTRIBUTION. — Norfolk Island, 392-423 m.

Genus **PACHYLASMA** Darwin, 1854 (emend.)

Fig. 19; Tables 3-4, 9-11

*Pachylasma* Darwin, 1854: 475.

DIAGNOSIS. — Adult with fixed shell pattern of 6 parietal plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C). Rostral plate compound, sutures obscure or visible (externally and internally or visible internally, inconspicuous externally), basal width of R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate. Length of S basal margin 1/2 or more length of occludent margin; externally growth lines smooth or convoluted, often cut by numerous longitudinal striae. Caudal appendages varying from vestigial or reduced to 1/3 greater than length of pedicel of cirrus VI, from uniarticular to 19 segments.

TYPE SPECIES. — *Pachylasma giganteum* (Philippi, 1836).

RECENT SPECIES. — *Pachylasma bacum* sp. nov.; *P. darwinianum* Pilsbry, 1912; *P. ecaudatum* Hiro, 1939; *P. giganteum* (Philippi, 1836); *P. integrirostrum* Broch, 1931; *P. laeviscutum* sp. nov.; *P. ovatum* sp. nov.; *P. scutistriata* Broch, 1922.

DISTRIBUTION. — Mediterranean Sea; Indian Ocean to central Pacific Ocean: Mediterranean Sea, "deep water" (*P. giganteum*); Indian Ocean to New Zealand, Japan, South China Sea to Malaysia, 104-2050 m (*P. scutistriata*); Kei Is, Indonesia, 140 m (*P. integrirostrum* Broch, 1931); Japan, 200 m (*P. ecaudatum*); Philippines, 146 m (*P. darwinianum*); Vanuatu, Loyalty Islands, 182-270 m (*P. bacum*); New Caledonia, 300-616 m (*P. ovatum*); Vanuatu, New Caledonia, Norfolk Ridge, Futuna I., 140-466 m (*P. laeviscutum*).

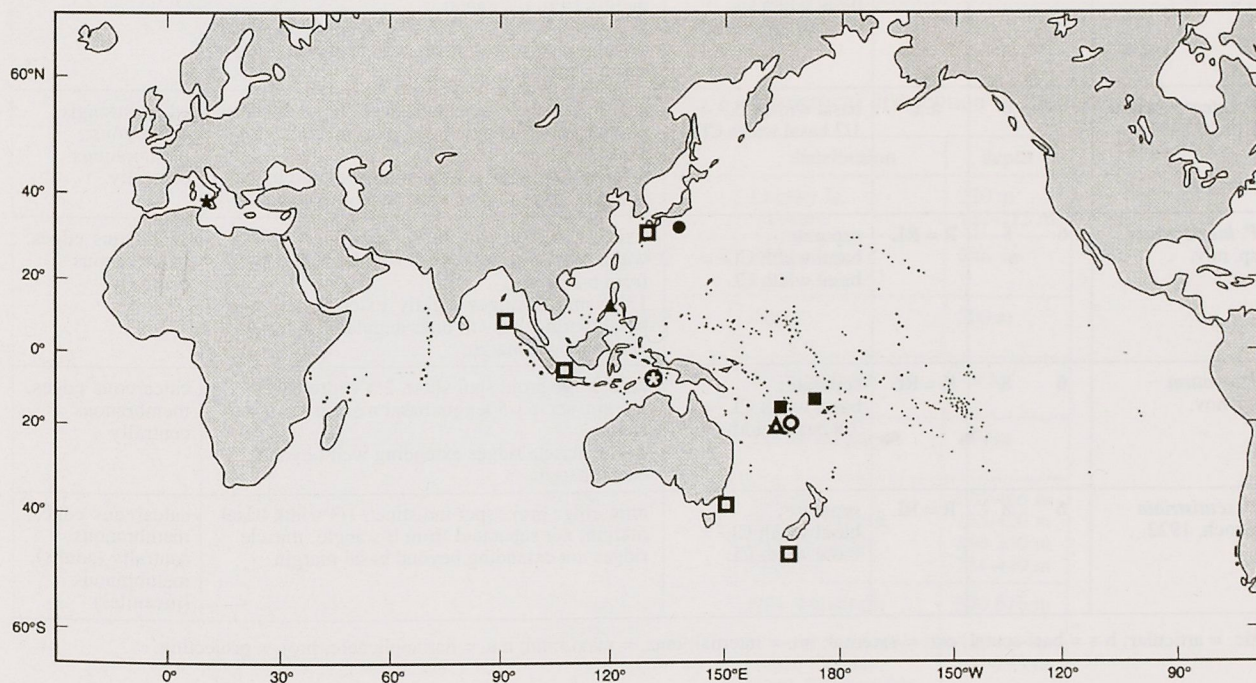


FIG. 19. — *PACHYLASMA* Darwin, 1854. Distribution map: ★, *P. giganteum* ("deep water"); □, *P. scutistriata* (104-2050 m); ☆, *P. integrirostrum* (140 m); ●, *P. ecaudatum* (200 m); ▲, *P. darwinianum* (146 m); ○, *P. bacum* (182-270 m); △, *P. ovatum* (300-616 m); ■, *P. laeviscutum* (140-466 m).



REMARKS. — In the present paper *Pachylasma* is considered a grouping whose resolution has yet to be determined. The affinities of the various species included under this genus are as yet unclear, but may be resolved as more material comes to hand. Differences between *Pachylasma*, *Eutomolasma*, *Microlasma*, *Eurylasma* and *Tetrapachylasma* are listed in tables 3 and 4. The species included herein are small (maximum: RC length 7.0, C height 2.5), moderate (maximum: RC length 10.5, C height 7.2), and large (maximum: RC length 30.0, C height 30.5) in size, and occur attached to gorgonians, sponges, bivalves, balanomorph barnacles, crinoids, antipatharians and coral rubble.

TABLE 9. — *Pachylasma*: characters of the species

	no. plates ext. int.	R:RL	CL: CL <sup>2</sup>	T	basis
<i>P. bacum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = basal width CL	artic. ridge barely proj.; spur short, 1/2 width basal margin, set 1/10 length basal margin from b-s angle; 11-15 muscle ridges extending well beyond basal margin	calcareous
<i>P. darwinianum</i> Pilsbry, 1912	6 8	R = RL	separate; basal width CL <sup>2</sup> ≥ 1/2 basal width CL	artic. ridge slightly proj.; spur absent; 8-10 muscle ridges extending well beyond basal margin; low rounded rib bounded by depressions on S 1/2	membranous
<i>P. ecaudatum</i> Hiro, 1939	6 6	n.a.	separate; basal width CL <sup>2</sup> = or slightly < than basal width CL	artic. ridge not proj.; spur indistinct, 3/8 width basal margin, set 1/8 length basal margin from b-s angle; 8-11 muscle ridges extending well beyond basal margin; slight ridge parallel to S margin where growth lines angularly upturned	calcareous edges; membranous centrally
<i>P. giganteum</i> (Philippi, 1836)	6 6	n.a.	separate; basal width CL <sup>2</sup> = basal width CL	artic. ridge slightly proj.; spur short, indistinct, 1/2 width basal margin, set 1/7 length basal margin from b-s angle; 8-10 muscle ridges extending well beyond basal margin; growth lines angularly upturned close along S margin	calcareous
<i>P. integristrostrum</i> Broch, 1931	6 6	n.a.	basal width CL <sup>2</sup> = 1/2 basal width CL	artic. ridge proj.; spur indistinct, 1/2 width basal margin, set 1/9 length basal margin from b-s angle; 4-6 muscle ridges not extending beyond basal margin; S side of spur with shallow groove	edges strongly calcareous; membranous centrally
<i>P. laeviscutum</i> sp. nov.	6 8	R = RL	separate; basal width CL <sup>2</sup> = basal width CL	artic. ridge proj.; spur short, indistinct, >1/3 width basal margin, set 1/9 length basal margin from b-s angle; 13-18 muscle ridges slightly extending beyond basal margin; growth lines angularly upturned close along S margin	calcareous edges, membranous centrally
<i>P. ovatum</i> sp. nov.	6 8	R = RL	separate; basal width CL <sup>2</sup> = 7/8 basal width CL	artic. ridge proj.; spur short, 2/5 width basal margin, set < 1/5 length basal margin from b-s angle; 12-14 muscle ridges extending well beyond basal margin	calcareous edges, membranous centrally
<i>P. scutistriata</i> Broch, 1922	6 8	R = RL	separate; basal width CL <sup>2</sup> = basal width CL	artic. ridge proj.; spur indistinct, 1/3 width basal margin; not separated from b-s angle; muscle ridges not extending beyond basal margin	calcareous edges, membranous centrally (adults); membranous (juveniles)

artic. = articular; b-s = basi-scutal; ext. = external; int. = internal; max. = maximum; n.a. = not applicable; proj. = projecting.



TABLE 10. — *Pachylasma*: characters of the species (continued)

	S shape	S growth lines	caudal appendage	mandible
<i>P. bacum</i> sp. nov.	S basal margin = 7/12 length of S occludent margin; artic. ridge slightly proj.	extremely convoluted; cut by 10-14 long. striae, giving 'beaded' appearance	uniarticulate; extremely reduced, leaf-like	tridentate; upper margins of tooth 3 or upper margins of 2 and 3 often with small subsidiary cusps
<i>P. darwinianum</i> Pilsbry, 1912	S width = 1/2 S length; artic. ridge barely proj.	strongly convoluted; not cut by long. striae	uniarticulate; extremely reduced, represented by swollen mounds with minute bristles	tridentate; upper margins of teeth 1 and/or 2 often with small subsidiary cusps
<i>P. ecaudatum</i> Hiro, 1939	S basal margin = 5/9 length of S occludent margin; artic. ridge not proj.	convoluted; cut by 8 long. striae	uniarticulate; extremely reduced, represented by swollen mounds with few minute bristles	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps
<i>P. giganteum</i> (Philippi, 1836)	S basal margin 3/5 length of S occludent margin; artic. ridge not proj.	sinuous; cut by 4-6, faint long. striae	19 segs; 1/3 > than height of pedicel of CVI	tridentate; upper margins of teeth smooth
<i>P. integrirostrum</i> Broch, 1931	S basal margin = 1/2 length of S occludent margin; artic. ridge slightly proj.	not convoluted, feeble; not cut by long. striae	6 segs; = height of basal segment of pedicel of CVI	tridentate; tooth 1 well separated from 2 and 3; upper margins of tooth 2 with small subsidiary cusps
<i>P. laeviscutum</i> sp. nov.	S basal margin = 1/2 length of S occludent margin; artic. ridge slightly proj.	slightly sinuous; cut by traces of 2-3 faint long. striae	8-9 segs; = height of basal segment of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps
<i>P. ovatum</i> sp. nov.	S basal margin = >1/2 length of S occludent margin; artic. ridge proj.	moderately convoluted; cut by 12-15 long. striae	absent	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps
<i>P. scutistriata</i> Broch, 1922	S basal margin = >1/2 length of S occludent margin; artic. ridge slightly proj.	convoluted; cut by many long. striae	15-18 segs; slightly longer than pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps

artic. = articular; long. = longitudinal; max. = maximum; proj. = projecting; segs = segments.

TABLE 11. — *Pachylasma*: maximum size, geographical and bathymetrical distribution of the species

	size (max.)	distribution	depth
<i>P. bacum</i> sp. nov.	RC length 14.0 C height 7.0	Loyalty Is, Vanuatu	270 m 182-215 m
<i>P. darwinianum</i> Pilsbry, 1912	basal diameter 18.0-20.5	Philippines	146 m
<i>P. ecaudatum</i> Hiro, 1939	RC length 10.0 C height 6.0	Japan	200 m
<i>P. giganteum</i> (Philippi, 1836)	basal diameter 30.0 C height 30.5	Mediterranean Sea	'deep'
<i>P. integrirostrum</i> Broch, 1931	RC length 7.0 C height 2.5	Kei Is, Indonesia	140 m
<i>P. laeviscutum</i> sp. nov.	RC length 10.5 C height 7.2	Vanuatu, New Caledonia, Norfolk Ridge, Futuna I.	140-466 m 135-420 m 260-350 m 244-440 m
<i>P. ovatum</i> sp. nov.	RC length 14.6 C height 10.7	New Caledonia	300-616 m
<i>P. scutistriata</i> Broch, 1922	RC length 20.0 C height 15.0	Indian Ocean, Japan, S China Sea, Malaysia, Tasmania, Bass Strait New Zealand	104-293 m



*Pachylasma bacum* sp. nov.

Figs 19-22; Tables 9-11

MATERIAL EXAMINED. — **Loyalty Islands.** MUSORSTOM 6: stn CP 401, 270 m: 1 specimen, attached to sponge (MNHN-Ci 2503). Drawn.

**Vanuatu.** MUSORSTOM 8: stn CP 1086, 182-215 m: 1 specimen (MNHN-Ci 2397).

TYPES. — *Holotype*: MNHN-Ci 2397 (MUSORSTOM 8, stn CP 1086).

*Paratype*: MNHN-Ci 2503 (MUSORSTOM 6, stn CP 401). Drawn.

DIAGNOSIS. — Rostral plate broad, sutures obscure. Basal width of CL<sup>1</sup> equal to basal width of CL<sup>2</sup>. S with externally convoluted growth ridges cut by 10-14 radial striations; articular ridge slightly projecting. T spur short, almost indistinguishable from basal margin; 11-15 muscle attachment ridges extending well beyond basal margin; articular ridge barely projecting. Caudal appendages reduced, leaf-like.

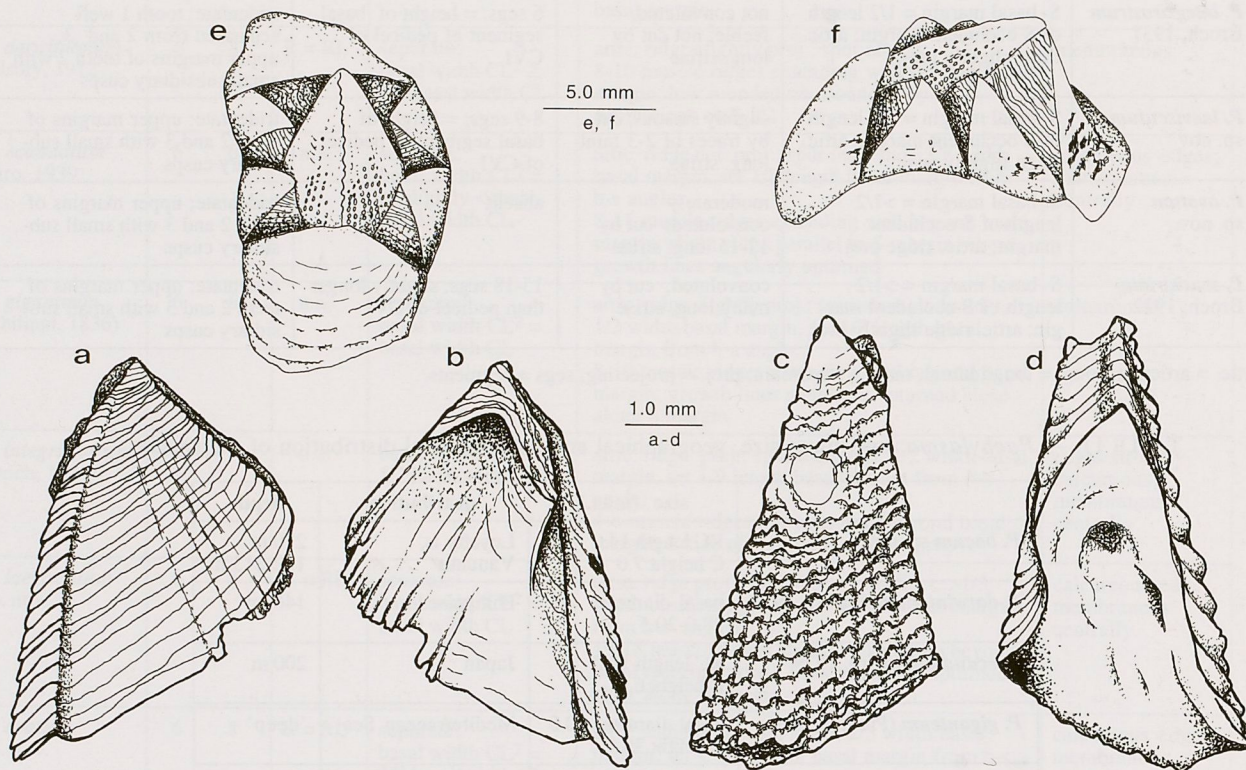


FIG. 20. — *Pachylasma bacum* sp. nov. Paratype from MUSORSTOM 6, stn CP 401 (MNHN-Ci 2503): a, T, external view; b, T, internal view; c, S, external view; d, S, internal view; e, whole animal, from above; f, whole animal, lateral view.

DESCRIPTION. — Shell large (maximum: RC length 14.0, C height 7.0); form circular. Parietal plates with irregular growth ridges not well-defined, except on rostral plate. Rostral plate slightly broader than C, sutures obscure. Basal width of CL<sup>1</sup> equal to basal width of CL<sup>2</sup>, 1/2 to 1/3 basal width of rostral plate. C wider than CL<sup>1</sup> and CL<sup>2</sup>, narrower than rostral plate, height equal to or greater than rostral plate; plate sloping toward orifice; apex acute. Alae wide, triangular; growth ridges well-developed, parallel to inferior alar margin; superior alar margins oblique, not serrate; alae of C widest, alae of CL<sup>1</sup> and CL<sup>2</sup> equal in size, 1/2 width of carinal alae. Basis calcareous. Orifice small, pentagonal, slightly toothed; apex of rostral plate curving in toward orifice, apices of



CL<sup>1</sup> and CL<sup>2</sup> sloping toward C. Opercular plates set at angle of approximately 20° to basis. S triangular, apex acute, basal margin convex, 7/12 length of occludent margin; externally growth ridges extremely convoluted, cut by 10-14 radial striations, giving 'beaded' appearance; internally with adductor muscle pit approximately medial; lateral depressor muscle pit indistinct; articular furrow narrow; articular ridge extending 1/2 length of valve, projecting slightly beyond articular margin; adductor ridge indistinct. T larger than S, triangular; as wide as high; externally with prominent, regular growth ridges, few radial striations in carinal area; internally with 11-15 strong muscle attachment ridges extending beyond basal margin; articular ridge barely projecting beyond articular margin; articular furrow broad; spur short, almost indistinguishable from basal margin, 1/2 width of basal margin, set at distance of 1/10 length of basal margin from basi-scutal angle. Color of parietal plates orange-yellow with rusty orange markings; alae creamy yellow, those of C, CL<sup>1</sup> and CL<sup>2</sup> with rusty orange markings. Measurements of 2 specimens as follows:

	RC length	LD	C height	R height
<i>Holotype</i> : MNHN-Ci 2397	10.6	9.8	7.0	3.6
<i>Paratype</i> : MNHN-Ci 2503	14.0	8.7	6.0	6.3

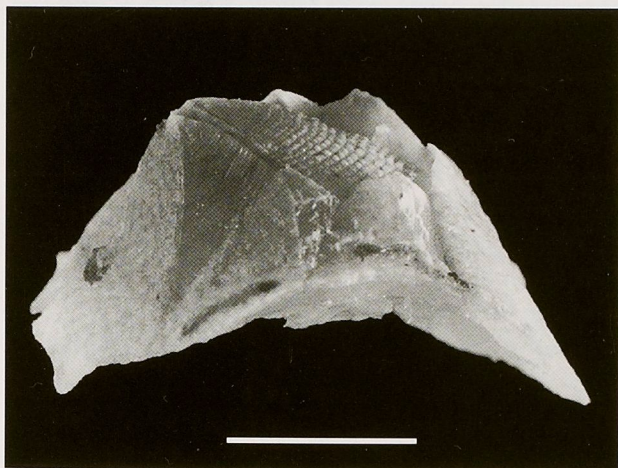


FIG. 21. — *Pachylasma bacum* sp. nov. Paratype from MUSORSTOM 6, stn CP 401 (MNHN-Ci 2503): lateral view. Scale = 5 mm.

Labrum with shallow medial depression, small teeth absent. Mandibular palp broadly ovate; dense, serrate setae terminally. Mandible with 3 teeth, tooth 1 largest, separated from teeth 2 and 3; upper margins of 3 or upper margins of 2 and 3 often with small subsidiary cusps, 2 sometimes with subsidiary, smaller tooth distally; inferior angle large, bluntly molariform, dentate. Maxillule with pair of long, stout setae at upper angle; notch below upper angle wide (right maxillule of illustrated specimen with notch barely defined), with 3-5 pairs of smaller setae; straight cutting margin below with 6-8 pairs of larger setae; inferior angle protuberant, with 5-6 pairs of smaller setae. Maxilla wide, coxal endite well developed; long serrulate setae terminally.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior ramus anteriorly protuberant; both rami with

segments thickly setose. Cirrus II longer than cirrus I; rami subequal, anterior ramus shorter than posterior; proximal segments of anterior ramus anteriorly protuberant; posterior ramus distally antenniform, small spines along distal margins of segments; all segments setose, setae simple or serrulate, especially distally. Cirrus III longer than cirrus II, with rami subequal, segments becoming oblong distally; posterior ramus with 3-5 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 3-5 pairs of long, finely serrulate setae on anterior faces of more distal segments, proximal segments with 8 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4-5 pairs of setae on anterior faces, distal 2 pairs longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

<i>Paratype</i> :		C I	C II	C III	C IV	C V	C VI	c. a.
MNHN-	left	10, 9	12, 16	21, 20	23, 23	25, 24	25, 25	reduced
Ci 2503	right	10, 9	13, 17	21, 19	22, 23	24, 24	24, 25	reduced

Caudal appendages reduced, leaf-like, with small, stout setae apically. Penis equal to length of basal segment of pedicel of cirrus VI; sparsely setose, with circlet of short setae distally.



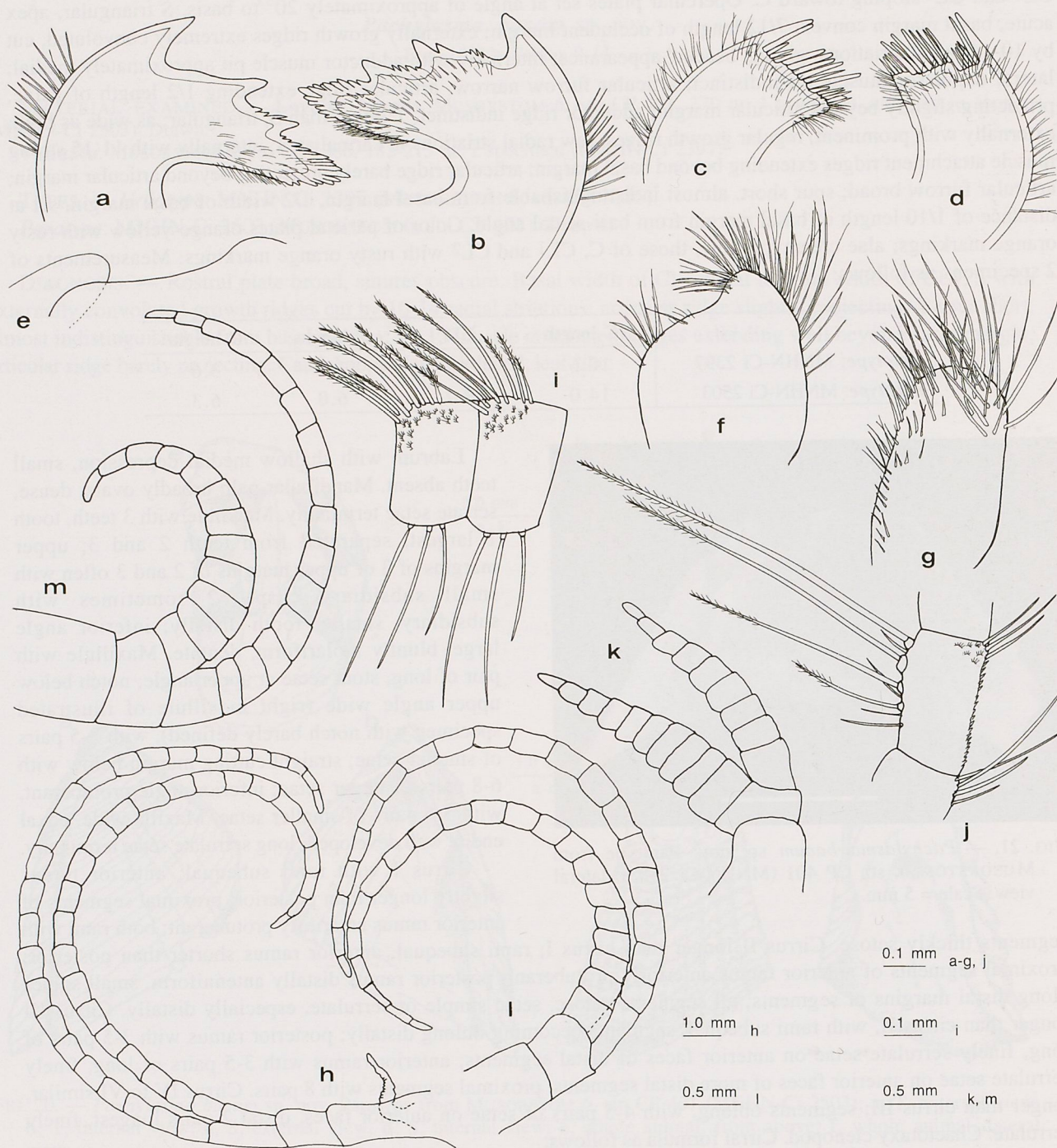


FIG. 22. — *Pachylasma bacum* sp. nov. Paratype from MUSORSTOM 6, stn CP 401 (MNHN-Ci 2503): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, labrum; **f**, left maxilla; **g**, mandibular palp; **h**, cirrus VI and penis; **i**, cirrus I, posterior ramus, median segments; **j**, cirrus II, posterior ramus, median segments; **k**, cirrus I; **l**, cirrus III; **m**, cirrus II.

REMARKS. — The circular form of the specimen from the Loyalty Islands is modified to an elongated oval, due to its attachment position on the host sponge. *Pachylasma bacum* sp. nov. is similar to *P. ovatum* sp. nov., but the 2 may be separated by the presence or absence of rostral plate sutures, visible in *P. ovatum*, obscure in



*P. bacum*. There are also differences in the relative sizes of the parietal plates - in *P. bacum* the basal width of CL<sup>1</sup> is equal to the basal width of CL<sup>2</sup> and 1/2 to 1/3 the width of the rostral plate; in *P. ovatum* the basal width of CL<sup>2</sup> is 7/8 the basal width of CL<sup>1</sup> and is equal to the basal width of the rostral plate. The basis is calcareous in *P. bacum* but is membranous with calcareous edges in *P. ovatum*. In *P. bacum* the S articular ridge is 1/2 the length of the valve and slightly projects beyond the articular margin; in *P. ovatum* it is 3/4 the length of the valve and projects beyond the articular margin. The tergal articular ridge of *P. bacum* barely projects beyond the articular margin; in *P. ovatum* it is short, well-developed and prominent, projecting beyond the articular margin. The caudal appendages are reduced and leaf-like in *P. bacum*, and absent in *P. ovatum*. The color of *P. bacum* is orange-yellow with rusty orange markings; *P. ovatum* is a dirty creamy white color.

The new species is similar to *P. ecaudatum* Hiro, 1939, but there are the following differences: the caudal appendages are reduced and leaf-like, with small, stout setae apically in *P. bacum* and absent in *P. ecaudatum*; the basis is entirely calcareous in *P. bacum* rather than calcareous, thin and centrally membranous (*P. ecaudatum*); cirral counts for cirri III-VI are greater in *P. bacum* (CIII 21/19, CIV 22/23, CV 24/24, CVI 24/25) than in *P. ecaudatum* (CIII 16/16, CIV 17/17, CV 18/18, CVI 20/20) and the colour of *P. bacum* is orange-yellow with rusty orange markings, whereas in *P. ecaudatum* the parietal plates are whitish, mottled with pink reticulations and the alae are uniformly rosy. *Pachylasma bacum* is larger in size (RC diameter 14.0, C height 7.0) and found attached to sponges, whilst *Pachylasma ecaudatum* (RC diameter 10.0, C height 6.0) has been found attached to the bivalve *Malleus regulus* (Forskål, 1775).

ETYMOLOGY. — From the Latin *bacum*, "bead", in reference to the beaded appearance of the scuta.

DISTRIBUTION. — Loyalty Islands, 270 m; Vanuatu, 182-215 m.

*Pachylasma darwinianum* Pilsbry, 1912

Fig. 19; Tables 9-11

*Pachylasma darwinianum* Pilsbry, 1912: 293; 1916: 329. — NEWMAN & ROSS, 1976: 40. — ROSELL, 1991: 37.

MATERIAL EXAMINED. — **Philippines.** "Albatross": stn 5168, Sulu Arch., Tawi Tawi Group, 4°56'30"N, 119°45'40"E, 146 m, 25.02.1908: holotype (USNM 43465).

TYPES. — *Holotype*: USNM 43465; Philippines, "Albatross", stn 5168, Tawi Tawi Group, Sulu Arch., 146 m; dry (1 lot) and slides (3).

*Holotype depository*: USNM.

DIAGNOSIS. — Rostral plate with sutures visible internally but not externally. Basal width of CL<sup>2</sup> more than 1/2 basal width of CL<sup>1</sup>. S growth ridges strongly convoluted, not cut by longitudinal striae; articular ridge barely projecting. T spur absent, 8-10 muscle crests projecting beyond basal margin; articular ridge slightly projecting. Mandible with upper margins of teeth 1 and/or 2 often with small subsidiary cusps. Caudal appendages uniarticulate, represented by swollen mounds with few, minute bristles.

REMARKS. — *Pachylasma darwinianum* is a large species (maximum RC length 20.5). It is most similar to *P. bacum* sp. nov. and *P. ecaudatum*, as all have extremely reduced caudal appendages which are uniarticulate. In *P. darwinianum* and *P. ecaudatum* the caudal appendages are represented by swollen mounds with a few, minute bristles apically; in *P. bacum* they are leaf-like, with small, stout setae apically. In *P. darwinianum* the basal width of CL<sup>1</sup> is greater than 1/2 the basal width of CL<sup>2</sup>, in *P. bacum* it is equal to the basal width of CL<sup>2</sup>, in *P. ecaudatum* it is equal to or slightly less than the basal width of CL<sup>2</sup>. The basis of *P. darwinianum* is membranous, that of *P. bacum* is calcareous and that of *P. ecaudatum* is membranous centrally, with calcareous edges. The T spur is absent in *P. darwinianum* and there are 8-10 muscle attachment ridges projecting well beyond the basal margin; in *P. bacum* the spur is short, 1/2 the width of the basal margin and set at 1/10 the length of the basal margin from the basi-scutal angle, and there are 11-15 muscle attachment ridges projecting well beyond



the basal margin; in *P. ecaudatum* it is indistinct, 3/8 the width of the basal margin and set at 1/8 the length of the basal margin from the basi-scutal angle, and there are 8-11 muscle attachment ridges projecting well beyond the basal margin. The dull red to whitish color of the parietal plates further distinguish *P. darwinianum* from all others in the genus.

DISTRIBUTION. — Tawi Tawi Group, Sulu Archipelago, Philippines, 146 m.

***Pachylasma ecaudatum* Hiro, 1939**

Fig. 19; Tables 9-11

*Pachylasma ecaudatum* Hiro, 1939: 52, figs 3-4. — NEWMAN & ROSS, 1976: 40.

*Hexelasma ecaudatum* - UTINOMI, 1968: 31, fig. 6.

TYPES. — *Holotype*: SMBL Type 30; Japan, Ogasawara I., 200 m, associated with bivalves (*Malleus regulus* Forskål, 1775).

*Holotype depository*: SMLB (specimen has not been located).

DIAGNOSIS. — Rostral plate lowest of all plates, sutures obscure. Basal width of CL<sup>2</sup> equal to or narrower than basal width of CL<sup>1</sup>. S externally with convoluted growth ridges cut by 8 longitudinal striae; articular ridge not projecting. T articular ridge not projecting; externally with growth ridges prominent, spur indistinct, 3/8 width of basal margin; 8-11 muscle attachment ridges extending well beyond basal margin. Caudal appendages uniarticulate, represented by few minute bristles on swollen mounds.

REMARKS. — *Pachylasma ecaudatum* is a moderate sized species (maximum: RC length 10.0, C height 6.0). The thin calcareous basis which is centrally membranous, the form of the T, the reduction of the caudal appendages and the whitish parietal plates, mottled with pink reticulations, determine this species. *Pachylasma ecaudatum* is most similar to *P. bacum* sp. nov.; differences between these 2 species are listed under *P. bacum*.

DISTRIBUTION. — Ogasawara Is, Japan, 200 m.

***Pachylasma giganteum* (Philippi, 1836)**

Fig. 19; Tables 9-11

*Chthamalus giganteus* Philippi, 1836: 250.

*Pachylasma giganteum* - DARWIN, 1854: 477, pl. 19 figs 5 a-d. — WELTNER, 1897: 273. — GRUVEL, 1905: 198, fig. 218. — PILSBRY, 1916: 329. — KOLOSVÁRY, 1942: 143; 1943: 77; 1952: 412. — WITHERS, 1953: 60. — RELINI, 1969: 169. — STUBBINGS, 1967: 263. — NEWMAN & ROSS, 1976: 40.

TYPES. — *Holotype*: BMNH Cat. No. 12060 Seguenza, in Jeffreys collection; Strait of Messina.

*Holotype depository*: BMNH. [specimen has not been located in the collections of the BMNH (Ms A. MORGAN, pers. Comm. 05.02.1996)].

DIAGNOSIS. — Rostral plate sutures obscure. CL<sup>1</sup> and CL<sup>2</sup> equal sized. S with prominent, sinuous growth ridges cut by 4-6, longitudinal striae; articular ridge not projecting. T with growth ridges prominent; spur short, 1/2 width of basal margin; 8-10 muscle attachment ridges projecting well beyond basal. Caudal appendages 1/3 longer than pedicel of cirrus VI, 19 segments.

REMARKS. — This species (maximum: RC length 30.0, C height 30.5) is distinguished from all others in the genus by its large size, by the dirty white color of the parietal plates and the form of the opercular plates. *Pachylasma giganteum* is similar to *P. bacum* as both species have a calcareous basis; the basis of *P. giganteum* is of variable thickness. Differences between *P. giganteum* and *P. bacum* are listed under *P. bacum*.

DISTRIBUTION. — Sicily, Mediterranean Sea; "deep water" (DARWIN, 1854).



*Pachylasma integrirostrum* Broch, 1931

Fig. 19; Tables 9-11

*Pachylasma integrirostrum* Broch, 1931: 50, fig. 18. — NEWMAN & ROSS, 1976: 40.

MATERIAL EXAMINED. — **Indonesia**. DANISH EXPED. TO KEI IS 1922: Mollucas, Amboina Bay, 140 m, 22.02.1922: syntypes (ZMC Cru 1977).

TYPES. — *Syntypes*: ZMC Cru 1977; Indonesia, MORTENSEN'S PACIFIC EXPED. 1914-16, Kei Islands, Amboina Bay, 140 m, 22.02.1922; 4 specimens.

*Syntypes Location*: ZMC.

DIAGNOSIS. — Parietal plates covered by persistent yellowish/brownish epidermis. Rostral plate sutures obscure. Basal width of CL<sup>2</sup> almost 1/2 basal width of CL<sup>1</sup>. S growth ridges feeble, radial striations absent; articular ridge slightly projecting. T with growth ridges feeble, smooth, not cut by longitudinal striae; spur indistinct, 1/2 width of basal margin; 4-6 weak muscle crests not extending beyond basal margin; S side of spur marked by shallow groove; articular ridge projecting. Caudal appendages equal to height of basal segment of pedicel of cirrus VI; 6 segments.

REMARKS. — In his description of *Pachylasma integrirostrum* from Ambon, BROCH (1931: 50) referred to the development of the alae of CL<sup>2</sup> (determined as CL by BROCH) as "....subject to variations: in three specimens - among them also in the type specimen (fig. 18a) they are externally visible only in the uppermost part of the plate, but in the fourth they are almost as conspicuous as those of the lateral plates". After examining the 4 specimens of *P. integrirostrum* described by BROCH, the alae of CL<sup>2</sup> of the 3 intact specimens are conspicuous, especially when the small size of the specimens is taken into account. The alae of CL<sup>2</sup> are approximately 1/2 the width of the alae of CL<sup>1</sup>, and extend most of the height of the shell. The fourth specimen, labelled 'type', is disarticulated, but was illustrated whole by BROCH prior to disarticulation. BROCH illustrated a small CL<sup>2</sup> ala (BROCH, 1931, fig. 18a). By inference from BROCH's written description, similar small-sized CL<sup>2</sup> alae should also be found in 2 of the 3 remaining whole specimens. However, in these 3 intact specimens I regard the CL<sup>2</sup> alae as conspicuous.

This small species (maximum: RC length 7.0, C height 2.5) differs from all others presently included in *Pachylasma* by 2 features; the basal width of CL<sup>2</sup> is almost 1/2 the basal width of CL<sup>1</sup>, rather than equal or subequal, as in the other species within *Pachylasma*; and the S external growth lines are feeble, not sinuous or convoluted, and not cut by longitudinal striae. In the remaining species within *Pachylasma* the S external growth lines are sinuous or convoluted, and cut by longitudinal striae, which may be faint in some species (e.g. *P. laeviscutum* sp. nov.).

*Pachylasma integrirostrum* is similar to *P. bacum*, *P. ecaudatum*, and *P. giganteum* as they all have a discrete, rather than tripartite, rostral plate. However, the basis of *P. bacum* and of *P. giganteum* is calcareous, rather than calcareous at the edges and membranous centrally, as in *P. integrirostrum* and *P. ecaudatum*. The S external growth lines of *P. ecaudatum* are convoluted and cut by 8 longitudinal striae; those of *P. integrirostrum* are feeble, not sinuous or convoluted, and not cut by longitudinal striae. These latter 2 species can be further separated by the caudal appendages - uniarticulate and extremely reduced being represented by swollen mounds with a few minute bristles in *P. ecaudatum*, 6-segmented and the height of the basal segment of the pedicel of cirrus VI in *P. integrirostrum*.

DISTRIBUTION. — Ambon, Mollucas, Indonesia; 140 m.

*Pachylasma laeviscutum* sp. nov.

Figs 19, 23-25; Tables 9-11

MATERIAL EXAMINED. — **Norfolk Ridge**. SMIB 5: stn DW 85, 260 m: 1 specimen (broken and lacking R). — Stn DW 88, 350 m: 1 specimen (dry), attached to gorgonian.



**New Caledonia.** MUSORSTOM 4: stn CP 190, 215 m: 1 specimen (shell only), attached to stem of dead gorgonian. — Stn DW 230, 390-420 m: 3 specimens, attached to stem of dead gorgonian (MNHN-Ci 2399).

**Vanuatu.** MUSORSTOM 8: stn DW 962, 370-400 m: several specimens, attached to gorgonian (WAM C 23249). — Stn CP 963, 400-440 m: 1 specimen. — Stn DW 988, 372-466 m: several specimens, attached to gorgonian. — Stn DW 1131, 140-175 m: several specimens, attached to gorgonian.

**Futuna Island.** MUSORSTOM 7: stn CP 508, 245-440 m: 3 specimens, attached to stem of dead gorgonian (MNHN-Ci 2697). — Stn CP 515, 224-252 m: 2 specimens, attached to stem of gorgonian (MNHN-Ci 2398, WAM 253-96). Drawn.

**TYPES.** — *Holotype*: MNHN-Ci 2398 (MUSORSTOM 7, stn CP 515).

*Paratypes*: MNHN-Ci 2399 (MUSORSTOM 4, stn DW 230). — MNHN-Ci 2697 (MUSORSTOM 7, stn CP 508). — WAM 253-96 (MUSORSTOM 7, stn CP 515). Drawn.

**DIAGNOSIS.** — Rostral plate with basal width R equal to basal width of RL. Basal width of CL<sup>1</sup> subequal to basal width of CL<sup>2</sup>. S externally with growth ridges slightly sinuous, cut by traces of 2-3 slight radial striations; S articular ridge slightly projecting. T spur indistinct, more than 1/3 length of basal margin; 13-18 muscle attachment ridges extending slightly beyond basal margin; articular ridge projecting. Caudal appendages equal to height of basal segment of pedicel of cirrus VI, 8-9 segments.

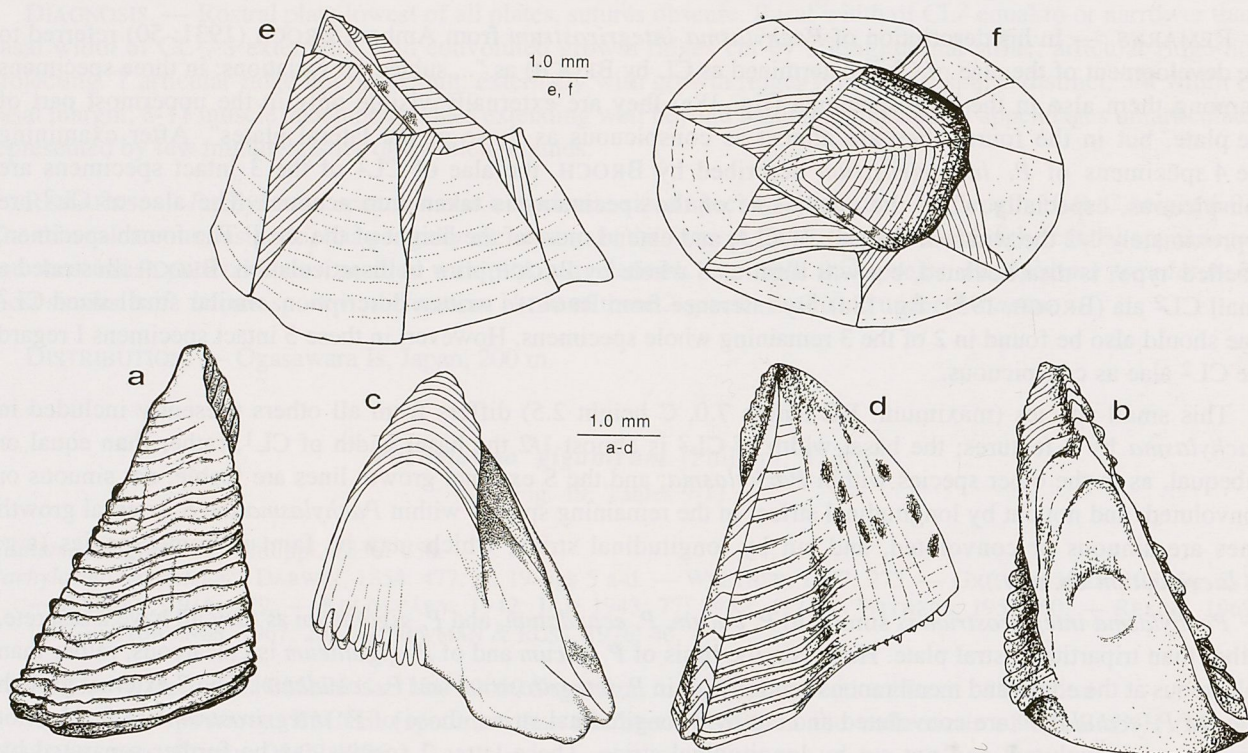


FIG. 23. — *Pachylasma laeviscutum* sp. nov. Paratype from MUSORSTOM 7, stn CP 508 (MNHN-Ci 2697): **a**, S, external view; **b**, S, internal view; **c**, T, internal view; **d**, T, external view; **e**, whole animal, lateral view; **f**, whole animal, from above.

**DESCRIPTION.** — Size moderate (maximum: RC length 10.5, C height 7.2). Shell form upright, parietal plates gently sloping toward orifice. Parietal plates smooth, growth ridges regular, faint, not marked by setae, in larger specimens paries more rugged, growth ridges less regular. Tripartite rostral plate convex, basal width twice basal width of C; rostral sutures visible externally and internally, basal width of R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate, basal width of CL<sup>1</sup> subequal to basal width of CL<sup>2</sup>. C higher than rostral plate, basal width 1/2 basal width of rostral plate. Alae wide, those of C widest, alae of CL<sup>1</sup> 1/2 width of C alae, alae of CL<sup>2</sup> 1/4 width



of C alae; growth ridges parallel to inferior alar margins, well-marked, summits oblique. Orifice large, pentagonal, not toothed. Basis thin, calcareous at edges, membranous centrally; flat. Opercular plates sloping at angle of approximately  $45^\circ$  to basis. S subequal to T; elongated triangle, basal margin 1/2 length occludent margin; externally growth ridges slightly sinuous, not fluted, cut by traces of 2-3 slight radial striations; internally adductor muscle pit situated at 1/2 length of valve; lateral depressor muscle pit indistinct; articular furrow narrow; articular ridge extending 2/3 length of valve, projecting slightly beyond articular margin; adductor ridge indistinct. T subtriangular; width equal to height; externally growth ridges prominent, angularly upturned close along scutal margin, longitudinal striations in carinal area over depressor muscle region; internally with 13-18 small muscle crests projecting beyond basal margin; articular ridge long, slightly extending beyond articular margin; articular furrow broad, shallow; spur short, truncate, width more than 1/3 length of basal margin, set at distance of 1/9 length of basal margin from basi-scutal angle. Color of parietal plates orange with some rusty-red markings. Measurements of 10 specimens examined as follows:

	RC length	LD	C height	R height
rg	4.9-10.5	3.8-7.6	2.6-7.2	1.6-6.0
$\bar{x}$	8.0	5.8	4.9	3.8

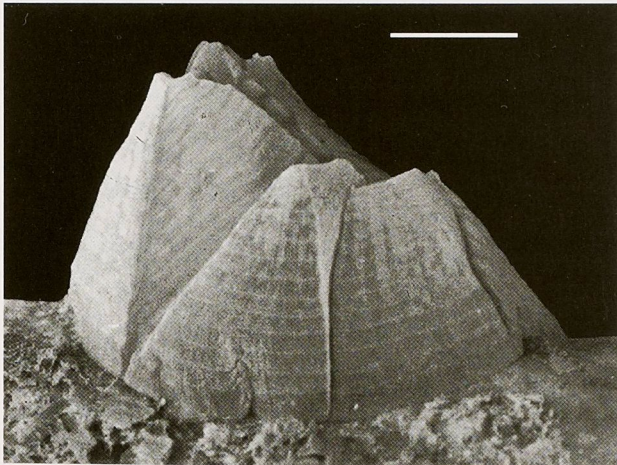


FIG. 24. — *Pachylasma laeviscutum* sp. nov. Holotype from MUSORSTOM 7, stn CP 515 (MNHN-Ci 2397); lateral view. Scale = 1 cm.

Labrum with shallow medial depression; teeth absent but irregular groups of minute denticles present. Mandibular palp ovate, elongated; long serrate setae terminally. Mandible with 3 primary teeth, tooth 1 largest, well separated from 2 and 3; upper margins of 2 and 3 with small subsidiary cusps; inferior angle large, bluntly molariform, dentate. Maxillule setose; 3 long setae at upper angle; indistinct notch below with 2-3 pairs of smaller setae; cutting margin below notch slightly stepped, with 7-8 pairs of longer setae; inferior angle slightly stepped, with 4-7 pairs of smaller setae. Maxilla wide, with dense, long setae; coxal endite more developed than basal endite.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior ramus protuberant anteriorly; both rami with segments thickly setose. Cirrus II longer than cirrus I, similar

to cirrus III; rami subequal; proximal segments of anterior ramus broad, slightly protuberant anteriorly, all segments thickly setose; posterior ramus antenniform, segments elongated, narrow, distal segments with 2-3 long setae antero-distally. Cirrus III more similar to cirri IV-VI than to cirri I and II; rami subequal, segments becoming oblong distally, more distal segments of both rami with 4 pairs of long setae on anterior faces. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4 pairs of setae on anterior faces, distal 2 pairs of setae longest. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		C I	C II	C III	C IV	C V	C VI	c. a.
WAM	left	12, 10	14, 11	18, 18	21, 23	24, 21	25, 24	9
253-96	right	13, 11	14, 12	20, 21	22, 23	24, 21	25, 26	8

Caudal appendages length of proximal segment of pedicel of cirrus VI; 8-9 segmented; long setae terminally and around distal segmental margins. Penis more than 1/2 length of cirrus VI; finely annulated; sparsely setose, with dense rosette of moderately long, fine setae distally.



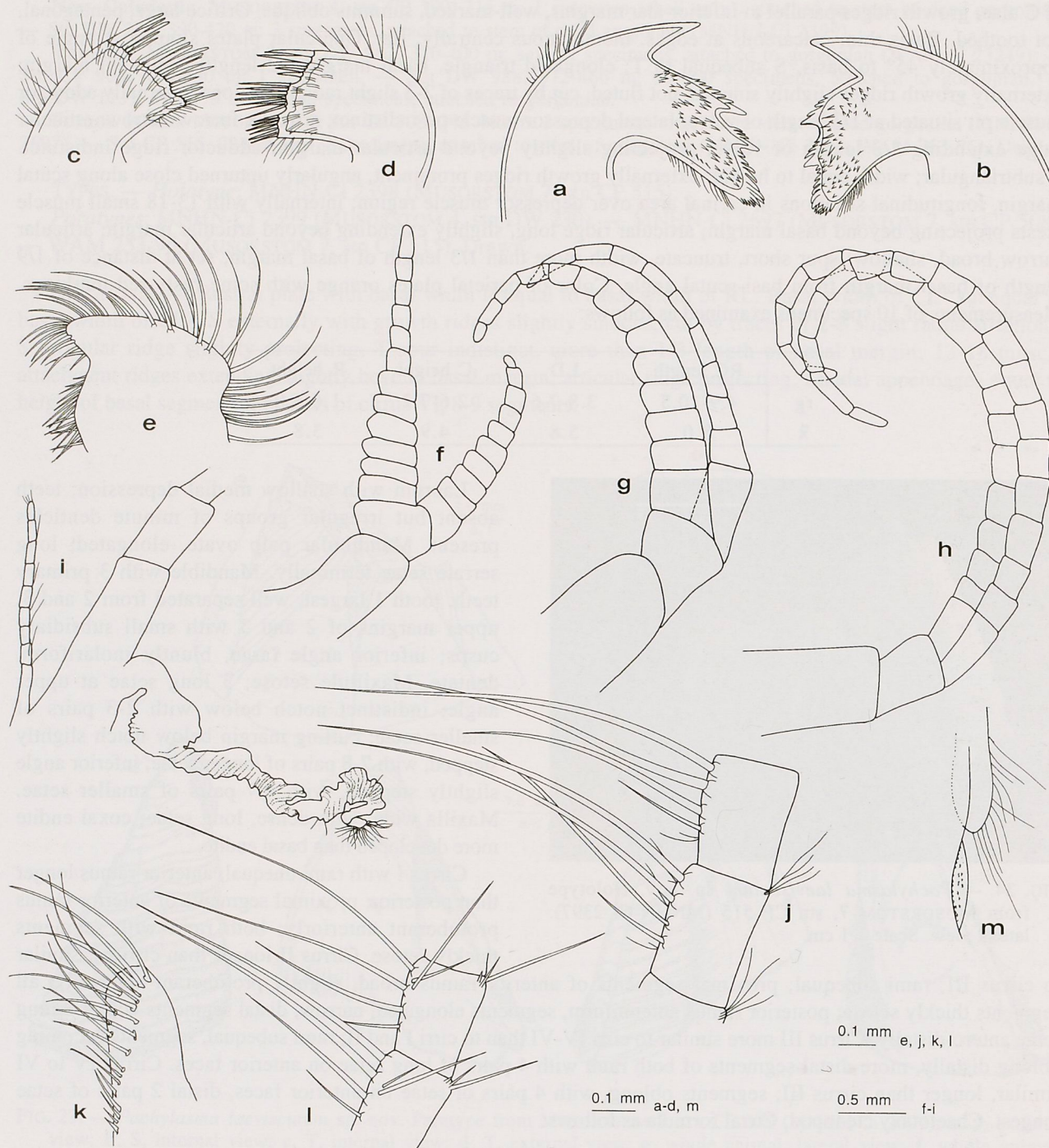


FIG. 25. — *Pachylasma laeviscutum* sp. nov. Paratype from MUSORSTOM 7, stn CP 508 (MNHN-Ci 2697): a, right mandible; b, left mandible; c, right maxillule; d, left maxillule; e, maxilla; f, cirrus I; g, cirrus II; h, cirrus III; i, pedicel of cirrus VI, caudal appendage and penis; j, cirrus VI, posterior ramus, median segments; k, mandibular palp; l, cirrus III, posterior ramus, median segments; m, labrum.

