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Hubert Lyman Clark.

THE ECHINODERM FAUNA OF AUSTRALIA

Its Composition and Its Origin

HUBERT LYMAN CLARK

Robert Bennett.

CARNEGIE INSTITUTION OF WASHINGTON PUBLICATION 566
WASHINGTON, D. C.
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The Echinoderm Fauna of Australia

Its Composition and Its Origin

INTRODUCTION

It must not be assumed because of the amplitude of the title that the author considers our knowledge of the Australian echinoderm fauna as practically complete. Far from it! But that knowledge is now great enough to warrant assembling it in one volume and trying to make some deductions from it as to the origin and history of Australia's marine fauna. It is hoped, further, that these deductions may throw some light on the history of the Australian continent and its relation, if any, to Africa, Asia, and New Zealand. Owing to their relatively sedentary habits, their aversion to fresh or even brackish water, the brevity or complete absence of a free-swimming larval life, and the usually small bathymetrical range, echinoderms are remarkably suitable as material for studying changes in shore lines or the relation of land masses to each other.

A study of this kind was published by the Carnegie Institution of Washington some twenty-five years ago (H. L. Clark, 1921), dealing with the Torres Strait region and the origin of the echinoderm fauna of the Great Barrier Reef and the eastern coast of tropical Australia. The evidence is strong, if not strictly conclusive, that Torres Strait has not been the chief route by which the eastern coast of Australia has received its marine fauna, the greater part of that fauna having come from the northeast around the eastern end of New Guinea. So definite were the results of that study, it seemed worth while to extend it to the entire continent of Australia and see if light could thus be thrown on the history and possible "drift" of that land mass. Thanks to the generosity of the Carnegie Institution of Washington and the Milton Fund of Harvard University, with the hearty cooperation of the Museum of Comparative Zoölogy, two extended visits to Australia were made in 1929 and 1932. All parts of the continental coast were visited except the western half of the southern coast and the great northern Gulf of Carpentaria. In both these areas the local conditions are unfavorable to a diversified echinoderm fauna, so it is not likely that visits to those relatively inaccessible coasts would add very much that is significant to our knowledge of Australian echinoderms. (Exception may perhaps well be made of the southern coast of Western Australia, west of the Great Australian Bight, where indications of an interesting echinoderm fauna have been found.)

The two visits resulted in the collection of a very large amount of material, upon which a report has already been published (H. L. Clark, 1938). Aside

from the material obtained and the extensive observations made, the contacts with local "naturalists" and collectors were invaluable. The generous cooperation and assistance received from scientific colleagues, and particularly from the museums, have been encouraging and helpful beyond words. Whatever results have been achieved must be attributed in large part to this unselfish and magnanimous helpfulness. In both the 1921 and 1938 reports, the attempt has been made to express something of the debt owed to more than fifty individuals for their help. It is unnecessary to repeat those names here, but this introduction cannot be closed without expressing the author's lasting gratitude to the late Dr. C. Anderson, Director of the Australian Museum; the late Dr. John C. Merriam, President of the Carnegie Institution of Washington, 1920–1938; and particularly to the late Dr. Thomas Barbour, Director of the Museum of Comparative Zoölogy, without whose constant interest, encouragement, and support the work could never have been done.

In order to make use of all the available evidence, it has been deemed desirable to include in this report all the echinoderms known from Australia, regardless of whether they are living or extinct. To separate the various species by that arbitrary line is unnatural and unnecessary. The fossil echinoderms of Australia are therefore included herein in their natural positions in the system,[1] but groups or species which no longer have living representatives (so far as we know) are indicated by an asterisk (*). The report is divided into two parts. The first deals with the composition of the echinoderm fauna; the second discusses its relationships and possible origin. In the first, artificial keys are given to all the groups in the five classes of echinoderms known to occur in Australia, down to species. This part will therefore be of service, it is hoped, to all zoologists and paleontologists who wish to identify material with which they are working. The boundary of this geographical unit, Australia, is for practical reasons set at the 500-fathom line, except on the northern coast between longitude 128° and 145°, where it is arbitrarily set at 9° 30′ south latitude, so as to include the northern end of the Great Barrier Reef, but exclude New Guinea and the Arafura Sea. Sahul Bank and "Challenger" stations 188 and 189 are thus included in Australia, but 190 is not. Since Lord Howe Island is politically a part of New South Wales, and its echinoderms are essentially Australian, it is also, perhaps somewhat arbitrarily, included as part of Australia. *It must be emphasized that the keys are limited strictly to the species known up to January 1, 1941, from within the limits of the Australia thus artificially defined.* It is hoped that all such species both fossil and living are included. No illustra-

[1] Fossil species based on very imperfect material which defy any adequate specific diagnosis are omitted, but it is impossible to be consistent in this matter. I can only hope that none of my omissions will be considered unreasonable. The great help of the late Dr. Frederick Chapman, of Melbourne, in connection with the inclusion of the extinct echinoderms is herewith very gratefully acknowledged.

tions are published herewith, as nearly all the species have been figured and references to such figures are given.

The second part of the report undertakes to analyze the composition of this Australian fauna, to ascertain its interrelations and probable point or points of origin, and, particularly, to compare it with the corresponding faunas (so far as they are known) of southern and eastern Africa, of India and adjoining seas, of the East Indian and western Pacific islands, and of New Zealand. As a result of such comparisons, it is hoped some light may be thrown on the plausibility of the Wegener hypothesis concerning the flotation of continents, as regards Australia. Conclusive evidence cannot be expected from the study of a single phylum of animals, but it may be hoped nevertheless that the usefulness of the hypothesis may be either increased or diminished by the results of this investigation.

PART I

ANNOTATED LIST OF THE ECHINODERMS OF AUSTRALIA, BOTH FOSSIL AND RECENT

ANNOTATED LIST OF THE ECHINODERMS OF AUSTRALIA, BOTH FOSSIL AND RECENT

The echinoderm fauna of Australia is both large and diversified, including nearly 900 known species. There is every reason to believe that many more remain to be discovered, not only in the greater depths where little collecting has been done, but even in shallow water on the reefs and along shore where most of the known species have been found. Nevertheless, our knowledge has now reached a point where it is necessary to assemble and arrange it in a single volume, that it may be available to the zoologists and nature lovers of the oncoming generation. Fortunately, echinoderms are an exceptionally well defined and sharply limited group, and are moreover divisible into very clearly separated and easily distinguished classes. Seven of these classes are universally recognized, of which two have long been extinct and have no known representative in Australia. The other five occur abundantly on all parts of the Australian coast, where local conditions permit, and four of them are also of more or less general occurrence in fossiliferous rocks. These five classes are so sharply defined that a "key" by which to distinguish them is scarcely necessary. The Crinoidea (crinoids, sea lilies, or feather stars in popular phraseology) are at once recognizable by their feather-like arms and by the usual presence, at the center of the dorsal or aboral side, of a cluster of slender, segmented appendages (cirri) or, much more rarely, of a more or less elongated stalk, with or without cirri. The Asteroidea (sea stars) show great variety of size and form, but the arms are hollow, with parts of the digestive system enclosed; in extreme cases the arms are so short that they are not readily distinguishable from the body, the animal being more or less perfectly pentagonal or hexagonal. Cirri and feather-like arms are never present. The Ophiuroidea (ophiurans, brittle stars, or serpent stars) have solid, slender, more or less extensively segmented arms, which in some highly specialized groups are arborescent or fork dichotomously three or more times; in several genera (sometimes called sea spiders or basket fish) more than a dozen divisions of each arm may occur. The Echinoidea (echini, sea urchins, shield urchins, sand dollars, sand shillings, and heart urchins) are encased in a firm, usually rigid test, more or less covered with spines, and have no projecting arms. The test is commonly more or less hemispherical with the oral (lower) side flattened, but the form ranges from ellipsoidal (the vertical axis longer than the horizontal) to discoidal (the vertical axis only a small fraction of the horizontal). The spines are incredibly diversified in character, ranging from minute, well-nigh microscopic, short, slender ones to the heavy ones of the slate-pencil urchins, 100 mm. or more in length

and 10–12 mm. in diameter. The Holothurioidea (holothurians or sea cucumbers) are conspicuously unlike the other classes in that the skeleton is reduced, so that the body wall is (with a few notable exceptions) soft. Associated with this peculiarity is the elongation of the oral-aboral axis so that the animal lies on one side with the mouth at the anterior end of the body, the anus posterior. At first sight there is no indication of the radial symmetry so obvious in the other classes, but a cross section through the animal, midway between the mouth and anus, reveals a symmetry essentially the same as that of a regular sea urchin or a pentagonal sea star cut in a similar plane. The five classes, so sharply defined thus in their respective patterns of structure, show an equal and similar diversity in their movements, methods of feeding, and other habits. It is therefore most natural and feasible to treat each class by itself, and that course will here be followed.

CRINOIDEA

The crinoid fauna of Australia, so far as is now known, is made up of 101 species, of which 18 (11 genera) are extinct. The 83 living species (grouped in 44 genera) are most abundant on or about the coral reefs of tropical Australia, but a few hardy species brave the cooler waters of the southern coast. Only 3 species of Recent stalked crinoid have as yet been taken, and of one of these, a single specimen from an unknown locality is all we have. The other 2 are known only from moderately deep water, 90–200 fms., off the northwestern and southeastern corners of the continent. Both at Mer near the northern end of the Barrier Reef, and at Broome on the northwestern coast, the free-living, unstalked crinoids are abundant, with some 20 species in each region. But on the coast of New South Wales only 3 or 4 small species occur, and at the southwestern corner of the continent only 5 or 6 species are as yet known. The extinct crinoids are all, except 2, stalked forms which have been found for the most part in the strata of Queensland, New South Wales, and Victoria. A few interesting forms, however, have been obtained in Western Australia. None of them have any direct relationship with the existing crinoid fauna. In connection with the preparation of this section on the crinoids, Mr. Austin Hobart Clark's invaluable publications have been of inestimable service, and his friendly assistance by correspondence and conversation entitles him to my warmest thanks.

Key to the Orders of Crinoidea

A. Lower brachials part of dorsal cup; all are now extinct:
  All plates of calyx united by close sutures, and immovable ..... Camerata
  Plates of calyx variously incorporated in dorsal cup, but never rigidly .... Flexibilia
AA. Lower brachials free above radials and not normally incorporated in dorsal cup:
  Tegmen plated; mouth subtegminal; all now extinct ..... Inadunata
  Tegmen coriaceous, with minute calcareous particles, which may be enlarged into small plates; mouth and food grooves exposed; many extinct but chiefly Recent ..... Articulata

Order *CAMERATA

Three families in this order are known from Australian strata. All are extinct. They may be distinguished from one another as follows:

Key to the Families of Camerata

A. Base hexagonal; radials separated posteriorly by anal plate:
  Anal plate heptagonal, followed by 3 plates ..... Batocrinidae
  Anal plate hexagonal, followed by 2 plates ..... Actinocrinidae
AA. Base pentagonal; radials not separated by an anal plate ..... Platycrinidae

Family *BATOCRINIDAE

Although some 40 genera have been described and referred to this family, only a single one has been as yet discovered in Australia. This genus was first described from the Silurian rocks of England and Gotland (Sweden). Since the Australian species is based on a single, very incomplete specimen, which came from rocks dubiously indicated as Carboniferous, there is good reason for being skeptical as to the occurrence in Australia of crinoids congeneric with the European species.

*PERIECHOCRINUS

Periecocrinites Thomas Austin and Thomas Austin, Jr., 1842. Ann. Mag. Nat. Hist., vol. 10, p. 110 (*nomen nudum*).
Periechocrinites Thomas Austin and Thomas Austin, Jr., 1843. Ann. Mag. Nat. Hist., vol. 11, p. 203.
Periechocrinus Morris, 1843. Cat. Brit. Foss., p. 56.

Genotype: *Periechocrinites articulosus* Austins, 1843, p. 204.

It is, as already suggested, extremely doubtful whether this genus ever really occurred in Australia, but until we have much better and more abundant material, we must accept the identification of so good an authority as Etheridge, who recognizes the following species.

*Periechocrinus indicator

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 78; pl. 22, fig. 4.

A single imperfect specimen, from New South Wales, "Chalky Gully, Wollumba River, Co. Gloucester: ?Carboniferous," is the only basis for this name. "Some flattened and decorticated plates" from "Greenhills, Paterson to Dungog Road, Co. Durham, Mirari Limestone, Carboniferous" are, however, also referred by Etheridge to *Periechocrinus,* as he considers the resemblance to *indicator* "strong," but the specific distinctness "evident."

Family *ACTINOCRINIDAE

This is a smaller family than the preceding, with only 10 to 12 genera, nearly all North American. Its right to a place in the Australian fauna is even more dubious than that of the Batocrinidae, although de Koninck is sure that his Australian material is identical with that from Ireland and refers it to the Irish species of the following genus.

*ACTINOCRINUS

Actinocrinites Miller, 1821. Nat. hist. Crin., p. 94.
Actinocrinus L. Agassiz, 1835*a*. Mem. Soc. sci. nat. Neuchâtel, vol. 1, p. 196.

Genotype: *Actinocrinites triacontadactylus* Miller, 1821, p. 95.

The material so far collected which is referred to this genus has been designated as "sp. indet." or has been referred to the following species originally described from Ireland.

*Actinocrinus polydactylus

Miller, 1821. Nat. hist. Crin., p. 103; pl. 1, figs. 1, 2.

The fragmentary material referred to *Actinocrinus* has come from the following localities. That which de Koninck (1877, p. 160) unhesitatingly calls *polydactylus* was from "un psammite grisâtre" at Glen William, New South Wales. McCoy (1847, p. 229) notes the occurrence of "fragments of pelvic plates of this genus" in the Dunvegan shale (Carboniferous), but makes no attempt to give them specific designation. Etheridge (1892, p. 77) refers to "impressions of a few highly ornamented plates" found "in the Star Series of Corner Creek" and the "Gympie Series of the Rockhampton district," which he refers provisionally to *Actinocrinus*. He also describes and figures 2 fragmentary specimens from the Mirari Limestone (Carboniferous) at Greenhills, Paterson to Dungog Road, County Durham, New South Wales. He believes these are identical with de Koninck's material, but considers their identity with the European *polydactylus* "very problematical." The truth is, there is no satisfactory evidence of the occurrence of the European *Actinocrinus* in Australia.

Family *PLATYCRINIDAE

This family is represented in Australia by 2 quite distinct genera, which may be distinguished by these characters:

Tegmen low; stem cylindrical ..... *Hapalocrinus*
Tegmen fairly high; stem pentagonal ..... *Helicocrinus*

*HAPALOCRINUS

Jaekel, 1895. Palaeontol. Abhandl., vol. 7, no. 1, p. 95.

Genotype: *Hapalocrinus elegans* Jaekel, 1895, p. 96.

This genus was based on material from the Paleozoic rocks of Germany, usually considered to be Lower Devonian. The single Australian species was described by one of the best paleontologists who ever studied fossil crinoids, and yet one can but wonder whether there is really a generic relationship between the Devonian European crinoid and the Australian Silurian species.

*Hapalocrinus victoriae

Bather, 1897. Geol. Mag., n. s., dec. 4, vol. 4, p. 337; pl. 15.

The specimen on which this species is based was found in supposedly Silurian rocks, in the vicinity of the Yarra Improvement Works near Princes Bridge, Melbourne, Victoria. Additional material is still lacking.

*HELICOCRINUS

Chapman, 1903. Proc. Roy. Soc. Victoria, n. s., vol. 15, p. 107.

Genotype: *Helicocrinus plumosus* Chapman, 1903, p. 108.

This genus seems to be well justified by the splendid condition of the handsome fossil on which it is based, but it is still monotypic and the type specimen unique.

*Helicocrinus plumosus

Chapman, 1903. Proc. Roy. Soc. Victoria, n. s., vol. 15, p. 108; pls. 17, 18, figs. 1–5.

The type specimen of this crinoid is a beautifully preserved fossil of striking appearance. It was found in a quarry at West Brunswick, Victoria, between Albert and Victoria streets, in rocks considered to be of Silurian age. No further material has been obtained.

Order *FLEXIBILIA

Only a single crinoid which belongs in this order has as yet been found in Australia.

Family *LECANOCRINIDAE

The members of this family have the infrabasals forming a noticeable part of the calyx wall; the crown is commonly small, more or less rotund, with arms abutting, frequently interlocking, and closely infolding distally.

*LECANOCRINUS

J. Hall, 1852. Nat. hist. New York, Palaeontol., vol. 2, p. 199.

Genotype: *Lecanocrinus macropetalus* Hall, 1852, p. 199.

This genus is based on American material but is known also from England and Gotland (Sweden). A single specimen of a remarkable crinoid from New South Wales is considered by Chapman to be congeneric with a Swedish species.

*Lecanocrinus breviarticulatus

Chapman, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 190; pl. 10.

The unique holotype of this species was collected long ago in Silurian rocks at Hatton's Corner, Yass, New South Wales. Height of crown 34 mm., greatest width 31.5 mm.

Order *INADUNATA

Of the 17 families recognized in this order, only 2 seem to deserve a place in this catalogue, although fragmentary specimens have been listed under the names of genera belonging elsewhere. The single small calyx on which *Synbathocrinus ogivalis* de Koninck (1877, p. 158) is based is not an adequate basis for a species, and *Cyathocrinites pinnatus* Blandowski (1858, p. 132) rests on even less satisfactory material. Chapman suggests (*in litt.*) it may possibly be based on fragments of *Helicocrinus plumosus* (*q.v.*). The 2 inadunate families deserving place here may be distinguished thus:

Arms with 2 main branches bearing smaller rami.....Botryocrinidae
Arms pinnulate, dichotomous, branching frequently.....Poteriocrinidae

Family *BOTRYOCRINIDAE

Only a single genus of this family has been found in Australia.

*BOTRYOCRINUS

Angelin, 1878. Icon. Crin. Silur., p. 24.

Genotype: *Botryocrinus ramosissimus* Angelin, 1878, p. 24.

The records in Australia for this genus of England, Sweden, and North America rest upon relatively imperfect remains of a single species from one locality.

*Botryocrinus longibrachiatus

Chapman, 1903. Proc. Roy. Soc. Victoria, n. s., vol. 15, p. 108; pl. 18, figs. 6–8.

Our knowledge of this crinoid is based on remains "chiefly in casts, in bluish micaceous sandstone" of Silurian age, occurring at Royal Park, Brunswick, Victoria. Relatively small, dorsal cup about 7.5 mm. high, 10 mm. wide at top and 3.5 mm. at bottom. Arms can be traced about 40 mm., and stem is not quite 3 mm. in diameter, 5 mm. from top.

Family *POTERIOCRINIDAE

This large and diversified family is rather well represented in Australia by 9 species referred to 3 genera. But the material is fragmentary and leaves much to be desired as the basis for specific or even generic determinations. The following key shows on what grounds the 3 genera are distinguished:

Key to the Genera of Poteriocrinidae

A. Infrabasals 5; calyx not globose:
  Radianal present, arms dichotomous, branching freely ..... *Poteriocrinus*
  Radianal wanting; arms 5–10, uniserial ..... *Phialocrinus*
AA. Infrabasals 3; calyx globose ..... *Tribrachyocrinus*

*POTERIOCRINUS

Poteriocrinites Miller, 1821. Nat. hist. Crin., p. 67.
Poteriocrinus L. Agassiz, 1835*a*. Mem. Soc. sci. nat. Neuchâtel, vol. 1, p. 197.

Genotype: *Poteriocrinites crassus* Miller, 1821, p. 68.

The occurrence of this genus in Australia was first noted by de Koninck (1877, p. 159), though his material was so fragmentary that he was not able to identify it specifically. Some years later Etheridge (1892*a*, p. 209) gave a specific name, with description and figure, to what he believed was a member of this genus. He was not very sure of the genus, however, as he includes a question mark as part of the proposed name.

*Poteriocrinus (?) smithii

Etheridge, 1892*a*. *In* Jack and Etheridge, Geol. and palaeontol. Queensland, p. 209; pl. 8, fig. 1.

The specimen on which this name rests was collected by James Smith in the Gympie Beds (Carboniferous), at Stanwell, near Rockhampton, Queensland. The figure given indicates a well preserved specimen, but Etheridge says that "the state of preservation does not allow of an exact generic determination" (1892*a*, p. 82).

*PHIALOCRINUS

Eichwald, 1856. Bull. Soc. imp. nat. Moscou, vol. 29, no. 1, sec. 2, p. 114 (second).[1]

Genotype: *Phialocrinus impressus* Eichwald, 1856, p. 115 (second).

Whether this genus should be treated as a synonym of *Graphiocrinus* or not need not be entered into here. Both Trautschold (1879) and Wachsmuth and Springer (1879) overlooked Eichwald's original publication (1856) of *Phialocrinus* with diagnosis and designated species, *impressus*. Since Eichwald himself seems to ignore this paper in his "Lethaea Rossica" (1860), perhaps they can hardly be blamed. The fact remains that *Phialocrinus* must date from Eichwald, 1856. If his species *impressus* is really unrecognizable, then the generic name must be discarded. It surely cannot be used for any other genus. As Etheridge (1892) has used it for 4 Australian fossil crinoids, it seems best to make use of it here, especially as material is scanty and imperfect and the actual generic position of these forms is still open to debate. The 4 species accepted by Etheridge, all from Carboniferous or Permocarboniferous rocks, may be distinguished by the following key:

Key to the Species of Phialocrinus

A. Size very large; calyx globular-globose:
  Calyx base markedly depressed; infrabasal plates not visible in normal side view ..... *konincki*
  Calyx base not so depressed; infrabasal plates visible in side view ..... *princeps*
AA. Size not notably large; calyx depressed, more or less saucer-shaped (generic position dubious):
  Costals more or less consolidated ..... *stephensi*
  Costals not consolidated ..... *nodosus*

*Phialocrinus konincki

Cyathocrinus konincki de Koninck, 1877. Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 164; pl. 6, figs. 4–4*b*.
Phialocrinus konincki Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 107; pl. 16, figs. 1–4.

This fine large species is based on material from Osterly, on the banks of the Hunter River, New South Wales. Additional material has been collected at Nowra, County St. Vincent, New South Wales. Since the collector, W. B. Clarke, had nothing to do with either figuring or describing the species, de Koninck must be designated as the author. His intention to do as Clarke expressly stipulated is achieved, but he must bear the responsibility for the name himself. This is one

[1] The pagination in this volume is confusing; pages 1–151 have the page numbers repeated.

more illustration of the unwisdom of letting sentiment—no matter how worthy—determine the choice of a supposedly scientific name.

*Phialocrinus princeps

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 110; pl. 17, fig. 1; pl. 18, fig. 1; pl. 22, fig. 5.

This very large and notable species is based on a remarkable specimen in the "Collection of the Maitland Scientific Society," which was found at Bow-wow Creek, Mount Vincent, near East Maitland, County Northumberland, New South Wales.

*Phialocrinus (?) stephensi

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 113; pl. 20, figs. 1–5.

The single very imperfect specimen on which this species is based was found at Nowra, County St. Vincent, New South Wales. As even its generic position is uncertain, it might well be omitted from this volume, but in view of its authorship and possible relation to the other species referred to *Phialocrinus,* its inclusion is defensible.

*Phialocrinus (?) nodosus

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 112; pl. 14, figs. 4, 5.

The single fragment on which this species is based was found at Copper Point, County St. Vincent, New South Wales, and is in the Australian Museum collection. Its inclusion here is even less justifiable than that of *P. stephensi.*

*TRIBRACHYOCRINUS

McCoy, 1847. Ann. Mag. Nat. Hist., vol. 20, p. 228.

Genotype: *Tribrachyocrinus clarkii* McCoy, 1847, p. 228.

This definitely Australian genus was based on material from Darlington, New South Wales, which McCoy saw was quite different from any of the genera of fossil crinoids known up to that time. In a belief, apparently, that there were only three arms, he gave his new genus the name *Tribrachyocrinus,* but he makes no statement as to the derivation of the name. Wachsmuth and Springer (1886), assuming that the name referred to three arms (τριβράχια), emended the spelling to *Tribrachiocrinus,* but under the International Code such an emendation is hardly justifiable, and it seems better to retain the original spelling. Since the genus was established more material has been obtained, and 4 species have been recognized, all Carboniferous or Permocarboniferous. They may be distinguished as follows:

Key to the Species of Tribrachyocrinus

A. Calyx highly asymmetrical, with protuberant posterior side:
  Calyx plates smooth, or, when decorticated, with delicate concentric ridges ..... *clarkei*
  Calyx plates with characteristic ornamentation ..... *ornatus*

AA. Calyx more or less symmetrical, with posterior side hardly at all protuberant:
Calyx globose; sculpture in form of spots and anastomosing, tubercular, vermicular grooves ..... *corrugatus*
Calyx depressed (saucer-shaped); sculpture delicate, concentric lines or minute, compact granulation ..... *granulatus*

*Tribrachyocrinus clarkei

McCoy, 1847. Ann. Mag. Nat. Hist., vol. 20, p. 228; pl. 12, figs. 2*a–c*.

The specimen on which McCoy based his new genus and species was collected by the widely known geologist W. B. Clarke, for whom, by his own statement in his description, McCoy intended to name his species. By an obvious *lapsus calami,* however, he wrote the collector's name as Clark and the specific name as *clarkii.* The correction to *clarkei* was made by Ratte (1885) and has been generally accepted. According to Etheridge (1892), a considerable number of specimens of this crinoid have been found in New South Wales, but only in the Upper Marine series of strata. Fragments have also been found in Tasmania which Etheridge refers to this species.

*Tribrachyocrinus ornatus

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales., Palaeontol., no. 5, pt. 2, p. 94; pl. 19.

The single specimen on which this species is based was found in the Nowra Grit, Upper Marine series, County St. Vincent, New South Wales. Calyx 60 mm. in diameter, arms over 150 mm. in length. Etheridge says it is the only species of the genus in which any trace of arms has been observed.

*Tribrachyocrinus corrugatus

Ratte, 1885. Proc. Linn. Soc. N. S. Wales, vol. 9, p. 1158; pl. 68, figs. 1–12.

Several specimens of this well marked species have been found in County Camden, New South Wales, in the Upper Marine series. The sculpture of the plates when well preserved is very characteristic, but unfortunately the ridges are apt to be worn.

*Tribrachyocrinus granulatus

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 97; pl. 22, figs. 2, 3.

A single, rather small calyx is the basis of this species. It is characterized by ornamentation which Etheridge considers "can hardly be mistaken" for that of *corrugatus,* to which species *granulatus* is apparently closely allied. The unique type was found on the "banks of the Minumurra River, near Jamberoo, Co. Camden, N. S. W., in the Upper Marine Series."

Order ARTICULATA

This order contains all Recent crinoids as well as many extinct forms. The arrangement of the numerous genera in natural families and higher groups is complicated

by the fact that the obvious feature which sets off the Recent comatulids so sharply from the Recent stalked forms is not of great morphological importance, and any effort to group the stalked forms apart from the comatulids tends to do violence to natural relationships. The arrangement here used is offered in the hope that it makes provision for a fairly natural definition and sequence of families without doing great violence to natural relationships. The first step is the recognition of 3 suborders, which may be distinguished as follows:

Key to the Suborders of Articulata

More or less elongated stalk, of many segments and usually without cirri, retained throughout life; radicular outgrowths may be present at base of stalk, or rudimentary cirri elsewhere. Non-Australian ..... Apiocrinida

Stalk present or wanting, but cirri usually numerous, in regular whorls when stalk is present, or clustered about a small or rudimentary columnal or centrodorsal plate; if cirri are wholly wanting, centrodorsal is a smooth, flat, more or less pentagonal plate ..... Pentacrinida

Cirri wanting; stalk short with a few long segments, or wanting (body directly attached), or replaced by short, thick, unsegmented support. Non-Australian ..... Holopocrinida

Suborder Apiocrinida

Although this suborder has not yet been taken in Australian waters, it is probably represented there. There are 4 families, which may be distinguished thus:

Key to the Families of Apiocrinida

A. Distal part of stem with radicular cirri, and not enlarged into a terminal stem plate ..... Bourgueticrinidae

AA. No radicular cirri:

B. Distal end of stem enlarged into a heavy terminal plate:

Proximal end of stem enlarged and continuous with sides of calyx .. Apiocrinidae

Proximal end of stem not enlarged ..... Phrynocrinidae

BB. Neither end of stem enlarged ..... Plicatocrinidae

The last family, Plicatocrinidae, might better perhaps be placed in the order Inadunata, as suggested by A. H. Clark (1913).

Suborder Pentacrinida

This suborder is large and varied and includes all the living crinoids known from Australian seas. For convenience it may be divided into 2 sections, but the division is probably more artificial than natural.

With more or less of a stem persistent throughout life ..... Caulocrinida

With no persistent stem, though so far as known the early stages of development are stemmed ..... Comatulida

Section *Caulocrinida*

The Caulocrinida include but 2 families, one of which (Thiollericrinidae) is based on and known only from a single genus of European Jurassic and Cretaceous

fossils, *Thiolliericrinus,* which has the stem persistent but consisting of only a single nodal, enlarged and thickened. The other family, PENTACRINIDAE, has a more or less well developed stem with cirri arranged in whorls. More than a dozen genera have been named, but their limits are by no means clear and several are of dubious validity. The Australian species are considered as representing 3 genera, the differences between which are shown in the following key:

Key to the Genera of Pentacrinidae

A. First axillary beyond third, almost always beyond fourth, postradial ossicle ..... *Metacrinus*
AA. Second postradial ossicle an axillary:
Division series with more than 4 elements ..... *Isocrinus*
Division series with fewer than 5 elements, often only 2 or even 1 ..... *Teliocrinus*

METACRINUS

Carpenter, 1882*a*. Bull. Mus. Comp. Zoöl., vol. 10, p. 167.

Genotype: *Metacrinus wyvillii* Carpenter, 1884, pp. 339, 358, 360.

Two species of this genus are known from Australian seas, but the question has arisen whether one of these does not include 2 distinct species representing 2 different genera. The species from southeastern Victoria, described in 1916 as *Metacrinus cyaneus,* is the suspected form. A. H. Clark (1923, p. 9) says in a footnote: "It is evident from Dr. H. L. Clark's description of *Metacrinus cyaneus* that some of his specimens belonged to a species of this genus; the figure, however, represents a true Metacrinus." The genus *Saracrinus* A. H. Clark was distinguished from *Metacrinus* by a single character: "the fourth post-radial ossicle is the first axillary," whereas in *Metacrinus* "the first axillary is beyond the fourth, and is usually the seventh, post-radial ossicle." Gislen (1927, p. 66) discusses the validity of this character and cites considerable evidence to show its unreliability. His conclusion as to *Saracrinus* is, "I cannot consider this new genus as valid." My own observations on the material I have examined lead me to the same conclusion, and I am therefore recognizing only the 2 following species of *Metacrinus* from Australia, distinguishable thus:

Longest cirri with 60–64 segments; third to fifth pinnules longest and largest ..... *cyaneus*
Longest cirri with 40–45 segments; first pinnule longest and largest ..... *interruptus*

Metacrinus cyaneus

H. L. Clark, 1916. "Endeavour" rept., p. 9; pl. 1.

This very handsome crinoid was met with by the "Endeavour" at three stations off the southeastern coast of Victoria in 90–200 fms. No other specimens of *Metacrinus* have been taken in Australian seas except at Sahul Bank, near Timor, nor indeed within 2500 miles of the region where *cyaneus* occurs, but the relationship of *cyaneus* to other species of *Metacrinus* seems to be open to debate. Austin H. Clark writes me that it is "very close to *M. wyvillii* and it is not quite clear just what the differences are." A cotype of *wyvillii* in the Museum of Comparative Zoölogy being available for comparison, reliance need not be placed wholly on Carpenter's (1884) description and figures. As regards the stem, the differences in form and

number of internodals, relation of cirri to nodals, form and size of cirrus sockets, number of cirrus joints, and character of stem surface preclude any belief that the two species are identical. The differences (all given in the very detailed description of *cyaneus,* of which there were 7 specimens) in the calyx, in the crown of arms, and particularly in the pinnules amply confirm this conclusion. As was stated in the original description, the Australian species is nearer to *rotundus,* but comparison with specimens of that Japanese species reveal such differences as to prevent any confusion between the two. Whereas *wyvillii* is a smaller, smoother, more delicate species than *cyaneus, rotundus* is a rougher, coarser species, nearly as large as, and stouter than, the Australian. The most conspicuous and perhaps the most important difference is in the lower pinnules; in *rotundus* the distal ventrolateral angle of the basal segments is conspicuously produced and spiniferous, but in *cyaneus* this is not the case. Gislen's (1922) opinion that *cyaneus* "ought to be considered as a variety of *M. rotundus*" is erroneous.

Metacrinus interruptus

Carpenter, 1884. "Challenger" stalked crin., p. 367; pl. 52.

There is room for debate as to the propriety of including this crinoid in the Australian fauna, since its nearest approach to the continent is at Sahul Bank, which is much nearer to Timor than to Australia. The Bank, however, is south of 9° 30′ south latitude and within the 500-fm. line around the continent. Any echinoderms occurring there would almost surely be found sooner or later on Holothuria Bank or elsewhere in the shallow waters of the southern half of the Timor Sea. It is justifiable, therefore, to include *Metacrinus interruptus* in this volume, since Bell in his casual way says (1893, p. 339): "The specimens in the present collection were taken from a telegraph wire in 11° 30′ S, 125° E, . . . the depth, unfortunately, is not given. . . . There can however be no doubt that the species is the *Metacrinus interruptus* of P. H. Carpenter." Since this identification has been confirmed by A. H. Clark (1911, pp. 794, 797), we may accept it, even though the following year (1912, p. 269) he himself lists *interruptus* from Sahul Bank with a question mark. The species is known from southern Japan and the Philippines.

*ISOCRINUS

von Meyer, 1837. Abhandl. Mus. senckenb., vol. 2, p. 251.

Genotype: *Isocrinus pendulus* von Meyer, 1837, p. 260.

Among the first crinoids found preserved in Australian strata were fragments of a large pentacrinoid to which the specific name *australis* was attached. Different writers have assigned it to different genera, but so far material has been inadequate for the determination of its ultimate position. The superficial resemblance to the figures of *Isocrinus pendulus,* the type species of that genus, are so striking, however (see von Meyer, 1837, pl. 16, figs. 1–5), that it seems justifiable to call the Australian fossil an *Isocrinus.*

*Isocrinus australis

Pentacrinus australis Moore, 1870. Quart. Jour. Geol. Soc. London, vol. 26, p. 243; pl. 17, fig. 3; pl. 18, fig. 1.

Isocrinus australis Etheridge, 1901. Bull. Geol. Surv. Queensland, vol. 13, p. 6; pl. 1, fig. 4; pl. 3, figs. 1–3.
Isocrinus australis var. *albascopularis* Etheridge, 1904. Rec. Australian Mus., vol. 5, p. 251; pl. 28, figs. 1–4.
Isocrinus parvus Howchin, 1921. Trans. Roy. Soc. S. Australia, vol. 45, p. 1; pl. 1, figs. 1–3.

The more or less fragmentary remains of this species, which is undoubtedly the commonest fossil crinoid in Australia, have been found in the Cretaceous strata of various localities in Queensland, New South Wales, northern South Australia, and southeastern Northern Territory. Most of the material so far found consists of arm fragments, and really good material of calyx and stalk is still to be described. Fully grown specimens seem to have had arms more than 20 cm. long. Howchin's species *parvus* is apparently based on the terminal part of the arms of a young or at least small individual of *australis;* Etheridge's variety *albascopularis* is a lithological, rather than a zoological, variety. Probably the crinoidal fragments found in Victoria and referred to *Pentacrinus stellatus* Hutton (1873, p. 38) might more properly be assigned to *Isocrinus australis.*

TELIOCRINUS [1]

Döderlein, 1912. "Valdivia" stalked crin., p. 22.

Genotype: *Hypalocrinus springeri* A. H. Clark, 1909*f*, p. 650.

Almost at the same time that Döderlein named this group, A. H. Clark determined that it was worthy of recognition and called it *Comastrocrinus.* But Clark's name was not published for several weeks after Döderlein's. The German writer recognized but 1 species, whereas the American gave names to 3 different forms. In 1928, I gave a new name to a single specimen of *Teliocrinus* in the South Australian Museum, from an unknown locality, which seemed to me recognizably different from any of the 4 already described. Meanwhile, A. H. Clark had decided that all his species are identical with Döderlein's; but one of his was described before the German's, and hence, although Döderlein's genus stands, its type species is one of Clark's. Now, after examining some cirri and arms of my supposedly new species, Clark writes me: "I cannot see anything diagnostic in the fragments of the holotype of *Teliocrinus monarthrus.* They seem to agree perfectly with corresponding portions of the form I described as *Comastrocrinus liliaceus.* This species seems to be very variable and scarcely any two specimens are alike. It occurs chiefly in the Bay of Bengal ranging west to the west coast of India and south to the southern coast of Sumatra. It would be very likely to occur in the vicinity of Timor but I would not expect to find it in South Australian waters except that it might be picked up by a cable-ship working on one of the cables to Darwin in the Northern Territory." In view of Clark's much wider experience with the genus, I feel bound to accept his decision and regard *Teliocrinus* as monotypic.

Teliocrinus springeri

Hypalocrinus springeri A. H. Clark, 1909*f*. Proc. U. S. Nat. Mus., vol. 36, p. 650.
Teliocrinus asper Döderlein, 1912. "Valdivia" stalked crin., p. 22.

[1] A blunder on my part (1928, p. 365) assigns this genus without comment or date to A. H. Clark.

Comastrocrinus springeri A. H. Clark, 1912. Crin. Indian Ocean, p. 254.
Hypalocrinus ornatus A. H. Clark, 1909*f*. Proc. U. S. Nat. Mus., vol. 36, p. 651.
Hypalocrinus liliaceus A. H. Clark, 1909*c*. Proc. Biol. Soc. Washington, vol. 22, p. 150.
Teliocrinus springeri A. H. Clark, 1923. Jour. Washington Acad. Sci., vol. 13, p. 10.
Teliocrinus monarthrus H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 365.

The only excuse for including *Teliocrinus* in this list of Australian echinoderms is the occurrence of a specimen without a locality label in the collection of the South Australian Museum. It is a pure assumption, but by no means unwarrantable, that this specimen was taken in South Australian seas, probably (as suggested above) by a cable ship off the coast of the Northern Territory. Whether it is identical, as A. H. Clark believes, with the various forms from the Indian Ocean to which four names have been given remains to be proved, but I surrender to Clark's more experienced judgment. Only a much more considerable series of specimens can really solve the problem.

Section *Comatulida*

This large group, containing most of the Recent crinoids, falls naturally into 3 superfamilies, as follows:

Key to the Superfamilies of Comatulida

A. Pelagic forms with more or less swollen calyx, its plates large, thin, and more or less strongly curved outwardly; no cirri; extinct ..... Natanteata
AA. Bottom-inhabiting forms with relatively small, saucer- or cup-shaped calyx, its plates not large, thin, and outwardly curved; cirri generally present:
  Disk more or less studded or even completely covered with large calcareous concretions or plates; pinnules, at least the lower, wholly or in part prismatic, composed of short segments; arms usually more than 10 ..... Oligophreata
  Disk naked or studded with minute plates, which may become grouped in the interradial angles; pinnules cylindrical or flattened, slender, with long segments; arms commonly 10 ..... Macrophreata

Superfamily **NATANTEATA*

The 3 families composing this group are all extinct, but 2 of them have representatives in the Cretaceous strata of Australia. They may be distinguished as follows:

Key to the Families of Natanteata

A. Calyx relatively large, composed of many (a dozen or more) plates; Cretaceous:
  Greatest bulk of calyx below radials; infrabasals 5, very large; arms small, bifurcate ..... Marsupitidae
  Greatest bulk of calyx above radials; infrabasals very small or wanting; arms 10, unbranched ..... Uintacrinidae
AA. Calyx small, composed almost exclusively of 5 radials, which are very thin and elevated into prominent ridges along mid-line; European Upper Jurassic ..... Saccocomidae

Family *MARSUPITIDAE

There is but a single genus in this family, a well known and widely distributed Mesozoic fossil.

*MARSUPITES

Miller, 1821. Nat. hist. Crin., p. 134.

Genotype: *Marsupites ornatus* Miller, 1821, p. 136.

Although the fossils referred to this genus have been found in Europe, North America, India, Madagascar, and Australia, and names have been given to several of these widely separated forms, only a single species is now generally recognized. The suggested differences are unsatisfactory and unreliable, as most of the known material is fragmentary.

*Marsupites testudinarius

Encrinites testudinarius von Schlotheim, 1820. Die Petrefactenkunde, etc., p. 339 (no description, but reference is made to Parkinson's [1808, pl. 13, fig. 24] unmistakable figure).
Marsupites ornatus Miller, 1821. Nat. hist. Crin., p. 136; plate, no number.
Marsupites testudinarius Bather, 1889. Quart. Jour. Geol. Soc. London, vol. 45, p. 172.

The occurrence of *Marsupites* in Australia was discovered by L. Glauert, curator of the Western Australian Museum, Perth, whose diligent investigations of the Gingin deposits (often called the Gingin "chalk") have yielded a number of interesting animals, indicating an Upper Cretaceous age. In view of the wide distribution of *Marsupites,* its occurrence in Australia is not surprising, but it is none the less interesting and important. There is no evidence of its having lived in eastern Australian seas.

Family *UINTACRINIDAE

In its wide distribution, its monogeneric character, and the monotypic nature of that single genus, this family closely resembles the preceding. Its genetic relationship is probably less close.

*UINTACRINUS

Grinnell, 1876. Amer. Jour. Sci., ser. 3, vol. 12, p. 81.

Genotype: *Uintacrinus socialis* Grinnell, 1876, p. 81.

The remarkable free-swimming crinoid on which this genus is based occurred in great numbers in the Cretaceous seas of North America, where it reached a large size with arms several feet long. Since its discovery in America, similar fossils have been found in England and Germany and more recently in Australia. The general opinion is that all represent a single species.

*Uintacrinus socialis

Grinnell, 1876. Amer. Jour. Sci., ser. 3, vol. 12, p. 81.

The only evidence for the occurrence of *Uintacrinus* in Australian seas is the presence of fragments in the Gingin Cretaceous deposits discovered by L. Glauert, of the Western Australian Museum. These are so fragmentary and of such a nature that it is impossible either to assert or to deny that they are a different

species from that which occurred in American seas. No remains of *Uintacrinus* have been found in eastern Australia.

Superfamily *OLIGOPHREATA*

The great majority of living comatulids are included in this group. More than a dozen families are recognized, but of course only those known to occur in Australian waters are included in the following key.

Key to the Families of Oligophreata

I. Oral pinnules with terminal segments modified to form a so-called "comb"; mouth usually more or less marginal in position and anus correspondingly more or less central ..... Comasteridae

II. Oral pinnules without terminal comb; mouth more or less central and anus marginal:

A. Elements of IBr series united by syzygy ..... Zygometridae

AA. Elements of IBr series united by synarthry:

B. At least distal pinnules very slender, cylindrical, composed of much elongated segments; side and covering plates feebly developed or wanting:

C. Cirri smooth, carinate dorsally, or bearing single, median dorsal spines:

D. Cirri not laterally compressed, dorsal side flattened ..... Aporometridae

DD. Cirri laterally compressed distally, dorsal side more or less strongly carinate:

IIBr 4 (3+4), or with 10 arms having brachials very short, more or less discoidal at least distally ..... Himerometridae

IIBr 2; arms more than 10 ..... Mariametridae

CC. Cirrus segments bearing serrate, transverse ridge (or 2), or paired or tricuspid spines, dorsally ..... Colobometridae

BB. All pinnules, even distally, prismatic (triangular in cross section), rather stout, the outer with comparatively short segments:

E. Pinnule ambulacra without well developed side and covering plates ..... Tropiometridae

EE. Pinnule ambulacra with well developed side and covering plates:

F. P_1 very delicate, flexible and weak, the 2 basal segments (especially the lower) greatly enlarged; P_2, P_3, or both, much enlarged and stiffened, with elongated segments; disk globose, enclosed by solid pavement of plates ..... Calometridae

FF. P_1 without any special modification of basal segments:

G. Cirri comparatively slender, with more than 25 segments, of which distal are short and usually bear well developed dorsal spines:

H. P_1 shorter and smaller than P_2:

Centrodorsal large, broad, thick, discoidal; cirri numerous, crowded, tending to arrangement in 15 columns ..... Ptilometridae

Centrodorsal a short, more or less pentagonal column with conical apex; cirri in double column in each radial area ..... Asterometridae

HH. P_1 larger and longer than P_2 ..... Thallasometridae

GG. Cirri stout, with fewer than 25 segments, which are subequal and without dorsal spines ..... Charitometridae

Family COMASTERIDAE

This is the largest family of Australian crinoids, containing no fewer than a dozen genera. They are chiefly denizens of the coral reefs of tropical Australia and are beyond question the most beautiful animals found there. The diversity of color and form is beyond description, so that a large basin with a dozen or so comasterids is as lovely as the finest bouquet of flowers. The species occurring on the southern coasts are plainly colored, of smaller size, and hence far less conspicuous.