REMARKS. — *Pachylasma laeviscutum* sp. nov., *P. ovatum* sp. nov. and *P. scutistriata* are similar because all have the rostral sutures visible externally. However, there are differences in the form and length of the caudal appendages, which are 8-9 segmented and the length of the basal segment of the pedicel of cirrus VI in



*P. laeviscutum*; absent in *P. ovatum*; and 15-18 segmented and a little longer than the pedicel of cirrus VI in *P. scutistriata*. There are also differences in the ornamentation of the S - the scutal growth ridges are slightly sinuous and cut by 2-3 slight radial striations in *P. laeviscutum*; moderately convoluted and cut by 12-15 radial striations in *P. ovatum*; and convoluted and distinctly divided by many radial striations in *P. scutistriata*. Features of the T also separate these species. In *P. laeviscutum* the indistinct tergal spur is more than  $1/3$  the width of the basal margin, set at distance of  $1/9$  the length of the basal margin from the basi-scutal angle, 13-18 muscle attachment crests slightly extend from the basal margin, and the articular ridge slightly projects beyond the articular margin. In *P. ovatum* the short spur is more than  $2/5$  the width of the basal margin, set at distance of less than  $1/5$  the length of the basal margin from the basi-scutal angle, 12-14 muscle attachment crests extend well beyond the basal margin, and the articular ridge projects beyond the articular margin. In *P. scutistriata* the spur is indistinct, not separated from the basi-scutal angle, the muscle attachment crests do not extend well beyond the basal margin, and the articular ridge projects beyond the articular margin.

*Pachylasma laeviscutum* sp. nov. differs from *P. darwinianum* as the rostral sutures are visible internally but not externally in the latter species. Additionally, *P. darwinianum* has a membranous basis, and the caudal appendages are extremely reduced, being represented by swollen mounds, whereas *P. laeviscutum* has 8-9 segmented caudal appendages which are the height of the basal segment of the pedicel of cirrus VI. The S of *P. darwinianum* externally has strongly convoluted growth lines which are not cut by longitudinal striae, whilst those of *P. laeviscutum* are slightly sinuous and cut by traces of 2-3 faint longitudinal striations. The T spur of *P. laeviscutum* is more than  $1/3$  the length of the basal margin, whereas the spur is absent in *P. darwinianum*.

*Pachylasma laeviscutum* differs from *P. ecaudatum*, *P. bacum* sp. nov. and *P. giganteum* because in these latter species the rostral sutures are obscure. The form and length of the caudal appendages (equal to the length of the basal segment of the pedicel of cirrus VI in *P. laeviscutum*, extremely reduced in *P. ecaudatum* and *P. bacum*, and  $1/3$  longer than the pedicel of cirrus VI in *P. giganteum*) further separate these species. There are also differences regarding the form of S and T between these species. The scutal growth ridges are slightly sinuous, not fluted, and cut by traces of 2-3 slight radial striations in *P. laeviscutum*; the S of *P. ecaudatum* has convoluted growth ridges cut by 8 radial striations; the S of *P. bacum* sp. nov. has extremely convoluted growth ridges, cut by 10-14 radial striations, giving it a 'beaded' appearance; and the S of *P. giganteum* has prominent, sinuous growth ridges cut by 4-6 slight longitudinal furrows. The T of *P. laeviscutum* has prominent growth ridges which are angularly upturned close along the scutal margin, longitudinal striations in the carinal area over the depressor muscle region, and a short spur more than  $1/3$  the length of the basal margin and set at  $1/9$  the length of the basal margin from the basi-scutal angle. The T of *P. ecaudatum* has prominent growth ridges and a slight ridge parallel to the S margin where the growth ridges are angularly upturned, and an indistinct spur which is  $3/8$  the length of the basal margin and set at  $1/8$  the length of the basal margin from the basi-scutal angle. The T of *P. bacum* sp. nov. has prominent, regular growth ridges and a short, broad spur which is  $1/2$  the width of, and almost indistinguishable from, the basal margin, set at distance of  $1/10$  the length of the basal margin from the basi-scutal angle. The T of *P. giganteum* has prominent growth ridges, which are angularly upturned close along the scutal margin, and a short, broad spur which is  $1/2$  the width of the basal margin and set at a distance of  $1/7$  the length of the basal margin from the basi-scutal angle.

*Pachylasma laeviscutum* sp. nov. differs from *P. integrirostrum* as in the latter the basal width of CL<sup>1</sup> is almost twice the basal width of CL<sup>2</sup>, rather than equal to the basal width of CL<sup>2</sup>. The S growth ridges of *P. integrirostrum* are feeble with no radial striations, whilst those of *P. laeviscutum* are slightly sinuous and cut by 2 to 3 faint longitudinal striae. The T of *P. integrirostrum* has feeble growth ridges, a broad spur which is  $1/2$  the width of the basal margin and 4-6 muscle attachment ridges which do not extend beyond the basal margin. The T of *P. laeviscutum* has well marked growth ridges, a broad spur which extends more than  $1/3$  the width of the basal margin and 13-18 muscle attachment ridges which extend beyond the basal margin.

ETYMOLOGY. — From *scutum*, and the Latin *laevis*, 'smooth', in reference to the smooth, slightly sinuous scutal growth ridges.

DISTRIBUTION. — Vanuatu, 140-466 m; New Caledonia, 215-420 m; Norfolk Ridge, 260-350 m; Futuna Island, 224-440 m.



*Pachylasma ovatum* sp. nov.

Figs 19, 26-28; Tables 9-11

MATERIAL EXAMINED. — **New Caledonia**. LAGON: stn 444, 300-350 m: 1 specimen (MNHN-Ci 2401). Drawn. MUSORSTOM 4: stn CP 193, 415 m: 1 specimen, attached to a sponge (MNHN-Ci 2400); 1 specimen, attached to coral rubble.

BATHUS 4: stn DW 914, 600-616 m: 2 specimens, attached to sponges. — Stn DW 924, 344-360 m: 1 specimen, attached to coral rubble (WAM 254 -96).

TYPES. — *Holotype*: MNHN-Ci 2400 (MUSORSTOM 4, stn CP 193).

*Paratypes*: MNHN-Ci 2401 (LAGON, stn 444). Drawn. — WAM 254-96 (BATHUS 4, stn DW 924).

DIAGNOSIS. — Rostral plate sutures visible, basal width of R equal to basal width of RL. Basal width of CL<sup>2</sup> 7/8 basal width of CL<sup>1</sup>. S growth ridges convoluted, cut by 12-15 radial striations; articular ridge projecting. T with regular growth ridges; spur almost indistinguishable from basal margin, width 2/5 length of basal margin; 12-14 muscle attachment ridges extending well beyond basal margin; articular ridge projecting. Caudal appendages absent.

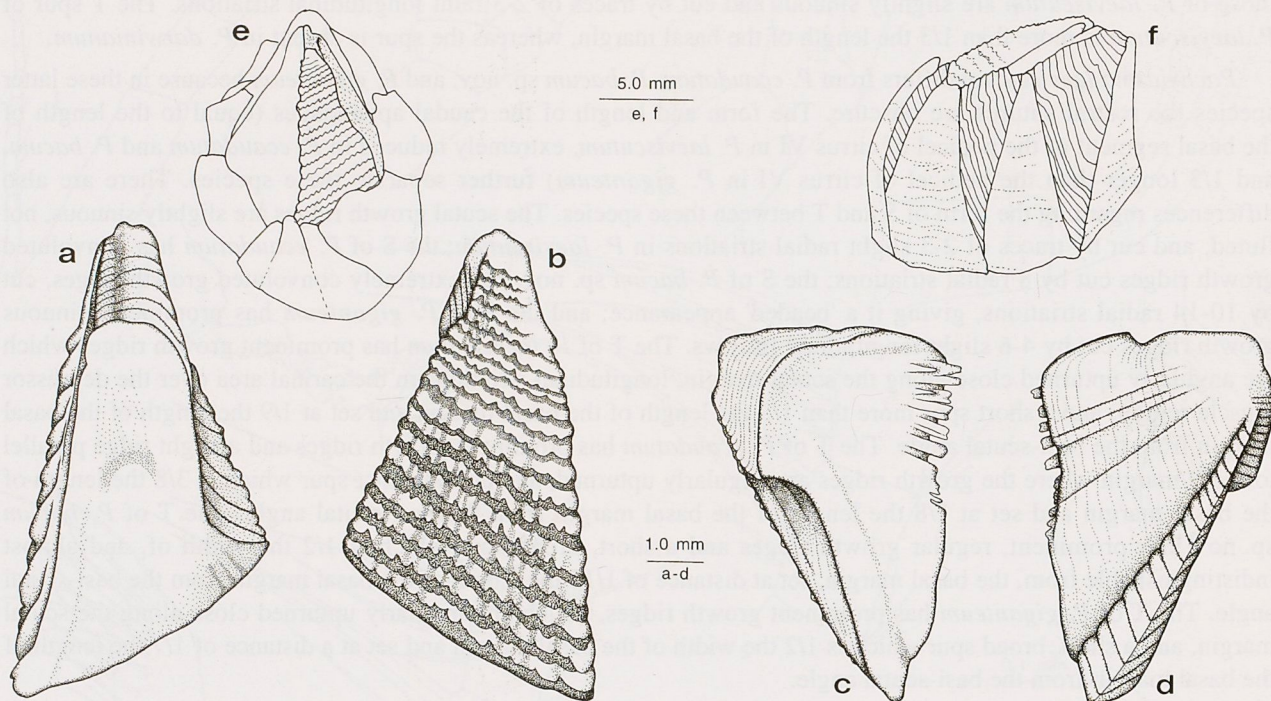


FIG. 26. — *Pachylasma ovatum* sp. nov. Paratype from LAGON, stn 444 (MNHN-Ci 2401): a, S, internal view; b, S, external view; c, T, internal view; d, T, external view; e, whole animal, from above (right S and T removed); f, whole animal, lateral view.

DESCRIPTION. — Size large (maximum: RC length 14.6, C height 10.7). Shell form oval from above. Parietal plates thick, growth ridges not well-defined, irregular; apices of rostral and CL<sup>1</sup> plates curved in toward orifice. Rostral plate convex; sutures visible internally and externally (sometimes obscure externally), dividing plate into 3 subequal parts; apex curved in toward orifice. CL<sup>1</sup> and CL<sup>2</sup> separate; basal width of CL<sup>1</sup> equal to basal width of rostral plate; basal width of CL<sup>2</sup> 7/8 basal width of CL<sup>1</sup>; apices of CL<sup>1</sup> and CL<sup>2</sup> curved in toward orifice. C convex; apex curving out from orifice; basal width of C equal to basal width of CL<sup>1</sup> and of rostral plate; shorter than, or approaching height of, R. Alae wide, triangular, those of C widest, alae of CL<sup>1</sup> and CL<sup>2</sup> equal in size,



width 1/2 width of carinal ala; superior alar margins finely serrate, oblique; alar growth ridges parallel to inferior alar margin. Basis thin, calcareous, centrally membranous. Orifice large, wide, roundly pentagonal; not toothed. Basis calcareous at edges, membranous centrally. Opercular plates lodged subparallel to basis. S triangular, elongated, basal margin greater than 1/2 length of occludent margin; apex bluntly pointed; externally with convoluted growth ridges, cut by 12-15 radial striations; internally adductor muscle pit in middle of valve; few short crests for lateral depressor muscle in shallow pit; articular furrow narrow, shallow; articular ridge running 3/4 length of valve, extending beyond articular margin; adductor ridge indistinct. T similar size to S, wide, triangular; externally growth ridges regular; internally with 12-14 strong muscle crests projecting beyond basal margin; articular ridge short, well-developed, prominent, extending beyond articular margin; articular furrow well-developed; spur short, almost indistinguishable from basal margin, width 2/5 width of basal margin, set at distance of 1/5 width of basal margin from basi-scutal angle. Color of parietal and opercular plates dirty creamy white. Measurements of 4 specimens examined as follows:

	RC length	LD	C height	R height
rg	10.0-14.6	9.0-19.8	3.6-10.7	4.7-9.2
$\bar{x}$	12.8	13.0	7.5	6.9

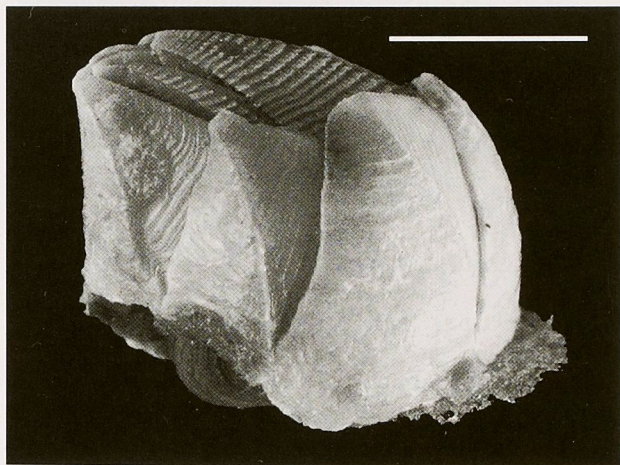


FIG. 27. — *Pachylasma ovatum* sp. nov. Holotype from MUSORSTOM 4, stn CP 193 (MNHN-Ci 2400): lateral view. Scale = 5 mm.

Labrum with shallow medial depression, small teeth present, bi- or tricuspid. Mandibular palp wide, ovate; dense, serrate setae terminally. Mandible with 3 teeth, tooth 1 separated from teeth 2 and 3; upper margins of 2 and 3 with small subsidiary cusps; inferior angle molariform, strongly dentate. Maxillule with 1 pair of long, stout setae at upper angle; notch below upper angle broad, with 4-5 pairs of smaller setae; cutting margin below almost straight, with 5-7 pairs of longer, stout setae; inferior angle slightly protuberant, with 7-9 pairs of small setae. Maxilla wide; lobes subequal; long serrulate setae distally.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior ramus anteriorly protuberant; both rami with segments moderately setose. Cirrus II similar to but longer than cirrus I; rami subequal; proximal segments of anterior ramus anteriorly slightly

protuberant, all segments setose, setae simple or serrulate, serrulate setae distally; antenniform distal segments of posterior ramus with tuft of setae and spines at posterior distal margins. Cirrus III longer than cirrus II; rami subequal, segments becoming oblong distally; posterior ramus with 3-5 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 3-5 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 10 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 5 pairs of setae on anterior faces, distal 2 pairs longest, finely serrulate; distal segments of posterior ramus with spines at distal margin. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	11, 11	17, 20	22, 24	25, 26	26, 28	26, 26	absent
Ci 2401	right	11, 12	17, 16	18, 21	24, 26	26, 27	26, 27	absent

Penis 1/2 length of basal segment of pedicel of cirrus VI; sparsely setose; tufts of long setae distally. Caudal appendages absent.



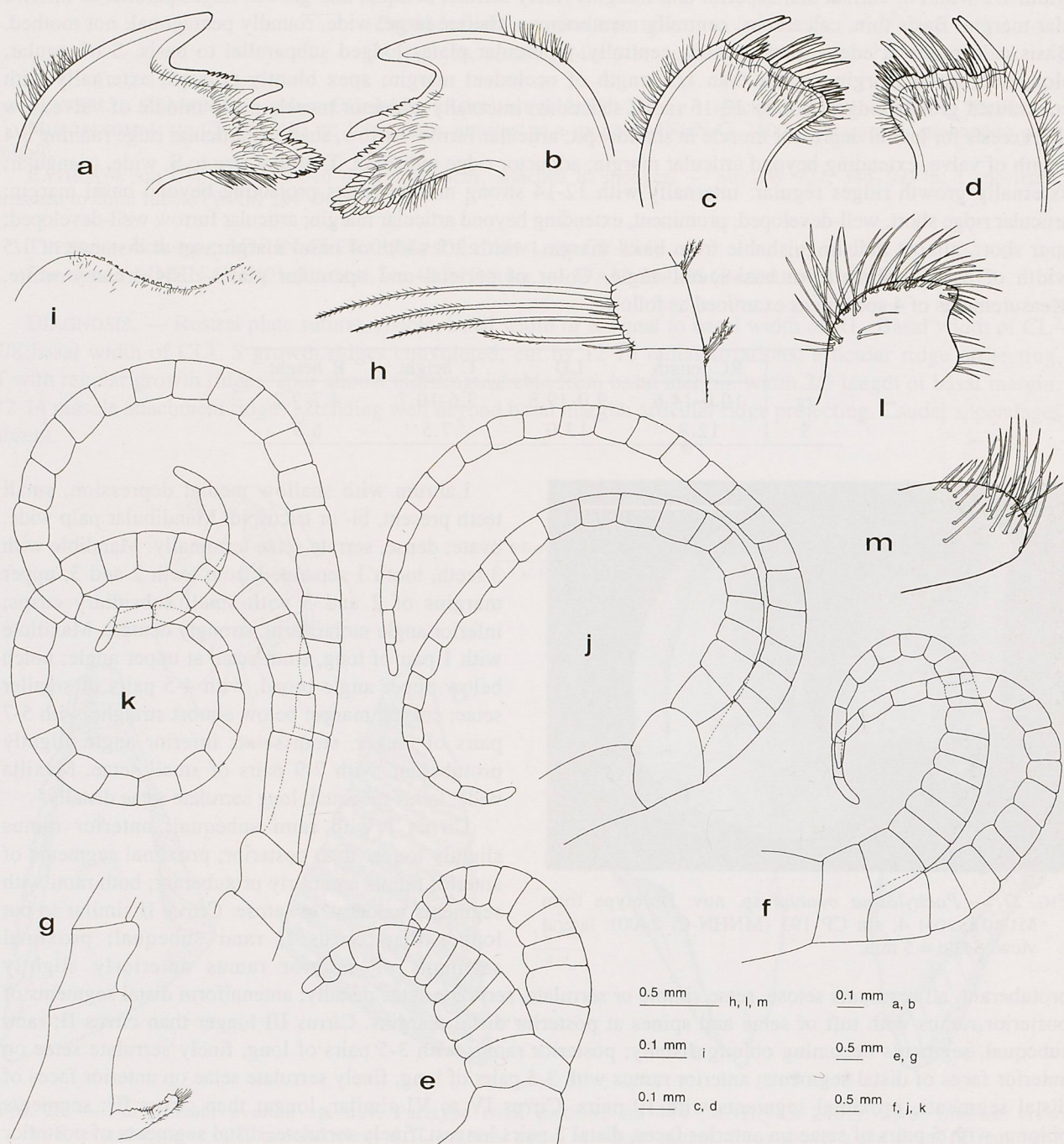


FIG. 28. — *Pachylasma ovatum* sp. nov. Paratype from LAGON, stn 444 (MNHN-Ci 2401): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, cirrus I; **f**, cirrus II; **g**, pedicel of cirrus VI and penis; **h**, cirrus VI, posterior ramus, median segments; **i**, labrum; **j**, cirrus III; **k**, cirrus VI; **l**, maxilla; **m**, mandibular palp.

REMARKS. — *Pachylasma ovatum* sp. nov. is similar to *P. scutistriata* but they may be separated by a number of characters. In *P. ovatum* the basal width of CL<sup>2</sup> is 7/8 the basal width of CL<sup>1</sup>, rather than equal to the basal width (*P. scutistriata*). The caudal appendages are absent in *P. ovatum* rather than 15-18 segmented and a little longer than the pedicel of cirrus VI (*P. scutistriata*). In *P. ovatum* the S growth ridges are moderately convoluted



and divided by 12-15 radial striations; in *P. scutistriata* they are distinctly convoluted and divided by a few radial striations. There are also differences in the form of the T - the muscle attachment crests do not project beyond the basal margin in *P. scutistriata*, but there are 12-14 well-developed muscle crests projecting well beyond the basal margin in *P. ovatum*; the tergal spur is  $2/5$  the width of the basal margin and set at a distance of less than  $1/5$  the width of the basal margin from the basi-scutal angle in *P. ovatum*, but the spur is indistinct,  $1/3$  the width of the basal margin and not separated from the basi-scutal angle in *P. scutistriata*; and the tergal articular ridge extends much further beyond the articular margin in *P. scutistriata* than in *P. ovatum*. In addition, the parietal plates of *P. scutistriata* are pale pink colored with white alae, whilst those of *P. ovatum* are dirty creamy white.

ETYMOLOGY. — From the Latin *ovatum*, 'oval', in reference to the ovate form of the basis.

DISTRIBUTION. — New Caledonia, 300-616 m.

*Pachylasma scutistriata* Broch, 1922

Fig. 19; Tables 9-11

*Pachylasma scutistriata* Broch, 1922: 301, figs 48-50. — NILSSON-CANTELL, 1927: 781. — POPE, 1965: 10. — UTINOMI, 1968: 26, figs 4-5. — NEWMAN & ROSS, 1976: 40. — FOSTER, 1978: 77, fig. 47, pl. 9 E-F.

MATERIAL EXAMINED. — **Australia.** "Endeavour": 38°12'S, 149°40'E, 256-274 m, 16.09.1914: holotype (ZMC Cru 1978). — E of East Sister Island, Bass Strait, 104-110 m: 1 dry specimen (AM E 6629). — SE Australia, few specimens, on alcyonarian stock covered by anemones (AM P 23757).

TYPES. — *Holotype*: ZMC Cru 1978; Australia, "Endeavour", 38°12'S, 149°40'E, 256-274 m, 16.09.1914; 2 slides plus material in alcohol.

*Paratypes*: AM E 6565; Australia, "Endeavour", 38°12'S, 149°40'E, 256-274 m, 16.09.1914; ZMC Cru 1978. *Holotype depository*: ZMC.

*Paratypes depository*: ZMC, AM.

DIAGNOSIS. — Rostral plate shortest plate; sutures visible, basal width R equal to basal width RL. Basal width of CL<sup>1</sup> equal to basal width of CL<sup>2</sup>. S externally with growth ridges convoluted, cut with many radial striations; articular ridge slightly projecting. T with faint growth ridges, spur almost indistinguishable from basal margin, width  $1/3$  length of basal margin, set at basi-scutal angle; prominent articular ridge projecting beyond scutal margin; muscle attachment ridges not extending beyond basal margin. Caudal appendages slightly longer than pedicel of cirrus VI, 15-18 segments.

REMARKS. — Size large (maximum: RC length 20.0, C height 15.0). *Pachylasma scutistriata* is similar to *P. ovatum* sp. nov. but they may be separated by a number of characters, which are listed in the Remarks section under *P. ovatum* sp. nov. The vivid pink color of the parietal plates, and the form of the caudal appendages (15-18 segmented and a little longer than the pedicel of cirrus VI) separate *P. scutistriata* from the remaining species presently included within *Pachylasma*.

DISTRIBUTION. — Indian Ocean to New Zealand, Japan, South China Sea to Malaysia, 104-2050 m.

Genus *EURYLASMA* gen. nov.

Fig. 29; Tables 3-4, 12-14

DIAGNOSIS. — Adult externally with fixed shell pattern of 6 parietal plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C). Rostral plate with sutures obscure, or visible externally and internally with R reduced to narrow sliver, RL correspondingly well developed, basal width of RL 3 times or 6 times basal width of R. CL<sup>1</sup> and CL<sup>2</sup> partially coalesced, coalescence



incomplete as CL<sup>2</sup> retains minute ala. S concave externally; pyramidal or sub-pyramidal in form. Length of caudal appendages ranging from 1/2 height of distal segment of pedicel of cirrus VI to longer than pedicel of cirrus VI by 1/4; 5-13 segments.

TYPE SPECIES. — *Eurylasma angustum* sp. nov.

RECENT SPECIES. — *Eurylasma angustum* sp. nov.; *E. ferulum* sp. nov.; *E. pyramidale* sp. nov.

TABLES 12 and 13. — *Eurylasma*: characters of the species

	no. plates ext . int.		R:RL	CL <sup>1</sup> : CL <sup>2</sup>	T	basis
<i>E. angustum</i> sp. nov.	6	8	basal width RL = 3 x basal width R; apical width RL = apical width R	partially coalesced, but CL <sup>2</sup> retains ala; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup> ; height CL <sup>2</sup> 3/4 height of CL <sup>1</sup>	not proj.; spur indistinct, 5/9 width of basal margin, not separated from b-s angle; 7-9 muscle crests extending well beyond basal margin	calcareous
<i>E. ferulum</i> sp. nov.	6	8	basal width RL = 6 x basal width R; apical width RL = 2 x apical width R	partially coalesced, but CL <sup>2</sup> retaining ala; basal width CL <sup>2</sup> = 3/4 basal width CL <sup>1</sup> ; height CL <sup>2</sup> 9/10 height of CL <sup>1</sup>	not proj.; spur indistinct, 1/2 width basal margin, not separated from b-s angle; 16-20 muscle crests, not extending beyond basal margin	calcareous
<i>E. pyramidale</i> sp. nov.	6	6	n.a.	partially coalesced, but CL <sup>2</sup> retaining ala; basal width CL <sup>2</sup> = 9/10 basal width CL <sup>1</sup> ; height CL <sup>2</sup> 8/9 height of CL <sup>1</sup>	not proj.; spur indistinct, 2/3 width basal margin, not separated from b-s angle; 10-14 muscle crests barely extending beyond basal margin	calcareous

b-s = basi-scutal; ext. = external; int. = internal; n. a. = not applicable; proj. = projecting.

	S shape	S growth lines	c.a.	mandible
<i>E. angustum</i> sp. nov.	concave externally in upper 1/3; tending to sub-pyramidal; S basal margin 3/5 length of occludent margin, curved toward artic. margin at point 2/3 length of basal margin from occludent margin; S artic. ridge not proj.	convoluted; not cut by long. striae	5-6 segs; 1/2 height of distal segment of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 often with small subsidiary cusps
<i>E. ferulum</i> sp. nov.	concave externally in middle region; sub-pyramidal; S basal margin 2/5 length of occludent margin, bent at almost 90° toward artic. margin at point 2/3 length of basal margin from occludent margin; S artic. ridge not proj.	convoluted; not cut by long. striae	11-12 segs; = height of pedicel of CVI	tridentate; upper margin of tooth 3 with small subsidiary cusps
<i>E. pyramidale</i> sp. nov.	pyramidal; concave externally in upper 1/2; S basal margin 5/12 length of occludent margin, bent at almost 90° toward artic. margin at point 2/3 length of basal margin from occludent margin; S artic. ridge not proj.	convoluted; cut by many faint, long. striae, giving slight beaded effect	13 segs; longer than pedicel of CVI by 1/4	tridentate; upper margins of teeth 2 and 3 with strong subsidiary cusps

artic. = articular; c.a. = caudal appendage; long. = longitudinal; max. = maximum; proj. = projecting; segs = segments.

TABLES 14. — *Eurylasma*: maximum size, geographical and bathymetrical distribution of the species

	size (max.)	distribution	depth
<i>E. angustum</i> sp. nov.	RC length 9.7; C height 7.5	Loyalty Is, Vanuatu	295-400 m
<i>E. ferulum</i> sp. nov.	RC length 15.0; C height 10.6	Norfolk Ridge	460-470 m
<i>E. pyramidale</i> sp. nov.	RC length 14.1; C height 6.7	Norfolk Ridge	255-365 m

REMARKS. — The well developed carinal alae, and the partial coalescence of CL<sup>1</sup> and CL<sup>2</sup>, with the concomitant reduction of the ala of CL<sup>2</sup>, are characteristic of the genus. In addition, the angle of lodgement of the



opercular plates in the orifice, and the curved form of the S, due to its external concavity, plus the almost right-angle formed by the basal and tergal margins (resulting in the sub-pyramidal to pyramidal form), are unique characters. Furthermore, in species where the rostral sutures are visible, the reduction of R to a narrow sliver, associated with the great development of RL, are characters not found in any other pachylasmatine genera. Species included herein are moderate (maximum: RC length 9.7, C height 7.5) to large (maximum: RC length 15.0, C height 10.6) in size and have been found attached to gorgonians and *Corallium* species.

In *Eutomolasma* sp. nov., *Microlasma* sp. nov. and *Pachylasma*, CL<sup>1</sup> and CL<sup>2</sup> are discrete entities, resulting in the adult fixed wall pattern of 6 plates. CL<sup>1</sup> and CL<sup>2</sup> are coalesced to a certain degree in *Eurylasma* sp. nov. although the ala of CL<sup>2</sup> is still evident, albeit reduced. This arrangement also results in an adult fixed wall pattern of 6 parietal plates. In *Tetrapachylasma*, CL<sup>1</sup> and CL<sup>2</sup> may be coalesced, partially or totally, resulting in a variable shell pattern in the adult of 6 (partial coalescence of CL<sup>1</sup> and CL<sup>2</sup>) or 4 (total coalescence of CL<sup>1</sup> and CL<sup>2</sup>) parietal plates.

ETYMOLOGY. — From the Greek *eurys*, 'wide', in reference to the characteristically broad carinal alae of species included in this genus.

DISTRIBUTION. — Western Pacific Ocean: Norfolk Ridge, 255-365 m (*E. pyramidale*); Norfolk Ridge, 460-470 m (*E. ferulum*); Vanuatu, Loyalty Islands, 295-400 m (*E. angustum*).

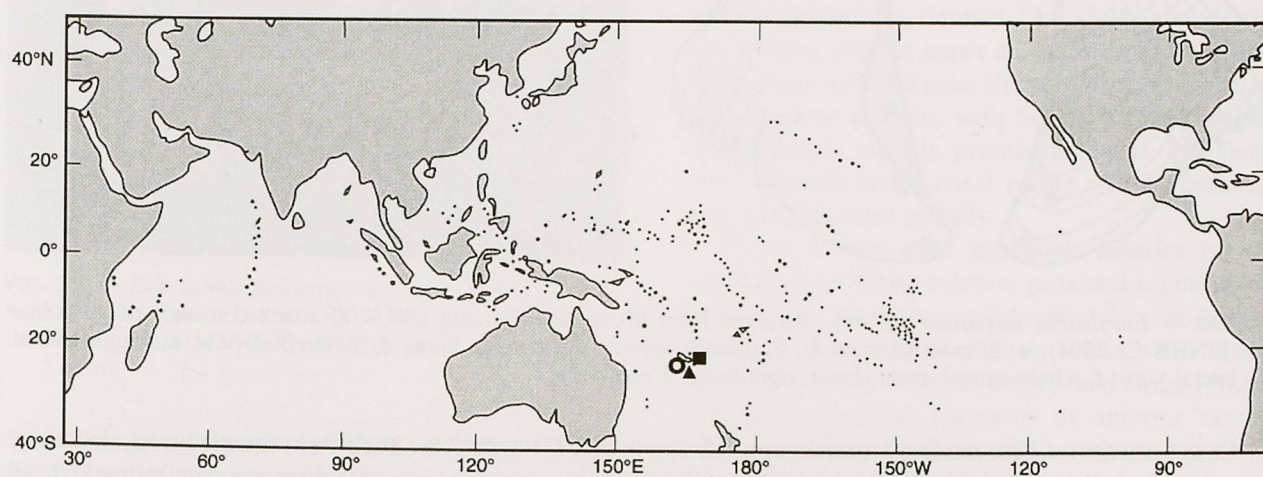


FIG. 29. — *Eurylasma* gen. nov. Distribution map: ○, *E. pyramidale* sp. nov. (255-365 m); ▲, *E. ferulum* sp. nov. (460-470 m); ■, *E. angustum* sp. nov. (295-400 m).

*Eurylasma angustum* sp. nov.

Figs 29-32; Tables 12-14

MATERIAL EXAMINED. — **Loyalty Islands.** MUSORSTOM 6: stn DW 478, 400 m: several specimens, attached to gorgonian (MNHN-Ci 2402, Ci 2504). Drawn.

**Vanuatu.** MUSORSTOM 8: stn DW 967, 295-334 m: 2 specimens, attached to gorgonian (WAM C 23250). — Stn DW1060, 375-397 m: 1 specimen, attached to gorgonian (MNHN-Ci 2698).

TYPES. — *Holotype*: MNHN-Ci 2402 (MUSORSTOM 6, stn DW 478).

*Paratypes*: MNHN-Ci 2504 (MUSORSTOM 6, stn DW 478). Drawn. — WAM C 23250 (MUSORSTOM 8, stn DW 967). — MNHN-Ci 2698 (MUSORSTOM 8, stn DW 1060).

DIAGNOSIS. — Rostral plate with sutures visible, R reduced to sliver; basal width of RL 3 times basal width of R; apical width RL equal to apical width R. CL<sup>1</sup> and CL<sup>2</sup> partially united; CL<sup>2</sup> 3/4 height, 1/2 basal width



of CL<sup>1</sup>. S elongated, triangular tending to sub-pyramidal, growth ridges convoluted, longitudinal striations absent. T with 7-9 muscle crests extending well beyond basal margin. Caudal appendages extending 1/2 height of distal segment of pedicel of cirrus VI, 5-6 segments.

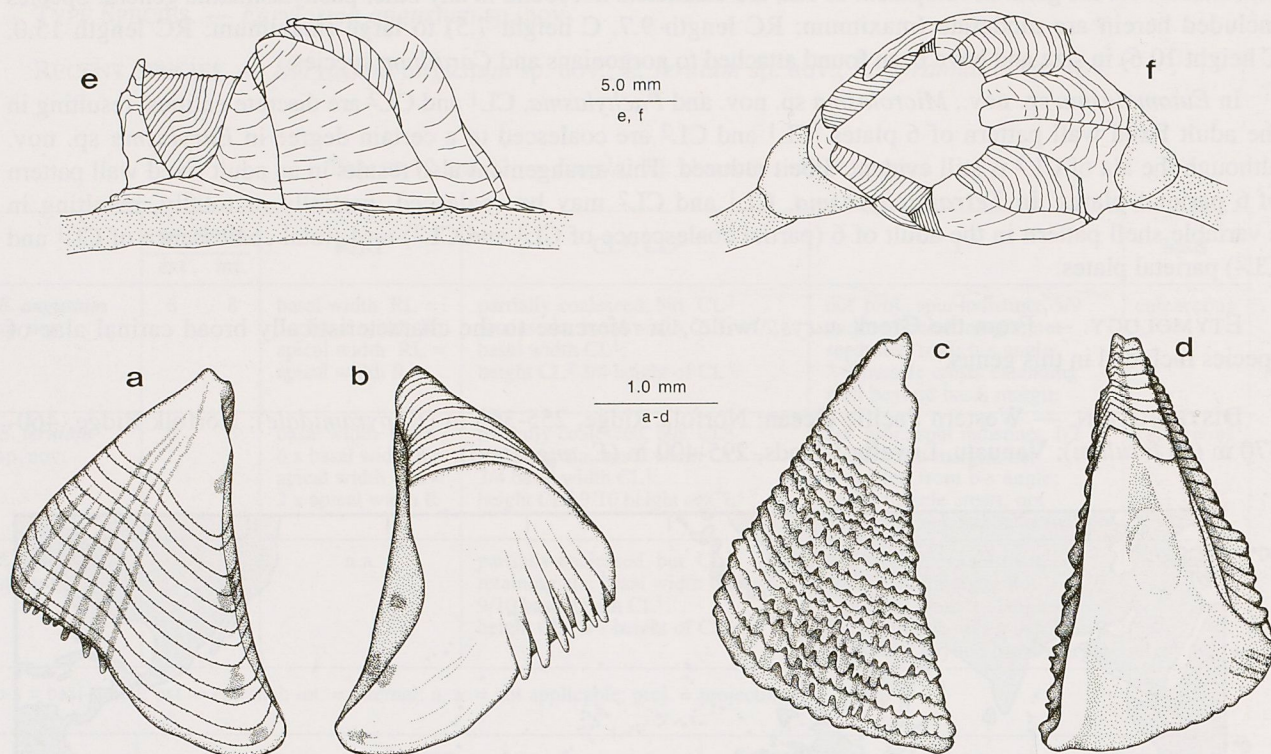


FIG. 30. — *Eurylasma angustum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478, attached to axis of gorgonian (MNHN-Ci 2504): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view; e, whole animal, lateral view; f, whole animal, from above (right S and T removed).

DESCRIPTION. — Size moderate (maximum: RC length 9.7, C height 7.5). Shell form rounded oval, depressed at carinal end. Parietal plates rough textured basally, smoother apically, growth ridges not deeply marked; all parietes except C curving in toward orifice; orifice pentagonal. Rostral plate convex, almost bowed, basal width equal to basal width of CL<sup>1</sup>, wider and higher than C; apex well curved in toward orifice; rostral sutures visible externally and internally, R reduced to narrow sliver; RL tapering, basal width 3 times basal width of R, apical width equal to apical width of R. CL<sup>1</sup> and CL<sup>2</sup> partially united but CL<sup>2</sup> retaining small ala, suture line visible externally; basal width of CL<sup>1</sup> subequal to basal width of rostral plate, apex of CL<sup>1</sup> curving toward orifice; CL<sup>2</sup> 3/4 height, 1/2 basal width of CL<sup>1</sup>; apex of CL<sup>2</sup> slightly curving toward orifice. C bowed, basal width equal to basal width of CL<sup>1</sup>; height 7/10 rostral height; apex erect, not spout-like. Alae of C wide, growth ridges sinuously parallel to inferior alar margins, superior alar margins subparallel to basis; alae of CL<sup>2</sup> 1/4 width of carinal alae, alae of CL<sup>1</sup> 1/2 width of carinal alae; superior alar margins minutely serrate. Basis calcareous, thin centrally; flat, central groove axis of gorgonian host. Orifice pentagonal from above, not toothed. Opercular plates placed parallel to basis; slightly sunken down in orifice in rostral area, then gently curving upward at angle of 30°, due to concave form of scuta. S elongated, triangular tending to subpyramidal, basal margin 3/5 length of occludent margin; basal margin without angled bend, but curved toward articular margin at point 2/3 length of basal margin from occludent margin; externally valve concave in upper 1/3, lower 1/3 retroverted away from concavity (thus curved in side-view); externally with regular, convoluted growth ridges, longitudinal striations absent; apex acute; internally muscle scar visible at 2/3 height of valve, small lateral depressor muscle crests developed; articular furrow narrow; articular ridge not projecting beyond articular margin; adductor ridge indistinct.



T larger than S, triangular, slightly higher than wide; externally with well-spaced growth ridges; internally with 7-9 strong muscle crests extending well beyond basal margin; articular ridge not extending beyond articular margin; articular furrow shallow; spur indistinct, short, set at basi-scutal angle, occupying 5/9 width of basal margin. Color of preserved material creamy lemon-yellow with darker pinkish-orange markings on opercular plates, C and carinal alae; color after bleaching pearly white with hint of shell pink, C rose-pink with color suffusing onto carinal alae; eggs orange-yellow. Measurements of 8 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height	R height
rg	3.7-9.7	3.2-7.5	2.3-7.5	2.2-7.1
$\bar{x}$	6.3	4.6	3.8	4.0

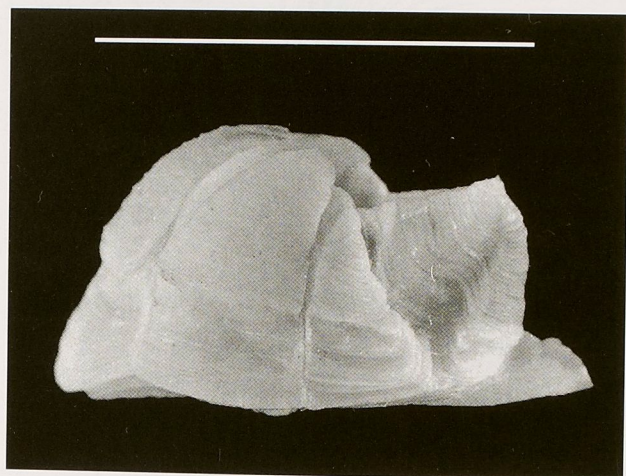


FIG. 31. — *Eurylasma angustum* sp. nov. Holotype from MUSORSTOM 6, stn DW 478, attached to axis of gorgonian (MNHN-Ci 2402); lateral view. Scale = 5 mm.

Labrum with shallow median depression, small teeth and setae present. Mandibular palp ovate, with moderately dense, finely serrulate setae terminally. Mandible with 3 teeth, tooth 1 largest, separated from teeth 2 and 3; upper margins of 2 and 3 with or without small subsidiary cusps; inferior angle acutely molariform, dentate. Maxillule setose, with pair of long setae at upper angle; wide notch below upper angle with 4-6 pairs shorter setae, cutting edge below almost straight, with 5-7 pairs longer setae, inferior angle slightly protuberant, with 4-6 short setae. Maxilla wide, coxal endite weakly defined; long serrulate setae apically.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior and posterior rami moderately protuberant anteriorly; both rami moderately setose, setae finely serrulate distally. Cirrus II longer than cirrus I; rami subequal; proximal segments of anterior ramus

moderately protuberant anteriorly; rami with segments moderately clothed with setae, some serrulate, especially distally; posterior ramus with fine spines at antero-distal angles of segments. Cirrus III longer than and similar to cirrus II, with rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of more distal segments, proximal segments with 6 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 3-4 pairs of setae on anterior faces, distal 2 pairs longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	10, 9	10, 11	14, 14	15, 16	20, 18+	20, 23	6
Ci 2504	right	10, 10	10, 11	14, 15	14, 16	18, 20	21, 20	5

Caudal appendages 1/2 height of distal segment of pedicel of cirrus VI; 5-6 segmented; long setae apically, with circlets of sparse, fine setae around distal margins of segments, length of setae 2/3 length of segment. Penis 1/2 length of cirrus VI; finely annulated; sparsely setose with circlet of long setae distally. Eggs large, 0.37 x 0.43 mm.

REMARKS. — *Eurylasma angustum* may be distinguished from *E. pyramidale* sp. nov. by the form of the rostral sutures (visible in the former, obscure in the latter); by differences in the relative proportions of the



CL plates (the basal width of CL<sup>2</sup> is 1/2 the basal width of CL<sup>1</sup> in *E. angustum*, and 9/10 the basal width of CL<sup>1</sup> in *E. pyramidale*); by the form of the S (tending toward sub-pyramidal in *E. angustum*, pyramidal in

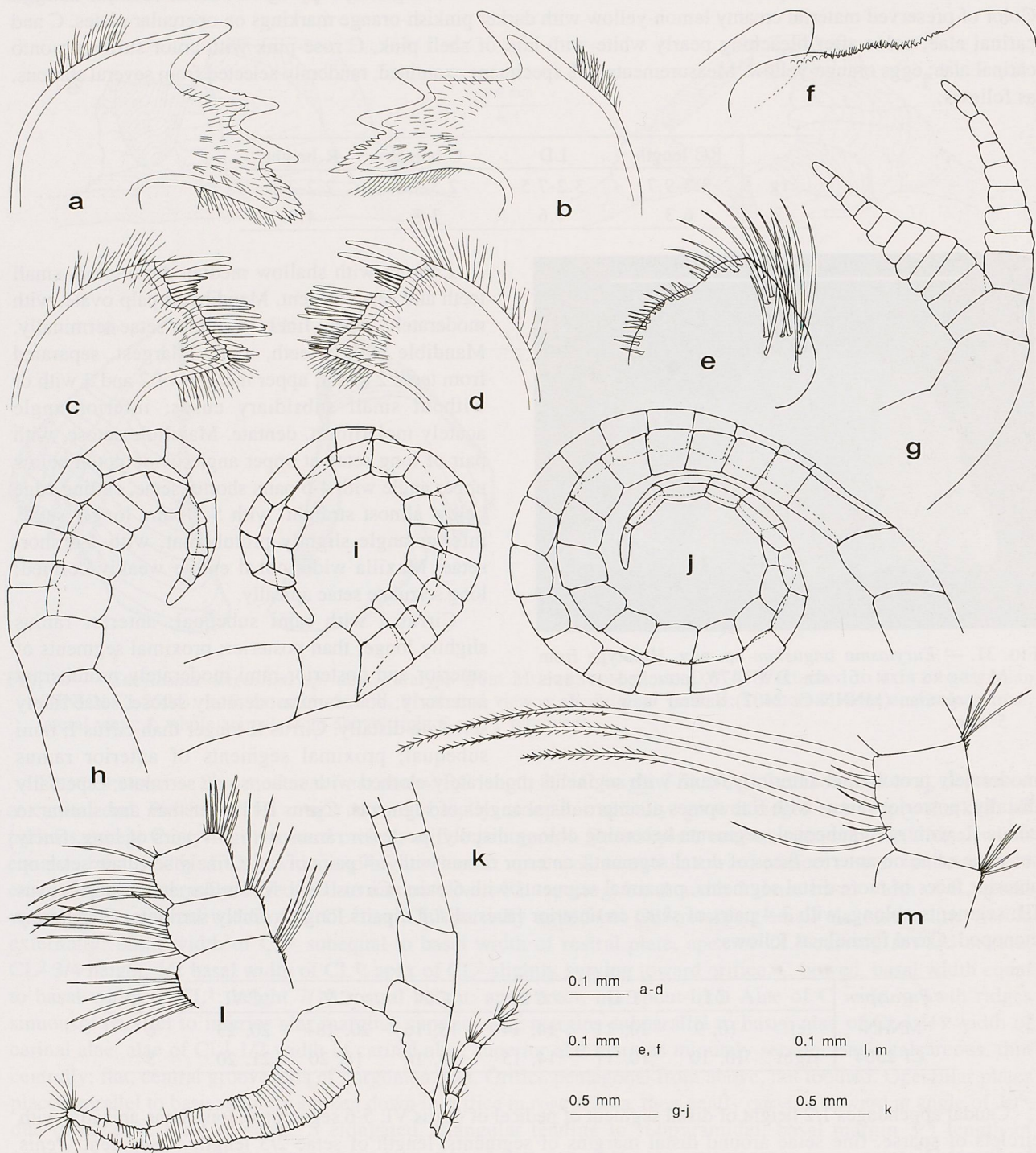


FIG. 32. — *Eurylasma angustum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478, attached to axis of gorgonian (MNHN-Ci 2504): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, maxilla; **f**, labrum; **g**, cirrus I; **h**, cirrus II; **i**, cirrus III; **j**, cirrus VI; **k**, pedicel of cirrus VI, penis and caudal appendage; **l**, cirrus I, posterior ramus, median segments; **m**, cirrus VI, posterior ramus, median segment.



*E. pyramidale*); by the form of the T (spur of *E. angustum* is  $5/9$  the width of the basal margin and there are 7-9 strong muscle crests extending well beyond the basal margin; the spur of *E. pyramidale* is  $2/3$  the width of the basal margin and there are 10-14 muscle crests barely extending beyond the basal margin); by the length of the caudal appendages (5-6 segments and  $1/2$  the height of the distal segment of the pedicel of cirrus VI, rather than 13 segments and longer than the pedicel of cirrus VI by  $1/4$ ); by the dentition of the mandible (strong subsidiary cusps on the upper margins of teeth 2 and 3 in *E. pyramidale*, small cusps often on upper margins of teeth 2 and 3 in *E. angustum*); by the size (maximum RC length 9.7, 14.1 respectively); and by the color (creamy lemon-yellow with darker pinkish-orange markings).

*Eurylasma angustum* is similar to *E. ferulum* sp. nov. but R is more reduced in the latter (basal width RL 6 times basal width of R, rather than 3 times), and the basal width of CL<sup>2</sup> is  $1/2$  the basal width of CL<sup>1</sup> in *E. angustum*, and  $3/4$  the basal width of CL<sup>1</sup> in *E. ferulum*. The rostral plate is higher than the C in *E. angustum* (C  $7/10$  the height of the rostral plate), but the rostral plate is shorter ( $5/6$  the height of the C) in *E. ferulum*. The T spur of *E. angustum* is  $5/9$  the width of the basal margin and there are 7-9 strong muscle crests extending well beyond the basal margin; the spur of *E. ferulum* is  $1/2$  the width of the basal margin and there are 16-20 strong muscle crests which do not extend beyond the basal margin. The form and length of the caudal appendages (5-6 segments and  $1/2$  the height of the distal segment of the pedicel of cirrus VI in *E. angustum*, 11-12 segments and equal to the height of the pedicel of cirrus VI in *E. ferulum*) further separate these two species.

ETYMOLOGY. — From the Latin *angustus*, 'very narrow', in reference to the very narrow form of the rostral plate.

DISTRIBUTION. — Vanuatu, Loyalty Islands, 295-400 m.

*Eurylasma ferulum* sp. nov.

Figs 29, 33-35; Tables 12-14

MATERIAL EXAMINED. — **Norfolk Ridge**. BATHUS 3: stn CP 815, 460-470 m: 1 specimen (MNHN-Ci 2405). Drawn.

TYPES. — *Holotype*: MNHN-Ci 2405 (BATHUS 3, stn CP 815). Drawn.

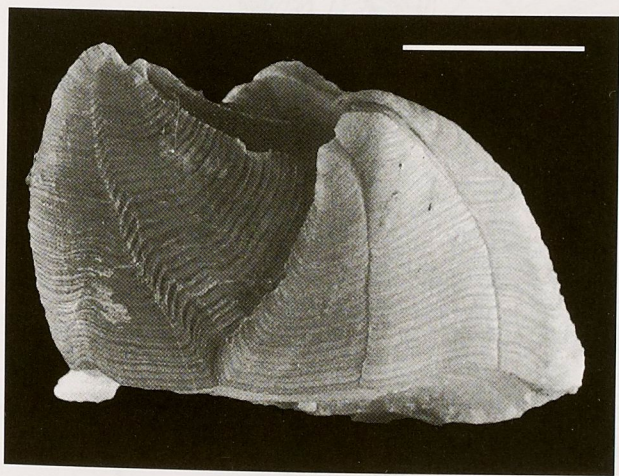


FIG. 33. — *Eurylasma ferulum* sp. nov. Holotype from BATHUS 3, stn CP 815 (MNHN-Ci 2405): lateral view. Scale = 5 mm.

DIAGNOSIS. — Rostral sutures visible, R reduced to narrow sliver; basal width of RL 6 times basal width of R. CL<sup>1</sup> and CL<sup>2</sup> partially united; CL<sup>2</sup>  $9/10$  height of CL<sup>1</sup>, basal width of CL<sup>2</sup>  $3/4$  basal width of CL<sup>1</sup>. S sub-pyramidal; externally with many extremely convoluted growth ridges, longitudinal striations absent. T with 16-20 muscle attachment crests not extending beyond basal margin. Caudal appendages height of pedicel of cirrus VI, 11-12 segments.