The sequence of genera in the following key is not as natural as possible, but is the most convenient for the purpose. The more natural sequence, followed by A. H. Clark in his great monograph on the family (1931, Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3), is followed in the subsequent text here. For correlation of key and text, the page number of each genus is given before its name in the key.

Key to the Genera of Comasteridae

I. Ten arms only:[1]
- A. Several distal cirrus segments bear, each, a tubercle, spinelet, or ridge on dorsal side:
  - Distal end of basal segments of lower pinnules not markedly enlarged ..... (p. 28) *Comissia*
  - Distal end of basal segments of lower pinnules flaring greatly, projecting as rough spurs on aboral side ..... (p. 27) *Comanthoides*
- AA. Distal cirrus segments without dorsal processes (except on penultimate segment):
  - Fewer than 25 cirrus segments, some (usually many) longer than broad ..... (p. 30) *Comatula*
  - More than 30 cirrus segments, mostly twice as broad as long .. (p. 29) *Comatulella*

II. More than 10 arms:
- B. Arms 20 (rarely more); no cirri in adults; all division series of 2 ossicles united by syzygy ..... (p. 29) *Validia*
- BB. Not as above:
  - C. First pinnule of undivided arm arising from a IIBr or a subsequent axillary on first brachial; syzygy between brachials 2 and 3:
    - Distal cirrus segments more or less carinate dorsally, with spinelets or small tubercles on mid-dorsal line ..... (p. 26) *Capillaster*
    - Distal cirrus segments not carinate dorsally, but each bears straight transverse ridge ..... (p. 27) *Comanthoides*
  - CC. First pinnule of undivided arm on second brachial; never syzygy between brachials 2 and 3:
    - D. All division series of 2 elements only:
      - Cirri well developed, numerous, rather long; distal segments with dorsal tubercle or spinelet ..... (p. 25) *Comatella*
      - Cirri poorly developed in single, more or less deficient series; distal segments (except penultimate) without dorsal tubercle or spinelet ..... (p. 30) *Comatula*
    - DD. Some division series of 4 elements:
      - E. Elements of IBr series and first 2 ossicles after every axillary united by syzygy ..... (p. 31) *Comaster*

[1] In certain genera of this group, more than 10 arms may occur, in some species regularly. These genera will also be found in section II of this key.

EE. Elements of IBr series and first 2 ossicles after every axillary united by synarthry:
F. Some of IIIBr series 4 (3+4):
G. Outer IIIBr series of each ray 2, inner 4 (3+4) . . (p. 32) *Comanthina*
GG. Outer IIIBr series 4 (3+4) or some irregularly 4 and some 2:
Cirri always present, numerous, and evenly distributed around periphery of centrodorsal; distal segments markedly shorter than proximal and laterally compressed; IIBr and IIIBr series almost invariably 4 (3+4) . . . . . (p. 35) *Cenolia*
Cirri few, small, or wanting; distal segments not much shorter than basal and little compressed; some, often many, division series 2 . . . . . (p. 37) *Comanthus*
FF. All IIIBr series 2, or sometimes a IIBr 2 series followed by a IIIBr 4 (3+4) series . . . . . (p. 34) *Comantheria*

COMATELLA

A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 207.

Genotype: *Actinometra nigra* P. H. Carpenter, 1888, p. 304.

This is one of the commonest genera of comatulids in tropical Australia, occurring in very shallow water on the reefs and along shore. Though the 3 species are distinguishable, the lines between them are not sharply drawn, and small specimens of the larger species and large individuals of the smaller are confusing. But in general, the 3 species may be distinguished as follows:

Key to the Species of Comatella

A. Arms more than 40; cirrus segments commonly 26–30 . . . . . *nigra*
AA. Arms not more than 35; cirrus segments not more than 25:
Arms usually 30–40; cirrus segments 20–25 . . . . . *stelligera*
Arms usually 20 or fewer; cirrus segments 15–20 . . . . . *maculata*

Comatella nigra

Actinometra nigra P. H. Carpenter, 1888. "Challenger" Comat., p. 304.
Comatella nigra A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 207.
——— 1912. Crin. Indian Ocean, p. 69; fig 1.
——— 1918. "Siboga" unst. crin., pl. 1 (colored).
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 92; figs. 1–3.
H. L. Clark, 1921. Ech. Torres Strait, p. 12.

The northern coasts of Australia mark the extreme southern limit of the range of this big East Indian comatulid. It is so closely related to the following smaller species that the line between them is far from distinct. It has been taken in Australia only at the Murray Islands; near Lizard Island, Queensland (lat. 14° 40′ S.), at the northern tip of the Barrier Reef; and at Long Island, Abrolhos, Western Australia. In life the colors range from bright red to nearly black, but preserved specimens tend to be dull brown or nearly black. Fully grown specimens may be 350 mm. across and have up to 80 arms, but the known Australian specimens had not

reached this maximum size. The specimens from Lizard Island are said to have been in life "purple, distal ends of arms, yellow."

Comatella stelligera

Actinometra stelligera P. H. Carpenter, 1888. "Challenger" Comat., p. 308; pl. 58.
Comatella stelligera A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 207.
——— 1918. "Siboga" unst. crin., pl. 2 (colored).
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 98; figs. 6–9.
H. L. Clark, 1921. Ech. Torres Strait, p. 13; pl. 2, fig. 2 (colored).

Although this species ranges throughout the East Indian region and has been reported from the Barrier Reef region as far south as lat. 18° and on the west coast as far south as Wooded Isle, Abrolhos, Western Australia, lat. 29°, it has not been taken at either Darwin or Broome. It is very common at the Murray Islands, where the color varieties are numerous and baffling, ranging from bright green to deep purple, with markings of orange-yellow, bright yellow, and yellow-green. A common form has the basal parts of the arms purple and the distal parts green, but the line between the two colors is not abrupt. The shades of both colors are very varied, but are commonly lighter in youthful specimens. These comatulids live among the corals and under the margins of slabs of coral rock at low-water mark or just below. They do not live in areas exposed to the surf, but the margins of tidal channels are decidedly favored. They are inactive and apparently move about but little. Their food consists of the minute animal and plant life brought to them in the tidal currents.

Comatella maculata

Actinometra maculata P. H. Carpenter, 1888. "Challenger" Comat., p. 307; pl. 55, fig. 2.
Comatella maculata A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 207.
H. L. Clark, 1921. Ech. Torres Strait, p. 12; pl. 3, fig. 1 (colored).

Widespread in the East Indian region from the Maldives to the Caroline Islands, this comatulid occurs on the tropical coast of Australia as far south as Bowen, Queensland. Originally taken in Torres Strait, it has since been found to range northward to southern Japan. The Great Barrier Reef Expedition failed to find it at Low Isles, but it has been taken at Port Denison. It is common at the Murray Islands, living on the lower surface of large rock fragments, avoiding the light. It does not show great diversity in coloration, but is very dark brownish purple, with the tips of the pinnules brownish orange. It occurs also on the northwestern coast of Australia, at Cape Leveque and at Broome, where it reaches its maximum size, 100–150 mm. across the arms. Small specimens show a dark green tint which becomes yellowish green near the arm tips; very large specimens are nearly black.

CAPILLASTER

A. H. Clark, 1909*b*. Proc. Biol. Soc. Washington, vol. 22, p. 87.

Genotype: *Actinometra sentosa* P. H. Carpenter, 1888, p. 325.

Although 2 species of this genus are recorded from Australia, neither seems to be very common. They may be distinguished as follows:

Arms more than 40; cirrus segments 30–40 ..... *sentosa*
Arms not more than 35; cirrus segments usually 23–26 ..... *multiradiata*

Capillaster sentosa

Actinometra sentosa P. H. Carpenter, 1888. "Challenger" Comat., p. 325; pl. 66, figs. 4–7.
Capillaster sentosa A. H. Clark, 1909*b*. Proc. Biol. Soc. Washington, vol. 22, p. 87.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 160; figs. 28, 29, 31.

There is but one record of this wide-ranging East Indian comatulid from Australia, 2 specimens having been taken between Fremantle and Geraldton, Western Australia, by the "Endeavour" in June 1912. The depth is not given in the record, but the dredge hauls made by the "Endeavour" along that coast were between 29 and 120 fms. Little if any collecting at such depths has been done elsewhere on the coast of Western Australia, of the Northern Territory, or of Queensland, so perhaps it is not strange that *sentosa* has not yet been found elsewhere in Australian seas.

Capillaster multiradiata

Asterias multiradiata Linné, 1758. Syst. Nat., ed. 10, p. 663.
Capillaster multiradiata A. H. Clark, 1909*g*. Zool. Anz., vol. 34, p. 364.
——— 1918. "Siboga" unst. crin., pl. 3 (colored).
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 173; figs. 30, 34–36.

Though this comatulid has been reported from a number of stations along the tropical coasts of Australia, it has not been found common anywhere, except possibly at Broome, where 10 specimens were collected, chiefly near low-water mark. It was taken by the "Endeavour" in June 1912 on the western coast between Geraldton and Fremantle, 29–120 fms. The "Gazelle" took it near Dirk Hartog Island, well north of Geraldton, but Dakin did not find it at Houtman's Abrolhos. On the eastern side of the continent, it has been reported from as far south as Cape Flattery (lat. 15° S.), but the Great Barrier Reef Expedition (1928–1929) did not find it at the Low Isles, and the Carnegie Expedition (1913) took but 1 specimen at the Murray Islands. North of Australia, it ranges throughout the East Indian region from the Maldives to Formosa.

In life the colors are dull so far as records show. The specimen taken at the Murray Islands was "black, orally, brown dorsally, with joints between the segments much darker; whole dorsal surface including the cirri heavily silvered or frosted with white." In its dried condition this specimen is light gray, the joints on the dorsal side of the arms noticeably darker.

COMANTHOIDES

A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 240.

Genotype: *Comanthus spanoschistum* H. L. Clark, 1916, p. 17.

This monotypic genus is distinctively Australian, and combines certain features of *Capillaster, Comissia,* and *Comanthus.* Its author considers it more nearly related to *Comissia* than to *Capillaster,* but nearer to the latter than to *Comanthus.*

Comanthoides spanoschistum

Comanthus spanoschistum H. L. Clark, 1916. "Endeavour" rept., p. 17; pl. 4, fig. 3.
Comanthoides spanoschistum A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 241; figs. 52–58.

This interesting small comatulid has been taken as yet only by the ill-fated "Endeavour," but the collectors on that vessel obtained 46 specimens at seven stations off the southeastern coast of Australia, in Bass Strait, and near Maria Island, eastern Tasmania. It is a small, variable species, and the characters of *Comanthus* and *Comissia,* and even *Capillaster,* seem to be confused in some individuals. There is no information about the appearance in life. In dry or alcoholic material, "the color is more or less yellowish, with either a green or brown cast; one specimen is very dull purplish with yellow cirri, others are yellowish more or less clouded with purplish." In a 19-armed individual dull purplish predominates. Since the arms are usually 10, and 19 is the maximum number, it is reasonable to infer that purple pigment increases with age. Specimens taken in March and April have the genital pinnules swollen with reproductive cells, indicating a breeding season in late summer or early fall. The condition of these pinnules in September, when half the specimens were taken, is unfortunately not recorded.

COMISSIA

A. H. Clark, 1909*e*. Proc. U. S. Nat. Mus., vol. 36, p. 501.

Genotype: *Comissia lütkeni* A. H. Clark, 1909*e*, p. 502.

Although more than a dozen species are assigned to this genus, all are relatively little known, and only one has been reported from Australia.

Comissia lütkeni

Comanthus spanoschistum H. L. Clark, 1916. "Endeavour" rept., p. 18 (a specimen from Queensland).
Comissia lütkeni A. H. Clark, 1909*e*. Proc. U. S. Nat. Mus., vol. 36, p. 502.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 249; figs. 66, 67.

The only known Australian specimen of *Comissia* was taken by the "Endeavour" in 1914, off Noosa Head, Queensland, 16 fms. It was identified by me as *Comanthus spanoschistum,* and is presumably in the Australian Museum now with that label. Although A. H. Clark has not seen the specimen, on the basis of my statement that it "is noticeably more slender than the other" specimens of *spanoschistum* which were then in my hands, and "the cirri are somewhat more compressed," he says it "seems undoubtedly to be" *Comissia lütkeni.* Since *spanoschistum* is not known from north of Bass Strait, and in view of Clark's great experience in studying the Comasteridae, I yield to his judgment and trust that further collecting off southern Queensland will vindicate it. The species is a small one with only 10 arms and, Clark says, "is rather easily confused with *Comatula pectinata*" in spite of the very different cirri. It is known from only a few East Indian stations, hence this Australian occurrence is of special interest.

COMATULELLA

A. H. Clark, 1911*c*. Amer. Jour. Sci., ser. 4, vol. 32, p. 130.

Genotype: *Comatula brachiolata* Lamarck, 1816, vol. 2, p. 535.

No proper diagnosis of this genus was published until 1931, but since only a single species was associated with the new name when it was first used, in 1911, it must be accepted as of that date, especially since its author made use of it repeatedly in the years 1911–1915. Only a single species is known, the most striking comatulid of the southern coasts of Australia.

Comatulella brachiolata

Comatula brachiolata Lamarck, 1816. Anim. sans vert., vol. 2, p. 535.
Comatulella brachiolata A. H. Clark, 1911*c*. Amer. Jour. Sci., ser. 4, vol. 32, p. 130.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 296; figs. 93–97.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 15.

A curiously rigid and ungraceful creature, this little crinoid is given a special charm by its bright color and odd form. Its range seems to be only from the vicinity of Perth southward and eastward to Port Phillip, Victoria. In large individuals, the arms may be 65–85 mm. long, but those at hand from Koombana Bay are considerably smaller. Apparently *brachiolata* is local in its distribution, for only a few specimens were recorded prior to 1911, when its frequent occurrence on the southwestern coast of Western Australia was first made known. It is most common apparently in 5–10 fms., but it occasionally occurs nearer to low-water mark, and the "Endeavour" took it between Fremantle and Geraldton in deeper water, 29–120 fms. There is no record of the actual locality or depth.

VALIDIA

A. H. Clark, 1909*i*. Vidensk. Medd., vol. 61, p. 142.

Genotype: *Comatula rotalaria* Lamarck, 1816, vol. 2, p. 534.

Although this group was first proposed as a subdivision of a subgenus, its author later recognized it as subgenus of *Comatula*. Owing to its unique character, a generic status seems warranted.

Validia rotalaria

Comatula rotalaria Lamarck, 1816. Anim. sans vert., vol. 2, p. 534.
A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 309; fig. 98.
Comanthus (*Comanthus, Validia*) *rotalaria* A. H. Clark, 1909*i*. Vidensk. Medd., vol. 61, p. 142.
Comanthus (*Validia*) *rotalaria* A. H. Clark, 1918. "Siboga" unst. crin., p. 6.
Validia rotalaria H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 16.

No adequate figure of this fine comatulid has yet been published. It is known to range from Port Molle, Queensland (20° 30′ S.) to Lagrange Bay, northwestern Australia (18° 40′ S.). It does not, however, seem to occur in the vicinity of Darwin or at Cape Leveque, so it is quite possible that its range on the tropical Australian coast is not continuous. There are specimens in the British Museum

from the Aru Islands, but *Validia* does not seem to occur in East Indian seas north of that group. The colors in life are striking: pink, yellow, or light brown dorsally; pinnules silvery dorsally, more or less yellow-tipped; sutures dark, more or less purplish; oral surface very dark. Dry specimens, or even alcoholic, show little evidence of such handsome colors. Though the normal number of arms is 20 and their length 100–120 mm., large specimens in Lagrange Bay had 30 or 31 arms, 140 mm. long, and specimens with arms 165 mm. long are recorded.

COMATULA

Lamarck, 1816. Anim. sans vert., vol. 2, p. 530.

Genotype: *Comatula solaris* Lamarck, 1816, vol. 2, p. 533.

This easily recognized genus is represented by a very common species all along the tropical coast of Australia. A second, larger, species also occurs but is relatively rare. A third form, also large, has been taken on the coast of Queensland, but very few specimens are known and its exact status is still to be determined. The 3 species are distinguishable as follows:

Key to the Species of Comatula

A. Cirri wanting (1–3 rarely present); terminal combs on basal pinnules confined to first 3 pairs ..... *cratera*

AA. Cirri present; terminal combs not confined to first 3 pairs of pinnules:
- Cirrus segments 17 or more ..... *solaris*
- Cirrus segments 15 or fewer ..... *pectinata*

Comatula cratera

H. L. Clark, 1916. "Endeavour" rept., p. 12; pl. 2, fig. 1.

This fine crinoid is known only from Port Molle, Queensland, in 12 fms., and from 35–40 fms. off Sandon Bluffs, New South Wales. Dorsal side light fawn color, usually with purple markings, stripes, or spots. Disk and oral side of arms yellowish. Arms 175 mm. or more in length. The status of *cratera* is possibly still open to question. A. H. Clark (1931, p. 323) says it is "merely a form of *C. solaris,* related to it in much the same way that *C. purpurea* is to *C. pectinata.*" But *pectinata* and *purpurea* occur together in the same localities and even in the same habitat (see H. L. Clark, 1938, p. 18), whereas no specimens of *cratera* are known from the same stations as *solaris* (with a possible exception at Port Molle) and *cratera* ranges much farther south. Apparently *solaris* prefers shallower water, ranging from low-water mark to 12–13 fms., whereas *cratera* has been taken only from 12–13 fms. to 35–40 fms. Moreover, the differences between the two forms in coloration and in the character of the lower pinnules are not to be ignored. Further collecting at Port Curtis and Port Molle, Queensland, and along that coast may produce connecting links that will warrant treating *cratera* as a mere variety of *solaris,* but it is very improbable that it will ever be found mingled with *solaris* as *purpurea* mingles with *pectinata.* It is more probable that it is a species of southern Queensland which occasionally gets as far north as Port Molle.

Comatula solaris

Lamarck, 1816. Anim. sans vert., vol. 2, p. 533.
A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, pl. 323; fig. 99.

One of the largest and handsomest of the 10-armed comatulids, this fine East Indian species occurs on the Queensland coast from Port Denison to Torres Strait and on the coast of Western Australia from the Abrolhos Islands to Roebuck Bay, and also at Holothuria Bank. It has not yet been reported from the coast of the Northern Territory. Full-grown individuals are nearly half a meter across when expanded and are handsomely colored with great diversity of tints (see H. L. Clark, 1938, p. 20).

Comatula pectinata

Asterias pectinata Linné, 1758. Syst. Nat., ed. 10, p. 663.
Comatula pectinata A. H. Clark, 1908*a*. Proc. U. S. Nat. Mus., vol. 33, p. 685.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 339; figs. 49, 100–109, 111, 114.
H. L. Clark, 1921. Ech. Torres Strait, p. 14; pl. 1, fig. 3 (colored); pl. 3, fig. 2 (colored).
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 18.

Wide-ranging in the East Indian region and probably the commonest comatulid of tropical Australia, *pectinata* ranges from Port Curtis, Queensland, northward to Torres Strait, and from the Abrolhos Islands, Western Australia, to Dundas Strait in the Northern Territory. It is most abundant just below low-water mark and down to 7–8 fms. Its diversity in both form and color is very great. In large specimens the arms opposite the mouth may exceed 190 mm., those adjoining the mouth being only about three-fifths as long. In small specimens the disproportion is not nearly so marked and in many cases is hardly noticeable. Specimens with more than 10 arms are extremely rare in Australia, but one with 11 has been recorded from Holothuria Bank. A very common form has only 10 cirri (or fewer), a pair (or a single one or none) at each angle of the centrodorsal. Nearly a century ago the name *purpurea* was given to this form, and it has persisted down to the present time. But there is no longer room for doubt that this supposed "species" is based on nothing but an inconstant feature as unreliable as the coloration (see H. L. Clark, 1938, p. 18). The diversity of color is amazing and is apparently in no way associated with habits or habitat. Shades of red or purple are most frequent, and unicolor specimens are more common than varied ones. The colors, especially if bright, are very fugacious. Even in sea water, if Epsom salts are added, the color comes out rapidly and copiously, usually being of a brownish-red shade.

COMASTER

L. Agassiz, 1835*a*. Mem. Soc. sci. nat. Neuchâtel, vol. 1, p. 193.

Genotype: *Comatula multiradiata* Lamarck, 1816, vol. 2, p. 354 = *Alecto* or *Comatula multifida* J. Müller, 1841, p. 147 (NON *Asterias multiradiata* Linné, 1758, p. 663 = *Capillaster multiradiata* A. H. Clark, 1909*g*, p. 364).

This East Indian genus of a dozen species is represented in Australian seas by 2 very unlike species, a large one with 45–150 arms (*multifida*), and a small, very delicate form with fewer than 40 arms (*minima*). In both these strikingly differ-

ent forms, the cirri are wanting or weak and poorly developed, whereas in 9 of the other 10 species they are well developed.

Comaster multifida

Alecto multifida J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 147.
Comaster multifida A. H. Clark, 1911*f*. Proc. U. S. Nat. Mus., vol. 41, p. 171.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 413; figs. 140, 141.

This apparently perplexing East Indian comatulid has been reported under at least five different names from tropical Australia. A. H. Clark (1931, p. 424) records it from Port Walcott, Western Australia, Thursday Island, Albany Island, Prince of Wales Channel, and Port Molle, Queensland. I have never seen an Australian specimen, so it probably seldom occurs on the reefs or shores, though Clark says (*loc. cit.*, p. 425) "most of the specimens have been taken in very shallow water." It reaches a large size, with 125–150 arms, 200 mm. or more in length. According to Herklots' (1869) figure, the colors in life are bright, pink, yellow, and orange-brown. Specimens from the Philippine Islands are recorded as "in life, brown of some shade, ranging from dark chocolate to burnt orange."

Comaster minima

Phanogenia minima A. H. Clark, 1909*d*. Proc. U. S. Nat. Mus., vol. 36, p. 392.
Comaster minima A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 435; figs. 155, 156.

This species is as yet but very slightly known, only a few specimens having been taken. It has been found but once on the Australian coast, a single specimen having been obtained in 5–15 fms. off Ellison Reef, outer Great Barrier Reef, Queensland, in 1924 by W. E. J. Paradice. Other specimens are known from five stations in the East Indies and Philippines. Nothing is reported as to the color in life, but an alcoholic specimen is recorded (A. H. Clark, 1931, p. 435) as "dull yellowish with numerous longitudinal narrow lines on the radials and division series, and transverse lines on the arms, of dark brown."

COMANTHINA

A. H. Clark, 1909*i*. Vidensk. Medd., vol. 61, p. 142.

Genotype: *Actinometra nobilis* P. H. Carpenter, 1888, p. 336.

There are but 2 species in this genus of big tropical comatulids, and both occur in Australian waters. They are easily distinguished thus:

IVBr and following series, 2, rarely 4; proximal pinnule segments with strong dorsal processes ..... *belli*
IVBr and following series, 4 (3+4), rarely 2; proximal pinnule segments without strong dorsal processes ..... *schlegelii*

Comanthina belli

Actinometra belli P. H. Carpenter, 1888. "Challenger" Comat., p. 334.
Comanthina belli A. H. Clark, 1911*c*. Amer. Jour. Sci., ser. 4, vol. 32, p. 130.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 458; figs. 157, 199.

It is hard to say whether this beautiful big "feather star" is more lovely than the equally showy *Comanthus timorensis*. Both deserve the title of "most beautiful marine animal" in tropical Australia. At the Murray Islands the *Comanthus* is much the more abundant, but at Broome the *Comanthina* was much more frequently seen. The diversity of color in *belli* defies description, for it ranges from pale cream color to nearly black; even sky blue, lemon yellow, and grass green are now and then found. Few specimens are unicolor. In the specimens taken at Broome, the cirri were apparently always white, but this does not seem to hold true for material taken elsewhere. In preserved specimens, the cirri are usually no longer really white, but are yellowish, grayish, or light brown. This is one of the largest of Australian crinoids; the arms of fully grown specimens exceed 100 mm. and often are 140–150; individuals with more than 150 arms are occasionally found, but it is virtually impossible to count them accurately without serious injury to the specimen. A large individual may be more than 400 mm. across when fully expanded. The favorite haunt of these beautiful feather stars is among the nooks and crannies of living corals at the edge of well aerated marginal tide pools on the reefs, but they also occur on the lower side of rock and coral fragments that are so supported as to leave ample room for constantly moving sea water. So far as is known at present, *belli* is an endemic Australian crinoid, ranging from Torres Strait westward and southward to the Abrolhos Islands. It is not yet known from the Barrier Reef or the Queensland coast south of lat. 11°.

Comanthina schlegelii

Actinometra schlegelii P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, p. 210.
Comanthus schlegelii A. H. Clark, 1911*d*. Proc. U. S. Nat. Mus., vol. 39, p. 536.
H. L. Clark, 1921. Ech. Torres Strait, p. 20.
Comanthina schlegelii A. H. Clark, 1911*a*. Notes Leyden Mus., vol. 33, p. 176.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 466; figs. 158–161.

According to A. H. Clark, this fine comatulid has a very extensive range, from the Maldives to the Caroline Islands and south to northern Australia. But he admits only one Australian record, that of a single specimen in the British Museum from the Percy Islands, Queensland, called by Bell (1884) *Actinometra multifida*. The 3 specimens from the Murray Islands which were identified by me (1921) as *Comanthus schlegelii* seem to Clark to be *belli*. I have therefore carefully re-examined the specimens concerned.

Even a superficial examination shows that the 3 specimens represent a single species, and this impression is confirmed by prolonged and critical comparison. All have cirri well developed as in *belli*, but stout and smooth as in *schlegelii*. None have conspicuous dorsal processes on the basal segments of the proximal pinnules, but on a few pinnules at or near the middle of the arm, one or two basal segments have a small process. As a rule the pinnules are definitely more like those of *schlegelii* from the Philippines than they are like those of *belli* from Broome. The 3 specimens must be considered good examples of *schlegelii* if 2 species of *Comanthina* are to be recognized. I am not at all sure that 2 species can rightly be maintained; but until more material is available from the northern coast of Queensland, the Barrier Reef, and Torres Strait, the conspicuous varicolored beauty found from Prince of Wales Channel westward and southward to the Abrolhos Islands and so common at Broome may be called *belli*, and the duller-colored

form from the Percy Islands northward along the Barrier Reef, northeastward to the Carolines, and northwestward to the Maldives may be designated as *schlegelii*. As yet the latter seems to be a rare member of Australia's fauna.

COMANTHERIA

A. H. Clark, 1909*i*. Vidensk. Medd., vol. 61, p. 142.

Genotype: *Antedon briareus* Bell, 1884, p. 163.

This is another group of about a dozen large comatulids, ranging from southern Japan to Western Australia and New South Wales. Four nominal species occur in Australian seas, but the line between 2 of these is very vague and it seems unlikely that it exists in nature. The following key points out the features which are supposed to separate these 4 forms, but the use of such a key is attended with obvious difficulties.

Key to the Species of Comantheria

I. Centrodorsal reduced; cirri absent or rudimentary:
  A. More than 45 arms:
    VBr series 2 ..... *alternans*
    VBr series 4 (3 + 4) ..... *briareus*
  AA. Arms 40 or fewer ..... *rotula*
II. Centrodorsal well developed, with 15–20 cirri ..... *perplexum*

Comantheria alternans

Actinometra alternans P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, p. 208.
Comanthus alternans A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 206.
H. L. Clark, 1921. Ech. Torres Strait, p. 16; pl. 20, fig. 1.
Comantheria alternans A. H. Clark, 1911*a*. Notes Leyden Mus., vol. 33, p. 176.

This is a fine big comatulid with numerous (80–160) arms, dividing frequently, a VIBr series being often present in adults. The IIBr series are commonly 4 (3+4) and the succeeding series alternate 2 and 4; occasionally the alternation is reversed, with the IIBr series 2 and the succeeding series 4 and 2. The color is usually some shade of brown, ranging from yellow-brown to deep orange-brown. Specimens are not numerous, however, and the color in life may show great diversity as in related species. The only Australian records for *alternans* are Port Molle, Penguin Channel, and the Murray Islands, Queensland, and the Abrolhos Islands, Western Australia.

Comantheria briareus

Antedon briareus Bell, 1884. "Alert" rept., p. 163; pl. 14.
Comantheria briareus A. H. Clark, 1911*g*. Fauna Südwest-Australiens, vol. 3, p. 437.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 492; figs. 163, 164.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 23.

Widespread from Formosa to the coast of Western Australia, this varicolored and multibrachiate comatulid is very common at Broome, but has not been found in numbers elsewhere. It has been taken at Port Denison, Queensland, and twice on the outer Great Barrier Reef, between 17° and 19° S. But it was not taken by the Great Barrier Reef Expedition nor by the Carnegie Expedition to the Murray

Islands. At Broome it is a striking feature of the shallow-water fauna. The aboral side in nearly all the larger specimens is a bright yellowish green or greenish yellow; the oral surface is black and the pinnules are black and white, in striking contrast. It is more slender-armed and delicate than *Comanthina belli* or *Comanthus timorensis,* and will not be confused with them when mature. But young specimens are by no means readily identifiable (see H. L. Clark, 1938, pp. 23–25).

Comantheria rotula

A. H. Clark, 1912*b*. Proc. Biol. Soc. Washington, vol. 25, p. 23.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 503; fig. 165.

On the strength of a photograph of a comatulid taken at Broome, Western Australia, by Mjöberg in 1911, A. H. Clark includes this species in the Australian fauna. Several small Comantherias taken at Broome in 1929 and 1932 suggest *rotula* but show no constant features to distinguish them from young *briareus.* It seems very doubtful whether the two nominal species are really distinct. Indeed, *briareus* is not clearly defined.

Comantheria perplexum

Comanthus perplexum H. L. Clark, 1916. "Endeavour" rept., p. 14; pl. 3, fig. 2.
Comantheria perplexum A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 506.

Since the unique holotype of this species was taken, "eleven miles south by east of Ballina, N. S. W., 27–28 fms.," only a single additional specimen has been reported. It was taken "in 15 fms., off Norwest Islet, Capricorn group, Queensland, in December, 1930." The holotype is in the Australian Museum. The second specimen is in the Museum of Comparative Zoölogy, gift of the Australian Museum. The 2 specimens are of approximately the same size (200± mm. across) and color (dorsally, light fawn color; orally, disk yellowish gray, arms and pinnules dark). The number of cirri present is 6 in one case, 7 or 8 in the other, with 16–19 segments. As there are about 15 cirrus sockets around the margin of the centrodorsal, it is evident the cirri are more or less fugacious. This is apparently an endemic species quite distinct from its nearest East Indian ally, *C. weberi,* of the Lesser Sunda Islands.

CENOLIA

A. H. Clark, 1916. Proc. Biol. Soc. Washington, vol. 29, p. 48 (as a subgenus).

Genotype: *Comatula trichoptera* J. Müller, 1846, p. 178.

This genus was suggested as a subgenus of *Comanthus,* but may well be given generic rank. It is well represented in Australia by 5 species, which may be distinguished as follows:

Key to the Species of Cenolia

I. More than 60 arms; cirri large, stout, with 20–35 segments, without dorsal processes ..... *bennetti*
II. Fewer than 60 arms; cirrus segments with dorsal processes:
  A. Cirri long, stout, numerous (more than 50), with more than 30 segments; usually about 40 arms ..... *plectrophorum*

AA. Cirri shorter and more slender, with fewer than 30 segments; fewer than 30 arms:
B. Axillaries with anterior angle obtuse, not produced; cirrus segments 12–15; arms 15–21 ..... *samoana*
BB. Axillaries with anterior angle acute and somewhat produced; arms 20–40:
Cirrus segments about 14–17; arms about 37 ..... *tasmaniae*
Cirrus segments up to 18–20, often fewer; arms 15–30, sometimes up to 37 ..... *trichoptera*

Cenolia bennetti

Alecto bennetti J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 187 (duplicated in Arch. f. Naturgesch., vol. 7, p. 146).
Comanthus (*Cenolia*) *bennetti* A. H. Clark, 1918. "Siboga" unst. crin., p. 50.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 531; figs. 186–189.

This big East Indian comatulid is rare in Australia. Only 2 individuals have been recorded, 1 from Port Denison, Queensland, and 1 from 19 fms. near Direction Island, Great Barrier Reef. The Port Denison record is an old one (1877); the one from Direction Island is of a small individual, with only 30 arms, taken by the Great Barrier Reef Expedition. It is dull olive-brown, with a broad longitudinal whitish band on the distal third of the longer arms; the cirri are yellow and the very young arms (of which there are 10) are cream yellow.

Cenolia plectrophorum

Comanthus plectrophorum H. L. Clark, 1916. "Endeavour" rept., p. 15; pl. 4, fig. 1.
Comanthus (*Cenolia*) *plectrophorum* A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 530; figs. 62, 190, 191.

As far as is now known, this is one of Australia's endemic comatulids, having a very restricted range. The only recorded specimens have been taken near the eastern end of Bass Strait in rather deep water (100–300 fms.). There are 38–44 arms in adults, and the numerous long cirri have 28–38 segments. The basal segments of the lower pinnules have very characteristic large T-shaped processes. The color in alcohol is light brown, which becomes light fawn or pale buff on drying.

Cenolia samoana

Comanthus (*Comanthus*) *samoana* A. H. Clark, 1909*h*. Proc. U. S. Nat. Mus., vol. 37, p. 30.
Comanthus luteofusca H. L. Clark, 1915*b*. Carnegie Inst. Wash. Pub. 212, p. 102.
——— 1921. Ech. Torres Strait, p. 18; pl. 20, figs. 2, 3.
Comanthus (*Cenolia*) *samoana* A. H. Clark, 1918. "Siboga" unst. crin., p. 52.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 593; figs. 208, 219, 220.

This is a relatively small and stout, dark-colored comatulid, easily confused with small specimens of *Comanthus parvicirra* and *C. timorensis*. But the rather stocky appearance, the yellowish-brown or darker coloration, the small number of arms, and the cluster of short, stout, strongly recurved cirri enable one to recognize it without great difficulty. It ranges along the tropical Australian coast from Broome southwestward to the Abrolhos Islands, and from Mer, at the northern end of

the Barrier Reef, south to the Low Isles. It has not yet been taken between Broome and Torres Strait, though it is known from Timor and Salawati. Its extra-Australian range is from Ceylon to Samoa, but it is not yet known from the coast of Asia or north of Mindoro, Philippine Islands.

Cenolia tasmaniae

Comanthus tasmaniae A. H. Clark, 1918*a*. Proc. Biol. Soc. Washington, vol. 31, p. 41.
Comanthus (*Cenolia*) *tasmaniae* A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, pp. 531, 586.

This little comatulid is known only from Bass Strait and Tasmanian waters. No figure has been published and little information has been given as to its distribution. A. H. Clark (1931, p. 587) refers to "a fine series of 24 specimens collected by the "Endeavour," but gives no information as to where they were taken. Apparently it may be considered a distinctively Tasmanian species. As I have seen no specimens, I cannot pass on the validity of the species, but I am very skeptical.

Cenolia trichoptera

Comatula trichoptera J. Müller, 1846. Monatsber. K. preuss. Akad. Wissensch., p. 178.
Comanthus trichoptera A. H. Clark, 1909*h*. Proc. U. S. Nat. Mus., vol. 37, p. 30.
Comanthus (*Cenolia*) *trichoptera* A. H. Clark, 1916. Proc. Biol. Soc. Washington, vol. 29, p. 48.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, pp. 531, 579; figs. 4, 203.

This may be considered the most typical crinoid of the endemic fauna of Australia, for it is confined to the southern coasts along with the very characteristic sea urchins *Amblypneustes* and *Holopneustes*. It ranges along that coast westward to Albany and Bunbury and northward thence to Dongarra, Western Australia. On the eastern coast its range extends northward to Cape Hawke, New South Wales. At Lord Howe Island, it is common among the living corals in the lagoon at Ned's Beach. It has probably reached Lord Howe Island on the foul bottoms of ships from Australian ports. In this locality it is seldom more than 100 mm. across, whereas at Port Jackson and elsewhere on the mainland coast it reaches twice that size. The colors are never showy, commonly white and brown of various shades, more generally yellowish. Alcoholic and dry specimens are often yellowish brown, with or without gray and brownish mottling. It lives under rock fragments or among corals, bryozoa, sponges, etc., usually near low-water mark, but the range extends out to about 40 fms.

As was stated above, the differences supposed to distinguish this species from *tasmaniae* are unreliable and need clarification. Probably the two are identical.

COMANTHUS

A. H. Clark, 1908*d*. Proc. Biol. Soc. Washington, vol. 21, p. 220.

Genotype: *Alecto parvicirra* J. Müller, 1841, p. 185.

Individuals of this genus occur in great numbers near low-water mark on the reefs and shores of tropical Australia, particularly in the Barrier Reef region. Their large size and beautiful colors make them very conspicuous, and their diversity

of form and shade combine to make them the loveliest of marine animals, rivaled only by their close relatives in the genus *Comanthina.* So great is the individual diversity, it is exceedingly difficult to draw specific lines. Of 1 species only a single specimen is known, hence its validity is open to question. The other 2 species are so common that all degrees of intergradation seem to occur. Though the two extremes are very different, many specimens cannot be indisputably determined, but must be arbitrarily placed on the basis of general appearance.

Key to the Species of Comanthus

A. Arms very numerous (78), extraordinarily variegated with pale brown, deep yellow, black, white, and green, but general impression light-colored; cirri present but few and small, with up to 16 segments..... *callipepla*

AA. Arms fewer than 70 (usually much fewer); color very diversified, but commonly bright shades of brown, green, or red, often very deep brown or nearly black; never variegated as in *callipepla:*

Arms more than 30; functional cirri usually wanting, never well developed ..... *timorensis*

Arms not more than 30; size small; functional cirri present..... *parvicirra*

Comanthus callipepla

H. L. Clark, 1915*b*. Carnegie Inst. Wash. Pub. 212, p. 102.
——— 1921. Ech. Torres Strait, p. 17; pl. 1, fig. 1 (colored).

Since this unusually beautiful species rests upon a single specimen taken at Mer, Murray Islands, in 1913, its validity is open to question. A. H. Clark is of the opinion (1931, p. 614) that it is only an unusual specimen of *timorensis.* I believe, however, that further collecting on the Barrier Reef at the northern end will reveal more specimens of *callipepla* and that its status as a valid species will be vindicated. The holotype was nearly 200 mm. across in life, and had 78 arms and 8 small cirri about 7 mm. long. The coloring defied description, but is perfectly shown in the published figure.

Comanthus timorensis

Alecto timorensis J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 186.
Comanthus timorensis A. H. Clark, 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, pp. 159 *et al.;* figs. 204–207.

This big, common, widespread comatulid ranges from Ceylon to Tonga and Fiji, and from the Bonin Islands in the north to Geraldton, Western Australia, and the Capricorn Islets, Queensland, in the south. So diversified are its multibrachiate forms that it has been given no fewer than 11 specific names, and has frequently been confused with the following species. The intricate synonymy has been admirably worked out by A. H. Clark.

At the Murray Islands this is the most conspicuous feature of the reef life (see *Comanthus annulata,* H. L. Clark, 1921, p. 16), but on the northwestern coast near Broome it finds a notable rival in *Comanthina belli* (see H. L. Clark, 1938, p. 21). Under projecting edges of large coral or rock fragments or among coral heads and branches where there is an abounding supply of pure sea water, near low-water mark or in large tide pools, *timorensis* flourishes in all its varied beauty.

Under such conditions it may attain a diameter of 400 mm. The number of arms is normally 32–42 but may exceed 60; the largest number recorded is 68.

One of the color forms found at the Murray Islands was so striking and so fundamentally different from all other individuals of *timorensis* seen that it was designated var. *xantha.* Three specimens were obtained. Its brilliant colors are fugacious, and preserved specimens are apparently not distinguishable from ordinary *timorensis.* In life, however, it is unmistakable; the calyx and dorsal side of the arms are bright yellow, and the pinnules are bright red in striking contrast (see H. L. Clark, 1921, p. 17; pl. 1, fig. 6). No examples of this variety were found in 1929 or in 1932. Quite possibly it is found only at the Murray Islands or along the northern part of the Barrier Reef.

Comanthus parvicirra

Alecto parvicirra J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 185.
Comanthus (*Comanthus*) *parvicirra* A. H. Clark, 1911*d*. Proc. U. S. Nat. Mus., vol. 39, p. 536.
——— 1931. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3, p. 631; figs. 184, 209–218, 221.
H. L. Clark, 1921. Ech. Torres Strait, p. 19; pl. 1, figs. 5, 7 (colored).

The wide geographical distribution of this comatulid (from Madagascar and Mauritius to the Tonga Islands, north to southern Japan and Amoy, China, south to Fremantle, Western Australia, and Moreton Bay, Queensland) combines with its general commonness and its almost infinite diversity of color, form, and structural details to make it the most frequently misidentified crinoid in the world. It is no wonder that A. H. Clark's list of synonyms (1931, pp. 631–636) extends to more than 5 pages and includes 22 specific names assigned to 8 different genera. The truth seems to be that nature has not yet completed the line of division between *parvicirra* and *timorensis,* and even the lines between *Comanthus, Cenolia, Comantheria, Comanthina,* and *Comaster* are continually crossed by individual variants. Order has been brought out of chaos by the competent efforts of A. H. Clark, but there is no reliable character or group of characters that will always distinguish specimens of *parvicirra* from the related species.

In its typical condition, with 20 arms and a dozen or so cirri having 13 or 14 segments, *parvicirra* is usually easily recognized; in life, the arms have a relatively soft texture and greater width than is ever found in *timorensis.* The trouble begins as the arms increase and the cirri decrease in number. A further discussion of these points and of the problem of color will be found in H. L. Clark 1921, page 19. Although many specimens of *parvicirra* were taken at Mer (Murray Islands, 1921), none were seen at either Darwin or Broome (1929 and 1932). Further studies on the northern coast of Queensland and the Barrier Reef may ultimately reveal the true distinctions between *timorensis* and *parvicirra.*

Family ZYGOMETRIDAE

This is a small family containing only a few genera, of which but one occurs in Australia. The distinguishing character is that the union of the elements of the IBr series is by syzygy, a feature not found in any of the following families. It is a character much easier to state than to see clearly, but it seems to be constant and trustworthy.

ZYGOMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 347.

Genotype: *Antedon microdiscus* Bell, 1884, p. 163.

The 4 species of this genus occurring in Australia are confined to the tropical coasts and reefs, where they are often to be found in large numbers. They are among the most characteristic animals on the vast flats exposed at low water during spring tides at Broome. The species may be distinguished as follows, but the line between the 2 smaller species is vague and arbitrary.

Key to the Species of Zygometra

A. More than 33 cirrus segments:
  IIIBr and following division series 4 (3 + 4) ..... *microdiscus*
  IIIBr and following division series 2 ..... *elegans*
AA. Fewer than 33 cirrus segments:
  20–30 cirrus segments ..... *comata*
  Fewer than 20 cirrus segments ..... *punctata*

Zygometra microdiscus

Antedon microdiscus Bell, 1884. "Alert" rept., p. 163; pl. 15.
P. H. Carpenter, 1888. "Challenger" Comat., pl. 37, figs. 4–6.
Zygometra microdiscus A. H. Clark, 1909*g*. Zool. Anz., vol. 34, p. 367.

In spite of the specific name, given (according to A. H. Clark) through a misinterpretation of the character of the disk in the original type, the disk is normally large. In a big specimen taken at Broome, rather more than 300 mm. across, the disk was 35–40 mm. This specimen was carefully dried (from alcohol) fully extended, and in drying the margin of the disk detached itself from the arm bases and shrank symmetrically to a present diameter of about 18 mm., leaving a conspicuous scar all around. There are about 110 arms; the exact number cannot be counted without damage.

This handsome crinoid is not uncommon at Broome (see H. L. Clark, 1938, p. 32), but it is rarer and seems to prefer deeper water than the following species. We did not find it at Darwin or even at Cape Leveque, nor did the Carnegie party (1913) find it in Torres Strait or at the Murray Islands. A. H. Clark (1911) reports it from several points in the Torres Strait region and on the northwestern coast (Nicol Bay and Dampier Archipelago). Bell gives Port Molle, Queensland, 12 fms., as the type locality, but apparently the species is not common on the Queensland coast.

Zygometra elegans

Antedon elegans Bell, 1884. "Alert" rept., p. 162; pl. 13, figs. B, B*a*.
P. H. Carpenter, 1888. "Challenger" Comat., pl. 8.
Zygometra elegans A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 348.

The differences between this species and the preceding are obvious enough where the two are found side by side, as at Broome (see H. L. Clark, 1938, p. 31). No Zygometras were met with by us in 1913 in the Torres Strait region, but the

present species has been found as far south as Port Curtis, Queensland. We found it at Darwin and abundantly at Broome, but not at any intermediate point. It is known, however, from Baudin Island and Mermaid Strait, and even as far south as between Geraldton and Fremantle. Although it reaches about as large a size as *microdiscus,* it does not develop so many division series and hence so many arms. The maximum number seems to be about 60. The "Siboga" did not take this species in the East Indies, so it is quite possible that its range is limited to the tropical coasts of Australia.

Zygometra comata

A. H. Clark, 1911. Recent crin. Australia, p. 762, footnote.
——— 1912. Crin. Indian Ocean, p. 105; fig. 6.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 29.

This is a common comatulid at Broome, but has not as yet been found elsewhere on the Australian coast. It occurs, according to its author, "in the Mergui Archipelago, at Singapore and among the Philippine Islands." At Broome (see H. L. Clark, 1938) it is a common species, but shows very great diversity in size, number of arms, color, and number of segments in the cirri. The largest specimens were 175–200 mm. across when spread out, and the number of arms ranged from 11 to 25. The number of segments in the cirri was usually 20–23, rarely up to 27, never less than 20.

Zygometra punctata

A. H. Clark, 1912*b*. Proc. Biol. Soc. Washington, vol. 25, p. 24.
——— 1918. "Siboga" unst. crin., p. 61; pl. 19, figs. 40, 41.

The validity of this species is open to serious question, for it seems to be impossible to draw a sharp line between it and *comata.* Now that the latter species has been found abundantly at Broome, the recorded occurrence of *punctata* at the Low Isles and northern end of the Barrier Reef (H. L. Clark, 1932), as well as at the Aru Islands, places it in virtually the same area as that occupied by *comata.* If, as A. H. Clark holds, the little comatulid on which *Heterometra delicata* H. L. Clark (1915*b*) was based is a young *punctata,* another Australian locality is added for the small *Zygometra.* I am not convinced that *delicata* is a *Zygometra,* but believe it wise to let the species lapse (see under *Heterometra*). Further collecting in Torres Strait may some day reveal its real relationship.

Three small comatulids whose cirri seemed to warrant regarding them as *punctata* were taken at the Low Isles and near Direction Island, Barrier Reef, by the Great Barrier Reef Expedition. When I identified them in 1930–1931, I had not critically studied the Zygometras from Broome. Now, comparison of the Low Isles specimen, retained by the Museum of Comparative Zoölogy, with the specimens from Broome leaves no doubt that they are all the same species. It may quite properly be claimed that I have not yet seen a real example of *punctata.* The conclusion is, however, inescapable that if *punctata* is a valid species it has not yet been taken in Australia, unless the little type of "*Heterometra delicata*" is really a young one.

Family HIMEROMETRIDAE

There are only half a dozen species representing this family in the Australian fauna, and these are all found on the reefs and shores of the tropical coasts. The record of *Craspedometra acuticirra* from Sydney, New South Wales, is based on an old and erroneous locality label. None of the species is sufficiently common to be conspicuous, with the possible exception of *Heterometra crenulata* at Broome.

Key to the Genera of Himerometridae

A. More than 10 arms:
  P_D longer and stouter than P_1, which is longer and stouter than P_2 . . *Himerometra*
  P_D shorter and more slender than P_1, which is shorter and more slender than P_2 . . . . . *Heterometra*
AA. Only 10 arms; cirri large and stout . . . . . *Amphimetra*

HIMEROMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 355.

Genotype: *Antedon crassipinna* Hartlaub, 1890, p. 185.

Only a single species of this conspicuous group of comatulids has as yet been taken in Australian seas, and this is apparently rare.

Himerometra robustipinna

Actinometra robustipinna P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, p. 201.
Himerometra robustipinna A. H. Clark, 1912. Crin. Indian Ocean, p. 117.
H. L. Clark, 1926. Rec. Australian Mus., vol. 15, p. 184.
Antedon crassipinna Hartlaub, 1891. Nova acta Deutsch. Akad., vol. 58, p. 11; pl. 1, figs. 1, 5, 10.

The only occurrence of this fine comatulid in Australian waters, as yet reported, was off Ellison Reef, outer Great Barrier Reef, Queensland, in 5–15 fms. W. E. J. Paradice, surgeon on the "Geranium," collected 2 specimens, one with 29, the other with 36 arms. The cirri are peculiar in having the dorsal teeth confined to the outermost 1–6 segments.

HETEROMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 11.

Genotype: *Antedon quinduplicava* P. H. Carpenter, 1888, p. 262.

Only 2 species of *Heterometra* occur on the Australian coasts. A third supposed species, *H. delicata* H. L. Clark, was based on a single specimen, which, after being relegated to the synonymy of *Zygometra punctata* by A. H. Clark, is now abandoned by mutual consent as being "altogether too young for determination." The 2 Australian species are quite different from each other, and may be distinguished thus:

Arms 35–40; enlarged proximal pinnules smooth, slender, the segments without lateral processes or produced, spinous distal edges . . . . . *nematodon*
Arms 14–26; enlarged proximal pinnules with broad, rounded, lateral processes, making a strongly serrate profile . . . . . *crenulata*

Heterometra nematodon

Antedon nematodon Hartlaub, 1890. Nachrich. Gesellsch. Göttingen, no. 5, p. 185.
——— 1891. Nova acta Deutsch. Akad., vol. 58, p. 27; pl. 1, fig. 9.
Heterometra nematodon A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 11.

This is apparently a rare or at least a seldom collected comatulid. It is known only from Bowen and Port Molle on the Queensland coast, but probably occurs at many places on the Barrier Reef. It has numerous arms (38) about 80 mm. long, and the cirri have 40–50 segments.

Heterometra crenulata

Antedon crenulata P. H. Carpenter, 1882. Jour. Linn. Soc. (Zool.), vol. 16, p. 507.
——— 1888. "Challenger" Comat., p. 256; pl. 36, figs. 1–6; pl. 48, figs., 3–5; pl. 49, figs. 1, 2 (all as *Antedon variipinna*).
Heterometra crenulata A. H. Clark, 1918. "Siboga" unst. crin., p. 77.

This is a very widespread and variable East Indian comatulid to which many specific names have been given. It ranges from Double Island Point, in southern Queensland, to Singapore and the Philippines; on the Australian coast, it has been taken in Torres Strait, at Holothuria Bank, Dundas Strait, and Baudin Island. At Broome it is very common and wonderfully diversified in color and in ruggedness of structure (see H. L. Clark, 1938, p. 33). Large specimens of *crenulata* have 20–30 arms, 75–90 mm. long. Specimens with milk-white arms and rose-red cirri are beautiful beyond words.

AMPHIMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 6.

Genotype: *Comatula* (*Alecto*) *milberti* J. Müller, 1846, p. 178 = *Amphimetra tessellata tessellata* A. H. Clark, 1941, p. 360.

There are apparently 3 species or "forms" of this genus in the coastal waters of tropical Australia, but none of them is a conspicuous feature of the fauna, as all are rather rare. They may be distinguished by the characters of the cirri, but the status and validity of these forms are still debatable.

Key to the Species of Amphimetra

A. Cirrus segments 30–50:
  Cirri rather slender, tapering more or less distally, longer proximal segments about as long as broad, sometimes slightly longer, distal segments with small dorsal spinules ..... *tessellata discoidea*
  Cirri stouter, with dorsal spines appearing in side view as broad triangles with apex produced ..... *tessellata tessellata*
AA. Cirrus segments fewer than 30 ..... *pinniformis*

Amphimetra tessellata discoidea

Alecto tessellata J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 184.
Himerometra discoidea A. H. Clark, 1908*c*. Smithsonian Misc. Coll., vol. 52, pt. 2, p. 215.

Amphimetra discoidea A. H. Clark, 1911*b*. Bull. Mus. hist. nat. Paris, no. 4, p. 250.
——— 1918. "Siboga" unst. crin., pl. 6 (colored); pl. 18, fig. 35.
Amphimetra tessellata discoidea A. H. Clark, 1941. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 4*a*, p. 376.

Although this comatulid is recorded from half a dozen places on the tropical coast of Australia between Port Molle, Queensland, on the east, and south of Geraldton, Western Australia, on the other side of the continent, we did not meet with it during the three expeditions of 1913, 1929, and 1932. It may reach a considerable size, with arms 150–200 mm. long and cirri 30–50 mm. long. The color is "uniform dark purple or violet" or "yellow brown, the cirri and pinnules purple," but there is probably considerable individual diversity. A. H. Clark (1941) now thinks *discoidea* is best treated as a subspecies of a species *tessellata*, but the species itself also occurs in the same area, and the supposed difference in the cirri seems trivial. One form or the other (or both) is widely distributed in the East Indian region from Formosa and Sunda Strait to subtropical Australia.

Amphimetra tessellata tessellata

Comatula jaquinoti J. Müller, 1846. Monatsber. K. preuss. Akad. Wissensch., p. 178.
Amphimetra jaquinoti A. H. Clark, 1918. "Siboga" unst. crin., p. 85; pl. 18, fig. 36.
Amphimetra tessellata tessellata A. H. Clark, 1941. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 4*a*, p. 360.

Unlike most comatulids, this form is notably lacking in grace and beauty. The long arms (125–135 mm.) are ungainly and somewhat rigid, and the rather numerous cirri are also long and stiff, 40–50 mm., with numerous segments (28–47). The color is deep reddish purple or violet, often more or less marked or banded with white or yellow, but the amount and location of the light color show great diversity; sometimes it is confined to the pinnules or to the dorsal side of the arm tips, or to regenerating parts of injured arms. Though not uncommon at Broome, this comatulid was met with only three times. It is, however, widely distributed on the tropical coast of Australia, having been taken at several stations on the Queensland coast (Port Molle and northward) and on the Western Australian coast between Geraldton and Fremantle and at Houtman's Abrolhos. It is also known from several stations in the East Indian islands.

Amphimetra pinniformis

Antedon pinniformis P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, pp. 175, 180.
Amphimetra pinniformis A. H. Clark, 1911*a*. Notes Leyden Mus., vol. 33, p. 182.

This little-known species, originally described from Andai, New Guinea, is included in this volume on the strength of a single dubious record from 15 fms. on Holothuria Bank, northwestern Australia. The specimen is in the British Museum, and A. H. Clark (1913, p. 25) says it is "probably" this species. Many years later (1941, p. 360) he says it is "probably" (line 6), and then "definitely" (line 25), *pinniformis*. Until more material is available the validity of *pinniformis* is open to doubt. No figure has been published.

Family MARIAMETRIDAE

The Australian members of this family fall into 3 genera, all of which are more or less conspicuous because of form or color or both. They occur only in the tropics and are obviously members of the East Indian fauna. One species ranges westward to Madagascar and others eastward to Tonga and perhaps to Hawaii. None is peculiar to Australia. The 3 genera are distinguished by the following characters:

Key to the Genera of Mariametridae

A. One or more of proximal pinnules enlarged, stiffened, and spinelike, usually with fewer than 18 long segments ..... *Stephanometra*

AA. None of lower pinnules stiffened and spinelike; enlarged lower pinnules with at least 20 segments, flagellate distally:

P_2 and P_3 similar and of equal length ..... *Liparometra*

P_2 markedly longer and more or less stouter than P_3 or P_1 ..... *Lamprometra*

STEPHANOMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 9.

Genotype: *Antedon monacantha* Hartlaub, 1890, p. 179 (p. 12 of reprint).

The 3 species of this genus occurring in tropical Australia show considerable diversity, but the following key will help to distinguish them:

Key to the Species of Stephanometra

A. P_2 only pinnule enlarged and stiff:

P_2 more or less recurved, becoming very slender distally, composed of 15–20 segments, of which fourth and fifth are not noticeably longest ..... *indica*

P_2 much enlarged and stiffened, of 11–15 segments, of which fourth and fifth are typically longest ..... *monacantha*

AA. P_3, like P_2, enlarged, stiffened, and spinelike ..... *spicata*

Stephanometra indica

Comatula indica E. A. Smith, 1876. Ann. Mag. Nat. Hist., ser. 4, vol. 17, p. 406.
Stephanometra indica A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 10.
Stephanometra callipecha H. L. Clark, 1921. Ech. Torres Strait, p. 21; pl. 1, fig. 9 (colored); pl. 36, figs. 2*a–e*.

This is a species of the western part of the Indo-Pacific area, ranging from northern Australia and the Lesser Sunda Islands to Madagascar. It is evidently rare in Australian seas, being known there only from the single specimen taken at the Murray Islands, October 27, 1913, which I made the basis of a new species (*callipecha*), not having any specimens of *indica* for comparison. Further experience leads me to accept A. H. Clark's present opinion that the specimen is best considered typical *indica*.

Stephanometra monacantha

Antedon monacantha Hartlaub, 1890. Nachrich. Gesellsch. Göttingen, no. 5, p. 179 (p. 12 of reprint).
——— 1891. Nova acta Deutsch. Akad., vol. 58, p. 59; pl. 3, figs. 33, 38.
Stephanometra monacantha A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 9.
——— 1912. Crin. Indian Ocean, p. 137; fig. 14.

This species is known to range from the Maldive Islands to Tonga, but it is rare in Australia, where it has been taken only in Torres Strait and at the Murray Islands. The Torres Strait record seems to be dubious, for A. H. Clark (1918, p. 96) says of Hartlaub's specimen from that region that it "represents *indica*." If that is the case, then my specimen from Mer (M.C.Z. no. 599) is the only one known from Australia. In 1918, Clark thought this specimen was also *indica,* but subsequent examination satisfied him that it really is *monacantha,* which he now (1941) considers a synonym of *S. indica protecta.* In my opinion, it is a distinct species.

Stephanometra spicata

Antedon spicata P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, p. 190.
Stephanometra spicata A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 10.
——— 1918. "Siboga" unst. crin., pl. 7 (colored).
Stephanometra stypacantha H. L. Clark, 1915*b*. Carnegie Inst. Wash. Pub. 212, p. 103.
——— 1921. Ech. Torres Strait, p. 22; pl. 22, fig. 4; pl. 36, figs. 3*a–e*.

Although this species is widely distributed in the East Indian region from Ceylon to the Loyalty Islands, the only recorded occurrence in Australian seas is the single specimen taken at the Murray Islands, in October 1913. In this individual, the 16 arms, about 70 mm. long, were a uniform deep red-purple, strikingly different from the "Siboga" specimen, taken in the Sulu Archipelago and suggestive of a distinct species.

LIPAROMETRA

A. H. Clark, 1913*a*. Proc. Biol. Soc. Wash., vol. 26, p. 143.

Genotype: *Himerometra grandis* A. H. Clark, 1908*d*, p. 222.

Only a single species of this genus occurs in Australia, and it is apparently rare or unusually secretive.

Liparometra articulata

Comatula (*Alecto*) *articulata* J. Müller, 1849. Abhandl. K. preuss. Akad. Wissensch. (1847), p. 263 (p. 27 of reprint).
Liparometra articulata A. H. Clark, 1913*a*. Proc. Biol. Soc. Washington, vol. 26, p. 143.
Antedon reginae Bell, 1884. "Alert" rept., p. 160; pl. 12, figs. A, A*a*.

The range of this species is given by A. H. Clark as "Molucca to Northern Australia," but the only Australian record is the single specimen taken by the "Alert" at Port Molle, Queensland, which Bell called *Antedon reginae.* It must be a secretive, if not a very rare, comatulid in Australia.

LAMPROMETRA

A. H. Clark, 1913*a*. Proc. Biol. Soc. Washington, vol. 26, p. 143.
——— 1941. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 4*a*, p. 472.

Genotype: *Antedon imparipinna* P. H. Carpenter, 1882, p. 505 = *Alecto palmata* J. Müller, 1841, p. 185.

The species of this genus show such differences in structure and so much individual diversity in details that they are by no means well defined. The 2 Australian species may be distinguished as follows if the specimens are mature and in good condition:

P_2 very long, rather stiff, and very stout, though tapering gradually to a more or less flagellate tip ..... *palmata*
P_2 resembling P_1 but of greater length ..... *gyges*

Lamprometra palmata

Alecto palmata J. Müller, 1841. Monatsber. K. preuss. Akad. Wissensch., p. 185.
Lamprometra protectus A. H. Clark, 1913*a*. Proc. Biol. Soc. Washington, vol. 26, p. 144.
——— 1918. "Siboga" unst. crin., p. 271; pl. 8 (colored).
Lamprometra brachypecha H. L. Clark, 1921. Ech. Torres Strait, p. 22; pt. 2, fig. 1 (colored); pl. 22, figs. 1, 2.
Lamprometra palmata A. H. Clark, 1929. Jour. Linn. Soc. (Zool.), vol. 36, p. 641.
——— 1941. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 4*a*, p. 474.

The diversity shown by this perplexing comatulid is emphasized by the fact that A. H. Clark in 1918 (p. 100) assigned 16 names to its synonymy, and in 1941 he devotes more than 4 pages to the synonymy and 37 pages to a discussion of its diversity and distribution. It ranges throughout the East Indies from Ceylon to Hong Kong and southward to the northern coasts of Australia. To the east, it extends to Tonga, and Clark lists it as from Hawaii. There are 7 specimens from the "northern coast of Australia" in the South Australian Museum (see H. L. Clark, 1928, p. 368), and 4 specimens were taken at Mer, Murray Islands, in 1913. These latter specimens were regarded by me as representing a new species which I called *brachypecha*. A. H. Clark, however, considers them "a form of *palmata* with the lower pinnules rather more slender than usual." At Mer, this crinoid is, in life, beautifully colored with green, white, and deep yellow. It occurs on the under surface of large coral fragments on the reef flat on the southeastern side of the island.

Lamprometra gyges

Antedon gyges Bell, 1884. "Alert" rept., p. 160; pl. 12, figs. B*a–b*.
Lamprometra gyges A. H. Clark, 1913*a*. Proc. Biol. Soc. Washington, vol. 26, p. 144.
H. L. Clark, 1921. Ech. Torres Strait, pl. 1, fig. 4 (colored); pl. 21, figs. 4, 5; pl. 22, fig. 3.

This species has been repeatedly taken on the northern coast of Australia, and as far south on the east coast as Port Denison and on the west as Wooded Isle, Houtman's Abrolhos. At Darwin, 5 specimens were taken in 1929, and at Broome, where 19 specimens were obtained, it is fairly common (see H. L. Clark, 1921, p. 23; 1938, p. 35). A. H. Clark now considers *gyges* a subspecies or form of *palmata*, but I feel sure that the latter name already covers 2 or more distinct species whose limits will be determined only when good series can be studied in the field at several different, well separated places.

Family COLOBOMETRIDAE

Second only to the Comasteridae in the number of its representatives among the comatulids of Australia, this family is found on all suitable parts of the tropical and even subtropical coasts of the continent. A dozen species are known, and there is reason to believe that others, perhaps many, remain to be discovered. They are, for the most part, small, 10-armed forms, active in their movements but secretive in habits. The dozen species are grouped in 8 genera, which may be distinguished as follows:

Key to the Genera of Colobometridae

A. P_a present on all arms:
  B. More than 10 arms ..... *Cenometra*
  BB. Only 10 arms:
    C. P_1, P_2, and P_3 similar, elongated, stiffened, segments beyond basal 2 much elongated; P_2 longest ..... *Iconometra*
    CC. Not as above:
      D. P_1 shorter, smaller, weaker than P_2 ..... *Oligometra*
      DD. P_1 longest, stoutest pinnule on arm:
        Some basal segments of genital pinnules more or less expanded laterally; cirrus segments each with single transverse dorsal ridge ..... *Austrometra*
        No basal segments of genital pinnules expanded; cirrus segments each with 2 transverse ridges ..... *Oligometrides*
AA. P_a absent:
  E. More than 10 arms ..... *Petasometra*
  EE. Only 10 arms:
    Outer cirrus segments each with long, prominent dorsal spinelet ... *Colobometra*
    Outer cirrus segments each with serrate, transverse dorsal ridge ..... *Decametra*

CENOMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Wash., vol. 22, p. 8.

Genotype: *Himerometra unicornis* A. H. Clark, 1908*c*, p. 216.

This is a genus chiefly of the western and northern parts of the East Indian region, and only 1 species has been reported from Australia.

Cenometra cornuta

A. H. Clark, 1911. Rec. crin. Australia, p. 772.
——— 1913. Smithsonian Misc. Coll., vol. 61, no. 15, p. 33.

Only a single specimen, the holotype in the British Museum, was recorded in connection with the original description of this species, and no figure has been published. This individual was reported to have 26 arms, about 110 mm. long, banded white and purple, and 14 brown cirri. The type locality was given as "Adele Island, north Australia," which lies off Cape Leveque, Western Australia. The locality "Baudin Island," which lies 200 miles or so northeast of Adele, is also given, though no specimen from there is mentioned. Two years later (1913, p. 33) the type is again described and no mention is made of Baudin Island, but a "broken specimen" from "no locality" is mentioned as being like the holo-

type in color. Obviously *Cenometra cornuta* is a rare comatulid, possibly confined to a seldom visited area of Australia's northwestern coast.

ICONOMETRA

A. H. Clark, 1929. Jour. Linn. Soc. (Zool.), vol. 36, p. 643.

Genotype: *Iconometra speciosa* A. H. Clark, 1929, p. 643.

This little genus is represented in Australia by a single species, originally taken in Torres Strait but now known to range farther south on the Queensland coast. The other 2 species occur in the Philippines and off southern Annam.

Iconometra anisa

Oligometra anisa H. L. Clark, 1915*b*. Carnegie Inst. Wash. Pub. 212, p. 105.
——— 1921. Ech. Torres Strait, p. 23; pl. 1, fig. 10 (colored); pl. 4, figs. 1, 3 (colored); pl. 21, figs. 1–3; pl. 36, figs. 1*a–e*.
Iconometra anisa A. H. Clark, 1929. Jour. Linn. Soc. (Zool.), vol. 36, p. 643.

Although this pretty, diversely colored little comatulid was not rare at the Murray Islands, we did not meet with it anywhere else along the northern coast of the continent. The Great Barrier Reef Expedition took 2 specimens ½ mile north of Eagle Island, northern Queensland, in 10 fms., indicating that this is really a Barrier Reef species. Its diversity of color, general appearance, and activities are recorded in H. L. Clark, 1921, pages 23–24.

OLIGOMETRA

A. H. Clark, 1908. Proc. Biol. Soc. Washington, vol. 21, p. 126.

Genotype: *Antedon serripinna* P. H. Carpenter, 1881, p. 182.

This widely spread Indo-Pacific genus is represented in Australia by 2 species whose ranges overlap in the Torres Strait region. They may be distinguished thus:

P_2 very stout, composed of short segments bearing long lateral processes..... *carpenteri*
P_2 not so conspicuously stout, lateral processes only moderately developed..... *serripinna*

Oligometra carpenteri

Antedon carpenteri Bell, 1884. "Alert" rept., p. 157; pl. 10, figs. A*a–c*.
Oligometra carpenteri A. H. Clark, 1908. Proc. Biol. Soc. Washington, vol. 21, p. 126.

This comatulid ranges from Port Curtis, Queensland, to Baudin Island, off Cape Voltaire, northern Western Australia. It is reported from the Aru Islands, but is otherwise strictly Australian. We did not find it at Darwin, or at Cape Leveque, Western Australia, but W. E. J. Paradice took 2 specimens in 1923 at the Sir Edward Pellew group of islands in the Gulf of Carpentaria.

Oligometra serripinna

Antedon serripinna P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, pp. 175, 182.
Oligometra serripinna A. H. Clark, 1908. Proc. Biol. Soc. Washington, vol. 21, p. 126.
——— 1912. Crin. Indian Ocean, pp. 169–174; fig. 28.

This is a wide-ranging species, having been taken at Ceylon, in the Philippines, in New Guinea, and at Long Island, in Houtman's Abrolhos, Western Australia. The last is the only Australian record of which I know, but the specimen was examined by A. H. Clark, who considers it undoubtedly *serripinna,* though not typical.

AUSTROMETRA

A. H. Clark, 1916*a*. Jour. Washington Acad. Sci., vol. 6, p. 115.

Genotype: *Oligometra thetidis* H. L. Clark, 1909, p. 522.

This monotypic genus is peculiar to southeastern Australia.

Austrometra thetidis

Oligometra thetidis H. L. Clark, 1909. "Thetis" rept., p. 522; pl. 47, figs. 1–3.
Austrometra thetidis A. H. Clark, 1916*a*. Jour. Washington Acad. Sci., vol. 6, p. 115.

In addition to the 15 specimens taken by the "Thetis" off Wollongong, New South Wales, in 55–56 fms. on a bottom of "sand and mud to rock," this little comatulid is known from 2 specimens taken by the "Endeavour" on the "eastern slope, Bass Strait," depth and character of bottom not recorded; and from 3 specimens taken in December 1929, west-southwest of Gabo Island, Victoria, in 70 fms., character of bottom not recorded. It is small, with 10 arms only a little more than 25 mm. long, and about 16 cirri with 15–18 segments. The color ranges from cream color or yellowish to reddish violet or dull purplish, but most commonly is variegated, either light with purplish markings or violet with small light areas. The fact that all the "Thetis" specimens were taken at one station suggests that the species is more or less gregarious.

OLIGOMETRIDES

A. H. Clark, 1913. Smithsonian Misc. Coll., vol. 61, no. 15, p. 37.

Genotype: *Comatula adeonae* Lamarck, 1816, vol. 2, p. 535.

This is another monotypic genus occurring in Australia but not confined to those coasts, as the "Siboga" obtained specimens in the Aru Islands and near Flores.

Oligometrides adeonae

Comatula adeonae Lamarck, 1816. Anim. sans vert., vol. 2, p. 535.
Oligometrides adeonae A. H. Clark, 1913. Smithsonian Misc. Coll., vol. 61, no. 15, p. 37.
Antedon bidens Bell, 1884. "Alert" rept., p. 158; pl. 11, figs. A*a–c*.
Döderlein, 1898. Semon's Crin., *in* Jena Denkschr., vol. 8, p. 476; pl. 36, figs. 3–3*d*.

Although the Carnegie Expedition of 1913 failed to find this species in the Torres Strait region, both Coppinger, in 1881, and Semon, in 1892, obtained specimens. Döderlein (1898, p. 476) says there were "many specimens" in Semon's collection from Thursday Island. Coppinger found *adeonae* at Port Curtis and Port Denison, Queensland, also. We did not find it at Darwin or at Port Essington, but at Broome, both in 1929 and in 1932, it was common, more than 60 speci-

mens being collected. These showed a great deal of diversity in color and some were very handsome. One specimen having 11 arms was taken, a single IIBr 2 series being present. For further details see H. L. Clark, 1938, p. 40.

PETASOMETRA

A. H. Clark, 1912*a*. Smithsonian Misc. Coll., vol. 60, no. 10, p. 25.

Genotype: *Antedon clarae* Hartlaub, 1890, p. 174 (p. 7 of reprint).

This is a small group of handsome comatulids characteristic of the East Indies and northern Australia. The Australian species are very distinct from one another as well as from the genotype, which has not yet been taken so far south. None of the species are well known or at all common, for of all 3 combined, only 4 specimens have been taken.

Key to the Species of Petasometra

A. Arms 15; cirri with only 18–22 segments ..... *brevicirra*
AA. Arms more than 20:
Color light yellowish with brown articulations; cirrus segments, 28–31 ..... *helianthoides*
Color black or dark brown variegated with cream color; cirrus segments, 22–25 ..... *variegata*

Petasometra brevicirra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 36; figs. 1, 2.

This species is based on a single specimen with 15 arms 45–60 mm. long. The coloration is a variegated combination of deep buff, purplish brown, and dark purple. The specimen was taken at False Cape Bossut, Western Australia, southwest of Broome, September 9, 1929; although we were repeatedly in that region both in 1929 and in 1932, no other individual was seen.

Petasometra helianthoides

A. H. Clark, 1912*a*. Smithsonian Misc. Coll., vol. 60, no. 10, p. 26 (no figure).

This handsome species is also based on a single specimen, taken by Michaelsen and Hartmeyer, June 16, 1905, in 5 fms. in the south passage of Shark Bay, Western Australia.

Petasometra variegata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 38; figs. 3, 4.

This is one of the few echinoderms found at Darwin and not elsewhere. Only 2 individuals were taken, both being dredged near the Shell Islands, in Darwin harbor, in 3–6 fms. on a sponge and alcyonarian bottom. The short, strongly recurved cirri and the very dark, though more or less variegated, color set this species apart from its congeners. It is evidently a secretive form and not at all gregarious.

COLOBOMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 5.

Genotype: *Antedon perspinosa* P. H. Carpenter, 1881, p. 178.

Here is another genus represented in Australia by a single species, and again the material is scanty and the records are far from satisfactory.

Colobometra perspinosa

Antedon perspinosa P. H. Carpenter, 1881. Notes Leyden Mus., vol. 3, p. 178.
Antedon loveni Bell, 1884. "Alert" rept., p. 158; pl. 10, figs. B, C*a–e*.
Colobometra perspinosa A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 6.
——— 1918. "Siboga" unst. crin., p. 124; pl. 28, fig. 103.

Although this species is recorded from Port Jackson, New South Wales, and Lord Howe Island, as well as from Penguin Channel, 16 fms., and Port Denison, Queensland, the type locality is the island of Jobi, New Guinea, and later collections are from the southern East Indian region. It obviously belongs to the tropical fauna and ought not to be included in that of New South Wales until the supposed records are verified. The long cirri, the slender and rather rigid lower pinnules, and the dark color are a combination of characters that should distinguish it easily among Australian crinoids.

DECAMETRA

A. H. Clark, March 1911*e*. Proc. U. S. Nat. Mus., vol. 40, p. 31 (no diagnosis).
——— August 1911. Rec. crin. Australia, p. 774 (diagnosis and type given as *D. mobiusi* sp. nov., a *nomen nudum*).
——— 1912. Crin. Indian Ocean, p. 158 (type given as *Antedon informis* P. H. Carpenter, 1888, p. 205).

In March 1911, the name *Decametra* is used without even a hint that it is a new genus, and 3 species, listed as new, are described, the first being *möbiusi*. Two other species, *D. informis* (presumably *Antedon informis* P. H. Carpenter) and *D. taprobanes* (presumably *Cyllometra taprobanes* A. H. Clark), are mentioned incidentally. If "*mobiusi*" of August is to be considered a typographical error for "*möbiusi*" of March, as seems indubitable, then it is the type of the genus. But if it is to be arbitrarily treated as a different name, then *informis*, designated in 1912, must be accepted as the type. It does not greatly matter which species we accept, but the case illustrates well the annoyances which arise from publishing a new generic name without either a diagnosis or a designated type.

The genus seems to be represented in Australia by 1 species of the west coast and 1 of the east. Each is known from only a single specimen, and the 2 may be distinguished by the cirri:

Cirrus segments 16–18 ..... *studeri*
Cirrus segments 26–28 ..... *zebra*

Decametra studeri

Oligometra studeri A. H. Clark, 1909*a*. Proc. Biol. Soc. Washington, vol. 22, p. 41.
Decametra studeri A. H. Clark, 1911. Rec. crin. Australia, p. 774.

This species is known only from the unique holotype taken during the voyage of the "Gazelle" at Turtle Bay Anchorage, Dirk Hartog Island, Western Australia, in 7 fms. No figure has been published.

Decametra zebra

Oligometra zebra H. L. Clark, 1916. "Endeavour" rept., p. 22; pl. 2, fig. 2.

The unique holotype of this species was taken by the "Endeavour" in 35–36 fms., 11 miles east-southeast of the mouth of the Clarence River, New South Wales. A. H. Clark has suggested that it is better considered a *Decametra.* It has arms about 70 mm. long, pale buff or brownish white, with the joints (that is, the lines between the segments) rich reddish purple in sharp contrast.

Family TROPIOMETRIDAE

This family contains but a single genus and only a few species.

TROPIOMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 349.

Genotype: *Comatula carinata* Lamarck, 1816, vol. 2, p. 534.

Of the 7 species recognized by A. H. Clark in this tropical genus, only 1 occurs in Australia.

Tropiometra afra

Antedon afra Hartlaub, 1890. Nachrich. Gesellsch. Göttingen, no. 5, p. 172 (p. 5 of reprint).
——— 1891. Nova acta Deutsch. Akad., vol. 58, p. 86; pl. 5, figs. 50, 52.
Tropiometra afra A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 349.
——— 1918. "Siboga" unst. crin., p. 132; pl. 28, fig. 106.

This big, rigid, nearly black comatulid has but rarely been taken, only 8 being recorded. Of these, 1, taken long ago by the United States Exploring Expedition, is from an unknown locality in the "South Pacific"; 2 are from Bowen, Queensland; 1 was taken by the "Siboga" between Misol and New Guinea in 18 fms.; 3 are from Mer, Murray Islands, Queensland; and 1 is from between Geraldton and Fremantle, Western Australia, 60–80 fms. Of the first 3 specimens, A. H. Clark says (1911, p. 780), "So far as known the color is always either entirely yellow or entirely violet, never mottled," but the "Siboga" specimen was "violet with large blotches of light yellow." The other 4 specimens were in life "dark purplish-brown" or "at first sight, black," "in bright light, deep purple." Judging from the specimens taken at Mer, *afra* is an exceptionally inert and rigid comatulid (see H. L. Clark, 1921, p. 25). It grows to a large size, with arms 200 mm. or more in length and cirri 35–45 mm. long.

Family CALOMETRIDAE

This is a small family of East Indian crinoids ranging from southern Japan to southwestern Australia. Only 2 genera reach Australia, and they are easily distinguished thus:

IIBr series 4 (3 + 4) ..... *Reometra*
IIBr series 2 ..... *Neometra*

REOMETRA

A. H. Clark, 1934. Proc. Biol. Soc. Washington, vol. 47, p. 14.

Genotype: *Oreometra mariae* A. H. Clark, 1912, p. 179.

The name *Reometra* was proposed to replace the *Oreometra* of 1912, which proved to be preoccupied, the name having been used in 1910 by Aurivillius for a genus of geometrid moths. *Reometra* is a small and apparently rare genus, as only 2 specimens are known, one the type of *R. mariae* from an unknown locality, the other the type of the following species. A. H. Clark tells me that he cannot see that *pericalles* differs from *mariae*. Of course he means that he does not think the differences are sufficiently weighty to warrant considering the 2 specimens as representing 2 species. There can be no doubt, however, about the existence of the differences which are given in the original description of *pericalles*. In my judgment it would be an error to regard the 2 specimens as 1 species, and the matter must rest here until more material is available.

Reometra pericalles

Oreometra pericalles H. L. Clark, 1916. "Endeavour" rept., p. 20; pl. 3, fig. 1.

This species rests on a single badly damaged specimen lacking cirri and some of the arms. The comatulid in life was apparently more than 150 mm. across and was handsomely colored with purple and white. It was taken by the "Endeavour" 13 miles north by west of Double Island Point, Queensland, in 25–26 fms. More material is greatly to be desired, as several morphological details demand new and careful study.

NEOMETRA

A. H. Clark, 1912. Crin. Indian Ocean, p. 181.

Genotype: *Antedon multicolor* A. H. Clark, 1907*a*, p. 130.

This East Indian genus has been found on the western coast of the Australian continent in moderately deep water, but it has not yet been found on the eastern coast. Apparently it is not strictly littoral in its habitat. The 2 species are to be distinguished as follows:

Dorsal processes on outer cirrus segments triple, a median carination with a dorsolateral keel on either side; about 40 arms ..... *gorgonia*
Dorsal processes on outer cirrus segments a median keel only; 30 arms or fewer .. *conaminis*

Neometra gorgonia

A. H. Clark, 1914. Rec. W. Australian Mus., vol. 1, pt. 3, p. 125 (no figure).

The "Endeavour" took 7 specimens of this comatulid in 80–120 fms. between Fremantle and Geraldton. It has not been taken since either in Australia or elsewhere. The numerous arms are nearly 100 mm. long and the 19–22 cirri are 35–45 mm. long with 40–50 segments. The coloration is purple and white.

Neometra conaminis

A. H. Clark, 1914. Rec. W. Australian Mus., vol. 1, pt. 3, p. 129 (no figure).

The "Endeavour" took this species also in 80–120 fms. between Fremantle and Geraldton, but there is no indication of "stations" and we do not know whether the 2 Neometras were taken in the same dredge hauls or not. This species has not been taken elsewhere as yet, and must therefore be considered, like the preceding, endemic. It is somewhat smaller with only about half as many arms, somewhat fewer and much shorter cirri, and different coloration, yellow and white.

Family PTILOMETRIDAE

This family, containing a single genus, is endemic in Australia and is confined to the southern temperate coasts. It is thus isolated geographically, though structurally it is allied to the Asterometridae of the East Indian region and to the large tropicopolitan family Himerometridae. Probably *Antedon protomacronema* Chapman (1913, p. 179), based on 2 minute centrodorsals from borings in the Lower Miocene of western Victoria, is more nearly related to this family than to the Antedonidae.

PTILOMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 358.

Genotype: *Comatula macronema* J. Müller, 1846, p. 179.

When this genus was established, *Alecto macronema* J. Müller, 1841, was designated as the type, but there is no such combination in Müller's writings and no such combination is listed in A. H. Clark's "Nomenclature of the Recent Crinoids" (1908*b*). In 1911 (Rec. crin. Australia, p. 781) Clark corrected the error and designated the type as given above. The 2 species of this genus are the most characteristically Australian crinoids that there are. Inhabiting the colder southern coast, they are strikingly different in habit and structure from their tropical relatives. They are distinguished from each other by details of form in the segments of their long, numerous cirri:

Basal cirrus segments twice as broad as long; cirrus sockets irregularly arranged; middle segments of proximal pinnules not so long as broad ..... *australis*
Basal cirrus segments as long as broad or longer; cirrus sockets in more or less regular columns; middle segments of proximal pinnules 1.5–2 times as long as broad ..... *macronema*

Ptilometra australis

Encrinus australis Wilton, 1843. Tasmanian Jour. Nat. Sci., vol. 2, pp. 118–120.
Ptilometra mülleri A. H. Clark, 1909*a*. Proc. Biol. Soc. Washington, vol. 22, p. 41.
——— 1921. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 2, pl. 53, fig. 1346.
Ptilometra australis A. H. Clark, 1941 (*in litt.*).

The first *Ptilometra* studied in Europe came from King George Sound nearly a century ago, receiving the name *Comatula macronema.* Thereafter, until 1909, all Ptilometras from Australia were called by that name. A. H. Clark, however,

discovered that the specimens from Sydney were definitely different from those taken in Western Australia, and suggested the specific name *mülleri* for the eastern form. In 1911, he used this name in his work on the Recent crinoids of Australia (p. 783), at the same time (p. 735) making clear the characters which distinguished the two species.[1] At the conclusion of the paper, its editor, R. Etheridge, director of the Australian Museum, called attention to the paper published in 1843 by Charles P. N. Wilton "On a New Species of Encrinite (*Encrinus australis*)." Careful study of this paper convinces Clark that Wilton's *Encrinus* is a *Ptilometra,* and in this conclusion I concur. Since his specimens were taken at Newcastle, New South Wales, at the mouth of the Hunter River, he was unquestionably dealing with *Ptilometra mülleri* A. H. Clark, and consequently the correct name for this crinoid is *Ptilometra australis* (Wilton).

This *Ptilometra* is essentially a species of New South Wales; it ranges as far north as the Clarence River and southward to the entrance of Bass Strait. There are no reliable records west of Bass Strait. The record from Port Phillip is probably based on a specimen of *Aporometra wilsoni.* Fully grown specimens have 18–23 arms 75 mm. long, and the numerous cirri nearly equal them, having 70–94 segments. Nothing is recorded as to the color in life. Museum specimens range from "pinkish white" to dark brown, either reddish or yellowish or grayish. One of the few disappointments of my Australian collecting was my failure to meet with *Ptilometra* anywhere. Apparently it does not occur near low-water mark, but only from 6 fms. down to 78, though it is recorded from Sow and Pigs reef, Port Jackson.

Ptilometra macronema

Comatula macronema J. Müller, 1846. Monatsber. K. preuss. Akad. Wissensch., p. 179.
Antedon macronema P. H. Carpenter, 1888. "Challenger" Comat., pl. 38, figs. 4, 5.
Ptilometra macronema A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 358.

The "Endeavour" found this species "very abundant" at Geraldton, well up on the coast of Western Australia, in 25–40 fms. She also took specimens in the Great Australian Bight in 62 fms., and in 28–37 fms. off the South Australian coast. Verco found it common in his numerous dredgings in St. Vincent and Spencer gulfs. It is reported from Port Phillip, Victoria, and may well occur there, but that is apparently the eastern limit of its range. There are 25–31 arms in large specimens, but in size and coloration, so far as we know, there are no important differences between this species and the preceding.

Family ASTEROMETRIDAE

The only members of this family that can be called Australian were taken on Sahul Bank many years ago. As is stated on page 2, it seems necessary to include that area within the limits of Australia, as accepted for this report. The Asterometridae must therefore be included here, since 2 species of *Asterometra* are among the Sahul Bank crinoids. Both were listed by Bell (1893, p. 339) as *Antedon longicirra* P. H. Carpenter.

[1] In this paper, the specific name is spelled *mülleri* only 5 times in 26 trials, the incorrect *mulleri* being generally used.

ASTEROMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, p. 358.

Genotype: *Antedon macropoda* A. H. Clark, 1907*a*, p. 136.

Although Bell (1893) listed the Asterometras from Sahul Bank as all 1 species, A. H. Clark's re-examination of the material determined that there were 2 species, neither of which was the species of Carpenter to which Bell assigned them all. The 2 species may be distinguished thus:

Elements of IBr series and first 2 brachials without prominent median keels.....*acerba*
Elements of IBr series and first 2 brachials with prominent median keels.....*mirifica*

Asterometra acerba

A. H. Clark, 1909*c*. Proc. Biol. Soc. Washington, vol. 22, p. 147.
——— 1912. Crin. Indian Ocean, p. 194; fig. 34.

This comatulid is known as yet only from the original specimen (apparently unique) taken on Sahul Bank.

Asterometra mirifica

A. H. Clark, 1909*c*. Proc. Biol. Soc. Washington, vol. 22, p. 146.
——— 1912. Crin. Indian Ocean, p. 192; fig. 33.

Neither Bell nor Clark gives a hint as to how many specimens there were of this species from Sahul Bank, but apparently there were several. Two specimens were reported by Clark in 1912 (p. 647) from Rotti Strait, 100 fms.

Family THALASSOMETRIDAE

This large and cosmopolitan family is represented in Australian seas by only 2 genera, neither of which is common. They may be distinguished by the number of arms:

Arms 10–12 .....*Daidalometra*
Arms more than 15.....*Cosmiometra*

DAIDALOMETRA

A. H. Clark, 1916*a*. Jour. Washington Acad. Sci., vol. 6, p. 116.

Genotype: *Antedon hana* A. H. Clark, 1907*a*, p. 137.

A single species of this genus is recorded from Australia.

Daidalometra arachnoides

Stenometra arachnoides A. H. Clark, 1909*d*. Proc. U. S. Nat. Mus., vol. 36, p. 402.
Daidalometra arachnoides A. H. Clark, 1918. "Siboga" unst. crin., p. 157; pl. 23, fig. 60.

The right of this comatulid to a place in the Australian fauna is based on a single specimen supposed to be from Port Denison, Queensland. All other known species are from the East Indies and southern Philippine Islands, and from deep water.

COSMIOMETRA

A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 16.

Genotype: *Thalassometra komachi* A. H. Clark, 1908*e*, p. 311.

There are 2 representatives of this genus in Australia, but they seem to be rare indeed, for one has been taken once at the northwestern corner of the continent, and the other is known from 2 specimens taken at the southeastern corner. They are easily distinguished by their cirri:

Cirri with 68–74 segments ..... *dasybrachia*
Cirri with about 40 segments ..... *woodmasoni*

Cosmiometra dasybrachia

H. L. Clark, 1916. "Endeavour" rept., p. 24; pl. 4, fig. 2.

This well marked species has 20 arms about 90 mm. long and some 35 cirri about half as long. The color in alcohol is light yellow-brown. Two specimens were taken by the "Endeavour" east of Flinders Island, Bass Strait, in 70–100 fms.

Cosmiometra woodmasoni

Antedon woodmasoni Bell, 1893. Jour. Linn. Soc. (Zool.), vol. 24, p. 340; pl. 23; pl. 24, fig. 1.
Cosmiometra woodmasoni A. H. Clark, 1909. Proc. Biol. Soc. Washington, vol. 22, p. 17.

This notable comatulid is known only from Sahul Bank, where at least 2 specimens were taken at an unrecorded depth. The 20 arms were 110 mm. long and there were about 18 cirri. The color was "white with faint patches of brown here and there."

Family APOROMETRIDAE

This little family of small comatulids is peculiar to the southern coasts of Australia. It contains a single genus, differentiated apparently into 3 species.

APOROMETRA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 41.

Genotype: *Himerometra paedophora* H. L. Clark, 1909, p. 524.

For a full account of this group and a discussion of its place in the system, see the memoir referred to above (H. L. Clark, 1938), which gives A. H. Clark's conclusions in regard to its relationships. The small size and relatively long and conspicuous cirri make it a very interesting and well characterized genus.

Key to the Species of Aporometra

A. Longest cirrus segments not longer than broad:
  Cirri with 39–61 segments, of which even the longest are distinctly broader than long ..... *occidentalis*
  Cirri with 25–35 segments, of which most are about as long as broad .... *paedophora*
AA. Longest cirrus segments half again as long as broad ..... *wilsoni*

Aporometra occidentalis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 43 (no figure).