DESCRIPTION. — Size large (maximum: RC length 15.0, C height 10.6). Shell form elongate oval from above; all parietes curving in toward orifice. Parietal plates with smooth, regular growth ridges. Rostral plate convex, bowed, basal width subequal to basal width of C, height  $5/6$  height of C; apex curved in toward orifice; rostral sutures visible externally and internally; R reduced to narrow sliver; RL tapering apically, basal width of RL 6 times basal width of R, apical width of RL twice apical width of R. Basal width of CL<sup>1</sup> subequal to basal width of RL, apex



curved toward orifice. CL<sup>1</sup> and CL<sup>2</sup> partially united but CL<sup>2</sup> retaining minute ala; suture lines visible externally; height of CL<sup>2</sup> 9/10 height of CL<sup>1</sup>, basal width of CL<sup>2</sup> 3/4 basal width of CL<sup>1</sup>; apex slightly curving in toward orifice. C bowed, basal width subequal to basal width of rostral plate, C higher than rostral plate by 1/6; apex slightly curved toward orifice. Alae of C widest, growth ridges sinuously parallel to inferior alar margin, superior alar margins not parallel to basis, minutely serrate; alae of CL<sup>2</sup> 1/10 width of carinal alae, alae of CL<sup>1</sup> 2/5 width of carinal alae. Basis calcareous, thick; slightly cup-shaped, with central groove. Orifice subtriangular from above; not toothed. Opercular plates not parallel to basis, gently curving upward from rostral end at angle of 40°, due to concave form of S. Basal margin of S 2/5 length of occludent margin; sub-pyramidal shape produced by almost 90° bend on basal margin toward articular margin, bend at 2/3 length of basal margin from occludent margin; externally middle area of valve concave, areas above and below retroverted away from concavity (thus curved in side-view); externally with many extremely convoluted growth ridges, producing frilled appearance; apex pointed; internally shallow adductor muscle scar at 2/3 height of valve; few small lateral depressor muscle crests developed; articular furrow narrow; articular ridge not projecting beyond articular margin; adductor ridge indistinct. T larger than S, triangular; externally with well-marked growth ridges; internally with 16-20 muscle crests, not extending beyond basal margin; articular ridge short, not projecting beyond articular margin; articular furrow wide; short spur set at basi-scutal angle, rounded, 1/2 width of basal margin. Color of preserved material mottled creamy/lemon yellow with C and CL alae more orange-ochre; opercular plates mottled orange-ochre and cream; basis creamy-white. Measurements of holotype as follows:

Holotype:	RC length	LD	C height	R height
MNHN-Ci 2405	15.0	9.0	10.6	8.7

Labrum with shallow medial depression; small teeth in irregular row, with some long fine setae; dense spicules on both sides of depression below teeth. Mandibular palp oblong; dense, serrate setae terminally. Mandible with

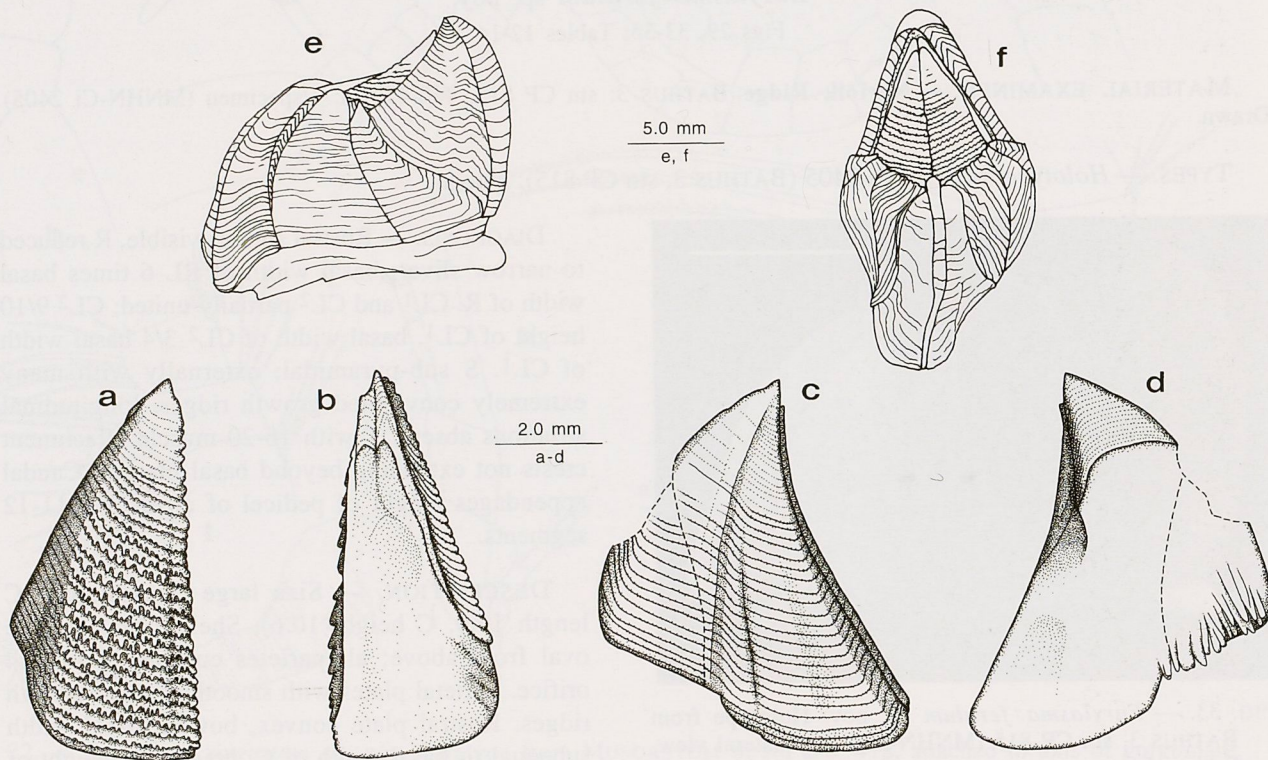


FIG. 34. — *Eurylasma ferulum* sp. nov. Holotype from BATHUS 3, stn CP 815 (MNHN-Ci 2405): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view; e, whole animal, lateral view; f, whole animal, from above.



3 teeth, tooth 1 well-separated from 2 and 3; upper margin of 3 with small subsidiary cusps; inferior angle bluntly molariform, dentate. Maxilla wide, coxal endite barely defined; long serrulate setae terminally. Maxillule with 1-2 pairs of long, stout setae at upper angle; notch below upper angle moderately large, indistinct, with 4-5 pairs of smaller setae; cutting margin below almost straight, with 7-8 pairs of larger setae; inferior angle with 4-5 pairs of smaller setae and 1 longer seta.

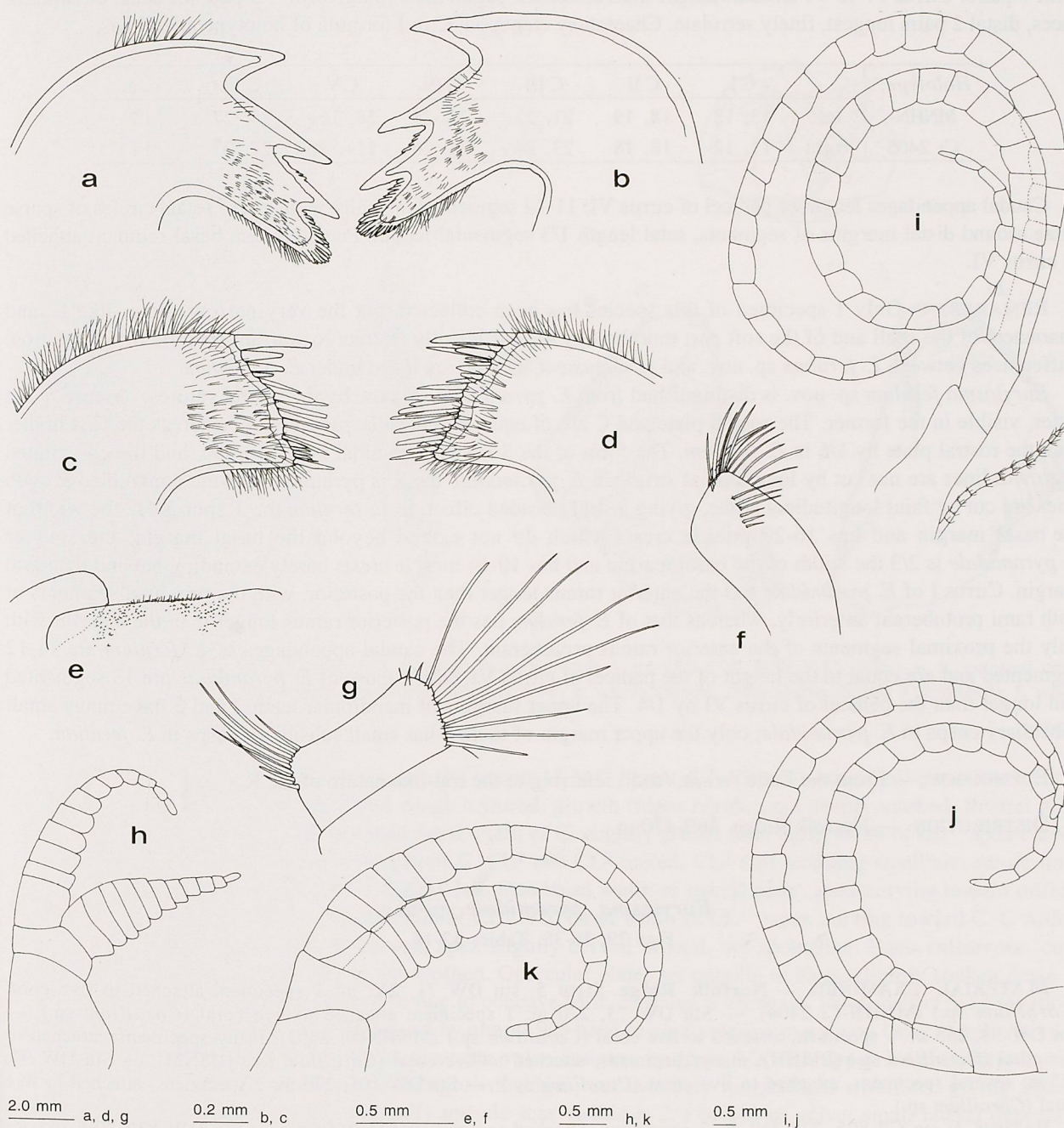


FIG. 35. — *Eurylasma ferulum* sp. nov. Holotype from BATHUS 3, stn CP 815 (MNHN-Ci 2405): a, right mandible; b, left mandible; c, right maxillule; d, left maxillule; e, labrum; f, mandibular palp; g, cirrus I, anterior ramus, median segments; h, cirrus I; i, cirrus VI; j, cirrus III; k, cirrus II.



Cirrus I with rami subequal; posterior ramus slightly longer than anterior; proximal segments of anterior ramus protuberant anteriorly; both rami thickly setose, setae finely serrulate distally. Cirrus II similar to cirrus III and longer than cirrus I; rami subequal; proximal segments of anterior ramus protuberant anteriorly; rami with segments thickly setose, setae finely serrulate, especially distally. Cirrus III with rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 7 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4-5 pairs of setae on anterior faces, distal 2 pairs longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula of holotype as follows:

Holotype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	13, 12	18, 19	21, 22	24, 25	28, 16+	28, 27	12
Ci 2405	right	11, 12	18, 18	23, 24	24, 26	11+, 26	27, 27	11

Caudal appendages length of pedicel of cirrus VI; 11-12 segmented; apically with sparse setae, circles of sparse setae around distal margins of segments, setal length 1/3 segmental length. Penis broken, basal remnant attached to cirrus VI.

REMARKS. — Only 1 specimen of this species has been collected, but the very narrow, sliver-like R, and characters of the shell and of the soft part morphology are sufficiently distinct to warrant specific differentiation. Differences between *E. ferulum* sp. nov. and *E. angustum* sp. nov. are listed under *E. angustum*.

*Eurylasma ferulum* sp. nov. is distinguished from *E. pyramidale* sp. nov. by the rostral sutures, obscure in the latter, visible in the former. The rostral plate and C are of equal height in *E. pyramidale*, whereas the C is higher than the rostral plate by 1/6 in *E. ferulum*. The form of the S is sub-pyramidal in *E. ferulum*, and the convoluted S growth lines are not cut by longitudinal striae. In *E. pyramidale* the S is pyramidal and the convoluted growth lines are cut by faint longitudinal striae, giving a slight beaded effect. In *E. ferulum* the T spur is 1/2 the width of the basal margin and has 16-20 muscle crests which do not extend beyond the basal margin; the spur of *E. pyramidale* is 2/3 the width of the basal margin and has 10-14 muscle crests barely extending beyond the basal margin. Cirrus I of *E. pyramidale* has the anterior ramus longer than the posterior, with the proximal segments of both rami protuberant anteriorly, whereas that of *E. ferulum* has the posterior ramus longer than the anterior with only the proximal segments of the anterior ramus protuberant. The caudal appendages of *E. ferulum* are 11-12 segmented and are equal to the height of the pedicel of cirrus VI, whilst those of *E. pyramidale* are 13 segmented and longer than the pedicel of cirrus VI by 1/4. The upper margins of mandibular teeth 2 and 3 have many small subsidiary cusps in *E. pyramidale*; only the upper margin of tooth 3 has small subsidiary cusps in *E. ferulum*.

ETYMOLOGY. — From the Latin *ferula*, 'rod', referring to the rod-like nature of the R.

DISTRIBUTION. — Norfolk Ridge, 460-470 m.

*Eurylasma pyramidale* sp. nov.

Figs 29, 36-38; Tables 12-14

MATERIAL EXAMINED. — **Norfolk Ridge**. SMIB 5: stn DW 71, 265 m: 1 specimen, attached to live coral (*Corallium* sp.) (MNHN-Ci 2404). — Stn DW 75, 270 m: 1 specimen, attached to live coral (*Corallium* sp.). — Stn DW 93, 255 m: 1 specimen, attached to live coral (*Corallium* sp.) (MNHN-Ci 2403); many specimens, attached to live coral (*Corallium* sp.) (BMNH); many specimens, attached to live coral (*Corallium* sp.) (USNM). — Stn DW 94, 275 m: several specimens, attached to live coral (*Corallium* sp.). — Stn DW 101, 270 m: 2 specimens, attached to live coral (*Corallium* sp.).

BATHUS 3: stn CP 805, 278-310 m: 3 specimens, attached to coral (WAM 255-96). — Stn DW 830, 361-365 m: 4 specimens, attached to coral. (MNHN-Ci 2699). Drawn.

TYPES. — *Holotype*: MNHN-Ci 2403 (SMIB 5, stn DW 93).



*Paratypes*: BMNH (SMIB 5, stn DW 93). — MNHN-Ci 2404 (SMIB 5, stn DW 71). — MNHN-Ci 2699 (BATHUS 3, stn DW 830). Drawn. — USNM (SMIB 5, stn DW 93). — WAM 255-96 (BATHUS 3, stn DE 830).

**DIAGNOSIS.** — Rostral plate sutures obscure. CL<sup>1</sup> and CL<sup>2</sup> partially united; basal width of CL<sup>2</sup> 9/10 basal width of CL<sup>1</sup>; height of CL<sup>2</sup> 8/9 height of CL<sup>1</sup>. S elongated, pyramidal shape; externally convoluted growth ridges cut with many faint longitudinal striations. T with 10-14 muscle attachment ridges barely extending beyond basal margin. Caudal appendages longer than pedicel of cirrus VI by 1/4, 13 segments.

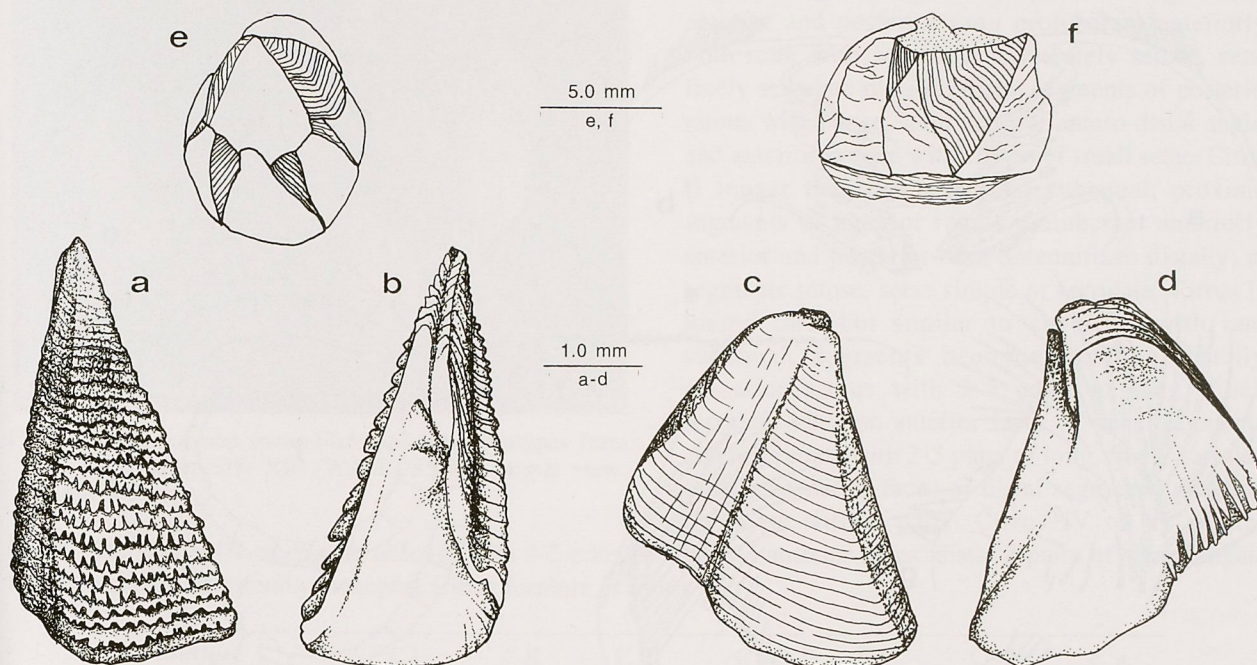


FIG. 36. — *Eurylasma pyramidale* sp. nov. Paratype from BATHUS 3, stn DW 830 (MNHN-Ci 2699): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view; e, whole animal, from above (S and T removed); f, whole animal, lateral view.

**DESCRIPTION.** — Size large (maximum: RC length 14.1, C height 6.7). Form rounded, all parietes except C curving in toward orifice. Parietal plates rough textured; growth ridges regular, not deeply marked. Rostral plate with sutures obscure; basal width less than basal width of C, slightly greater than basal width of CL<sup>1</sup>; apex curved in toward orifice; height subequal to height of C. CL<sup>1</sup> and CL<sup>2</sup> united, CL<sup>2</sup> still retaining small ala, suture lines visible externally. Basal width of CL<sup>1</sup> slightly less than basal width of rostral plate; apex curving toward orifice. Height of CL<sup>2</sup> 8/9 height of CL<sup>1</sup>, basal width of CL<sup>2</sup> 9/10 basal width of CL<sup>1</sup>; apex curving toward C. C widest of all plates, slightly higher than R, bowed, apex slightly curved inward, not spout-like. Basis calcareous, cup-shaped. Orifice triangular from above; not toothed. Opercular plates set parallel to basis, slightly sunken down in orifice, making gently concave depression due to concave form of scuta. S elongate, basal margin 5/12 length of occludent margin; pyramidal shape, produced by almost 90° bend toward articular margin on basal margin, bend at 3/4 length of basal margin from occludent margin; valve concave in upper 1/2 with upper 1/4 retroverted away from concavity; externally with convoluted growth ridges, cut by many longitudinal striations, giving almost beaded appearance; apex pointed; internally muscle scar visible at 2/3 height of valve; small lateral depressor muscle crests present; articular furrow wide; articular ridge barely projecting beyond articular margin; adductor ridge indistinct. T larger than S, triangular; externally with well-marked growth ridges; internally with 10-14 muscle crests barely extending beyond basal margin; articular ridge short, not projecting beyond articular margin; articular furrow wide; short spur set at basi-scutal angle, rounded, width 2/3 basal margin. Parietes of bleached specimens



pearly white with hint of shell pink, covered by pearly white, moderately thick membrane; specimens from live *Corallium* sp. with parietes, opercular plates and covering membrane yellowish-cream, sometimes C orange-yellow. Measurements of largest specimen examined as follows:

RC length	LD	C height	R height
14.1	9.6	6.7	6.1

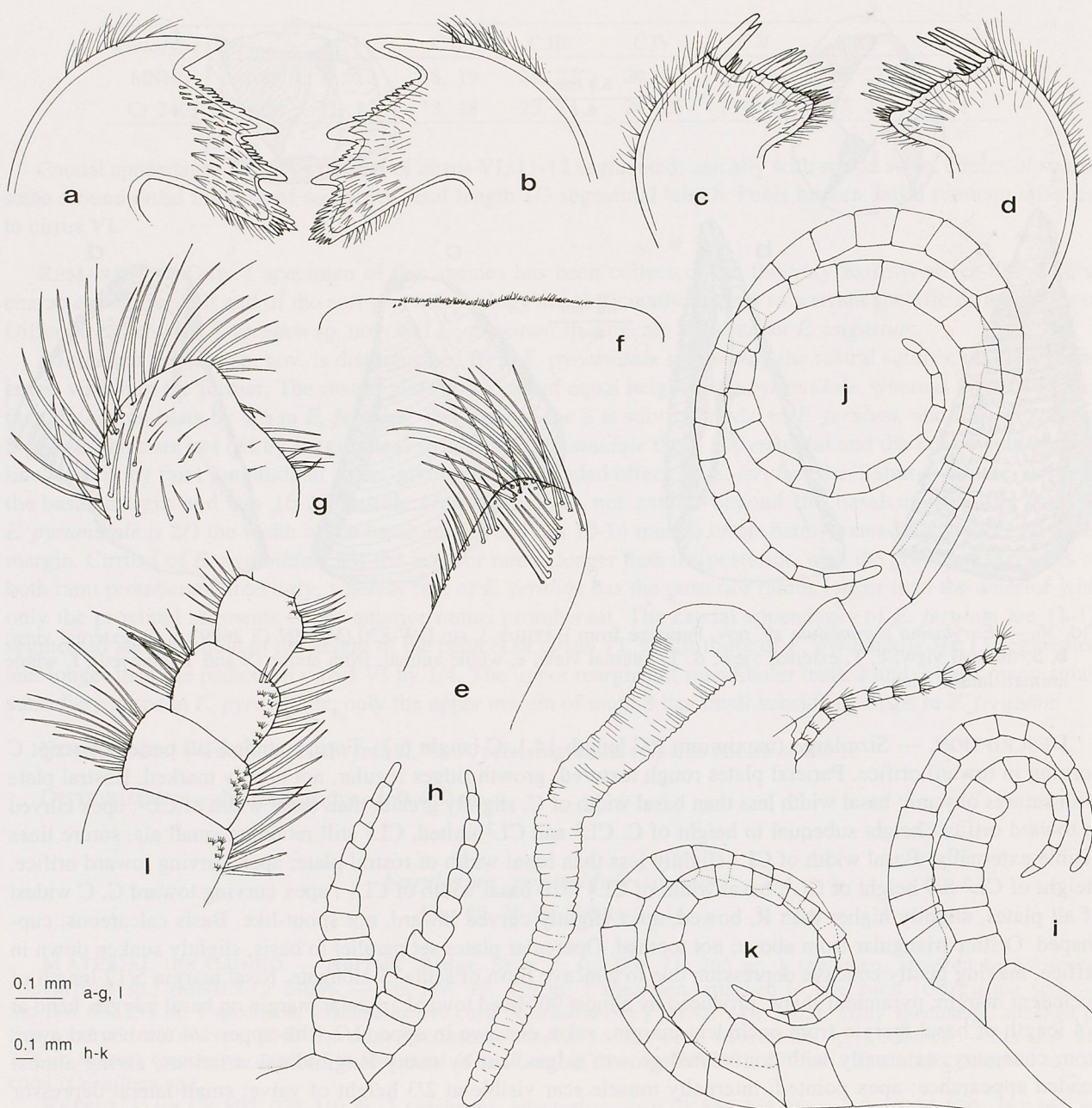


FIG. 37. — *Eurylasma pyramidale* sp. nov. Paratype from BATHUS 3, stn DW 830 (MNHN-Ci 2699): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, mandibular palp; **f**, labrum; **g**, maxilla; **h**, cirrus I; **i**, cirrus II; **j**, cirrus VI, penis and caudal appendage; **k**, cirrus III; **l**, cirrus I, posterior ramus, median segments.



Labrum with shallow medial depression; few scattered, small teeth present. Mandibular palp oblong; dense, serrate setae terminally. Mandible with 3 teeth, tooth 1 largest and well-separated from 2 and 3; upper margin of 2 and 3 strongly dentate; inferior angle moderately large, bluntly molariform, dentate. Maxillule with 1-2 pairs of long, stout setae at upper angle; notch below upper angle moderately wide, with 3-4 pairs of smaller setae; long cutting margin below with 7-10 pairs of larger setae; inferior angle small, with 4-6 pairs of smaller setae. Maxilla wide, coxal endite barely discernible; long serrulate setae terminally.

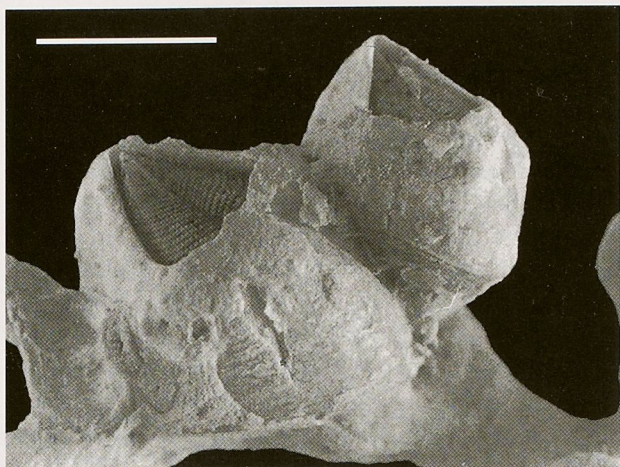


FIG. 38. — *Eurylasma pyramidale* sp. nov. Paratypes from BATHUS 3, stn DW 830 (WAM 255-96): lateral view. Scale = 5 mm.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior and posterior rami protuberant anteriorly; both rami with segments moderately setose, setae finely serrulate distally; distal segments of posterior ramus with dense, stout setae at antero-distal angles and anterior surface with combs of small setae. Cirrus II longer than cirrus I; rami subequal; proximal segments of anterior ramus protuberant anteriorly; anterior and posterior rami antenniform distally; all segments setose, setae simple or serrulate. Cirrus III longer than but similar to cirrus II, with rami subequal, segments becoming oblong distally; posterior ramus with 2-5 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-5 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 9 pairs. Cirrus IV to VI similar,

longer than cirrus III; segments oblong, with 4-5 pairs of setae on anterior faces, distal 2 pairs of setae longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	12, 12	13, 15	17, 18	22, 22	23, 25	23, 24	11
Ci 2699	right	12, 13	14, 17	17, 19	23, 26	26, 25	22, 26	12

Caudal appendages slightly longer than pedicel of cirrus VI; 13 segmented; long setae apically, circlets of short setae around distal margins of segments. Penis almost as long as cirrus VI; annulated; sparsely setose with circlet of long setae distally.

REMARKS. — Differences between *E. pyramidale* and *E. angustum* sp. nov. are listed under *E. angustum* and between *E. pyramidale* and *E. ferulum* sp. nov. are listed under *E. ferulum*.

ETYMOLOGY. — From the Greek *pyramidalis*, 'of a pyramidal shape', relating to the pyramidal form of the scuta.

DISTRIBUTION. — Norfolk Ridge, 255-365 m.

Genus **TETRAPACHYLASMA** Foster, 1988 (emend.)

Fig. 39; Tables 3-4, 15-17

*Tetrapachylasma* Foster, 1988: 226.

DIAGNOSIS. — Adult with variable wall pattern of 6-plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C), or 4-plates (R-CL-C); in 6-plated wall, RL coalesces with R to form compound rostrum (RL+R+RL); in 4-plated wall RL and R form compound



rostrum and CL<sup>2</sup> coalesces with CL<sup>1</sup> to form compound CL plate. Rostral plate sutures obscure; basal width of R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate, partially coalesced, or totally concrescent. S with growth lines cut by longitudinal striae. Caudal appendages varying from short (1/8 height of basal segment of pedicel of cirrus VI) to long (approximately twice height of pedicel of cirrus VI).

TYPE SPECIES. — *Tetrapachylasma trigonum* Foster, 1988.

RECENT SPECIES. — *Tetrapachylasma arcuatum* sp. nov.; *T. aurantiacum* (Darwin, 1854); *T. ferrugomaculosa* (Jones, 1993b); *T. ornatum* sp. nov.; *T. trigonum* Foster, 1988.

REMARKS. — FOSTER's (1988) diagnosis of *Tetrapachylasma* defined the genus as having "...Four (adult) solid calcareous compartmental plates including a carina, a rostrum and paired laterals ...". However, new material and re-examination of *P. aurantiacum* Darwin, 1854 and *P. ferrugomaculosa* Jones, 1993 (all attributed to *Tetrapachylasma* herein) confirm that the number of wall plates in the adults of these species is variable. The adult may have a 4-plated pattern, consisting of a compound rostral plate, a pair of plates formed by the coalescence of CL<sup>1</sup> and CL<sup>2</sup>, and a C. However, within the same sample, 6-plated individuals of the same species also occur, where CL<sup>1</sup> and CL<sup>2</sup> are either separate or partially coalesced (but in the latter condition CL<sup>2</sup> still retains a minute ala). In these individuals the rostral sutures may be obscure or visible. I consider that FOSTER's (1988) diagnosis of *Tetrapachylasma* applies to the 4-plated adult condition found in the above samples and I have broadened the diagnosis of *Tetrapachylasma* accordingly, to embrace the variable plate numbers also found in the above samples. The variable 4- or 6-plated pattern, however, makes specific identification and attribution difficult when dealing with a single or few specimens. *Tetrapachylasma trigonum* may represent a condition where the 4-plated pattern has become fixed - the small number of specimens (3) in FOSTER's sample of *T. trigonum* is not significant to determine intra-specific variation within this species.

In *Tetrapachylasma*, RL coalesces with R to form a compound rostrum (RL+R+RL) in both the 6- and 4-plated wall forms. RL is not incorporated into the sheath, with the exception of *T. ornatum* sp. nov., where RL is clearly incorporated into the sheath (contrary to the definition of the Pachylasmatoidea). Thus in *Tetrapachylasma*, as re-defined, the adult wall condition (6- or 4-plated) is achieved through a reduction in the number of plates by coalescence, rather than by exclusion as was postulated by FOSTER (1988). The pattern of coalescence of the plates has not become fixed, at least within *T. arcuatum* sp. nov., *T. aurantiacum*, *T. ferrugomaculosa* and *T. ornatum* sp. nov., and the plates are disposed symmetrically rather than asymmetrically, since both the 4- and the 6-plated condition occur within the same species and no instances have been found of a 5-plated condition (i.e. CL<sup>1</sup> and CL<sup>2</sup> totally coalesced on one side only). Thus the adult condition for this genus is considered to be a variable wall pattern of either 4 or 6 parietal plates.

Such intra-specific variation is also seen in the Balanomorpha. Within the Chthamaloidea *Jehlius gilmorei* Ross, 1971, an unusual species from San Ambrosia and San Felix Islands, Chile, exhibits an array of wall patterns in the adult condition (ROSS, 1971). In *Jehlius*, development of the adults is in a transitional stage between 6 and 4 plates, with reduction in the number of plates by coalescence rather than by exclusion. In the 4-plated stage the wall plates are not secondarily coalesced, the plates are disposed symmetrically or asymmetrically and the coalescence pattern is variable throughout the population. It appears, from the few specimens known of this species, that the pattern of coalescence of the plates has not become fixed. In the 4-plated *Tetrachthamalus*, however, a different pattern is seen. Here RL are coalesced with R and, during the ontogeny of individuals, the 4 plates coalesce.

DARWIN's (1854) diagnosis of *Pachylasma* defines the adult condition as 6- or 4-plated viz. "...when mature, either six, or in appearance only four owing to the close union of the lateral compartments...". There is an implicit assumption in DARWIN's diagnosis that it applies to the fixed plate number in the adult condition (i.e. it refers to inter-specific variation). DARWIN's diagnosis was based on 2 species - *P. giganteum* (adult condition recognised as fixed 6-plated in the present paper) and *P. aurantiacum* (adult condition recognised as variable 4- or 6-plated in the present paper). The fixed 6-plated adult condition is herein recognised for *Pachylasma* (type species *P. giganteum*) and the variable 4- or 6-plated adult condition is herein recognised for *Tetrapachylasma* (type species *T. trigonum*).



TABLES 15 and 16. — *Tetrapachylasma*: characters of the species

	no. plates		R: RL	CL <sup>1</sup> : CL <sup>2</sup>	T	basis
	ext.	int.				
<i>T. arcuatum</i> sp. nov.	6 4	8 6	basal width R = basal width RL	separate, partially coalesced with CL <sup>2</sup> retaining minute ala, or totally coalesced; basal width CL <sup>2</sup> = to basal width CL <sup>1</sup> ; height CL <sup>2</sup> sub = height CL <sup>1</sup>	artic. ridge slightly proj.; spur indistinct, 3/7 width basal margin; set 1/12 length basal margin from b-s angle; 12-16 muscle ridges proj. beyond basal margin; artic. margin with growth ridges raised to form elevated ridge	calcareous, sometimes centrally membranous
<i>T. aurantiacum</i> (Darwin, 1854)	6 4 4	8 6 4	basal width R = basal width RL	coalesced; basal width CL <sup>2</sup> = basal width CL <sup>1</sup>	artic. ridge slightly proj.; spur indistinct, 3/7 width basal margin; set 1/12 length basal margin from b-s angle; 12-16 muscle ridges proj. beyond basal margin; artic. margin with growth ridges raised to form elevated ridge	calcareous
<i>T. ferrugomaculosa</i> (Jones, 1993)	6 4 4	8 6 4	basal width R = 2 x basal width RL	partially coalesced with CL <sup>2</sup> retaining ala; or coalesced; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	artic. ridge not proj.; spur indistinct, 1/2 width basal margin, set 1/12 length basal margin from b-s angle; 7-9 muscle ridges proj. beyond basal margin; artic. margin with growth ridges raised to form elevated ridge	calcareous edges, centrally membranous
<i>T. ornatum</i> sp. nov.	6 4 4	8 6 4	basal width R = basal width RL	basal width CL <sup>2</sup> = slightly < basal width CL <sup>1</sup>	artic. ridge proj.; spur 1/3 width basal margin; set 1/12 length basal margin from b-s angle; 8-12 muscle ridges projecting beyond basal margin; artic. margin with growth ridges raised to form elevated ridge	calcareous (inferred)
<i>T. trigonum</i> Foster, 1988	4	4	n.a.	totally coalesced	artic. ridge proj.; spur broad, 1/3 width basal margin, set 1/7 length basal margin from b-s angle; basal corner of articular margin hollowed for reception of dwarf males; 6 muscle ridges proj. beyond basal margin; artic. margin with growth ridges raised to form elevated ridge	calcareous

artic. = articular; b-s = basi-scutal; ext. = external; int. = internal; n.a. = not applicable; proj. = projecting.

	S shape	S growth lines	c.a.	mandible
<i>T. arcuatum</i> sp. nov.	S basal margin 2/3 length of occludent margin; S artic. ridge proj.; occludent margin convex	sinuous; cut by 7-8 slight long. striae	16-18 segs; 2 x length of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with subsidiary cusps
<i>T. aurantiacum</i> (Darwin, 1854)	S width < 1/2 S length; basal margin 1/2 length of occludent margin; artic. ridge not proj.; occludent margin not convex	extremely convoluted; cut by 5-6 slight long. striae	5 segs; = 1/5 height of pedicel of CVI	tridentate; margins of teeth 2 and 3 with small subsidiary cusps
<i>T. ferrugomaculosa</i> (Jones, 1993)	S basal margin 7/10 length of occludent margin; S artic. ridge barely proj.; occludent margin not convex	very convoluted; cut by 6-8 long. striae	7-9 segs; = height of basal segment of pedicel of CVI	tridentate; small subsidiary cusps in angle between teeth 1 and 2; upper margins of teeth 2 and 3 with strong subsidiary cusps
<i>T. ornatum</i> sp. nov.	S basal margin 1/2 length of occludent margin; artic. ridge not proj.; occludent margin not convex	complexly sculptured; cut by 4-6 deep, long. striae	unknown	unknown
<i>T. trigonum</i> Foster, 1988	S basal margin > 5/8 length of occludent margin; artic. ridge not proj.; occludent margin not convex	ruffled, overlapping; not cut by long. striae	1 seg.; = 1/8 height of basal segment of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps

artic. = articular; c.a. = caudal appendage; long. = longitudinal; max. = maximum; proj. = projecting; segs = segments.



DISTRIBUTION. — Southwestern and eastern Australia, Western and Central Pacific Ocean: Western Australia, 3-30 m (*T. ferrugomaculosa*); eastern Australia, Kermadec Islands, 122-490 m (*T. aurantiacum*); Vanuatu, Chesterfield Islands, Loyalty Islands, Loyalty Ridge, Norfolk Ridge, 226-1220 m (*T. arcuatum*); Marianas Islands, 6 m (*T. ornatum* sp. nov.); Cook Islands, 15 m (*T. trigonum*).

TABLE 17. — *Tetrapachylasma*: maximum size, geographical and bathymetrical distribution of the species

	size (max.)	distribution	depth
<i>T. arcuatum</i> sp. nov.	RC length 11.4; C height 9.5	Chesterfield Islands New Caledonia Loyalty Islands Loyalty Ridge Norfolk Ridge Vanuatu	385-610 m 255-610 m 300-460 m 400 m 226-1220 m 400-440 m
<i>T. aurantiacum</i> (Darwin, 1854)	RC length 24.0; C height 7.0	Eastern Australia, Kermadec Is	122-490 m
<i>T. ferrugomaculosa</i> (Jones, 1993)	RC length 11.4; C height 10.2	Western Australia	3-30 m
<i>T. ornatum</i> sp. nov.	RC length 6.0, C height 2.5	Marianas Islands	6 m
<i>T. trigonum</i> Foster, 1988	RC length 10.0; C height 8.0	Cook Islands	15 m

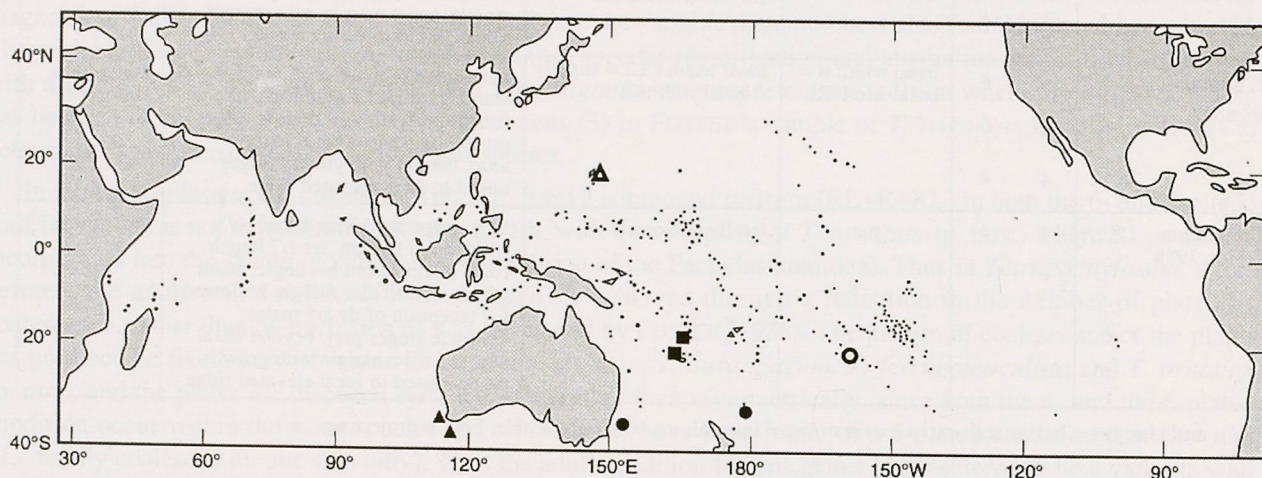


FIG. 39. — *Tetrapachylasma*. Distribution map:  $\Delta$ , *T. ornatum* (6 m);  $\blacksquare$ , *T. arcuatum* (226-1220 m);  $\bullet$ , *T. aurantiacum* (122-490 m);  $\blacktriangle$ , *T. ferrugomaculosa* (3-30 m);  $\circ$ , *T. trigonum* (15 m).

*Tetrapachylasma arcuatum* sp. nov.

Figs 39-42; Tables 15-17

MATERIAL EXAMINED. — **Chesterfield Islands.** MUSORSTOM 5: stn DW 255, 280-295 m: 2 specimens (MNHN-Ci 2407); 3 specimens, attached to coral. — Stn DW 301, 487-610 m: 5 specimens (2 juveniles), attached to sponge. — Stn DW 304, 385-420 m: 3 specimens.

**Loyalty Islands.** MUSORSTOM 6: stn DW 407, 360 m: 1 specimen. — Stn CP 471, 460 m: 1 specimen, attached to coral. — Stn CP 471, 460 m: 1 specimen, attached to coral (BMNH). — Stn DW 472, 300 m: 1 specimen, attached to sponge (MNHN-Ci 2406); several specimens, attached to sponge; 1 specimen, attached to dead stylasterid coral; 1 specimen, attached to a stone. — Stn DW 478, 400 m: 1 ovigerous specimen (broken), large orange eggs, attached to dead coral (MNHN-Ci 2700). Drawn; several specimens.

**Loyalty Ridge.** MUSORSTOM 6: stn DW 478, 400 m: 1 specimen, attached to 1 specimen of *Hexelasma persicum* sp. nov. (MNHN); 1 specimen (WAM 256-96); 1 specimen (WAM C 23251).

**Vanuatu.** MUSORSTOM 8: stn CP 963, 400-440 m: several specimens, attached to sponge.

**New Hebrides Arc.** VOLSMAR: stn DW 16, 500m: 1 specimen.



**Norfolk Ridge.** CHALCAL 2: stn CH 4, 253 m: 1 specimen, attached to sponge.

SMIB 5: stn DW 87, 370 m: 1 specimen, attached to coral rubble (USNM). — Stn DW 93, 255 m: many specimens.

HALIPRO 2: stn BT 70, 226-238 m: 1 specimen, attached to gorgonian. — Stn BT 71, 820-1220 m: 2 specimens, attached to gorgonian.

**TYPES.** — *Holotype*: MNHN-Ci 2406 (MUSORSTOM 6, stn DW 472).

*Paratypes*: BMNH (MUSORSTOM 6, stn CP 471). — MNHN-Ci 2407 (MUSORSTOM 5, stn DW 255). — MNHN-Ci 2700 (MUSORSTOM 6, stn DW 478). Drawn. — USNM (SMIB 5, stn DW 87). — WAM 256-96 (MUSORSTOM 6, stn DW 478).

**DIAGNOSIS.** — Rostral plate sutures visible; basal width of R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate, partially or totally coalesced; basal width of CL<sup>2</sup> equal to basal width of CL<sup>1</sup>. Articular margin of S curved toward occludent margin in upper 1/3; externally sinuous growth lines cut by 7-8 slight longitudinal striae; articular ridge projecting. T articular ridge slightly projecting; 12-16 muscle attachment ridges projecting beyond basal margin. Caudal appendages twice length of pedicel of cirrus VI; 16-18 segments.

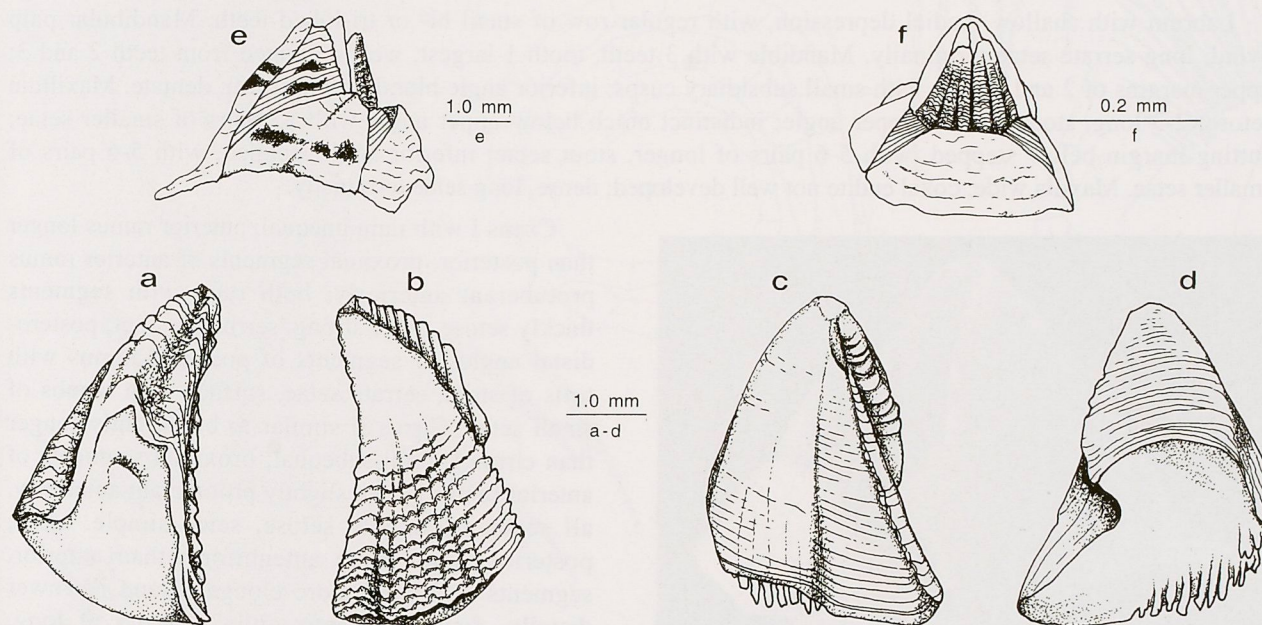


FIG 40. — *Tetrapachylasma arcuatum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478 (MNHN-Ci 2700): a, S, internal view; b, S, external view; c, T, external view; d, T, internal view; e, whole animal, lateral view; f, whole animal, rostral view.

**DESCRIPTION.** — Size moderate (maximum: RC length 11.4, C height 9.5). Shell form upright, all parietal plates except C gently sloping in toward orifice; C sloping toward orifice at acute angle. Parietal plates solid, growth ridges irregular, not marked by small setae. Rostral plate broad, slightly convex, basal width twice basal width of C; sutures between R and RL visible internally, partially visible or obscure externally; basal width of R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> separate in juveniles, partially or totally coalesced in mature specimens; basal width of CL<sup>1</sup> equal to basal width of CL<sup>2</sup>, height of CL<sup>2</sup> subequal to height of CL<sup>1</sup>; external suture sometimes indistinct, giving superficial impression of 1 plate, coalescence of plates incomplete with CL<sup>2</sup> retaining minute ala, latter obscure in adults if plates apically eroded; ala of CL<sup>1</sup> 1/4 width of carinal ala, ala of CL<sup>2</sup> minute, 1/6 width of alae of CL<sup>1</sup>. C alae widest; C highest of all plates, almost twice height of R, basal width 1/2 basal width of R. Basis thin, flat; calcareous, centrally thin, sometimes membranous. Orifice large, subtriangular, not toothed. Basis thin, flat; calcareous, centrally thin, sometimes membranous. Opercular plates lodged upright in orifice; C seemingly forming hood over opercular plates. S smaller than T; triangular, elongated,



convex basal margin 2/3 length of occludent margin; articular margin distinctly curved toward occludent margin in upper 1/3; externally growth ridges sinuous, cut with 7-8 radial striations; apex blunt; internally adductor muscle pit deep, situated 2/3 up length of valve; lateral depressor muscle pit indistinct; articular furrow narrow; articular ridge 1/2 length of valve, projecting beyond articular margin; adductor ridge indistinct. T triangular, wider than S; externally growth ridges well marked, articular margin with growth ridges raised to form elevated ridge; internally with 12-16 strong muscle attachment crests projecting well beyond basal margin; articular ridge short, prominent, projecting slightly beyond articular margin; articular furrow broad; spur set at 1/12 length of basal margin from basi-scutal angle, truncate, 3/7 width of basal margin, barely defined from basal margin. Color of parietal plates dirty cream with orange-brown markings on C and carinal alae. Eggs orange. Measurements of 6 specimens examined, randomly selected from several stations, as follows:

	RC length	LD	C height	R height
rg	6.9-11.4	5.6-11.3	5.5-9.5	3.3-5.7
$\bar{x}$	9.5	8.8	7.8	4.8

Labrum with shallow medial depression, with regular row of small bi- or tri-lobed teeth. Mandibular palp ovoid; long serrate setae terminally. Mandible with 3 teeth, tooth 1 largest, well separated from teeth 2 and 3; upper margins of 2 and 3 teeth with small subsidiary cusps; inferior angle bluntly molariform, dentate. Maxillule setose; 2-3 long, stout setae at upper angle; indistinct notch below upper angle with 23 pairs of smaller setae; cutting margin below stepped, with 5-6 pairs of longer, stout setae; inferior angle stepped, with 5-6 pairs of smaller setae. Maxilla wide; coxal endite not well developed; dense, long setae terminally.

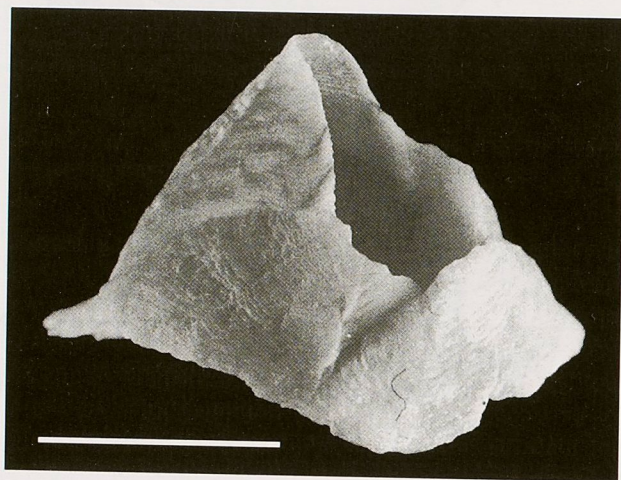


FIG. 41. — *Tetrapachylasma arcuatum* sp. nov. Holotype from MUSORSTOM 6, stn DW 472 (MNHN-Ci 2406): lateral view. Scale = 5 mm.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior ramus protuberant anteriorly; both rami with segments thickly setose, setae strong, serrulate, stout; postero-distal angles of segments of posterior ramus with tufts of stout, serrate setae, surface with combs of small setae. Cirrus II similar to but slightly longer than cirrus I; rami subequal; proximal segments of anterior ramus broad, slightly protuberant anteriorly, all segments thickly setose, setae simple, stout; posterior ramus more antenniform than anterior, segments becoming more elongated and narrower distally, distal segments with 3-4 pairs of long, finely serrulate setae on anterior faces. Cirrus III similar to cirri IV-VI; rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal

segments, proximal segments with 6 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4 pairs of setae on anterior faces, distal 2 pairs longest. Chaetotaxy ctenopod. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	10, 9	11, 13	18, 19	20, 22	24, 24	24, 25	16
Ci 2700	right	10, 9	12, 13	16, 19	21, 23	21, 24	24, 25	18

Caudal appendages twice length of pedicel of cirrus VI; 16-18 segmented; long setae apically and around distal segmental margins. Penis slightly shorter than length of cirrus VI; annulated; sparsely setose; circlet of long setae distally. Eggs large, rounded, 0.40 x 0.42 mm.



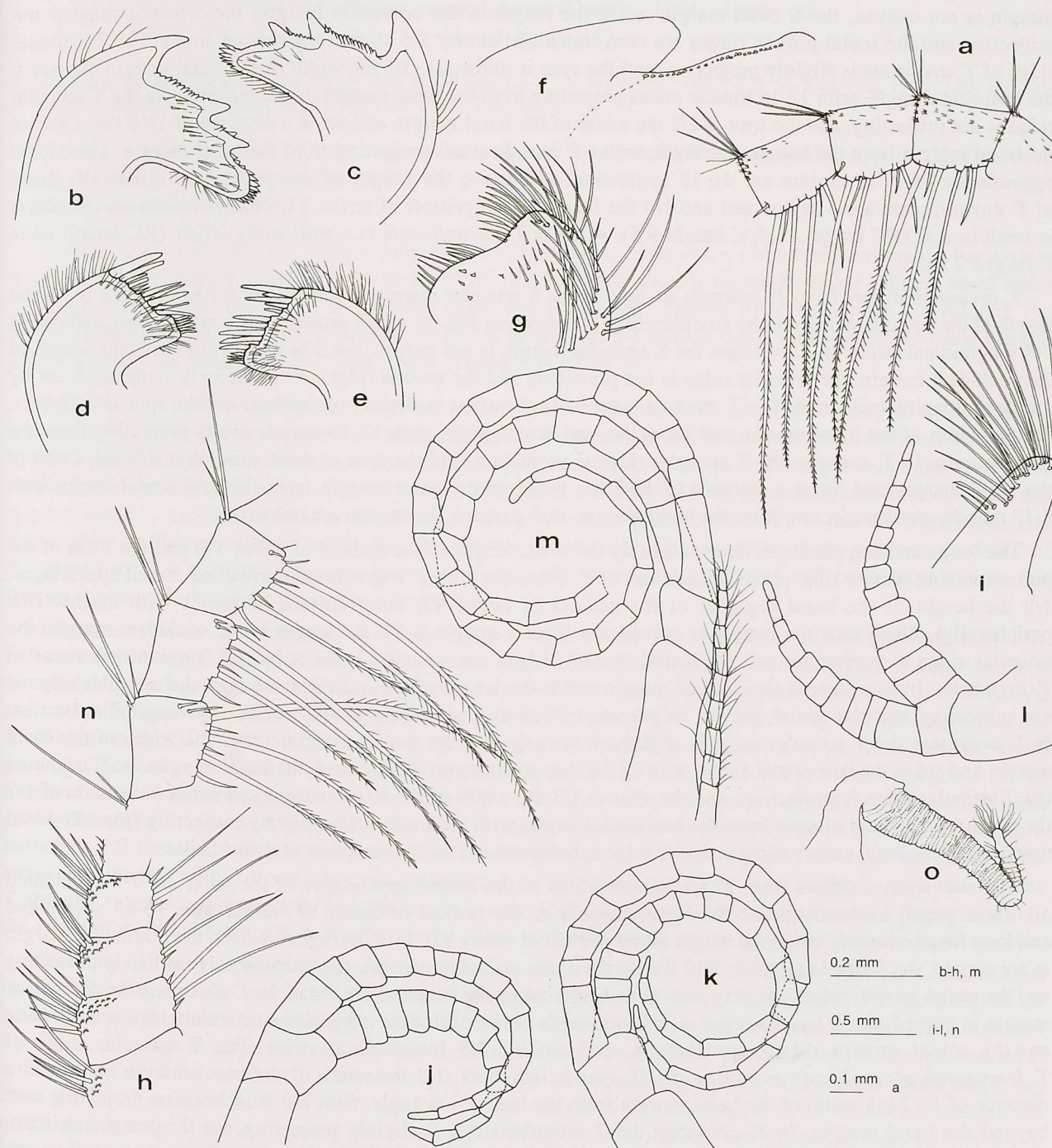


FIG. 42. — *Tetrapachylasma arcuatum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478 (MNHN-Ci 2700): a, cirrus VI, posterior ramus, median segments; b, right mandible; c, left mandible; d, right maxillule; e, left maxillule; f, labrum; g, maxilla; h, cirrus I, posterior ramus, median segments; i, mandibular palp; j, cirrus II; k, cirrus III; l, cirrus I; m, cirrus VI and caudal appendage; n, cirrus III, posterior ramus, median segments; o, penis.

REMARKS. — *T. arcuatum* sp. nov. can be separated from *T. aurantiacum* as follows: the S articular margin is convex, the S basal margin is 2/3 the length of the occludent margin, the articular ridge is projecting and the scutal



growth ridges are sinuous and cut by 7-8 longitudinal striae in *T. arcuatum*. In *T. aurantiacum* the S articular margin is not convex, the S basal margin is  $1/2$  the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are convoluted and cut by 5-6 slight longitudinal striae. The T articular ridge of *T. arcuatum* is slightly projecting, and the spur is indistinct,  $3/7$  the width of the basal margin and set at the basi-scutal angle, with 12-16 muscle crests projecting from the basal margin. In *T. aurantiacum* the T articular ridge is not projecting, and the spur is  $1/2$  the width of the basal margin and set at a distance of  $1/10$  the width of the basal margin from the basi-scutal angle, with 6-7 muscle crests projecting from the basal margin. The caudal appendages of *T. arcuatum* are 16-18 segmented and twice the height of the pedicel of cirrus VI; those of *T. aurantiacum* are 5 segmented and  $1/5$  the height of the pedicel of cirrus VI. *Tetrapachylasma arcuatum* is small in size (RC length 11.4, C height 9.5), whereas *T. aurantiacum* is significantly larger (RC length 24.0, C height 7.0).

*T. arcuatum* differs from *T. ornatum* sp. nov. as the S articular margin is curved, the S basal margin is  $2/3$  the length of the occludent margin, the articular ridge is projecting and the scutal growth ridges are sinuous, and cut by 7-8 longitudinal striae. In *T. ornatum* the S articular margin is not curved, the S basal margin is  $1/2$  the length of the occludent margin, the articular ridge is not projecting and the growth ridges are complexly sculptured, cut by 4-6 deep, longitudinal striae. The T articular ridge of *T. arcuatum* is slightly projecting, and the spur is indistinct,  $3/7$  the width of the basal margin and set at the basi-scutal angle, with 12-16 muscle crests projecting from the basal margin. In *T. ornatum* the T articular ridge is projecting, and the spur is short, more than  $1/3$  the width of the basal margin and set at a distance of  $1/12$  the width of the basal margin from the basi-scutal angle, with 8-12 muscle crests projecting from the basal margin. Soft parts of *T. ornatum* are unknown.

The long caudal appendages (approximately twice the length of the pedicel of cirrus VI) and the form of the paries (without narrow ribs) prevent confusion of *T. arcuatum* with *T. trigonum* (uniarticulate caudal appendages,  $1/8$  the height of the basal segment of the pedicel of cirrus VI; outer surface of paries with narrow ribs peripherally). The S articular margin is curved, the S basal margin is  $2/3$  the length of the occludent margin, the articular ridge is projecting and the scutal growth ridges are sinuous, and cut by 7-8 longitudinal striae in *T. arcuatum*. In *T. trigonum* the S basal margin is  $5/8$  the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are ruffled and overlapping, and not cut by longitudinal striae. In *T. arcuatum* the T articular ridge is slightly projecting, and the spur is indistinct,  $3/7$  the width of the basal margin and set at the basi-scutal angle, with 12-16 muscle crests projecting from the basal margin. In *T. trigonum* the T articular ridge is projecting, and the spur is  $1/3$  the width of the basal margin and set at a distance of  $1/7$  the width of the basal margin from the basi-scutal angle, with 6 muscle crests slightly projecting from the basal margin, and the basal corner of the articular ridge is hollowed out for the reception of dwarf males.

The new species differs from *T. ferrugomaculosa* as the caudal appendages of the latter are 7-9 segmented and short (equal to the height of the basal segment of the pedicel of cirrus VI) rather than 16-18 segmented and long (approximately twice the height of the pedicel of cirrus VI). In *T. ferrugomaculosa* the S articular margin is not curved, the S basal margin is  $7/10$  the length of the occludent margin, the articular ridge is barely projecting and the scutal growth ridges are very convoluted, and cut by 6-8 longitudinal striae. In *T. arcuatum* the S articular margin is curved, the S basal margin is  $2/3$  the length of the occludent margin, the articular ridge is projecting and the scutal growth ridges are sinuous, and cut by 7-8 longitudinal striae. The T articular ridge of *T. ferrugomaculosa* is not projecting, the T spur is indistinct,  $1/2$  the width of the basal margin and set at a distance of  $1/12$  the width of the basal margin from the basi-scutal angle, with 7-9 muscle crests projecting well beyond the basal margin. In *T. arcuatum* the T articular ridge is slightly projecting, the T spur is indistinct,  $3/7$  the width of the basal margin and set at the basi-scutal angle, with 12-16 muscle crests projecting from the basal margin.

ETYMOLOGY. — From the Latin *arcuatus*, 'curved', in reference to the curved form of the articular margin of the S.

DISTRIBUTION. — Chesterfield Islands, 280-610 m; Loyalty Islands, 300-460 m; Loyalty Ridge, 400 m; Vanuatu, 400-440 m; New Hebrides Arc, 500 m; Norfolk Ridge, 226-1220 m.



*Tetrapachylasma aurantiacum* (Darwin, 1854), comb. nov.

Fig. 39; Tables 15-17

*Pachylasma aurantiacum* Darwin, 1854: 480, pl. 20 figs 1 a-d. — WELTNER, 1897: 273. — GRUVEL, 1905: 199, fig. 219. — NEWMAN & ROSS, 1976: 40. — FOSTER, 1981: 354, figs 2 E, 4 A-L.

TYPES. — *Holotype*: BMNH (no registration number) New South Wales, Australia, apparently from deep water, attached to sandstone; dry specimen.

*Holotype depository*: BMNH.

DIAGNOSIS. — R and RL closely united by linear sutures, latter often obliterated externally but visible internally; basal width R equal to basal width of RL. CL<sup>1</sup> and CL<sup>2</sup> closely united by linear sutures; basal width CL<sup>2</sup> equal to basal width CL<sup>1</sup>. S articular ridge not projecting; growth lines extremely convoluted, cut by 5-6 slight longitudinal striae. T articular ridge not projecting; 6-7 muscle crests projecting from basal margin. Caudal appendages 5 segmented, 1/5 the height of pedicel of cirrus VI.

REMARKS. — The variable nature of the adult plate pattern has been noted previously for *Pachylasma aurantiacum* but the significance of the variability has not been recognised. DARWIN (1854) commented that '...the compartments in appearance are only four; but on close examination, the lateral compartments are seen to be divided by a very fine fissure into 2 equal compartments...' and FOSTER (1981), examining new collections of this species, noted '... carinolatus/latus or latus/rostral plate variously coalesced externally so that no intermediate alar areas show (although always with distinct sutures internally).' The variable plate pattern of adults of *P. aurantiacum* is recognised herein. Comparing shell plate, opercular plate and soft body morphology, this species is now included in the genus *Tetrapachylasma*.

*Tetrapachylasma aurantiacum* is a large species (maximum: RC length 24.0, C height [inferred] 7.0). Differences between *T. aurantiacum* and *T. arcuatum* sp. nov. are listed under *T. arcuatum*. In *T. ferrugomaculosa* the caudal appendages are 7-9 segmented and equal to the height of the basal segment of the pedicel of cirrus VI, rather than 5 segmented and 1/5 the height of the pedicel of cirrus VI (*T. aurantiacum*). In *T. ferrugomaculosa* the S basal margin is 7/10 the length of the occludent margin, the articular ridge is barely projecting and the scutal growth ridges are convoluted, and cut by 6-8 longitudinal striae. In *T. aurantiacum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are convoluted and cut by 5-6 slight longitudinal striae. The T articular ridge of *T. ferrugomaculosa* is not projecting, the T spur is indistinct, 1/2 the width of the basal margin and set at a distance of 1/12 the width of the basal margin from the basi-scutal angle, with 7-9 muscle crests projecting well beyond the basal margin. In *T. aurantiacum* the T articular ridge is not projecting, and the spur is 1/2 the width of the basal margin and set at a distance of 1/10 the width of the basal margin from the basi-scutal angle, with 6-7 muscle crests projecting from the basal margin.

Characters of the T separate *T. aurantiacum* from *T. ornatum* sp. nov. The T articular ridge of *T. aurantiacum* is not projecting, and the spur is 1/2 the width of the basal margin and set at a distance of 1/10 the width of the basal margin from the basi-scutal angle, with 6-7 muscle crests projecting from the basal margin. In *T. ornatum* the T articular ridge is projecting, and the spur is indistinct, more than 1/3 the width of the basal margin and set at a distance of 1/12 the width of the basal margin from the basi-scutal angle, with 8-12 muscle crests projecting from the basal margin. In *T. aurantiacum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are extremely convoluted and cut by 5-6 slight, longitudinal striae. In *T. ornatum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the growth ridges are complexly sculptured, cut by 4-6 deep, longitudinal striae. Soft parts of *T. ornatum* are unknown. *Tetrapachylasma ornatum* is small in size (RC length 6.0, C height 2.5), whereas *T. aurantiacum* is large (RC length 24.0, C height 7.0).

*Tetrapachylasma aurantiacum* can be separated from *T. trigonum* by the form of the caudal appendages (5 segmented, 1/5 the height of the pedicel of cirrus VI, and unarticulate, 1/8 the height of the basal segment of the pedicel of cirrus VI, respectively). In *T. aurantiacum* the paries are without narrow ribs; in *T. trigonum*



the surface of the paries have narrow ribs peripherally. In *T. aurantiacum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are extremely convoluted and cut by 5-6 slight, longitudinal striae. In *T. trigonum* the S basal margin is 5/8 the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are ruffled and overlapping, and not cut by longitudinal striae. The T articular ridge of *T. aurantiacum* is not projecting, and the spur is 1/2 the width of the basal margin and set at a distance of 1/10 the width of the basal margin from the basi-scutal angle, with 6-7 muscle crests projecting from the basal margin. In *T. trigonum* the T articular ridge is projecting, and the spur is 1/3 the width of the basal margin and set at a distance of 1/7 the width of the basal margin from the basi-scutal angle, with 6 muscle crests slightly projecting from the basal margin, and the basal corner of the articular ridge hollowed out for the reception of dwarf males.

DISTRIBUTION. — New South Wales, Australia; Kermadec Is, New Zealand; 122-490 m.

*Tetrapachylasma ferrugomaculosa* (Jones, 1993), comb. nov.

Fig. 39; Tables 15-17

*Pachylasma ferrugomaculosa* Jones, 1993b: 116, fig. 1 a-o.

MATERIAL EXAMINED. — **South-western Australia (between Rottnest I. and Albany).** Rottnest Island, 30 m: holotype (WAM 220-91). — Roe Reef, Rottnest Island, 30 m: paratype (WAM 223-91).

*Other material:* Duffield Ridge, Rottnest Island, 30 m (WAM 224-91). — Roe Reef, Rottnest Island, 30 m (WAM 225-91). — Salmon Bay, Rottnest Island (WAM 427-95). — Kwinana, 3-5 m (WAM 180-75). — Kwinana, 3-5 m (WAM 186-75). — Off Castle Rock, Dunsborough, 20 m (WAM 221-91). — From wreck off Dunsborough (WAM 464-92). — King George Sound, Albany (WAM 222-91).

TYPES. — *Holotype:* WAM 220-91; Western Australia; Duffield Ridge, Rottnest Island, 30 m.

*Paratype:* WAM 223-91; Western Australia; Roe Reef, Rottnest Island, 30 m.

*Holotype and paratype depository:* WAM.

DIAGNOSIS. — R and RL closely united by linear sutures, latter often obliterated externally but visible internally; basal width R twice basal width of RL. Basal width CL<sup>2</sup> 1/2 basal width CL<sup>2</sup>; plates separate, or partially or totally coalesced. S articular ridge barely projecting; growth lines convoluted, cut by 6-8 longitudinal striae. T articular ridge not projecting; 7-9 muscle crests projecting from basal margin. Caudal appendages 7-9 segmented, equal to height of basal segment of pedicel of cirrus VI.

REMARKS. — Re-examination of the type material as well as of new collections of specimens of *Pachylasma ferrugomaculosa* have revealed that the number of shell plates in the adult condition is variable within this species. The adult form may be 6-plated (rostral plate, CL<sup>1</sup> and CL<sup>2</sup> distinct entities or partially coalesced, and C) or 4-plated (rostral plate, CL<sup>1</sup> and CL<sup>2</sup> totally coalesced, and C). Comparing wall, opercular plate and soft body morphology, *T. arcuatum* sp. nov., *T. aurantiacum* (Darwin, 1854), *T. ornatum* sp. nov. and *T. trigonum* Foster, 1988 are closely related to *P. ferrugomaculosa* (*sensu* JONES, 1993b) and the latter is now included within *Tetrapachylasma*. JONES (1993b) noted the similarity between *P. ferrugomaculosa* and *P. aurantiacum*.

*Tetrapachylasma ferrugomaculosa* is a moderate sized species (maximum: RC length 11.4, C height 10.2). Differences between *T. ferrugomaculosa*, *T. arcuatum* sp. nov. and *T. aurantiacum* (Darwin, 1854) are listed under *T. arcuatum* and *T. aurantiacum*, respectively. Soft parts of *T. ornatum* are unknown; thus only hard parts can be compared with *T. ferrugomaculosa*. In *T. ornatum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the growth ridges are complexly sculptured, cut by 4 deep, longitudinal striae. In *T. ferrugomaculosa* the S basal margin is 7/10 the length of the occludent margin, the articular ridge is barely projecting and the convoluted scutal growth ridges are cut by 6-8 longitudinal striae. The T articular ridge of *T. ferrugomaculosa* is not projecting, the T spur is indistinct, 1/2 the width of the basal margin and set at a distance of 1/12 the width of the basal margin from the basi-scutal angle, with 7-9 muscle crests projecting well beyond the basal margin. In *T. ornatum* the T articular ridge is projecting, and the spur is short, more than 1/3



the width of the basal margin and set at a distance of  $1/12$  the width of the basal margin from the basi-scutal angle, with 8-12 muscle crests projecting from the basal margin. *Tetrapachylasma ornatum* is small in size (RC length 6.0, C height 2.5), whereas *T. aurantiacum* is larger (RC length 11.4, C height 10.2).

*Tetrapachylasma ferrugomaculosa* can be separated from *T. trigonum* by the form of the caudal appendages (7-9 segmented, equal to the height of the basal segment of the pedicel of cirrus VI, and uniarticulate,  $1/8$  the height of the basal segment of the pedicel of cirrus VI, respectively). The paries of *T. ferrugomaculosa* are without narrow ribs; in *T. trigonum* the surface of the paries have narrow ribs peripherally. In *T. ferrugomaculosa* the S basal margin is  $7/10$  the length of the occludent margin, the articular ridge is barely projecting and the scutal growth ridges are very convoluted, and cut by 6-8 longitudinal striae. The S basal margin of *T. trigonum* is  $5/8$  the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are ruffled and overlapping, and not cut by longitudinal striae. The T articular ridge of *T. ferrugomaculosa* is not projecting, the T spur is indistinct,  $1/2$  the width of the basal margin and set at a distance of  $1/12$  the width of the basal margin from the basi-scutal angle, with 7-9 muscle crests projecting well beyond the basal margin. In *T. trigonum* the T articular ridge is projecting, and the spur is  $1/3$  the width of the basal margin and set at a distance of  $1/7$  the width of the basal margin from the basi-scutal angle, with 6 muscle crests slightly projecting from the basal margin, and the basal corner of the articular ridge is hollowed out for the reception of dwarf males.

DISTRIBUTION. — South-western Australia, 3-30 m.

*Tetrapachylasma ornatum* sp. nov.

Figs 39, 43-44; Tables 15-17

MATERIAL EXAMINED. — **Marianas Islands.** The Grotto, Puntan, Madog, Saipan, 6 m, 27.07.1969: 2 specimens attached to the sclerosponge *Astrosclera* sp. (YPM 9303 A, B); 1 specimen attached to the sclerosponge *Astrosclera* sp. (YPM 9305).

TYPES. — *Holotype*: YPM 9303 A (The Grotto, Puntan, Madog, Saipan, 6 m, 27.07.1969).

*Paratypes*: YPM 9303 B (The Grotto, Puntan, Madog, Saipan, 6 m, 27.07.1969). — YPM 9305 (The Grotto, Puntan, Madog, Saipan, 6 m, 27.07.1969).

DIAGNOSIS. — R and RL closely united by inconspicuous linear sutures; basal width of R equal to basal width of RL; RL clearly incorporated in the sheath. Basal width of CL<sup>2</sup> slightly less than basal width of CL<sup>1</sup>; CL<sup>1</sup> and CL<sup>2</sup> partially or totally coalesced. S basal margin sinuous, externally growth ridges complexly sculptured, cut by 4-6 deep radial striations; articular ridge not projecting beyond articular margin. T articular ridge projecting; 8-12 strong muscle attachment ridges extending well beyond basal margin.

DESCRIPTION. — Size small (maximum: RC length 6.0, C height 2.5). Shell form low conical, higher at carinal end; almost circular when viewed from above. Parietal plates externally differentiated in adult as 6 plates - rostral plate, paired CL<sup>1</sup> and CL<sup>2</sup> (sometimes partially coalesced) and C - or 4 plates (rostral plate, CL<sup>1</sup> and CL<sup>2</sup> coalesced, C); plates solid, thicker basally, internally calcareous pegs developed along basal margins of paries; externally growth ridges ill-defined, irregularly scalloped, more regular and defined on rostral plate; outer surface of paries rough. Alae of C and CL<sup>1</sup> wide, triangular, well-developed; alae of CL<sup>2</sup> minute or absent; alar growth ridges widely spaced, parallel to inferior alar margin; superior alar margins serrate; alar welting absent. Rostral plate broad, convex, smaller than C; apex pointing inward; sutures between R and RL not or slightly visible externally and internally. In adults CL<sup>1</sup> and CL<sup>2</sup> coalesced (4-plated condition) or incompletely coalesced (6-plated condition); CL<sup>1</sup> triangular, slightly larger than CL<sup>2</sup>; apices sloping inward, toward C. CL<sup>2</sup> triangular; apex sloping inward, toward C. C largest, highest plate, occupying almost  $1/2$  circumference of shell; apex pointed, V-shaped from above; plate sloping inward toward orifice; alae wide. Basis unknown, presence of calcareous pegs along basal margins of parietes indicative of interdigitation with calcareous basis. Orifice large, triangular, not toothed. S thick; elongate triangular; basal margin sinuous,  $3/7$  length of occludent margin; externally growth ridges complexly sculptured, cut by 4 deep radial striations; apex pointed; internally smooth, adductor muscle pit absent,



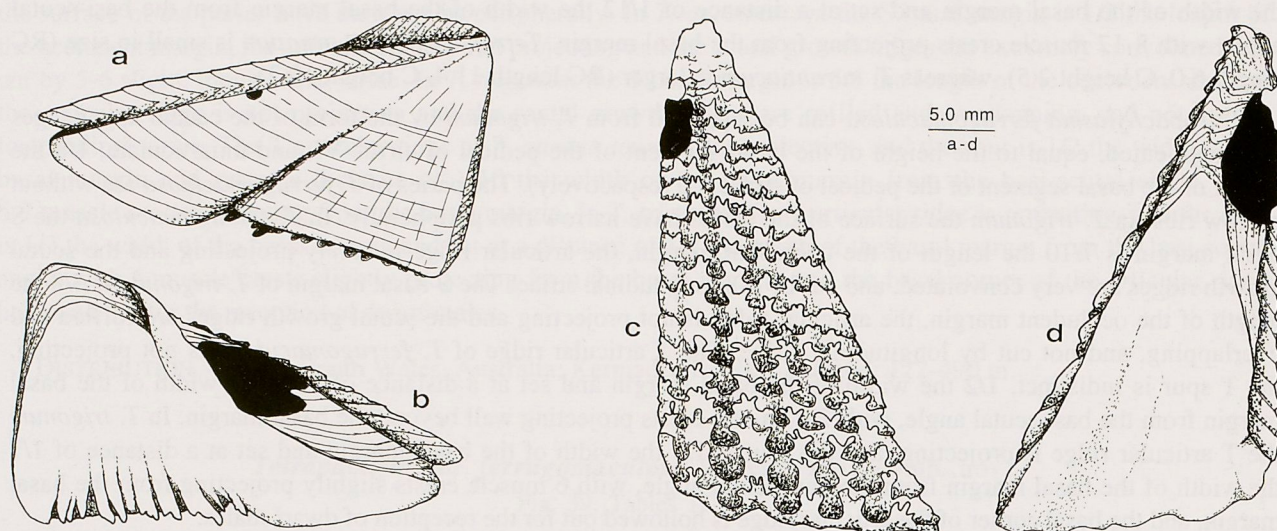


FIG. 43. — *Tetrapachylasma ornatum* sp. nov. Holotype from Puntan, Madog, Saipan (YPM 9303A): a, T, external view; b, T, internal view; c, S, external view; d, S, internal view.

depressor muscle pits indistinct; articular furrow broad, deep; articular ridge high, not projecting beyond articular margin; adductor ridge indistinct. T wider than S, triangular, basal margin twice height of valve; externally with regular growth ridges; internally with 8-12 strong muscle attachment ridges extending well beyond basal margin; articular ridge projecting beyond articular margin; articular margin with growth ridges raised to form elevated ridge; articular furrow broad, deep; spur furrow shallow, spur 1/3 width of basal margin, truncate, pointing toward and set a distance of 1/12 length of basal margin from basi-scutal angle. Color of parietal plates, alae and opercular plates buff with dull ochre/orange. Measurements (approximate) of holotype:

Holotype:	RC length	RC width	C height	R height
YPM 9303 A	6.0	6.0	2.5	2.1

Soft parts not known presently.

REMARKS. — During the course of the present study 3 dry specimens from the Marianas Islands were sent to me, for comparative purposes, by Professor W. NEWMAN. The cirripeds had been collected by T. GOREAU and J. LANG who had sent them, and the associated sclerosponge, to Willard HARTMAN of YPM for identification. The cirriped material is herein described as *Tetrapachylasma ornatum* sp. nov. On examination it is clear that the RL does enter the sheath, a unique attribute not found in any other tetrapachylasmatid or pachylasmatoid species presently known. Apart from this unique character, the complex S sculpturing separates *T. ornatum* from all other species in the genus and warrants specific status. Differences between *T. ornatum* sp. nov. and *T. arcuatum* sp. nov., *T. aurantiacum* and *T. ferrugomaculosa* are listed under and *T. arcuatum* sp. nov., *T. aurantiacum* and *T. ferrugomaculosa*, respectively. Details of the soft part anatomy of *T. ornatum* are presently unknown.

*Tetrapachylasma ornatum* differs from *T. trigonum* in the form of the parietal plates (narrow peripheral ribs present in *T. trigonum*, absent in *T. ornatum*). The S basal margin of *T. trigonum* is 5/8 the length of the occludent margin, the articular ridge is not projecting and the scutal growth ridges are ruffled and overlapping, and not cut by longitudinal striae. In *T. ornatum* the S basal margin is 1/2 the length of the occludent margin, the articular ridge is not projecting and the complexly sculptured scutal growth ridges are cut by 4-6 deep, longitudinal striae. The T articular ridge of *T. ornatum* is projecting; the spur is indistinct, more than 1/3 the width of the basal margin and set at a distance of 1/12 the width of the basal margin from the basi-scutal angle; and there are 8-12 muscle crests projecting from the basal margin. In *T. trigonum* the T articular ridge is projecting; the spur is



1/3 the width of the basal margin and set at a distance of 1/7 the width of the basal margin from the basi-scutal angle; and there are 6 muscle crests slightly projecting from the basal margin. Additionally, the basal corner of the articular ridge is hollowed out for the reception of dwarf males in *T. trigonum*. *Tetrapachylasma ornatum* is small in size (RC length 6.0, C height 2.5), *T. aurantiacum* is larger (RC length 10.0, C height 8.0).

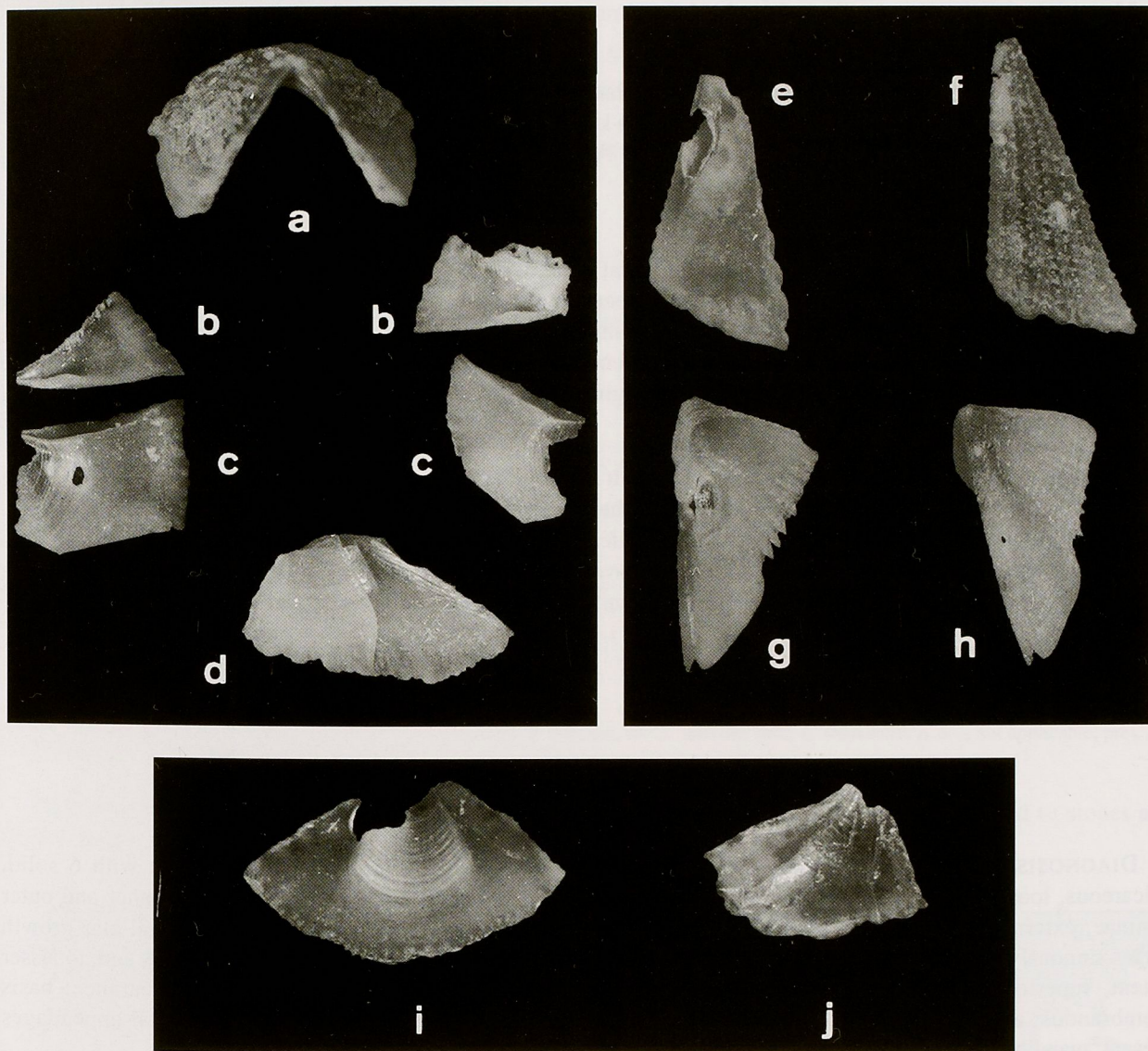


FIG. 44. — *Tetrapachylasma ornatum* sp. nov.

a-d. — Paratype from Puntan, Madog, Saipan (YPM 9305). Wall plates: **a**, C from above; **b**, CL<sup>2</sup>, internal view; **c**, CL<sup>1</sup> internal view; **d**, R+RL+ missing RL, internal view.

e-i. — Holotype from Puntan, Madog, Saipan (YPM 9303A). **e-h**, Opercular plates: **e**, S, internal view; **f**, S, external view; **g**, T, internal view; **h**, T, external view. — **i**, Compound rostrum, sutures absent, internal view.

j. — Paratype from Puntan, Madog, Saipan (YPM 9303B). Compound rostrum, sutures present, internal view.

ETYMOLOGY. — From the Latin *ornatus*, 'adorned', in reference to the complex sculpting of the growth ridges on the S.

DISTRIBUTION. — Marianas Islands, 6 m.



*Tetrapachylasma trigonum* Foster, 1988

Fig. 39; Tables 15-17

*Tetrapachylasma trigonum* Foster, 1988: 226, figs 1-3.

**MATERIAL EXAMINED.** — **Cook Islands.** Off Avarua, Rarotonga, 15 m, 09.1984: 2 paratypes, under coral rubble (NMNZ Cr 3641).

**TYPES.** — *Holotype*: NMNZ CR 3640; Cook Islands, off Avarua, Rarotonga, 15 m, 09.1984; 2, dissected appendages on microslide with dry disarticulated plates kept separately.

*Paratypes*: NMNZ Cr 3641; Cook Islands, off Avarua, Rarotonga, 15 m, 09.1984; 2 whole specimens, attached to piece of coral rubble, in alcohol.

*Holotype and paratype depository*: NMNZ.

**DIAGNOSIS.** — Adult with 4 parietal plates (rostral plate, CL<sup>1</sup> and CL<sup>2</sup> coalesced, and C); plates solid, thin, externally finely stellate basally, outer surface of paries with narrow ribs peripherally. S articular ridge not projecting; external growth ridges ruffled, overlapping, not cut by longitudinal striae. T articular ridge wide, projecting wing-like from articular margin, basal corner hollowed for reception of dwarf males; 6 muscle attachment ridges extending just beyond basal margin. Caudal appendages uni-articulate, 1/8 height of basal segment of pedicel of cirrus VI.

**REMARKS.** — The 4 plates composing the adult shell, the basal corner of the T articular margin being hollowed for the reception of dwarf males, and the vestigial caudal appendages, distinguish this species. *Tetrapachylasma trigonum* is a moderate sized species (maximum: RC length 10.0, C height 6.4). Differences between *T. trigonum* and *T. arcuatum* sp. nov., *T. aurantiacum*, *T. ferrugomaculosa* and *T. ornatum* sp. nov. are listed under *T. arcuatum*, *T. aurantiacum*, *T. ferrugomaculosa* and *T. ornatum*, respectively.

**DISTRIBUTION.** — Cook Islands, 15 m.

## Subfamily METALASMATINAE nov.

Tables 1-2

**DIAGNOSIS.** — Primary shell wall not surrounded by whorl(s) of imbricating plates; adult with 6 solid, calcareous, loosely articulated plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C); thin lamina of chitin dividing paries into inner and outer laminae; externally paries with prominent, irregular growth ridges lined with small setae; external alar growth ridges sinuously parallel to inferior alar margin; superior margins of C alae thickened in distal halves and, to lesser extent, superior margins of alae of CL<sup>1</sup> and CL<sup>2</sup> thickened in distal 1/3, giving dentate appearance; basis membranous; articular ridges of S and T prominent, articular furrow of T well developed; caudal appendages present; mandible tridentoid.

**TYPE GENUS.** — *Metlasma* gen. nov.

**REMARKS.** — Only 1 genus, *Metlasma*, is assigned to this subfamily. The metalasmatines have lost any trace of the suture between the R and RL but retain the more plesiomorphic pachylasmatoid basic 6-plated wall. The body morphology of the Metalasmatinae is intermediate between the Pachylasmatinae (retention of the caudal appendages, a tridentoid mandible, form of T) and the Hexelasmatinae (chitin in the parietal wall, form of the cirri - cirrus II resembling I more than III). The presence of caudal appendages, the presence of chitin in the parietal wall, and the tridentoid nature of the mandible, separate the Metalasmatinae from the Bathylasmatinae, which is also phylogenetically between the Pachylasmatinae and the Hexelasmatinae.



ETYMOLOGY. — From the Greek *meta*, 'between', in reference to the intermediate position of this subfamily within the Pachylasmatidae.

DISTRIBUTION. — Recent; Western Pacific: Loyalty Islands; New Hebrides Arc; 300-500 m; attached to stones and Stylasteridae.

Genus *METALASMA* gen. nov.

Fig. 45; Tables 18-19

DIAGNOSIS. — As for the subfamily, which is monogeneric.

TYPE SPECIES. — *Metalasma crassum* sp. nov.

REMARKS. — One species is presently assigned to this genus.

TABLES 18 and 19. — *Metalasma* gen. nov.: characters of *M. crassum* sp. nov.

no. plates		R: RL	CL <sup>1</sup> : CL <sup>2</sup>	T		basis
ext.	int.					
6	6	n.a.	separate; CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup> ; CL <sup>2</sup> shorter than CL <sup>1</sup> by 1/10	artic. ridge proj. well beyond artic. margin; spur indistinct, 1/3 width of basal margin, set at 1/6 width basal margin from b-s angle; 13-16 muscle crests, some just extending beyond basal margin		membranous

alar welting	chitin in paries	S shape	S growth lines	caudal appendage	mandible	size (max.)
absent; ala of C with superior alar margin thickened in distal 1/2; alae of CL <sup>1</sup> and CL <sup>2</sup> similarly but less thickened in distal 1/3	lamina of chitin dividing paries into inner (1/4) and outer laminae (3/4)	basal margin 3/4 length of occludent margin; artic. ridge extending beyond artic. margin	many well-spaced, regular; not cut by long. striae	10-12 segs; 2 x length of pedicel of CVI	tridentate; upper margins of teeth 2 and 3 with small subsidiary cusps	RC length 6.5 C height 2.2

artic. = articular; b-s = basi-scutal; distrib. = distribution; ext. = external; int. = internal; max. = maximum; n. a. = not applicable; proj. = projecting; segs = segments.

DISTRIBUTION. — Western Pacific: Loyalty Islands, New Hebrides Arc; 300-500 m; attached to stones and Stylasteridae.

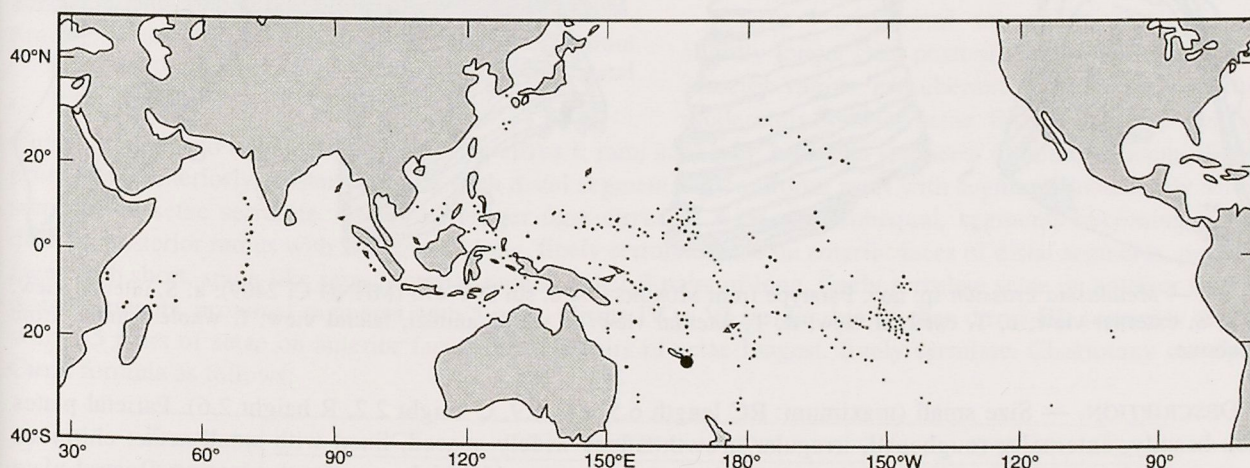


FIG. 45. — *Metalasma* gen. nov. Distribution map: ●, *M. crassum* (300-500 m).



*Metalasma crassum* sp. nov.

Figs 45-48; Tables 18-19

MATERIAL EXAMINED. — **New Hebrides Arc.** VOLSMAR: stn DW 16, 500 m: 8 specimens (MNHN-Ci 2708).

**Loyalty Islands.** MUSORSTOM 6: stn DW 460, 420 m: many specimens, attached to rocks (MNHN-Ci 2701). — Stn DW 476, 300 m: 2 specimens (ovigerous), attached to stone (MNHN-Ci 2408, Ci 2409). Drawn. — Stn DW 478, 400 m: 1 specimen (broken), attached to Stylasteridae (MNHN-Ci 2505). — Stn DW 479, 310 m: many specimens, attached to rocks (WAM C 23252).

TYPES. — *Holotype*: MNHN-Ci 2408 (MUSORSTOM 6, stn DW 476).

*Paratypes*: MNHN-Ci 2409 (MUSORSTOM 6, stn DW 476). Drawn. — MNHN-Ci 2505 (MUSORSTOM 6, stn DW 478). — MNHN-Ci 2701 (MUSORSTOM 6, stn DW 460). — MNHN-Ci 2708 (VOLSMAR, stn DW 16). — WAM C 232-52 (MUSORSTOM 6, stn DW 479).

DIAGNOSIS. — Shell form low, rounded from above. Parietal plates with thin chitinous laminae dividing paries into inner lamina (1/4 thickness) and outer lamina (3/4 thickness). Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Narrow remnants of radii on CL<sup>1</sup>, CL<sup>2</sup> and rostral plate. Superior alar margins oblique; carinal superior alar margins thickened in distal 1/2 giving dentate appearance, to lesser extent superior alar margins of CL<sup>1</sup> and CL<sup>2</sup> thickened in distal 1/3. Basis membranous. S externally with many regular growth ridges, not cut by longitudinal striae; articular ridge projecting. Tergal spur indistinct; 13-16 muscle attachment crests, some extending below basal margin; articular ridge projecting. Caudal appendages twice length of pedicel of cirrus VI; 10-12 segmented.

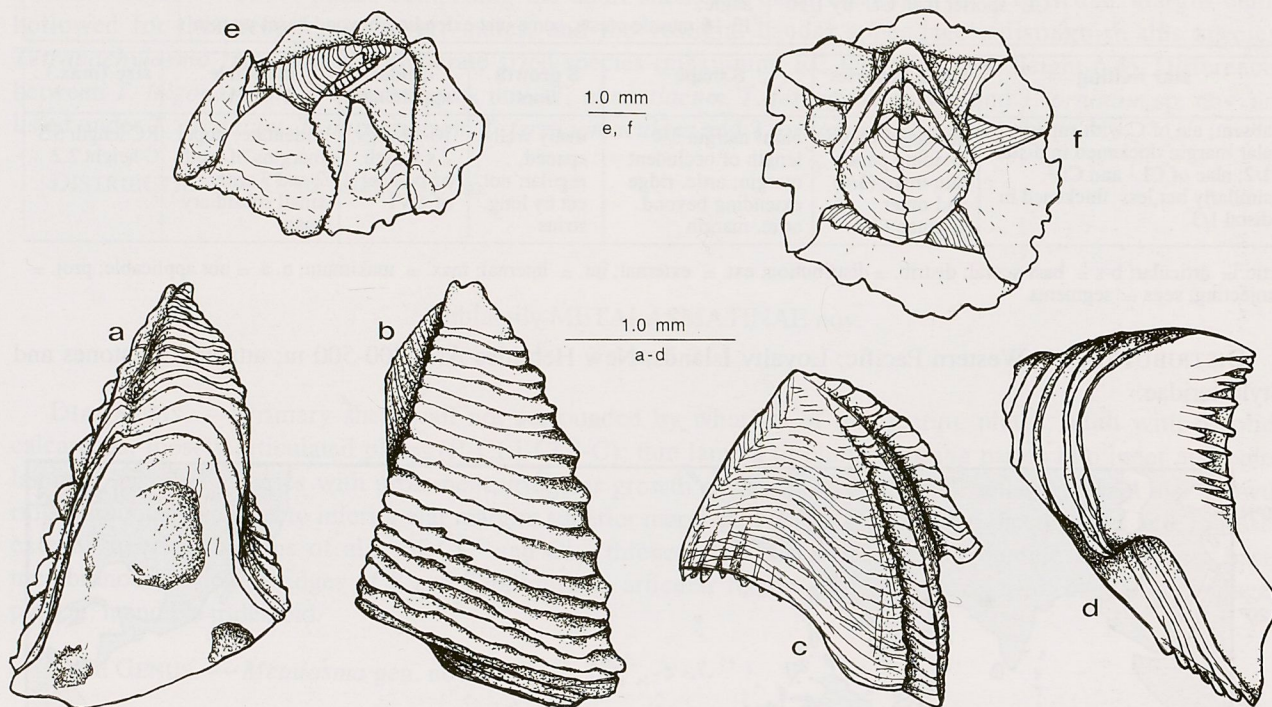


FIG. 46. — *Metalasma crassum* sp. nov. Paratype from MUSORSTOM 6, stn DW 476 (MNHN Ci 2409): a, S, internal view; b, S, external view; c, T, external view; d, T, internal view; e, whole animal, lateral view; f, whole animal, from above.

DESCRIPTION. — Size small (maximum: RC length 6.5, LD 6.9, C height 2.2, R height 2.6). Parietal plates thick basally, externally roughened, irregular growth ridges widely spaced, lined with small setae; chitinous laminae dividing paries into inner and outer laminae, inner lamina 1/4 thickness of outer lamina. Rostral plate flattened, angled inward, apex not curved in toward orifice, basal width twice basal width of C. CL<sup>1</sup> and CL<sup>2</sup>



separate; basal width of CL<sup>1</sup> just greater than 1/2 basal width of R, apex not curved in toward orifice; basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>, height less than CL<sup>1</sup> by 1/10; apex not curved in toward orifice. C highest plate, basal width subequal to basal width of CL<sup>1</sup>, apex bowed, spout-like, curved away from orifice. Superior alar margins oblique, growth ridges sinuously parallel to inferior alar margins; alae of C widest, alae of CL<sup>1</sup> 1/3 width of carinal alae, alae of CL<sup>2</sup> 1/2 width of carinal alae; carinal superior alar margins thickened in distal 1/2 giving dentate appearance, to lesser extent superior alar margins of CL<sup>1</sup> and CL<sup>2</sup> thickened in distal 1/3. Narrow remnants of radii on CL<sup>1</sup>, CL<sup>2</sup> and rostral plate. Basis membranous, flat. Orifice pentagonal, slightly toothed. Opercular plates lodged subparallel to basis. S triangular; basal margin 3/4 length of occludent margin; externally with many spaced, regular growth ridges, not cut by longitudinal striae; apex pointed; internally adductor muscle scar at 1/2 height of valve; lateral depressor muscle pit well developed; articular furrow moderately deep; articular ridge long, projecting well beyond articular margin; adductor ridge indistinct. T subequal to S, sub-triangular; externally with fine growth ridges; internally with 13-16 depressor muscle crests, some extending just beyond basal margin; prominent tergal articular ridge projecting well beyond and standing clear of convex articular margin; articular furrow broad, deep; indistinct spur, roundly truncate, 1/3 width of basal margin, set at distance of 1/6 width of basal margin from basi-scutal angle. Color of preserved material creamy yellow, opercular plates more yellow; eggs yellow. Measurements of 2 specimens examined as follows:

	RC length	LD	C height	R height
<i>Paratype</i> : MNHN-Ci 2409	5.0	5.5	2.1	1.8
<i>Holotype</i> : MNHN-Ci 2408	6.5	6.9	2.2	2.6

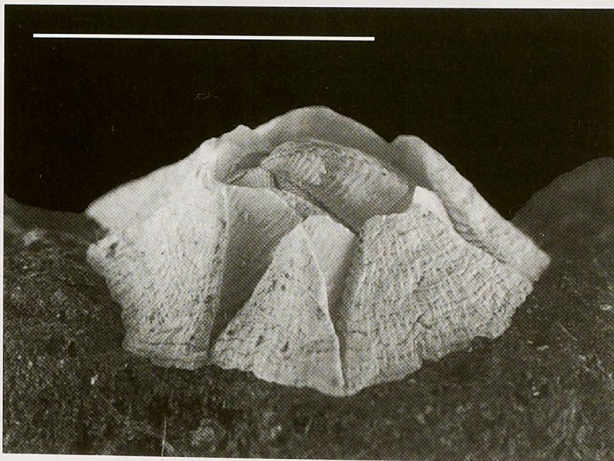


FIG. 47. — *Metalasma crassum* sp. nov. Holotype from MUSORSTOM 6, stn DW 476 (MNHN-Ci 2408): lateral view. Scale = 5 mm.

Labrum with shallow medial depression and numerous small, pointed teeth. Mandibular palp oblong; dense setae terminally. Mandible with 3 teeth, tooth 1 largest, separated from tooth 2 and 3; upper margins of 2 and 3 with small subsidiary cusps; inferior angle large, bluntly molariform, dentate. Maxillule setose; 2 pairs of long, stout setae at upper angle; notch below upper angle large, with 3-4 pairs of smaller setae; straight, stepped cutting margin below with 5-6 pairs of larger setae; inferior angle small, with 4-5 pairs of smaller setae. Maxilla wide; endites indistinct; long, serrulate setae terminally.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior ramus protuberant anteriorly; both rami moderately setose, setae finely serrulate distally.

Cirrus II similar to but slightly longer than cirrus I; rami subequal; proximal segments of anterior ramus slightly protuberant anteriorly; posterior ramus with distal segments antenniform; rami with segments moderately setose, some distal setae serrulate. Cirrus III longer than cirrus II, with rami subequal, segments becoming oblong distally; posterior ramus with 2-4 pairs of long, finely serrulate setae on anterior faces of distal segments, posterior faces with short, spine-like setae; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 5 pairs. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 4-5 pairs of setae on anterior faces, distal 2 pairs of setae longest, finely serrulate. Chaetotaxy ctenopod. Cirral formula as follows:

<i>Paratype</i> :		CI	CII	CIII	CIV	CV	CVI	c. a.
MNHN-	left	9, 9	9, 12	16, 15	19, 19	21, 21	21, 5+	10
Ci 2409	right	9, 9	11, 12	15, 16	18, 18	21, 20	21, 20+	12



Caudal appendages twice length of pedicel of cirrus VI; 10-12 segmented; apically with sparse, long setae, distal margins of segments with sparse setae, setal length more than 1/2 segmental length. Penis length of proximal segment of pedicel of cirrus VI; finely annulated; sparsely setose with irregular circlet of sparse, short setae apically. Eggs large, ovoid, 0.36 x 0.24 mm.

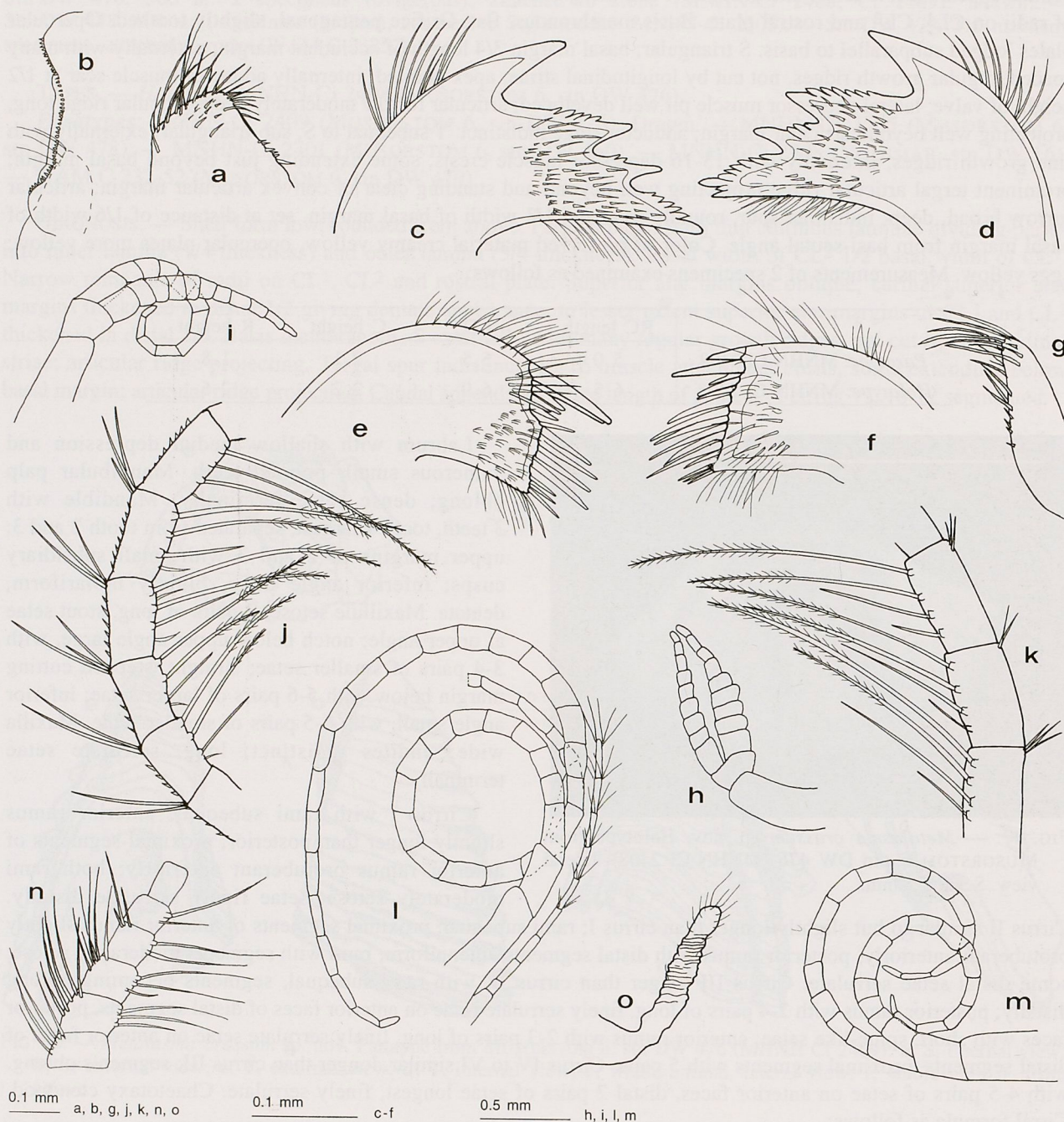


FIG. 48. — *Metalasma crassum* sp. nov. Paratype from MUSORSTOM 6, stn DW 476 (MHNH Ci 2409): a, maxilla; b, labrum; c, right mandible; d, left mandible; e, right maxillule; f, left maxillule; g, mandibular palp; h, cirrus I; i, cirrus II; j, cirrus III, posterior ramus, median segments; k, cirrus VI, posterior ramus, median segments; l, cirrus VI and caudal appendage; m, cirrus III; n, cirrus I, posterior ramus, median segments; o, penis.