This is a very common comatulid at Koombana Bay, Western Australia, and it has also been found near Garden Island, Fremantle, Western Australia. A full account was given with the description of the species.

Aporometra paedophora

Himerometra paedophora H. L. Clark, 1909. "Thetis" rept., p. 524; pl. 47, figs. 4–10.
Ptilometra mülleri A. H. Clark, 1911. Rec. crin. Australia, p. 785 (*partim*).
Aporometra paedophora H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 42.

This species is known as yet only from the "Thetis," "St-28, off Manning River, N. S. W., 22 fms., fine gray sand," where 23 specimens were taken. Apparently the species is, like the preceding, gregarious and local.

Aporometra wilsoni

Antedon Wilsoni Bell, 1888. Ann. Mag. Nat. Hist., ser. 6, vol. 2, p. 403 (no figure).
Aporometra wilsoni H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 42 (no figure).

The only locality for this species known as yet is Port Phillip, Victoria, and it does not seem to have been taken there since the original collection by J. Bracebridge Wilson. Bell does not say how many specimens there were, but he does say (1888, p. 402) there was "quite sufficient material" to warrant describing a new species. Apparently, therefore, *wilsoni* is uncommon but gregarious in Port Phillip, as the 2 other Aporometras are in their respective habitats.

Family CHARITOMETRIDAE

This large cosmopolitan family is virtually absent from Australia, only a single species of an East Indian genus having been taken on Sahul Bank.

PERISSOMETRA

A. H. Clark, 1916*b*. Jour. Washington Acad. Sci., vol. 6, p. 606.

Genotype: *Antedon flexilis* P. H. Carpenter, 1888, p. 217.

This genus of more than a dozen species is included here on the strength of specimens collected on Sahul Bank and identified by Bell as a species taken by the "Challenger" near the Kei Islands.

Perissometra patula

Antedon patula P. H. Carpenter, 1888. "Challenger" Comat., p. 219; pl. 43.
Perissometra patula A. H. Clark, 1916*b*. Jour. Washington Acad. Sci., vol. 6, p. 607.

There were 4 specimens of this crinoid in the collection from Sahul Bank which was studied by Bell.

Superfamily *MACROPHREATA*

There are but 3 families of macrophreate comatulids, and of these only 1 has yet been found in Australia.

Family ANTEDONIDAE

This large and widely distributed family is rather poorly represented in Australian seas, as only 5 genera have as yet been taken there. Of these, however, one is endemic and known only from the vicinity of Broome. An Eocene fossil crinoid has been recorded by E. V. Clark (1900) from the South Australian coast, under the name "*Antedon pertusa* Tate, *mss.*," but nothing further has been published concerning it. A very small comatulid in the Australian Museum, taken in Albany Passage, Queensland, is thought by A. H. Clark (1912, p. 232) to represent the East Indian genus *Iridometra.*

Key to the Genera of Antedonidae

A. P_2 same length and character as P_3, much shorter than P_1; pinnule segments with strongly produced or everted, coarsely spinous distal edges ..... *Compsometra*
AA. Not as above:
B. Distal cirrus segments with prominent dorsal processes ..... *Nanometra*
BB. Distal cirrus segments without prominent dorsal processes:
C. P_3 same length and character as following pinnules ..... *Euantedon*
CC. Not as above:
First pinnules not moniliform ..... *Dorometra*
First pinnules moniliform, at least in basal half ..... *Monilimetra*

COMPSOMETRA

A. H. Clark, 1908. Proc. Biol. Soc. Washington, vol. 21, p. 131.

Genotype: *Antedon loveni* Bell, 1882*a,* p. 534.

This genus of delicate little comatulids is widely distributed, for in addition to the 2 following Australian species, A. H. Clark recognizes 1 from Japan, 1 from the Hawaiian Islands, and 1 from the West Indies. The last, however, is known from only 2 specimens. The Australian species may be distinguished from each other by the cirri:

Cirri comparatively stout, distalmost segments broader than long ..... *incommoda*
Cirri slender and delicate, distal segments much longer than broad ..... *loveni*

Compsometra incommoda

Antedon incommoda Bell, 1888. Ann. Mag. Nat. Hist., ser. 6, vol. 2, p. 404.
Compsometra incommoda A. H. Clark, 1910. Proc. U. S. Nat. Mus., vol. 38, p. 275.

This little comatulid is found all along the coast of Western Australia from Albany west and north as far at least as Geraldton. It is also recorded from South Australia and from Port Phillip, Victoria, and even from Port Jackson, New South Wales. But just where and how its range meets or overlaps with

that of the following species remains to be worked out. It seems to me very doubtful whether the record from Port Jackson can be trusted. No figure has been published.

Compsometra loveni

Antedon loveni Bell, 1882*a*. Proc. Zool. Soc. London, p. 534.
Compsometra loveni A. H. Clark, 1908. Proc. Biol. Soc. Washington, vol. 21, p. 131.
Antedon pumila Bell, 1884. "Alert" rept., p. 157; pl. 10, figs. B, B*a, b*.

This delicate little crinoid is very common in Port Jackson; we took scores near Middle Head in 4–5 fms., November 21, 1929. Whitelegge (1889) says "Very common in deep water; occasionally found under stones." The range outside Port Jackson is ill defined. Records from as far north as Port Stephens and Point Halliday, New South Wales, may well be accepted, but we may wisely be skeptical of the record from "Claremont Island" if the label refers to the islets of northern Queensland. There is no satisfactory evidence of occurrence west of Bass Strait or even south of Port Jackson. Records from Port Phillip, Victoria, need confirmation.

NANOMETRA

A. H. Clark, 1907. Smithsonian Misc. Coll., vol. 50, pt. 3, p. 348.

Genotype: *Antedon minor* A. H. Clark, 1907*a*, p. 144.

This small East Indian genus has recently been found to occur in southeastern Australian waters.

Nanometra johnstoni

D. D. John, 1939. Rept. British, Australian and New Zealand Antarctic Res. Exped., ser. B, vol. 4, pt. 6, p. 193; fig. 1.

Five specimens of this interesting little comatulid were taken in Bass Strait and near Tasmania in 70–90 fms. Little is said of the color, but in at least 2 specimens purple or purplish-brown spots were present. Presumably the ground color is more or less nearly white. Calyx about 3 mm. in diameter; cirri 10 mm. long.

EUANTEDON

A. H. Clark, 1912*a*. Smithsonian Misc. Coll., vol. 60, no. 10, p. 31.

Genotype: *Antedon moluccana* A. H. Clark, 1912, p. 129.

This is a small group of delicate little antedons occurring in the East Indian region and at Tahiti. The discovery of a species in South Australian waters was to say the least unexpected.

Euantedon paucicirra

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 369; fig. 109.

Two specimens of this comatulid were taken in St. Vincent's Gulf by Verco and presented to the South Australian Museum. Arms about 40 mm. long; color (perhaps more or less bleached) nearly white.

DOROMETRA

A. H. Clark, 1917. Jour. Washington Acad. Sci., vol. 7, p. 128.

Genotype: *Antedon nana* Hartlaub, 1890, p. 170 (p. 3 of reprint).

This is another genus of delicate little comatulids, characteristic of the East Indian region but ranging westward to the Red Sea and Madagascar. The 2 species that have been taken in Australia are distinguished primarily by the basal pinnules:

P_2 resembling P_1 in size and number of segments ..... *nana*
P_2 intermediate between P_1 and P_3 ..... *parvicirra*

Dorometra nana

Antedon nana Hartlaub, 1890. Nachrich. Gesellsch. Göttingen, no. 5, p. 170 (p. 3 of reprint).
——— 1891. Nova acta Deutsch. Akad., vol. 58, p. 89; pl. 5, figs. 57, 58.
Dorometra nana A. H. Clark, 1917. Jour. Washington Acad. Sci., vol. 7, p. 128.

Ranging from the Maldives to Tonga, this fragile little comatulid is found as far south as Torres Strait, where we took 2 specimens at Mer in 1913. For an account of its graceful swimming, see H. L. Clark, 1921, page 25.

Dorometra parvicirra

Antedon parvicirra P. H. Carpenter, 1888. "Challenger" Comat., p. 204; pl. 36, figs. 7, 8.
Dorometra parvicirra A. H. Clark, 1917. Jour. Washington Acad. Sci., vol. 7, p. 128.

We found this pretty little comatulid at Darwin in 1929 and again in 1932. It was known previously only from the Philippine Islands, but it is now known from Eagle Island, northern Queensland, so it undoubtedly occurs in the Torres Strait region. See H. L. Clark, 1938, page 46.

MONILIMETRA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 47.

Genotype: *Monilimetra nomima* H. L. Clark, 1938, p. 48.

This interesting group of small comatulids, reminding one of the West Indian Coccometras, is as yet known only from the northwestern coast of Australia in the vicinity of Broome. Four species have been differentiated, which may be distinguished as follows:

Key to the Species of Monilimetra

A. Cirrus segments 4–6 not conspicuously different from others, rather stout, slightly compressed, not twice as long as thick; color of arms dorsally, brown of some shade or yellowish or whitish, often more or less variegated with purple or dusky and light shades:
  B. Normal mature cirri short, with 13–15 segments, basal ones not much compressed; pinnules unicolor or at any rate not handsomely banded:
    Fourth pinnule very large, nearly or quite equaling third; first pinnule conspicuously moniliform, with more than 23 segments; color brown of some shade, sometimes variegated, sometimes very light ..... *nomima*

Fourth pinnule obviously much smaller than third; first pinnule moniliform only in basal half, with fewer than 23 segments; color light, faintly mottled with dusky, sometimes a broad longitudinal blackish stripe on dorsal side of arm ..... *lepta*

BB. Normal mature cirri with 16–18 segments, all rather short, compressed, though not markedly so proximally; pinnules handsomely banded purple and white ..... *poecila*

AA. Cirrus segments 4–6 elongated, more than twice as long as diameter of the nearly cylindrical middle; color purple and white; cirri pure white, except sometimes at base; arms usually deep purple, but may be white, and purple only on basal pinnules ..... *bicolor*

Monilimetra nomima

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 48; figs. 5, 6.

This is apparently the most common *Monilimetra* in the Broome region, but it is far from abundant, as only 7 specimens were taken in our three months of collecting. There is considerable diversity of color, but shades of brown predominate.

Monilimetra lepta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 51; figs. 7, 8.

Seven specimens of this species were taken, but it was apparently met with only twice, as 6 of the 7 were obtained at the same time and place. It is very light-colored, more or less nearly white with some dusky or purplish-gray blotches on the arm bases.

Monilimetra poecila

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 53; figs. 9, 10.

Only 4 specimens of this species were taken, and, owing to an extraordinary sensitivity, 3 of these were badly broken up in the process of collecting and preserving. The color, variegated white, yellow, and purple, is very striking, the handsome banding of the purple and white pinnules being especially notable.

Monilimetra bicolor

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 55; figs. 11, 12.

This species was met with four times, but only a single specimen was obtained each time. The contrast between the purple arm bases and the white cirri is very striking, but whether it will prove to be a constant and reliable species character remains to be demonstrated.

ASTEROIDEA

The sea stars of Australia are one of the most notable and attractive groups in her marine fauna. There are 206 species, of which only 17 are extinct; 73 of 83 genera are more or less widely distributed, living still, at all depths around the continental shores and on the reefs and outlying islands. Naturally the great majority of the species occur in the tropical and subtropical seas, but 30 or more are to be found in the cooler waters of the southern coast. The richness of Australia's sea-star fauna is striking in view of the fact that in the whole West Indian region fewer than 20 species are found in shallow water, and fewer than 100 including even the deep-water species. At Broome alone, in shallow water, we took 38 species, and even at Port Jackson on the opposite corner of the continent more than 20 species have been found. The 17 extinct species are all representatives of families which died out long ago, so that there is little indication that the present fauna has any direct relationship with the fossil forms.

Though some of the Australian sea stars are small (under 30 mm. in diameter) and of secretive habits, the great majority are more than 100 mm. across when adult, and live openly on the bottom. Several species exceed 300 mm. in diameter, and 2 or 3 may even exceed half a meter. The coloration is almost always notable in life and many species are very beautiful, but the colors are fugacious and preserved specimens rarely give any indication of their former beauty. Diversity of form is more easily preserved, and ranges from almost circular or definitely pentagonal to long-radiate, with rays 6 or 7 times as long as the diameter of the body. Most species are more or less flat, but in a few cases the height of the body above the mouth may be more than half its own diameter. None of the species are poisonous or disagreeable to handle in any way, and none have yet been shown to be of any economic importance either positively or negatively.

The 206 species represent all 3 of the known orders of sea stars, and these are separated by the following more or less obvious characters:

Key to the Orders of Asteroidea

A. Marginal plates large and conspicuous, defining outline of body; abactinal skeleton of arms made up of radial, lateral, and marginal series of plates, usually with numerous accessory plates; disk covered with numerous paxilliform, or flat, tessellate plates.....Phanerozonia

AA. Marginal plates not conspicuous or defining outline of body; abactinal skeleton of imbricated plates or more or less reticulate:

Pedicellariae very rare, never pedunculate, forcipiform, or forficiform.....Spinulosa

Pedicellariae numerous, pedunculate, forcipiform, or forficiform.....Forcipulata

Order PHANEROZONIA

This is a large group of many families, of which more than a dozen are represented in the Australian fauna, but 4 of these are extinct and not closely allied to the remaining groups. The following key indicates how these families may be distinguished, but the grouping is probably arbitrary and perhaps not altogether natural.

Key to the Families of Phanerozonia

A. Interbrachial arcs very small with single large axillary marginal or at most a pair:
  B. Single large axillary plate:
    No accessory ray plates of any kind; extinct ..... Hudsonasteridae
    Accessory ray plates present abactinally; extinct ..... Palaeasteridae
  BB. A pair of axillary plates in each interradius; extinct ..... Promopalaeasteridae
AA. Interbrachial arcs well developed, with several to many plates:
  C. Boundary of animal formed by inferomarginal plates:
    Superomarginal plates present but smaller than inferomarginals; no paxillae; extinct ..... Palasterinidae
    Superomarginals wanting; abactinal plates paxilliform ..... Luidiidae
  CC. Boundary of animal formed by 2 sets of marginal plates, superomarginals generally more prominent:
    D. Tube feet without sucking disks; dorsal surface covered with paxillae; actinal intermediate areas usually small ..... Astropectinidae
    DD. Tube feet with well developed sucking disk:
      E. Abactinal surface covered with paxillae or paxilliform plates:
        F. Marginal plates appreciably alternate, with sharp, conspicuous spines; papulae confined to small area near base of ray ..... Benthopectinidae
      FF. Marginal plates opposite (at least on basal part of ray); papulae not confined to basal part of ray:
        Disk small, it and upper surface of rays closely covered by paxilliform, tabulate plates; actinal intermediate plates very few ..... Archasteridae
        Disk large, covered by penicillate paxillae; actinal intermediate plates many ..... Radiasteridae
      EE. Abactinal plates neither tabulate nor paxilliform, but flattened or convex, with or without tubercles, spines, or granules:
        G. Disk large, with actinal intermediate areas extensive:
          Marginal plates large and conspicuous; disk covered with polygonal, circular, or stellate plates forming firm pavement; papulae single or few in an area .... Goniasteridae
          Marginal plates large but not conspicuous; abactinal skeleton stellato-reticulate; numerous papulae in large circumscribed areas ..... Oreasteridae
          Marginal plates small, more or less imbricated; whole body covered by thick, smooth, tough skin ..... Asteropidae
        GG. Disk very small, with greatly reduced actinal intermediate areas:
          Tegumentary developments spinulose; papulae few, isolated, strictly abactinal ..... Metrodiridae
          Tegumentary developments granulose or wanting, skin being very smooth as a rule ..... Ophidiasteridae

Family *HUDSONASTERIDAE

This is a small group, called by Schuchert (1915) the "most primitive known Phanerozonia" and said to be "the primordial stock out of which all asterids progressively developed"; this view, however, is not universally accepted. Of the 2 known genera, only 1 is reported from Australia.

*HUDSONASTER

Stürtz, 1900. Verhandl. Naturhist. Ver. preuss. Rheinland, vol. 56, p. 224.

Genotype: *Palasterina rugosa* Billings, 1857, p. 291.

The discovery of this primitive group in Australia is of exceptional interest. The material was studied by Withers and Keble, to whose excellent account of the Paleozoic sea stars of Victoria the present writer is greatly indebted.

*Hudsonaster australis

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 222; text figs. 1, 3; pl. 10, fig. 6.

This little sea star, less than 20 mm. across, was discovered by Withers and Keble "at the summit of an anticline in a cutting on Yan-Yean—Arthur's Creek road, one-third mile east of Doreen Junction," Victoria. The occurrence is "undoubtedly Silurian," but no more detailed stratigraphical location is attempted. The number of specimens obtained is not stated, but a reference to "other specimens" indicates that there were at least 3. Comparison is made with several American species of *Hudsonaster,* of which *H. narrawayi* (Hudson) seems to be the nearest, but the differences justify the conclusion that the Australian species is distinct.

Family *PALAEASTERIDAE

This family contains but 2 genera, *Palaeaster* and *Australaster,* of which the latter occurs in Australia and is not known as yet from elsewhere. It is said to differ from *Palaeaster* in having a larger disk, longer arms, and more distinct interbrachial arcs, but material is inadequate for a satisfactory diagnosis of either genus. The general facies justifies the recognition of 2 genera and even warrants the suspicion that they are not closely related.

*AUSTRALASTER

Schuchert, 1914. Foss. cat., Anim., pt. 3, p. 12.

Genotype: *Palaeaster* (*Monaster*) *giganteus* Etheridge, 1892, p. 74.

Schuchert (1915) includes in this genus 2 species of Australian fossil sea stars which Etheridge placed in *Palaeaster,* giving good figures of both. The descriptions are vague and not easily understood, such phrases as "body elongate" and rays "forming with one another an angle of 60° to 75°" being confusing. In any 5-rayed sea star the angles must average 72°. Apparently, however, the 2 species may be distinguished thus:

Oral plates very large, the twins forming a somewhat cordate plate; adambulacral plates each with a single row of spine-bearing tubercles..... *giganteus*

Oral plates very small, "pustuliform"; adambulacral plates each with about 3 alternating rows of spine-bearing tubercles.....*stutchburii*

*Australaster giganteus

Palaeaster (*Monaster*) *giganteus* Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 74; pl. 12.
Australaster giganteus Schuchert, 1914. Foss. cat., Anim., pt. 3, p. 12.

Apparently only a single specimen of this notable sea star has been found. R = 87–90 mm., r = 22–25 mm., br = about 20 mm. at base and nearly as much halfway to tip. This specimen was collected by T. Brown, in the Lower Marine series of the Permocarboniferous rocks of Ravensfield Quarry, near Farley, County Northumberland, New South Wales.

*Australaster stutchburii

Palaeaster (*Monaster*) *stutchburii* Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 73; pl. 13, fig. 1.
Australaster (?) *stutchburii* Schuchert, 1915. Bull. 88 U. S. Nat. Mus., p. 73.

A single specimen of this slightly smaller sea star was also found by T. Brown in the Lower Marine series at Ravensfield Quarry. R = 65–70r, r and br about 15 mm. The nature and condition of the specimen preclude accurate measurements. Schuchert (1915) thinks the systematic position of this sea star is dubious and cannot be satisfactorily determined until more specimens are obtained. It may be a smaller specimen of *giganteus,* or it may not be an *Australaster* at all.

Family *PROMOPALAEASTERIDAE

This family was instituted by Schuchert (1915) to include some 30 fossil sea stars which he grouped in half a dozen genera, only 1 of which occurs in Australia. Spencer (1916) established an additional genus, to which Withers and Keble (1934) assign some small sea stars from the Silurian rocks of Victoria. The 2 Australian genera are distinguishable thus:

Interbrachial areas small, with only 1 pair of inferomarginals.....*Caractacaster*
Interbrachial areas complex, with more than 1 pair of inferomarginals....*Promopalaeaster*

*CARACTACASTER

Spencer, 1916. Brit. Pal. Ast., pt. 2, p. 80.

Genotype: *Palaeaster caractaci* Gregory, 1899, p. 344.

The little Australian sea stars which seem to be associated with this genus are included in a single species.

*Caractacaster yarraensis

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 223; pl. 10, figs. 1, 2.

In the known specimens of this sea star, R = 8–10 mm., r = 3 mm. or less. They were found in the Yarravian series of Silurian rocks at South Yarra, Victoria, and are admirably described and figured.

*PROMOPALAEASTER

Schuchert, 1914. Foss. cat., Anim., pt. 3, p. 24.

Genotype: *Palaeaster speciosus* Meek, 1872, p. 277.

This genus is represented in America by 10 or more species, but in Australia only a single small species has been found.

*Promopalaeaster meridionalis

Palaeaster meridionalis Etheridge, 1891. Rec. Australian Mus., vol. 1, p. 199; pl. 30, figs. 16, 17.
Promopalaeaster meridionalis Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 225; pl. 12, fig. 7.

Withers and Keble (1934) have discussed this little sea star admirably, so far as the material permits. They have also proposed a variety *parvior* based on an individual about half the size of Etheridge's type. As all the available and scanty material comes from the Yarravian series of Silurian rocks near Moonee Ponds or Moonee Ponds Creek, Victoria, the varietal name is of dubious value.

Family *PALASTERINIDAE

This family, of half a dozen genera and perhaps 20 species, is well represented in the Silurian rocks of Victoria. Of the apparently 8 species seen by Withers and Keble, 5 are described as new, 1 is referred to as a form long ago named by McCoy, and 2 do not justify naming in view of the condition of the specimens. The half-dozen named species fall equally into 2 genera, which are distinguished thus:

Inferomarginal plates conspicuous, bounding entire outer edge of animal; rays relatively short and wide ..... *Petraster*
Inferomarginal plates small and often hard to make out; rays relatively long and narrow ..... *Palasterina*

*PETRASTER

Billings, 1858. Geol. Surv. Canada, Can. org. remains, dec. 3, p. 79.

Genotype: *Palasterina rigidus* Billings, 1857, p. 291.

Apparently at least 4 species of *Petraster* occur in the Silurian rocks of Victoria, but of 1 the material does not permit a description or warrant a name. The other 3 species may be distinguished thus:

Rays broad and flattened, width at middle about one-half length ..... *smythi*
Rays longer and narrower, width at middle about one-third length ..... *angustior*
Intermediate between the above two ..... *richi*

*Petraster smythi

McCoy, 1874. Prodr. palaeontol. Victoria, dec. 1, p. 41; pl. 10, figs. 1–1*b*.

This species has been well figured and discussed by Withers and Keble (1934). It is known as yet only from the Silurian rocks of Victoria.

*Petraster angustior

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 227; pl. 12, figs. 4, 5.

This species is contemporary with the preceding but seems to be distinct. It is as yet known only from the Yarravian series, of the Silurian rocks of South Yarra, Victoria.

*Petraster richi

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 228.

If any less competent authority had named this species, its validity might be questioned, but Withers and Keble's work is so obviously trustworthy, we may rest assured that there are at least 3 species of *Petraster* in the Silurian strata of Victoria. The present one was found "one mile southeast of the Clonbinane Pre-emptive Right, just above the junction of Comet and Sunday creeks." The 4 specimens were collected by T. Rich.

*PALASTERINA

Salter, 1857. Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 327.

Genotype: *Uraster primaevus* Forbes, 1848, p. 463.

Although this genus was proposed for certain British Paleozoic sea stars, Withers and Keble (1934) refer to it no fewer than 4 forms from the Silurian rocks of Victoria. Schuchert (1915), after stating that *Uraster primaevus* Forbes is the "genoholotype," takes the extraordinary step of designating *P. bonneyi* Gregory as "for the present" the genoholotype. Obviously a species which was not named for more than 40 years after the genus was established cannot possibly be the genoholotype. Of the 4 Victorian species discussed by Withers and Keble, 1 is left nameless because of inadequate material. The other 3 are distinguished as follows:

Key to the Species of Palasterina

A. No bosslike protuberances on ambulacral plates:
  Arms long and slender, tapering to a sharp extremity; length about 6 times greatest width ..... *flemingtonensis*
  Arms shorter and wider, tapering little; length about 5 times greatest width ..... *stachi*
AA. Conspicuous bosslike protuberances on ambulacral plates; arms relatively short and wide, length about 4.5–5 times width ..... *umbonata*

*Palasterina flemingtonensis

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 231; pl. 11, fig. 3.

This species was based on 4 specimens from the Silurian rocks of "Flemington," near Melbourne, Victoria. They show some diversity in size but are similar in structure. All lack the dorsal side. They are small, with R = 10–20 mm.

*Palasterina stachi

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 232; pl. 11, figs. 4, 6.

There are 2 specimens of this species, one showing the oral side, the other the dorsal. They have R = 20–27 mm. They were discovered in making excavations for foundations for the Herald Building in Melbourne. The strata are Yarravian series, Silurian.

*Palasterina umbonata

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 233; pl. 10, fig. 4.

This is a stouter species than either of the preceding, but it is no larger, as R = but 20 mm. Only a single specimen is known. This was found "6 feet beneath the surface," in Silurian strata near Plenty Ranges, Victoria.

Family LUIDIIDAE

This widely distributed family has such a characteristic facies, owing to the absence of superomarginal plates and the crowded, regularly arranged dorsal paxillae, that it is easily recognized. More than 50 nominal species have been assigned to it, but Döderlein (1920) in his monograph recognizes only 43 species and 3 subspecies, all of which he includes in the genus *Luidia,* though he groups them in 10 subgenera. They are widely distributed in tropical and subtropical seas, usually in shallow water. Few occur in depths over 200 fms., and fewer still more than 30° from the equator.

LUIDIA

Forbes, 1839. Mem. Wernerian Soc. Nat. Hist., vol. 8, p. 123 (p. 9 of reprint).

Genotype: *Luidia fragilissima* Forbes, 1839, p. 123 (p. 9 of reprint).

The 4 Australian species of *Luidia* are tropical, though one of them extends its range to the southern coast of the continent. Its nearest ally is restricted to the northwestern coast in the vicinity of Broome (so far as we now know). The other 2 species are as yet too little known to permit any definite statement as to their distribution, but one has been found as far south on the eastern coast as Newcastle Bight, New South Wales. The 4 are easily distinguished as follows:

Key to the Species of Luidia

A. Rays 5; central spinelets of paxillae elongated ..... *forficifera*
AA. Rays more than 5:
B. Rays 6, narrow, flat, smooth ..... *hexactis*
BB. Rays 7, broad, more or less arched; many of central paxillae near tip of arm enlarged:
Color cream, yellow, or buff blotched with dark green; large adults may be almost wholly dark green dorsally ..... typical *australiae*
No green; colors cream and chocolate brown ..... forma *brunnea*
BBB. Rays 8; no enlarged paxillae distally ..... *maculata*

Luidia forficifera

Sladen, 1889. "Challenger" Ast., p. 258; pl. 44, figs. 5, 6.

This sea star was first taken near the western end of Torres Strait, but in recent years it has been taken at several points on the eastern coast of Australia as far south as Newcastle Bight, New South Wales, in 10–40 fms. According to Döderlein (1920), it ranges northwestward to the Persian Gulf and northward to the Gulf of Siam; he thinks *limbata* Sladen is *quinaria* von Martens, and *limbata* Koehler, 1910, is *forficifera* Sladen; on that ground, the range of the present species extends to India and the Persian Gulf. The truth is, not nearly enough material is available as yet to determine whether we are dealing with a single widespread species or with 3 or possibly 4 separate forms. Sladen and Döderlein both were dealing with small specimens (R = 40–46 mm.), whereas the New South Wales specimens were nearly or quite twice that size. The Australian specimens so far taken are unicolor, a "bleached ashy white."

Luidia hexactis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 73; pl. 17, fig. 1.

This species is known only from the holotype, having R = 140 mm., and the color above, buff blotched and marked with dark greenish gray much as in *maculata*. Taken between Cockatoo and Augustus islands, northwestern Australia.

Luidia australiae

Döderlein, 1920. "Siboga" Ast.: Luidia, p. 266.

Apparently the big Luidias of southern Australia from Lord Howe Island to Fremantle have become differentiated from those found throughout the East African and East Indian region and northward to Japan. The difference first noted by Döderlein in the paxillae of the distal part of the rays seems to be constant, and the number of rays is apparently fixed at 7. How far to the northward *australiae* extends is still undetermined, for its distinctness from *maculata* was not recognized when my Torres Strait report was published (1921). The largest specimens yet reported are from Lord Howe Island, where individuals with R = 225–245 mm.[1] have been taken. Normally the dorsal surface is yellow or buff more or less blotched and marked with dark green. In extreme cases the green predominates, and in the largest known specimen the whole abactinal surface is a dark blackish green, "closer to black than to green." Near Fremantle the Luidias taken show no green but are cream color and chocolate brown. This very distinct color variety has been named "forma *brunnea*" (see H. L. Clark, 1938, p. 71). Neither the species nor the variety has been figured.

Luidia maculata

Müller and Troschel, 1842. Syst. Ast., p. 77.
Koehler, 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 267; pl. 15, fig. 1.

Apparently this East Indian species reaches a larger size than *australiae,* as Koehler (1910*a*) reports one with R = 350 mm. As a rule there are 8 arms,

[1] A specimen from an unknown locality, possibly Lord Howe Island, has R = 250 mm.

but specimens with 6, 7, or 9 arms are reported from north of Australia. As yet *maculata* is known in Australian seas only from the vicinity of Broome, which lies almost directly south of the southernmost East Indian islands. The specimen reported from Thursday Island, Torres Strait, by Döderlein (1896*a*) is probably *australiae,* as are all the specimens listed by me (1909, 1916) from the coasts of Queensland, New South Wales, and South Australia. In coloration the two species are indistinguishable.

Family ASTROPECTINIDAE

Although this family is well represented in Australian waters, nearly all the species belong in the genus *Astropecten.* Döderlein made (1917) a most useful study of this genus, in which he recognized 66 species, 11 subspecies, and 8 varieties. He fails to make clear what distinguishes varieties from subspecies, but apparently his subspecies have, as is usual in zoology, a geographical significance which his varieties lack. His keys, discussion, and figures are of the greatest value to all students of this widespread family. Besides *Astropecten,* the family is represented in Australia by only 2 genera, each with a single deep-water species. The 3 genera may be easily distinguished by means of the following key:

Key to the Genera of Astropectinidae

A. Supero- and inferomarginals nearly equally developed, forming more or less vertical lateral faces to ray:
  Inferomarginals touching adambulacrals throughout ray, as actinal intermediate plates are, for the most part, wanting ..... *Astropecten*
  Inferomarginals separated, at least basally, from adambulacrals by actinal intermediate plates ..... *Psilaster*
AA. Superomarginals much smaller than inferomarginals and confined to abactinal surface ..... *Dipsacaster*

ASTROPECTEN

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 180.

Genotype: *Asterias aranciaca* Linné, 1758, p. 662. Type first designated by Fisher, 1908, but both Gray and Fisher adopt Tiedemann's (1816) extensively emended spelling, *aurantiacus.*

This big cosmopolitan genus has, as already stated, been critically studied and revised by Döderlein (1917). He could not bring himself to break the group up into smaller genera, but he recognized 3 major divisions (Seriventrale Formen, Pluriventrale Formen, and Biventrale Formen). The first includes 7 species comprising the "*schayeri* Gruppe," the second includes 50 or more species, subspecies, and varieties arranged in 10 "Gruppen," and the third consists of 45 or more forms in 5 "Gruppen." These 16 "Gruppen" are of course subgenera, but apparently Döderlein did not consider them sufficiently well defined to warrant giving them names. Ultimately some of them will probably rank as distinct genera.

The 14 species of *Astropecten* now known from Australia are shallow-water sea stars, one or more of which have been taken wherever, on the coasts of the continent, collecting has been done. No species has yet been taken at Lord Howe Island, but dredging in the vicinity will probably yield at least one species. The Australian Astropectens include representatives of all 3 of Döderlein's primary

divisions, but the great majority are what he calls "Biventrale Formen." They may be distinguished as follows:

Key to the Species of Astropecten

A. Several series of ventrolateral plates on each side at base of arm:
  Short, stout, conical spine on inner margin of each superomarginal plate in interradial angle, but after third plate it is nearer outer margin; about 15–20 ventrolateral plates in each area ..... *schayeri*
  No spines on basal superomarginal plates; about 30 ventrolateral plates in each area ..... *syntomus*
AA. Only a single series of ventrolateral plates on each side at base of arm (or, at most, some rudimentary additional plates):
  B. 3 or more ventrolateral plates on each side of arm base:
    At least 3 very large inferomarginal spines forming oblique comb on each plate ..... *pectinatus*
    Not more than 1 conspicuous inferomarginal spine on each plate ... *problematicus*
  BB. Only 2 ventrolateral plates on each side (occasionally 3, very rarely 4, on one side of a mouth angle):
    C. All superomarginals narrower than long or high (or length and breadth about equal), with conspicuous stout acute spines, except on second (or second to fourth), which plates are somewhat dwarfed ..... *polyacanthus*
  CC. Not as above:
    D. Distal superomarginals with spines:
      E. Most superomarginals with 3 or more spines ..... *triseriatus*
      EE. Superomarginals with 2 or, more commonly, only a single spine:
        At least first superomarginal with a spine on its inner margin ..... *vappa*
        No spine on inner margin of first superomarginals ..... *carcharicus*
    DD. Distal superomarginals without spines:
      F. No superomarginal spines; covering of inferomarginals distinctly squamiform:
        G. Inferomarginals with at least a few distinct acute spines along distal margin ..... *granulatus*
        GG. No acute spines along distal margin of inferomarginals:
          Inferomarginals with only single sharp marginal spine, below which are 1 or 2 enlarged scales ..... *monacanthus*
          Inferomarginals with 2 flat, blunt marginal spines, the lower being smaller; along distal margin of each plate are 2 or 3 similar but smaller, elongated, wide scales ..... *pulcherrimus*
      FF. At least first superomarginal plate with a stout spine on inner margin, or, if this is not evident, covering of inferomarginals is definitely spiniform:
        H. Below the large inferomarginal spine are 2 or 3 subequal spines, distalmost only a little the largest:
          First (and usually second) superomarginal with low, stout spine ..... *velitaris*
          No such spines present ..... *preissi*
        HH. Below large inferomarginal spine is single smaller spine on distal corner of plate ..... *zebra*

Astropecten schayeri

Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 60; pl. 1, fig. 1; pl. 7, figs. 1–1*c*.

This species was based on a single specimen in the Berlin Museum, taken by "Schayer in Tasmania." It has R = 55 mm., so is probably adult, but its relation to *pectinatus* Sladen is an open question. A large series of specimens may show that the two are identical. A second specimen of *schayeri,* very similar to the type in size and appearance, is in the Victoria National Museum at Melbourne. It was taken in 1879 at Portland, Victoria.

Astropecten syntomus

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 372; fig. 110.

This species was also based on a single specimen, with R = 39 mm., allied to *pectinatus*. It is evidently allied to the preceding species also, but the differences between the 2 type specimens are obvious. It is not unlikely, however, that sufficient material would show that both are individual variants of *pectinatus*. The unique holotype of *syntomus* is from an unknown locality, supposedly South Australian.

Astropecten pectinatus

Sladen, 1883. Jour. Linn. Soc. (Zool.), vol. 17, p. 251.
——— 1889. "Challenger" Ast., p. 202; pl. 33, figs. 3, 4; pl. 37, figs. 4–6.

There is still much to be cleared up about the status of this species, and probably only a re-examination of the type material in the British Museum can determine whether it is identical with Döderlein's *schayeri* or not. The relationship to *vappa* (with which I confused it in 1909 and 1916) also needs further study, although it is probable that *pectinatus* is really distinct from that species. At present, Sladen's species is known only from Port Jackson, Bass Strait, Port Phillip, and South Australia. All the specimens are small, with R = 48 mm. or less.

Astropecten problematicus

Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 163; pl. 6, fig. 7; pl. 15, figs. 4–4*b*.

This species rests on a single small, dry specimen, with R = 47 mm., in the Berlin Museum and supposed to be from Australia. Its validity and its right to a place in the Australian fauna are open to debate, but only more specimens with accurate locality labels can settle the matter.

Astropecten polyacanthus

Müller and Troschel, 1842. Syst. Ast., p. 69.
Döderlein, 1917. "Siboga" Ast.: Astropecten, pl. 4, figs. 4, 5.

This striking species is widespread in the Indo-Pacific area, ranging from the Red Sea and Zanzibar to the Hawaiian Islands, north to Yokohama, Japan, and south to Port Jackson, New South Wales, and the northern island of New Zealand.

The largest specimen I have found recorded has R = 134 mm. (Mauritius); in none of those in the Museum of Comparative Zoölogy does R exceed 105 mm. The color in life is recorded only for specimens from Port Jackson, in which "the paxillar area of the dorsal surface was deep purple, while the oral surface was more or less red-orange with the margins pale yellow; the marginal plates were more or less purplish dorsally but faded out into yellow orally." Museum specimens range from a light brownish yellow to deep dingy, or purplish, brown.

In Australian seas, this conspicuous sea star is apparently confined to the eastern coast as far south as Port Jackson. Although it is listed as from western and northwestern Australia (H. L. Clark, 1921, p. 192), no records from that region seem to have been published. It is, however, known from the Aru Islands.

Astropecten triseriatus

Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 118.
Döderlein, 1917. "Siboga" Ast.: Astropecten, pl. 5, fig. 2.

This strikingly spiny species is apparently characteristic of the coast of Western Australia, as it has not yet been taken elsewhere. It is seldom collected (only 3 or 4 specimens are known), probably owing to some peculiarity in its manner of life or in its habitat. It reaches a rather large size (R = 110 mm.). The color in life (in the only recorded instance) is "grayish above, the sides of rays and lower surface, cream-color or yellowish."

Astropecten vappa

Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 119.
Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 124; pl. 5, fig. 1.
Astropecten hartmeyeri Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 156; pl. 5, fig. 8.

A critical examination of all the available material of *vappa* and *hartmeyeri* leads to the conclusion that there are no constant, reliable differences between these species, supposed by Döderlein to be so distinct that he makes no comparison of the two. In my earlier report (1938) I followed his lead, chagrined by the fact that I had previously confused *vappa* with *pectinatus*. I gave (p. 67) an account of *vappa,* showing its occurrence on the Queensland coast as well as on the southern coast of Western Australia. But under *hartmeyeri,* I listed (p. 62) 2 fine specimens of *vappa* from Augustus Island, which are exactly like specimens of the same size from Queensland, save for the pink tinge in their coloration. It seems clear that *vappa* is a common and widespread Australian species ranging from Augustus Island on the northern coast, westward and southward to Broome, Shark Bay, and Middleton Beach (Albany), eastward to the Great Australian Bight, Tasmania, and the coast of New South Wales, and northward to Lindeman Island, Queensland. Possibly it will be found on the northern coast of the continent between the Barrier Reef and Augustus Island, but it has not yet been reported from that extended coast line.

In life, *vappa* reaches a large size (R = 125 mm.), and the fully grown specimens tend to become a uniform dark brown. Specimens with R less than 50 mm. are light yellowish or cream color more or less mottled or marked with patches and blotches of gray; or the upper surface may be gray with margins and oral

surface cream color; the superomarginal spines may be tipped with bright brown-orange. Somewhat larger specimens (R = 60–70 mm.) have the upper surface variegated light and dark gray, the lower surface cream white.

Astropecten carcharicus

Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 140; pl. 5, figs. 9, 10; pl. 13, figs. 7, 7*a*.

This species is based on 2 specimens of nearly equal size (R = 70 mm.) from Shark Bay, Western Australia. They differ rather markedly in the form of the inferomarginal spines, indicating that the species is variable in this character. Döderlein considers the species closely related to *A. hemprichi* of the Red Sea, Eastern Africa, and Southern Asia. He identifies a very similar *Astropecten* from the southern coast of Formosa as *carcharicus,* but lists it as a subspecies, *formosanus.* Probably all these names refer to a single species, which of course carries the oldest name, *hemprichi.* Much more material is necessary to settle the question.

Astropecten granulatus

Müller and Troschel, 1842. Syst. Ast., p. 75.
Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 148; pl. 5, fig. 7.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 60; pl. 1, fig. 1 (colored).

Although the type locality for this species is not known, its range is now fairly well established as northern and western Australia from Thursday Island, Torres Strait, to Fremantle, Western Australia. It is the common sea star at Broome, where it lives buried in the sandy mud just below the surface. Large specimens have R over 100 mm. The dorsal surface is deep bluish gray like the sandy mud in which the animal lives, with light brown blotches and markings. The lower surface and marginal spines are pure white.

Astropecten monacanthus

Sladen, 1883. Jour. Linn. Soc. (Zool.), vol. 17, p. 263.
——— 1889. "Challenger" Ast., pl. 33, figs. 7, 8.
Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 150; pl. 14, figs. 5–5*b*.

Although a very well marked species when dried and examined carefully, this *Astropecten* is much like the preceding and resembles it in color as well as in form. It is smaller, however, with R less than 50 mm.; at least, larger specimens are not yet known. It lives in somewhat deeper water than *granulatus* and hence was not nearly so easy to collect, even at Broome, where both species occur. It has a wider range, however, as it occurs on the East African coast, at the Andaman Islands, on the coast of India, in the China Sea, and in the East Indies, as well as in the Gulf of Carpentaria and on the coast of northwestern Australia.

Astropecten pulcherrimus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 68; pl. 1, fig. 2 (colored).

All that is known of this beautiful sea star from Broome, Western Australia, is recorded in the original account.

Astropecten velitaris

von Martens, 1865. Arch. f. Naturgesch., vol. 31, pt. 1, p. 360.
Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 159; pl. 6, figs. 5, 15, 16; pl. 15, figs. 3–3*a*.

This East Indian species occurs not uncommonly on the northwestern coast of Australia. It was found in Mermaid Strait by the "Gazelle" and we found it fairly common in Roebuck Bay, where it reaches, apparently, its maximum size, with R = 96 mm. The upper surface is fawn color in life, with 2 irregular cross-bands of a dark shade on distal half of arm; superomarginal plates purple or violet with the superomarginal spines orange, tipped with purple; lower surface and inferomarginal spines white.

Astropecten preissi

Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 119.
Döderlein, 1917. "Siboga" Ast.: Astropecten, p. 161; pl. 5, figs. 4–6.

This is the characteristic sea star of the Fremantle region, but ranges southward and eastward not only to the Albany region, but to Kangaroo Island and St. Vincent Gulf, South Australia. We dredged good series of specimens between Fremantle and Garden Island, with R = 6–155 mm. In the largest specimens R = 71 and a number of the superomarginals bear small, erect spines. There are, in life, 2 strikingly different color forms, one being yellowish brown or brown-orange, the other, rich violet. These colors are evanescent and disappear in preserved material. Possibly they are secondary sex characters. Döderlein's proposed subspecies *albanicus* is of dubious validity, being based on a variable character which is greatly affected by the manner of preservation.

Astropecten zebra

Sladen, 1883. Jour. Linn. Soc. (Zool.), vol. 17, p. 261.
——— 1889. "Challenger" Ast., p. 212; pl. 36, figs. 3, 4.

This is a very dubious species. All the known specimens, taken between India and Thursday Island, Torres Strait, are small (R less than 40 mm.) and apparently immature, except one from Torres Strait figured by Döderlein (1896*a*, p. 306; pl. 18, figs. 31, 31*s*). This specimen is so similar to *vappa* of the same size, there can be little doubt that it should be referred to that species; but some of the smaller specimens referred to *zebra* are not so much like *vappa*, and may represent a valid species. The varieties *rosea* Sladen and *sibogae* Döderlein are obviously of dubious value and must be considered unworthy of recognition until mature specimens of *zebra* are adequately characterized. Good series of Astropectens from the Aru Islands and New Guinea should enable us to clarify the status of *zebra*.

PSILASTER

Sladen, 1885. "Challenger" Exped. narrative, vol. 1, pt. 2, p. 611.

Genotype: *Astropecten andromeda* Müller and Troschel, 1842, p. 129.

This is a characteristic deep-water genus with a number of species from various regions. In the southern hemisphere, a single species common to Australia and South Africa has been found in water of very moderate depth, 80–245 fms.

Psilaster acuminatus

Sladen, 1889. "Challenger" Ast., p. 225; pl. 40, figs. 1, 2.

This species was first taken at the Cape of Good Hope at an unrecorded depth, by the "Challenger," late in 1873. A few months later it was taken off the eastern coast of New South Wales, in 950 fms., and a few days later off the western coast of New Zealand, in 150 fms. The South African record has been confirmed by the "Pieter Faure," 131–175 fms., and by Mortensen (1933), 143–245 fms. The Australian occurrence was proved by the "Endeavour," 80–200 fms., and the New Zealand by Mortensen (1925), 19–55 fms. Though these specimens show no little diversity in the details of spinulation, it seems to be reasonably sure that *Psilaster acuminatus* occurs in the continental zone of three widely separated land masses of the southern hemisphere. Its bathymetrical range, 19–950 fms., is no less remarkable.

Challenger in 100 fath. N. Sydney Jan 1960 AB.

DIPSACASTER

Alcock, 1893. Ann. Mag. Nat. Hist., ser. 6, vol. 11, p. 87.

Genotype: *Dipsacaster sladeni* Alcock, 1893, p. 87.

According to Fisher (1919), the notable sea star taken by the "Endeavour" in the Great Australian Bight and named *Lonchotaster magnificus* by me (1916) is more correctly regarded as a *Dipsacaster*.

Dipsacaster magnificus

Lonchotaster magnificus H. L. Clark, 1916. "Endeavour" rept., p. 30; pl. 6, figs. 1, 2.
Dipsacaster magnificus Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 150.

This fine species is still known only from the single specimen collected by the "Endeavour" in the Great Australian Bight in 80–120 fms. With R = 155 mm., it ranks among the largest of Australian sea stars.

Family BENTHOPECTINIDAE

This family is essentially a deep-water group and has a place here merely because a single Indian Ocean species occurs on the northwestern coast of Australia in less than 200 fms.

CHEIRASTER

Studer, 1883. Sitzungsber. Gesellsch. naturforsch. Freunde, Berlin, p. 130.

Genotype: *Cheiraster gazella* Studer, 1883, p. 130.

This widely distributed genus is represented in Australia solely by its type species, which was first taken by the "Gazelle" in Mermaid Strait, northwestern Australia.

Cheiraster gazellae

Studer, 1883. Sitzungsber. Gesellsch. naturforsch. Freunde, Berlin, p. 130.
——— 1884. "Gazelle" Ast., p. 50; pl. 4, figs. 8*a, b, c* (amended spelling).
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 196; pl. 50; pl. 52, fig. 1.

The specimen on which this species was based had R = 61 mm., but the "Albatross" took scores in the Philippines in 195–256 fms., some of which were double that size. In life the "Gazelle" specimens were white beneath but clear orange above, with the genital bands showing through as red. Excepting the Mermaid Strait specimen, *Cheiraster* has not been taken in Australian waters.

Family ARCHASTERIDAE

This small tropical family, containing but a single genus, is represented on both the eastern and western coasts of Australia. There are 3 known species, and all have been reported from Australia.

ARCHASTER

Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., p. 104.

Genotype: *Archaster typicus* Müller and Troschel, 1840, p. 104.

The 3 species of *Archaster* seem to prefer sandy bottoms in shallow warm water. They are specially characteristic of the eastern Indian Ocean and do not occur in the Red or Arabian seas or on the East African coast or in New Zealand or Japan, but the range does extend to the Ryukyu, Gilbert, and Samoan islands. The following key shows how the species differ:

Key to the Species of Archaster

A. Inferomarginal plates with single wide, flat spine at upper end, which is usually more or less appressed to superomarginal plate ..... *typicus*

AA. Inferomarginal plates with 2 or 3 enlarged flat scales at upper end:

Paxillae of dorsal surface with short, cylindrical stumps more or less crowded but not making smooth surface ..... *angulatus*

Paxillae with low, flat, angular granules so crowded as to make a rather smooth pavement ..... *laevis*

Archaster typicus

Müller and Troschel, 1840. Monatsber. K. preuss. Akad. Wissensch., p. 104.
——— 1842. Syst. Ast., p. 65; pl. 5, fig. 2.

This is the best known of the Archasters and is very common in many places in the East Indian region. It does not seem to be common in Australian waters, but its range extends southward along the Barrier Reef at least to Lindeman Island, somewhat south of 20° S. lat. It has been reported from Torres Strait, and there is a specimen in the Museum of Comparative Zoölogy from Croker Island, Coburg Peninsula, about 133° E. long. Nevertheless, neither the "Challenger" nor Semon nor I found *Archaster* in the Torres Strait region. The "Alert" took it at Port Denison, but not elsewhere in Australian waters. It would not be unfair to consider it a relatively recent arrival in Australia from the East Indies, for it is abundant in western New Guinea and Amboina. It is the smallest of the 3 species, for specimens with R more than 80 mm. are rare. The color in life is said to be almost indistinguishable from that of the sand upon which the sea stars live. Museum specimens, however, sometimes show a uniformly orange-reddish color.

Archaster angulatus

Müller and Troschel, 1842. Syst. Ast., p. 66.
De Loriol, 1885. Mém. Soc. phys. hist. nat. Genève, vol. 29, no. 4, p. 78; pl. 22, figs. 2–2*c*.

This is the largest of the Archasters; one in the Museum of Comparative Zoölogy collection has R = 190 mm. It is the common species at Mauritius, but it seems to occur also in the Philippines and the East Indies. It has been reported from Torres Strait, Port Darwin, and Western Australia, but I think the records for Darwin and Torres Strait are misidentifications of *typicus,* and that from Western Australia probably refers to *laevis.* At any rate, the occurrence of *angulatus* in Australia very much needs confirmation.

Archaster laevis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 75; pl. 17, fig. 2.

This is a characteristic species of Western Australia. As it was taken both in Roebuck Bay and off Fremantle, it may be expected to occur anywhere between those widely separated places in depths of 5–10 fms. It has longer and more slender rays than *typicus,* and R may exceed 120 mm. The lower surface is cream color or whitish, and the upper side is more or less yellow-brown variegated with light fawn gray, bluish gray, or dull light purple.

Family RADIASTERIDAE

This very small family is represented in Australia by a single species taken off southeastern Australia by the "Endeavour," and farther south in much deeper water by the Australasian Antarctic Expedition.

RADIASTER

E. Perrier, 1881. Bull. Mus. Comp. Zoöl., vol. 9, p. 17.

Genotype: *Radiaster elegans* Perrier, 1881, p. 17.

This genus, subsequently called *Mimaster* by Sladen, has been much discussed by Verrill and Fisher, as well as by Perrier and Sladen. Apparently, however, it is now agreed that it is best placed in a family of which it is considered the typical genus. Sladen's name *Mimaster* has been very generally used, but Fisher (1919) shows that *Radiaster* is structurally the same genus and as a name has a year's priority. The Australian species seems to be unquestionably congeneric with Perrier's West Indian genotype.

Radiaster gracilis

Mimaster gracilis H. L. Clark, 1916. "Endeavour" rept., p. 33; pl. 7, figs. 1, 2.

The "Endeavour" took 5 specimens of this notable sea star in the vicinity of Gabo Island, Victoria, in 50–200 fms. Apparently it has been met with but once since then; the Australasian Antarctic Expedition took a specimen in December 1912, south of Maria Island, Tasmania, in 1300 fms. (see Koehler, 1920, p. 242; pl. 49, figs. 4, 18). The largest "Endeavour" specimen had R = 60 mm.; Koehler's specimen was somewhat smaller. The other species of the genus are from the North

Atlantic (Faeroe Channel), 516–555 fms.; South Pacific (off western coast of southern South America), 245–1325 fms.; and among the Molucca Islands, 569–647 fms.—surely a cosmopolitan distribution!

Family GONIASTERIDAE

This large and cosmopolitan family is well represented in Australia by some 19 genera, nearly half of which, if not actually peculiar to the continent, are definitely characteristic of it. They show extraordinary diversity in form and size, but most of them are relatively large and conspicuous. The most brilliantly colored and beautiful sea stars of Australia are with a few exceptions goniasterids. For the most part they live in shallow water (under 20 fms.), and very few occur at any considerable depth (over 100 fms.). The 20 genera may be distinguished as follows:

Key to the Genera of Goniasteridae [1]

I. Abactinal surface with paxilliform, tabulate, or markedly convex plates, not flat or covered with membrane:
  A. Superomarginal plates not contiguous on rays, except sometimes at very tip:
    B. Abactinal plates medium-sized or small, not conspicuously elevated; papulae single or in groups of 2 or 3:
      Several series of abactinal plates extend to near tip of ray, one or more reaching terminal plate ..... *Mediaster*
      Only single series of plates extends to near tip of ray and none reaches terminal plate ..... *Rosaster*
    BB. Abactinal plates of disk very large, more or less conspicuously elevated; papulae in irregular scattered groups, often of 10 or more:
      Large abactinal plates markedly convex, covered with coarse granules and often with low-pointed tubercle at center, but without any delimiting series of enlarged spinelets or granules ..... *Nectriaster*
      Large abactinal plates with big, more or less cylindrical tabulae, crowned with more or less flattened and often enlarged granules, surrounded by a sharply defined circle of short, wide spinelets or coarse, blocklike granules ..... *Nectria*
  AA. Superomarginal plates contiguous on long, slender rays ..... *Nymphaster*
II. Abactinal surface with flat or slightly convex, more or less circular, polygonal or stellate plates, smooth, granulose, or spiny:
  C. Body not covered by a smooth or granular membrane:
    D. Abactinal plates with upright spines or tubercles of considerable size; each marginal, with one or more rigid spines or tubercles ..... *Calliaster*
    DD. No considerable spines on rays or marginals, but some disk plates may carry tubercles:
      E. Superomarginals not contiguous, except possibly a few distal pairs:
        F. Last marginal in both upper and lower series enlarged; abactinal, marginal, and actinal intermediate plates smooth, bordered by single series of granules ..... *Pentagonaster*

[1] The record of *Goniaster tessellatus* (Lamarck) from "Melbourne, Aust." (H. L. Clark, 1909*a*, Bull. Mus. Comp. Zoöl., vol. 52, p. 110) is entirely untrustworthy.

FF. Not as above:
G. All plates closely granulated and some at least bearing tubercles or spinelets:
H. No large bivalve pedicellariae on actinal intermediate plates:
Distal inferomarginals not extending out conspicuously beyond superomarginals; poriferous areas not covered by coarse, flat, polygonal granules ..... *Goniodiscaster*
Distal inferomarginals projecting conspicuously beyond superomarginals; poriferous areas closely covered with coarse, flat, polygonal granules ..... *Styphlaster*
HH. Actinal intermediate plates with large bivalve pedicellariae as in *Anthenea* ..... *Pseudogoniodiscaster*
GG. Abactinal plates smooth, at least centrally ..... *Tosia*
EE. Superomarginals contiguous on long, slender rays ..... *Iconaster*
CC. Body covered by membrane obscuring outlines of underlying plates:
J. Granules on body surface minute, well spaced, or wanting:
Granules numerous but minute and well spaced ..... *Anthenoides*
Granules wanting or nearly so, especially actinally ..... *Ogmaster*
JJ. Granules on body surface very numerous, flat and crowded, forming dense, smooth coating ..... *Stellaster*
III. Abactinal skeleton stellate-reticulate, overlaid by thick skin, obscuring plate outlines; marginal plates heavy, beset with large granules; actinal plates with coarse granules and huge bivalved pedicellariae:
K. Dorsal surface and marginal plates closely covered with coat of flat-topped polygonal granules; some (often many) abactinal plates with large, smooth tubercle, which may however be replaced by 3–7 similar but smaller crowded tubercles ..... *Anthaster*
KK. Not as above:
L. Superomarginal plates of interbrachial arcs with 1–3 spines on outer margin; many actinal intermediate plates with tuft of spines instead of usual pedicellariae; only 3 adambulacral spines in furrow series ..... *Pseudanthenea*
LL. Superomarginal plates with granules or tubercles or both, but no spines; no spines on actinal intermediate plates; more than 3 adambulacral spines in furrow series:
M. Only 2 series of adambulacral spines; outer end of adambulacral plates bare and smooth (except on distal third of arm in some Pseudoreasters):
Some aboral plates, often many, particularly in carinal series, with big hemispherical tubercles, 2–6 mm. in diameter; superomarginal plates more or less vertical with numerous coarse granules, upper end not forming conspicuous part of aboral surface ..... *Pseudoreaster*
Tubercles on aboral surface much less conspicuous, usually not 2 mm. in diameter; superomarginal plates with upper half bare and smooth, forming marginal border for aboral surface, with few (often only 2 or 3) small tubercles or coarse granules on lower half ..... *Gymnanthenea*
MM. Adambulacral spines in at least 3 series ..... *Anthenea*

MEDIASTER

Stimpson, 1857. Boston Jour. Nat. Hist., vol. 6, p. 530.

Genotype: *Mediaster aequalis* Stimpson, 1857, p. 530.

This is a widely distributed genus occurring in shallow or moderately deep water, chiefly in the northern hemisphere, but 1 species occurs in South Africa, 1 in New Zealand, and 3 are Australian. These latter may be distinguished thus:

Key to the Species of Mediaster

A. Paxillae small and very numerous, with few granules (1–7) and marginal series on each, 1 granule often replaced by low, 2-jawed pedicellaria; rays very broad at base, tapering rapidly to nearly cylindrical tip ..... *australiensis*

AA. Paxillae relatively few, with coarse granules and no pedicellariae; rays not so broad at base, but flat and rather wide near tip:

Interradial superomarginals narrow (i.e., short), much wider than long; paxillae covered with numerous crowded granules and slender marginal spinelets ..... *boardmani*

Interradial superomarginals broad, length and breadth nearly equal; paxillae with few coarse, spaced granules and a marginal series of thick, truncate spinelets ..... *praestans*

Mediaster australiensis

H. L. Clark, 1916. "Endeavour" rept., p. 39; pl. 9, figs. 1, 2.

This fine sea star was taken by the "Endeavour" at three stations in Bass Strait and Tasmanian waters in 40–70 fms., but apparently has not been met with since. The attenuate arms and numerous paxillae are very distinctive.

Mediaster boardmani

Pseudarchaster boardmani Livingstone, 1934. Rec. Australian Mus., vol. 19, no. 3, p. 177; pl. 18, figs. 7–11.

This species is based on 4 specimens from off the coast of New South Wales in 75–90 fms., and apparently has not been taken since. Neither in the description nor in the figures of Livingstone is there any indication of the unpaired median tooth at the inner end of the oral plates which is characteristic of *Pseudarchaster,* and consequently it seems best to transfer the species to *Mediaster;* I have, however, never seen a specimen. Livingstone's description, including an account of the color in life, is most valuable.

Mediaster praestans

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 22; pl. 6.

A single specimen, with R scarcely 30 mm., taken off the Queensland coast, on the Great Barrier Reef, near Cairns, is the sole representative of this species yet known. The character of the paxillae distinguishes it from the preceding species. The color in life is not indicated.

ROSASTER

E. Perrier, 1884. Stell. "Travailleur" et "Talisman," p. 386.

Genotype: *Pentagonaster alexandri* Perrier, 1881, p. 22.

Although based on a West Indian sea star, this genus is characteristic of the East Indian area, where half a dozen species occur. One of these enters the northern part of the Australian area.

Rosaster symbolicus

Nymphaster symbolicus Sladen, 1889. "Challenger" Ast., p. 297; pl. 50, figs. 1, 2.
Rosaster symbolicus Fisher, 1913. Proc. U. S. Nat. Mus., vol. 43, p. 630.

As this species was taken by the "Challenger" at her station 188 near the western end of Torres Strait, in 28 fms., it must be included here, though the type locality is in the Philippines and the "Albatross" took it there twice. In the type specimen, R = 85 mm. and the color is given as "yellowish-white."

NECTRIASTER,[1] gen. nov.

Genotype: *Mediaster monacanthus* H. L. Clark, 1916, p. 41.

In the original description of this remarkable sea star, I suggested that it might be made the type of a new genus, intermediate between *Nectria* and *Mediaster*. In 1917, Fisher said he thought it belonged "unquestionably to Nectria." In 1925, however, Mortensen expressed his doubt of the wisdom of including *monacanthus* in *Nectria* and thought it better to make it "the type of a new genus between Mediaster and Nectria." On further study of the available material, Mortensen's opinion seems well justified, for the species does not fit well in either of the related genera. Accordingly, the following diagnosis of the genus is proposed: A group of Goniasteridae having the general character of *Mediaster* and *Nectria* but distinguished from both by the large convex but not tabulate abactinal plates, which lack any delimiting series of spinelets or enlarged granules. The interbrachial septa are markedly calcified and the papulae are in irregularly diffuse groups of from 6 to 18.

Nectriaster monacanthus

Mediaster monacanthus H. L. Clark, 1916. "Endeavour" rept., p. 41; pl. 10, figs. 1, 2.
Nectria monacantha Fisher, 1917. Ann. Mag. Nat. Hist., ser. 8, vol. 20, p. 167.

This very interesting sea star does not seem to have been taken since the "Endeavour" obtained 10 specimens in 47–50 fms., 6 miles east of Cape Hawke, New South Wales. Therefore nothing is yet known as to the color or appearance in life, or the geographical or bathymetrical distribution. It grows to a large size, with R = 100–110 mm., and the rich brown color of dry specimens suggests that the color in life is a deep red.

[1] The name indicates the intermediate position between *Mediaster* and *Nectria*.

NECTRIA

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

Genotype: *Asterias ocellifera* Lamarck, 1816, vol. 2, p. 553 (by *lap. cal., oculifera*).

This characteristically Australian genus occurs along the southern coast of the continent from New South Wales to Western Australia, but neither the geographical nor the bathymetrical limits of its range are known. No records north of 38° seem to be known from the coast of New South Wales, but on the coast of Western Australia, *Nectria* has been taken between Fremantle and Geraldton, apparently at about 30°. The bathymetrical records are equally hazy, ranging from 30 to 120 fms. Probably, however, it occurs in much less than 30 fms. Mortensen (1925, p. 291) has recorded *Nectria* from New Zealand, a single specimen in the Otago Museum, found at Gisborne, representing an endemic species. Sladen (1889, p. 318) reports a specimen of *Nectria* from Cicia Island, Fiji, but this record needs confirmation, as it is not altogether unlikely that the single individual was brought to Fiji from Australia by a curio-loving sailor or traveler. The 4 Australian species of *Nectria* are easily distinguished by the following characters:

Key to the Species of Nectria

A. Furrow spines of adambulacral armature 2 to 4, usually 3; no conspicuous pedicellariae on actinal plates near mouth:
  B. Disk large, R = 2.5–3r or br; rays wide at base, tapering rapidly to tip; actinal plates with rounded or somewhat polygonal granules, not usually so crowded but that the series of actinal intermediate plates are easily seen:
    Dorsal tabulae with rounded or polygonal granules, often crowded, marginal ones thick, not flattened ..... *ocellata*
    Dorsal tabulae with flat "granules" of very irregular shape and size, not at all crowded, marginal ones conspicuously flat and scalelike, forming regular, radiating marginal fringe ..... *ocellifera*
  BB. Disk smaller, R = 3.5–4r or br; rays narrower at base, less tapering; actinal surface covered with crowded, coarse prismatic granules, obscuring series of actinal intermediate plates ..... *macrobrachia*
AA. Furrow spines 5 or 6; conspicuous pedicellariae on first series of actinal intermediate plates proximally; dorsal tabulae covered by large, closely appressed granules of which 1 to 6 at center are much the largest (1–2 mm. across) ..... *multispina*

Nectria ocellata

E. Perrier, 1876. Arch. zool. exp., vol. 5, p. 4.
Sladen, 1889. "Challenger" Ast., pl. 55 (as *N. ocellifera*).

A re-examination of the literature and of all available specimens increases the conviction that Perrier was right in distinguishing the *Nectria* of southeastern Australia from that of the southwestern coast. Sladen's figures show the distinguishing dorsal paxillae admirably. So far as is now known, the range of *ocellata* is from the eastern coast of Tasmania to the western end of the Great Australian Bight in 30–120 fms. It is the largest species of the genus, with R = 120–130 mm. The color in life has been recorded but once; D. L. Serventy says (on label) that the 2 westernmost specimens (120° 22′ 15″ E.) were "chestnut-orange."

Nectria ocellifera

Asterias ocellifera Lamarck, 1816. Anim. sans vert., vol. 2, p. 553.
Oudart, 1815. Pl. 1.
Nectria oculifera (*lap. cal.*) Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 287.
Nectria ocellifera Gray, 1866. Syn. sp. starfish, p. 15.

Perrier (1876) discovered and demonstrated that Lamarck's species was not the common *Nectria* of southeastern Australia, but a smaller and less common species of Western Australia. According to Perrier, this sea star is figured by Oudart, 1815, plate 1, but it has not been possible to verify this, as Oudart's plate is not available in Cambridge. Lamarck says that Le Sueur assured him that in life the specimen was "un bon rouge." So far as available specimens show, *ocellifera* does not reach so large a size as *ocellata,* the largest west-coast specimen having R = 83 mm. The only known locality for *ocellifera* is the indefinite "between Fremantle and Geraldton, W. A., 60–100 fms." The label also says "color, orange."

Nectria macrobrachia

H. L. Clark, 1923*a*. Jour. Linn. Soc. (Zool.), vol. 35, p. 236; pl. 13, figs. 5, 6.

This species is known only from 2 specimens taken at Pelsart Island, in Houtman's Abrolhos, Western Australia, at an unrecorded depth. The larger has R = 60 mm. There are no notes on the color in life.

Nectria multispina

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 375; figs. 111*a, b*.

This species is a little better known than the preceding, but data are lacking for the types. They were taken by Verco in his extensive dredging for mollusks, and hence are almost surely from either Spencer or St. Vincent Gulf, South Australia, at an unrecorded depth. The largest of the 4 specimens has R = 80–85 mm. The only other specimen known has R = 75 mm. It is "one of many" found in "drift on the sand beach at Middleton Beach," near Albany, Western Australia, "about Christmas, 1929," by E. W. Bennett. When it was collected the color was "orange" below and "red" above. Evidently the ranges of *ocellata* and *multispina* overlap on the southern coast of Western Australia.

NYMPHASTER

Sladen, 1885. "Challenger" Exped. narrative, vol. 1, pt. 2, p. 612 (no species designated).
——— 1889. "Challenger" Ast., p. 294.

Genotype: *Nymphaster protentus* Sladen, 1889, p. 303. Type designated by Fisher, 1917, p. 168.

This widespread deep-water genus has been found twice in Australian seas, but it is apparently only on the outer edge of that fauna. The 2 species are evidently much alike, but may be distinguished thus:

Rays long and slender, R = about 4r; superomarginals short and numerous, 30–40, about 10 on each side of disk; numerous pedicellariae..... *moebii*

Rays shorter and wider, R = about 3r; superomarginals longer, flatter, and fewer, about 20, only 8 on each side of disk; no pedicellariae..... *pentagonus*

Nymphaster moebii

Pentagonaster (*Dorigona*) *moebii* Studer, 1884. "Gazelle" Ast., p. 35.
Nymphaster moebii Sladen, 1889. "Challenger" Ast., p. 869.
Macan, 1938. John Murray Exped. Ast., p. 375; pl. 4.

Studer's species was discovered by the "Gazelle" in 195 fms. of water off the northwestern coast of Australia. The color in life was clear orange above and white below. According to Macan (1938), the species reaches a large size (R = 112 mm.) and is very variable in details of structure. It is common in the Zanzibar area and occurs also in the Gulf of Aden and in the Maldives. The "Siboga" met with *moebii* twice (Döderlein, 1924) in the East Indies, but the "Albatross" did not find it in the Philippines (Fisher, 1919).

Nymphaster pentagonus

H. L. Clark, 1916. "Endeavour" rept., p. 36; pl. 8.

This sea star is still known only from the unique holotype in the Australian Museum, which was taken in 250–450 fms. in the Great Australian Bight, south of the boundary between South and Western Australia. It is extraordinary that the genus should occur there, as it is not elsewhere known south of 20° S. lat. The type has R = about 60 mm. (all the arms are broken) and gives no hint as to the color in life.

CALLIASTER

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 280.

Genotype: *Calliaster childreni* Gray, 1840, p. 280.

The 2 Australian species of this Indo-Pacific genus are so unlike in general appearance that one hesitates to call them congeneric, but as each was based on a single specimen, it seems best to await more material before attempting to discuss their relationship. Moreover, one is the largest *Calliaster* as yet described, and the other is scarcely one-fourth as large. The two may be easily distinguished thus:

Superomarginal plates very large, contiguous for nearly whole length of ray, each one smooth and bearing only a single huge, pointed spine..... *erucaradiatus*
Superomarginal plates relatively small, not contiguous, each bearing granules and a rather conspicuous blunt spine, diminishing distally..... *spinosus*

Calliaster erucaradiatus

Livingstone, 1936. Rec. Australian Mus., vol. 19, p. 383; pl. 27.

The single specimen on which this species rests was taken "about 11 miles off Crowdy Head, N. S. W., bearing north by west, 50 fms.," by Captain K. Möller of the trawler "Ben Bow," in September 1935. As R = only 34 mm., it probably is not adult, but the general stoutness of the plates indicates maturity. The specimen is no. J5996 in the Australian Museum.

Calliaster spinosus

H. L. Clark, 1916. "Endeavour" rept., p. 44; pl. 11.

The unique holotype of this species, in the Australian Museum, has R = 140 mm. and hence is 4 times the size of the preceding. It was taken on the eastern slope of Bass Strait in 80–200 fms. The dry specimen is pale yellowish brown, but nothing is recorded as to the color in life.

PENTAGONASTER

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 280.

Genotype: *Pentagonaster pulchellus* Gray, 1840, p. 280.

There is no more elastic name among sea stars (save *Asterias*) than *Pentagonaster,* first introduced by Linck (1733) for 2 species and used a hundred and fifty years later by Sladen (1889) for 49 species, with one of Linck's species as the type. This action of Sladen is of purely historic interest, since modern zoology does not accept pre-Linnaean names. The first post-Linnaean writer to use the name was Gray (1840), who included only the single species *pulchellus*, but later (1866) with his usual keen systematic sense added 2 congeneric species. E. Perrier (1875), however, with his lack of systematic sense, adopted the name *Pentagonaster* of Linck and included under it 8 of Gray's genera, listing 27 species. Sladen followed his lead, although he rearranged some of the related genera. Verrill (1899) and Fisher (1911) have straightened the matter out, and the use of *Pentagonaster* is now restricted to the New Zealand and Australian sea stars typified by *P. pulchellus* Gray. There has been some doubt as to the number of species known from Australia, since Perrier and Sladen both treat Gray's *Astrogonium inaequale* as a *Pentagonaster* and Sladen records it as from Endeavour River, northern Queensland. It seems improbable that Gray would have failed to call his species a *Pentagonaster* if it were really congeneric with *pulchellus,* and his description does not conform to the generic diagnosis. The species had best be ignored until further material is discovered. Only 2 species therefore are included here, and are to be distinguished thus:

Rays more or less tapering to blunt point; when R = 35 mm. or more, there are 5 (or more) superomarginals and 7 (or 6) inferomarginals on each side of each ray ..... *dübeni*
Rays expanded at tip, distalmost superomarginal (of which there are 4 or only 3) very large; inferomarginals 5 (or 6) ..... *crassimanus*

Pentagonaster dübeni

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 79.
——— 1866. Syn. sp. starfish, p. 11; pl. 3, fig. 2.

There seems to be no room for question that this is the common *Pentagonaster* of southeastern Australia. Gray gives "Western Australia" as the place whence his specimen came; but since he gives "China" as the locality for his species *pulchellus,* and we now know it must have come from New Zealand, it is justifiable to believe that the type of *dübeni* came from southeastern, and not western, Australia.

Under a stone in Watson's Bay, Port Jackson, a specimen was found August 25, 1913, which was conspicuous for its lovely coloration; the ground color was a bright vermilion red, but the plates were all outlined in milk white in sharp contrast. There is apparently no published statement concerning the color in life. The largest reported specimen has R = 67 mm., with 8 superomarginals on each side of each ray (see H. L. Clark, 1928, p. 380). The limits of the range of this species are not known; it certainly occurs in Port Jackson, New South Wales, and in St. Vincent Gulf, South Australia, but how far north or west it may go we have no information, nor are there any Tasmanian records. Specimens reported from Western Australia (H. L. Clark, 1938, for example) should be referred to the following species.

Pentagonaster crassimanus

Astrogonium crassimanum Möbius, 1859. Neue Seesterne, p. 8; pl. 2, figs. 1, 2.
Pentagonaster abnormalis Gray, 1866. Syn. sp. starfish, p. 11; pl. 8, figs. 1, 2.
Astrogonium crassissimum Gray, 1866. Syn. sp. starfish, p. 11.
Pentagonaster stibarus H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 136; pl. 17.
Pentagonaster dübeni H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 79.

Mortensen (1925) first suggested that *stibarus* was identical with *crassimanus*. The collecting of Western Australian material in 1929 and study of all the now available specimens of *Pentagonaster* proves he is probably correct. The chief debatable point is whether *crassimanus* is really distinct from *dübeni*. It is quite possible that material collected between Fremantle and Albany, Western Australia, would show that the two forms intergrade. Indeed, large series of specimens from any area might show the same thing. But in the absence of such material, it may be well to keep the two forms separate. That Möbius says his specimen was from "Ostindien" cannot be considered an insuperable difficulty, for there is plenty of evidence that in the first half of the nineteenth century, the terms India, China, East Indies, and Australia were very ill defined and vaguely used. No sea star similar to *Pentagonaster* is known from the East Indian region, in spite of all the collecting done in recent years by the "Investigator," "Siboga," and "Albatross." There can be little doubt that Möbius' type was from Australia, and apparently it was from the Swan River region.

One of the best reasons for keeping *crassimanus* distinct from *dübeni* is that the young are so different. In a specimen of *crassimanus* 17–18 mm. across, there are rather more than 40 dorsal plates and 20 relatively very large superomarginals, besides 5 plump terminals. But in a specimen of *dübeni* of the same size, there are more than 100 dorsal plates (many very small) and 40 superomarginals, besides 5 relatively wide terminals. Only 1 example of each species as small as this is available, but it is hard to doubt that they show real specific differences.

So far as color notes are available, the western species, *crassimanus,* tends to be orange rather than red, but it is doubtful how reliable a character this is, for of 4 specimens taken at Point Peron, Western Australia, in October 1929, 1 was vermilion and 1 a deeper red.

The range of *crassimanus* is quite unknown. It seems to be common at Point Peron, Western Australia, in water near low-tide mark, under stones. It is apparently not rare at the Abrolhos Islands in similar situations, but it has also been taken in 40–100 fms. between Fremantle and Geraldton. Presumably it

will be found farther south and possibly north to Shark Bay, but whether it reaches the region of Albany needs demonstrating.

GONIODISCASTER

H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, no. 7, p. 110.

Genotype: *Asterias pleyadella* Lamarck, 1816, vol. 2, p. 553.

This is one of the most characteristic genera of the sea stars in the Australian fauna, for although it occurs in the East Indies and Philippines, it is along the tropical coast of Australia that it shows its greatest abundance and diversity. The colors in life are, so far as known, striking, and several species must be ranked among the most beautiful of sea stars. The 8 Australian species may be distinguished as follows:

Key to the Species of Goniodiscaster

A. Primary radial plates each with a stout, pointed tubercle, relatively big:
  Arms relatively wide nearly to rounded tip; R = 2.5r or less ..... *pleyadella*
  Arms tapering evenly to blunt tip; R = 2.5r or more ..... *integer*
AA. Primary radial plates with no single large tubercle:
  B. Arms relatively long, tapering evenly to tip; R = 2.5–3.5r:
    Dorsal surface rough, with many coarse granules and pointed tubercles; R scarcely 3br ..... *australiae*
    Dorsal surface more finely granulated; R = 3.5br ..... *coppingeri*
  BB. Arms shorter, relatively wider distally, and blunter; R less than 2.5r, usually nearer 2:
    C. Dorsal plates with coarse granules and small, pointed tubercles; small pedicellariae not excessively numerous:
      D. Superomarginals very short and wide, forming much of dorsal surface of ray:
        Aboral surface bluish gray, with marginal plates and coarsest granules and tubercles bright brick red ..... *acanthodes*
        Disk and arm bases clear gray; remainder of arms bright rose red ..... *bicolor*
      DD. Superomarginals about as long as wide, not forming much of dorsal surface of ray ..... *seriatus*
    CC. Dorsal plates without coarse granules and pointed tubercles but with very numerous small pedicellariae ..... *foraminatus*

Goniodiscaster pleyadella

Asterias pleyadella Lamarck, 1816. Anim. sans vert., vol. 2, p. 553.
Goniodiscus pleyadella Döderlein, 1896*a*. Semon's Ast., *in* Jena Denkschr., vol. 8, p. 308; pl. 18, figs. 34–34*f*.
Goniodiscaster pleyadella H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, no. 7, p. 110.

This does not seem to be a very common sea star, for on none of my three visits to tropical Australia was a specimen taken, nor did the Great Barrier Reef Expedition find it. The "Alert," however, took specimens in Torres Strait, in 3–5 fms., which Bell (1884) described as a new species, *Pentagonaster validus*. Semon also obtained specimens in Torres Strait, 3 small individuals at Thursday

Island, which Döderlein (1896*a*) recognized as Lamarck's species. The largest of these Torres Strait specimens had R = 72 mm. No notes on the color in life are recorded.

Goniodiscaster integer

Livingstone, 1931*a*. Rec. Australian Mus., vol. 18, p. 135; pls. 17–19.

This seems to be a typical Barrier Reef species, having been taken at Lindeman Island, in Port Curtis, and near Peel Island, Moreton Bay. The largest individual has R = 99 mm., but most of those so far taken are much smaller, the smallest having R = 18 mm. Nothing has been recorded as to color.

Goniodiscaster australiae

Tortonese, 1935. Bull. Mus. zool. Univ. Torino, vol. 45, ser. 3, no. 60, p. 3; pl. 1.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 80; pl. 8, fig. 2 (colored).

This is one of the most beautiful sea stars in the rich marine fauna of northwestern Australia, and is by no means rare in the vicinity of Broome in water 5–18 fms. deep. The single dry specimen on which Tortonese based the species was collected by the Italian vessel "Calabria" in "Australia occidentale"; whether this means in the vicinity of Broome is not determinable. All the material of the Museum of Comparative Zoölogy is from that area. The smallest specimens are not notably different from the adults in color or form, but the largest have the disk more elevated and the arm bases wider. The beautiful diversity in color (deep rose pink, with or without more or less grass green or light gray or blackish) does not seem to be associated with size, though it may be with age or sex.

Goniodiscaster coppingeri

Pentagonaster coppingeri Bell, 1884. "Alert" rept., p. 128.
Goniodiscaster coppingeri H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, no. 7, p. 110.
——— 1921. Ech. Torres Strait, pl. 23, figs. 1, 2.

This species seems to be confined to the northern end of the Barrier Reef, the northern coast of Queensland, and the eastern coast of the Northern Territory. It occurs as far south as Port Curtis and as far west as Cape Bedwell, Northern Territory, but we did not find it near Darwin. The specimen taken at Cape Bedwell was found in the sand near low-water mark by Melbourne Ward, who kindly presented it to the Museum of Comparative Zoölogy. It is the largest specimen yet reported, having R = 93 mm. and r = 26. The color above is much like that of Bell's larger specimen, "slate," not at all red like the specimen from Adolphus Island, nor deep yellow-brown like those from Lindeman Island. The lower surface is light olive brown, very different from any other specimen seen. Information on the color in life is much to be desired.

Goniodiscaster acanthodes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 84; pl. 5, fig. 2 (colored).

No further information is available concerning this lovely species from Broome.

Goniodiscaster bicolor

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 87; pl. 5, fig. 1 (colored).

No further data are available than those given with the original description. It is greatly to be regretted that the striking colors of life are so fugacious, the original specimens are now only light yellowish brown.

Goniodiscaster seriatus

Goniodiscus seriatus Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 117.
Goniodiscaster seriatus Döderlein, 1935. "Siboga" Ast.: Oreasteridae, p. 80; pl. 20, fig. 5; pl. 21, figs. 4, 4*a*.

This species is the least known of the Australian Goniodiscasters, not having been taken in recent years. The type has R = 78 mm., and a paratype, also in Berlin, is only half as large. No other specimens are extant apparently, but Döderlein thinks that the 2 young Goniodiscasters on which Gray (1847) based his *Pentaceros granulosus* probably represented this species. Possibly these specimens are in the British Museum, but Sladen (1889) does not seem to have seen them. They were said to be from Western Australia, whereas the types are recorded as from "Südwest-Australien."

Goniodiscaster foraminatus

Goniodiscus foraminatus Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 415.
Goniodiscaster foraminatus Döderlein, 1935. "Siboga" Ast.: Oreasteridae, p. 79; pl. 20, fig. 6; pl. 21, figs. 5–5*b*.

This species is based on a series of specimens from Shark Bay, Western Australia, 7–11 fms. They ranged in size from R = 34 mm. to R = 69 mm. The only other specimen as yet known is no. 9018 in the Western Australian Museum, R = 35 mm., taken off Garden Island, near Fremantle, Western Australia. This individual is undoubtedly young, and the specific characters are not very convincingly developed.

STYPHLASTER

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 88.

Genotype: *Styphlaster notabilis* H. L. Clark, 1938, p. 88.

This is a very well marked genus so far as can be determined from a single specimen, but its relationship to *Goniodiscaster* is fairly obvious.

Styphlaster notabilis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 89; pl. 17, figs. 3, 4.

A full account of the unique holotype, which was dredged at Broome, and of the circumstances under which it was taken, was given in the original description of the species.

PSEUDOGONIODISCASTER

Livingstone, 1930. Rec. Australian Mus., vol. 18, no. 1, p. 15.

Genotype: *Pseudogoniodiscaster wardi* Livingstone, 1930, p. 16.

This is a very striking genus, actinally like *Anthenea* but abactinally very different. Its relationship with *Goniodiscaster* is not so obvious, but on the whole it is nearer to this genus than to the Antheneinae. It is monotypic.

Pseudogoniodiscaster wardi

Livingstone, 1930. Rec. Australian Mus., vol. 18, no. 1, p. 16; pl. 4, figs. 1, 2; pl. 5, figs. 1–3.

It is interesting to know that such novelties as this are still to be found on the Queensland coast. Nothing is known as to the distribution. The unique type, with R = 77 mm., was taken by Melbourne Ward, among "weeds," at Rat Island, near Curtis Island, Port Curtis, Queensland. Aborally the color was a dark green, like the "weeds" among which it was found.

TOSIA

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 281.

Genotype: *Tosia australis* Gray, 1840, p. 281.

This is a typical genus of southern Australia, occurring as far north on the eastern coast as the Capricorn Islets (23° 27′ S.), but on the western not known to occur north of 30°. It is as yet unknown from New South Wales, although well known from Tasmania. The South African *Tosia tuberculata* is not closely related to the Australian Tosias, and is better placed in a separate genus. Livingstone (1932*a*) has made a careful study of the Australian Tosias, recognizing 4 species and a variety. His conclusions are adopted here. The species *grandis* and *rubra* of Gray, and *Astrogonium nobile* and *ornatum* of Müller and Troschel, are probably based on variants of the species *australis* and *aurata*. The following key is adapted from Livingstone:

Key to the Species of Tosia

A. Terminal plate small and inconspicuous:
  B. Superomarginal plates 6–8 on each side of the more or less pentagonal body:
    C. Interbrachial arcs rounded, R = 1.5r or less; no actinal pedicellariae:
      Abactinal and superomarginal plates not markedly convex ..... *australis*
      Abactinal plates and especially superomarginals more or less convex ..... *australis* forma *astrologorum*
    CC. Interbrachial arcs comparatively acute, R = 1.6–1.9r; minute actinal pedicellariae ..... *tubercularis*
  BB. Superomarginal plates 10–16 on each side ..... *aurata*
AA. Terminal plate large, as big as or bigger than any superomarginal ... *queenslandensis*

Tosia australis

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 281.
Livingstone, 1932*a*. Rec. Australian Mus., vol. 18, no. 7, p. 375; pl. 43, figs. 1, 2, 10–13; pl. 44, fig. 6.

This is the commonest and most wide-ranging member of the genus, having been taken at many places from King Island and Hobart, Tasmania, on the east to Fremantle, Western Australia, on the west. Most specimens are so nearly pentagonal that it is natural to say, in speaking of their size, that the largest specimens are 70–72 mm. across. In life, the color ranges from "deep brown, variegated with fawn color above, cream-color variegated with brown below" to "dark gray variegated with a light bluish gray." Although inert in habit, these curious sea stars are capable of no little activity and may be found climbing wharf piles.

The forma *astrologorum* is an extreme morphological variant which is easily recognized but occurs with the typical form and has not become sufficiently differentiated from it to warrant being given varietal status. It may be found wherever *australis* occurs. For a more detailed discussion of *australis* and forma *astrologorum* see H. L. Clark, 1938, pages 381–384.

Tosia tubercularis

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 81.
Livingstone, 1932*a*. Rec. Australian Mus., vol. 18, no. 7, p. 378; pl. 44, figs. 1, 2, 7.

This is apparently either a rare or a local species, of which I have never seen a specimen. Livingstone's account indicates its occurrence on the coast of Victoria, but the type locality was "Swan River" (i.e., Western Australia). Gray's figures (1866, pl. 16, figs. 4, 4*a*) indicate that R = 30 mm., whereas Livingstone's specimens were all much smaller, the largest having R = 23.5 mm. Probably *tubercularis* is a form of *australis* of the same rank as *astrologorum*.

Tosia aurata

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 80.
Livingstone, 1932*a*. Rec. Australian Mus., vol. 18, no. 7, p. 377; pl. 43, figs. 3–9; pl. 44, fig. 8.

Though Livingstone's account and figures amply validate this species, which ranges from Hobart to Fremantle, the ratio of R to r shows considerable diversity. Thus, a specimen from Victoria in the Museum of Comparative Zoölogy has R = 60 mm. and r = 39, hence R = 1.5r; a second Victorian specimen has R = 63 mm. and r = only 34, so R = 1.9r. Specimens collected in Ralph Bay, Hobart, Tasmania were, in life, variegated brown and fawn color above, grayish fawn color and brown below.

Tosia queenslandensis

Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 243; pl. 5, figs. 1, 2, 7.

The relationship of this sea star is still in doubt, for its geographical isolation (Capricorn and Low Isles, Queensland) and its color in life (crimson) set it apart from all the other Tosias, and the color suggests *Pentagonaster dübeni*. The

original specimens (holotype and 2 paratypes) are all small (R only 17 mm. or less) and probably immature. When larger specimens are obtained, it is not impossible that a new genus will be desirable.

ICONASTER

Sladen, 1889. "Challenger" Ast., p. 261.

Genotype: *Astrogonium longimanum* Möbius, 1859, p. 7.

Whether this genus is monotypic or not depends on whether we use Fisher's (1919) name *Glyphodiscus* as a generic or subgeneric name. Bell's (1909) species, *gardineri,* belongs in *Nymphaster,* according to Fisher (1919), but the latter's *Glyphodiscus perierctus* looks so much like *Astroceramus,* it is hard to call it an *Iconaster*. It is not unreasonable, therefore, to consider *longimanus* the only known species of *Iconaster*.

Iconaster longimanus

Astrogonium longimanum Möbius, 1859. Neue Seesterne, p. 7.
Iconaster longimanus Sladen, 1889. "Challenger" Ast., p. 261.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., p. 303; pl. 77, fig. 2; pl. 104, fig. 3.

This is an apparently uncommon but rather widely distributed East Indian sea star, ranging as far south on the Australian coast as Percy Isles, Queensland, and as far west as Broome, Western Australia. The "Siboga" met with it at only three widely separated places, and the "Albatross" took it but once in the Philippines. The largest reported specimen has R = 110 mm. The color in life is light orange-brown, with the interradial areas reddish brown; on the upper side of each arm are two parallel cream-white lines.

ANTHENOIDES

E. Perrier, 1881. Bull. Mus. Comp. Zoöl., vol. 9, p. 23.

Genotype: *Anthenoides peircei* Perrier, 1881, p. 23.

This genus, originally monotypic, now contains no fewer than 9 supposedly distinct species. The genotype is a West Indian sea star, but all its congeners are from the Indo-Pacific region, the range extending from Natal to Hawaii. It is not strange, therefore, that a single small species is found on the northwestern coast of Australia.

Anthenoides dubius

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 91; pl. 17, figs. 5, 6.

There can be little doubt that all the known specimens of this species are immature, and its actual status is therefore still open to question. The largest specimen has R only 18 mm. All were taken near Broome or in Lagrange Bay, Western Australia. The color in life was pale olive gray above, somewhat variegated with a darker shade; terminal plates and a band on distal half of arm, darker; lower surface pure white.

OGMASTER

von Martens, 1865. Arch. f. Naturgesch., vol. 31, pt. 1, p. 359 (as a subgenus of *Goniaster*).
Sladen, 1889. "Challenger" Ast., p. 261.

Genotype: *Goniodiscus capella* Müller and Troschel, 1842, p. 61.

This monotypic genus has been universally recognized as distinct from its nearest relatives, but owing to the scarcity of material its position in the Goniasteridae seems to be still debatable. Neither the "Challenger" nor the "Albatross" met with *Ogmaster* in the East Indian region, but the "Siboga" took 3 very young individuals near Timor and the Kei Islands, and the "Investigator" found it twice in the vicinity of the Andaman Islands. Its occurrence on the coast of Queensland is quite unexpected.

Ogmaster capella

Goniodiscus capella Müller and Troschel, 1842. Syst. Ast., p. 61.
Goniaster (*Ogmaster*) *capella* von Martens, 1865. Arch. f. Naturgesch., vol. 31, pt. 1, p. 359.
Dorigona reevesii Gray, 1866. Syn. sp. starfish, p. 7; pl. 7, fig. 3 (*Dongona,* by error).
Ogmaster capella Sladen, 1889. "Challenger" Ast., p. 261.
Koehler, 1910. Indian Mus. Ast., pt. 6, p. 79; pl. 3, fig. 12.