REMARKS. — Specimens of *M. crassum* sp. nov. have been collected, by VOLSMAR and MUSORSTOM 6, from five separate stations which are spatially close. *Metasasma crassum* is remarkable in having a prominent tergal articular ridge extending well beyond and standing clear of the convex articular margin, and an extremely well developed, broad and deep articular furrow. The manner of articulation of the S and T ensure that the T fits closely into the trough formed by the broad carinal alae and the apical portion of the C, and is almost unexposed when the opercular plates are closed.

ETYMOLOGY. — From the Latin *crassa*, 'thick', in reference to the thickened areas on the upper edges of the alae of the C and CL<sup>2</sup> of this species.

DISTRIBUTION. — New Hebrides Arc, Loyalty Islands, 300-500 m.

#### Subfamily BATHYLASMATINAE Newman & Ross, 1976

Tables 1-2

DIAGNOSIS. — Primary shell wall not surrounded by whorl(s) of imbricating plates. Adult shell wall with 6 (R-CL<sup>1</sup>-CL<sup>2</sup>-C), or 4 (R-CL-C), solid compartmental plates; paries with prominent horizontal growth ridges lined with small setae; plates thin (*Bathylasma*) or thickened (*Mesolasma*); chitinous laminae in parietal plates absent. External alar growth ridges diverging from inferior alar margin. Basis membranous or calcareous. S with prominent articular ridge; "balanoid" in form. T articular ridge varies from not prominent to prominent. Mandible quadridentoid. Caudal appendages absent.

DISTRIBUTION. — Paleocene to Recent; Cosmopolitan.

REMARKS. — NEWMAN and ROSS (1971) proposed the Bathylasmatidae, in which they included *Bathylasma*, *Hexelasma*, *Aptolasma*, *Tetrachaelasma* and *Tessarelasma*. FOSTER (1978) indicated that there was only scant evidence for generic differentiation between *Hexelasma* and *Bathylasma*, these genera differing principally in the shape of the spur of the T and the number of paired setae on the anterior edge of the segments of cirrus VI. FOSTER (1978) also showed that there was considerable confusion concerning some of the holotypes of HOEK and suggested that more than 1 taxon may have been involved in the initial description of *H. velutinum* Hoek, 1913. FOSTER (1981) subsequently re-examined the type material, concluding that *H. velutinum* was an aptolasman and placing *Aptolasma* in *Hexelasma* as a junior synonym. FOSTER (1981) further proposed the *Mesolasma* for a genus intermediate between *Bathylasma* and *Hexelasma*. *Mesolasma* differed from *Bathylasma* in having opercular plates which lacked prominent articular ridges and from *Hexelasma* in the less specialised setation of the segments of the posterior cirri.

BUCKERIDGE (1983) remarked that the bathylasmatines retained the more primitive pachylasmatoid basic shell construction but had lost any trace of the suture between the R and the RL and that the body morphology was intermediate between the Pachylasmatinae and the Hexelasmatinae. BUCKERIDGE (1983) suggested that *Bathylasma* be retained for those forms with pachylasmatid-like terga, solid calcareous compartments and normal chaetotaxy of the posterior cirri.

The following genera are included within the Bathylasmatinae herein: *Bathylasma*, *Mesolasma*, *Tetrachaelasma* and *Tessarelasma*.

#### Genus **BATHYLASMA** Newman & Ross, 1971

Fig. 49; Tables 20-21

*Bathylasma* Newman & Ross, 1971: 143.

DIAGNOSIS. — Adult with fixed shell pattern of 6 thin, calcareous compartmental plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C); parietes with prominent horizontal growth ridges lined with small setae; chitinous laminae absent. External alar



ridges diverging from inferior alar margin; superior alar margin with welting. Basis membranous. Articular ridges of T and S prominent. Mandible quadridentoid. Caudal appendages absent.

TYPE SPECIES. — *Balanus corolliformis* Hoek, 1883.

RECENT SPECIES. — *Bathylasma alearum* (Foster, 1978) Eastern Australia, New Zealand, Vanuatu; 414-1750 m; *B. corolliforme* (Hoek, 1883) (includes *Hexelasma antarcticum* Borradaile, 1916) circum Antarctic; to 1464 m; Pleistocene, to 70 m above sea level.; *B. hirsutum* (Hoek, 1883) North-east Atlantic, from Faeroe Is south to Azores; 944-1829 m.

FOSSIL SPECIES. — *Bathylasma aucklandicum* (Hector, 1888) Oligocene to Pliocene (Duntroonian or Waitakian to Waitotaran); New Zealand. *Bathylasma rangatira* Buckeridge, 1983 Lower Palaeocene to Lower Eocene; Chatham Islands.

REMARKS. — Members of this genus have solid shells, pachylasmatid-like T and normal chaetotaxy of the posterior cirri (FOSTER, 1981).

TABLES 20 and 21. — *Bathylasma*: characters of the species

	no. plates ext. int.		R: RL	CL <sup>1</sup> : CL <sup>2</sup>	T	aperture and plates	basis	alar growth lines
<i>B. alearum</i> (Foster, 1978)	6	6	n.a.	separate; basal width CL <sup>2</sup> = 1/4 basal width CL <sup>1</sup>	artic. ridge projecting well beyond artic. margin; spur 1/7 width basal margin, set at 1/14 basal margin from b-s angle; 8-9 muscle crests proj. just below basal margin	parietal plates not flaring; prom. setae on prom. ext. growth lines	membranous	not parallel to inferior alar margin
<i>B. corolliforme</i> (Hoek, 1883)	6	6	n.a.	separate; basal width CL <sup>2</sup> = 1/10 basal width CL <sup>1</sup>	artic. ridge projecting well beyond artic. margin; spur indistinct, set at b-s angle; 8-9 muscle crests not proj. below basal margin	parietal plates flaring; short se- tae on membrane above coarse ext. growth lines	membranous	parallel to inferior alar margin
<i>B. hirsutum</i> (Hoek, 1883)	6	6	n.a.	separate; basal width CL <sup>2</sup> = 1/7 basal width CL <sup>1</sup>	artic. ridge projecting beyond artic. margin; spur 1/6 width basal margin, set at 1/12 basal margin from b-s angle; muscle crests not proj. below basal margin	parietal plates not flaring; small setae on fine ext. growth lines	membranous	not parallel to inferior alar margin

	alar welting	chitin in paries	S shape	S growth lines	c.a.	mandible	distribution	depth
<i>B. alearum</i> (Foster, 1978)	conspicuous; narrow	absent	basal margin 7/10 occludent margin; artic. ridge proj. beyond artic. margin	well-spaced, regular; not cut by long. folds	absent	quadridentate; teeth 2-4 with small side teeth; upper and lower margins of tooth 4 with small subsidiary cusps	E Australia, New Zealand, Vanuatu	414-1750 m
<i>B. corolliforme</i> (Hoek, 1883)	conspicuous; narrow	absent	basal margin 3/4 occludent margin; artic. ridge slightly proj. beyond artic. margin	in upper 1/2 well-spaced, narrow in lower 1/2; regular; not cut by long. folds	absent	quadridentate; upper and lower margin of teeth without small subsidiary cusps	circum Antarctic,  Pleistocene	to 1464 m  70 m above sea level
<i>B. hirsutum</i> (Hoek, 1883)	wide and flat, 1/2 alar width	absent	basal margin 5/8 occludent margin; artic. ridge proj. beyond artic. margin	many, well- spaced, regular; not cut by long. folds	absent	quadridentate; lower margin of tooth 4 with small subsidiary cusps	NE Atlantic, from Fareoe Is to Azores	944-1829 m

artic. = articular; b-s = basi-scutal; c.a. = caudal appendage; ext. = external; int. = internal; long. = longitudinal; max. = maximum; n.a. = not applicable; proj. = projecting; prom. = prominent; segs = segments.



**DISTRIBUTION.** — Palaeocene to Recent. Lower Palaeocene to Lower Eocene: Chatham Islands; Oligocene: New Zealand, Victoria; Miocene to Pliocene: New Zealand; Lower Miocene: Burma; Pleistocene to Recent in Antarctica.

Recent: North Atlantic and oceans bordering Antarctica (deep seas): Antarctica, to 1464 m (*B. corolliforme*); New Zealand, eastern Australia, Vanuatu, 414-1750 m (*B. alearum*); N E Atlantic, 944-1829 m (*B. hirsutum*).

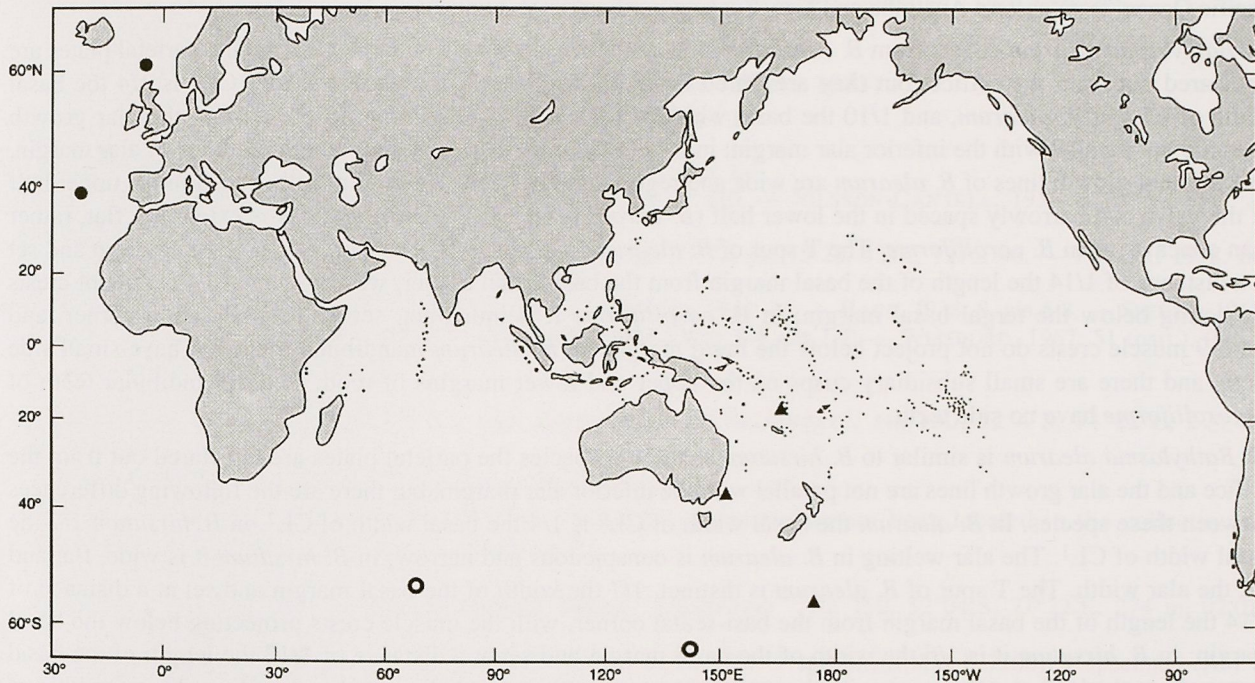


FIG. 49. — *Bathylasma* Newman & Ross, 1971. Distribution map: ○, *B. corolliforme* (to 1464 m); ▲, *B. alearum* (414-1750 m); ●, *B. hirsutum* (944-1829 m).

***Bathylasma alearum* (Foster, 1978)**

Fig. 49; Tables 20-21

*Hexelasma alearum* Foster, 1978: 80, fig. 49 A-L, pl. 10 A-B.

*Bathylasma alearum* - FOSTER, 1981: 356.

**MATERIAL EXAMINED.** — **Vanuatu.** MUSORSTOM 8: stn DW 1062, 619-658 m: 2 specimens (broken).

**New Zealand.** NZOI: stn F 132, 49°59'S, 177°32'E, 1335 m, 29.01.1965: holotype, on sponge *Epipolasis novaezelandiae* (NZOI 205).

**Australia.** Vessel unknown: stn BSS 641 Q, SSE Cape Conran, Victoria, 38°46'S, 148°34.8'E, 1750 m, 17.11.1981: several specimens (AM P 40930).

**TYPES.** — *Holotype*: NZOI 205; New Zealand, NZOI stn F 132, 49°59'S, 177°32'E, 1335 m, 29.01.1965: on sponge *Epipolasis novaezelandiae*; sandy substrate.

*Holotype depository*: NIWA.

**DIAGNOSIS.** — Parietal plates not flared out from orifice; prominent rows of setae on prominent external growth ridges. Basal width of CL<sup>2</sup> 1/4 basal width of CL<sup>1</sup>. Conspicuous narrow alar welting along superior alar margin; alar growth lines not parallel with inferior alar margin, leaving smooth, triangular extension of internal alar surface on outside towards alar angle beneath growth lines. S externally with regular, well-spaced growth lines, not cut by longitudinal folds; basal margin 7/10 length of occludent margin; articular ridge projecting. T articular ridge projecting well beyond articular margin; spur narrowly rounded, 1/7 width of basal margin, set at 1/14 width



of basal margin from basi-scutal angle; 8-9 strong muscle crests projecting just below basal margin. Mandible with teeth 2-4 with small side teeth, small subsidiary cusps on upper and lower margins of tooth 4.

REMARKS. — During the final preparation of this paper, A. CROSNIER showed me several samples recently collected by the MUSORSTOM 8 expedition in the waters of Vanuatu. Of this material, 2 specimens are identified as *Bathylasma alearum* (Foster, 1978). This record extends the range of *B. alearum* in the waters of the south-western Pacific Ocean, from eastern Australia and New Zealand northwards to Vanuatu.

*Bathylasma alearum* differs from *B. corolliforme* in a number of characters. In *B. alearum* the parietal plates are not flared out from the orifice, but they are flared in *B. corolliforme*. The basal width of CL<sup>2</sup> is 1/4 the basal width of CL<sup>1</sup> in *B. alearum*, and 1/10 the basal width of CL<sup>1</sup> in *B. corolliforme*. In *B. alearum* the alar growth lines are not parallel with the inferior alar margin; in *B. corolliforme* they are parallel with the inferior alar margin. The S scutal growth lines of *B. alearum* are wide and regular, rather than regular and well-spaced in the upper half of the valve and narrowly spaced in the lower half (*B. corolliforme*). In *B. alearum* the T is externally flat, rather than concave, as in *B. corolliforme*. The T spur of *B. alearum* is distinct, 1/7 the width of the basal margin and set at a distance of 1/14 the length of the basal margin from the basi-scutal corner, with 8-9 muscle attachment crests projecting below the tergal basal margin; in *B. corolliforme* it is indistinct, set at the basi-scutal corner, and the 8-9 muscle crests do not project below the basal margin. In *B. alearum* mandibular teeth 2-4 have small side teeth, and there are small subsidiary cusps on the upper and lower margins of tooth 4; the mandibular teeth of *B. corolliforme* have no side teeth.

*Bathylasma alearum* is similar to *B. hirsutum* as in both species the parietal plates are not flared out from the orifice and the alar growth lines are not parallel with the inferior alar margin, but there are the following differences between these species. In *B. alearum* the basal width of CL<sup>2</sup> is 1/4 the basal width of CL<sup>1</sup>, in *B. hirsutum* 1/7 the basal width of CL<sup>1</sup>. The alar welting in *B. alearum* is conspicuous and narrow; in *B. hirsutum* it is wide, flat and 1/2 the alar width. The T spur of *B. alearum* is distinct, 1/7 the width of the basal margin and set at a distance of 1/14 the length of the basal margin from the basi-scutal corner, with the muscle crests projecting below the basal margin; in *B. hirsutum* it is 1/6 the width of the basal margin and set at a distance of 1/12 the length of the basal margin from the basi-scutal corner, with the muscle crests not projecting below the basal margin. The mandible of *B. alearum* has mandibular teeth 2-4 with small side teeth, and small subsidiary cusps on the upper and lower margins of tooth 4; in *B. hirsutum* the lower margin of mandibular tooth 4 has small subsidiary cusps.

FOSTER (1978) noted similarities between *B. alearum* and the fossil *B. aucklandicum*, distinguishing the 2 species on size and the shape of the T articular ridge. BUCKERIDGE (1983) similarly considered *B. aucklandicum* to closely resemble *B. alearum*.

DISTRIBUTION. — New Zealand, eastern Australia, Vanuatu; 414-1750 m.

#### † *Bathylasma aucklandicum* (Hector, 1888)

*Scalpellum aucklandicum* Hector, 1888: 440.

*Pollicipes* (?) *aucklandicus* - BENHAM, 1903: 111. — PARK, 1910: 115, pl. 7 figs 3-7, 10-11.

*Pollicipes aucklandicus* - CLARKE, 1905: 419.

*Hexelasma aucklandicum* - WITHERS, 1913: 841, pl. 86 fig. 1; 1924: 19, figs 7-8, pl. 4 figs 1-4, pl. 5 fig. 1. — BUCKERIDGE, 1975: 121, figs 4 c, 5.1, 5.2. — FOSTER, 1978: 82, pl. 10 C-E.

*Bathylasma aucklandicum* - NEWMAN & ROSS, 1971: 151, pl. 25; 1976: 45; 1981: 356.

TYPES. — *Lectotype*: GS (locality no. 695); rostrum, figured on Pl. LXXXV fig. 1.

*Syntypes*: GS (locality no. 695); 6 rostral compartments, 9 carinal, 13 laterals (8 right and 5 left), 5 carino-laterals (3 right and 2 left), 1 tergum (Pl. LXXXV figs 2-13).

*Lectotype and syntypes depositary*: GS.

DIAGNOSIS. — Shell tall, cylindrical; aperture not flared. Parietal plates solid, calcareous, thin. External alar growth lines fine, diverging from inferior alar margin before turning abruptly downwards towards alar angle then



deflecting apically to form narrow welting along superior alar margin. Sheath insignificant or wanting. S flat with low articular ridge not projecting. T with elevated articular ridge projecting, short spur set close to basi-scutal angle.

REMARKS. — See remarks under *B. alearum* for similarities between *B. aucklandicum* and *B. alearum*.

DISTRIBUTION. — Oligocene to Pliocene (Duntroonian or Waitakian to Waitotaran); New Zealand.

***Bathylasma corolliforme* (Hoek, 1883)**

Fig. 49, Tables 20-21

*Balanus corolliformis* Hoek, 1883: 155, pl. 6 figs 21-22, pl. 13 figs 1-7.

*Hexelasma corolliforme* - HOEK, 1913: 245. — PILSBRY, 1916: 330. — NILSSON-CANTELL, 1930: 252, figs 11-1. — ZEVINA, 1968: 94, fig. 6 a-i.

*Bathylasma corolliforme* - NEWMAN & ROSS, 1971: 143, figs 71-72, pls 15-22, 43 A; 1976: 46. — FOSTER, 1978: 80, fig. 48 A-L; 1981: 356. — BUCKERIDGE, 1989: 333.

*Hexelasma antarcticum* Borradaile, 1916: 132, fig. 7. — WITHERS, 1924: 22. — BAGE, 1938: 8, pls 5-8. — SPEDEN, 1962: 746. — WEISBORD, 1965: 1015 (part.). — UTINOMI, 1965: 4, figs 1-4, pls 1-2. — WEISBORD, 1967: 51 (part.), figs 1-6, pls 1-2. — ZEVINA, 1968, fig. 1.

TYPES. — *Holotype*: BMNH 85.17; near Kerguelen I., "Challenger": stn 150, 52°4'S, 71°22'E, 274 m, 02.02.1874.

*Paratype*: BMNH 1917.2.9.59; "Terra Nova" Expedition.

*Holotype and paratype depository*: BMNH. (paratype specimen has not been located in the collection of BMNH) [Ms A. MORGAN, pers. comm., 05.02.1996].

MATERIAL EXAMINED. — **Near Kerguelen Island.** "Challenger": stn 150, 52°04'S, 71°22'E, 274 m, 02.02.1874: holotype (BMNH 85.17).

**Antarctic.** ANZARE: stn III, 66°32'S, 141°39'E, 297 m, 31.12.1913: 1 specimen (AM P 7206); 1 specimen (AM P 7207); 1 specimen (AM P 7209); 1 incomplete specimen (AM P 7210); 1 specimen (AM P 7211). All identified *Hexelasma antarcticum* Borradaile, 1916.

DIAGNOSIS. — Parietal plates flared out from orifice; rows of short setae on persistent membrane above coarse, external growth ridges. Basal width of CL<sup>2</sup> 1/10 basal width of CL<sup>1</sup>. Alae oblique; conspicuous, narrow alar welting along superior alar margin; alar growth lines parallel with inferior alar margin. S externally concave, with regular, well-spaced growth lines in upper half of valve, growth lines narrowly spaced in lower half, growth lines not cut by longitudinal folds; S basal margin 3/4 length of occludent margin; articular ridge slightly projecting. T externally concave, articular ridge projecting well beyond articular margin; spur indistinct, set almost at basi-scutal angle; 8-9 muscle crests not projecting below basal margin. Mandible with 4 teeth, small subsidiary cusps on upper and lower margins of teeth absent.

REMARKS. — The flaring orifice, the coarse growth ridges on the parietes and the alar growth ridges running along and closely paralleling the inferior alar margins distinguish this species. Differences between *B. corolliforme* and *B. alearum* are listed under *B. alearum*.

*Bathylasma corolliforme* differs from *B. hirsutum* as the parietal plates are flared out from the orifice in the former, rather than not flared in the latter; the growth lines of the parietal plates are coarse, rather than fine; and the alar growth lines are parallel, rather than not parallel, with the inferior alar margin. In *B. corolliforme* the basal width of CL<sup>2</sup> is 1/10 the basal width of CL<sup>1</sup>, in *B. hirsutum* 1/7 the basal width of CL<sup>1</sup>. The alar welting in *B. corolliforme* is conspicuous and narrow; in *B. hirsutum* it is wide, flat and 1/2 the alar width. The S scutal growth lines are regular and well-spaced in the upper half of the valve and narrowly spaced in the lower half in *B. corolliforme*; in *B. hirsutum* they are uniformly wide and regular. The T spur of *B. corolliforme* is indistinct, set almost at the basi-scutal corner, with the muscle crests not projecting below the basal margin; in *B. hirsutum* it is 1/6 the width of the basal margin and set at a distance of 1/12 the length of the basal margin from the basi-scutal corner, with the muscle crests not projecting below the basal margin. The mandible of *B. corolliforme*



has no subsidiary cusps on the upper and lower margins of tooth 4; in *B. hirsutum* the lower margin of mandibular tooth 4 has small subsidiary cusps.

DISTRIBUTION. — Circum Antarctic, to 1464 m; Pleistocene, to 70 m above sea level.

*Bathylasma hirsutum* (Hoek, 1883)

Fig. 49; Tables 20-21

*Balanus* sp. Jeffreys, 1878: 414 (*fide* SOUTHWARD & SOUTHWARD, 1958).

*Bathylasma hirsutus* Hoek, 1883: 158, pl. 13 figs 8-15. — GRUVEL, 1920: 55, pl. 1 figs 13-14.

*Hexelasma hirsutum* - HOEK, 1913: 245. — PILSBRY, 1916: 330. — SOUTHWARD & SOUTHWARD, 1958: 635. — UTINOMI, 1965: 11. — FOSTER, 1978: 79.

*Bathylasma hirsutum* - NEWMAN & ROSS, 1971: 149, fig. 73, pls 23-24; 1976: 46. — FOSTER, 1981: 356. — YOUNG, 1998: 66.

TYPES. — *Holotype*: BMNH 85.17; Faeroe Channel, "Triton": stn 10, 59°40'N, 7°21'W, 944 m, 24.10.1882.

*Holotype depository*: BMNH.

MATERIAL EXAMINED. — **Faeroe Channel**. "Triton": stn 10, 59°40'N, 7°21'W, 944 m, 24.10.1882: holotype (BMNH 85.17).

DIAGNOSIS. — Parietal plates thin, not flared out from orifice; rows of setae on yellow membrane above fine external growth ridges. CL<sup>1</sup> and CL<sup>2</sup> separate; basal width of CL<sup>2</sup> 1/7 basal width of CL<sup>1</sup>. Wide, flat alar welting along superior alar margin, 1/2 alar width; alar growth lines not parallel with inferior alar margin. S externally with regular, well-spaced growth lines, not cut by longitudinal folds; basal margin 5/8 length of occludent margin; articular ridge projecting. T articular ridge projecting well beyond articular margin; spur truncate, 1/6 width of basal margin, set at 1/12 width of basal margin from basi-scutal angle; muscle crests not projecting below basal margin. Mandible with lower margin of tooth 4 with small subsidiary cusps.

REMARKS. — This species can be distinguished by the non-flared aperture and by the fine, external growth ridges of the thin parietal plates. In addition the alar growth ridges are removed from and do not closely parallel the inferior alar margin, and the upturned alar margins of CL<sup>1</sup> and CL<sup>2</sup> are wide, 1/2 the width of the entire ala, and flat. Differences between *B. hirsutum* and *B. alearum* and *B. corolliforme* are listed under *B. alearum* and *B. corolliforme*, respectively

DISTRIBUTION. — North-east Atlantic, from the Faeroe Islands south to the Azores; 944-1829 m.

Genus *MESOLASMA* Foster, 1981

Fig. 50; Tables 22-23

*Mesolasma* Foster, 1981: 362.

DIAGNOSIS. — Adult with fixed shell pattern of 6 thickened, solid, calcareous compartmental plates including discrete rostral plate, paired CL<sup>1</sup> and CL<sup>2</sup>, and C (R-CL<sup>1</sup>-CL<sup>2</sup>-C); externally with prominent horizontal growth ridges lined with small setae and small beads; paries thickened and inflected inward basally; chitinous laminae absent. External alar growth ridges diverging from inferior alar margin; superior alar margin with narrow welting. Basis thin, calcareous. Articular ridge of S not prominent. Articular ridge of T not prominent. Mandible tridentoid or quadridentoid. Segments of posterior cirri longer than wide, with graded series of 3 or more setae on anterior edge. Caudal appendages absent.

TYPE SPECIES. — *Mesolasma fosteri* (Newman & Ross, 1971).



TABLES 22 and 23. — *Mesolasma*: characters of *Mesolasma fosteri*.

no. plates		R:RL	CL <sup>1</sup> : CL <sup>2</sup>	T	paries	basis	alar growth lines
ext.	int.						
6	6	n.a.	separate; basal width CL <sup>2</sup> subequal to basal width CL <sup>1</sup>	not proj.; spur pointed, 1/4 width basal margin, set 1/12 width basal margin from b-s angle	thickened; inflected inward basally; horizontal growth ridges prominent, lined with small setae	calcareous	diverging from inferior alar margin

alar wetting	chitin in paries	S shape	S growth lines	c.a.	mandible	size	distribution	depth
narrow	absent	artic. ridge not proj. beyond artic. margin	well-spaced, regular; not cut by long. striae	absent	tri- or quadri-dentate; upper and lower margins of teeth 3 and 4 sometimes with small subsidiary cusps	RC length 5.0 C height 4.0	New Zealand	490-1556 m

artic. = articular; b-s = basi-scutal; c.a. = caudal appendage; ext. = external; int. = internal; n.a. = not applicable; proj. = projecting.

REMARKS. — One species only is presently assigned to this genus. The genus occupies an intermediate position between *Bathylasma* and *Hexelasma* (FOSTER, 1981). The opercular plates of *Mesolasma* are more balanoid-like, lacking the prominent articular ridges found in *Bathylasma*, whereas the setation of the segments of the posterior cirri is less specialized than that found in *Hexelasma*.

DISTRIBUTION. — Oligocene to Recent. Oligocene: Victoria, Australia. Recent: Western Pacific Ocean: New Zealand, Norfolk and Kermadec Islands; 490-1556 m.

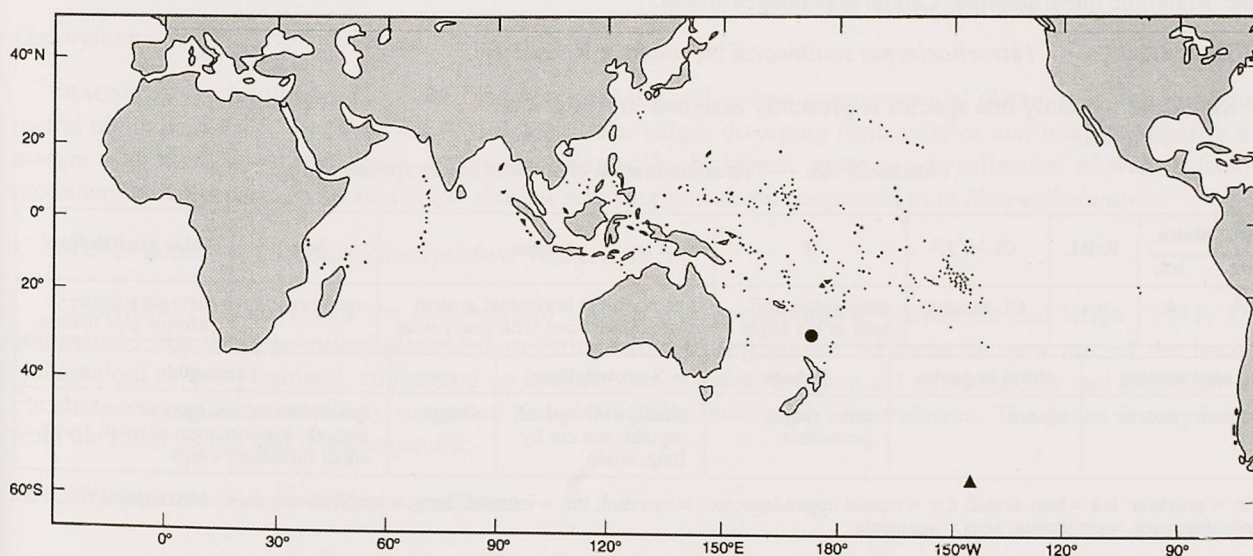


FIG. 50. — *Mesolasma* Foster, 1981 and *TETRACHAELASMA* Newman & Ross, 1971. Distribution map: ●, *M. fosteri* (490-556 m); ▲, *T. southwardi* (1190-2328 m).

*Mesolasma fosteri* (Newman & Ross, 1971)

Fig. 50; Tables 22-23

*Hexelasma fosteri* Newman & Ross, 1971: 155, figs 75-76; 1976: 46.

*Aptolasma fosteri* - FOSTER, 1978: 83 (part). Not pl. 10F, fig 50 (= *Hexelasma gracilis* Foster, 1981).

*Mesolasma fosteri* - FOSTER, 1981: 362, figs 8 C, 9.



**MATERIAL EXAMINED.** — **New Zealand.** TUI EXPED.: stn 011-14, north of Auckland, 30°45'S, 173°51'E, 538-676 m: holotype (USNM Type 125310).

**TYPES.** — *Holotype*: USNM Type 125310; New Zealand, TUI Exped., stn 011-14, north of Auckland, 30°45'S, 173°51'E, 538-676 m, with *Megalasma striatum* Hoek and *Trilasmis kaempferi* (Darwin), the former on the spine of echinoid, substratum of others unknown; slides (3).

*Holotype depository*: USNM.

**DIAGNOSIS.** — As for the genus.

**DISTRIBUTION.** — New Zealand, Norfolk and Kermadec Islands; 490-1556 m.

### Genus *TETRACHAELASMA* Newman & Ross, 1971

Fig. 50; Tables 24-25

*Tetrachaelasma* Newman & Ross, 1971: 152.

**DIAGNOSIS.** — Adult with fixed shell pattern of 4 thick, solid, calcareous compartmental plates including compound rostral plate, paired CL, and C (R-CL-C); parietes with fine horizontal growth ridges lined with small setae; chitin absent. External alar ridges diverging from inferior alar margin; superior alar margin with narrow, coarse welting. Basis membranous. S with prominent articular ridge. T similar to that of *Bathylasma* but articular margin sinusoidal rather than straight or concave; lateral depressor muscle crests few, restricted to small area below carinal angle. Rami of cirri II and III antenniform; intermediate articles of cirrus VI bearing 3 or 4 pairs of major setae. Mandible quadridentoid. Caudal appendages absent.

**TYPE SPECIES.** — *Tetrachaelasma southwardi* Newman & Ross, 1971.

**REMARKS.** — Only one species is presently assigned to this genus.

TABLES 24-25. — *Tetrachaelasma*: characters of the species

no. plates ext. int.		R:RL	CL <sup>1</sup> :CL <sup>2</sup>	T	paries	basis	alar growth lines
4	4	n.a.	CL present	artic. ridge proj.; spur at b-s angle	heavy; thick; horizontal growth ridges fine; lined with small setae	membranous	diverging from inferior alar margin
alar welting		chitin in paries		S shape	S growth lines	c.a.	mandible
narrow, coarse		absent		artic. ridge prominent	small, well-spaced, regular; not cut by long. striae	absent	quadridentate; margins of teeth 1-3 smooth; lower margin of tooth 4 with small subsidiary cusps

artic. = articular; b-s = basi-scutal; c.a. = caudal appendage; ext. = external; int. = internal; long. = longitudinal; max. = maximum; n.a. = not applicable; proj. = projecting; segs = segments.

**DISTRIBUTION.** — Southern Pacific Ocean, Antarctic Basin and off South America; 1190-2328 m.

### *Tetrachaelasma southwardi* Newman & Ross, 1971

Fig. 50; Tables 24-25

*Hexelasma antarcticum* Borradaile, 1916: 132 (part). — WEISBORD, 1965: 1015 (part); 1967: 51, pl. 2 figs 7-8 (part).  
*Tetrachaelasma southwardi* Newman & Ross, 1971: 152, fig. 74, pls 26-31.

**MATERIAL EXAMINED.** — **South Pacific Ocean.** "Eltanin": SOSC stn 6, 52°10'S, 142°10'W, 1260-1273 m, 20.03.1965: holotype (USNM 125305).



TYPES. — *Holotype*: USNM 125305; South Pacific Ocean, "Eltanin", SOSC stn 6, 52°10'S, 142°10'W, 1260-1273 m, 20.03.1965; dry (1 lot) and slide (1 lot).

*Paratypes*: USNM 125306, South Pacific Ocean, "Eltanin", SOSC stn 6, 52°10'S, 142°10'W, 1260-1273 m, 20.03.1965. — USNM 125307, off Falkland Is, "Eltanin", SOSC stn 376, 54°03'S, 56°03'W, 1720-1739 m, plates only. — USNM 125308, off southern Chile, "Eltanin", SOSC stn 216, 52°53'S, 75°36'W, 1190-1263 m, plates only. — USNM 125309, off Cape Horn, "Eltanin", SOSC stn 255, 59°45'S, 68°50'W, 1207-1591 m, plates only, in alcohol.

*Holotype and paratype depository*: USNM.

DIAGNOSIS. — As for the genus.

REMARKS. — The 4-platedness is due to the compound R and the absence of CL<sup>2</sup> (NEWMAN & ROSS, 1971). The morphology of this species is puzzling, not only because of the massive 4-plated wall and absence of radii, but also because of the flaring orifice and exceptionally broad carinal alae that internally contribute to about 1/2 of the sheath's circumference. Apparently, it reflects an early radiation into the deep sea, and has a combination of plesiomorphic and apomorphic characters that have likely evolved from the chionelasmatic level of organisation and, therefore, its relationship remains to be resolved.

DISTRIBUTION. — Southern Pacific Ocean, Antarctic Basin and off South America; 1190-2328 m.

### Genus *TESSARELASMA* Withers, 1936

Tables 26-27

*Tessarelasma* Withers, 1936: 591.

DIAGNOSIS. — Adult with fixed shell pattern of 4 solid, calcareous compartmental plates including compound rostral plate, paired CL, and C (R-CL-C). External alar ridges diverging from inferior alar margin; superior alar margin with narrow welting. Basis calcareous, marginally thickened, appearing as inflection of wall. S lacking prominent articular ridge, with area above shallow adductor muscle pit roughened as in *Hesperibalanus*.

TYPE SPECIES. — † *Tessarelasma pilsbryi* Withers, 1936.

REMARKS. — The T and the soft parts of this species are unknown. NEWMAN and ROSS (1971: 155) commented that the S is more balanoid than chthamaloid in appearance, whereas the structure of the basis is chthamaloid or bathylasmatid, suggesting an intermediate position between the chthamaloids and the balanoids. For these reasons they tentatively suggested bathylasmatid affinities for *Tessarelasma*. The genus is only known from the fossil record and is monospecific.

DISTRIBUTION. — Lower Miocene; Burma.

TABLES 26 and 27. — *Tessarelasma*: characters of the species

no. plates		R:RL	CL <sup>1</sup> :CL <sup>2</sup>	T	paries	basis	alar growth lines
ext.	int.						
4	4	n.a.	CL present	unknown	solid	calcareous, marginally thickened, as inflection of wall	diverging from inferior alar margin

alar welting		chitin in paries	S shape	S growth lines		c.a.	mandible
narrow, coarse		absent	balanoid, artic. ridge proj.	well-spaced, regular; not cut by long. striae		unknown	unknown

artic. = articular; c.a. = caudal appendage; ext. = external; int. = internal; long. = longitudinal; n.a. = not applicable; proj. = projecting.



† *Tessarelasma pilsbryi* Withers, 1936

Tables 26-27

*Tessarelasma pilsbryi* Withers, 1936: 591. — NEWMAN & ROSS, 1971: 155; 1976: 46.

TYPES. — *Holotype*: No registration number. Lower Miocene. Eastern Bengal in grey shale and greenish-grey sandstone, containing pebbles of shale, and forming part of the Surma series, about 2000 feet below the base of the Tipam Sandstone.

*Holotype depository*: Geological Department, BMNH.

DIAGNOSIS. — As for the genus.

REMARKS. — As for the genus.

DISTRIBUTION. — Lower Miocene; Burma.

## Subfamily HEXELASMATINAE Newman &amp; Ross, 1976

Tables 1-2

DIAGNOSIS. — Primary shell wall not surrounded by whorl(s) of imbricating plates. Adult shell wall with 6 plates (R-CL<sup>1</sup>-CL<sup>2</sup>-C) divided into inner and outer laminae by longitudinal chitinous rods; externally with prominent horizontal growth ridges lined with small setae. External alar growth ridges parallel to or diverging from inferior alar margin; superior alar margin with narrow to moderate welting. Basis calcareous, thin centrally; sometimes membranous. Opercular plates with articular ridges not prominent. Mandible quadridentoid. Caudal appendages absent.

REMARKS. — Only one genus, *Hexelasma*, is contained in this sub-family. Heretofore 9 species were included in *Hexelasma*. Six new species are described in the present report bringing to 15 the number of hexelasmatine presently known.

DISTRIBUTION. — Eocene to Recent. Eocene: Tonga. Lower Miocene: Victoria. Recent: Western Atlantic, Indo-west Pacific, Australasia.

Genus *HEXELASMA* Hoek, 1913

Figs 51, 64; Tables 28-30

*Hexelasma* Hoek, 1913: 244 (in part.). — PILSBRY, 1916: 329. — KRÜGER, 1940: 30. — WITHERS, 1953: 99. — UTINOMI, 1965: 13; 1968: 30. — ZEVINA, 1968: 64. — NEWMAN & ROSS, 1971: 155.  
*Aptolasma* Newman & Ross, 1971: 158. — FOSTER, 1981: 356.

DIAGNOSIS. — As for the subfamily, which is monogeneric.

TYPE SPECIES. — *Hexelasma velutinum* Hoek, 1913.

RECENT SPECIES. — *Hexelasma americanum* Pilsbry, 1916; *H. arafurae* Hoek, 1913; *H. aureolum* sp. nov.; *H. brintoni* (Newman & Ross, 1971); *H. callistoderma* Pilsbry, 1911; *H. flavidum* sp. nov.; *H. foratum* sp. nov.; *H. globosum* sp. nov.; *H. gracilis* Foster, 1981; *H. leptoderma* (Newman & Ross, 1971); *H. nolearia* (Foster, 1978); *H. persicum* sp. nov.; *H. sandaracum* sp. nov.; *H. triderma* (Newman & Ross, 1971); *H. velutinum* Hoek, 1913.



TABLE 28. — *Hexelasma*: characters of the species

	no. plates ext. int.	R:RL	CL <sup>1</sup> :CL <sup>2</sup>	T	basis
<i>H. americanum</i> Pilsbry, 1916	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/3 basal width CL <sup>1</sup>	artic. ridge not proj.; spur obliquely truncate, width 1/3 basal margin, slightly removed from b-s angle; inner surface smooth	membranous, with narrowly inflected calcareous borders
<i>H. arafurae</i> Hoek, 1913	6 6	n.a.	separate; basal width CL <sup>2</sup> ≥ 1/2 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncate, >1/3 width of basal margin, set almost at b-s angle; inner surface smooth	calcareous, thin
<i>H. aureolum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/4-1/3 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncate, 1/4 width of basal margin, set at its own width from b-s angle; inner surface rough with 6-9 irregular. low ridges and beading	calcareous, thin
<i>H. brintoni</i> (Newman & Ross, 1971)	6 6	n.a.	separate; basal width CL <sup>2</sup> = 3/5 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncated, 1/3 width of basal margin, forming abrupt angle of 130° with basal margin; spur set at 1/2 its own width from b-s angle; inner surface smooth	calcareous, thick
<i>H. callistoderma</i> Pilsbry, 1911	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/4-1/5 basal width CL <sup>1</sup>	artic. ridge not proj.; spur broadly 1/4 width of basal margin; spur set at 1/2 its width from b-s angle; inner surface roughened distally with linear beading	membranous (young); with thick calcareous ledge (adults)
<i>H. flavidum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/3 or <1/3 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncated, >1/3 width of basal margin forming abrupt angle of 130° with basal margin; spur set at 1/4 its own width from b-s angle; inner surface roughened	calcareous edges, membranous centrally; thin
<i>H. foratum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/4-1/3 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncate, 3/10 width of basal margin, set at less than 1/2 its own width from b-s angle; inner surface roughened over 2/3 of surface	calcareous; thick; pinprick holes perforating junction of basis and inner parietal surface
<i>H. globosum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	artic. ridge proj., spur truncate, 1/4 width of basal margin, set at distance of < 1/2 its width from b-s angle; inner surface rough over 2/3 surface	calcareous; thin
<i>H. gracilis</i> Foster, 1981	6 6	n.a.	separate; basal width CL <sup>2</sup> sub = to basal width CL <sup>1</sup>	artic. ridge not proj.; spur rounded, 1/4 width of basal margin, set at 1/2 its width from b-s angle; inner surface smooth	with wide calcareous ledge
<i>H. leptoderma</i> (Newman & Ross, 1971)	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	artic. ridge not proj.; spur pointed, 1/4 width of basal margin, set at 1/2 its width from b-s angle; inner surface rough distally	calcareous
<i>H. nolearia</i> (Foster, 1978)	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	artic. ridge not proj., artic. margin convex; spur indistinct, 1/3 width of basal margin, set at b-s angle; inner surface roughened distally	calcareous
<i>H. persicum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/2 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncated, broad, 1/4 width of basal margin; spur set at 1/3 its width to b-s angle; inner surface roughened distally	calcareous; thin
<i>H. sandaracum</i> sp. nov.	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/3-1/2 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncated, broad, 1/4 width of basal margin; spur set at 1/2 its width from b-s angle; inner surface slightly roughened in upper 1/2	calcareous; thin
<i>H. triderma</i> (Newman & Ross, 1971)	6 6	n.a.	separate; basal width CL <sup>2</sup> = 1/2-2/3 basal width CL <sup>1</sup>	unknown	calcareous
<i>H. velutinum</i> Hoek, 1913	6 6	n.a.	separate; basal width CL <sup>2</sup> = 2/3 basal width CL <sup>1</sup>	artic. ridge not proj.; spur truncated, 1/3 width of basal margin, set at 1/12 length of basal mar- gin from basi-scutal angle; inner surface smooth	calcareous, thin



TABLE 29. — *Hexelasma*: characters of the species (continued)

	S shape	S growth lines	c.a.	mandible
<i>H. americanum</i> Pilsbry, 1916	S basal margin 1/2 length of S occludent margin; adductor ridge absent; few crests for lateral depressor muscles present; inner surface smooth; S artic. ridge not proj.	regular, smooth; long. striae absent	absent	quadridentate; teeth acute, upper and lower margins of teeth smooth
<i>H. arafurae</i> Hoek, 1913	S basal margin 2/3 length of S occludent margin; adductor ridge present; crests for lateral depressor muscles present; inner surface rough; S artic. ridge not proj.	smooth, even; cut by 1 broad, long. stria	absent	quadridentate; upper margins of teeth 3 and 4 with small subsidiary cusps
<i>H. aureolum</i> sp. nov.	S basal margin 9/14 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles present; inner surface with irregular beading distally; S artic. ridge slightly proj.	sinuous, transverse, cut by 2 narrow, long. striae	absent	quadridentate; 1 small subsidiary tooth sometimes between teeth 3 and 4; lower margin of tooth 4 with 1 small subsidiary cusp
<i>H. brintoni</i> (Newman & Ross, 1971)	S basal margin 2/3 length of S occludent margin; adductor ridge present; crests for lateral depressor muscles present; inner surface smooth; S artic. ridge not proj.	smooth, even, widely spaced; not cut by long. stria	absent	quadridentate; teeth 2 and 3 with side teeth, upper and lower margins of tooth 4 with small subsidiary cusps
<i>H. callistoderma</i> Pilsbry, 1911	S basal margin 5/9 length of S occludent margin; adductor ridge faint; crests for lateral depressor muscles present; inner surface smooth; S artic. margin not projecting	smooth, even; not cut by long. stria	absent	quadridentate; upper and lower margins of teeth smooth
<i>H. flavidum</i> sp. nov.	S basal margin 9/14 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles slight; inner surface smooth; S artic. ridge not proj.	sinuous, well-spaced; cut by slight, long. striae	absent	quadridentate; upper and lower margins of tooth 4 with irregular, small, subsidiary cusps
<i>H. foratum</i> sp. nov.	S basal margin 4/7 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles absent; inner surface roughened distally; S artic. ridge slightly proj.	sinuous, widely spaced; not cut by long. striae	absent	quadridentate; teeth 2 and 3 each with 1 small subsidiary cusp; upper and lower margins of tooth 4 with irregular, small subsidiary cusps
<i>H. globosum</i> sp. nov.	S basal margin 2/3 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles absent; inner surface smooth; S artic. ridge slightly proj.	sinuous, well spaced; cut by 3 slight, long. striae, middle stria most marked	absent	quadridentate; upper and lower margins of tooth 4 with irregular, small subsidiary cusps
<i>H. gracilis</i> Foster, 1981	S basal margin 3/4 length of S occludent margin; adductor ridge faint; crests for lateral depressor muscles faint; inner surface smooth; S artic. ridge not proj.	sinuous, widely spaced; not cut by long. striae	absent	quadridentate; tooth 2 with side teeth
<i>H. leptoderma</i> (Newman & Ross, 1971)	S basal margin 9/14 length of S occludent margin; adductor ridge present; crests for lateral depressor muscles present; inner surface roughened distally; S artic. ridge not proj.	smooth, well spaced, not cut by long. striae	absent	quadridentate; upper and lower margins of tooth 4 with small subsidiary cusps
<i>H. nolearia</i> (Foster, 1978)	S basal margin 4/7 length of S occludent margin; adductor ridge prominent; crests for lateral depressor muscles faint; inner surface smooth; S artic. ridge not proj.; occludent and articular margins folded	smooth, well spaced, not cut by long. striae	absent	tri- or quadri-dentate; upper and lower margins of all teeth smooth
<i>H. persicum</i> sp. nov.	S basal margin 9/16 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles feeble or absent; inner surface smooth; S artic. ridge not proj.; occludent and articular margins folded	sinuous, narrowly spaced; cut by 3 faint long. striae, 2 near occludent margin, 1 near artic. margin (latter only marked in lower 1/2)	absent	quadridentate; tooth 2 with 1 to several small subsidiary cusps; upper and lower margins of tooth 4 with small, irregular, subsidiary cusps
<i>H. sandaracum</i> sp. nov.	S basal margin 9/15 length of S occludent margin; adductor ridge feeble; crests for lateral depressor muscles low; inner surface smooth; S artic. ridge not proj.; occludent and articular margins folded, rounded	sinuous, widely spaced; cut by 3 long. striae, 2 near occludent margin (stria near middle most definite), 1 near artic. margin (marked only for 2/3 length)	absent	quadridentate; upper margin of tooth 3 with 1 or more small subsidiary cusps; upper and lower margins of tooth 4 with small, irregular, subsidiary cusps



<i>H. triderma</i> (Newman & Ross, 1971)	unknown	unknown	absent	unknown
<i>H. velutinum</i> Hoek, 1913	S convex ext.; convex basal margin 2/3 length of S occludent margin; adductor ridge weak; crests for lateral depressor muscles absent; inner surface distally roughened; S artic. ridge not proj.; occludent and articular margins folded, roughened	smooth, widely spaced; not cut by 3 long. striae	absent	quadridentate; upper margins of teeth 2-4 with side teeth; lower margin of 4 with small subsidiary cusps; lower angle produced into single or bifid spine

artic. = articular; b-s = basi-scutal; c.a. = caudal appendage; ext. = external; int. = internal; n.a. = not applicable; long. = longitudinal; proj. = projecting.

TABLE. 30. — *Hexelasma*: characters of the species (continued)

	welting on supra alar margin	chitin in paries	color of opercular valves	persistent epidermis
<i>H. americanum</i> Pilsbry, 1916	narrow; inferior alar margin not curved, with slight hook at free end	as long rods, sub-arcuate in x-section, regularly spaced, separated by calcareous bridges	pale orange	thin, pale color
<i>H. arafurae</i> Hoek, 1913	inconspicuous; externally with strong growth ridges	continuous lamina of chitin bisecting thickness of parietal plates	orange to brick red	absent
<i>H. aureolum</i> sp. nov.	sometimes inconspicuous; narrow; inferior alar margin curved, with slightly basally directed hook at free end; externally with fine, narrow growth ridges	as lamina on inner surface of paries, or as rods separating paries into inner (1/4) and outer (3/4) laminae	whitish apically, sometimes pink orange-brown	thick; golden yellow
<i>H. brintoni</i> (Newman & Ross, 1971)	ridged, narrow; inferior alar margin curved, without basally directed hook at free end; externally with weakly marked growth ridges	long rods, sub-arcuate in x-section, regularly spaced, separated by broad calcareous bridges, bisecting thickness of parietal plates	white	brownish
<i>H. callistoderma</i> Pilsbry, 1911	thin; rough; externally with fine alar growth ridges	long rods, sub-arcuate in x-section, separated by regularly spaced, broad calcareous bridges	white	present on S and T
<i>H. flavidum</i> sp. nov.	serrate edge; narrow, ridged; inferior alar margin curved, slight hook at free end; externally with growth ridges well spaced	as lamina on inner surface of paries, between long. ribs, and within paries as long. rods, separating paries into inner (1/4) and outer (3/4) laminae	golden-orange externally, cream apices; orange-cream internally	absent
<i>H. foratum</i> sp. nov.	narrow, ridged, increasing in length toward free end; inferior alar margin curved, without distal hook at free end	long., spaced rods bisecting thickness of parietal plates	whitish	yellow
<i>H. globosum</i> sp. nov.	ridged, narrow at summit, wider toward alar angle; inferior alar margin curved, without hook at free end	thin lamina applied in long strips to inner surfaces of paries	whitish	absent
<i>H. gracilis</i> Foster, 1981	narrow, ridged; externally with growth ridges well marked, diverging from alar margin	as long rods, arcuate in x-section, separated by regularly spaced broad calcareous bridges dividing plate into laminae of equal width	dull orange internally	absent
<i>H. leptoderma</i> (Newman & Ross, 1971)	thin; inferior alar margin turning downward abruptly to form hook at free end; externally with fine growth ridges	as long., contiguous rods which form an almost continuous layer between inner and outer laminae; inner lamina and chitinous layer thin		yellow
<i>H. nolearia</i> (Foster, 1978)	narrow; inferior alar margin not curved, no basally directed hook at free end	as paired ribbons, situated inwards from grooves between ribs on inner surface of paries, dividing paries into thicker outer and thinner inner laminae		



<i>H. persicum</i> sp. nov.	ridged, increasing in width toward free end; inferior alar margin curved, with blunt, basally directed hook at free end	as chitinous rods, separating paries into inner (1/3) and outer (2/3) laminae	peachy-orange	ochre/yellow epidermis on scutum
<i>H. sandaracum</i> sp. nov.	narrow, ridged, serrated upper margin; inferior alar margin hollowed out, with blunt hook at free end; externally with widely spaced growth ridges	as lamina on inner surface of paries	orange (fresh material) or white	thin; colorless
<i>H. triderma</i> (Newman & Ross, 1971)	broad; inferior alar margin with abrupt, basally directed hook at free end; externally with strongly marked growth ridges	paries separated into 2 equal laminae by thin, almost continuous chitinous layer, of laterally elongate rods of chitin, straight in x-section, infrequently connected by small, inconspicuous calcareous bridges		brownish
<i>H. velutinum</i> Hoek, 1913	narrow, finely crenated; externally with parallel ridges	as lamina of orange chitin on inner surface of paries	white	velvety, thin; greyish

artic. = articular; b.-s. = basi-scutal angle; c.a. = caudal appendage; ext. = external; int. = internal; long. = longitudinal; n.a. = not applicable; proj. = projecting; segs = segments.

REMARKS. — Difficulties regarding the definition and familial placement of the deep-sea genera *Aaptolasma*, *Bathylasma* and *Hexelasma* were discussed by FOSTER (1978, 1981). Re-examination of the type material of *H. velutinum* led FOSTER (1981) to conclude that *Hexelasma* was a valid genus, but that *Aaptolasma* was a junior synonym of *Hexelasma*. FOSTER (1981) also described the new genus *Mesolasma* to accommodate *H. fosteri* (Newman & Ross, 1971). BUCKERIDGE (1983) included *Mesolasma* in the Bathylasmatinae.

HOEK (1913) established the genus *Hexelasma* but did not designate a type species. *Hexelasma velutinum* was designated as the type species of the genus by WITHERS (1913) and by subsequent selection by UTINOMI (1965) who, probably not realising that WITHERS (1913) had already designated a type species for *Hexelasma*, similarly designated *Hexelasma velutinum* as the type. FOSTER (1981) apparently also overlooked WITHERS' (1913) designation. BUCKERIDGE (1983) incorrectly listed *Balanus callistoderma* Pilsbry, 1911 as the type species of *Hexelasma*. *Balanus callistoderma* was the type species of *Aaptolasma* originally designated by NEWMAN and ROSS (1971).

Much confusion has stemmed from the fact that HOEK (1913) confounded more than 1 species in his description of *Hexelasma velutinum* — viz. *H. velutinum* s. str., *H. leptoderma* (Newman & Ross, 1971), and *H. arafurae* (Hoek, 1913). Of the 4 specimens originally included by HOEK (1913) in *H. velutinum*, 1 specimen had operculae which differed from those of the 2 specimens of *H. velutinum* ("Siboga", stn 105) and the single specimen from "Siboga", stn 251. This 'odd' specimen and its operculae were illustrated by HOEK (1913: 247, pl. 26 figs 3-5) and was later confirmed by FOSTER (1981) to be *H. leptoderma* Newman & Ross, 1971. FOSTER (1981) also determined that the parietal plates of *H. leptoderma* did not contain chitinous laminae, but that strips of orange chitin were present on the inner surface. The specimen from "Siboga", stn 251 was attributed to *H. arafurae* by FOSTER (1981). The types of *H. velutinum* show no chitinous lamellae in the parietal shell, but do have a lamina applied basally to the inner faces of the shell plates. These specimens are considered immature since, in the further development of these laminae in larger specimens, calcite layers are found on either side of the laminae (FOSTER, 1981).

DISTRIBUTION. — Eocene to Recent. *Eocene*: Tonga; *Lower Miocene*: Victoria; *Recent*: Western Atlantic, Indo-west Pacific, 70-1300 m.

Off Florida, 734-770 m (*H. americanum*); Arafura Sea, 560 m (*H. arafurae*); Kei Is, 290 m (*H. leptoderma*); Vanuatu, New Caledonia, Loyalty Is, Norfolk Ridge, Wallis Is, Combe Bank, Field Bank, Tuscarora Bank, 170-1300 m (*Hexelasma sandaracum*); Chesterfield Is, Lord Howe Ridge, New Caledonia, Loyalty Ridge, Norfolk Ridge, 257-730 m (*H. aureolum*); New Caledonia, Loyalty Is, Norfolk Ridge, 255-608 m (*H. flavidum*); New Caledonia, Loyalty Is, Norfolk Ridge, 275-585 m (*H. persicum*); New Caledonia, Loyalty Is, 370-575 m (*H. globosum*); Vanuatu, Loyalty Is, 270-500 m (*H. foratum*); New Zealand, 741 m (*H. nolearia*); New Zealand, 1024-1029 m (*H. gracilis*); Japan, 115-141 m (*H. callistoderma*); Japan, 549 m (*H. triderma*); Japan, Philippines to South China Sea, 204-390 m (*H. velutinum*); Vietnam, 110-198 m (*H. brintoni*).



TABLE 31. — *Hexelasma*: maximum size, geographical and bathymetrical distribution of the species

	size (max.)	distribution	depth
<i>H. americanum</i> Pilsbry, 1916	RC length 17.0 C height 21.0	off Florida	734-770 m
<i>H. arafurae</i> Hoek, 1913		Arafura Sea	560 m
<i>H. aureolum</i> sp. nov.	RC length 19.0 C height 18.0	Chesterfield Islands Lord Howe Ridge New Caledonia Loyalty Ridge Norfolk Ridge	500 m 500-580 m 500-530 m 257-420 m 470-730 m
<i>H. brintoni</i> (Newman & Ross, 1971)		S China Sea (Vietnam)	110-198 m
<i>H. callistoderma</i> Pilsbry, 1911		Japan	115-141 m
<i>H. flavidum</i> sp. nov.	RC length 10.0 C height 6.0	New Caledonia Loyalty Islands Norfolk Ridge	560-608 m 300 m 255-370 m
<i>H. foratum</i> sp. nov.	RC length 10.9 C height 4.4	Loyalty Islands	270-330 m
<i>H. globosum</i> sp. nov.	RC length 12.5 C height 14.0	New Caledonia Loyalty Islands	525-575 m 370-465 m
<i>H. gracilis</i> Foster, 1981		New Zealand	1024-1029 m
<i>H. leptoderma</i> (Newman & Ross, 1971)		Kei Islands, Indonesia	290 m
<i>H. nolearia</i> (Foster, 1978)		New Zealand	741 m
<i>H. persicum</i> sp. nov.	RC length 19.4 C height 16.9	New Caledonia Loyalty Islands Norfolk Ridge	300-585 m 400-515 m 275-535 m
<i>H. sandaracum</i> sp. nov.	RC length 33.0 C height 27.02	Vanuatu New Caledonia Loyalty Islands Norfolk Ridge Combe Bank Wallis Islands Tuscarora Bank Field Bank	344-1220 m 170-960 m 270-680 m 300-540 m 700-1300 m 360-765 m 547-552 m 510-600 m
<i>H. triderma</i> (Newman & Ross, 1971)	RC length 19.5 C height 12.0	Japan	549 m
<i>H. velutinum</i> Hoek, 1913	RC length 10.0 C height 13.0	Japan Philippines to S China Sea	204-390 m

*Hexelasma americanum* Pilsbry, 1916

Fig. 51; Tables 28-31

*Hexelasma americanum* Pilsbry, 1916: 330, fig. 98, pl. 69 figs 1-3 a. — UTINOMI, 1965: 12. — NEWMAN & ROSS, 1976: 46. — FOSTER, 1981: 356. — YOUNG, 1998: 66, figs 1, 20-21.

*Aptolasma americanum* - NEWMAN & ROSS, 1971: 161, pls 32 A-B, 36, 37. — FOSTER, 1978: 79.

MATERIAL EXAMINED. — **United States.** "Albatross": stn 2663, off E coast of Florida, 29°39'N, 79°49'W, 770 m, 04.04.1886: holotype (USNM Type 14559).

TYPES. — *Holotype*: USNM 14559; United States, off S Carolina, "Albatross" stn 2663, 29°39'N, 79°49'W, 770 m, 04.04.1886, bottom temperature 42.7°F, seated on a branch of coral; complete specimen, dry.



*Paratype*: USNM 48093, from "Albatross", stns 2662-3-9, 2671-2; remains of 3 individuals.

*Holotype and paratype depository*: USNM.

**DIAGNOSIS.** — Parietals with longitudinal chitin-filled tubes, sub-arcuate in cross-section, regularly spaced, separated from one another by pronounced calcareous bridges. Basal width of CL<sup>2</sup> 1/3 basal width of CL<sup>1</sup>. Inferior alar margin not curved, with slight hook at free end; narrow welting along superior alar margin. Basis membranous, with narrowly inflected calcareous borders. S internally smooth; few crests for lateral depressor muscles present; externally smooth, regular growth lines not cut by longitudinal striae. T spur obliquely truncate, 1/3 width of basal margin, slightly removed from basi-scutal angle. Mandibular teeth acute, margins smooth.

**REMARKS.** — *Hexelasma americanum* is a large sized species (maximum: RC length 17.0, C height 21.0), with pale orange opercular plates.

**DISTRIBUTION.** — Off Florida, 734-770 m.

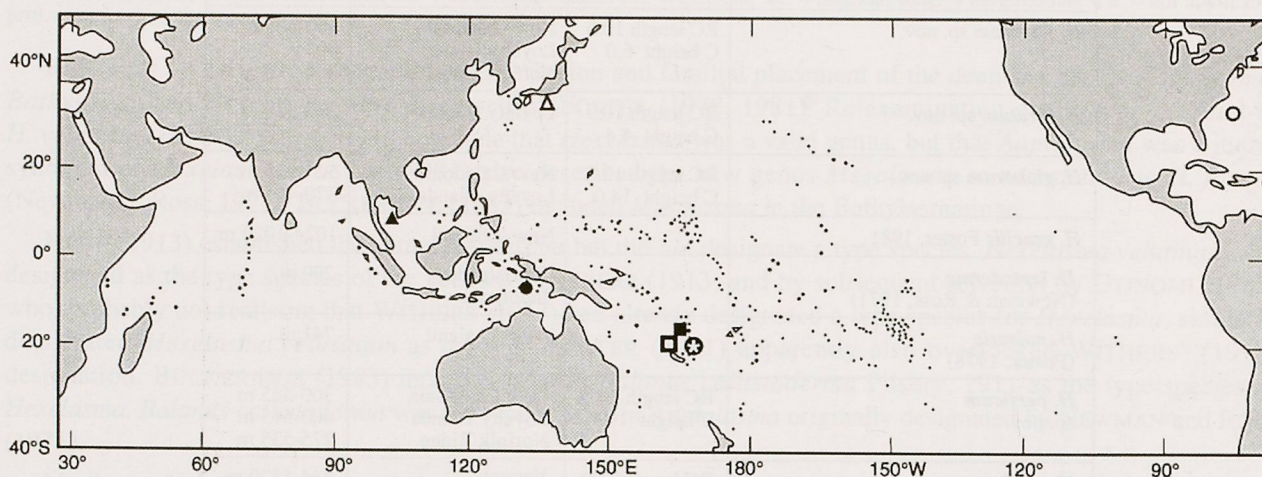


FIG. 51. — *Hexelasma* Hoek, 1913. Distribution map: ▲, *H. brintoni* (110-198 m); ○, *H. americanum* (734-770 m); △, *H. callistoderma* (115-141 m); ●, *H. arafurae* (560 m); □, *H. aureolum* (257-730 m); ■, *H. flavidum* (255-608 m); ⊗, *H. foratum* (270-500 m).

### *Hexelasma arafurae* Hoek, 1913

Fig. 51; Tables 28-31

*Hexelasma arafurae* Hoek, 1913: 251, pl. 25 figs 12-16. — UTINOMI, 1965: 11. — NEWMAN & ROSS, 1971: 155; 1976: 46. — FOSTER, 1981: figs 6 F-H.

*Aptolasma arafura* - FOSTER, 1978: 79.

**MATERIAL EXAMINED.** — **Indonesia.** "Siboga": stn 262, 5°53.8'S, 132°48.8'E, 560 m, 18.12.1899: holotype (ZMUA Cirr. 100.318).

**TYPES.** — *Holotype*: ZMUA Cirr. 100.318; Indonesia, "Siboga", stn 262, 5°53.8'S, 132°48.8'E, 560 m, 18.12.1899, in alcohol.

*Holotype depository*: ZMUA.

**DIAGNOSIS.** — Continuous chitinous lamina bisecting thickness of parietal plates. Basal width of CL<sup>2</sup> more than 1/2 basal width of CL<sup>1</sup>. Alae externally with strongly marked growth ridges; welting along superior alar margin inconspicuous. Basis calcareous, thin. S internal surface rough; crests for lateral depressor muscles present; externally smooth, even growth lines cut by a broad, longitudinal stria. T spur truncate, more than 1/3 width of basal margin, set almost at basi-scutal angle; inner surface smooth. Mandible with upper margins of teeth 3 and 4 with small subsidiary cusps.



REMARKS. — *Hexelasma arafurae* is a "large" species, with orange to brick-red orange opercular plates. The tall conical shell and the toothed orifice of *H. arafurae* are common to *H. aureolum* sp. nov., *H. callistoderma*, *H. persicum* sp. nov. and *H. velutinum*. Differences between *H. arafurae*, *H. aureolum* sp. nov. and *H. persicum* sp. nov. may be found under *H. aureolum* sp. nov. and *H. persicum* sp. nov., respectively.

*Hexelasma callistoderma* differs from *H. arafurae* as the former has parietal plates with longitudinal chitin-filled tubes, sub-arcuate in cross-section, separated from one another by regularly spaced, broad calcareous bridges; and the basal width of CL<sup>2</sup> is 1/4-1/5 the basal width of CL<sup>1</sup>. In juvenile *H. callistoderma* the basis is membranous, adults having a thick calcareous ledge. The opercular plates of *H. callistoderma* are white. The S internal surface is smooth and externally the smooth, even growth lines are not cut by longitudinal striae. The T spur is roundly truncated, 1/4 the width of the basal margin, and set at 1/2 its own width from the basi-scutal angle; the inner surface is distally roughened in the carinal area above the muscle crests with linear beading. The mandible with no small subsidiary cusps.

*H. velutinum* is a large species (maximum: RC length 10.0, C height 13.0), with orange chitin applied to the inner surfaces of the parietal plates, which differs from *H. arafurae* as follows: the basal width of CL<sup>2</sup> is 2/3 the basal width of CL<sup>1</sup>; the welting along the superior alar margin is narrow and finely crenated; the opercular plates are white; the S is convex externally, with smooth, widely-spaced, growth lines which are not cut by longitudinal striae; internally the adductor ridge is weak, crests for the lateral depressor muscles are absent; and the occludent and articular margins are rounded and folded; the T spur is set slightly apart from the basi-scutal angle; and the inner surface is roughened.

DISTRIBUTION. — Arafura Sea, 560 m.

*Hexelasma aureolum* sp. nov.

Figs 51-54; Tables 28-31

MATERIAL EXAMINED. — **Chesterfield Islands.** CORAIL 2: stn DE 16, 500 m: 2 specimens (WAM C 23253). — Stn CP 17, 500 m: 1 specimen.

**Lord Howe Ridge.** MUSORSTOM 5: stn DW 338, 540-580 m: 1 specimen (MNHN-Ci 2702). Drawn. — Stn CP 389, 500 m: 2 specimens (WAM C 23254, WAM C 23255).

**New Caledonia.** MUSORSTOM 4: stn DW 156, 525 m: 2 specimens. — Stn CP 238, 500-510 m: 1 specimen.

SMIB 8: stn DW 150, 519-530 m: 1 specimen.

**Loyalty Ridge.** MUSORSTOM 6: stn DW 422, 257 m: 1 specimen, attached to sponge. — Stn DW 460, 420 m: 1 specimen (incomplete) (WAM C 23256). — Stn DW 476, 300 m: 2 specimens, attached to stones (WAM C 23257). — Stn DW 478, 400 m: several specimens.

**Norfolk Ridge.** CHALCAL 2: stn DW 72, 527 m: 1 specimen, attached to sponge (MNHN-Ci 2411). — Stn DW 72, 527 m: 2 specimens, 1 attached to coral rubble, 1 to sponge (BMNH). — Stn DW 76, 470 m: 2 specimens.

SMIB 3: stn DW 5, 502-512 m: 1 specimen (MNHN-Ci 2412).

SMIB 4: stn DW 61, 550 m: 1 specimen, attached to coral.

BATHUS 3: stn DW 809, 650-730 m: 1 specimen. — Stn DW 819, 478-486 m: 1 specimen, attached to sponge (USNM).

TYPES. — *Holotype*: MNHN-Ci 2411 (CHALCAL 2, stn DW 72).

*Paratypes*: BMNH (CHALCAL 2, stn DW 72). — MNHN-Ci 2412 (SMIB 3, stn DW 5). — MNHN-Ci 2702 (MUSORSTOM 5, stn DW 338). Drawn. — USNM (BATHUS 3, stn CP 819). — WAM C 23253 (CORAIL 2, stn DE 16).

DIAGNOSIS. — Thin parietal plates with chitin either as lamina on inner walls of parietes, or as rods within paries separating paries into inner (1/4 thickness) and outer (3/4 thickness) lamina. Basal width of CL<sup>2</sup> 1/4-1/3 basal width of CL<sup>1</sup>; bases of plates thickened, forming calcareous ring. Inferior alar margin curved with slightly basally directed hook at free end; externally with fine, narrow growth ridges; narrow welting (sometimes inconspicuous) along superior alar margin. Basis calcareous, thin. Opercular plates whitish, apical areas of S and T pinkish orange-brown. S internal surface distally roughened with beading; crests for lateral depressor muscles



present; externally transverse, sinuous growth lines cut by 2 narrow, longitudinal striae. T spur truncate, 1/4 width of basal margin, set at its own width from basi-scutal angle; inner surface distally roughened with 6-9 low ridges and associated beading. Mandible with 1 small subsidiary tooth sometimes between teeth 3 and 4, lower margin of tooth 4 with 1 small subsidiary cusp.

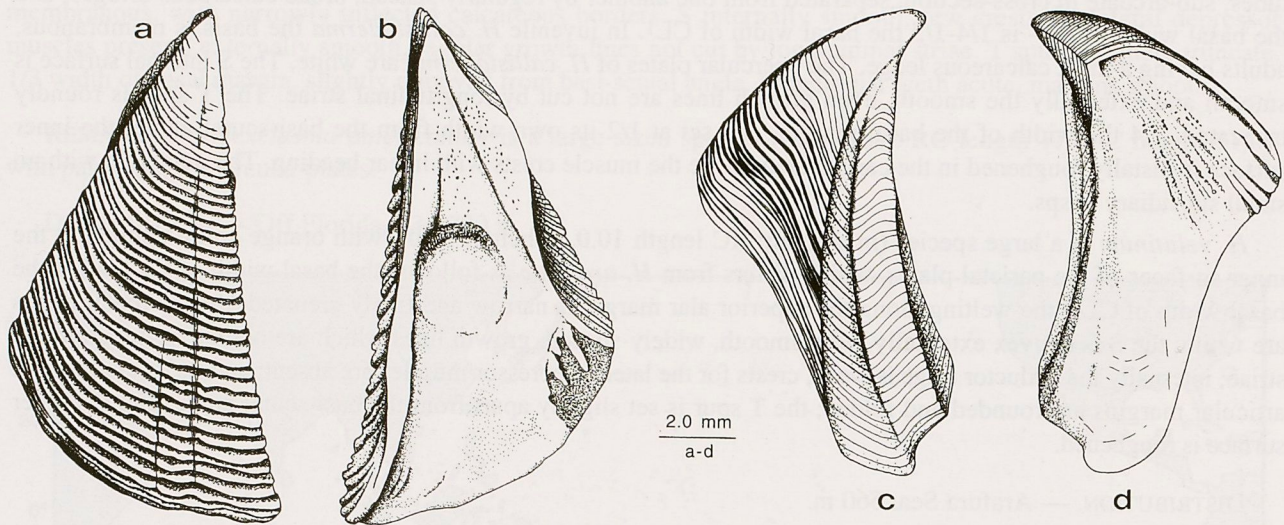


FIG. 52. — *Hexelasma aureolum* sp. nov. Paratype from MUSORSTOM 5, stn DW 338 (MNHN-Ci 2702): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view.

DESCRIPTION. — Size large (maximum: RC length 19.0, C height 18.0). Shell conical, mature specimens tall. Parietal plates, thin (especially in juveniles), all plates sloping inward toward orifice except outwardly curving C; thick, golden yellow, persistent epicuticle covering paries; growth ridges definite, regular, narrow, marked by small golden setae; bases of paries thickened, forming calcareous rim; internally walls ribbed basally. Paries with yellow chitin, either as lamina on inner walls, or as rods within paries separating paries into inner (1/4 thickness) and outer (1/4 thickness) laminae. Rostral plate flattened, basal width greater than basal width of CL<sup>1</sup>. CL<sup>1</sup> wider than CL<sup>2</sup>; CL<sup>2</sup> narrow, elongated triangular shape, basal width 1/4 to 1/3 basal width of CL<sup>1</sup>. C highest plate, not as wide as rostral plate; apex recurved outward. Alae with summits oblique; fine, narrow growth ridges directed upward parallel to inferior alar margin, then turning sharply downward toward alar angle, then upward again at sharp angle to form narrow welting, latter inconspicuous in some specimens; inferior alar margin curved, slightly basally directed hook at free end; alae visible externally for 3/4 (juvenile) to 2/3 (adult) length of parietes. Basis thin, calcareous. Orifice toothed, diameter smaller than that of basis; basis as wide as or wider than total height of shell. Opercular plates below level of orifice. S triangular, basal margin 9/14 length of occludent margin; apex acute; externally slight concavity in middle area; occludent margin longest margin, basal margin sinuous, shorter than articular margin, distinctly curved upward toward articular margin; sinuous growth ridges well defined, cut by 2 narrow, longitudinal ridges varying from slight to well marked, ridges not well separated, extending from apex to basal margin, ridge nearest occludent margin most well-marked; inner S surface with large, deep adductor muscle pit; adductor ridge weakly developed; lateral depressor muscle pit deep, with irregular muscle attachment crests; roughened, irregular ridges for attachment of rostral depressor muscle in deep pit; articular furrow deep; articular ridge extending almost 2/3 length of margin, slightly projecting; articular margin rounded, folded; inner surface of valve, including articular ridge, roughened with irregular beading distally. T smaller and narrower than S; externally sinuous growth ridges prominent; articular margin slightly concave; carinal margin convex; basal margin slightly hollowed, broad spur roundly truncated, 1/4 width of basal margin, set at its own width from basi-scutal angle; spur furrow open, basally shallow, broad; inner surface with articular ridge prominent in upper 1/3, not projecting; 4 well developed muscle attachment crests for depressor muscles; inner surface of valve roughened with



6-9 irregular, low ridges and associated beading in distal half. Parietal plates pale ochre/dirty lemon color, basally fading to whitish; alae whitish with lower areas peachy orange in young specimens. Opercular plates whitish; in some specimens apical areas of S and T pinkish orange-brown internally and externally. Measurements of holotype as follows:

MNHN-Ci	RC length	LD	C height	R height
2411	19.0	18.0	22.0	10.0

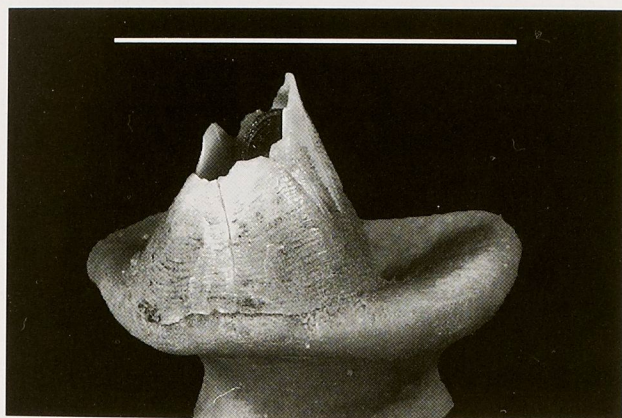


FIG. 53. — *Hexelasma aureolum* sp. nov. Holotype from CHALCAL 2, stn DW 72 (MNHN-Ci 2411): lateral view. Scale = 4 cm.

Labrum with shallow medial depression with row of small teeth and dense, short setae. Mandibular palp oblong-ovoid; long, finely serrate setae terminally. Mandible with 4 teeth, tooth 1 largest, well separated from teeth 2-4; with or without 1 small subsidiary cusp in angle between tooth 3 and 4; lower margin of tooth 4 with 1 small subsidiary cusp; inferior angle moderately large, molariform, with 2 protrusions, upper tooth-like, lower peg-like. Maxillule setose; 3 long, stout setae at upper angle; notch below upper angle wide, with 3-5 pairs of smaller setae; cutting margin below stepped, almost vertical, with 8-10 pairs of longer, stout setae; inferior angle not protuberant or stepped, barely demarked, with 5-7 pairs of smaller setae. Maxilla wide, coxal endite barely defined; setae long, finely serrulate.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior ramus not protuberant anteriorly, segments wider than posterior ramus; both rami with segments thickly setose, setae finely serrate. Cirrus II longer than cirrus I; rami unequal, anterior ramus shorter than posterior ramus; all segment, clothed with setae. Cirrus III similar to cirri IV-VI; rami subequal; segments becoming oblong distally; posterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments, posterior segments densely setose; anterior ramus with 2 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 3 pairs. Cirrus IV to VI similar, longer than cirrus III; rami subequal; segments oblong, with 3 pairs of long setae on anterior faces, distal 2 pairs of longest. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI
MNHN-	left	16, 13	15, 22	33, 38	41, 45	49, 51	55, 50
Ci 2702	right	14, 13	17, 22	32, 37	43, 49	49, 49	49, 51

Penis 1/2 length of cirrus VI; annulated; with few sparse setae; irregular circlet of longer setae distally.

REMARKS. — The tall conical shell and the toothed orifice are common to *H. aureolum* sp. nov., *H. arafurae*, *H. callistoderma* and *H. velutinum*. *Hexelasma aureolum* can be separated from *H. arafurae* as follows: in *H. aureolum* the basal width of CL<sup>2</sup> is 1/3 to 1/4 the basal width of CL<sup>1</sup>, rather than being more than 1/2, and the alae are narrower and exposed for 2/3-3/4 the height of the wall, rather than wide and exposed for the total height of the wall, as in *H. arafurae*. In *H. aureolum* the chitin is either as a lamina applied on the inner surface of the paries, or as rods which separate the paries into inner (1/4 thickness) and outer (3/4 thickness) laminae; in *H. arafurae* there is a continuous lamina of chitin bisecting the thickness of the parietal plates. The sinuous S growth lines of *H. aureolum* are cut by 2 narrow striae, those of *H. arafurae* are smooth and cut by 1 broad stria; the S basal margin of *H. aureolum* is distinctly curved upward toward the articular margin rather than being slightly rounded; and the S articular ridge is slightly, rather than not, projecting. In *H. aureolum* the T spur is 1/4 the width of the basal margin and set at its own width from the basi-scutal angle, rather than more than 1/3 of the



width of the basal margin and set almost at the basi-scutal angle; the inner surfaces of S and T are roughened with irregular beading distally, rather than being smooth, and are pale orange rather than brick-red. The cirral counts for *H. aureolum* are significantly higher than those for *H. arafuræ* (CI 14, 13; CII 17, 22; CIII 32, 37; CIV 43, 49; CV 49, 49; CVI 49, 51 and CI 14, 10; CII 12, 15; CIII 19, 43; CIV 30, 37; CV 38, 40; CVI 39, 41, respectively).

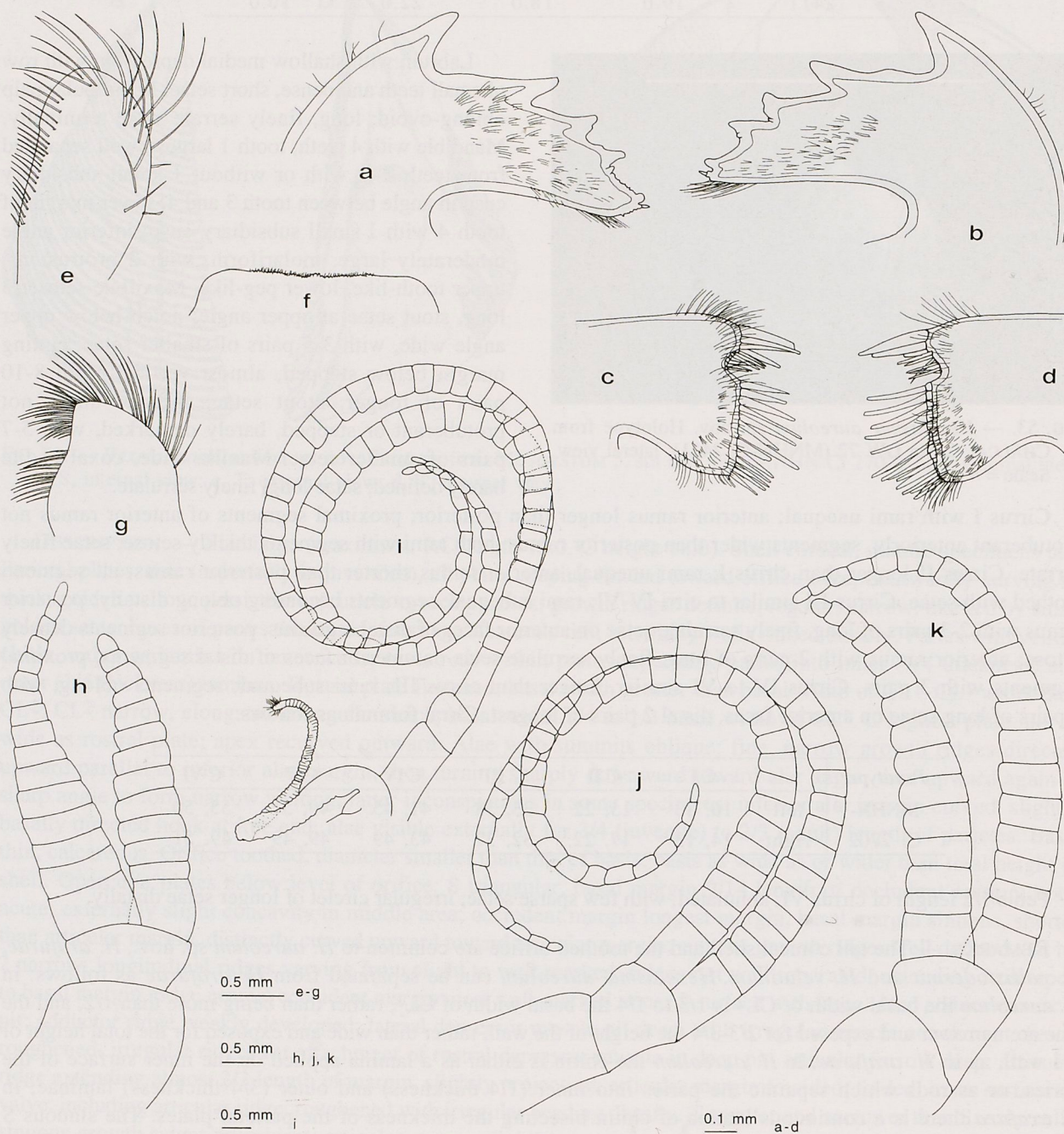


FIG. 54. — *Hexelasma aureolum* sp. nov. Paratype from MUSORSTOM 5, stn DW 338 (MNHN-Ci 2702): **a**, right mandible; **b**, left mandible; **c**, right maxillule, **d**, left maxillule; **e**, mandibular palp; **f**, labrum; **g**, maxilla; **h**, cirrus I; **i**, cirrus VI and penis; **j**, cirrus III; **k**, cirrus II.



*Hexelasma aureolum* is superficially similar to *H. callistoderma* but differs as follows: the basal width of CL<sup>2</sup> is 1/3 to 1/4 the basal width of CL<sup>1</sup>, rather than 1/4 to 1/5 the width; the chitin is either as a lamina applied on the inner surface of the paries, or as rods which separate the paries into inner (1/4 thickness) and outer (3/4 thickness) laminae, rather than as long rods, sub-arcuate in cross section, separated by regularly spaced, broad calcareous bridges. The basis of *H. aureolum* is calcareous and thin; that of *H. callistoderma* is membranous in young specimens, with adults developing a thick calcareous ledge. In *H. aureolum* the T spur is set at a distance of its own width from the basi-scutal angle rather than 1/2 its width; and the inner surfaces of S and T are orange-brown in *H. aureolum*, white in *H. callistoderma*.

*Hexelasma aureolum* is superficially similar to *H. velutinum* but there are the following differences: in *H. aureolum* the basal width of CL<sup>2</sup> is 1/4 to 1/3 the basal width of CL<sup>1</sup>, rather than 2/3 the width; the S adductor muscle pit is distinct rather than faint; the S articular ridge is slightly projecting, rather than not; the S depressor muscle pit is distinct rather than being a shallow excavation, the T basal margin is slightly hollowed out rather than straight; the T spur of *H. aureolum* is 1/4 the width of the basal margin and set at its own width from the basi-scutal angle, rather than 1/3 the width of the basal margin and set at 1/2 its own width from the basi-scutal angle; and the inner surface is roughened with 6-9 irregular, low ridges and associated beading in the distal half, rather than smooth. Cirral counts for *H. aureolum* are also higher than those for *H. velutinum* (CI 14, 13; CII 17, 22; CIII 32, 37; CIV 43, 49; CV 49, 49; CVI 49, 51 and CI 9, 13; CII 11, 14; CIII 22, 28; CIV 37, 39; CV 40, 43; CVI 42, 43, respectively).

ETYMOLOGY. — From the Latin *aureolum*, 'golden', referring to the golden color of the persistent epicuticle present on the compartmental plates.

DISTRIBUTION. — Chesterfield Islands, 500-580 m; New Caledonia, 500-530 m; Loyalty Ridge, 257-420 m; Norfolk Ridge, 470-730 m.

***Hexelasma brintoni* (Newman & Ross, 1971)**

Fig. 51; Tables 28-31

*Aptolasma brintoni* Newman & Ross, 1971: 162, fig. 78, pls 33 E-F, 38, 39 A-E; 1976: 46. — FOSTER, 1978: 79.  
*Hexelasma brintoni* - FOSTER, 1981: 356.

MATERIAL EXAMINED. — **South China Sea.** NAGA EXPED. 1959-61: stn 97, 15°40.0'N, 109°22.9'E, 110-198 m, 27.02.1960: holotype (USNM Type No. 125311).

TYPES. — *Holotype*: USNM 125311; South China Sea, NAGA EXPED. 1959-61, stn 97, 15°40.0'N, 109°22.9'E, 110-198 m, 27.02.1960; dry (1 lot) and slides (3).

*Holotype depository*: USNM.

DIAGNOSIS. — Parietal plates with longitudinal chitin-filled tubes sub-arcuate in cross-section, regularly spaced, separated from one another by broad calcareous bridges; tubes bisecting thickness of parietal plates. Basal width of CL<sup>2</sup> 3/5 basal width of CL<sup>1</sup>. Inferior alar margin curved, without basally directed hook at free end; externally with weakly marked growth ridges; ridged, narrow welting along superior alar margin. Basis calcareous, thick. Opercular plates white. S internal surface smooth; several crests for lateral depressor muscles present; externally smooth, even growth lines not cut by longitudinal striae. T spur truncate, 1/3 width of basal margin, forming abrupt angle of 130° with basal margin, set at 1/2 its width from basi-scutal angle; inner surface smooth. Mandibular teeth 2 and 3 with side teeth, upper and lower margins of tooth 4 with small subsidiary cusps.

REMARKS. — *Hexelasma brintoni* is superficially similar to *H. flavidum* sp. nov., *H. foratum* sp. nov. and *H. sandaracum* sp. nov. Differences between *H. brintoni* and these species may be found under *H. flavidum* sp. nov., *H. foratum* sp. nov. and *H. sandaracum* sp. nov., respectively.

DISTRIBUTION. — Off Da Nang, Vietnam, 110-198 m.



*Hexelasma callistoderma* Pilsbry, 1911

Fig. 51; Tables 28-31

*Balanus callistoderma* Pilsbry, 1911: 78, fig. 10, pl. 12 fig. 5, pl. 15 figs 3-7.*Balanus corolliformis* - KRÜGER, 1911: 55, figs 112-114, pl. 1 fig. 1, pl. 4 fig. 38.*Hexelasma callistoderma* - HOEK, 1913: 245. — PILSBRY, 1916: 332, fig. 99. — UTINOMI, 1958: 307; 1965: 12. — FOSTER, 1981: 356.*Aaptolasma callistoderma* - NEWMAN & ROSS, 1971: 159, fig. 77, pls 32 C-D, 35, 43 C; 1976: 46. — FOSTER, 1978: 79.MATERIAL EXAMINED. — **Japan**. "Albatross": stn 5068, off Ose Saki, 35°02'25"N, 138°46'55"E, 141 m, 15.10.1906: holotype (USNM Type 38690).TYPES. — *Holotype*: USNM 38690; "Albatross" stn 5068, off Ose-Saki, Japan, 35°02'25"N, 138°46'55"E, 141 m, 15.10.1906.*Paratype*: USNM 38690; "Albatross" stn 3741, Japan, about the same place than above, 115-124 m, 17.05.1900; in alcohol (1 lot), and slide (1).*Holotype and paratype depository*: USNM.

DIAGNOSIS. — Parietal plates with longitudinal chitin-filled tubes, sub-arcuate in cross-section, separated from one another by regularly spaced, broad calcareous bridges. Basal width of CL<sup>2</sup> 1/4-1/5 basal width of CL<sup>1</sup>. External alar growth ridges fine; thin, rough welting along superior alar margin. Basis membranous (juveniles), adults with thick calcareous ledge. Opercular plates white. S internal surface smooth; crests for lateral depressor muscles present; externally smooth, even growth lines not cut by longitudinal striae. T spur roundly truncated, 1/4 width of basal margin, set at 1/2 its own width from basi-scutal angle; inner surface distally roughened in carinal area above muscle crests with linear beading. Mandibular teeth lacking small subsidiary cusps.

REMARKS. — *Hexelasma arafurae* and *H. aureolum* sp. nov are superficially similar to *H. callistoderma*. Differences between these species may be found under *H. arafurae* and *H. aureolum* sp. nov., respectively.

DISTRIBUTION. — Japan, 115-141 m.

*Hexelasma flavidum* sp. nov.

Figs 51, 55-57; Tables 28-31

MATERIAL EXAMINED. — **New Caledonia**. BATHUS 4: stn CP 910, 560-608 m: 1 specimen (MNHN-Ci 2413).**Loyalty Islands**. MUSORSTOM 6: stn DW 472, 300 m: several specimens, attached to sponges (MNHN-Ci 2703). Drawn. — Stn DW 472, 300 m: 2 specimens, 1 attached to sponge, 1 to coral rubble (WAM 257-96).**Norfolk Ridge**. SMIB 5: stn DW 87, 370 m: 6 specimens, attached to coral rubble (MNHN-Ci 2414). — Stn DW 93, 255 m: 1 specimen, attached to live coral (*Corallium* sp.) (MNHN-Ci 2704).TYPES. — *Holotype*: MNHN-Ci 2413 (BATHUS 4, stn CP 910).*Paratypes*: MNHN-Ci 2414 (SMIB 5, stn DW 87). — MNHN-Ci 2703 (MUSORSTOM 6, stn DW 472). Drawn. — MNHN-Ci 2704 (SMIB 5, stn DW 93). — WAM 257-96 (MUSORSTOM 6, stn DW 472).

DIAGNOSIS. — Thin parietal plates with chitin present as lamina on inner walls of parietes between longitudinal ribs, or within paries as longitudinal tubes of chitin, separating paries into inner (1/4 thickness) and outer (3/4 thickness) lamina. Basal width of CL<sup>2</sup> 1/3 or less than basal width of CL<sup>1</sup>. Inferior alar margin curved, slight hook at free end; externally growth ridges well spaced; serrated, narrow, ridged welting along superior alar margin. Basis with calcareous edges, membranous centrally; thin. Opercular plates orange, apices cream. S internal surface smooth; crests for lateral depressor muscles slight; externally well-spaced, sinuous growth lines cut by slight longitudinal striae. T spur truncate, more than 1/3 width of basal margin, forming abrupt angle of 130° with basal margin, set at 1/4 its own width from basi-scutal angle; inner surface distally roughened. Mandible with upper and lower margins of tooth 4 with irregular, small subsidiary cusps.



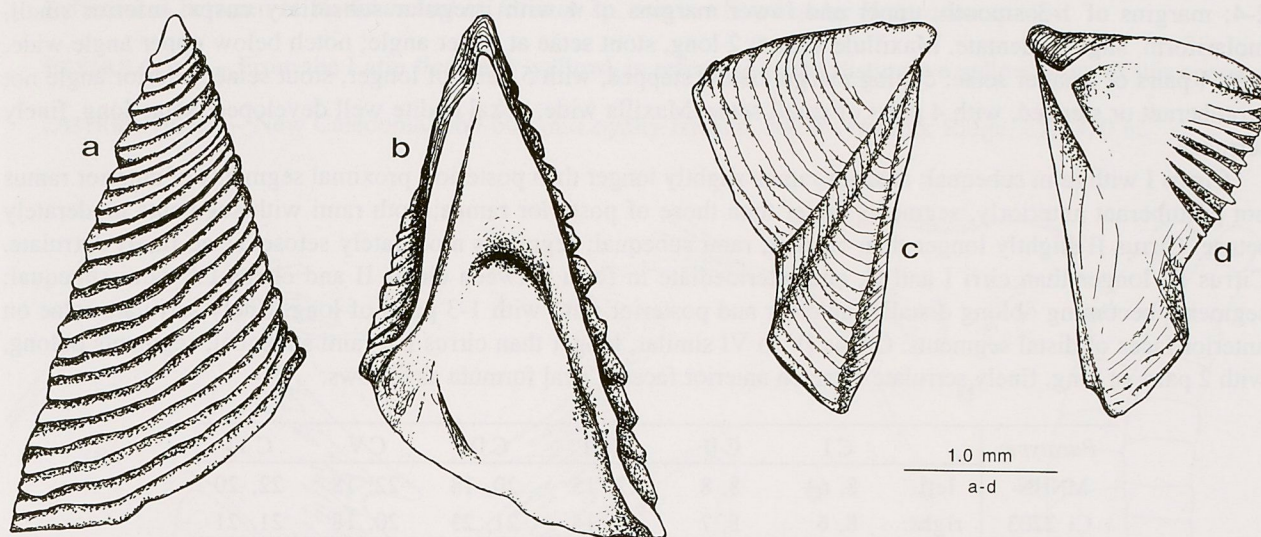


FIG. 55. — *Hexelasma flavidum* sp. nov. Paratype from MUSORSTOM 6, stn DW 472 (MNHN-Ci 2703): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view.

DESCRIPTION. — Size small (maximum: RC length 10.0, C height 6.0). Shell rounded, squat and flattened. Parietal plates thin, fragile; growth ridges faint, regular, finely beaded, lined with small, fine, golden setae, giving hirsute appearance; persistent epidermis absent; internally with longitudinal, low, spaced ribs extending  $1/2$  length of plates. Yellowish chitin applied either as lamina on inner surface of parietes, between longitudinal ribs, or as longitudinal tubes of chitin within plates, dividing thicker outer ( $3/4$  width) and thinner inner ( $1/4$  width) laminae. Rostral plate largest plate, convex; broad at base, height equal to height of C. Basal width of CL<sup>2</sup>  $1/3$  or less than  $1/3$  basal width of CL<sup>1</sup>. C larger than CL<sup>1</sup>; distinctly shaped, central longitudinal ridge dividing plate into halves, ridge more distinct in juveniles, slight in adults. Superior alar margins sub-parallel to basis; growth ridges well spaced, directed upward parallel to inferior alar margin, then curving outward toward alar angle and upward again at sharp angle to form ridged welting, latter with serrated superior margin formed from wide spacing of growth ridges; inferior alar margin curved, slight hook at free end. Basis membranous centrally, calcareous at edges, thin. Orifice smaller in diameter than basis; opercular plates subparallel to basis. S thin, triangular, S basal margin  $9/14$  length of occludent margin, shorter than articular margin; occludent margin longest margin; externally sinuous growth ridges prominent, well spaced, cut by slightly indicated external longitudinal striae; internal surface smooth; adductor muscle and lateral depressor muscle pits shallow; adductor ridge weak; articular furrow shallow; articular ridge extending for  $3/4$  length of margin, not projecting; articular margin rounded, folded; S when closed filling aperture. T smaller than S; valve thin; externally growth ridges sinuous, less defined than S growth ridges; articular and carinal margins almost straight; basal margin hollowed out, meeting spur at sharp angle; spur basally truncated, more than  $1/3$  width of basal margin, forming abrupt angle of  $130^\circ$  with basal margin, set at  $1/4$  its own width from basi-scutal angle; spur furrow open, shallow, flat, broadest basally; internally articular ridge not projecting, traceable through  $1/3$  length of valve; 9 distinct, prominent muscle attachment crests for depressor muscles, slightly extending below basal margin; inner surface distally roughened. Parietal plates yellowish-orange with ochre yellow longitudinal tubes showing through thin parietal wall; alae yellowish-orange, welting whitish; opercular plates externally golden-orange with cream apices, orange/cream internally. Measurements of holotype as follows:

MNHN-Ci	RC length	LD	C height	R height
2413	10.0	9.5	6.0	5.7

Labrum with shallow medial depression with row of 30-35 bi- or tri-cusped teeth. Mandibular palp ovate; long, finely serrate setae terminally, plumose setae medially. Mandible with 4 teeth, tooth 1 largest, well separated from



2-4; margins of 1-3 smooth, upper and lower margins of 4 with irregular subsidiary cusps; inferior small, molariform, slightly dentate. Maxillule setose; 2 long, stout setae at upper angle; notch below upper angle wide, with 4 pairs of smaller setae; cutting margin below stepped, with 5 pairs of longer, stout setae; inferior angle not protuberant or stepped, with 4 pairs of small setae. Maxilla wide, coxal endite well developed; setae long, finely serrulate.

Cirrus I with rami subequal; anterior ramus slightly longer than posterior; proximal segments of anterior ramus not protuberant anteriorly, segments wider than those of posterior ramus; both rami with segments moderately setose. Cirrus II slightly longer than cirrus I; rami subequal; segments moderately setose, setae finely serrulate. Cirrus III longer than cirri I and II, and intermediate in form between cirrus II and cirrus IV; rami subequal; segments becoming oblong distally; anterior and posterior rami with 1-3 pairs of long, finely serrulate setae on anterior faces of distal segments. Cirrus IV to VI similar, longer than cirrus III; rami subequal; segments oblong, with 2 pairs of long, finely serrulate setae on anterior faces. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI
MNHN-	left	8, 6	8, 8	12, 15	20, 18	22, 18	22, 20
Ci 2703	right	8, 6	8, 7	12, 14	21, 23	20, 18	21, 21

Penis 1/2 length of cirrus VI; annulated; with few sparse setae; circlet of longer setae distally.

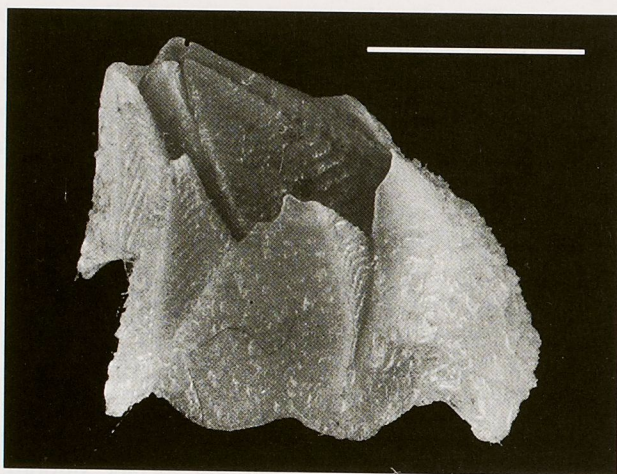


FIG. 56. — *Hexelasma flavidum* sp. nov. Holotype from BATHUS 4, stn CP 910 (MNHN-Ci 2413): lateral view. Scale = 5 mm.

REMARKS. — This species, with its wide, high alae and its low profile, is more similar to *H. brintoni*, *H. foratum* sp. nov. and *H. triderma* than to *H. callistoderma*, *H. americanum* or *H. leptoderma*.

*Hexelasma flavidum* sp. nov. can be separated from *H. brintoni* as follows: the shell is rounded, squat and flattened, rather than conical; the basal width of CL<sup>2</sup> is 1/3 or less than 1/3 the basal width of CL<sup>1</sup>, rather than 3/5 the basal width; at the free end of the curved inferior alar margin a slight, basally directed hook is present, rather than absent; longitudinal tubes of chitin divide the paries into a thicker outer (3/4) and thinner inner (1/4) lamina, rather than into laminae of equal width; the basis is thin, calcareous at the periphery and membranous centrally, rather than thick and calcareous; the T spur is more than 1/3 the width of the tergal basal margin and set at 1/4 its own width from the basi-scutal

angle, rather than 1/3 the width of the basal margin and set at 1/2 its width from the basi-scutal angle; the inner surface of T is roughened rather than smooth; and the color of S and T are orange-cream and not white. In addition the cirral counts are lower for *H. flavidum* than those for *H. brintoni*.