In spite of Gray's statement that this sea star is "common in boxes of insects brought from China and Japan," it is today one of the rarest of sea stars in museums. Goto (1914) says, "The occurrence of this species in Japan is questionable." There are no definite records from China or India, although Döderlein (1935) refers to a single specimen from "China." Leipoldt (1895) reports 3 young specimens from Assab, near the southern end of the Red Sea, but the "Mabahiss" (John Murray Expedition) failed to find *Ogmaster* anywhere. The only Australian record is that of 5 specimens taken by the "Endeavour," northeast of the Capricorn group, off Port Curtis, Queensland, in 50–75 fms. One of these, now in the Museum of Comparative Zoölogy collection, has R = 42 mm. and reveals well the generic characters of a thin, nongranular, naked covering membrane and the total absence of marginal spines. The resemblance to *Anthenoides* is little more evident than to *Stellaster.* The dry specimen is a rather bright yellow-brown, but no information is available as to the color in life.

STELLASTER

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 277.

Genotype: *Stellaster childreni* Gray, 1840, p. 278.

Döderlein's (1935) extended treatment of this fine genus is unsatisfactory, as he designates a half-dozen species and under the sixth lists a dozen named forms. This sixth species he calls *Asterias equestris* Retzius (1820), dividing it into 2 groups, the *childreni* group and the *incei* group. The type of the genus must be in the first group, since he uses Gray's name, *childreni,* for it. The other group includes the commonest Australian *Stellaster,* which he fails to define satisfactorily. He also fails to see that he has redescribed *inspinosus* H. L. Clark under the name *gibbosus,* and he has overlooked *megaloprepes* H. L. Clark—perhaps luckily, as the name is a pure synonym of *princeps* Sladen.

The Australian Stellasters do not seem to offer as great difficulties in identification. Besides the 3 well marked species, so striking a feature of the tropical Australian marine fauna, only 1 other need be included here. This is *S. squamulosus* Studer, the type of which Döderlein examined and validates. Perrier's *S. granulosus,* supposed to be from New South Wales, may well be ignored, as Döderlein was unable to identify it from Perrier's description, and only *S. incei* occurs as far south as New South Wales.

Key to the Species of Stellaster

A. Granules around papulae conspicuously swollen and scalelike..... *squamulosus*
AA. Granules around papulae not notably swollen and scalelike:
B. Many spines on inferomarginal plates; lower surface in life white, with large circular purple area around mouth..... *princeps*
BB. Only 1 inferomarginal spine, or none; lower surface not purple and white:
Inferomarginal spine usually present; larger plates of disk flat or slightly convex; many abactinal plates carry a bluntly pointed tubercle; abactinal surface in life brown; no red..... *incei*
Inferomarginal spine commonly wanting; larger plates of disk convex or swollen; few, if any, abactinal plates carry tubercles; abactinal surface and many actinal intermediate plates in life deep blood red..... *inspinosus*

Stellaster squamulosus

Studer, 1884. "Gazelle" Ast., p. 33; pl. 4, figs. 6*a–c*.

There is no question that the unique holotype of this species, taken off northwestern Australia in 110 fms., is very young. That it is a young *Stellaster princeps* seems to me quite probable. Studer frequently gives the colors in life of his sea stars, but in this case he does not. None of the specimens of *princeps* in our Broome collections are anywhere near small enough to make comparisons with the type of *squamulosus* of any use.

Stellaster princeps

Sladen, 1889. "Challenger" Ast., p. 323; pl. 58, figs. 1–3.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 98; pl. 4 (colored).
Stellaster megaloprepes H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 141; pl. 18.

This is the largest and most striking in its appearance of all the Stellasters, and well deserves the specific name bestowed on it by Sladen. It occurs only on the northern coast of Australia, from Booby Island to Port Hedland, Western Australia. Save for the "Challenger" specimen from Booby Island, it has not been found as yet east of Broome. It reaches a very large size, with R = 150 mm. and the height nearly 40 mm. The coloration (see H. L. Clark, 1938) is correspondingly striking.

Stellaster incei

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 76.
H. L. Clark, 1916. "Endeavour" rept., p. 47; pl. 12.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 94; pl. 2, figs. 1, 2 (colored).

The common *Stellaster* of the Australian coast ranges from northern New South Wales, in 18–74 fms., to Lagrange Bay, Western Australia, 5–18 fms.[1] Very large specimens have R = 75–90 mm., and Bell (1884) reports one with R = 120 mm. There is very great diversity in the ratio of R to r and to br, for R may be only 2r or may exceed 3r. There is an equal diversity in the matter of tubercles on the dorsal surface. Usually there are tubercles on the radial plates and often on the carinals; in many specimens there are additional tubercles both on disk and on rays; rarely they occur on the superomarginal plates also. In many specimens with R = 40 mm. or less, and even in some with R = 50–60 mm., tubercles are entirely wanting. On the whole, the absence of tubercles or their presence and number make very untrustworthy specific or varietal characters in this sea star. So far as is known, the brown dorsal side is characteristic of *incei,* and the occurrence of dusky or nearly black actinolateral plates, particularly in the series adjoining the adambulacrals, is a marked specific character even though the number and position of such plates is subject to great diversity.

Stellaster inspinosus

H. L. Clark, 1916. "Endeavour" rept., p. 48; pl. 13.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 97; pl. 3 (colored).
Stellaster gibbosus Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 412.

Although museum specimens of this *Stellaster* resemble many representatives of the preceding species, the appearance in life is so different that it would be impossible to confuse the two. Döderlein's types were from Barrow Island and Fremantle, Western Australia, and those of Clark were taken between Fremantle and Geraldton. The striking coloration makes the living specimens easily recognizable, but it is fugacious. In size, *inspinosus* is equal to *incei.*

ANTHASTER

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 27 (30).

Genotype: *Oreaster valvulatus* Müller and Troschel, 1843, p. 115.

This is a monotypic genus confined to the coasts of southern and southwestern Australia, recently rediscovered and redescribed.

Anthaster valvulatus

Oreaster valvulatus Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 115.
Anthaster valvulatus Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 27 (30); pl. 3.
H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 386.

This notable sea star seems to be fairly common on the South Australian coast, having been taken at Kangaroo Island, Althorpe Island, Glenelg, and in St. Vincent Gulf. It has not yet been found on the coast east of Encounter Bay, but westward the range extends to the Western Australian coast in the vicinity of Fremantle. Apparently it does not occur along shore or in very shallow water, for Bennett did

[1] The record (H. L. Clark, 1925*a*) from Long Island, the Abrolhos, Western Australia, undoubtedly refers to the following species, *inspinosus.*

not take it either near Albany or at Bunkers Bay, nor did we find it at Bunbury or at Fremantle. Moreover, the "Endeavour" did not take any specimens in her collecting in the Bight or on the Western Australian coast. The largest reported specimen has R = 112 mm., and the smallest has R = 42 mm. The color in life is recorded as brick red or violet-red with the lower surface much lighter, salmon red along the ambulacra.

[PSEUDANTHENEA

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 26.

Genotype: *Anthenea grayi* Perrier, 1876, p. 94.

This genus rests on a single species known from only a single small specimen (78 mm. across), supposed to be in the British Museum. It has not been met with during the past sixty-five years, apparently, and the place where it was collected is unknown. Since, however, Australia is the home of so many Antheneas and nearly related forms, it is not unreasonable to suppose that the unique type of *Anthenea grayi* was taken in that region.]

PSEUDOREASTER

Verrill, 1899. Trans. Connecticut Acad., vol. 10, pt. 2, p. 148.

Genotype: *Asterias obtusangula* Lamarck, 1816, vol. 2, p. 556.

This is also a monotypic genus characteristic of the northern coast of Western Australia. It has rather more the aspect, in life, of an *Oreaster* than of an *Anthenea,* as the height of the disk may be as much as 0.40R. In preserved specimens (particularly if dried) this marked elevation of the disk is commonly lost.

Pseudoreaster obtusangulus

Asterias obtusangula Lamarck, 1816. Anim. sans vert., vol. 2, p. 556.
Pseudoreaster obtusangulus Verrill, 1899. Trans. Connecticut Acad., vol. 10, p. 148.
Anthenea obtusangula Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 48; pl. 4.
Pseudoreaster obtusangulus H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 104; pl. 6 (colored).

Döderlein's (1915) figures are so good and his description so careful, it is odd he did not seem willing to recognize Verrill's genus for this handsome sea star. It is apparently confined to the northern coast of Western Australia between Augustus Island and Port Hedland. The diversity of color in life is notable (see H. L. Clark, 1938, pp. 104–105). Full-grown specimens have R = 100–115 mm.

GYMNANTHENEA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 105.

Genotype: *Anthenea globigera* Döderlein, 1915, p. (29) 50.

The sea stars of this genus have the oral surface much like that of *Pseudoreaster,* but otherwise are quite distinct. Like that genus, however, *Gymnanthenea* is found only in the seas of Western Australia, where it is represented by 2 species which may be easily distinguished as follows:

Dorsal tubercles more or less numerous; dorsal pedicellariae few, small, inconspicuous; dorsal surface covered with thin skin ..... *globigera*
Dorsal tubercles few or none; large pedicellariae conspicuous on aboral plates, especially on adradial series; 2–5 tubercles but no pedicellariae on superomarginal plates; dorsal surface covered with thick, dark skin ..... *laevis*

Gymnanthenea globigera

Anthenea globigera Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 50; pl. 8.
Gymnanthenea globigera H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 106; pl. 11, fig. 2 (juv., colored).

This species seems to range from Darwin, Northern Territory, to Turtle Island, northwestern Australia. It is common at and near Broome, but apparently rare at Darwin. The bright orange and red of early youth become variegated with, and often concealed by, duller shades. How far south *globigera* extends its range is still to be determined.

Gymnanthenea laevis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 108; pl. 19, figs. 4, 5.

Nothing is known of this species save what has been gleaned from the unique holotype, taken at the "Wallaby Group" of the Abrolhos Islands, Western Australia, in "shore collecting," by W. J. Dakin. It has R = 70 mm. and may therefore be considered adult.

ANTHENEA

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 279.

Genotype: *Anthenea chinensis* Gray, 1840, p. 279 = *Asterias pentagonula* Lamarck, 1816, vol. 2, p. 554.

This notable genus of large sea stars is characteristic of tropical Australia but occurs also in the East Indies and on the coasts of India and China. Of the 19 apparently valid species, 15 occur on the Australian coast; on the east, one species extends its range as far south as Tasmania, and on the west, another occurs down to Fremantle. Between Darwin and Cape Leveque, Western Australia, no Antheneas have yet been taken, probably because very little collecting has been done along that coast. On the Queensland coast, notably around Port Curtis, and on the Western Australian coast at Broome, Antheneas are common and diversified. Adult specimens of the 15 Australian species may be separated by the following key, but individuals with R less than 40 mm., and senescent adults, will give difficulty.

Key to the Species of Anthenea [1]

A. Arms relatively long, R = 2r more or less, narrowed distally and commonly more or less pointed, bluntly:
  B. Pedicellariae extraordinarily abundant on oral surface, many small; each inferomarginal with 6–15 or more ..... *polygnatha*

[1] Condensed from the more elaborate key in H. L. Clark, 1938, Mem. Mus. Comp. Zoöl., vol. 55, pp. 110–112.

BB. Pedicellariae not excessively abundant on oral surface, rarely more than 3 or 4 on an inferomarginal plate:
C. Disk elevated, covered with smooth, thin skin with few pedicellariae or small spinelets; interradial superomarginals low and wide, with few (1–8) granules ..... *obesa*
CC. Not as above:
D. Superomarginal plates in interbrachial arc more or less horizontal, forming conspicuous part of aboral surface:
E. Aboral surface with numerous bluntly pointed tubercles, forming 5–9 distinct longitudinal series on each ray; inferomarginal plates closely covered with small granules and only a single small pedicellaria or often none ..... *elegans*
EE. Aboral surface diverse; inferomarginals with coarse granules, at least at outer end, and usually 2 or more large pedicellariae:
Aboral tubercles numerous and coarse; upper half of superomarginals bare on each side, with a few coarse granules, often in a narrow, or even a single, vertical series ..... *crassa*
Aboral tubercles few, scattered, relatively insignificant; superomarginals rather uniformly covered with granules, though they may be fewer and coarser at upper end ..... *aspera*
DD. Superomarginal plates in interbrachial arc more or less vertical or so small they form inconspicuous part of aboral surface:
F. Pedicellariae very large both aborally (jaws up to 1.7 mm. wide) and orally (jaws up to 4 mm.), and correspondingly conspicuous ..... *crudelis*
FF. Pedicellariae numerous and not exceptionally large:
G. Disk more or less conspicuously elevated, reticulate nature of its skeleton often distinctly evident in large specimens; superomarginal plates well covered with granules clear to upper margin ..... *acuta*
GG. Disk usually not much elevated or reticulated; upper end of superomarginals more or less bare:
Superomarginals low, wide, with tubercles only on lower half; aboral tubercles low and more or less flattened ..... *australiae*
Superomarginals high, narrow, with a large granule near top and below it a swollen pair or trio, and lower half of plate covered with smaller though often coarse granules; aboral tubercles high, not flattened ..... *conjungens*
AA. Arms short and rounded at tip, form often quite pentagonal; R = 1.6–1.8r:
H. Enlarged aboral plates near arm tips, each with several (2–8) large granules or small tubercles:
I. Whole aboral surface covered with big pointed tubercles, 9–13 series on each ray ..... *acanthodes*
II. Aboral surface with relatively blunt or capitate small tubercles:
J. Aboral tubercles numerous, small, in about 9 parallel series on each ray ..... *godeffroyi*

JJ. Aboral tubercles fewer, larger, in not more than 5 series on each ray:
Dorsal surface with few small spinelets but many pedicellariae ..... *sibogae*
Dorsal surface with many more or less capitate spines and few pedicellariae ..... *mertoni*
HH. Enlarged aboral plates near arm tips, each with 1 granule or tubercle (rarely 2):
Tubercles of abactinal surface and of superomarginals few and coarse ..... *tuberculosa*
Tubercles of abactinal surface and of superomarginals small, more like large granules ..... *viguieri*

These species are now presented in alphabetical order, for convenience of reference.

Anthenea acanthodes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 124; pl. 18, fig. 2.

The status of this *Anthenea* rests on the unique holotype in the Australian Museum, from Port Curtis, Queensland. It has R = 97 mm. and hence is undoubtedly adult.

Anthenea acuta

Goniodiscus acutus Perrier, 1869. Ann. sci. nat., ser. 5, vol. 12, p. 280.
Anthenea acuta Perrier, 1876. Arch. zool. exp., vol. 5, p. 91.
Anthenea australiae var. *sidneyensis* Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 53; pl. 9, fig. 4.

Long known as the common *Anthenea* of New South Wales, this species ranges to Tasmania on the south and to Fraser Island, Queensland on the north. Whitelegge (1889) reports its occurrence at Port Jackson, in 6–15 fms.; he also lists a species *flavescens* as occurring in 0–5 fms. He remarks that "there is some confusion in reference to our single species of Anthenea." He does not lessen the confusion by listing it as two distinct species. The "Endeavour" dredged *acuta* in many places in 25–40 fms. The largest specimens had R = 115–120 mm., vertical diameter of high disk 40–50 mm. Nothing has been recorded as to the color in life.

Anthenea aspera

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 35; pl. 4, figs. 1, 2.

Two dry specimens from "Australia" served as the basis for this species, but specimens in the Australian Museum show that it is a native of the Queensland coast, where it attains a size of R = 125 mm. Occurrence at Port Curtis seems to be beyond question, but a specimen from Port Denison is less certainly *aspera*. According to a note with one of the Port Curtis specimens, the color in life was "irregular mottling of brown and sage green; actinal surface yellow."

Anthenea australiae

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 52; pl. 9, figs. 1–3.

The type locality for this species is given as Fremantle, and many specimens are said to be from there; also 1 small one from Shark Bay. It occurs at the Abrolhos

Islands and also at Broome. It reaches a size of R = 85–93 mm., but there is no record of the color in life. For further notes on the distribution of this *Anthenea,* see H. L. Clark, 1938, page 119.

Anthenea conjungens

Döderlein, 1935. "Siboga" Ast.: Oreasteridae, p. 107; pl. 27, figs. 3, 3*a*.

Based on a single specimen from Australia in the Hamburg Museum, this proves to be one of the commonest sea stars at Broome, Western Australia, and is, so far as we yet know, confined to the northwestern coast of the continent. It grows to a large size, with R = 125 mm., and the color in life shows great diversity.

Anthenea crassa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 124; pl. 18, fig. 1.

This seems to be the common *Anthenea* at Port Curtis, Queensland, where it apparently replaces *acuta,* of the coasts farther south. It reaches a fairly large size, as R may = 115 mm., and the arms are relatively long, R = 2.1–2.5r. How far *crassa* ranges north and south of Port Curtis remains to be determined.

Anthenea crudelis

Anthenea australiae var. *crudelis* Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 53; pl. 10, figs. 1, 2.
Anthenea crudelis H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 114.

The unique holotype of this species, in the Berlin Museum, is from an unknown locality, but there is some reason for thinking it came from Australia, so it seems wise to give its distinguishing characters in the key to the genus.

Anthenea elegans

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 126; pl. 18, fig. 4.

This is a common species at Broome, and is of nearly the same size as *conjungens.* Adult specimens are readily distinguished, but individuals with R less than 50 mm. are easily confused. The colors in life and the limits of the range of *elegans* are still to be discovered and recorded.

Anthenea godeffroyi

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 45; pl. 11.

This species rests on a single specimen in the Museum Godeffroy. When described, it was supposed to be from Samoa, but further consideration led Döderlein to believe it was from Australia.

Anthenea mertoni

Koehler, 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 268; pl. 16, figs. 1, 2.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 121; pl. 7 (colored).

Originally known from only a single specimen taken at the Aru Islands, this well marked species is now known to occur on the coast of the Northern Territory of Australia and in the Gulf of Carpentaria. Large specimens have R = 85–95 mm. A large adult from Darwin had (in life) the upper surface gray with large, irregular blackish-brown blotches, and the oral surface light reddish buff. We did not find *mertoni* west of Darwin.

Anthenea obesa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 127; pl. 19, fig. 1.

Nothing more is known of this apparently well marked species. The 2 known specimens were taken by the "Endeavour" off Geraldton, Western Australia, in 29 fms. The color in life was recorded as scarlet or crimson.

Anthenea polygnatha

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 128; pl. 18, fig. 3; pl. 19, figs. 2, 3.

The apparent dimorphism of this *Anthenea* is one of its striking features and deserves further investigation. Should it prove to be sexual, it would be a most interesting novelty among sea stars. The species is as yet known only from the Lacepede Islands and the vicinity of Broome. It grows to a large size, R = 125–130 mm., and is either purple-violet or orange in color, but difference in form does not seem to be associated with any constant difference in color.

Anthenea sibogae

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 47; pl. 10, fig. 5.

The status of this species is dubious, as it was described from a single large specimen (R = 102 mm.) and its relation to *tuberculosa* Gray, *mertoni* Koehler, and *viguieri* Döderlein is still a confusing problem. Material of all these species is scanty and so scattered that direct comparison between the types is impracticable. It is hard to believe that the specimen figured from life from Thursday Island (H. L. Clark, 1921, pl. 6, fig. 1) and the one, also figured in its living colors, from Darwin (H. L. Clark, 1938, pl. 7, figs. 1, 2) are the same species. It is at present impossible to determine how many valid species of this short-armed, flattened, more or less pentagonal type occur on the tropical Australian coast, east of Cambridge Gulf.

Anthenea tuberculosa

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 77.
——— 1866. Syn. sp. starfish, p. 9; pl. 4, figs. 1, 1*a*.

This species is based on a single specimen from Port Essington, but no *Anthenea* was found on my visit to that isolated spot in 1932. Without additional living material, I can throw no light on the validity and connections of this species. The record of McNeill and Livingstone (1926) probably refers to the preceding species, but the specimen was not full grown and its specific characters may be incompletely developed. Livingstone's (1932) specimens, taken by the Great Barrier Reef Expedition, are all much too young to be of any service in defining the species.

Anthenea viguieri

Döderlein, 1915. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, p. 34; pl. 5, figs. 2, 3.

This species, described from one individual from an unknown locality, is allowed a place in the Australian fauna on the strength of a specimen from Restoration Island, Queensland, now in the Museum of Comparative Zoölogy. But the identity of this specimen with Döderlein's type is not beyond debate.

Family OREASTERIDAE

This interesting family of large, littoral, tropical sea stars, almost wholly confined to the Indo-Pacific region, seems to need critical revision, as the limits accepted and used by Döderlein are much wider than those used by Fisher. In my judgment, the family is better defined and is a more natural group if recognized in Fisher's sense, and I am therefore following him here in the use of the name Oreasteridae. On the other hand, Döderlein's segregation of several groups of Oreasters, in the old sense of that generic name, seems proper and useful, and two of them are used here for some of the Australian members of the family. The genus *Asterodiscus* is regarded by Döderlein as a goniasterid, but it is, in my opinion, more naturally associated with the Oreasters. The 5 genera of this family which are found on the Australian coasts may be distinguished as follows:

Key to the Genera of Oreasteridae

A. Arms well developed, as distinct from disk; r much less than two-thirds R:
  B. Arms rather abruptly narrowed distally, tips without pair of swollen, smooth, hemispherical plates:
    Distal actinal and inferomarginal plates closely covered by pavement of unequal, polygonal platelets, flat and smooth; no obvious reticulation of abactinal skeleton ..... *Protoreaster*
    Distal actinal and inferomarginal plates covered by unequal, irregular, rounded granules; abactinal skeleton more or less markedly reticulate ..... *Pentaceraster*
  BB. Arms more or less triangular, not narrowed at tip, where there is conspicuous pair of swollen, smooth hemispherical plates ..... *Asterodiscus*
AA. Form nearly pentagonal or even circular; r more than two-thirds R:
  Upper surface with irregularly arranged, more or less circular but often ill defined papular areas; actinal surface not tessellated, covered with more or less irregular granules and spinelets ..... *Culcita*
  Upper surface with regularly arranged, triangular papular areas; actinal surface regularly tessellated, with no spinelets or granules ..... *Halityle*

PROTOREASTER

Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 420.

Genotype: *Asterias nodosa* Linné, 1758, p. 661.

This is a small but well defined group of 3 or 4 species, occurring in the Indian Ocean and northeastward to the Ryukyu Islands and southeastward to Queensland. The 2 Australian species may be distinguished thus:

Papular areas more or less confluent; big dorsal tubercles often pointed and bare ..... *nodosus*
Papular areas small and conspicuously distinct; dorsal tubercles rounded and not bare ..... *nodulosus*

Protoreaster nodosus

Asterias nodosa Linné, 1758. Syst. Nat., ed. 10, p. 661.
Protoreaster nodosus Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 420.
Oreaster nodosus H. L. Clark, 1921. Ech. Torres Strait, p. 31; pl. 24, fig. 1; pl. 25, figs. 1, 2.

This is a conspicuous East Indian sea star whose range extends to Torres Strait and the northern end of the Barrier Reef, and even as far south as Port Denison on the Queensland coast. In life, Torres Strait specimens are brilliantly colored red and blue, with considerable individual diversity as to shade and extent of each color. Whether this striking coloration is characteristic of the species throughout its range is not known, but Livingstone (1932) says that around Port Denison the predominating colors, according to E. H. Rainford, are crimson and white, and Barbour's notes on specimens collected at Amboina and New Guinea (see H. L. Clark, 1908*a*) indicate that although red is usual, blue is lacking in specimens from north of Torres Strait. Full-grown specimens have R = 175–200 mm., but most of those in museums are considerably smaller.

Protoreaster nodulosus

Pentaceros nodulosus Perrier, 1876. Arch. zool. exp., vol. 5, p. 53.
Protoreaster nodulosus Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 420.
——— 1936. "Siboga" Ast.: Oreasterinae, p. 323; pl. 22, figs. 1–5.

This is the common oreasterid of Australia's northwestern coast, having been taken at various points between Shark Bay and Augustus Island. In Roebuck Bay and southwestward it is particularly common and a striking feature of the shallow-water fauna. The absence of red in the coloration is a conspicuous difference between it and the preceding species. It is also somewhat smaller than *nodosus,* R not often exceeding 160 mm. A more detailed account of form and color will be found in H. L. Clark, 1938.

PENTACERASTER

Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 424.

Genotype: *Asterias mamillata* Audouin, 1826, p. 209.

This is another group segregated by Döderlein from *Oreaster sens. lat.,* and, like *Protoreaster,* it is represented in tropical Australia by 2 species, one of which is common on the Queensland coast; the other, apparently rare in Torres Strait, ranges southward on the Queensland coast to the vicinity of Port Curtis, and westward to the Lacepede Islands, Western Australia—perhaps farther, as is suggested by a specimen from an unknown locality in the Perth Museum. The 2 species are easily distinguished thus:

R = rather less than 2.5r usually, arms not abruptly narrowed distally; disk large but high (height one-sixth or more of maximum diameter of whole animal), not regularly reticulated; with more or less numerous

conical tubercles, 5 conspicuously big (one at beginning of each carinal series); interbrachial sides of disk concave ..... *australis*

R = 2.5r or more, rather abruptly narrowed distally; disk large, low (height not more than one-seventh or one-eighth of maximum diameter), markedly reticulated, with no conspicuously big tubercles, and more or less straight sides in interbrachial arcs ..... *gracilis*

Pentaceraster australis

Oreaster australis Lütken, 1871. Vidensk. Medd., vol. 23, pp. 252, 263.
Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 247; pl. 6, figs. 1–6; pl. 7, figs. 1–4; pl. 8, figs. 5, 6; pl. 10, figs. 1–4.
Pentaceraster australis Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 433.

This is the common oreasterid of the Queensland coast, ranging from south of Double Island Point to Lizard Island (Eagle Islet) in the far north. The exact limits of its range are not as yet known. Livingstone's (1932) account of his observations on the specimens from Eagle Islet is a most important and admirable piece of work. Döderlein's (1936) revision of the Oreasterinae is equally valuable, but leaves me unconvinced that *australis* is identical with *regulus* Müller and Troschel. The latter species is far too little known to justify such a conclusion. Hence it is better to retain the name *australis* for the Australian species. Livingstone's photographs of *australis* reveal a diversity of form and tuberculation which demands a still more detailed study of a far larger series of specimens. In large adults, R = 150 mm. and more. No accurate data on the color in life are available.

Pentaceraster gracilis

Oreaster gracilis Lütken, 1871. Vidensk. Medd., vol. 23, p. 260.
Pentaceraster gracilis Döderlein, 1916. Zool. Jahrb., Abt. syst., vol. 40, p. 427.
——— 1936. "Siboga" Ast.: Oreasterinae, p. 357; pl. 31, figs. 1, 2.

This is one of the rarest of the Oreasteridae and is still very imperfectly known. The few specimens in museums are from tropical Australia: several are known from Torres Strait; 1 from southwest of Lady Elliott Island, Queensland; 1 from North Island, Sir Edward Pellew group, Gulf of Carpentaria; 1 from the Lacepede Islands, Western Australia; and 1 is in the Perth Museum from "Western Australia." Bell's record from Saya de Malha, Indian Ocean, may be ignored, as his records from Port Denison and Port Molle almost certainly refer to the preceding species; Döderlein, however, reports 4 specimens in the Hamburg Museum from Port Denison, so it is possible Bell had an "Alert" specimen from that place. Koehler (1910*a*) gives excellent figures and a very detailed description of a young oreasterid (*Pentaceros rouxi*) which both Döderlein and I consider a young *gracilis*. It was taken at the Aru Islands, and this is the northernmost record for this species. The largest reported specimen is that taken by the "Challenger" near Booby Island, Torres Strait, which Sladen described under the name *Pentaceros callimorphus*. In this individual R measured 278 mm., but no other specimen is recorded with R over 235 mm. An interesting account of the coloration in life is recorded by McNeill and Livingstone (1926), based on the large specimen (R = 175 mm.) taken by W. E. J. Paradice at North Island, Gulf of Carpentaria. Paradice's notes show that white and olive green predominate, with tubercles orange and yellow.

ASTERODISCUS

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 75.

Genotype: *Asterodiscus elegans* Gray, 1847, p. 75.

Although Döderlein became convinced that this genus was goniasterid and removed it from the Oreasteridae, its relationship to the latter family seems to me more probable, and I follow Fisher (1919) in retaining it therein. The single Australian species is conspicuously different, however, from its allies in those seas and is easily distinguished from its East Indian congeners by the great size of the abactinal tubercles.

Asterodiscus truncatus

Coleman, 1911. Mem. Australian Mus., vol. 4, p. 699.

Apparently this sea star occurs along the southern coast of Australia from off Botany Bay, New South Wales, to the western end of the Great Australian Bight, in 47–200 fms. Nothing is recorded as to the color or appearance in life. The largest specimens as yet taken have R = 150–165 mm.

CULCITA

L. Agassiz, 1835*a*. Mém. Soc. sci. nat. Neuchâtel, vol. 1, p. 192.

Genotype: *Asterias discoidea* Lamarck, 1816, vol. 2, p. 554 = *Asterias schmideliana* Retzius, 1805, p. 11.

Specific lines in this genus are hard to draw, but apparently only a single species occurs in Australia. It shows no little individual diversity, but on the whole keeps its specific characters reasonably clear.

Culcita novaeguineae

Müller and Troschel, 1842. Syst. Ast., p. 38.
Döderlein, 1896*a*. Semon's Ast., *in* Jena Denkschr., vol. 8, p. 310; pl. 19, figs. 1–4.
H. L. Clark, 1921. Ech. Torres Strait, p. 32; pl. 5, fig. 1 (colored).

This remarkable pentagonal sea star seems to occur only on the most tropical coasts of Australia, ranging from the Low Isles, near the northern end of the Barrier Reef, westward through Torres Strait to Augustus and Champagny islands, on the northern coast of Western Australia. Young individuals (under 80 mm. in diameter) are so flat and otherwise unlike the adults that they have been described under three other generic names. Adults become so swollen and cushion-like that they tend to lose their sea-star traits aborally. They reach a large size, with a horizontal diameter of 200 mm. and a vertical one of 80 mm.. For a full account of form, color, habits, etc., see H. L. Clark, 1921. For a discussion of possible varietal forms see Livingstone, 1932*b*, but the desirability of recognizing these varieties by name is dubious. The range of the species appears to be from Mauritius to Samoa, and northward to southernmost Japan. The exact limits of its range to the south are as yet unknown, but Livingstone (1932) records it as being "as common as any other asteroid at Low Isles," except *Linckia laevigata*. He gives no clues to the size of his specimens.

HALITYLE

Fisher, 1913*a*. Proc. U. S. Nat. Mus., vol. 46, p. 211.

Genotype: *Halityle regularis* Fisher, 1913*a*, p. 211.

It seems quite certain that *Culcitaster* H. L. Clark, 1914, is not generically different from *Halityle,* though at first sight the body form seems quite unlike. Since only a single specimen of the Australian species is known, and only 3 of that from the Philippines, further discussion of their relationship had best await more material.

Halityle anamesus

Culcitaster anamesus H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 145; pl. 19.

The unique holotype of this species is in the Western Australian Museum at Perth, but lacks all data as to its origin, though "it is said to have been taken on the coast of West Australia." As R = 185 mm. and r = 110 mm., in its present dry state, it must have been at least 16 inches across when living. There is no hint as to the color in life.

Family ASTEROPIDAE

This small family consists of but 3 or 4 genera occurring in the southern hemisphere, 2 of which are Australian, though not confined to that continent. It is rather close to the Poraniidae, a family chiefly found in the northern hemisphere, which is somewhat more nearly allied to the Asterinidae. The 2 Australian genera may be distinguished as follows:

Marginal and some abactinal plates with large spines ..... *Asterope*
No large abactinal spines ..... *Petricia*

ASTEROPE

Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., Apr., p. 104.

Genotype: *Asterias carinifera* Lamarck, 1816, vol. 2, p. 556.

This well marked genus is widely distributed in the Indo-Pacific region, with one species ranging from Mozambique, Zanzibar, and the Red Sea on the west to the Hawaiian and Society islands on the east, and a second occurring in the Galápagos Islands and on the Mexican coast.

Asterope carinifera

Asterias carinifera Lamarck, 1816. Anim. sans vert., vol. 2, p. 556.
Asterope carinifera Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., p. 104.
H. L. Clark, 1921. Ech. Torres Strait, p. 33; pl. 5, fig. 2 (colored).
Gymnasteria carinifera von Martens, 1866. Arch. f. Naturgesch., vol. 32, pt. 1, p. 74.
Goto, 1914. Monog. Japan. Ast., p. 610; pl. 18, figs. 270, 271.

This widely distributed sea star seems to have but a limited occurrence in Australia, as it has been found as yet only at the northern end of the Barrier Reef from

the Low Isles to Mer. Fully grown individuals have R = 65–70 mm. Specimens from the Low Isles are recorded as "of a very dark chocolate hue," whereas those found at Mer were more olive green and drab. For details see H. L. Clark, 1921, page 33. The absence of *Asterope* from Torres Strait and the coast farther west is quite remarkable.

PETRICIA

Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 81.

Genotype: *Petricia punctata* Gray, 1847, p. 81 = *Asterias vernicina* Lamarck, 1816, vol. 2, p. 554.

This is a definitely Australasian genus, confined to the Kermadec Islands and the southern side of the Australian continent, where it occurs in shallow water along shore. There are seemingly 2 Australian species, but it is not certain that they do not intergrade. They are apparently to be distinguished by the following characters:

Rays narrow distally, with granules, spinelets, or tubercles on marginal plates; skin smooth and shiny in dried specimens ..... *vernicina*
Rays broad and rounded at tip, with no tubercles, spinelets, or even granules on distal marginal plates; skin thick and dull ..... *obesa*

Petricia vernicina

Asterias vernicina Lamarck, 1816. Anim. sans vert., vol. 2, p. 554.
Petricia vernicina Fisher, 1908*a*. Zool. Anz., vol. 33, p. 357.
Petricia punctata Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 80.
——— 1866. Syn. sp. starfish, p. 16; pl. 6, figs. 1, 1*a*.

Jan 1964 Brilliant mauve – Long Reef

This species is said by Whitelegge (1889) to be common under stones in Chowder Bay and at Watson's Bay in Port Jackson. A large series of specimens in the South Australian Museum suggests that it is not rare in Spencer and St. Vincent gulfs, and Stach (1938) reports it as common at Reevesby Island, Spencer Gulf. Adult specimens have R = 50–58 mm., and Stach (*loc. cit.*) reports the color in life as "brilliant brick-red." He gives photographs (pl. 18), one-half natural size, of 2 specimens, which supplement admirably the drawings reproduced by Gray (1866). The diversity in the number and arrangement of the big, isolated, sunken, bivalve pedicellariae is very great (see H. L. Clark, 1928, p. 388), and no reliance can be placed on them for specific characters.

Petricia obesa

H. L. Clark, 1923. Jour. Linn. Soc. (Zool.), vol. 35, p. 241; pl. 13, figs. 1, 2.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 142; pl. 10, fig. 1 (colored).

This beautiful sea star was first taken at Pelsart Island, Abrolhos group, Western Australia, but has since been found on the mainland coast near Point Peron and farther south at Bunkers Bay. The largest specimen has R = 75 mm. The color in life is such a brilliant scarlet that *obesa* is one of the most striking of Australian sea stars. Whether it is really isolated on the west coast and specifically distinct from *vernicina* remains to be shown.

Family METRODIRIDAE

This is an isolated group, the correct status and relationships of which it is very difficult to determine. It is based on a single monotypic genus. Formerly associated with the Echinasteridae, it is now considered more nearly allied to the Asteropidae, chiefly because of the character of the dorsal plates. The single genus is easily recognized by the small disk, long, slender, terete arms, isolated papulae, and small but numerous, rather stout spinelets.

METRODIRA

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

Genotype: *Metrodira subulata* Gray, 1840, p. 282.

This genus, though a hundred years old, is still known only from a single species, which has a definitely East Indian distribution and has been frequently described, figured, and discussed.

Metrodira subulata

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 282.
Koehler, 1910. Indian Mus. Ast., p. 172; pl. 4, figs. 1, 2; pl. 18, fig. 9.
——— 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 284; pl. 15, figs. 3–5.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 187; pl. 11, fig. 3 (colored).

This odd sea star seems to be widely distributed from Ceylon and the Andaman Islands eastward to the Philippines and southward to Lindeman Island, Queensland, but it has been taken in some numbers only at Broome on the northwestern coast of Australia; a single specimen from Carnarvon reveals that the range extends to that northwestern corner of the continent. The largest reported specimen, having R = 82 mm., is from Lindeman Island. The great majority of known specimens are much smaller, with R = 50 mm. or less. The handsome blue, white, and rust coloration in life is very fugitive. There is much diversity in the relative length and thickness of the arms and the size of the disk, as R = 5.5–9br; as a rule R = 6–7r and 7–8br.

Family OPHIDIASTERIDAE

This is a large tropicopolitan family of sea stars occurring on all the coasts of Australia, commonly in shallow water, and particularly associated with corals and rock slabs on the tropical reefs. The small disk and long, often cylindrical or subcylindrical arms are characteristic features. The colors in life are often bright; red, blue, purple, and variegated forms are frequent. The 11 genera occurring in Australia may be distinguished as follows, but a more extended key accompanying a revision of the whole family was published in H. L. Clark, 1921, pages 36–94.

Key to the Genera of Ophidiasteridae

A. Abactinal plates of ray not in regular longitudinal series:
  B. Adambulacral armature spiniform:
    C. Papulae on actinal surface as well as on abactinal:

D. Papulae isolated, not in groups:
Size moderate or small, usually much less than 100 mm. across alternate rays; seldom more than 2 series of actinal papulae ..... *Fromia*
Much larger, often more than 100 mm. across; 3–6 series of actinal papulae ..... *Austrofromia*
DD. Papulae in groups; rays more or less terete ..... *Nardoa*
CC. No papulae on actinal surface ..... *Neoferdina*
BB. Adambulacral armature granuliform:
Papulae in groups; skeletal plates covered with granules ..... *Linckia*
Papulae usually single or in groups of 2–4; skeletal plates swollen and bare, separated by granules ..... *Bunaster*
AA. Abactinal plates in regular longitudinal series; obscured in some senescent Ophidiasters:
E. Body wall rigid, with well developed skeleton:
F. Whole test covered with thick, smooth skin ..... *Leiaster*
FF. Whole test more or less covered with granules or little tubercles:
G. Papular areas present on actinal surface, at least 1 series below inferomarginals:
Papular areas in 8 series; rays cylindrical ..... *Ophidiaster*
Papular areas in 10 series; rays often somewhat trigonal at base ..... *Hacelia*
GG. Papular areas wanting on actinal surface, in only 6 series abactinally ..... *Tamaria*
EE. Body wall thick and leathery without rigid abactinal skeleton ..... *Pseudophidiaster*

FROMIA

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

Genotype: *Asterias milleporella* Lamarck, 1816, vol. 2, p. 564.

This genus of more than a dozen species is typically Indo-Pacific in its distribution, ranging from the Red Sea and Madagascar to Hawaii and Samoa. None is of large size, R rarely exceeding 50 mm. These sea stars live under slabs of rock or coral, or among coral fragments. Only 3 species occur in Australia. Two of these are from the Queensland coast in very shallow water, but neither has been found in Torres Strait or on the northern coast. One of the 2, however, has been found at the Abrolhos Islands, Western Australia, where half a dozen specimens of the third species were also taken.

Key to the Species of Fromia

A. Rays short and wide, R = 2.5–3.8r and 2.5–3.3br:
Disk and rays flat; rays often more than 5 and madreporites often 2 or 3; furrow spinelets 3 or 4 ..... *milleporella*
Disk and rays convex; rays 5; madreporite single; only 2 furrow spinelets ..... *andamanensis*
AA. Rays 5, long and narrow; R = 3.5–5.5r and 4–5br ..... *elegans*

Fromia milleporella

Asterias milleporella Lamarck, 1816. Anim. sans vert., vol. 2, p. 564.
Fromia milleporella Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 286.
de Loriol, 1885. Mém. Soc. phys. hist. nat. Genève, vol. 29, no. 4, p. 44; pl. 16, figs. 2–4.
H. L. Clark, 1921. Ech. Torres Strait, p. 40; pl. 7, figs. 4, 5 (colored).

This pretty little sea star seems to extend its range southward along the Barrier Reef to Low Isles and to Coates Reef, outer Great Barrier Reef, between 17° and 19° S., but it is not known from the mainland coast, nor from Torres Strait. Northward it reaches the Ryukyu Islands, Japan, and westward it is known from the Red Sea, Mauritius, and Madagascar. To the east it reaches Fiji and Samoa at least, and a specimen in the Museum of Comparative Zoölogy is said to be from the Low Archipelago, collected by the U. S. Exploring Expedition. As is well known, too much reliance must not be placed on this label. The specimen may be from Samoa. No Fromias are known from Hawaii or the Society Islands. The bright red color is very fugacious, and preserved specimens range from dull brown to white. In life, these little sea stars, rarely over 60 mm. across, live on the under surface of rock fragments in shallow water.

Fromia andamanensis

Koehler, 1909. Indian Mus. deep sea Ast., p. 105; pl. 7, figs. 5, 6.
H. L. Clark, 1923*a*. Jour. Linn. Soc. (Zool.), vol. 35, p. 239.

The status of this species is very dubious. Originally described from a single small specimen (R = 27–29 mm.) taken at the Andaman Islands, supposedly at 238–290 fms., it has since been reported only from Houtman's Abrolhos Islands, Western Australia, where half a dozen specimens were taken by W. J. Dakin in very shallow water, in 1913 or 1915. Owing to lack of material for comparison, the identification of these specimens needs verification. In fact, the specific limits in *Fromia* are most unsatisfactory, since only 1 of the 15 species which have been assigned to the genus is known from as many as a dozen specimens, and of most, not more than 2 or 3 specimens are known. The probability that the type of *andamanensis* is from shallow water, and that the depth to which it is assigned by Koehler (and presumably by the label with it) is due to a mistake, is very great. The largest of the Australian specimens has R = 54 mm., and hence is practically double the size of the unique holotype of the species. Notes on the color in life would be a great help in determining relationships.

Fromia elegans

H. L. Clark, 1921. Ech. Torres Strait, p. 43; pl. 7, fig. 3 (colored); pl. 29, figs. 5, 6.

This is an endemic species so far as is yet known, and since it has been found at three widely separated points, it is probably pretty well distributed on the tropical coasts of Australia. It has not been found elsewhere, for although Domantay and Roxas (1938) record it from the Philippines, it is evident both from the figures given and from their description of the color in life that their specimens are different from the Australian species. The Murray Islands at the northern end of the Barrier Reef are the type locality, and the next record was from the Abrolhos Islands, Western Australia, where Dakin collected 2 specimens which seem to be identical with Murray Islands material (see H. L. Clark, 1923*a*). In 1924, W. E. J. Paradice took 2 Fromias on Coates Reef, outer Great Barrier Reef, Queensland, between 17° and 19° S., which cannot be distinguished from the type specimens. And yet diligent collecting in 1929 and 1932 failed to find a single *Fromia* of any species between Torres Strait and Fremantle, Western Australia, although

no little collecting was done in areas where local conditions seem very suitable. Evidently these sea stars require very definitely balanced environmental conditions.

AUSTROFROMIA

H. L. Clark, 1921. Ech. Torres Strait, p. 48.

Genotype: *Fromia polypora* H. L. Clark, 1916, p. 51.

This is a south temperate genus with a single species in South African waters and one in those of southern Australia. It is possible that there is more than one Australian species, but material is still much too scanty to make it feasible to determine whether the Tasmanian form differs constantly from the West Australian.

Austrofromia polypora

H. L. Clark, 1916. "Endeavour" rept., p. 51; pl. 14, figs. 1, 2.

Large specimens of this species have R = 95–112 mm. with the minor radius about one-fifth as much. The width of the arms is from one-fifth to one-fourth of their length. The color of living specimens has never been recorded, but some alcoholic specimens are reddish buff, suggesting that in life the color is some shade of red. Only 7 specimens have as yet been taken, but these show that the species ranges from Tasmania to Rottnest Island, Western Australia. It is possible that more than one species is represented in this series.

NARDOA

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

Genotype: *Asterias variolatus* Lamarck, 1816, vol. 2, p. 565.