*Hexelasma flavidum* is distinguished from *H. triderma* by the following characters: the parietal plates are thin and relatively fragile, are without a persistent epidermis, and have faint, regular growth ridges lined with golden setae, in contrast to the robust, thicker plates of *H. triderma*, which are covered with a brownish cuticle marked by heavy, transverse growth ridges supporting numerous chitinous setae; the basal width of CL<sup>2</sup> is 1/3 or less than 1/3 the basal width of CL<sup>1</sup> in *H. flavidum*, in *H. triderma* 1/2-2/3. In *H. flavidum* longitudinal, chitin-filled tubes divide the paries into an outer (3/4 width) and thinner inner lamina (1/4 width), rather than an almost continuous sheet of chitin dividing the paries into an outer (2/3 width) and an inner lamina (1/3 width), as in *H. triderma*. The curved inferior alar margin of *H. flavidum* has a slight hook at its free end, rather than an abrupt, basally directed hook; and the basis of *H. flavidum* is thin, calcareous at the periphery and membranous centrally rather than thin, calcareous and marginally thickened (*H. triderma*). Opercular and soft parts are unknown for *H. triderma*.



Differences between *H. flavidum* and *H. foratum* sp. nov. are listed under *H. foratum* sp. nov.

ETYMOLOGY. — From the Latin *flavidum*, 'yellow', in reference to the distinctive yellow scuta of this species.

DISTRIBUTION. — New Caledonia, 560-608 m; Loyalty Islands, 300 m; Norfolk Ridge, 255-370 m.

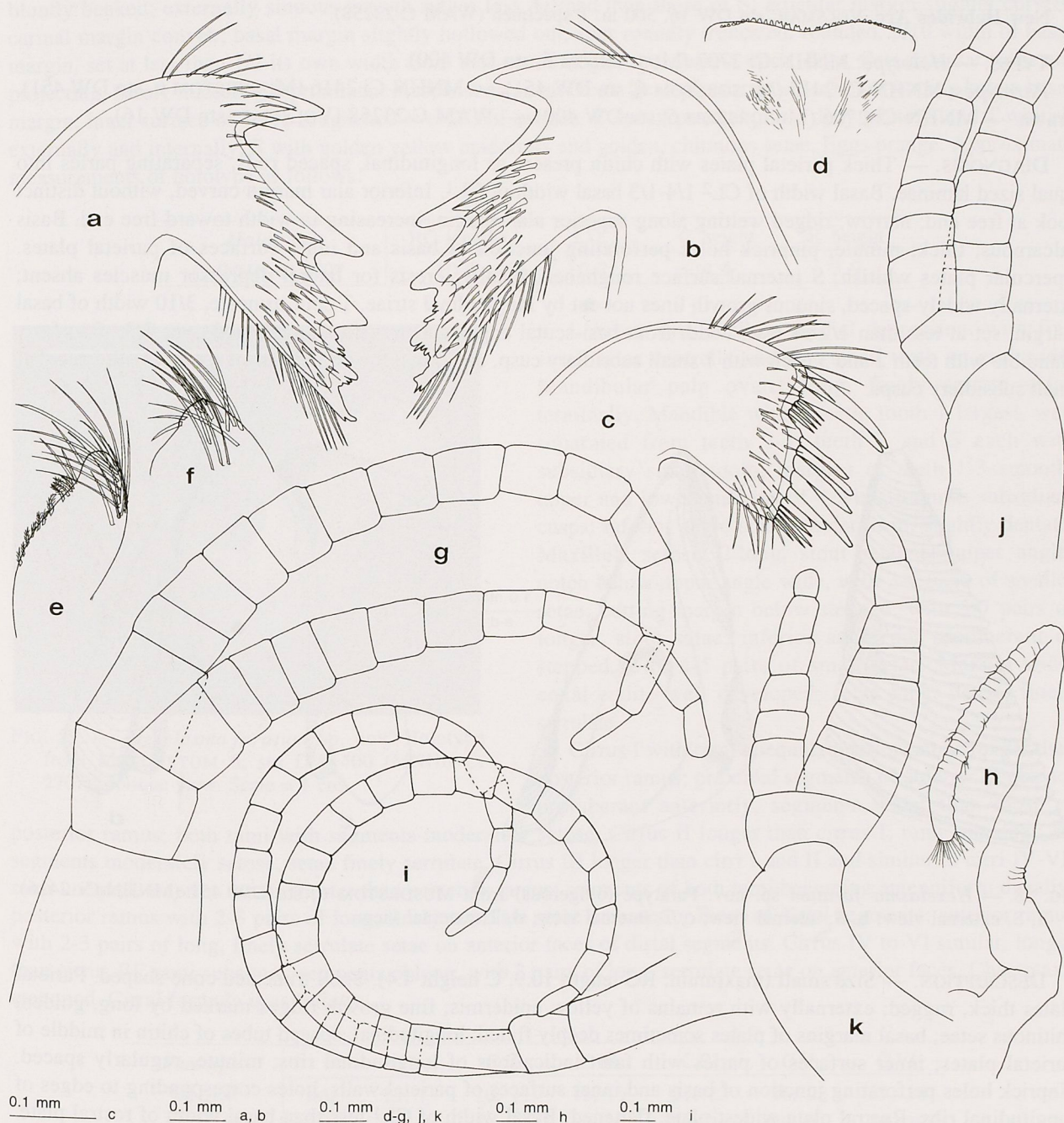


FIG 57. — *Hexelasma flavidum* sp. nov. Paratype from MUSORSTOM 6, stn DW 472 (MNHN-Ci 2703): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, labrum; **e**, mandibular palp; **f**, maxilla; **g**, cirrus III; **h**, penis; **i**, cirrus VI; **j**, cirrus II; **k**, cirrus I.



*Hexelasma foratum* sp. nov.

Figs 51, 58-60; Tables 28-31

**MATERIAL EXAMINED.** — **Loyalty Islands.** MUSORSTOM 6: stn DW 400, 270 m: 3 specimens (2 incomplete) (MNHN-Ci 2706, Ci 2707). — Stn DW 451, 330 m: 2 specimens (1 ovigerous, both incomplete) (MNHN-Ci 2415, Ci 2416). Drawn.

**New Hebrides Arc.** VOLSMAR: stn DW 16, 500 m: 1 specimen (WAM C 23258).

**TYPES.** — *Holotype*: MNHN-Ci 2707 (MUSORSTOM 6, stn DW 400).

*Paratypes*: MNHN-Ci 2415 (MUSORSTOM 6, stn DW 451). — MNHN-Ci 2416 (MUSORSTOM 6, stn DW 451). Drawn. — MNHN-Ci 2706 (MUSORSTOM 6, stn DW 400). — WAM C 23258 (VOLSMAR, stn DW 16).

**DIAGNOSIS.** — Thick parietal plates with chitin present as longitudinal, spaced rods, separating paries into equal sized laminae. Basal width of CL<sup>2</sup> 1/4-1/3 basal width of CL<sup>1</sup>. Inferior alar margin curved, without distinct hook at free end; narrow, ridged welting along superior alar margin, increasing in width toward free end. Basis calcareous, thick; minute, pinprick holes perforating junction of basis and inner surfaces of parietal plates. Opercular plates whitish. S internal surface roughened distally; crests for lateral depressor muscles absent; externally widely-spaced, sinuous growth lines not cut by longitudinal striae. T spur truncate, 3/10 width of basal margin, set at less than 1/2 its own width from basi-scutal angle; inner surface roughened over 2/3 of surface. Mandible with teeth 2 and 3 each with 1 small subsidiary cusp, upper and lower margins of tooth 4 with irregular, small subsidiary cusps.

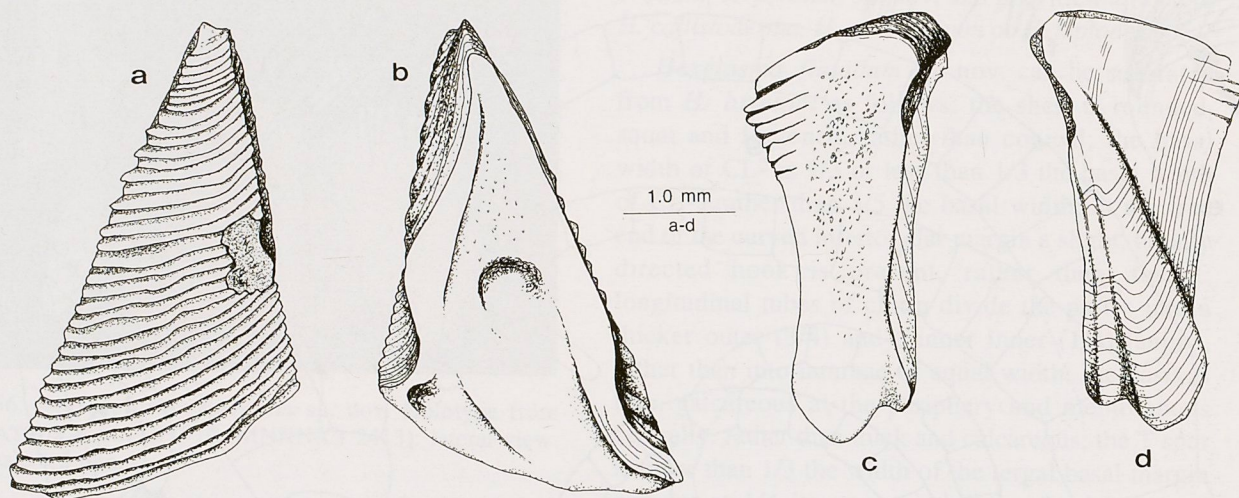


FIG. 58. — *Hexelasma foratum* sp. nov. Paratype (ovigerous) from MUSORSTOM 6, stn DW 451 (MNHN-Ci 2416): a, S, external view; b, S, internal view; c, T, internal view; d, T, external view.

**DESCRIPTION.** — Size small (maximum: RC length 10.9, C height 4.4). Shell truncated cone shaped. Parietal plates thick, rugged; externally with remains of yellow epidermis; fine growth ridges marked by long, golden, chitinous setae; basal margins of plates sometimes deeply fluted; longitudinal, spaced tubes of chitin in middle of parietal plates; inner surfaces of paries with faint indications of longitudinal ribs; minute, regularly spaced, pinprick holes perforating junction of basis and inner surfaces of parietal walls, holes corresponding to edges of longitudinal ribs. Rostral plate widest plate, flattened. Basal width of CL<sup>1</sup> less than basal width of rostral plate. Basal width of CL<sup>2</sup> 1/4-1/3 basal width of primary CL<sup>1</sup>. Carinal proportions similar to, but smaller than, those of rostral plate. Alae small; superior alar margins sub-parallel to basis; growth ridges directed upward, parallel to inferior alar margin, then curving outward toward alar angle and again upward at sharp angle to form narrow, ridged welting; inferior alar margin curved, without distinct hook at free end. Orifice small compared to basis; slightly



toothed. Basis sub-circular; calcareous, thick. S triangular, apex acute; sinuous basal margin 4/7 length of occludent margin; basal margin just shorter than straight articular margin; occludent margin longest margin; externally sinuous growth ridges prominent, wide, not cut by external longitudinal ridges; internally adductor muscle pit well defined, roughened area distally above adductor muscle pit; lateral depressor muscle pit deep, crests for lateral depressor muscles absent; adductor ridge feebly developed; articular ridge slightly projecting, extending 2/3 to 3/4 length of articular margin; articular margin rounded, slightly folded. T distinctly smaller than S; apex bluntly beaked; externally sinuous growth ridges less defined than those of S; articular margin slightly curved; carinal margin convex; basal margin slightly hollowed out; spur roundly truncated, rounded, 3/10 width of basal margin, set at less than 1/2 its own width from basi-scutal angle; spur furrow open, deep, flat; articular ridge not projecting, barely traceable; 6 prominent muscle attachment crests for depressor muscles not extending below basal margin; inner surface of valve roughened over 2/3 of surface. Color of parietal plates dirty white, S and T whitish externally and internally, S with golden yellow epidermis and golden, chitinous setae. Eggs orange. Approximate measurements of holotype as follows:

<i>Holotype:</i>	RC length	LD	C height	R height
MNHN-Ci 2707	10.9	10.7	4.4	3.9

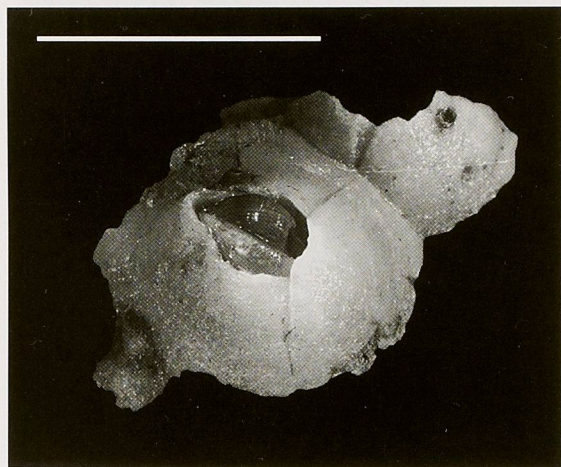


FIG. 59. — *Hexelasma foratum* sp. nov. Holotype from MUSORSTOM 6, stn DW 400 (MNHN-Ci 2707); oblique view. Scale = 1 cm.

Labrum with shallow medial depression, with fine small setae centrally and few small teeth on each side. Mandibular palp ovate; long, finely serrate setae terminally. Mandible with 4 teeth, tooth 1 largest, well separated from teeth 2-4; teeth 2 and 3 each with subsidiary small tooth; margins of teeth 1-3 smooth, upper and lower margins of 4 with irregular subsidiary cusps; inferior angle small, molariform, slightly dentate. Maxillule setose; 2 long, stout setae at upper angle; notch below upper angle wide, with 3-4 pairs of smaller setae; cutting margin below stepped, with 5-7 pairs of longer, stout setae; inferior angle not protuberant or stepped, with 4-5 pairs of small setae. Maxilla wide, coxal endite well developed; setae long, dense, finely serrulate.

Cirrus I with rami unequal; anterior ramus longer than posterior ramus; proximal segments of anterior ramus not protuberant anteriorly, segments wider than those of posterior ramus; both rami with segments moderately setose. Cirrus II longer than cirrus I; rami subequal; all segments moderately setose, setae finely serrulate. Cirrus III longer than cirri I and II and similar to cirri IV-VI; rami unequal, anterior ramus shorter than posterior ramus; segments of both rami becoming antenniform distally; posterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments. Cirrus IV to VI similar, longer than cirrus III; rami subequal; segments oblong, with 2 pairs of long, serrulate setae on anterior faces. Chaetotaxy ctenopod. Cirral formula is as follows:

<i>Paratype:</i>		CI	C II	C III	C IV	CV	C VI
MNHN-	left	13, 7	10, 11	15, 19	21, 23	26, 28	29, 28
Ci 2416	right	13, 7	9, 11	15, 20	24, 26	29, 31	27, 29

Penis 1/3 length of cirrus VI; finely annulated; with few sparse setae; circlet of longer setae distally. Eggs large, rounded, 0.45 x 0.51 mm.



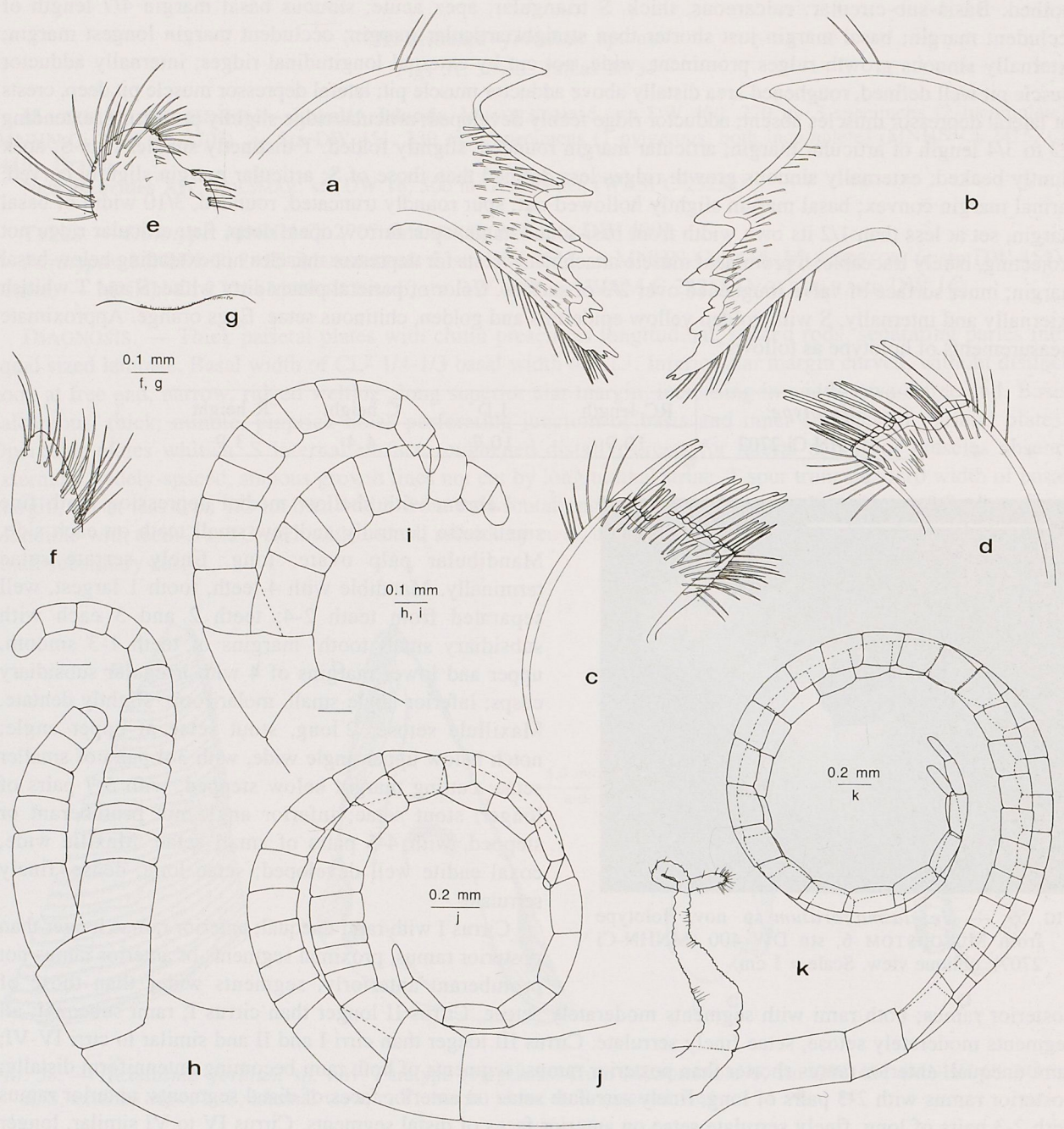


FIG. 60. — *Hexelasma foratum* sp. nov. Paratype (ovigerous) from MUSORSTOM 6, stn DW 451 (MNHN-Ci 2416): a, right mandible; b, left mandible; c, right maxillule; d, left maxillule; e, maxilla; f, mandibular palp; g, labrum; h, cirrus I; i, cirrus II; j, cirrus III; k, cirrus VI and penis.

REMARKS. — The minute pinpoint holes, which correspond to the edges of the longitudinal ribs on the inner surface of the parietes, and which perforate the junction of the basis and the inner surfaces of the parietal plates, are unique structures not found in other hexelasmatine. *Hexelasma foratum* sp. nov., with its low profile and high alae nearly parallel to the basis, stands closer to *H. brintoni*, *H. triderma* and *H. flavidum* sp. nov. in form than to the other known members of the genus, where the alae are oblique.



*Hexelasma foratum* may be separated from *H. triderma* by the form of the chitin in the paries; in the former long, spaced rods of chitin bisect the thickness of the paries, in the latter the chitinous layer is developed as an almost continuous, thin sheet between the laminae which are about equal in thickness. In *H. foratum* the basal width of CL<sup>2</sup> is 1/4-1/3 the basal width of CL<sup>1</sup>; in *H. triderma* the basal width of CL<sup>2</sup> is 1/2-2/3 the basal width of CL<sup>1</sup>. The parietal plates of *H. foratum* are thick and rugged, externally fine growth ridges marked by long, golden, chitinous setae and with the remains of yellow epidermis; the robust, thicker plates of *H. triderma* are covered with a brownish cuticle marked by heavy, transverse growth ridges supporting numerous chitinous setae. In *H. foratum* the basis is calcareous and thick; in *H. triderma* it is thin, calcareous and marginally thickened. No opercular or soft parts are known for *H. triderma*.

The shape of *Hexelasma foratum* sp. nov. is a truncated cone; that of *H. flavidum* sp. nov. is rounded, squat and flattened. Longitudinal rods of chitin divide the paries into a thicker outer (3/4) and thinner inner (1/4) laminae in *H. flavidum*, and into laminae of equal width in *H. foratum*. In *H. foratum* the basal width of CL<sup>2</sup> is 1/4-1/3 the basal width of CL<sup>1</sup>, and there is a yellow, persistent epidermis covering the parietal plates; in *H. flavidum* the basal width of CL<sup>2</sup> is 1/3 or less the basal width of CL<sup>1</sup> and a persistent epidermis is absent. The basis is thick and calcareous, with pinprick holes perforating the parietal/basal junction in *H. foratum*; that of *H. flavidum* is thin, calcareous at the periphery and membranous centrally, and perforations are absent. In *H. foratum* the S basal margin is 4/7 the length of the occludent margin, crests for the lateral depressor muscles are absent, the articular ridge is slightly projecting, and the inner surface is roughened distally. In *H. flavidum* the S basal margin is 9/14 the length of the occludent margin, slight crests for the lateral depressor muscles are present, the articular ridge is not projecting, and the inner surface is smooth. The T spur of *H. foratum* is 3/10 the width of the basal margin and set at 1/2 its own width from the basi-scutal angle; in *H. flavidum* it is 1/3 the width of the basal margin, set at 1/4 its width from the basi-scutal angle, and forms an abrupt angle of 130° with the basal margin. The color of S and T are whitish in *H. foratum*, orange-cream in *H. flavidum*.

*Hexelasma foratum* sp. nov. can be distinguished from *H. brintoni* as the basal width of CL<sup>2</sup> of the former is 1/4-1/3 the basal width of CL<sup>1</sup>, rather than 3/5 the width. The basis is thick and calcareous, with pinprick holes perforating the parietal/basal junction in *H. foratum*; the basis is thick and calcareous, with no perforations in *H. brintoni*. The new species can be further separated by its low profile and truncated cone shape, compared to the conical form of *H. brintoni*. The T spur of *H. foratum* curves into the basal margin, rather than forming an abrupt angle of 130° with the basal margin, as in *H. brintoni*, and the T is internally roughened over 2/3 of the surface, rather than smooth. In *H. foratum* the S basal margin is 4/7 the length of the occludent margin, the internal surface is roughened distally, crests for the lateral depressor muscles are absent and the articular ridge is slightly projecting. In *H. brintoni* the S basal margin is 2/3 the length of the occludent margin, the internal surface is smooth, there are several crests for the lateral depressor muscles, and the articular ridge is not projecting.

ETYMOLOGY. — From the Latin *foratum*, 'to perforate', in reference to the small pinprick holes, corresponding to edges of parietal tubes, which perforate the junction between the basis and the inner surface of the parietal walls.

DISTRIBUTION. — New Hebrides Arc, Loyalty Islands, 270-500 m.

*Hexelasma globosum* sp. nov.

Figs 61-64; Tables 28-31

MATERIAL EXAMINED. — **New Caledonia.** MUSORSTOM 4: stn DW 156, 525 m: 3 specimens. — Stn CP 167, 575 m: 6 specimens, attached to pumice and coral rubble (MNHN-Ci 2418). Drawn. — Stn CP 197, 550 m: 5 specimens (MNHN-Ci 2417, WAM 258-96).

**Loyalty Islands.** BIOCAL: stn CP 45, 430-465 m: 1 specimen.

MUSORSTOM 6: stn DW 486, 370 m: 2 specimens, attached to surface of sponge.

TYPES. — *Holotype*: MNHN-Ci 2417 (MUSORSTOM 4, stn CP 197).



*Paratypes*: MNHN-Ci 2418 (MUSORSTOM 4: stn CP 167). Drawn. — WAM 258-96 (MUSORSTOM 4, stn CP 197).

**DIAGNOSIS.** — Thin parietal plates with thin lamina of chitin developed in longitudinal strips on inner surface of paries; bases of plates slightly thickened to form rim. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Basis calcareous, thin. Inferior margin of alae curved with slightly basally directed hook at free end; externally growth ridges well spaced, marked by fine tubercles; ridged welting along superior alar margin, increasing in width toward free end. Opercular plates whitish. S internal surface smooth; crests for lateral depressor muscles absent; externally well-spaced, sinuous growth lines cut by 3 slight longitudinal striae, middle stria most marked. T spur truncate, 1/4 width of basal margin, set at distance of less than 1/2 its own width from basi-scutal angle; inner surface roughened over 2/3 of surface. Mandible with upper and lower margins of tooth 4 with irregular, small subsidiary cusps.

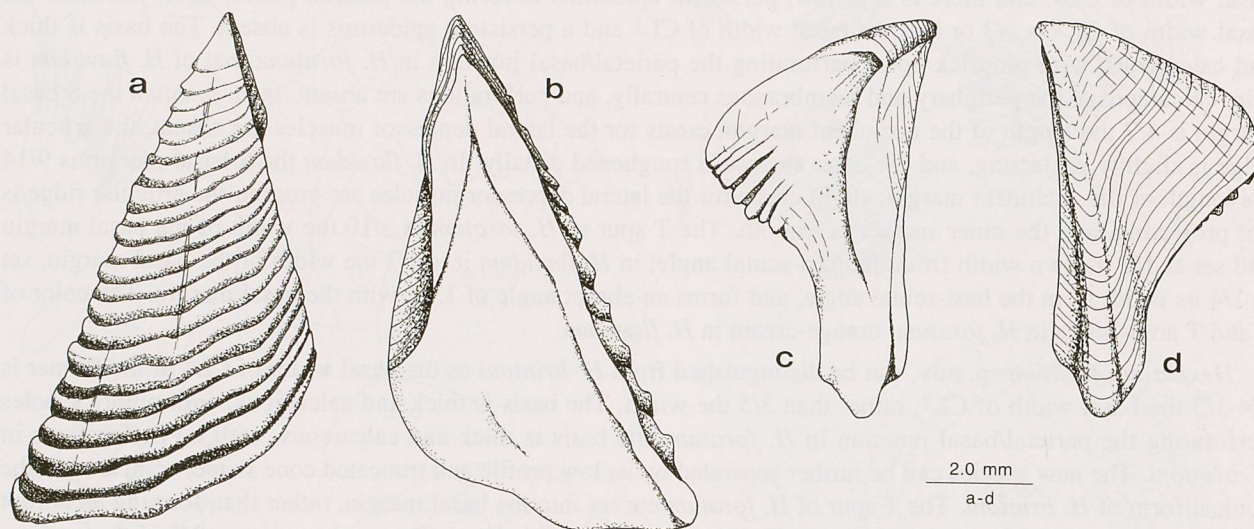


FIG. 61. — *Hexelasma globosum* sp. nov. Paratype from MUSORSTOM 4, stn CP 167 (MNHN-Ci 2418): a, S, external view; b, S, internal view; c, T, internal view; d, T, external view.

**DESCRIPTION.** — Size moderate (maximum: RC length 12.5, C height 14.0). Shell form globose or sub globose; rostral plate, CL<sup>1</sup> and CL<sup>2</sup> sloping inward toward orifice, C upright or sloping outward from orifice, apex slightly retroverted; opercular plates erect in orifice. Thin parietal plates; externally irregular, faint growth ridges defined by well spaced, small tubercles, and fine setae; bases of plates thickened to form rim. Thin lamina of chitin applied in longitudinal strips to inner surface of paries; bases of plates slightly thickened to form rim. Rostral plate wide, slightly convex. Basal width of CL<sup>1</sup> less than 1/2 basal width of rostral plate; basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>, narrow distally. C as wide as, but higher than, rostral plate; transversely bent, V-shaped from above. Alae of C and CL<sup>2</sup> well developed. Summits of alae oblique, especially those of C; growth ridges well spaced, marked by fine tubercles, directed upward parallel to inferior alar margin then curving outward and slightly downward to alar angle before upward again at sharp angle to form ridged welting, latter narrowing toward summit, widening toward alar angle; superior margin of welting serrate due to well spaced growth ridges; inferior margin of alae curved with hook slightly basally directed. Basis calcareous, thin. Orifice triangular; toothed; wider than basis. S triangular, apically acute; basal margin 2/3 length of occludent margin; occludent margin longest margin, basal margin longer than articular margin; externally sinuous growth ridges well spaced, cut by 3 slight longitudinal ridges in some specimens, shallow middle ridge most obvious; internal surface smooth; adductor and depressor muscle pits absent, crests for lateral depressor muscles absent; adductor ridge feeble, often visible only on 1 valve; articular furrow shallow; articular ridge extending 1/2 length valve, slightly projecting; occludent margin folded, articular margin deeply folded. T thin, smaller than S, apex bluntly beaked; externally sinuous growth ridges



strong; articular margin almost straight, carinal margin convex; basal margin hollowed out; spur narrow, truncated, 1/4 width of basal margin, set at distance of less than 1/2 its own width from basi-scutal angle; spur furrow open, shallow wide; internally articular ridge prominent in upper 1/4 of valve; 7 well developed depressor muscle attachment crests, slightly extending below basal margin; inner surface of valve distinctly roughened over 2/3 surface; articular ridge not projecting. Parietal plates whitish with yellow tinge; alae pale yellow; opercular plates whitish. Measurements of holotype as follows:

<i>Holotype:</i>	RC length	LD	C height	R height
MNHN-Ci 2417	12.5	12.0	14.0	9.8

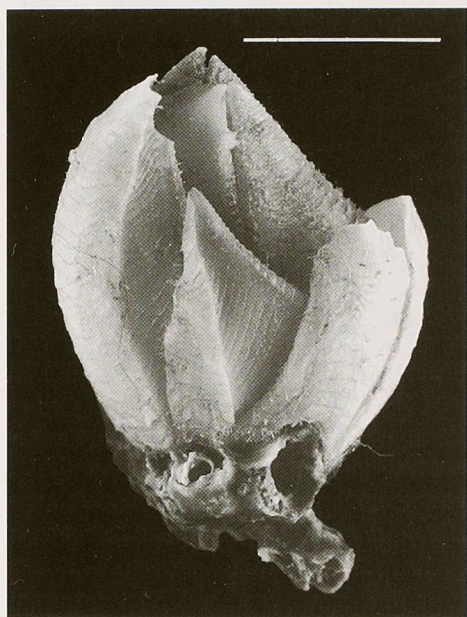


FIG. 62. — *Hexelasma globosum* sp. nov.  
Holotype from MUSORSTOM 4, stn  
CP 197 (MNHN-Ci 2417): lateral view.  
Scale = 5 mm.

Medial depression of labrum with regular row of small teeth. Mandibular palp ovate; long, finely serrate setae terminally. Mandible with 4 teeth, tooth 1 largest, well separated from teeth 2-4; margins of teeth 1-3 smooth, upper and lower margins of 4 with irregular subsidiary cusps; inferior angle bluntly molariform, slightly dentate. Maxillule setose; 2 long, stout setae at upper angle; notch below upper angle wide, with 4-5 pairs of smaller setae; cutting margin below stepped, with 5-7 pairs of longer, stout setae; inferior angle slightly stepped, with 5-7 pairs of small setae. Maxilla wide, coxal endite well developed; setae long, dense, finely serrulate.

Cirrus I with rami unequal; anterior ramus slightly longer than posterior; proximal segments of anterior ramus not protuberant anteriorly, segments wider than posterior ramus; both rami with segments thickly setose. Cirrus II longer than cirrus I; rami subequal; all segments thickly setose, setae finely serrulate. Cirrus III longer than cirri I and II, similar to cirri IV-VI; rami subequal, segments slightly antenniform distally; anterior and posterior ramus with 1-2 pairs of long, finely serrulate setae on anterior faces of distal segments. Cirrus IV to VI similar, longer than cirrus III; segments oblong, with 2 pairs of long, serrulate setae on anterior faces. Cirral formula as follows:

<i>Paratype:</i>		CI	CII	CIII	CIV	CV	CVI
MNHN-Ci 2418	left	13, 10	12, 13	18, 27	33, 34	44, 47	44, 48
	right	11, 9	11, 13	12+, 17+	21+, 16	23+, 45	48, 48

Penis equal to length of proximal segment of pedicel of cirrus VI; finely annulated; with few sparse setae; irregular circlet of longer setae distally.

REMARKS. — *Hexelasma globosum* sp. nov. is similar to *H. leptoderma* but the form of the latter is conical and high with the orifice much smaller than the basis, rather than sub-globose with a large, triangular, toothed orifice which is wider than the basis. *Hexelasma leptoderma* has yellowish plates externally due to a persistent yellow epicuticle; there is no epicuticle associated with *H. globosum* and the plates are whitish with a yellow tinge. The alar growth ridges of *H. globosum* turn slightly downward before reaching the superior alar margin to form a slight hook, rather than turning abruptly downward, forming a definite hook. A thin lamina of chitin is developed in longitudinal strips on the inner surface of the parietal plates of *H. globosum*, rather than contiguous chitinous rods forming a continuous layer between the inner and the outer chitinous laminae. The S and T of *H. globosum* are not covered with a persistent yellow epidermis; the S and T of *H. leptoderma* are covered by



a persistent yellow epidermis. The T spur of *H. globosum* is truncated; that of *H. leptoderma* pointed. In *H. globosum* the scutal adductor muscle pit is not defined, rather than being distinct, the depressor muscle pits are absent rather than present, the adductor ridge is feebly developed, often on one valve only, rather than being developed on both plates, and the occludent and articular margins are deeply folded, rather than only the articular margin being slightly folded. The labrum of *H. globosum* has a medial depression with a regular row of approximately 70 small teeth, that of *H. leptoderma* has 42 teeth.

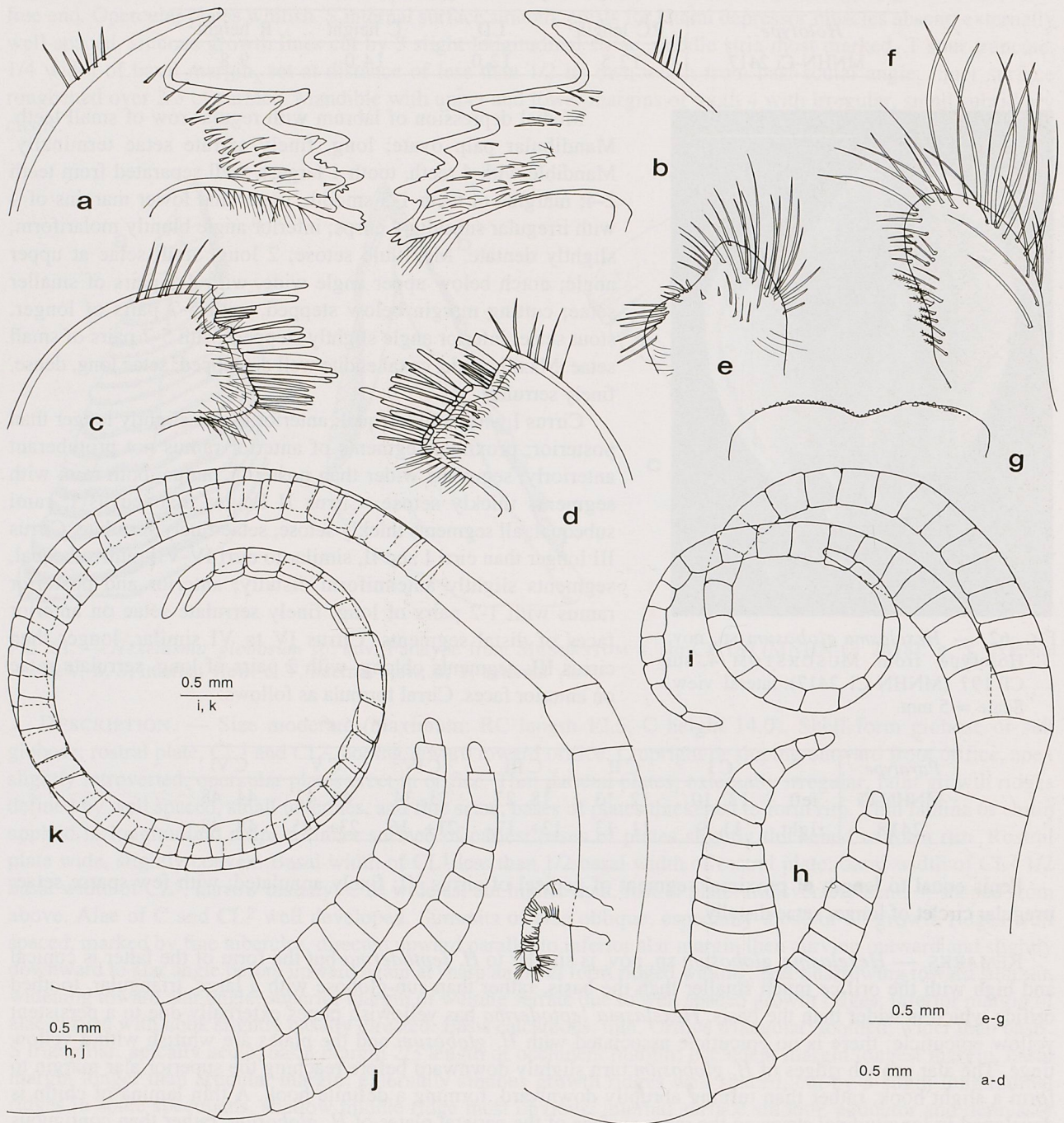


FIG. 63. — *Hexelasma globosum* sp. nov. Paratype from MUSORSTOM 4, stn CP 167 (MNHN-Ci 2418): a, right mandible; b, left mandible; c, right maxillule; d, left maxillule; e, maxilla; f, mandibular palp; g, labrum; h, cirrus I; i, cirrus III; j, cirrus II; k, cirrus VI and penis.



ETYMOLOGY. — From the Latin *globosus*, 'globose', in reference to the globular form of the shell.

DISTRIBUTION. — New Caledonia, 525-575 m; Loyalty Islands, 370-465 m.

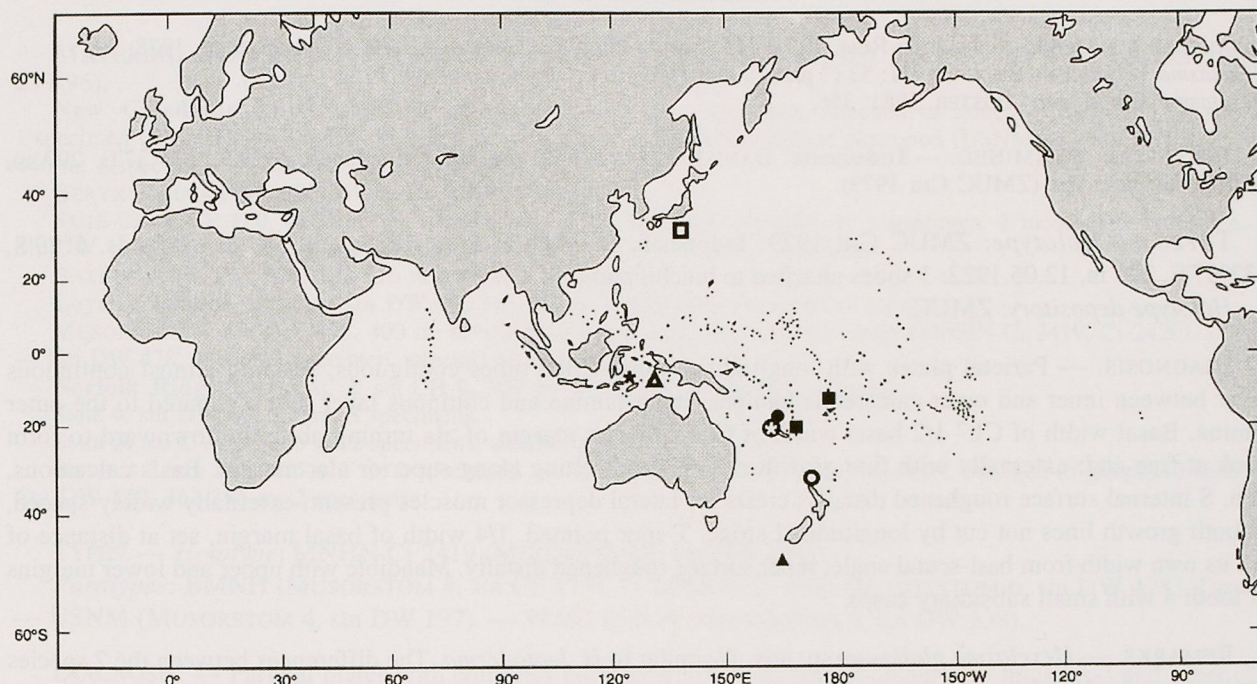


FIG. 64. — *HEXELASMA* Hoek, 1913 (continued). Distribution map: □, *H. triderma* (549 m); ★, *H. velutinum* (204-390 m); △, *H. leptoderma* (290 m); ⊕, *H. globosum* (370-575 m); ●, *H. persicum* (275-585 m); ■, *H. sandaracum* (170-1300 m); ▲, *H. nolearia* (741 m); ○, *H. gracilis* (1024-1029 m).

*Hexelasma gracilis* Foster, 1981

Fig. 64; Tables 28-31

*Hexelasma fosteri* Foster, 1978: 83 (part).

*Aptolasma fosteri* - FOSTER, 1978: (part), fig. 50, pl. 10 F.

*Hexelasma gracilis* Foster, 1981: 361.

MATERIAL EXAMINED. — **New Zealand.** NZOI: stn E 852, 33°38.00'S, 170°55.00'E, 1024-1029 m, 17.03.1968: holotype (NZOI Type H-357).

TYPES. — *Holotype*: NZOI H-357; New Zealand, NZOI stn E 852, 33°38.00'S, 170°55.00'E, 1024-1029 m, 17.03.1968.

*Holotype depository*: NIWA.

DIAGNOSIS. — Parietal plates with longitudinal chitin-filled tubes arcuate in cross-section, separated by regularly spaced, broad, calcareous bridges, dividing plate into laminae of equal width. Basal width of CL<sup>2</sup> sub-equal to basal width of CL<sup>1</sup>. Alae externally with growth ridges well marked, narrow ridged welting along superior alar margin. Basis with wide calcareous ledge. Opercular plates internally dull orange. S internal surface smooth; crests for lateral depressor muscles faint; externally widely-spaced, sinuous growth lines not cut by longitudinal striae. T slender; spur rounded, 1/4 width of basal margin, set at 1/2 its own width from basi-scutal angle; inner surface smooth. Mandibular tooth 2 with side tooth.

DISTRIBUTION. — New Zealand, 1024-1029 m.



*Hexelasma leptoderma* (Newman & Ross, 1971)

Fig. 64; Tables 28-31

*Aaptolasma leptoderma* Newman & Ross, 1971: 165, figs 79-80, pls 33 A-B, 40; 1976: 46. — FOSTER, 1978: 79.*Hexelasma velutinum* - BROCH, 1931: 53 (? part). ? non *Hexelasma velutinum* Hoek, 1913.*Hexelasma leptoderma* - FOSTER, 1981: 356.

MATERIAL EXAMINED. — **Indonesia**. DANISH EXPED. 1922: stn 58, Kei Islands, 5°29'S, 132°37'E, 290 m, 12.05.1922: holotype (ZMUC Cru 1979).

TYPES. — *Holotype*: ZMUC Cru 1979; Indonesia, DANISH EXPED. 1922, stn. 58, Kei Islands, 5°29'S, 132°37'E, 290 m, 12.05.1922: 3 slides attached to brachiopod.

*Holotype depository*: ZMUC.

DIAGNOSIS. — Parietal plates with longitudinal chitin-filled tubes contiguous, forming almost continuous layer between inner and outer calcareous laminae, inner lamina and chitinous layer thin compared to the outer lamina. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Inferior margin of ala turning abruptly downward to form hook at free end; externally with fine growth ridges, thin welting along superior alar margin. Basis calcareous, thin. S internal surface roughened distally; crests for lateral depressor muscles present; externally widely-spaced, smooth growth lines not cut by longitudinal striae. T spur pointed, 1/4 width of basal margin, set at distance of 1/2 its own width from basi-scutal angle; inner surface roughened distally. Mandible with upper and lower margins of tooth 4 with small subsidiary cusps.

REMARKS. — *Hexelasma globosum* sp. nov. is similar to *H. leptoderma*. The differences between the 2 species are listed under *Hexelasma globosum* sp. nov.

DISTRIBUTION. — Kei Islands, 290 m.

*Hexelasma nolearia* (Foster, 1978)

Fig. 64; Tables 28-31

*Aaptolasma nolearia* Foster, 1978: 85, fig. 51, pl. 10 G-H.*Hexelasma nolearia* - FOSTER, 1981: 356, 361.

MATERIAL EXAMINED. — **New Zealand**. NZOI: stn D159, 49°01.00'S, 164°30.00'E, 741 m, 17.01.1964: holotype (NZOI Type H-206).

TYPES. — *Holotype*: NZOI H-206; New Zealand, NZOI stn D 159, 49°01.00'S, 164°30.00'E, 741 m, 17.01.1964.

*Holotype depository*: NIWA.

DIAGNOSIS. — Parietal plates with pairs of chitinous ribbons, situated inward from grooves between prominent ribs of inner surface, dividing plates into thicker outer and thinner inner laminae. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Inferior margin of ala not curved, with no basally directed hook at free end; narrow welting along superior alar margin. Basis calcareous. S occludent and articular margins folded; internal surface smooth; faint crests for lateral depressor muscles; externally, well-spaced, smooth growth lines not cut by longitudinal striae. T articular margin convex; spur indistinct, 1/3 width of basal margin, set at basi-scutal angle; inner surface roughened distally. Mandible with upper and lower margins of teeth smooth.

DISTRIBUTION. — New Zealand, 741 m.



*Hexelasma persicum* sp. nov.

Figs 64-67; Tables 28-31

**MATERIAL EXAMINED.** — **Chesterfield Islands.** MUSORSTOM 5: stn DW 338, 540-580 m: 1 specimen (WAM 259-96).

**New Caledonia.** MUSORSTOM 4: stn DW 159, 585 m: 1 specimen, attached to stone. — Stn CP 179, 475 m: 1 specimen (BMNH). — Stn DW 197, 550 m: 1 specimen, attached to shell of gastropod (USNM). — Stn DW 222, 410-440 m: 1 specimen. — Stn DW 223, 545-560 m: 1 specimen.

BERYX 2: stn CP 46, 300-350 m: 2 specimens.

SMIB 8: stn CP 180, 425-460 m: 1 specimen. — Stn DW 185, 305-355 m: 1 specimen, 1 incomplete specimen. — Stn DW 193, 500-508 m: several specimens. — Stn DW 194, 491 m: 3 specimens.

BATHUS 4: stn DW 929, 502-516 m: several specimens.

**Loyalty Islands.** BIOCAL: stn DW 66, 505-515 m: 1 specimen, attached to coral.

MUSORSTOM 6: stn DW 478, 400 m: several specimens, some attached to sponge (MNHN-Ci 2419, Ci 2420). Drawn. — Stn DW 478, 400 m: 1 specimen, attached to rocks.

**Norfolk Ridge.** CHALCAL 2: stn CH 9, 300 m: 2 specimens, attached to sponge.

SMIB 4: stn DW 60, 535 m: 3 specimens.

SMIB 5: stn DW 94, 275 m: 2 specimens, attached to *Rhizotrochus* sp.

BATHUS 3: stn 818, 405-411 m: 2 specimens. — Stn CH 820, 394-401 m: 1 specimen, attached to gastropod shell. — Stn DW 830, 361-365 m: 2 specimens.

**TYPES.** — *Holotype*: MNHN-Ci 2419 (MUSORSTOM 6, stn DW 478).

*Paratypes*: BMNH (MUSORSTOM 4, stn CP 179). — MNHN-Ci 2420 (MUSORSTOM 6, stn DW 478). Drawn.

— USNM (MUSORSTOM 4, stn DW 197). — WAM 259-96 (MUSORSTOM 5, stn DW 338).

**DIAGNOSIS.** — Parietal plates with chitinous rods separating parietes into inner (1/3 thickness) and outer (2/3 thickness) laminae. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>. Inferior margin of ala curved, with blunt, basally directed hook at free end; ridged welting along superior alar margin, increasing in width toward free end. Basis calcareous; thin. Opercular plates peachy-orange. S internal surface smooth; crests for lateral depressor muscles feeble or absent; externally sinuous, narrowly-spaced, growth lines cut by 3 faint longitudinal striae, 2 near occludent margin, 1 near articular margin. T spur truncate, 1/4 width of basal margin, set at distance of 1/3 its own width from basi-scutal angle; inner surface roughened distally. Mandibular tooth 2 with 1 or a few small subsidiary cusps, upper and lower margins of tooth 4 with small, irregular subsidiary cusps.

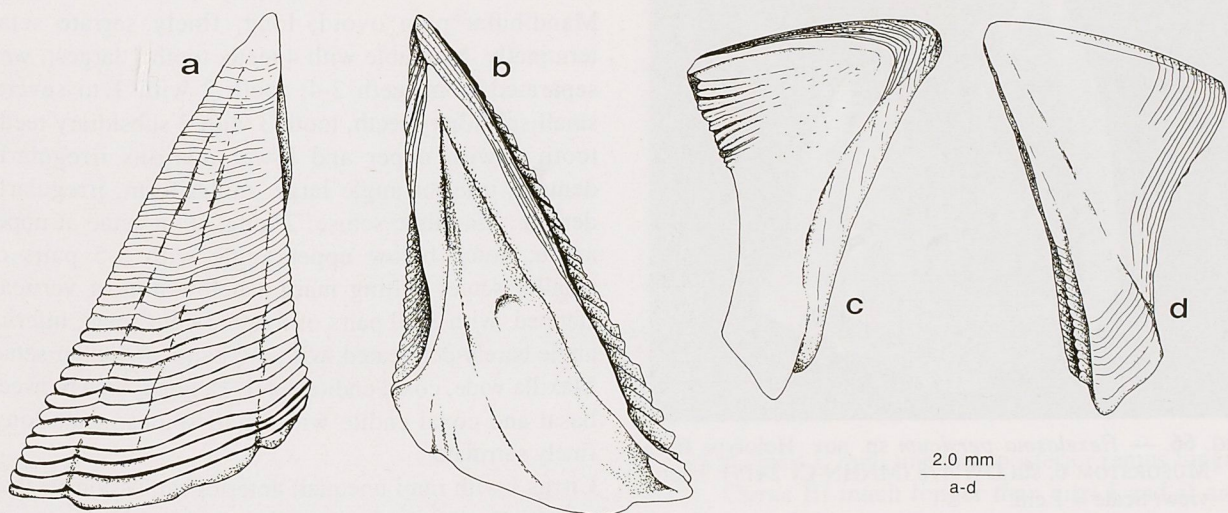


FIG. 65. — *Hexelasma persicum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478 (MNHN-Ci 2420): a, S, external view; b, S, internal view; c, T, internal view; d, T, external view.