The Nardoas are notable sea stars of graceful form and often of large size. About a dozen species are known, of which half occur in the tropical waters of northeastern Australia. None are known from Torres Strait or west thereof except *tuberculata,* whose right to a place in the Australian fauna is dubious. The other 5 species are all found at the Murray Islands, where they form a conspicuous feature of the echinoderm fauna (see H. L. Clark, 1921, pp. 49–55). The Australian Nardoas may be distinguished thus:

Key to the Species of Nardoa

A. No abactinal or marginal plates noticeably tuberculiform:
  B. Superomarginal plates not alternately large and small:
    C. Abactinal plates on distal part of ray not markedly and rather abruptly different from those on basal part ..... *pauciforis*
    CC. Abactinal plates on distal part of ray markedly and somewhat abruptly smaller and more crowded than basally:
      Many large abactinal plates 2.5 mm. in diameter or more; ground color light brown ..... *novaecaledoniae*
      Few or no large abactinal plates; ground color deep, rich brown ..... *mollis*
  BB. Superomarginal plates more or less regularly alternating, large and small ..... *rosea*

AA. Some and often many abactinal plates swollen and more or less conspicuously tuberculiform:
Tubercles small, 2 mm. or less in diameter ..... *tuberculata*
Tubercles very large, often 2.5–4 mm. in diameter ..... *mamillifera*

Nardoa pauciforis

Linckia pauciforis von Martens, 1866. Arch. f. Naturgesch., vol. 32, pt. 1, p. 69.
Nardoa pauciforis Sladen, 1889. "Challenger" Ast., p. 412.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 381; pl. 108, fig. 3.
Nardoa finschi de Loriol, 1891. Mém. Soc. phys. hist. nat. Genève, suppt. vol., no. 8, p. 28; pl. 2 (11), figs. 4–4*g*.

This species, in which R may be as much as 140 mm., is fairly common at the northern end of the Barrier Reef from Seaforth Island, about 50 miles north of Mackay, to Mer and Erub at the entrance to Torres Strait. It is also known from Flores, Amboina, New Britain, and the Philippines (Cebu). The color in life is more or less bright buff or fawn color.

Nardoa novaecaledoniae

Scytaster novaecaledoniae Perrier, 1875. Arch. zool. exp., vol. 4, p. 426 (p. 162 of reprint).
Nardoa novaecaledoniae Sladen, 1889. "Challenger" Ast., p. 412.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 380; pl. 108, fig. 2.

This species has the same distribution (from Green Island, Queensland, to New Caledonia and the Philippines) as the preceding, which it resembles in size and color. The difference in the distal abactinal plates seems to be constant, and dissection shows it is not associated with sex.

Nardoa mollis

de Loriol, 1891. Mém. Soc. phys. hist. nat. Genève, suppt. vol., no. 8, p. 26; pl. 3 (12), figs. 4–4*f*.

This is a less common species than the 2 preceding, and has as yet been taken only at Mer; New Britain; Port Galera Bay, Mindoro, Philippine Islands; the Sulu Archipelago; and Andaman Islands. It reaches almost as large a size as its congeners, but the color is much darker, a deep olive brown associated with a velvety texture quite different from that of the allied species.

Nardoa rosea

H. L. Clark, 1921. Ech. Torres Strait, p. 53; pl. 10, fig. 1 (colored); pl. 29, figs. 1, 2.

As this beautiful sea star is known only from the northern end of the Barrier Reef, it must be regarded as the most definitely endemic species of Australian Nardoas, but it is by no means common, as only half a dozen specimens are known. One of these is from Heron Island in the Capricorn group, one from Eagle Islet, and the remainder from Mer. It is somewhat smaller than the species already listed, as R = 78 mm. or less. The roseate color so striking in life is unfortunately evanescent, and no trace of it remains in preserved specimens.

Nardoa tuberculata

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 287.
Koehler, 1910. Indian Mus. Ast., p. 160; pl. 17, figs. 1, 2.

This is a widely distributed East Indian *Nardoa* of large size (R = 130 mm.) and distinctive appearance, but it is very doubtful whether it occurs in Australian waters. It is included here on the basis of Bell's (1894) record "from Northwestern Australia, 9–38 fms." Though it is not at all impossible that it should occur in that region, *Nardoa* is not otherwise known from west of Torres Strait, south of Timor.

Nardoa mamillifera

Livingstone, 1930. Rec. Australian Mus., vol. 18, p. 20; pl. 7, figs. 1–5.

This well marked species is based on a unique specimen, with only 3 rays, in which R = 63 mm. Obviously the absence of 2 rays is accidental, probably the result of an attack by a fish. The color in life is unknown. This extraordinary sea star was taken in 1907 at Mer, where six years later the Carnegie Institution's party during a stay of five weeks took 4 other species of *Nardoa,* but failed to find a second specimen of *mamillifera.* Apparently it is most nearly allied to *N. tumulosa* Fisher from the Philippines, but Livingstone makes no reference to that species in his account of *mamillifera.*

NEOFERDINA

Livingstone, 1931. Australian Zoologist, vol. 6, p. 307.

Genotype: *Ferdina cumingii* Gray, 1840, p. 283.

Livingstone's clear differentiation of the two quite distinct types of sea stars confused in Gray's genus *Ferdina* justifies his establishment of this genus, in which he includes half a dozen species. It is probable, however, that abundant material will reduce this number at least one-half. Only a single species has yet been reported from Australia, but the few known specimens show so much diversity that it seems probable more than one species is involved.

Neoferdina ocellata

Ferdina ocellata H. L. Clark, 1921. Ech. Torres Strait, p. 60; pl. 6, fig. 5 (colored); pl. 31, figs. 1, 2.
Livingstone, 1930. Rec. Australian Mus., vol. 18, p. 18; pl. 6, figs. 1, 2.
Neoferdina ocellata Livingstone, 1931. Australian Zoologist, vol. 6, p. 307.

This beautiful and unusual sea star is known as yet from only 3 specimens. Of these, the 2 from Mer seem to be unquestionably conspecific, but the one from Northwest Islet, described and figured by Livingstone, is superficially very different. Until further material is obtained, however, it is best to use a single name for the trio. No Neoferdinas have been taken in Torres Strait or west thereof.

LINCKIA

Nardo, 1834. Oken's Isis, vol. 7, p. 717.

Genotype: *Linckia typus* Nardo, 1834, p. 717 = *Asterias laevigata* Linné, 1758, p. 662.

This tropicopolitan genus, to which no fewer than 45 nominal species have been referred, is widespread on the tropical coasts of Australia, but of the 3 species, only 1 is locally common, and 1 is known from but 2 specimens taken at a single place. The 45 nominal species are now considered to represent not more than 8 or 10 valid forms, a fact which shows how great are the growth changes and the individual diversity in the genus. The 3 Australian species, however, are easily recognized and may be distinguished by the following characters:

Key to the Species of Linckia

A. Adambulacral furrow spines separated by vertical series of several granules ..... *laevigata*

AA. Furrow spines not separated by granules:

No abactinal plates conspicuously enlarged and swollen ..... *guildingii*

Numerous abactinal plates enlarged and swollen ..... *tyloplax*

Linckia laevigata

Asterias laevigata Linné, 1758. Syst. Nat., ed. 10, p. 662.

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

H. L. Clark, 1921. Ech. Torres Strait, p. 64; pl. 9, figs. 1, 2 (colored); pl. 26, fig. 1.

Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 254; pl. 3, fig. 1; pl. 4, figs. 2, 5.

This sea star is notable among all its kin for its conspicuous blue color when adult, and its habit, then, of lying exposed to the tropical sun without shelter. A full account of its habits and reactions is given in H. L. Clark, 1921. It is abundant at Mer, but does not occur in, or west of, Torres Strait. Its Australian range reaches as far south as the Palm Islands (19° S.), and wherever conditions are favorable it is abundant. It is widespread in the Indo-Pacific region, but owing to its confusion with other species hitherto, the exact limits of its range are still uncertain. It reaches a large size, R sometimes 200 mm., but most adults are not much more than half that.

Linckia guildingii

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 285.

A. Agassiz, 1877. Mem. Mus. Comp. Zoöl., vol. 5, p. 105; pl. 14, figs. 1–6.

Linckia ehrenbergii de Loriol, 1885. Mém. Soc. phys. hist. nat. Genève, vol. 29, no. 4, p. 31; pl. 10, figs. 1–7*a*.

This large, inert, and ungraceful sea star is notable for its tropicopolitan distribution and for its peculiarly unreliable coloration. In the West Indies small specimens are dull purplish red often mottled indefinitely with gray, and thus are inconspicuous among corals and coral fragments. As they get bigger they become more unicolor, and when adult (R = 150–215 mm.) they are often found out on sandy bottoms, a uniform yellow-brown. This is also often the color in the Indo-

Pacific area and in Australia, but both in the West Indies and in the Pacific, the uniform color may not be brown, but violet or even (in Australia) bright blue. So far, no structural characters have been discovered associated with these color vagaries, and their cause and purpose is unknown. Here is a problem of fascinating interest for a physicochemical-experimentally minded zoologist to attack.

In Australia, *guildingii* has been found at Lord Howe Island, at Masthead Island, Queensland, at Yonge and Ribbon reefs (farther north on the Great Barrier, where it is reported as "very common"), and at Broome, Western Australia, where half a dozen specimens of widely different colors have been taken. But nowhere does it seem to multiply and become a conspicuous feature of the shallow-water fauna as *laevigata* does.

Linckia tyloplax

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 147; pl. 20.

This curious species is more of a deep-water form than either of the preceding, for it is known, as yet, only from 80–120 fms. off the coast of Western Australia, between Geraldton and Perth. The color is very dark, and the numerous swollen abactinal plates give it a very un-*Linckia*-like appearance. It reaches a large size, 1 of the 2 specimens having R = 150 mm.

BUNASTER

Döderlein, 1896*a*. Semon's Ast., *in* Jena Denkschr., vol. 8, p. 317.

Genotype: *Bunaster ritteri* Döderlein, 1896*a*, p. 317.

The members of this genus are among the smallest species in the family and are as yet little known. Of the 4 species, 3 are known from only a single specimen each. One of these is from the Philippine Islands and one from Amboina. The 2 Australian species may be distinguished as follows:

Rays with single series of abactinal plates between superomarginals ..... *uniserialis*
Rays with 3 series of abactinal plates on basal half ..... *variegatus*

Bunaster uniserialis

H. L. Clark, 1921. Ech. Torres Strait, p. 69; pl. 7, fig. 2 (colored); pl. 36, figs. 5–7.

The unique holotype of this pretty little sea star was taken from a cranny in coral in 5–6 feet of water on the southwestern reef at Mer, Murray Islands, Torres Strait. It had R = only 11 mm., so it probably is not more than half grown. The color in life was prettily variegated with maroon, brown, and bluish white. The dried specimen is variegated with brown of different shades and buffy white. The supposedly distinctive character, a single series of abactinal plates on the rays, may be associated with youthfulness.

Bunaster variegatus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 134; pl. 22, fig. 1.

Of this species 17 specimens are known, of which the largest, presumably adult, have R = 23 mm. As in the other species, the color is variegated, with brown,

diverse reddish shades, and white predominating; the colors are for the most part lost in alcoholic material. Apparently *variegatus* is an endemic species of southwestern Australia, as it has not been taken on the mainland coast north of Rottnest Island. It was found, however, by Dakin at the Abrolhos Islands, at both Pelsart and Wooded islands. E. W. Bennett found 2 specimens at Bunkers Bay, near the southwestern corner of the continent. Although 11 of the known specimens are from Rottnest Island, all were taken after our visit October 18–19, 1929, when we did not find a single specimen.

LEIASTER

Peters, 1852. Monatsber. K. preuss. Akad. Wissensch. Berlin, p. 177.

Genotype: *Leiaster coriaceus* Peters, 1852, p. 177.

Although 8 species of *Leiaster* have been described, none is known from sufficient material to give an adequate understanding of its distinctive characters. Apparently these sea stars live so closely associated with corals that they are difficult to find and even when found are very hard to collect. Robert Baxter, who gave us the specimen brought from Lord Howe Island in 1932, said that it took him half an hour to dig it out of the coral rock. It is very doubtful whether more than a single species occurs in Australia. The few specimens known are from the two widely separated islands, Mer and Lord Howe. Apparently the only distinguishing character is the color, and on this character alone they may for the present be maintained.

Color variegated, orange-yellow and bright red, with or without magenta.....*leachii*
Color uniformly crimson.....*speciosus*

Leiaster leachii

Ophidiaster leachii Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 284.
Leiaster leachii de Loriol, 1885. Mém. Soc. phys. hist. nat. Genève, vol. 29, no. 4, p. 40; pl. 14, figs. 1–2*c*.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 136; pl. 9 (colored).

Although de Loriol's colored figure indicates a uniformly red sea star, his description refers to orange and two quite different shades of red, which would seem to indicate a variegated coloration in his Mauritius specimens similar to that of those taken at Lord Howe Island. No Leiasters are yet recorded from the Australian mainland, and the geographical distribution of *leachii* is very imperfectly known. It is at least odd that the Lord Howe species should be the one best known from Mauritius and East Africa. It reaches a very large size, R = 250–275 mm.

Leiaster speciosus

von Martens, 1866. Arch. f. Naturgesch., vol. 32, pt. 1, p. 70.
H. L. Clark, 1921. Ech. Torres Strait, p. 74; pl. 11 (colored); pl. 27, figs. 1, 2.

Judging wholly from the appearance in life of the *Leiaster* collected at Mer in 1913 and of the one Baxter gave me at Lord Howe Island in 1932, it is hard to believe they can be the same species. But in preserved specimens, the differences

are insignificant. Until far more material is available, however, it may be best to continue using the name *speciosus* for the short-armed (R = 7br in life), unicolored crimson individuals, and *leachii* for the long-armed (R = 14br in life), particolored ones. Flores, Mindoro in the Philippines, and Macclesfield Bank are the only other known localities for *speciosus* unless we accept Sladen's record from Kandavu in Fiji. According to Domantay and Roxas (1938), the Leiasters from Mindoro are "gorgeously brilliant red," and even when dried, R = about 8br. Their largest specimen had R = 250 mm.

OPHIDIASTER

L. Agassiz, 1835*a*. Mém. Soc. sci. nat. Neuchâtel, vol. 1, p. 191.

Genotype: *Asterias ophidiana* Lamarck, 1815, vol. 2, p. 567.

This is the largest and most widely distributed genus in the family, with at least 20 valid species, of which 7 are reported from Australia, all from the eastern tropical coast. No *Ophidiaster* has been found west of Torres Strait or of Bass Strait. The smaller species are not clearly distinguishable, and the line between *Ophidiaster* and *Tamaria* is by no means sharply drawn in nature. Adult Australian Ophidiasters, however, may be distinguished by the following key. In life the species are more or less distinctively colored, but in preserved material these characters have generally vanished. Of 3 of the species, the holotype alone is known, and of the other 4, only 1 (*confertus*) has as yet been collected in adequate numbers.

Key to the Species of Ophidiaster

A. Adambulacral spines in close contact, no granules separating them:
- B. No abactinal plates conical with bare tips:
  - C. No spinelets or conspicuously enlarged granules abactinally even at tip of rays ..... *lioderma*
  - CC. Spinelets or enlarged granules present abactinally near distal end of rays:
    - Rays stout, R = 4–4.5br; distal spinelets rather inconspicuous; actinal papular areas well developed ..... *granifer*
    - Rays slender, R = 5–7br; distal spinelets well marked; actinal papular areas only on basal part of rays or wanting in small specimens ..... *armatus*
- BB. Many abactinal plates conical with bare tips ..... *watsoni*

AA. Adambulacral spines separated more or less markedly by granules:
- D. Adambulacral spines in pairs, pairs separated by granules ..... *propinquus*
- DD. Adambulacral spines not clearly in pairs and separated by granules:
  - Papulae numerous in conspicuous large groups (10–20 in each); pedicellariae numerous ..... *confertus*
  - Papulae 3–8 in each rather ill defined area; pedicellariae few or wanting ..... *squameus*

Ophidiaster lioderma

H. L. Clark, 1921. Ech. Torres Strait, p. 80; pl. 27, figs. 3, 4.

This fine species is still known only from the holotype, which in life had R = 115 mm. and a dull light brownish-red coloration. It was found near extreme low-water mark on the southwestern reef at Mer, Murray Islands.

Ophidiaster granifer

Lütken, 1871. Vidensk. Medd., vol. 23, p. 276.
H. L. Clark, 1921. Ech. Torres Strait, p. 81; pl. 7, fig. 1 (colored); pl. 29, figs. 3, 4.

Ranging from Port Galera, Mindoro, and Port Palapag, Samar, Philippine Islands, eastward to the Carolines and to the Tonga Islands, and south to Green Island, Queensland, this small *Ophidiaster* (R = only 30–32 mm.) has a characteristic facies. The colors are gray and brownish red. It is fairly common at Mer and was also found at Erub (Darnley Island).

Ophidiaster armatus

Koehler, 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 277; pl. 15, fig. 8; pl. 17, fig. 6.

This species is still too imperfectly known (only half a dozen specimens) to make a discussion of its relationships profitable. The largest known specimen (R = 66 mm.) is from Lindeman Island, Queensland, and Koehler's types are from the Aru Islands. Specimens recorded from the Caroline and Andaman islands are apparently wrongly identified. The color in life has not been recorded, but preserved specimens range from brown, with papular areas much darker than the convex plates which separate them, to deep yellowish violet with 2 or 3 irregular yellowish annulations on the distal third of the arm.

Ophidiaster watsoni

Livingstone, 1936. Rec. Australian Mus., vol. 19, no. 6, p. 386; pl. 28, figs. 1, 3, 5, 7.

This interesting species is known only from the holotype, which has R = 50 mm. It was taken at Bushy Island, off Mackay, Queensland, on the edge of the coral reef at low tide. That it is an *Ophidiaster* seems doubtful, nor does the relationship to *armatus* seem at all obvious. Further material is essential.

Ophidiaster propinquus

Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 255; pl. 12, figs. 5, 11, 16, 18.

This is another species known only from the holotype. It was taken on Ribbon Reef, Great Barrier Reef, northeast of Cape Flattery, Queensland. It is a small form with R only 26.5 mm., and has several important diagnostic characters. Aside from the arrangement of the adambulacral spines in separated pairs, the double series of subambulacral spines or tubercles and the rather uniform granulation of the abactinal plates are good recognition marks.

Ophidiaster confertus

H. L. Clark, 1916. "Endeavour" rept., p. 53; pl. 15, figs. 1, 2.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 138; pl. 10, figs. 2, 3 (colored).

This is the one Australian *Ophidiaster* of which sufficient material has been collected to warrant confidence in its specific characters. It is one of the common

echinoderms of Lord Howe Island, and Livingstone (1930) reports it from three stations on the coast of New South Wales. He also records a specimen from North-West Islet, Capricorn group, Queensland, and a specimen from Heron Island, in the same group, is in the Museum of Comparative Zoölogy, the gift of Melbourne Ward. Full-grown specimens have R = 155–160 mm. The usual habitat is among coral heads and rock fragments with little attempt at concealment. The color in life is deep tawny yellow or orange-brown; extremes are yellow-orange and, on the other hand, almost a red-brown. The oral side along the ambulacral grooves shows the brightest tint.

Ophidiaster squameus

Fisher, 1906. Bull. U. S. Fish Comm. no. 23, p. 1079; pl. 31, figs. 6–6*b*; pl. 37, fig. 4.
H. L. Clark, 1921. Ech. Torres Strait, p. 83; pl. 8, fig. 2 (colored).

This species seems to be widely distributed in the Pacific region, as it is reported from the Philippines, Hawaii, the Paumotus, and the Murray Islands. The type locality is in Hawaii, but the type specimens were very small, the larger having R only 19 mm. Specimens with R = 35–45 mm. from off Waikiki Beach in 4½ fms. are now in the Museum of Comparative Zoölogy. The only specimen from the Paumotus is very small (R = 23 mm.), but the identification is seemingly correct. The Murray Island specimens are apparently adults of the Hawaiian species; they are the only ones known from Australia. The record for the Philippines (Domantay and Roxas, 1938) rests on a single specimen with R = 37 mm. found under a rock at Gabino Point, Port Galera, Mindoro. It differs markedly in coloration from all the other known specimens, for whereas the latter were red (vermilion to crimson, in different cases, and more or less variegated), the Port Galera specimen was "reddish-purple, mottled with dull violet and grayish-brown"; the madreporite was "deep orange," and the actinal side was "reddish-purple mottled with brown," with orange on the "adambulacral and ambulacral spines." The figures given certainly look like *squameus,* but obviously more material is necessary.

HACELIA

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 284 (as subgenus).

Genotype: *Ophidiaster attenuatus* Gray, 1840, p. 284.

Only 4 species are assigned to this genus, but they are widely distributed, with 1 in the Mediterranean and eastern Atlantic, 1 in the West Indies, 1 in the East Indies, 1 in tropical Australia. The Australian species seems to be most like the European, but the latter is the only one of which adequate material has been collected.

Hacelia helicosticha

Ophidiaster helicostichus Sladen, 1889. "Challenger" Ast., p. 405; pl. 69, figs. 5–7.
Hacelia helicosticha H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, no. 7, p. 111.

Originally taken near Booby Island, Torres Strait, this fine sea star was later collected by the "Alert" in Prince of Wales Channel and in the Arafura Sea. It has been reported also from Holothuria Bank, much farther west, and a large

specimen in the Australian Museum, with R = 150–155 mm., is from "northwestern Australia." The bathymetrical range is 6–36 fms. Bell's (1884) record of a specimen with R = 213 mm. is obviously an error, as the measurement of the lesser radius is out of proportion. If his other measurements are correctly given, R in the biggest specimen would be about 165 mm., making it much the largest specimen known. Nothing is recorded as to the color in life.

TAMARIA

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

Genotype: *Tamaria fusca* Gray, 1840, p. 283.

This is the most perplexing group of sea stars occurring in the Australian region, for the absence of adequate adult material of the type species and the extraordinary growth changes that occur in at least one of the others have led to much confusion. Livingstone (1930, 1932, 1932*a*) has given much attention to the group and has published many admirable figures, but since he has given no "key" to the species and no comparative tabulation of their characters, I am unable to make out what distinctive features his 18 figures of *fusca* reveal which set that species apart from *ornata* and young *megaloplax*. He is, moreover, skeptical as to the validity of the genus *Tamaria* because young Ophidiasters often pass through a *Tamaria*-like stage, and large (probably senescent) Tamarias are quite *Ophidiaster*-like. It may be that the line between the two genera is arbitrary and unnatural, but in the species, such as *tumescens* and *megaloplax,* which can be defined from adequate adult material, the generic limits of *Tamaria* seem fully justified. To prevent further confusion, I am accepting both *fusca* and *ornata* as valid species. The only specimens available to me are very youthful ones identified by Livingstone, but although they are obviously not conspecific, I do not think either shows reliable specific characters. My key to the Australian species of *Tamaria* must be presented in the following negative form:

Key to the Species of Tamaria

A. Abactinal plates conspicuously tumid, covered with a rather smooth coat of coarse granules; papular areas large with many (10–20) papulae; inferomarginal spines may or may not be present ..... *tumescens*

AA. Not as above:

B. Granulation very coarse; papular areas small, deep-sunken, with very few papulae; large central pointed tubercles or spinelets present on many marginal plates, especially near tip of arm ..... *ornata*

BB. Not as above:

Granulation irregular, with central granules on each plate large, often becoming conspicuous pointed tubercles or spines, most frequent and evident in half-grown specimens but becoming resorbed in adults; papular areas large, with 10–20 papulae ..... *megaloplax*

Not as above ..... *fusca*

Tamaria tumescens

Ophidiaster tumescens Koehler, 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 277; pl. 16, figs. 3, 4.

Tamaria propetumescens Livingstone, 1932*a*. Rec. Australian Mus., vol. 18, p. 369; pl. 42.

Tamaria tumescens H. L. Clark, 1921. Ech. Torres Strait, p. 94.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 141.

This fine *Tamaria* was first described from the Aru Islands in 10 fms. and later was reported from Parry Shoal, west of Melville Island, northern Australia. In 1932, it was found to be fairly common near Broome, and its lovely old-rose color was first revealed. It grows to a large size (R = 98 mm.) and shows much diversity in the arrangement of the aboral plates.

Tamaria ornata

Ophidiaster ornatus Koehler, 1910. Indian Mus. Ast., p. 151; pl. 18, figs. 3, 4.
Tamaria ornata Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 260; pl. 12, fig. 2.

As the only known specimens of this *Tamaria* are very young, its validity as a species is dubious. Its right to a place in the Australian fauna is based on the fact that a small specimen with R = 22 mm. is in the Museum of Comparative Zoölogy from Holothuria Bank in the Timor Sea.

Tamaria megaloplax

Linckia megaloplax Bell, 1884. "Alert" rept., p. 126.
Tamaria megaloplax Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 259; pl. 9, figs. 1–3; pl. 12, figs. 8, 12, 14.
——— 1932*a*. Rec. Australian Mus., vol. 18, p. 369; pl. 40.
Ophidiaster tuberifer Sladen, 1889. "Challenger" Ast., p. 404; pl. 55, figs. 1–4.
Tamaria tuberifera H. L. Clark, 1921. Ech. Torres Strait, p. 90; pl. 8, fig. 1 (colored).
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 139.

Livingstone has given much attention to the problems involved in Bell's confusion of 2 or more species in his original description of this sea star. It was well described and figured by Sladen under a different name, but Bell's has priority. The range of the species extends from the northern part of the Barrier Reef (off Snake Reef, 13½ fms.), Queensland, to Broome, and Livingstone includes also the Andaman Islands and Philippines (Sulu Archipelago, *fide* Fisher, 1919). Full-grown specimens have R = 90–100 mm. and lack entirely the spinelets so evident in half-grown individuals, an extraordinary growth change. The color in life is an attractive combination of shades of brown and gray. Further material is necessary for understanding the diversity involved in the growth changes.

Tamaria fusca

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 283.
Livingstone, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 8, p. 257; pl. 9, figs. 4–7; pl. 11, figs. 1–4, 7, 8; pl. 12, figs. 1, 4, 6, 7, 10, 15, 17, 19.

The only specimen of this species at hand is one with R = 12 mm. from off Direction Island, Queensland, taken by the Great Barrier Reef Expedition and identified by Livingstone. It is of course very young and its specific characters are uncertain. It has more pedicellariae and a finer coating of granules than any other *Tamaria* I have seen. It is very different from the adult *fusca* (R = 50 mm.)

figured by Livingstone in 1930 (pl. 8, figs. 2, 5). The distribution of *fusca* as given by Livingstone in 1932 is "Philippine Islands, Celebes and coast of North Queensland."

PSEUDOPHIDIASTER

H. L. Clark, 1916. "Endeavour" rept., p. 54.

Genotype: *Pseudophidiaster rhysus* H. L. Clark, 1916, p. 54.

This odd ophidiasterid seems to be quite set apart from the rest of the family by its characteristic modification for a deep-water life.

Pseudophidiaster rhysus

H. L. Clark, 1916. "Endeavour" rept., p. 55; pl. 16, figs. 1, 2.

The few known specimens of this endemic Australian sea star were taken along the southern coast of the continent between Oyster Bay, Tasmania, and the Great Australian Bight in 60–200 fms. In size they range from R = 58 to R = 150 mm. The color in life is reported to be dark purple; dry specimens are dingy gray or brown.

Order SPINULOSA

This order is not so large as the preceding and is not nearly so conspicuous a feature of the Australian marine fauna. Of the 9 families represented, 3 are now extinct and occur only as fossils, and 3 of the remainder have but one representative each. The extinct forms are very different from any of the living sea stars and throw little light on the history of the present fauna. The 9 families are to be distinguished as follows:

Key to the Families of Spinulosa

A. Inferomarginal plates wanting or, if present basally, in contact with adambulacrals, hence no actinolateral plates; all extinct:
  B. Rays short and wide with single series of superomarginal plates; lower surface covered by huge adambulacrals and opposite ambulacrals ..... Monasteridae
  BB. Not as above:
    Interbrachial areas practically wanting; no inferomarginals; rays long and tapering; abactinal surface covered with numerous small plates ..... Urasterellidae
    Interbrachial areas more or less well developed; inferomarginals developed proximally but only in contact with adambulacrals .. Schuchertiidae
AA. Inferomarginal plates present, more or less separated from adambulacrals by well developed actinolateral plates; chiefly Recent:
  C. Mouth plates small; ambulacral furrows narrow:
    D. Abactinal skeleton formed of closely imbricating plates, usually bearing spines or spinelets; actinal skeleton formed of imbricating plates, bearing a tuft or fan of spinelets or 1 or 2 small spines ..... Asterinidae

DD. Abactinal skeleton formed of plates in longitudinal and transverse series forming a more or less open meshwork:
E. No pedicellariae; abactinal skeleton reticulated, with spines, spinelets, or groups of spinules; interbrachial septa rudimentary or wanting ..... Echinasteridae
EE. 2-jawed pedicellariae present; disk large; interbrachial septa well developed:
Rays and madreporites numerous; skeleton open-reticulated, armed with large, isolated spines ..... Acanthasteridae
Rays 5; madreporite single; abactinal plates regularly arranged, bearing small, isolated spines ..... Valvasteridae
CC. Mouth plates large, plowshare shape; ambulacral furrows wide; adambulacral armature pectinate:
No supradorsal membrane, or segmental pores or papillae; interbrachial septa calcified ..... Solasteridae
Supradorsal membrane complete; segmental pores and papillae present; interbrachial septa not calcified ..... Pterasteridae

Family *MONASTERIDAE

This family was instituted by Schuchert (1915) for a single genus containing a remarkable sea star occurring in the Permocarboniferous rocks of New South Wales. It is an isolated form, and, though included in the Spinulosa, has very little resemblance to any of the other sea stars included in the order; the real relationships have yet to be worked out.

*MONASTER

Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 71.

Genotype: *Palaeaster clarkei* de Koninck, 1877, p. 166.

Etheridge proposed this group as a subgenus, but Schuchert (1915), after careful study and discussion, raised it to full generic rank, as it has no close relationship with *Palaeaster*. Only a single species is known.

*Monaster clarkei

Palaeaster clarkei de Koninck, 1877. Foss. Pal. Nouv.-Galles du Sud, pt. 3, p. 166; pl. 7, figs. 6, 6*a*.
Palaeaster (*Monaster*) *clarkei* Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 71; pl. 14, figs. 1, 2; pl. 15, fig. 4.

Only 4 specimens of this remarkable sea star have as yet been found, 1 in the Upper Marine series, and 3 in the Lower Marine series of the Permocarboniferous rocks of County Northumberland, New South Wales. As Paleozoic sea stars go, it is a large species, R = 50–65 mm. The great width of the rays in proportion to the length is one of the most striking features.

Family *URASTERELLIDAE

This family was believed by Schuchert (1915) to contain but a single genus, to which he assigned a dozen species from North America, Europe, and Australia.

Withers and Keble (1934), however, consider the Australian species are best placed in 2 genera, which may be distinguished thus:

All the rows of adradials exactly similar ..... *Salteraster*
Rows of adradials not exactly alike ..... *Urasterella*

*SALTERASTER

Stürtz, 1893. Verhandl. Naturhist. Ver. preuss. Rheinland, vol. 50, pp. 43, 60.

Genotype: *Palaeaster asperrimus* Salter, 1857, p. 325.

Schuchert (1915) was doubtful about the validity of this genus, but Withers and Keble (1934) after careful study of Victorian specimens consider it worthy of recognition. They distinguish 2 Australian species thus:

Rays elongate, tapering, with median radial series of plates and 3 series of adradials on each side ..... *selwyni*
Rays short, not tapering, with only 2 series of plates on dorsal side above inferomarginals ..... *biradialis*

*Salteraster selwyni

Urasterella selwyni McCoy, 1874. Prodr. palaeontol. Victoria, dec. 1, p. 42; pl. 10, figs. 2, 3.
Salteraster selwyni Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 235; pl. 11, figs. 1, 2.

This little sea star, with R only 13 mm., is known only from the Silurian rocks of the range on the eastern side of Commonage Reserve, Kilmore, Victoria.

*Salteraster biradialis

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 237; text figs. 9, 10; pl. 11, fig. 5.

Of this tiny sea star only 2 specimens were found, 1 with R about 12 mm., the other with R only about 7 mm. They were taken "from the same open reddish sandstone bed on the eastern side of Commonage Reserve, Kilmore, Victoria" as *S. selwyni*.

*URASTERELLA

McCoy, 1851. Brit. Pal. foss., p. 59.

Genotype: *Uraster ruthveni* Forbes, 1848, p. 463.

McCoy's account gives no distinctive features of the genus, but he proposes it for 2 species, *ruthveni* and *hirudo*. As the latter is very possibly the young of *ruthveni*, the first-named and better-known species should be regarded as the genotype. Of the dozen species listed by Schuchert, only 1 occurs in Australia, and that is now included in the preceding genus. But a new species of *Urasterella* was described in 1934 from Victoria, and thus the genus remains in the Australian fauna.

*Urasterella creswelli

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 234; pl. 12, fig. 6.

Based on a single specimen, with R only 10 mm., this little sea star is possibly a *Salteraster,* but the high quality of the work of its authors warrants accepting their judgment as to its generic position. It was found in the "mudstone quarries" in the Yeringian (Silurian) strata of Lilydale, Victoria, associated with an abundant fauna of marine invertebrates.

Family *SCHUCHERTIIDAE

This family, including but a single genus, is regarded by Schuchert (1915) as "the most primitive and ancient of all large-disked or pentagonal sea-stars devoid of marginals." He stated that it was known only from North America, but Spencer (1922) records it from Great Britain, and Withers and Keble (1934) have added it to the Australian fauna.

*SCHUCHERTIA

Gregory, 1899. Geol. Mag., n. s., dec. 4, vol. 6, p. 351.

Genotype: *Palasterina stellata* Billings, 1857, p. 290.

Two good-sized fossils which are apparently congeneric but are certainly not conspecific justify including this North American and British genus in the Australian fauna. The 2 forms are easily separated as follows:

Disk large, its diameter greater than length of free arms.....*macrata*
Disk rather small, its diameter much less than length of free arms.....*junori*

*Schuchertia macrata

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 239; pl. 12, fig. 3.

A poorly preserved fossil from Hoffman Brick Pit, Brunswick, Victoria, is the holotype and only known specimen of this sea star. It has R = 40 mm., r = 15. The rock in which it was found is a "bluish mudstone," in Silurian strata "100 feet below the surface."

*Schuchertia junori

Withers and Keble, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 238; pl. 10, fig. 3.

This species is also based on a single specimen in the National Museum at Melbourne, but it is finely preserved, though the apical side is wanting. It has R = 35 mm., r = 9. It was found "in hard greenish sandstone" in "Collins Quarry, Kinglake West," Victoria, the facies of which is "distinctly upper Silurian."

Family ASTERINIDAE

This widely distributed family is very well represented in Australia, and on rocky shores and reefs these sea stars are an interesting part of the fauna, especially in the tropics. Most of the species are secretive and are found clinging closely to the under side of rock fragments or concealed in crevices, but a few occur on sandy

bottoms, and one of the largest species lives concealed just beneath the surface on bottoms of pure sand. Many species are brightly colored, but in some the specific coloration is excessively diversified and inconstant. Most of the species are small, with R less than 50 mm. There is great diversity of form, however, some being flattened with r nearly equal to R, while at the other extreme are species with slender, more or less nearly cylindrical rays and R = 5–6r. The 9 genera occurring in Australia are distinguished from one another chiefly by body form and proportions, by the character of the abactinal plates, and by the spinulation.

Key to the Genera of Asterinidae

A. Form not excessively flattened, v.d. = 0.15 h.d. or more; papulae widely distributed over abactinal surface:
  B. Disk large; rays and body more or less flattened, with r tending to be ½ R or more:
    C. Abactinal skeleton rigid, no plates carrying long spines:
      D. Actinal spinulation not sacculate; no patch of uncalcified membrane in actinal intermediate areas near mouth:
        E. Abactinal plates not obviously divided into 2 areas; no regular, crowded, transverse series of small rounded plates along sides of rays:
          Abactinal plates of papular areas all of one kind, not crescentic or notched for papulae, wholly or partly spinulose ..... *Asterina*
          Abactinal plates of papular areas of 2 or more kinds, the larger crescentic or notched for papulae ..... *Patiriella*
        EE. Abactinal plates divided into 2 areas: one, on disk and along radial crests, of crescentic plates; the other, comprising rest of upper surface, covered by regular, crowded transverse series of small, rounded plates ..... *Paranepanthia*
      DD. Actinal spinulation sacculate; patch of uncalcified membrane in each actinal intermediate area near mouth ..... *Disasterina*
    CC. Abactinal skeleton not rigid, many plates not in close contact with their fellows; on distal part of arm they carry long, slender spines ..... *Manasterina*
  BB. Disk small; rays more or less elongate and tending to be cylindrical or at least arched dorsally, or markedly trigonal:
    F. Rays not trigonal and keeled:
      Abactinal plates, at least larger ones, definitely crescentic; papulae evident ..... *Nepanthia*
      Abactinal plates not crescentic, crowded, often swollen; papulae inconspicuous or invisible ..... *Parasterina*
    FF. Rays trigonal and keeled ..... *Tegulaster*
AA. Form excessively flattened, v.d. less than 0.10 h.d.; papulae confined to narrow radial bands ..... *Anseropoda*

ASTERINA

Nardo, 1834. Oken's Isis, vol. 7, p. 716.

Genotype: *Asterina minuta* Nardo, 1834, p. 716 = *Asterias gibbosa* Pennant, 1777, p. 62.

The sea stars composing this genus are mostly small, pentagonal forms living on the lower surface of rocks and coral fragments. A few species have 6 or more

rays and, at least in youth, reproduce by fission. They show great diversity in color, but within each species the general tint is fairly constant. They are most abundant in the tropics, but are to be found on all the coasts of Australia and particularly at Lord Howe Island, where 4 species were taken.

Key to the Species of Asterina

A. Rays 5 only:
- B. Form more or less pentagonal, though sides may be concave; r = ⅔ R or more:
  - C. Actinal intermediate plates with single short, blunt spine or none ..... *atyphoida*
  - CC. Actinal intermediate plates with 2 or more spinelets:
    - D. Spinelets of actinal plates 2 or 3, long and slender, exceeding width of plate ..... *perplexa*
    - DD. Spinelets of actinal plates short, often minute:
      - E. Abactinal plates practically bare; actinal plates with minute spinules in central group of 2–4:
        - Interradial margins markedly concave; papulae large, in about a dozen longitudinal series on basal half of each ray; colors in life gray, orange, and white ..... *nuda*
        - Interradial margins nearly straight or even convex; papulae small, in about 8 series; colors in life white and dull blue ..... *inopinata*
      - EE. Abactinal plates with minute spinelets in crescentic series; actinal plates with distinct "fans" of 4–6 slender spinules; color in life orange or orange-yellow ..... *lutea*
- BB. Form more or less stellate; r = about ½ R or less:
  - F. Abactinal plates bare; actinal plates with 1–3 minute spinelets ..... *alba*
  - FF. Abactinal plates with numerous spinelets:
    - G. Abactinal plates with straight or curved compressed ridges, densely crowned with very minute spinules ..... *scobinata*
    - GG. Not as above:
      - H. Abactinal spinelets blunt, scarcely twice as long as thick, forming granular coat ..... *crassispina*
      - HH. Abactinal spines slender and acute, often minute:
        - Some, usually many, abactinal plates along radial areas irregularly and conspicuously enlarged as bases for clusters of enlarged spinules ..... *coronata*
        - No such swollen plates ..... *burtonii*

AA. Rays 6, 7, or 8:
- Abactinal spinelets low, blunt; 1 or 2 minute acute spinelets on actinal intermediate plates ..... *heteractis*
- Abactinal spinelets minute, acute; 3 or more minute, short spinelets on each actinal plate ..... *anomala*

Asterina atyphoida

H. L. Clark, 1916. "Endeavour" rept., p. 57; pl. 17, figs. 1, 2.

This is the *Asterina* characteristic of the southern coasts of Australia, as it has been taken as yet only in the vicinity of Kangaroo Island and in Spencer and St. Vincent gulfs. It is a small species, the largest yet taken being only 22 mm. across. Nothing is recorded as to the color in life. The close resemblance to the Panamic *Asterina modesta* is noteworthy.

Asterina perplexa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 155; pl. 22, fig. 4.

A single specimen of this *Asterina* was taken at Ned's Beach, Lord Howe Island, April 6, 1932, and no other specimen is as yet known. It has R = 14 mm. and is now pale brown; in life it was "white but with indefinite orange-yellow areas aborally; orally, pure-white."

Asterina nuda

H. L. Clark, 1921. Ech. Torres Strait, p. 98; pl. 23, figs. 3, 4.

This species also was described from a single specimen, from the other end of the Barrier Reef, found on the under side of a rock fragment at Weier, Murray Islands, September 30, 1913. It was about 33 mm. in diameter and the color was notably different from that of any other *Asterina* found at the Murray Islands. The upper surface was deep pearl gray, lightest in interradii, darkest on crest of rays; plates at tip of ray distinctly purple; marginal plates orange-brown; area around anus bright orange; madreporite white; lower surface faintly mottled brown, orange, and white; tube feet whitish. The dry specimen is dull brownish yellow. Livingstone (1933) reports 2 specimens in the Australian Museum from the "type locality" (presumably meaning the Murray Islands), but he gives no information about them.

Asterina inopinata

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 3; pl. 5, figs. 1–8, 14.

This is one of the most attractive species of *Asterina* yet known, the flattened, nearly circular form and the very unusual coloration combining to give it a fine appearance. The color in life is white more or less clouded and blotched with blue; the younger the specimen, the less the blue. The shade of blue varies in different individuals, from dusky to a definite dark blue. In alcohol, the white becomes cream color and the blue a dusky green. Dried specimens lose all distinctive coloring. The largest specimen yet reported has R = 20 mm. Livingstone has recorded interesting growth changes, very young individuals having interradial slits (lunules) as in *Tremaster,* which are gradually obliterated as the individual grows. The significance of this extraordinary fact is a complete mystery. *Tremaster* is known as yet only from moderately deep water in the western North Atlantic, whereas *inopinata* is found only on the southeastern corner of the Australian continent, from the Tuggerah "lakes," New South Wales, to Tasmania, in very shallow water.

Asterina lutea

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 153; pl. 12, fig. 2 (colored).

This is one of the characteristic sea stars of the Broome region, but we did not find it west of Roebuck Bay. Bardwell obtained a specimen far to the east, however, at either Augustus or the Champagny islands. Its bright color makes it fairly easy to discover on overturned rock fragments. The very young are white, becoming more and more bright orange as they mature, but some individuals be-

come only a dull yellow or a grayish orange. Full-grown specimens are 40–45 mm. across, with the sides nearly straight but sometimes concave, sometimes convex. Non-pentamerous variants are rare, but 1 tetramerous and 1 hexamerous specimen were taken.

Asterina alba

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 150; pl. 22, fig. 7.

So far as is yet known, this species is endemic at Lord Howe Island, but it will probably be found on the Barrier Reef and possibly on the mainland coast. It is so small (R = 7–9 mm.) and secretive that it is easily overlooked, yet the color is not at all protective. It is more or less pure white, but the largest individuals show, under a lens, traces of orange-yellow and a few scattered dusky or purple patches on the aboral surface. It occurs often with the usually non-pentamerous species *anomala,* but its consistent pentamerous symmetry is evidenced by the occurrence of only 1 hexamerous individual, which shows no evidence of autotomy.

Asterina scobinata

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 1; pl. 5, figs. 9–12, 15.

This species was based on 3 pentamerous individuals, with R = 11–13 mm., from Tasmania. Five additional specimens from Tasmania were taken in 1929, and 4 are now in the Museum of Comparative Zoölogy. In them, R = 7–15 mm. They show considerable diversity in body form, but it is probable that this is largely due to varied methods of killing and preservation. The color in life of 2 of these was deep brown above, cream color below, in sharp contrast. If this coloration is constant, it is distinctive. The types had 5 pairs of small noncalcified spots in the actinal interradial areas, and these can be made out with more or less difficulty in the other specimens, but are of diverse size and position.

Asterina crassispina

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 390; fig. 112.

Only a single specimen of this *Asterina* is known. It is in the South Australian Museum, dry, and not in very good condition, but shows the distinctive characters well. In it, R = 20 mm. and r = 11. It is supposed to be from the coast of the Northern Territory, but whether from the northeastern or northwestern side there is no clue.

Asterina coronata

von Martens, 1866. Arch. f. Naturgesch., vol. 32, pt. 1, p. 73.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, pp. 411–416; pl. 115, figs. 1–3; pl. 116, figs. 1, 2.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 145; pl. 12, fig. 1 (colored).

This is the distinctive and characteristic sea star of Darwin and vicinity, but it has not yet been taken either in Queensland or in Western Australia. It is known from various stations in the East Indian region north to southern Japan and east to the Caroline Islands. Fisher (1919) has made a careful study of the

diversities shown and recognizes 3 subspecies besides von Martens' original *coronata*. The name *fascicularis* belongs to the North Australian form. It is a rather handsome green and red star with R = 30–33 mm. The references given above supply all details.

Asterina burtonii

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 289.
H. L. Clark, 1921. Ech. Torres Strait, p. 96; pl. 6, fig. 2 (colored).
Asterina cepheus Müller and Troschel, 1842. Syst. Ast., p. 41.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 411; pl. 115, fig. 4.

As I said in 1921, the abandoning of Gray's name seems to me unjustified, despite my dislike for attaching human proper names to plants and animals. There is, I believe, no doubt as to the sea star which Gray called *Asterina burtonii*. It is widespread in the Indo-Pacific region from Mozambique to the Paumotus, but does not seem to have been found common anywhere. Full-grown specimens may be 40 mm. across, but most museum specimens are less than that. Little is recorded as to the color in life. Australian specimens were orange-vermilion when small (R = 10–12 mm.), but big ones were greenish gray. They have been taken at the Murray Islands, Torres Strait, at Roebuck Bay and Shark Bay, Western Australia, and at Long and Wooded islands, Houtman's Abrolhos.