DESCRIPTION. — Size large (maximum: RC length 19.4, C height 16.9). Shell tall, nearly vertical. Parietal plates thick, covered by thin, pale cream, persistent epicuticle; growth ridges irregular, marked by small setae and minute calcareous knobs; basally inflected, forming thin rim; internally ribbed parietal walls with ribs prominent basally; chitinous rods separating parietes into inner (1/3 thickness) and outer (2/3 thickness) laminae. Rostral plate convex, wide basally; apex curving in toward orifice. Basal width of CL<sup>1</sup> 1/2 basal width of rostral plate. Basal width of CL<sup>2</sup> 1/2 basal width of CL<sup>1</sup>; triangular. C highest plate; apex curving toward orifice. Alae wide, broadly triangular, extending full height of parietes; summits oblique; growth ridges directed upward parallel to inferior alar margin before curving downward and outward toward alar angle, then sharply upward to form ridged welting, increasing in width toward free end; inferior alar margin curved, with blunt, basally directed hook at free end. Orifice triangular; deeply toothed. Basis thin, calcareous. S triangular, elongated, apically sharply acute; occludent margin longer than other margins, basal margin 9/16 length of articular margin; externally with persistent ochre-yellow epidermis; sinuous growth ridges narrowly spaced, cut by 3 narrow, longitudinal ridges (some specimens with 1), 2 near to occludent margin, extending from apex to basal margin, 1 close to articular margin, traceable through 3/4 of valve, well-marked in lower half; basal margin sinuous, sometimes notched at bases of ridges; internally with indistinct, oval adductor muscle pit; adductor ridge feeble; lateral depressor muscle pit faint, feeble muscle attachment ridges on S; articular furrow shallow; articular ridge extending 2/3 margin, slightly projecting; articular and occludent margins rounded, folded, inner edges sinuous. T slightly smaller than S; apex blunt; externally sinuous growth ridges less defined than on S; articular margin straight/slightly convex; carinal margin straight; basal margin hollowed out; spur basally truncate, pointed toward and set close to basiscutal angle; spur furrow open, slightly sunken, broad basally; internally with articular ridge not projecting; 7 distinct and 3 smaller muscle attachment crests for depressor muscles, not extending below basal margin; inner surface of valve lightly roughened with irregular beading in distal half. Color of parietal plates dirty white; cleaned specimens with some peachy-orange on parietes and alae. Apical and carinal areas of T often peachy-orange color internally and externally; remainder of valve whitish. Externally apical tip of S, and internally and externally central lower parts of valve tinged peachy-orange in some specimens, valve whitish elsewhere. Measurements of holotype as follows:

<i>Holotype:</i>	RC length	LD	C height	R height
MNHN-Ci 2419	19.4	14.2	16.9	14.6

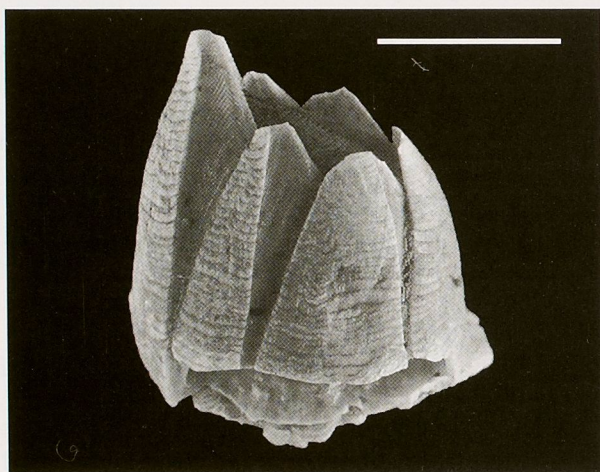


FIG. 66. — *Hexelasma persicum* sp. nov. Holotype from MUSORSTOM 6, stn DW 478 (MNHN-Ci 2419): lateral view. Scale = 1 cm.

Labrum with shallow medial depression provided with row of bifid teeth and dense, short setae. Mandibular palp ovoid; long, finely serrate setae terminally. Mandible with 4 teeth, tooth 1 largest, well separated from teeth 2-4; tooth 2 with 1 to several small subsidiary teeth, tooth 3 with 2 subsidiary teeth, tooth 4 with upper and lower margins irregularly dentate; inferior angle large, molariform, irregularly dentate. Maxillule setose; 2 long, stout setae at upper angle; notch below upper angle with 3-5 pairs of smaller setae; cutting margin below almost vertical, stepped, with 8-10 pairs of longer, stout setae; inferior angle barely delineated, with 4-6 pairs of smaller setae. Maxilla wide, coxal endite barely defined; area between basal and coxal endite with small spines; setae long, finely serrulate.

Cirrus I with rami unequal; anterior ramus longer than posterior; proximal segments of anterior ramus not protuberant anteriorly, segments wider than posterior ramus, becoming antenniform distally; both rami with



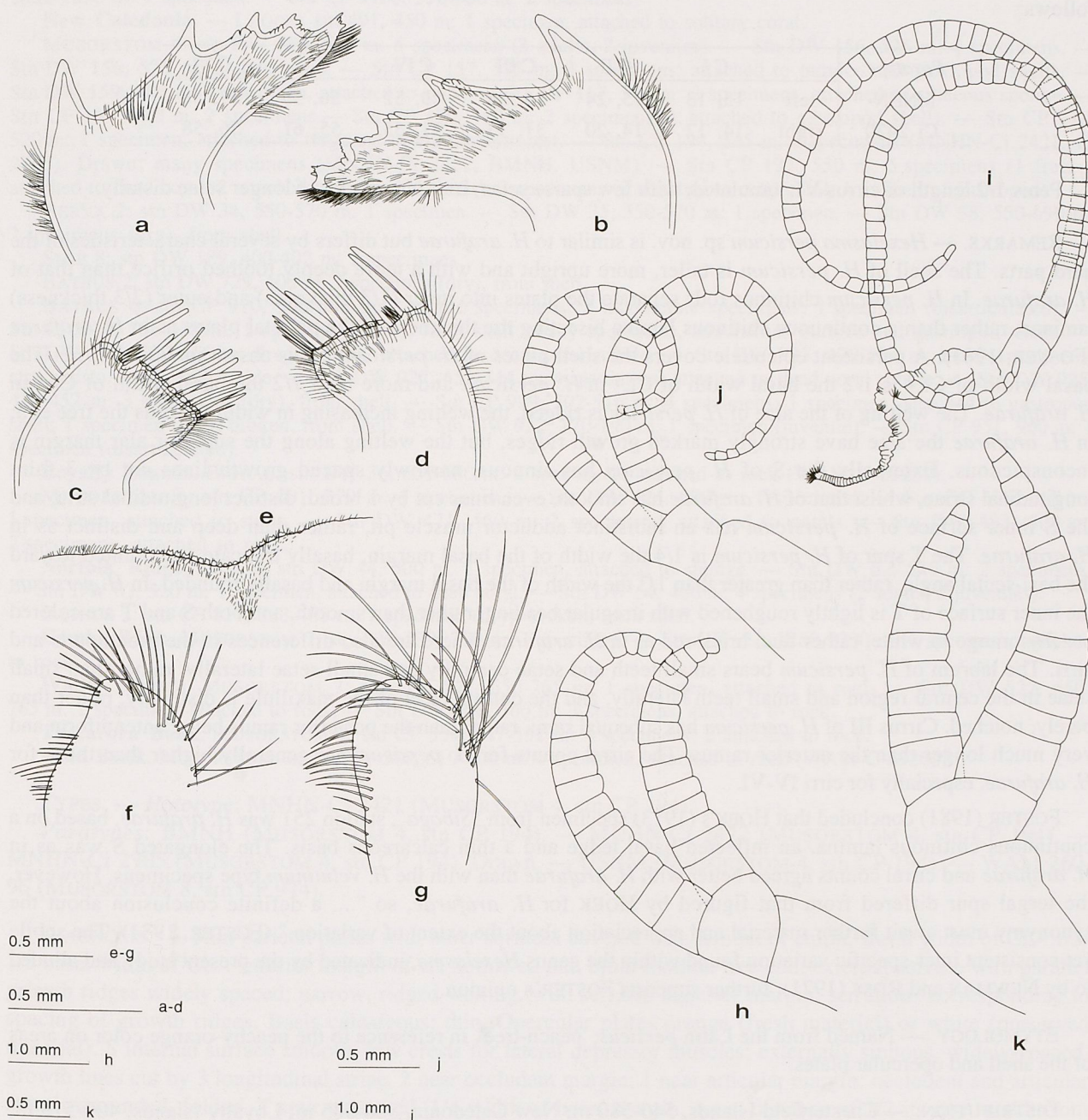


FIG. 67. — *Hexelasma persicum* sp. nov. Paratype from MUSORSTOM 6, stn DW 478 (MNHN-Ci 2420): **a**, right mandible; **b**, left mandible; **c**, right maxillule; **d**, left maxillule; **e**, labrum; **f**, maxilla; **g**, mandibular palp; **h**, cirrus II; **i**, cirrus VI and penis; **j**, cirrus III; **k**, cirrus I.

segments setose; setae finely serrulate distally. Cirrus II longer than cirrus I; rami unequal, posterior ramus longer than anterior ramus; all segments setose, especially proximally. Cirrus III much longer than cirri I and II and similar to cirri IV-VI; rami subequal, segments becoming oblong distally; anterior and posterior ramus with 2 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments densely setose. Cirrus IV to VI similar, longer than cirrus III; rami subequal; segments oblong, with 2 pairs of long, finely



serrulate setae on anterior faces; proximal segments wider than long, becoming oblong distally. Cirral formula as follows:

Paratype:		C I	C II	C III	C IV	C V	C VI
MNHN-	left	15, 13	15, 24	35, 38	49, 52	56, 55	57, 58
Ci 2420	right	14, 12	14, 20	31, 33	41, 53	55, 61	56, 58

Penis 1/2 length of cirrus VI; annulated; with few sparse setae; irregular circlet of longer setae distally.

REMARKS. — *Hexelasma persicum* sp. nov. is similar to *H. arafurae* but differs by several characteristics of the hard parts. The shell of *H. persicum* is taller, more upright and with a more deeply toothed orifice than that of *H. arafurae*. In *H. persicum* chitinous rods separate the plates into inner (1/3 thickness) and outer (2/3 thickness) laminae, rather than a continuous chitinous lamina bisecting the thickness of the parietal plates as in *H. arafurae* (FOSTER, 1981). A persistent epicuticle covers the shell plates of *H. persicum* but is absent in *H. arafurae*. The basal width of CL<sup>2</sup> is 1/2 the basal width of CL<sup>1</sup> in *H. persicum* and more than 1/2 the basal width of CL<sup>1</sup> in *H. arafurae*. The welting of the alae of *H. persicum* is ridged, the welting increasing in width towards the free end; in *H. arafurae* the alae have strongly marked growth ridges, but the welting along the superior alar margin is inconspicuous. Externally the S of *H. persicum* has sinuous, narrowly spaced growth lines cut by 3 faint longitudinal striae, whilst that of *H. arafurae* has smooth, even lines cut by 1 broad, distinct longitudinal stria; and the S inner surface of *H. persicum* has an indistinct adductor muscle pit, rather than deep and distinct as in *H. arafurae*. The T spur of *H. persicum* is 1/4 the width of the basal margin, basally truncate and pointed toward the basi-scutal angle, rather than greater than 1/3 the width of the basal margin and basally rounded. In *H. persicum* the inner surface of T is lightly roughened with irregular beading, rather than smooth, and both S and T are colored peachy orange to white, rather than brick-red as in *H. arafurae*. There are also differences in the mouthparts and cirri. The labrum of *H. persicum* bears small teeth and setae centrally and small setae laterally, rather than small setae in the central region and small teeth laterally, and the cutting edge of the maxillule is distinctly, rather than barely, notched. Cirrus III of *H. persicum* has subequal rami, rather than the posterior ramus being antenniform and very much longer than the anterior ramus. The cirral counts for *H. persicum* are generally higher than those for *H. arafurae*, especially for cirri IV-VI.

FOSTER (1981) concluded that HOEK's (1913) specimen from "Siboga", station 251 was *H. arafurae*, based on a continuous chitinous lamina, an inflected basal ledge and a thin calcareous basis. The elongated S was as in *H. arafurae* and cirral counts agreed better with *H. arafurae* than with the *H. velutinum* type specimens. However, the tergal spur differed from that figured by HOEK for *H. arafurae*, so "... a definite conclusion about the synonymy must await further material and appreciation about the extent of variation." (FOSTER, 1981). The subtle yet consistent inter-specific variation found within the genus *Hexelasma*, indicated by the present study and alluded to by NEWMAN and ROSS (1971), further supports FOSTER's opinion.

ETYMOLOGY. — Named from the Latin *persicus*, 'peach-tree', in reference to the peachy-orange color on areas of the shell and opercular plates.

DISTRIBUTION. — Chesterfield Islands, 540-580 m; New Caledonia, 300-585 m; Loyalty Islands, 400-515 m; Norfolk Ridge, 275-535 m.

### *Hexelasma sandaracum* sp. nov.

Figs 64, 68-70; Tables 28-31

MATERIAL EXAMINED. — **Vanuatu**. MUSORSTOM 8: stn CP 972, 487-507 m: 4 specimens. — Stn CP 973, 460-480 m: 7 specimens. — Stn CP 974, 492-520 m: many specimens (WAM 260-96). — Stn DW 978, 413-408 m: 7 specimens. — Stn DW 989, 650-669 m: 2 specimens. — Stn CP 1026, 437-504 m: 1 specimen. — Stn CP 1027, 550-571 m: 4 specimens. — Stn CP 1045, 459-488 m: many specimens. — Stn DW 1046, 461-480 m: 1 specimen. — Stn DW 1067, 344-366 m: 2 specimens. — Stn CP 1080, 799-850 m: 1 specimen. — Stn CP 1083, 397-439 m:



1 specimen. — Stn CP 1114, 647 m: 1 specimen. — Stn CP 1125, 1160-1220 m: many specimens. — Stn CP 1127, 1052-1058 m: 1 specimen. — Stn CP 1136, 398-400 m: 2 specimens.

**New Caledonia.** — LAGON: stn 491, 450 m: 1 specimen, attached to solitary coral.

MUSORSTOM 4: stn DW 156, 530 m: 5 specimens (3 adults, 2 juveniles). — Stn DW 156, 525 m: 4 specimens. — Stn DW 156, 525 m: 3 specimens. — Stn CP 157, 575 m: 3 specimens, attached to pumice and gastropod shells. — Stn DW 159, 585 m: 1 specimen, attached to rock. — Stn CP 167, 575 m: 2 specimens, attached to siliceous sponge. — Stn CP 169, 590 m: 2 specimens. — Stn CP 170, 480 m: 2 specimens (1 attached to gastropod shell). — Stn CP 178, 520 m: 1 specimen, attached to fragment of echinoderm test. — Stn CP 194, 545 m: 3 specimens (MNHN-Ci 2421, Ci 2705). Drawn; many specimens (MNHN-Ci 2422, BMNH, USNM). — Stn CP 197, 550 m: 5 specimens (1 free, 2 attached to dead coral, 2 attached to gastropod shells); 3 specimens (2 attached to dead coral, 1 to shell of gastropod).

BERYX 2: stn DW 34, 550-570 m: 1 specimen. — Stn DW 35, 550-570 m: 1 specimen. — Stn DW 38, 550-690 m: 2 specimens (dry), from shell.

SMIB 8: stn DW 189, 400-402 m: 2 specimens.

BATHUS 2: stn DW 729, 400 m: 1 specimen (dry), from shell.

BATHUS 4: stn CP 910, 560-608 m: 3 whole specimens; 2 incomplete specimens; 1 specimen (disarticulated). — Stn CP 911, 566-558 m: 2 specimens (dry), from shell; many specimens, attached to pumice and gastropod shells. — Stn DW 916, 600-616 m: 4 specimens, attached to dead coral rubble. — Stn DW 923, 470-502 m: many specimens, attached to dead coral rubble. — Stn DW 927, 452-444 m: 4 specimens, attached to dead coral rubble. — Stn DW 928, 420-452 m: 3 specimens (dry), from shell. — Stn CP 929, 502-516 m: 4 specimens; 1 specimen, attached to gastropod shell; 1 specimen (dry), broken, from shell. — Stn DW 932, 170-190 m: 1 specimen (juvenile). — Stn CP 951, 960 m: 1 specimen (disarticulated).

**Loyalty Islands.** BIOCAL: stn DW 36, 650-680 m: 2 specimens, attached to rock (WAM C 23259).

MUSORSTOM 6: stn CP 401, 270 m: 1 specimen. — Stn DW 424, 599 m: 1 specimen. — Stn CC 470, 560 m: 1 specimen, attached to stone. — Stn DW 471, 460 m: 2 specimens, attached to corals. — Stn DW 483, 600 m: 2 specimens, attached to rock.

**Norfolk Ridge.** SMIB 4: stn DW 44, 300 m: 1 specimen, attached to sponge. — Stn DW 62, 540 m: 2 specimens. — Stn DW 63, 520 m: 1 specimen, attached to dead coral. — Stn DW 64, 460 m: 4 specimens (2 adults, 2 juveniles).

BATHUS 3: stn CP 811, 383-408 m: 1 specimen (dry), broken, from shell.

**Combe Bank.** MUSORSTOM 7: stn DW 539, 700 m: 1 specimen. — Stn CP 622, 1280-1300 m: 1 specimen, attached to rock.

**Wallis Islands.** MUSORSTOM 7: stn DW 522, 650-765 m: 1 specimen, attached to rock. — Stn DW 522, 650-765 m: 1 specimen, attached to rock. — Stn DW 582, 360 m: 3 specimens, attached to rock.

**Tuscarora Bank.** MUSORSTOM 7: stn CP 559, 547-552 m: 4 specimens, 2 attached to rock.

**Field Bank.** MUSORSTOM 7: stn DW 586, 510-600 m: 1 specimen, attached to rock (WAM C 23260).

**TYPES.** — *Holotype*: MNHN-Ci 2421 (MUSORSTOM 4, stn CP 194).

*Paratypes*: BMNH (MUSORSTOM 4, stn CP 194). — MNHN-Ci 2422 (MUSORSTOM 4, stn CP 194). — MNHN-Ci 2705 (MUSORSTOM 4, stn CP 194). Drawn. — USNM (MUSORSTOM 4, stn CP 194). — WAM 260-96 (MUSORSTOM 8, stn CP 974).

**DIAGNOSIS.** — Thin parietal plates with inner surfaces covered with lamina of chitin. Basal width of CL<sup>2</sup> 1/3-1/2 basal width of CL<sup>1</sup>. Inferior margin of ala hollowed out, blunt tooth at free end; external surface with parallel growth ridges widely spaced; narrow, ridged welting, with serrated superior margin, serrations corresponding to spacing of growth ridges. Basis calcareous; thin. Opercular plates orange (fresh material) or white (preserved material). S internal surface smooth; low crests for lateral depressor muscles; externally sinuous, widely-spaced, growth lines cut by 3 longitudinal striae, 2 near occludent margin, 1 near articular margin; occludent and articular margins rounded, folded. T spur truncated, 1/4 width of basal margin, set at distance of 1/2 its own width from basi-scutal angle; inner surface slightly roughened in upper 1/2. Mandible with upper margin of tooth 3 with 1 or more small, subsidiary cusps, upper and lower margins of tooth 4 with small, irregular subsidiary cusps.

**DESCRIPTION.** — Size large (maximum: RC length 33.0, C height 27.0). Shell with paries erect, not curved inward toward C. Parietal plates thin; covered with colorless, thin, persistent epidermis; growth ridges well spaced; marked by fine, ochre setae and small tubercles; basal edges of plates irregularly toothed; inner surface of paries smooth, covered with lamina of chitin. Rostral plate convex, triangular; height subequal to C height, basal width greater than that of C. CL<sup>1</sup> with apex erect. Basal width of CL<sup>2</sup> 1/2-1/3 basal width of CL<sup>1</sup>; apex suberect. C strongly bent transversely, more pronounced toward apex with lateral halves meeting at precise angle. Alae wide, triangular, summits oblique; parallel growth ridges widely set, directed upward parallel to inferior alar margin



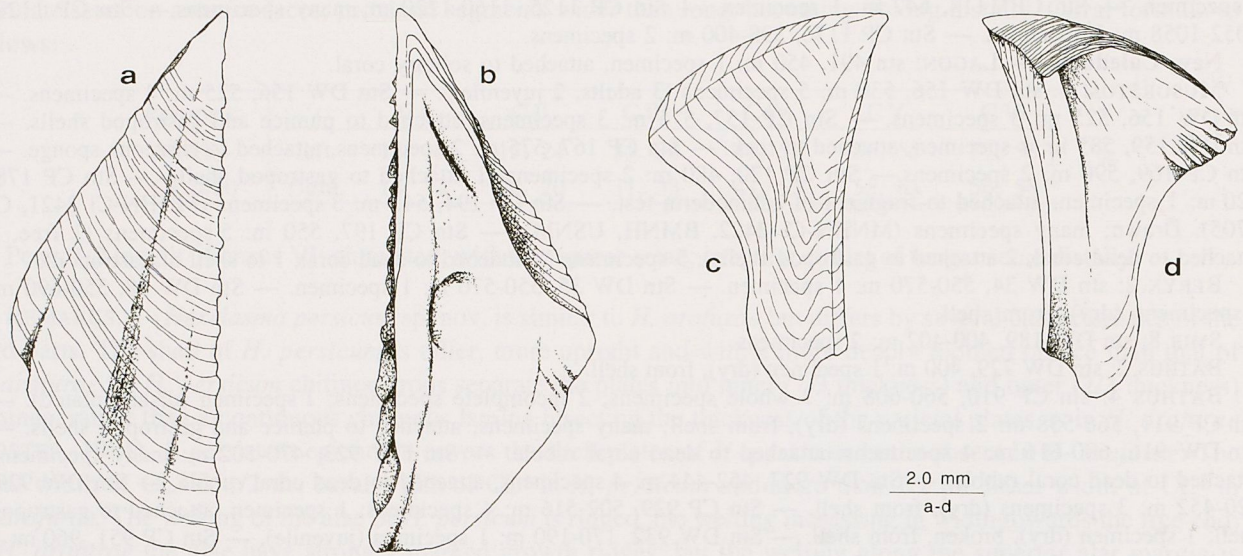


FIG. 68. — *Hexelasma sandaracum* sp. nov. Paratype from MUSORSTOM 4, stn CP 194 (MNHN-Ci 2705): a, S, external view; b, S, internal view; c, T, external view; d, T, internal view.

before curving outward and slightly downward toward alar angle and then up again at sharp angle to form narrow, ridged welting, with serrated upper margin, serrations corresponding to spacing of growth ridges; inferior alar margin hollowed out, blunt tooth at free end. Orifice pentagonal; toothed. Basis calcareous, thin, uneven; circumference circular. Opercular plates flush with orifice, inclined at angle to basis. S triangular, sharply pointed apically, externally gently concave in middle area; basal margin 9/15 length of occludent margin; occludent margin longest margin, basal margin slightly shorter than articular margin; sinuous growth ridges prominent, widely spaced, cut by 3 slight longitudinal striae (some specimens with 1), 2 near occludent margin, extending from apex to basal margin (stria nearest middle of valve shallower, longer than narrower stria nearest occludent margin), 1 near articular margin shallow, extending from apex for 2/3 length of valve; internally adductor muscle scar shallow, low lateral depressor muscle ridges in slight pit; adductor ridge feeble, often distinct on one S only; articular furrow shallow; articular ridge extending for 1/2 to 2/3 margin, slightly projecting; articular and occludent margins rounded, folded. T thin, distinctly smaller than S; apex beaked; externally sinuous growth ridges less defined than on S; articular margin slightly curved; carinal margin convex; basal margin weakly hollowed out; broad spur truncate, 1/4 width of basal margin, pointed toward and set at distance of 1/2 its width from basi-scutal angle; spur furrow open, shallow, flat, broad basally; articular ridge not projecting but traceable through 2/3 length of valve; 5-7 distinct depressor muscle crests, some slightly extending below basal margin; inner surface of valve slightly roughened in distal 1/2. Freshly preserved specimens with T vivid orange externally and internally in middle regions of valve; S similarly colored orange apically, externally and internally; C internally with sheath vivid orange, externally color suffusing through upper portions of C, including ala, through partly transparent paries; elsewhere paries externally pale lemon yellow; internally with yellow chitinous layer applied to inner faces. Long-preserved material with parietal plates externally creamy white-yellowish; summits of alae of C and CL<sup>2</sup> orange-tinged; internally parietes yellow; external and internal surfaces of S and T white. Eggs orange. Measurements of holotype and of largest specimen, respectively, as follows:

	RC length	LD	C height	R height
<i>Holotype</i> : MNHN-Ci 2421	16.2	14.6	13.2	10.9
<i>Largest specimen</i>	33.0	25.0	27.0	23.0

Shallow medial depression of labrum with row of well-developed teeth. Mandibular palp oblong; long, finely serrate setae terminally. Mandible with 4 teeth, tooth 1 largest, well separated from teeth 2-4; tooth 3 with 1 or



more small subsidiary cusps on upper margin, upper and lower margins of tooth 4 with irregular, small subsidiary cusps; inferior angle small, molariform, dentate. Maxillule setose; 3 long, stout setae at upper angle; notch below upper angle wide, with 4 pairs of smaller setae; cutting margin below stepped, sloping, with 7-10 pairs of longer, stout setae; inferior angle barely demarcated, with 4-6 pairs of smaller setae. Maxilla wide, coxal endite barely defined; setae long, finely serrulate.

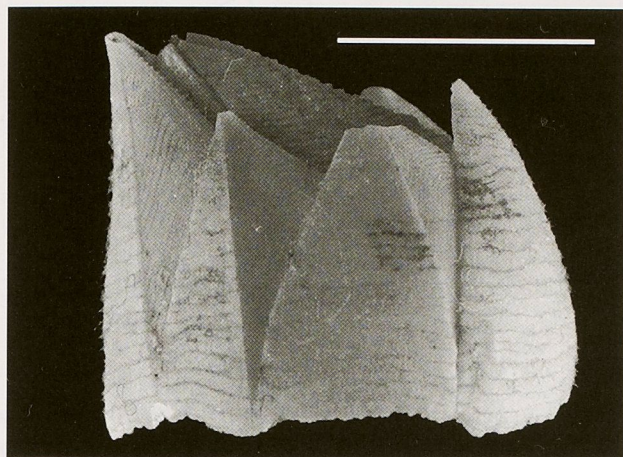


FIG. 69. — *Hexelasma sandaracum* sp. nov. Holotype from MUSORSTOM 4, stn CP 194 (MNHN-Ci 2421): lateral view. Scale = 1 cm.

Cirrus I with rami subequal; anterior ramus longer than posterior; proximal segments of anterior ramus not protuberant anteriorly, segments wider than posterior ramus; both rami with segments setose, setae finely serrulate distally. Cirrus II longer than cirrus I; rami subequal, all segments setose, setae finely serrulate. Cirrus III longer than cirri I and II and similar to cirri IV-VI; rami subequal, segments slightly antenniform distally; posterior ramus with 1-2 pairs of long, finely serrulate setae on anterior faces of more distal segments; anterior ramus with 2-3 pairs of long, finely serrulate setae on anterior faces of distal segments, proximal segments with 4 pairs of long setae. Cirrus IV to VI similar, longer than cirrus III; rami subequal; segments becoming oblong distally, with 2 pairs of finely serrulate, long setae on anterior faces. Cirral formula as follows:

Paratype:		CI	CII	CIII	CIV	CV	CVI
MNHN-	left	13, 9	14, 18	19+, 39	37, 43	47, 48	47, 47
Ci 2705	right	13, 9	13, 16	20, 25	38, 43	33, 36	46, 46

Penis 1/4 length of cirrus VI; annulated; with few sparse setae; irregular circlet of longer setae distally. Large ellipsoidal eggs, few in number, 0.35 x 0.25 mm.

REMARKS. — *Hexelasma sandaracum* sp. nov. is similar to *H. brintoni* but the two can be separated on characters of the hard and soft parts. The basal width of CL<sup>2</sup> of *H. sandaracum* is 1/2-1/3 the basal width of CL<sup>1</sup> rather than 3/5 the basal width. In *H. sandaracum* the inferior alar margin is hollowed out, with a blunt, downwardly directed tooth at the free end, as opposed to curved and without a basally directed hook at the free end, as in *H. brintoni*. Chitin is present as a lamina on the inner surface of the paries in *H. sandaracum*. In *H. brintoni* the parietal plates have longitudinal, chitin-filled rods, sub-arcuate in cross-section, regularly spaced and separated from one another by broad calcareous bridges, which bisect the thickness of the parietal plates. The calcareous basis is thin in *H. sandaracum* and thick in *H. brintoni*. In *H. sandaracum* the tergal spur is 1/4 rather than 1/3 the width of the basal margin; and the tergal basal margin rounds into the spur, rather than meeting it at an abrupt angle as in *H. brintoni*. The S of *H. sandaracum* externally has sinuous growth lines cut by 3 longitudinal striae; that of *H. brintoni* has smooth, even growth lines not cut by longitudinal striae. In addition the cirral counts are higher for *H. sandaracum* than those for *H. brintoni*.

*Hexelasma sandaracum* sp. nov. is also similar to *H. triderma* but there are differences in the overall shell form. The opercular plates and soft parts of *H. triderma* are undescribed. In *H. sandaracum* the shell plates are covered with a colorless, thin, persistent epidermis, and the growth ridges are well spaced and marked by fine, ochre setae and small tubercles, rather than covered with brownish cuticle and marked by heavy transverse growth ridges with numerous setae. In *H. sandaracum* the alar welting is narrow rather than broad, and the inferior alar margin is hollowed out, with a blunt, downwardly directed tooth at the free end, rather than curved, with an abrupt, basally directed hook at the alar angle. The basal width of CL<sup>2</sup> of *H. sandaracum* is 1/2-1/3 the basal width of CL<sup>1</sup> rather than 1/2-2/3. Chitin is present as a yellow lamina on the inner surface of the paries in *H. sandaracum*, rather than



REMARKS. — *Hexelasma velutinum* is a large sized species (maximum: RC length 10.0, C height 13.0). *Hexelasma arafurae* and *H. aureolum* sp. nov. are superficially similar to *H. velutinum*. Differences between these species may be found under *H. arafurae* and *H. aureolum*, respectively.

DISTRIBUTION. — Japan, Philippines to South China Sea; 204-390 m.

## DISCUSSION

**Wall structure in Chionelasmatoidea and Pachylasmatoidea.** — A basal whorl, or whorls, of imbricating plates is present in the chionelasmatooids *Chionelasmus* and *Eochionelasmus*. The wall is 6-plated (R-RL-CL-C), with the RL derived from an imbricating plate which is added to protect the R/CL suture. The upper portion of RL is not incorporated into the sheath and the lower portion is not fully incorporated into the wall.

In the higher balanomorphs, such as the Pachylasmatoidea, CL<sup>2</sup> is added to the wall structure. Within the Pachylasmatidae, four whorls of imbricating plates are present in the eolasmatine *Waikalasma*. The wall is 8-plated (R-RL-CL<sup>1</sup>-CL<sup>2</sup>-C), with CL<sup>2</sup> added by the replication of CL<sup>1</sup>, rather than by transfer from the imbricating whorls. CL<sup>2</sup> only slightly enters the sheath as a very narrow zone. In the pachylasmatine *Pachylasma*, imbricating plates are absent in Recent forms. Imbricating plates are also absent in the new pachylasmatine genera described in the present paper (*Eutomolasma* gen. nov., *Eurylasma* gen. nov. and *Microlasma* gen. nov.). In these pachylasmatines the wall is 6-plated (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL and CL<sup>2</sup> are incorporated into the wall but RL is not incorporated into the sheath. In *Eurylasma* CL<sup>2</sup> is partially coalesced with CL<sup>1</sup>, but CL<sup>2</sup> enters the sheath as a very narrow zone. The pachylasmatine *Tetrapachylasma*, has a wall that may be 6- or 4-plated, depending on the degree of coalescence of the plates. In the 6-plated form (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL coalesces with R to form a compound rostrum (RL+R+RL). In the 4-plated wall (R-CL-C), RL and R form a compound rostrum (RL+R+RL) and CL<sup>2</sup> coalesces with CL<sup>1</sup> to form a compound CL plate. CL<sup>2</sup> enters the sheath as a narrow zone but RL is not incorporated into the sheath, with the exception of *T. ornatum* sp. nov., which shows the incipient inclusion of RL into the sheath.

Imbricating plates are absent in the Metalasmatinae, the Bathylasmatinae and the Hexelasmatinae. In the Metalasmatinae, the Hexelasmatinae and the bathylasmatines *Bathylasma*, *Mesolasma* and *Tessarelasma*, the wall is 6-plated (R-CL<sup>1</sup>-CL<sup>2</sup>-C), RL and CL<sup>2</sup> are incorporated into the wall but RL is not incorporated into the sheath. The bathylasmatine *Tetrachaelasma* has a 4-plated wall (R-CL-C) due to the absence of CL<sup>2</sup>.

Thus the RL does not enter the sheath in the Pachylasmatoidea, with the exception of *T. ornatum* sp. nov. The early balanids (*Palaeobalanus*) and coronulids (*Chelonibia*) reflect the 8-patterned form seen in some pachylasmatooids, including a "tripartite" or compound rostrum (RL-R-RL). In *Chelonibia* DARWIN (1854) noted vestigial sutures on the inner surface as evidence for the coalescence of RL with R. The tripartite rostrum of these higher forms, however, is distinguished from that of pachylasmatooids by the fact that RL enters the sheath. For this situation to occur RL must have been incorporated into the sheath before coalescence with R and, therefore, the two types of tripartite rostra are convergent (BUCKERIDGE & NEWMAN, 1992).

**Morphological Characters.** — The subtlety of the specific differences within the Pachylasmatoidea can only be determined by examination of a large number of specimens and ontogenetic series. Intra- and inter-specific variation can thus be recognised, definition relying on the combination of consistent differences in a number of characters (e.g. the form of the S and T, the pattern of the wall plates, the length of the caudal appendages). BROCH (1931) first noted the subtle variation found within the Hexelasmatinae in a specimen which he considered to be *H. velutinum*, although he commented that the external features of the S differed from HOEK's description of *H. velutinum*. On re-examining BROCH's material, NEWMAN & ROSS (1971) noted other subtle character differences and re-described the specimen as a new species, *Aptolasma leptoderma* (Newman & Ross, 1971). These authors also suggested that HOEK (1913) had confounded 2 species in his description of *H. velutinum* and it was



not improbable that the specimens from "Siboga" stations 59 and 251 represented *A. leptoderma* rather than *H. velutinum*. A further re-examination of HOEK's material by FOSTER (1981) led him to conclude that in fact 3 species had been confounded in the description - *H. velutinum* from "Siboga" station 105, *A. leptoderma* from HOEK's specimen from "Siboga" station 59 and *H. arafurae* from "Siboga" station 251. However, FOSTER commented that the identification of *H. arafurae* was provisional, as the tergal spur differed from that figured by HOEK for *H. arafurae*, so ".... a definite conclusion about the synonymy must await further material and appreciation about the extent of variation". The studies of NEWMAN and ROSS (1971) and FOSTER (1981) have described a number of new species within *Hexelasma*. The present contribution significantly increases the number of species within *Hexelasma* from 9 to 15 and further extends the known distribution of the genus in the western Pacific Ocean.

Species diversity within *Pachylasma* has also been unrecognised heretofore, primarily due to a paucity of collections and a lack of comparative material. Many of the original species descriptions have been based on an individual or few specimens, with some species having never been re-collected. When a species has been re-collected at a later date, in some instances it has been from an area distant from the type locality and although differences (such as in the form of the S, the T, the pattern of the shell plates, the length of caudal appendages) between the more recently collected specimen(s) and the type specimen have been documented or illustrated, they have received little comment and; presumably, have been attributed to intra-specific variation. However, re-examination of species such as *P. scutistriata* of NILSSON-CANTELL, 1927 (p. 781, fig. 17, pl. 1 fig. 14); *P. scutistriatum* of UTINOMI, 1968 (p. 26, figs 4-5); and *P. aurantiacum* of FOSTER, 1981 (p. 354, figs 2 E, 4) may be warranted.

**Significance of antenniformy, reproductive state and regression and/or loss of the penis.** — In the Balanomorpha the regression and/or loss of the penis after the reproductive period has been documented in some species (see review of BARNES, 1992). The amount of regression appears to be related to the number of broods produced per year. In species producing 1 brood a year, or with a synchronised first brood of the year, the penis may be completely lost during the long non-breeding period. However, in other species the variable reproductive state of the population may mask this loss. A similar connection between the loss or regression of the penis after reproduction, and which also seems to be related to the number of broods produced in a year, has been found in the Littorinidae. Based on the above evidence, BARNES (1992) argued that the length of the penis of an individual is irrelevant in a species description unless the reproductive state of the individual is also given.

A connection exists between antenniformy, the reproductive state of the cirriped and the regression and/or loss of the penis (ROSS, 1969). ROSS (1969) discussed the functional significance of antenniformy and BARNES (1992) reviewed the reproductive periods and condition of the penis. In cirripeds which have antenniform cirri the penis is usually absent or much reduced. Antenniformy is not found in the Balanidae and is uncommon in the Chthamalidae. In *Chthamalus antennatus* (Pope, 1965) and *Tetrachthamalus oblitteratus* (Newman, 1967) there is clearly a connection between antenniformy and reproduction. Antenniformy is more common in the Tetraclitidae e.g. *Tetraclita* and *Newmanella hentscheli* (Ross & Perreault, 1999); only *Tetraclitella* does not exhibit antenniformy and it is rare in *Tesseropora*, although ROSS (1969) recorded antenniformy, a reduced penis and eggs occurring together in the mantle cavity of *T. pacifica* (Pilsbry, 1928). Antenniform rami occur immediately before, during, and directly after the reproductive period. ROSS (1969) suggested that individuals brooding eggs or nauplii, having antenniform rami, and lacking or having reduced penes, assume the morphology of and act as females. The penis remains non-functional until the beginning of the next reproductive season, whilst the antenniform ramus is replaced by a functional feeding appendage after release of the nauplii.

In the present paper a connection between antenniformy, the reproductive state of the cirriped and the regression of the penis is indicated for the Pachylasmatidae (Table 32). Antenniformy of cirrus II and/or cirrus III was recorded in 11 species - in the pachylasmatines *Eutomolasma maclaughlinae* sp. nov., *E. orbiculatum* sp. nov., *Pachylasma bacum* sp. nov., *P. laeviscutum* sp. nov., *P. ovatum* sp. nov., *Eurylasma pyramidale* sp. nov. and *Tetrapachylasma arcuatum* sp. nov.; in the metalasmatine *Metalasma crassum* sp. nov.; and in the hexelasmatines *Hexelasma foratum* sp. nov., *H. globosum* sp. nov. and *H. sandaracum* sp. nov. Antenniformy was associated



TABLE 32. — Relationship between antenniformy, regression of penes and eggs.

Species	egg size (mm) and colour	antenniformy of CII and/or CIII	penis length	collection date	station no.	depth (m)	registration no.
<i>Eutomolasma maclaughlinae</i>	0.40 x 0.50 orange	+	subequal to CVI	11.05.93	BATHUS 2 DW 719	444-455	WAM C 23247
<i>E. orbiculatum</i>	—	+	1/4 length CVI	06.09.85	BIOCAL DW 83	460	Paratype MNHN Ci 2696
<i>Microlasma fragile</i>	0.40 x 0.42 orange	—	subequal to CVI	16.02.89	MUSORSTOM 6 DW 421	245	Paratype MNHN Ci 2396
<i>Pachylasma bacum</i>	—	+	= length of basal segment of pedicel of CVI	14.02.89	MUSORSTOM 6 CP 401	270	Paratype MNHN Ci 2503
<i>P. laeviscutum</i>	—	+	>1/2 length CVI	12.05.92	MUSORSTOM 7 CP 515	224-252	Paratype MNHN Ci 2697
<i>P. ovatum</i>	—	+	= 1/2 length of basal segment of pedicel of CVI	28.02.85	LAGON DW 444	300-350	Paratype MNHN Ci 2401
<i>Eurylasma angustum</i>	0.37 x 0.43 orange/yellow	—	1/2 length CVI	28.02.85	MUSORSTOM 6 DW 478	400	Paratype MNHN Ci 2504
<i>E. pyramidale</i>	—	+	almost length of CVI	29.11.89	BATHUS 3 DW 830	361-365	Paratype MNHN Ci 2699
<i>Tetrapachylasma arcuatum</i>	0.40 x 0.42 orange	+	slightly shorter than length of CVI	22.02.89	MUSORSTOM 6 DW 478	400	Paratype MNHN Ci 2700
<i>Metalsma crassum</i>	0.36 x 0.24 yellow	+	= length of basal segment of pedicel of CVI	22.02.89	MUSORSTOM 6 DW 476	300	Paratype MNHN Ci 2409
<i>Hexelasma foratum</i>	0.45 x 0.51 orange	+	1/3 length CVI	20.02.89	MUSORSTOM 6 DW 451	330	Paratype MNHN Ci 2416
<i>Hexelasma globosum</i>	—	+	= length of basal segment of pedicel of CVI	16.09.85	MUSORSTOM 4 CP 167	575	Paratype MNHN Ci 2418
<i>Hexelasma sandaracum</i>	0.35 x 0.25 orange	+	1/4 length CVI	19.09.85	MUSORSTOM 4 CP 194	545	Paratype MNHN Ci 2705

with small numbers of large eggs in 5 species - i.e. *E. maclaughlinae*, *T. arcuatum*, *M. crassum*, *H. foratum* and *H. sandaracum*. Regression of the penis was shown by *M. crassum* (penis equal to the length of the basal segment of the pedicel of cirrus VI). Penile lengths for the remaining 4 species were as follows: subequal to length of cirrus VI (*E. maclaughlinae*, *M. fragile*), slightly shorter than length of cirrus VI (*T. arcuatum*), 1/3 the length of cirrus VI (*H. foratum*) and 1/4 the length of cirrus VI (*H. sandaracum*). Of the remaining 6 species which showed antenniformy, but which did not have eggs in the mantle cavities, 3 species (*P. bacum*, *P. ovatum*, *H. globosum*) showed regression of the penis; penile lengths were 1/2 the length of the basal segment of the pedicel of cirrus VI (*P. ovatum*), and equal to the length of the basal segment of the pedicel of cirrus VI (*P. bacum*, *H. globosum*). The remaining 3 species (*E. orbiculatum*, *E. pyramidale*, *P. laeviscutum*) had larger penes; penile lengths were 1/4 the length of the pedicel of cirrus VI (*E. orbiculatum*), 1/2 the length of cirrus VI (*P. laeviscutum*) and equal to the length of cirrus VI (*E. pyramidale*). One species with large eggs, *Microlasma fragile* sp. nov., showed neither antenniformy nor regression of the penis (length of the penis subequal to cirrus VI). SOUTHWARD & SOUTHWARD (1958) recorded antenniformy of cirrus III in *Bathylasma hirsutum* (as *Hexelasma hirsutum*, then regarded as a chthamaliid but now as a bathylasmatine), and NEWMAN & ROSS (1971) recorded antenniformy of the rami of cirri II and III of the bathylasmatine *Tetrachaelasma southwardi*.



Although many cirriped nauplii are pelagic and planktotrophic, some can be lecithotrophic, and develop to the cyprid stage within the mantle cavity of the parent. Animals producing lecithotrophic nauplii usually produce small broods of large size eggs, e.g. deep-water *Scalpellum* and *Arcoscalpellum* species (see BARNES, 1989 for review of egg production in cirripeds). In the present study large eggs, few in number, were recorded in 7 species - the pachylasmatines *Eutomolasma macLaughlinae*, *Microlasma fragile*, *Eurylasma angustum*, *Tetrapachylasma arcuatum*, the metalasmatine *M. crassum* and the hexelasmatines *Hexelasma foratum* and *H. sandaracum*, suggesting that these species are likely to have lecithotrophic larvae. The large size of the eggs of these species is similar to the size of those of hydrothermal vent barnacles (Table 33). Eggs which produce planktotrophic larvae are ovoid, those which produce lecithotrophic larvae are more globular, due to an increased amount of yolk. Lecithotrophy is advantageous for species, such as the deep-water pachylasmatids and scalpellomorphs, and vent barnacles, where restricted dispersal in habitats with few suitable substrata for settlement is advantageous. Abbreviated naupliar development occurs within the mantle cavity and, when released, the cyprid remains in the vicinity of the parent group. No nauplii or cyprids were found in any of the material examined in the present study.

TABLE 33. — Egg characters of hydrothermal vent barnacles.

Species	egg size (mm)	collection date	locality and temp	depth	reference
<i>Neolepas rapanuii</i>	0.3 x 0.5	16.04.89	Easter Island 23°32.52'S, 115°34.0'W	2600 m	Jones, 1993c
<i>Neolepas zeviniae</i>	0.3 x 0.5	21.04.89	East Pacific Rise 20°50'S, 109°00'W 1.5-5.0°C	2600 m	Newman, 1979
<i>Neoverruca brachylepadoformis</i>	0.25 x 0.5	-04.87	Mariana Back-Arc Basin 18°12'S, 144°42'E 5-15°C	3600 m	Newman & Hessler, 1989
<i>Eochionelasmus ohtai ohtai</i>	0.29 x 0.47 (mean)	81.12.87	North Fiji Basin 16°59.4'S, 173°54.9'E +0.1 to +0.2° above ambience of +2.2°C	1990 m	Yamaguchi & Newman, 1997b

**Endemism and Species Diversity.** — The material examined herein is both rich in numbers of species and numbers of individuals, with an exceptional diversity of species occurring within the subfamilies Pachylasmatinae and Hexelasmatinae. Of the new species described, 1 pachylasmatine (*Tetrapachylasma ornatum* sp. nov.) is endemic to the Marianas Islands, 8 pachylasmatines (*Eutomolasma orbiculatum*, *Microlasma fragile* sp. nov., *Pachylasma bacum* sp. nov., *P. ovatum* sp. nov., *Eurylasma angustum* sp. nov., *E. ferulum* sp. nov., *E. pyramidale* sp. nov., *Tetrapachylasma arcuatum* sp. nov.), 1 metalasmatine (*Metalasma crassum* sp. nov.) and 5 hexelasmatines (*Hexelasma aureolum* sp. nov., *H. flavidum* sp. nov., *H. foratum* sp. nov., *H. globosum* sp. nov., *H. persicum* sp. nov.) are considered endemic to the region of Vanuatu/New Caledonia. Two pachylasmatines (*Eutomolasma macLaughlinae* sp. nov., *Pachylasma laeviscutum* sp. nov.) and 1 hexelasmatine (*Hexelasma sandaracum* sp. nov.) occur in a broader area, extending from the Indo-Australian Plate to the Futuna and Wallis Islands on the Pacific Plate. The number of new pachylasmatines described in the present study represents 46% of the known species and that of the new hexelasmatines 40%.

The most diverse chionelasmatooid and pachylasmatooid fauna occurs at the Loyalty Islands where 15 species have been collected (1 chionelasmatooid, 1 eolasmatine, 6 pachylasmatines, 1 metalasmatine, 6 hexelasmatines). At the Norfolk Ridge, 11 species have been collected (1 chionelasmatooid, 6 pachylasmatines and 4 hexelasmatines), and nine species are known from both Vanuatu and New Caledonia (1 eolasmatine, 4 pachylasmatines, 1 metalasmatine, 1 bathylasmatine, 2 hexelasmatines and 1 chionelasmatooid, 3 pachylasmatines, 5 hexelasmatines respectively). Three species are known from the Chesterfield Islands (2 pachylasmatines, 1 hexelasmatine). On the Pacific Plate, 2 species were collected at Combe Bank (1 pachylasmatine, 1 hexelasmatine). A single pachylasmatine species was collected at both Futuna Island and Waterwich Bank and a single hexelasmatine at the Wallis Islands, at Field Bank and at Tuscarora Bank.



The present study has confirmed that 2 relictual species, the chionelasmatid *Chionelasmus darwini* and the eolasmatine *Waikalasma boucheti* occur in the waters of New Caledonia and of Vanuatu, respectively. However, although *C. darwini* is represented by many specimens, collected at various localities throughout the New Caledonian region, *W. boucheti* is known only by an incomplete specimen from the Loyalty Islands (present report) as well as by 2 specimens from the waters of Vanuatu (BUCKERIDGE, 1996). Similarly, only 1 bathylasmatine - *B. alearum*, represented by 2 specimens from the waters of Vanuatu - has been collected. Sampling by the French deep-sea expeditions has been from comparable depths in the waters of Vanuatu, New Caledonia and the Wallis and Futuna Islands. Whether sampling has been from comparable habitats, however, is a more difficult question to answer, so the possibility exists that species which occur in specialised habitats either have not been collected, or have been collected infrequently.

The cruises BIOCAL and MUSORSTOM 6 gathered a variety of faunas from the Loyalty Islands, of which many are relictual species, e.g. a group of crinoids that were assumed to have died out in the Jurassic - the pedunculate crinoid *Gymnocrinus* and a small black crinoid *Holopus* reported previously from the Caribbean but not from the Pacific Ocean (AMEZIANE-COMINARDI *et al.*, 1987). The presence of the relictual species *Chionelasmus darwini* and *Waikalasma boucheti* at the Loyalty Islands further supports the hypothesis that this bathyal fauna is a vestige of marine populations of the ancient Tethys Sea, and that the south-west Pacific is a relictual area (NEWMAN, 1991).

An abundance and diversity of benthic material has also been collected at the Norfolk Ridge (CHALCAL 2, SMIB 2-5, BATHUS 3, 4). Several groups, such as the calcified sponges of the Sphinctozoa group, the pedunculate crinoid *Gymnocrinus*, molluscs of the family Pleurotomariidae, as well as hydroids and echinoderms, show a clear relationship with the Mesozoic fauna of the ancient Tethys (VACELET, 1977, 1978; BOURSEAU *et al.*, 1987; RICHER DE FORGES, 1990). These living fossils are located on the eastern rim of the ancient continent of Gondwanaland. Abundant zoological collections have also been made from New Caledonia (MUSORSTOM 4, BERYX 2, BATHUS 2), especially sponges, molluscs, stylasters and echinoderms. Many fossilised shark teeth, especially those of the giant species *Procarcharodon megalodon* Agassiz, 1843, have also been collected (RICHER DE FORGES, 1990).

In contrast to the diverse chionelasmatoid and pachylasmatoid fauna occurring in the New Caledonian area, a pachylasmatoid fauna low in diversity and in numbers of individuals and no chionelasmatoids have been found at the Wallis and Futuna Islands on the Pacific plate. The pachylasmatoid species are not new, but are known also from New Caledonian waters. In general, the deep sea faunas from these waters are diverse but quite poor compared to those of New Caledonia, with species described from New Caledonian waters being rediscovered on the Pacific plate (e.g. Sphinctozoa, *Gymnocrinus*, *Amalda*) (RICHER DE FORGES & MENU, 1993).

## ACKNOWLEDGMENTS

The author is deeply indebted to A. CROSNIER, IRD (ex ORSTOM) and Muséum national d'Histoire naturelle, Paris, and B. RICHER DE FORGES, IRD, Nouméa, for the opportunity to study the cirripeds from Vanuatu, New Caledonia and the Wallis and Futuna Islands. The study was carried out partly at the Muséum national d'Histoire naturelle, Paris, with the support of grants from ORSTOM (August-October, 1994) and the Muséum national d'Histoire naturelle (September-October, 1997), and partly at the Western Australian Museum, Perth. I also thank D. DEFAYE, Laboratoire de Zoologie (Arthropodes) Muséum national d'Histoire naturelle, Paris, for her assistance with this project. I am indebted to my colleagues W. NEWMAN and A. ROSS, Scripps Institution of Oceanography, La Jolla, California, J. BUCKERIDGE, Auckland Institute of Technology, Auckland, and P. McLAUGHLIN, for critically reading drafts of the manuscript and for valuable discussions.

Thanks are also extended to Clay BRYCE, Western Australian Museum, and P. LOZOUET, Muséum national d'Histoire naturelle, Paris, for photography of specimens, to Simon JONES, Lisa KING, Jane MACRAE and Nadine GUTHRIE who inked some of my drawings, to Anne NEVIN who typed the tables. At the Muséum national d'Histoire naturelle, J.-F. DEJOUANNET prepared the plates and at the IRD Center of Nouméa, M. TORTELIER prepared the distribution maps.



I also wish to thank colleagues in the following institutions who kindly lent type specimens for comparisons with the new material described in this study: P. BERENTS, The Australian Museum, Sydney; G. BOXSHALL and A. MORGAN, The Natural History Museum, London; N. BRUCE and P. JEPPESEN, Zoologisk Museum, University of Copenhagen; S. O'SHEA, National Institute of Water and Atmospheric Research, Wellington, New Zealand; D. PLATVOET, Zoölogisch Museum, Amsterdam; K.J. REED, Smithsonian Institution, Washington; R. WEBBER, Museum of New Zealand, Wellington.

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