Asterina heteractis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 152; pl. 22, fig. 5.

As all the known material of this species came from Lord Howe Island, it must be considered endemic there, but as it is small and secretive and not easily seen and collected, it may well be found in the Barrier Reef region if not on the coast of New South Wales. There are 4 specimens, but only 1, the holotype, with R = 7 mm., can be considered even approximately adult. It has 7 similar rays, and the color in life was salmon pink above and whitish below. The other specimens show that reproduction occurs by autotomy, for 1 has 6 rays, with 3 on one side twice as large as the opposite 3, and the other 2 have but 3 arms each. These 3 specimens were light orange or whitish in life.

Asterina anomala

H. L. Clark, 1921. Ech. Torres Strait, p. 95; pl. 7, fig. 8 (colored); pl. 23, fig. 5; pl. 26, figs. 2, 3.

In addition to the account given in 1921, all that is further known of this odd little sea star is given in H. L. Clark, 1938, pages 143–144. Intensive collecting at Mer and at Lord Howe revealed this species at each end of Australia's eastern reef region. It is of course probable that it will be found in many suitable spots between these extremes. The species is very small, with R = 10–12.5 mm. in the largest individuals. The number of rays ranges up to 8, with 5 the least common—only about 1 in 75 is pentamerous. More than half the known specimens have 7 rays. Conditions at Lord Howe seem to suit this little sea star well, as it is found there by the hundred. It was found just once west of Torres Strait, 2 small specimens being collected at Cape Leveque, Western Australia. These had

the characteristic green and red coloration of the Barrier Reef specimens, with the red predominant. A careful study of the asexual reproduction of this species would be rewarding.

PATIRIELLA

Verrill, 1913. Amer. Jour. Sci., ser. 4, vol. 35, pp. 480, 483.

Genotype: *Asterina* (*Asteriscus*) *regularis* Verrill, 1867, p. 250.

This genus is characteristic of the southern hemisphere and is well represented in Australia by 7 species, at least 3 of which are among the commonest of Australian sea stars. They occur among and under rocks in very shallow water, even above low-water mark in some favored areas. Excepting *exigua,* they do not occur in the tropics, but only on the more southern coasts of the continent. The species are distinguished as follows, but it should be noted that 2 species are known from only a single specimen each, 1 is known from 1 indubitable and 3 more dubious examples, and a fourth supposed species is not certainly distinct from *gunnii.*

Key to the Species of Patiriella

A. Rays normally more than 5; no suboral spine on oral plates:
  B. Rays 7–9, normally 8; actinal intermediate plates usually with single spine ..... *calcar*
  BB. Rays 5–7, normally 6; actinal intermediate plates usually with 2 spines:
    Colors in life diversified; spines of actinal plates more or less cylindrical and bluntly pointed ..... *gunnii*
    Unicolor, usually more or less purple; tube feet orange; spines of actinal plates very short, flat, and truncate ..... *brevispina*
AA. Rays normally 5; 1 or more suboral spines on oral plates:
  C. Only a single suboral spine:
    Form stellate; only a single spine on actinal intermediate plates except sometimes near disk margin ..... *mimica*
    Form pentagonal; 2 spines on distal actinal intermediate plates; color in life, black ..... *nigra*
  CC. 2 or more suboral spines, though there may be but 1 on some plates:
    Rather large, R = 27 mm.; markedly stellate; innermost oral spine flat, very wide, notched at tip ..... *inornata*
    Small, R rarely exceeds 15 mm.; more or less pentagonal; innermost oral spine not peculiar ..... *exigua*

Patiriella calcar

Asterias calcar Lamarck, 1816. Anim. sans vert., vol. 2, p. 557.
Asterina calcar Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 290.
McCoy, 1890. Prodr. zool. Victoria, dec. 20, p. 371; pl. 200, figs. 1–1*d* (1, 1*a,* 1*d* colored).
Patiriella calcar Verrill, 1913. Amer. Jour. Sci., ser. 4, vol. 35, p. 484.

McCoy (1890) calls this the commonest sea star on the coast of Victoria. It is also common at favored places on the coasts of New South Wales, at least as far north as Coffs Harbour; all around the island of Tasmania; and on the South Australian coast at least to Spencer Gulf. There are no published records from farther west. It occurs in shallow water along shore, even above low-water mark.

The number of rays is usually 8, but 7- and 9-rayed specimens are not very rare. The adults are commonly 60–80 mm. in diameter, occasionally 100 mm. or a little more. The coloration is more or less diversified and often notably handsome. Green is common as a tinge, if not as a ground color, and orange and brown are very generally evident; white blotches or markings may occur.

Patiriella gunnii

Asterina gunnii Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 289.
McCoy, 1890. Prodr. zool. Victoria, dec. 20, p. 372; pl. 200, figs. 2–2*e* (2, 2*a* colored).
Patiriella gunnii Verrill, 1913. Amer. Jour. Sci., ser. 4, vol. 35, p. 484.

Like the preceding, this is an endemic species of the southern coast of Australia, but it has a far wider range, as it is common on the southwestern corner of the continent and ranges as far north as Dongarra on the western coast. On the east coast, the farthest north recorded is at Long Reef, Colloroy, New South Wales. I have seen no specimens or records from Tasmania. Like *calcar,* it lives in very shallow water, near low-tide mark. The number of rays ranges from 5 to 8. Of 539 specimens, practically 90 per cent had 6 rays, 6.5 per cent had 7, 2.5 per cent had 8, and rather more than 1 per cent had but 5. Adults are usually about 100 mm. across, but may be as much as 140 mm. The outline is normally hexamerous with R = 1.16r, but rarely it is circular, with r = R; on the other hand, individuals occur with R = 1.25–1.50r. The vertical diameter varies greatly with the method used and care taken in killing and preservation; v.d. = 0.06–0.40 h.d. in museum specimens. The coloration is as varied as in *calcar,* but is perhaps on the average darker and duller, with little or no white or pale yellow. McCoy (1890) says the color is "generally purple above," though his colored figure does not show it. Apparently he had been impressed by specimens of the following species, *brevispina.*

Patiriella brevispina

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 166; pl. 22, figs. 2, 3.

This unicolored sea star is characteristic of the southwestern corner of Australia. The color in life is "deep purple or brownish-crimson or more nearly brown (but with surprisingly little difference), with deep orange tube-feet." It is somewhat smaller than *gunnii,* the largest specimen as yet seen being 90 mm. across. The actinal spines are remarkably small, flat, and truncate. Aside from a large specimen taken at Port Willunga, South Australia, this species is known only from Koombana Bay, Bunbury; Bunkers Bay; and Ellenbrook Bay, Western Australia. But, as was noted above under *gunnii,* McCoy had apparently found specimens of *brevispina* on the coast of Victoria and considered them purple *gunnii.*

Patiriella mimica

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 16; pl. 1, figs. 6, 7; pl. 2, figs. 8, 10, 11.

The unique holotype of this species, having R = 24 mm., was dredged in 16–19 fms. off Newcastle Bight, New South Wales. Its color in life was not noted, nor

is it very evident how it is to be distinguished from the New Zealand species *regularis,* which has been shown by both Farquhar and Mortensen to be anything but regular.

Patiriella nigra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 167; pl. 21, figs. 3, 4.

This extraordinary black sea star has been found as yet only at Lord Howe Island. The holotype has R = 27–28 mm., but a specimen in the Australian Museum has R = 35 mm. Further collecting of Patiriellas of the *regularis* type at Lord Howe Island is essential for determining the true status of *nigra.*

Patiriella inornata

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 17; pl. 1, figs. 2, 4; pl. 2, figs. 1, 4, 7.

This species is based on a single 5-rayed specimen, with R = 27 mm., from "Western Australia." If the character of the oral spines as shown in this individual is constant, it is a good recognition mark, but obviously more material is essential.

Patiriella exigua

Asterias exigua Lamarck, 1816. Anim. sans vert., vol. 2, p. 554.
Asterina exigua Perrier, 1876. Arch. zool. exp., vol. 5, p. 222 (p. 302 of reprint).
Koehler, 1910. Indian Mus. Ast., p. 129; pl. 9, figs. 6, 7.
H. L. Clark, 1921. Ech. Torres Strait, p. 97; pl. 7, figs. 6, 7 (colored).
Patiriella exigua Verrill, 1913. Amer. Jour. Sci., ser. 4, vol. 35, p. 484.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 163.

This little sea star ranges along the whole eastern coast of Australia from Hobart, Tasmania, to Erub (or Darnley Island), Torres Strait, but it has not been found west of Spencer Gulf on the southern coast or anywhere on the western or northern coasts of the continent, save for 1 specimen in the South Australian Museum labeled "North Australia." The occurrence throughout the western Indo-Pacific area from South Africa to the Philippines and southeastward to the New Hebrides would lead one to expect it on the coast of northwestern Australia, but not one individual did we find either in 1929 or in 1932. It is a gregarious species and occurs in great numbers in favored localities, as at Erub and Lord Howe Island. At Erub conditions seem to be particularly favorable, and *exigua* reaches its maximum size there, 35 mm. in diameter. For discussions of its habits and diversity, see H. L. Clark, 1921 and 1938.

PARANEPANTHIA

Fisher, 1917. Ann. Mag. Nat. Hist., ser. 8, vol. 20, p. 172.

Genotype: *Nepanthia platydisca* Fisher, 1913*a,* p. 218.

This is a well marked genus of half a dozen species, of which 3 occur in the temperate waters of southern Australia, and the others in the tropical seas of the Andaman Islands, the Philippines, and Celebes. Fisher's name replaces Verrill's

Asterinopsis, a name given to a somewhat heterogeneous group with Lamarck's *penicillaris* designated as the type, and Mortensen (1933, p. 258) has pointed out that this name is invalid. Its revival by Cotton and Godfrey (1942) is unnecessary and regrettable.

Key to the Species of Paranepanthia

A. Interbrachial arcs rather deep and more or less acute; plates of disk and radial areas different from those of interradii and sides of rays:
  Large, R up to 70 mm.; actinal plates along rays very numerous and in distinctly separated transverse series; color dull ..... *grandis*
  Small, R less than 12 mm.; actinal plates along ray not very numerous, arranged in 2 or 3 longitudinal series; color in life rose red, more or less variegated with cream color ..... *rosea*
AA. Interbrachial arcs shallow and more or less rounded; plates of disk and radial areas not conspicuously different from those of interradii and sides of rays ..... *praetermissa*

Paranepanthia grandis

Nepanthia grandis H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 393; fig. 113.
Paranepanthia grandis H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 159.

This is an endemic and characteristic sea star of southern and southwestern Australia, apparently not rare on the coast of Victoria, judging from specimens in the National Museum at Melbourne, and in St. Vincent and Spencer gulfs, South Australia, but reaching a maximum size on the coast of Western Australia, where it has been found at Bunkers Bay and even at Point Peron. The specimen taken at the latter place is of maximum size, with R about 70 mm. in life. Owing to the dull coloration and the close adhesion to the lower surface of rock fragments, even so large a sea star may easily escape observation. The color in life is dull fawn color or some shade of yellowish brown or grayish brown.

Paranepanthia rosea

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 161; pl. 22, fig. 8.

Common at Rottnest Island, and occurring also at Point Peron, this pretty little sea star seems to be an endemic species of Western Australia. Its rose and cream coloration attracts attention in spite of the small size (less than 20 mm. across). It lives appressed to the lower surface of rock fragments and may be easily overlooked if there is much animal or plant growth thereon. Hexamerous individuals are by no means rare.

Paranepanthia praetermissa

Asterinopsis praetermissa Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 14; pl. 3, figs. 1, 2; pl. 4, figs. 2, 3.
Paranepanthia praetermissa H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 161.

Across the continent from the preceding, this sea star represents the genus on the coast of New South Wales, where 7 specimens have been taken and listed from

Port Jackson, besides the holotype from Little Bay. It is much larger than *rosea,* adults having R = 32–36 mm., but it is not known to approach *grandis* in maximum size. No notes on the color in life are recorded, but apparently it is somewhat lighter and more yellowish than that of *grandis.* The spinulation is noticeably different from that of the larger species, but the difference is difficult to show in a photograph and almost impossible to describe. The tufts of spinules are better spaced and the spinules are fewer, shorter, and more flaring than in *grandis,* but such a statement tends to exaggerate the difference. See the published figures, noting especially the interradial areas of the upper surface.

DISASTERINA

E. Perrier, 1875. Arch. zool. exp., vol. 4, pp. 292, 302 (no adequate diagnosis and no species mentioned).
——— 1876. Arch. zool. exp., vol. 5, p. 209 (no diagnosis, but 1 species described).

Genotype: *Disasterina abnormalis* Perrier, 1876, p. 209.

Livingstone (1933) did an admirable piece of work in clarifying this genus and in demonstrating that my *Habroporina* (1921, p. 34) is a synonym of Perrier's quite inadequately diagnosed genus. I had not noticed *Disasterina,* being of the opinion that my Murray Islands specimens belonged in the Poraniidae. Livingstone has now shown that my specimens from Mer are identical with Perrier's from New Caledonia. Moreover, he has shown that another of my species (*Asterina leptalacantha*) also belongs in Perrier's genus, and he has added a third species from Port Curtis, Queensland. A single specimen of a little sea star from Broome seems to warrant including *Disasterina* in the fauna of that happy hunting ground of the marine zoologist, but it is apparently distinct from the Barrier Reef species. The 4 Australian forms may be distinguished thus:

Key to the Species of Disasterina

A. Rays not short and broad, R = 2r or more:
  B. Abactinal surface covered by bare, thick skin, more or less obscuring underlying plates even when dry ..... *abnormalis*
  BB. Abactinal surface more or less bare but not skin-covered:
    Abactinal plates near center of disk with small spinelets; adambulacral armature, 4–6 (usually 5) spinelets; oral plates with 7–9 marginal spines ..... *leptalacantha*
    No abactinal spinelets except low down in interradii; adambulacral spinelets 3 or 4; oral spinelets 4 ..... *spinulifera*
AA. Rays short and broad; R = 1.7r; no abactinal spinelets save a few granule-like ones near anus and madreporite ..... *praesignis*

Disasterina abnormalis

Perrier, 1876. Arch. zool. exp., vol. 5, p. 209.
Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 7; pl. 4, figs. 6, 7; pl. 5, fig. 13.
Habroporina pulchella H. L. Clark, 1921. Ech. Torres Strait, p. 34; pl. 4, fig. 2 (colored); pl. 24, figs. 2, 3; pl. 26, figs. 4, 5.

This little but attractive sea star is as yet known only from New Caledonia and the northern end of the Barrier Reef. The Australian records are from Murray

Islands, Torres Strait, and from Michaelmas Cay, off Cairns, Queensland. The few individuals so far collected do not exceed R = 25 mm. The color in life is green and white with a distinct spot of blue at the tip of each arm. Dried or alcoholic specimens are commonly "museum color." The few *abnormalis* that have been taken were found on the lower surface of broken slabs or fragments of rock or coral in very shallow water.

Disasterina leptalacantha

Asterina leptalacantha H. L. Clark, 1916. "Endeavour" rept., p. 57; pl. 18, figs. 3, 4.
Disasterina leptacantha (*lap. cal.*) Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 8; pl. 3, figs. 5, 6; pl. 4, figs. 1, 4.

This species is of about the same size as the preceding, but seems to be of somewhat stouter build. Nothing is recorded of its color in life. It has been taken as yet only at the Capricorn group of islets on the Barrier Reef, under rocks or coral fragments, in pools at low tide.

Disasterina spinulifera

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 156; pl. 22, fig. 6.

The holotype and only known specimen of this species was taken at Broome, Western Australia, in June 1932. It was so small (R = 7–8 mm.) and its coloration so inconspicuous that its capture was not even noted in the field books. Its occurrence on the northwestern coast is of great interest, as all the other Australian Disasterinas come from the Barrier Reef region. Its general appearance is strikingly different from that of its congeners, but how much of this difference is due to its youth and the method of preservation, one cannot say.

Disasterina praesignis

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 10; pl. 1, figs. 5, 8; pl. 2, fig. 5.

This species also is known from only a single specimen, but the strikingly different facies sets it apart from the other members of the genus. The holotype has R = 14 mm., and the rays are so short and wide that the resemblance to a true *Asterina* is rather marked. It was taken in North Channel, off Curtis Island, Port Curtis, Queensland, in 3–4 fms., on a somewhat muddy bottom having patches of dead and living coral.

MANASTERINA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 157.

Genotype: *Manasterina longispina* H. L. Clark, 1938, p. 157.

It is unfortunate to create a monotypic genus, but it is doubly unfortunate when the type species is known from but a single specimen. Such is the case here, but the characters of the extraordinary sea star concerned do not admit of any other course. It is apparently not very nearly related to *Disasterina* or any other of the Asterinidae.

Manasterina longispina

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 157; pl. 21, figs. 1, 2.

The unique holotype of this sea star was collected at Rottnest Island, Western Australia, in 1934 by Beresford E. Bardwell, who very generously sent it to the Museum of Comparative Zoölogy. He reports that in life it was "about 3½ inches across," very soft and fleshy, reddish pink above and pale lemon yellow below. It was living attached to a flat sandstone rock on pure sand bottom. In its dry condition it is scarcely half as large, with R = only 24 mm., an unusual shrinkage but in keeping with its soft and fleshy appearance in life.

NEPANTHIA

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

Genotype: *Nepanthia maculata* Gray, 1840, p. 287.

Although Perrier (1876) recognized the validity of this group, he considered it only a subgenus of *Asterina,* to which he added 2 species which he found in the British Museum. Sladen (1889) restored *Nepanthia* to its full generic rank, and it has not been questioned since. The genus is common on the tropical coasts of Australia, and is further known from the Philippine Islands and the coast of Indo-China. The half-dozen Australian species may be distinguished as follows:

Key to the Species of Nepanthia

A. Arms short, R = 3–4r:
- B. Rays 6 or 7 (rarely 5 or 8), short and thick in adults; madreporites 2–8; autotomy very general; adambulacral armature with about 5 furrow spines ..... *belcheri*
- BB. Rays 5, rarely 6 or 7; madreporite usually single, 2 or 3 in multiradiate individuals; autotomous only when young; furrow spines more than 5:
  - C. Aboral plates densely clothed with minute spinelets almost like velvet; innermost oral spine not notable:
    - Aboral skeleton with short, wide, crescentic plates, not arranged in very regular longitudinal series except near tip of arms; adambulacral and oral armature of numerous very slender, acute spines ..... *brevis*
    - Aboral skeleton with fewer, longer, narrower, more crescentic plates in very regular series; adambulacral armature of fewer, coarse, blunt spines ..... *variabilis*
  - CC. Aboral plates with fewer, coarser spinelets, not at all velvety; innermost oral spine conspicuously large, flattened and acute ..... *magnispina*

AA. Arms long, R = 5–6r:
- Small supplemental plate proximal to each papula;[1] furrow spines 8–10; R a little more than 6r ..... *maculata*
- No conspicuous supplemental plates proximal to papulae; furrow spines 5 or 6; R rather less than 6r ..... *tenuis*

[1] Fisher (1919) says this little plate is wanting in all the Philippine specimens.

Nepanthia belcheri

Asterina (*Nepanthia*) *belcheri* Perrier, 1876. Arch. zool. exp., vol. 5, p. 240 (p. 320 of reprint).
Henricia heteractis H. L. Clark, 1909. Mem. Australian Mus., vol. 4, p. 530; pl. 49, figs. 1, 2.
Nepanthia polyplax Döderlein, 1926. K. svenska Vetensk.-Akad. Handl., ser. 3, vol. 2, no. 6, p. 20; pl. 4, figs. 2, 2*a*.
Nepanthia belcheri H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 169.

A full account of this interesting species is given in H. L. Clark, 1938. It is one of the commonest and most characteristic sea stars of Lord Howe, but has not yet been found in sufficient numbers on the mainland coast of Australia to enable us to know what the limits of its range there are. Livingstone (1932) records skeptically a "*Nepanthia* (? *brevis*) Perrier" from Low Isles, but as it had 6 arms and 5 madreporites it would be better to refer it to *belcheri*. Döderlein's type of *polyplax* was from Rockhampton, so the occurrence of *belcheri* as far north as Low Isles is not improbable. There are several records from Port Jackson, but none from farther south. Full-grown specimens have R = 30–35 mm., but most of the specimens taken at Lord Howe were considerably smaller than that. The color in life is an inconspicuous dull green, indistinctly speckled orally with reddish, but the colors are very fugacious.

Nepanthia brevis

Asterina (*Nepanthia*) *brevis* Perrier, 1876. Arch. zool. exp., vol. 5, p. 241 (p. 321 of reprint).
Nepanthia brevis Sladen, 1889. "Challenger" Ast., p. 387; pl. 63, figs. 3–5.
H. L. Clark, 1921. Ech. Torres Strait, p. 95; pl. 6, figs. 3, 4 (colored).

This is one of the characteristic sea stars of Torres Strait, but its range extends southward to Port Curtis, overlapping that of *belcheri,* and westward to Darwin. Studer's record from northwestern Australia probably is based on specimens of *variabilis,* as none of the Nepanthias which we took west of Darwin are *brevis*. The colors of the upper side are dull, grayish olive, whitish, and black; orally, white with blue lines, speckled with light brown and orange. But the colors are completely fugacious and museum specimens give no hint of their variety. The largest specimens of *brevis* have R up to 55 mm., but few individuals reach that size, most having R = 30–45 mm. The habitat is the under side of rock fragments in very shallow water, near low-tide mark.

Nepanthia variabilis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 176; pl. 10, figs. 4, 5 (colored); pl. 20, figs. 4, 5.

A very striking and characteristic sea star of the Broome region, this fine *Nepanthia* reveals an astonishing diversity of color, though the adambulacral and oral spines are commonly deep green, sometimes appearing almost black. It reaches a considerable size, with R = 60 mm. and more. Very young individuals are hexamerous, but about 95 per cent of adults are pentamerous. Further details

are given in H. L. Clark, 1938. As yet *variabilis* is known only from Roebuck and Lagrange bays, Western Australia, and along the intervening coast.

Nepanthia magnispina

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 174; pl. 20, figs. 1, 2.

This species rests wholly on a unique specimen from Augustus (or Champagny) Island, northern Western Australia, collected by Beresford E. Bardwell. Though the supposed specific characters may prove to be elusive, the holotype is obviously different from any of the other Nepanthias taken on the northwestern coast.

Nepanthia maculata

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 287.
Sladen, 1889. "Challenger" Ast., p. 388; pl. 64, figs. 1–4.
Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 422; pl. 113, figs. 3, 4.

This species is included in this account because the fine specimen, with R = 66 mm., from which Sladen's figures were made was taken at "Challenger" station 188, which is in shallow water (28 fms.) at the extreme western end of Torres Strait. Perhaps this is just outside the arbitrary limits I have set for the Australian region, but the genus is so typically Australian, it seems proper to include *maculata* here.

Nepanthia tenuis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 175; pl. 20, fig. 3.

Only 3 specimens of this well marked species were taken by us at Broome, all in 1932. The largest has R = 64 mm., the other 2 are much smaller. No other specimens have as yet been reported, but the species is probably not restricted to the Roebuck Bay region. It resembles the genotype more closely than does any other Australian *Nepanthia*.

PARASTERINA

Fisher, 1908. Smithsonian Misc. Coll., vol. 52, p. 90.

Genotype: *Patiria*? *crassa* Gray, 1847, p. 83.

Fisher (1941) points out that the character which was supposed to distinguish *Parasterina* from its allies does not exist and that the genus is so near *Nepanthia* it may well be discarded. It seems to me, however, that the 3 Western Australian species, *crassa, troughtoni,* and *occidentalis,* form a homogeneous group, easily distinguished from *Nepanthia* by the rather conspicuous difference in the character of the abactinal surface. A fourth species, *Patiria ocellifera,* is listed by Gray from an unknown locality, and Sladen (1889) refers it to Western Australia, on the testimony of Tenison-Woods. But I am inclined to think there is confusion here with *Nectria ocellifera,* which Gray (1866) puts just before *Nepanthia.* Certainly I know of no good reason for including *Patiria ocellifera* in a list of Australian sea stars. The 3 species here included in *Parasterina* are distinguished thus:

KEY TO THE SPECIES OF PARASTERINA

Swollen plates of abactinal surface low hemispherical, densely covered with very slender and numerous spinules, well spaced, with small plates and numerous large papulae among them ..... *crassa*
Most abactinal plates somewhat raised but rather flat-topped, covered with low granule-like spinelets; small plates and papulae rather numerous ..... *troughtoni*
Abactinal plates elevated, transversely elongated, densely covered with granule-like spinelets, forming a more or less smooth coat without small plates, and with few large, somewhat hidden papulae ..... *occidentalis*

Parasterina crassa

Patiria? *crassa* Gray, 1847. Proc. Zool. Soc. London, pt. 15, p. 83.
Parasterina crassa Fisher, 1908. Smithsonian Misc. Coll., vol. 52, p. 90.
Nepanthia crassa Fisher, 1941. Proc. U. S. Nat. Mus., vol. 90, p. 453; pl. 70, fig. 2.

Apparently fairly common on the Western Australian coast between Geraldton and Rockingham, this species has been a source of much confusion from the days of Gray until now. Fisher's recent (1941) notes and figures leave no room for further misunderstanding. It is not a conspicuous sea star, as it lives among or under rock fragments in tide pools or below low-water mark. The color in life is reddish brown so far as we have any record. Large specimens have R = 60–64 mm., r and br about one-fourth as much.

Parasterina troughtoni

Livingstone, 1934. Rec. Australian Mus., vol. 19, no. 3, p. 179; pl. 18, figs. 1–6.

Little is known of this species, for it was described from a single small specimen (R = 16 mm.) from Albany, King Georges Sound, Western Australia, where it was taken in shore collecting. A specimen of the same size is in the Museum of Comparative Zoölogy, and one twice as large is in the Western Australian Museum at Perth. These 2 specimens are from an unknown locality on the Western Australian coast. Nothing is known as to the color in life.

Parasterina occidentalis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 180; pl. 21, fig. 5.

This well marked species has been found as yet only near Fremantle, but it is apparently not very uncommon there, for at least five local stations have yielded specimens. Full-grown ones have R = 65 mm., r and br about one-fifth as much. The color in life is reported to be brick red.

TEGULASTER

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 11.

Genotype: *Tegulaster emburyi* Livingstone, 1933, p. 12.

This genus was erected to include *Disasterina ceylonica* Döderlein and a closely related sea star found on the Great Barrier Reef. Livingstone stresses the trigonal

character of the arms, but this is not very obvious in the figures given, which are strikingly suggestive of *Asterina coronata.* That sea star, however, does not have bare abactinal plates.

Tegulaster emburyi

Livingstone, 1933. Rec. Australian Mus., vol. 19, no. 1, p. 11; pl. 1, figs. 1, 3; pl. 2, figs. 2, 3, 6, 9.

This interesting sea star was described from a single specimen collected at Norwest Island, Capricorn group, Queensland, where it was "living under a dead coral boulder." It is small, R = only 19 mm. The color in life is said to be "very gaudy," being a combination of orange and magenta, both light and dark, on a deep cream-colored ground.

ANSEROPODA

Nardo, 1834. Oken's Isis, vol. 7, p. 716.

Genotype: *Asterias membranacea* Retzius, 1783, p. 238.

This very remarkable group of sea stars presents the most extreme reduction in vertical diameter to be found in the whole echinoderm phylum. The genus occurs in European but not in American seas. Several species are known in the East Indian region, and of these the following occurs in Australia, not only on the northwestern coast, but also in Queensland waters.

Anseropoda rosacea

Asterias rosaceus Lamarck, 1816. Anim. sans vert., vol. 2, p. 558.
Anseropoda rosacea Fisher, 1906. Bull. U. S. Fish Comm. no. 23, p. 1089.
H. L. Clark, 1916. "Endeavour" rept., p. 59; figs. 5, 6.
Palmipes rosaceus Koehler, 1910. Indian Mus. Ast., p. 127; pl. 20.

This extraordinary sea star has been so well figured by Koehler that detailed description is unnecessary. It grows to a large size, as much as 240 mm. across. It is excessively flat in life, but in drying it may become elevated or even considerably arched centrally. It lives apparently just below the surface of the sand in shallow water, but not near low-tide mark. The color in life is gray above and creamy white beneath, with black speckling above, and more or less rust color along the ambulacra. It is widely distributed in the northern and northeastern Indian Ocean, and the range extends to southern Queensland (25 miles southeast of Double Island Point, 33 fms.) and to northern Western Australia at Broome and Port Hedland. For a discussion of the number of rays and other details see H. L. Clark, 1938, page 182.

Family ECHINASTERIDAE

This cosmopolitan family is represented in Australia by 3 genera. One of these is a monotypic endemic and another is a tropical genus containing many species, of which several endemic forms are a conspicuous feature of the sea-star fauna of South and Western Australia. The third genus is the highly differentiated and perplexing *Henricia,* widespread in both the northern and southern hemispheres,

the despair of any orderly-minded systematist. These genera are quite unlike in general appearance and are easily distinguished as follows:

Key to the Genera of Echinasteridae

A. Adambulacral spines and spinelets disposed in transverse series on each plate; abactinal plates forming meshwork of small, ill defined papular areas:
  Abactinal plates covered with thick skin and bearing isolated or clustered spines, often of considerable size ..... *Echinaster*
  Abactinal plates with numerous minute spines, often granuliform ..... *Henricia*
AA. Adambulacral spines arranged in 2 longitudinal series; abactinal plates forming very coarse network, with meshes 5–10 mm. across ..... *Plectaster*

ECHINASTER

Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., Apr., p. 102.

Genotype: *Asterias seposita* Lamarck, 1816, vol. 2, p. 562 = *Asterias sagena* Retzius, 1805, p. 21.

This is a large group of some 25 nominal species of world-wide distribution in tropical and warm-temperate seas. Fisher thinks it may well be broken into 2 genera according to the distribution of the papulae, those with intermarginal and actinal papulae being segregated under the name *Othilia* Gray. This is not, however, an easy line of division to follow, as large specimens of *sagenus* have papulae in the intermarginal area and below it on the proximal part of the rays. It is possible that the division between *Othilia* and *Echinaster* is a natural one and should be maintained; but for the present, it seems best to let the Australian species remain under the name with which they were described. They are a rather striking group of relatively large sea stars with considerable diversity of appearance. They may be distinguished as follows:

Key to the Species of Echinaster

A. Abactinal spines large, coarse, and well spaced, or in elevated groups:
  B. Abactinal spines acute or blunt, low or high, but not chisel-shaped or clavate:
    C. Abactinal spines not grouped in elevated clusters:
      Abactinal plates do not form conspicuous reticulum; abactinal spines high, acute, rather uniformly scattered ..... *acanthodes*
      Abactinal plates form coarse reticulum with large meshes; abactinal spines low and blunt ..... *arcystatus*
    CC. Abactinal spines in elevated groups of 5–12 or more, well spaced ..... *glomeratus*
  BB. Abactinal spines numerous, rather uniformly scattered, low and stout, with chisel-shaped or clavate tips ..... *superbus*
AA. Abactinal spines small, numerous, blunt or pointed, rather uniformly scattered:
  Small (R = 75–125 mm.), 5–7 rays, autotomous; rays rather slender, covered with numerous small, blunt spinelets; subambulacral and actinal spinelets tend to form series parallel to adambulacrals; color rust red speckled with blackish, or whole upper surface blackish, but with no trace of purple ..... *luzonicus*

Large (R = 150–190 mm.), 5 rays, not autotomous; rays stouter with less numerous spinelets; bare area on actinal surface of rays just outside adambulacral spines, not occupied by series of subambulacral and actinal spines parallel to furrow; color deep buff spotted or blotched with purple, or unicolor either purple or bright red ..... *varicolor*

Echinaster acanthodes

H. L. Clark, 1916. "Endeavour" rept., p. 61; pl. 19, figs. 1, 2.

This is a rather small sea star with slender rays for an *Echinaster,* and finds its nearest relative in *E. stereosomus* Fisher from the Philippine Islands. It is, however, much more spiniferous, and its conspicuous subambulacral spines are distinctive. It has as yet been taken only near the southern coasts of Queensland, off Fraser Island in 32 fms., and 25 miles southeast of Double Island Point in 33 fms. The largest specimen has R = 70 mm. Nothing is recorded as to the color in life.

Echinaster arcystatus

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 148; pl. 21.

This is another well marked species of which too few (only half a dozen) specimens are known. They were taken between Fremantle and Geraldton, and at Bunkers Bay, Western Australia—one at each place—and in South Australian waters; of 4 specimens there taken, only 1 has a definite label, "between Backstairs Passage and the Pages, 25 fms." The Fremantle specimen is said to have been "purple" in life; the dry specimens are deep red or reddish brown or brown. The largest specimen has R = 172 mm., and the arms taper markedly so that R = 11br at the middle of the arm but only 7br at base. In the holotype R = about 5.5br at base and 7br near middle. In the Bunkers Bay specimen R = about 4.5br, the arms being conspicuously short and stout. No doubt some of this great discrepancy in proportions is due to differences in the killing and preserving of the specimens.

Echinaster glomeratus

H. L. Clark, 1916. "Endeavour" rept., p. 62; pls. 22, 23.

So far as is yet known, this is an endemic South Australian sea star, all known specimens being from near Kangaroo Island or from the Verco collections in St. Vincent and Spencer gulfs. It is a smaller species than the preceding, the largest individual of the 8 known having R = 97 mm. Nothing is recorded as to the color in life, the yellow-brown of the dried specimens giving no clues. A specimen in the South Australian Museum has the arms so short and nearly cylindrical and the groups of spinelets so large and numerous, it has been designated by a varietal name, *extremus* (see H. L. Clark, 1928, p. 396), but it probably intergrades with the typical form. The suggestion by Cotton and Godfrey (1942) that *glomeratus* might be placed in *Henricia* indicates a lack of acquaintance with that genus.

Echinaster superbus

H. L. Clark, 1916. "Endeavour" rept., p. 64; pls. 24, 25.

If ever a specific name was happily chosen, this notable sea star bears it, for not only is it the most beautiful of Australian sea stars in coloration, but its large size and extraordinary spinulation justify enthusiasm in any reference to it. It is greatly to be regretted that the only specimen we obtained during our two visits to Broome was taken when we were in Pender Bay, far from town, and Mrs. Clark was not available to make a colored figure. My notes are quite inadequate to set forth the striking green, white, and rose coloring. Only 4 specimens are as yet known, 2 in the museum at Perth, 1 in Sydney (the holotype), and 1 in the Museum of Comparative Zoölogy, the largest of all (R = 145 mm., over 150 mm. in life). All are from Broome or the immediate vicinity; though one in the Perth museum has no locality label, there is no reason to doubt it is from the vicinity of Broome. The extraordinary spinulation sets *superbus* quite apart from the other members of the genus. The Pender Bay specimen was brought up by a diver who said he found it "on top of a rock." Possibly the normal habitat is among rocks and corals where it cannot be reached with a dredge.

Echinaster luzonicus

Othilia luzonica Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 282.
Echinaster luzonicus Müller and Troschel, 1842. Syst. Ast., p. 23.
H. L. Clark, 1921. Ech. Torres Strait, p. 98; pl. 10, figs. 2–4 (2, 3 colored).
Echinaster eridanella Müller and Troschel, 1842. Syst. Ast., p. 24.
H. L. Clark, 1916. "Endeavour" rept., p. 62; pl. 20, figs. 1, 2; pl. 21, fig. 2 (fig. 1 of pl. 21 is *Echinaster purpureus* Gray, a poorly preserved specimen).
Othilia purpurea Fisher, 1919. Bull. 100 U. S. Nat. Mus., vol. 3, p. 432; pl. 122, fig. 1; pl. 132, figs. 7, 7*a*, *b* (NON *Othilia purpurea* Gray, 1840, p. 282, the closely allied species of the western Indian Ocean).

The close resemblance between the Echinasters of the western Indian Ocean and those of the East Indian region, combined with the very poor and often unidentifiable condition of dried specimens, has led to much confusion. The question was discussed in H. L. Clark, 1921, pages 98–100, and the conclusion was reached that the name *purpureus* might well be retained for the western *Echinaster,* Gray's name *luzonicus* being restricted to the species of the East Indian region and northeastern Australia. This decision accounts for the presence of Fisher's *purpurea* in the synonymy given above. Müller and Troschel's *fallax* and Perrier's *vestitus* are apparently identical with *purpureus* and are not found in the Australian fauna, though I listed Perrier's species in 1914 from Port Hedland, Western Australia. The specimen so named was undoubtedly a small adult of the following species (*varicolor*).

At the northeastern corner of Australia and southward along the Queensland coast to the Low Isles, to Bowen, and even to "25 miles southeast of Double Island Point, 33 fms.," *luzonicus* is more or less common in shallow water along shore. Most specimens have R less than 100 mm., but big adults may reach 125. The color is fundamentally "rusty red," but this is commonly speckled with blackish, and adult specimens tend to become dark, even a dull black, at least aborally; there is no tendency toward violet or purple. Although common in Torres Strait, *luzonicus*

has not been found on the Australian coast west of there, but it ranges northward to the Philippines. Livingstone (1932) records some interesting data concerning the occurrence of this *Echinaster* at the Low Isles.

Echinaster varicolor

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 184; pl. 11, fig. 1 (colored).
Echinaster vestitus H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 150 (NON Perrier, 1869, p. 254).

The remarkable diversity of color shown by this big *Echinaster* is very perplexing and suggests what an interesting bit of research it would be to fertilize a few hundred eggs, carry them through their development to maturity, and see whether all three color forms would appear as the offspring of one female. The spotted form is undoubtedly the most common, but the uniformly violet individuals were not very rare, and several examples of the bright red form were taken. Yet when dried, all lost their bright tints and became brown of some shade with no correlation between the color in life and the shade of brown. The largest specimen has R = 190 mm.; in life it probably exceeded 200. The species seems to be very local and does not occur along shore; all the specimens were obtained by dredging or by a diver in 5–10 fms. The specimen of *Echinaster* from Port Hedland which I reported in 1914 as *vestitus* Perrier is undoubtedly a small adult *varicolor*.

HENRICIA

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 184.

Genotype: *Henricia oculata* Gray, 1840, p. 184 = *Asterias sanguinolenta* O. F. Müller, 1776, p. 234.

It is probably no exaggeration to say that this is the most perplexing genus of sea stars, because it is so widely distributed in the cooler waters of both northern and southern hemispheres and shows an extraordinary lack of constancy in elementary species characters such as body form and proportions, and type of spinulation. The species are fewer and individuals apparently less numerous in the southern than in the northern seas, but even the southern species are ill defined and difficult to delimit. The genus, however, is seldom taken in Australian waters, the only specimens as yet reported being those dredged by the "Endeavour" during her fisheries investigations. These were all referred to the following species.

Henricia hyadesi

Cribrella hyadesi Perrier, 1891. Miss. Sci. Cap Horn, vol. 6, pt. 3, p. K100; pl. 9, figs. 1*a–d*.
Henricia hyadesi Fisher, 1911. Bull. 76 U. S. Nat. Mus., pt. 1, p. 293.
H. L. Clark, 1916. "Endeavour" rept., p. 60.

In his important discussion of the Henricias taken by the "Discovery," Fisher (1940, pp. 162–169) treats *hyadesi* as identical with *obesa* Sladen. He also reports (p. 166) his observations on 3 of the Henricias taken by the "Endeavour." He considers 2 of them forms of *Cribrella sufflata* Sladen (taken by the "Challenger" near the Kermadec Islands); the one from the Great Australian Bight he says is "of the *compacta* group," this also a "Challenger" species taken in deep water west of New Zealand. After a re-examination of the "Endeavour" specimens, now

in the Museum of Comparative Zoölogy, and comparison with two Henricias from off eastern Patagonia, supposed to be *hyadesi,* and a cotype of *H. compacta* var. *aucklandiae* Mortensen, I am still unable to reach a definite conclusion. Meanwhile it seems best to let the "Endeavour" specimens remain listed under the name *hyadesi,* but with the added statement that the Great Australian Bight material probably represents a different species from the one taken farther east in Bass Strait and off eastern Tasmania. All the "Endeavour" Henricias were taken in comparatively deep water (50–200 fms.). The largest has R = 80 mm.

PLECTASTER

Sladen, 1889. "Challenger" Ast., p. 535.

Genotype: *Echinaster decanus* Müller and Troschel, 1843, p. 114.

This is, in striking contrast with the preceding genus, a sharply defined, monotypic, endemic group confined to the southern side of the Australian continent.

Plectaster decanus

Echinaster decanus Müller and Troschel, 1843. Arch. f. Naturgesch., vol. 9, no. 1, p. 114.
Plectaster decanus Sladen, 1889. "Challenger" Ast., p. 535.
H. L. Clark, 1916. "Endeavour" rept., p. 66; pl. 26, figs. 1, 2.

This is one of the most typically Australian of all the remarkable sea stars in the fauna. It ranges from Port Jackson southward and westward to the Bight in shallow or moderately deep water (90 fms.), but does not seem to be common anywhere. In large specimens, R = 100–110 mm. The colors in life are striking, for the skeletal network, abactinally, is red and the big papular areas are purple.

Family SOLASTERIDAE

A group of sea stars of conspicuous appearance, frequently with more than 5 and often with more than 10 rays, this family is more common in northern than in tropical or southern seas. Only 2 genera occur in Australia. One was taken by the "Challenger" at the western end of Torres Strait, and the other by the "Endeavour" in her fisheries investigations off southeastern Australia. The two are easily distinguished thus:

Actinal intermediate plates few and inconspicuous ..... *Crossaster*
Actinal intermediate plates, each with curved comb of spines, extend to tip of ray ..... *Rhipidaster*

CROSSASTER

Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., Apr., p. 103.

Genotype: *Asterias papposa* Linné, 1767, p. 1098.

A northern genus of rather more than half a dozen species, *Crossaster* was found by the "Challenger" in South Africa, by the "Albatross" in the Philippines, and by the "Endeavour" near the southeastern corner of Australia. The Australian species is quite distinct from the others, particularly in the multiplicity of adambulacral and oral spines.

Crossaster multispinus

H. L. Clark, 1916. "Endeavour" rept., p. 66; pl. 18, figs. 5, 6.

Nothing further has been recorded of this sea star since the original description. It was taken off southeastern Victoria in 50–100 fms. and also off Bruni Island, Tasmania, 150–230 fms. The 4 known specimens are small (R = 40 mm.) and may not be mature. Nothing is known of the color in life, but in the preserved material, the 3 Tasmanian specimens are lighter than the fourth.

RHIPIDASTER

Sladen, 1889. "Challenger" Ast., p. 447.

Genotype: *Rhipidaster vannipes* Sladen, 1889, p. 448.

A monotypic genus is this, resting on a single species, which in turn rests on a single specimen.

Rhipidaster vannipes

Sladen, 1889. "Challenger" Ast., p. 448; pl. 69, figs. 1–4.

The unique holotype of this interesting sea star was taken at "Challenger" station 188 at the western end of Torres Strait, just within the Australian limits adopted for this report, in 28 fms. It has 8 rays, 85–88 mm. long, and the color in alcohol is light yellowish brown.

Family ACANTHASTERIDAE

This is a monogeneric family which Fisher considers a relict of an old and at one time more extensive group. These remarkable asteroids are, however, distinct from any others now living, the large size, the multiplicity of rays and madreporites, and the big, articulated spines setting them quite apart. At least 4 species seem to be known, but only 1 occurs in Australia and it is by no means common.

ACANTHASTER

Gervais, 1841. Dict. sci. nat., suppt. 1, pt. 2, p. 470.

Genotype: *Acanthaster echinus* Gervais, 1841, p. 474 = *Asterias planci* Linné, 1758, p. 823.

This extraordinary genus barely enters the Australian region, but a few specimens have been taken at the northern end of the Barrier Reef. They all seem to represent the type species.

Acanthaster planci

Asterias planci Linné, 1758. Syst. Nat., ed. 10, p. 823.
Acanthaster planci Verrill, 1914. Shallow water starfishes, N. Pacific coast, p. 364.
Acanthaster echinites Döderlein, 1896*a*. Semon's Ast., *in* Jena Denkschr., vol. 8, p. 320; pl. 21, figs. 2–7.

Revised to 1958. Acanthaster brevispinus Fisher

This extraordinary sea star, with 13–16 rays and exceeding 400 mm. in diameter when full grown, just enters the Australian region at the northern end of the Barrier Reef, having been taken at Warrior Reef, at the Murray Islands, and at the Low Isles. In my Torres Strait report (1921, p. 101) I have given an account of this curious animal as it appears in life. Apparently it may be found anywhere from Zanzibar to Hawaii.

Family VALVASTERIDAE

Originally proposed as a subfamily, this monogeneric group has been elevated to family rank by Fisher, as in the case of *Acanthaster*. *Valvaster* has such an unusual combination of characters that Koehler has also approved of recognizing the family.

VALVASTER

E. Perrier, 1875. Arch. zool. exp., vol. 4, p. 376 (p. 112 of reprint).

Genotype: *Asterias striata* Lamarck, 1816, vol. 2, p. 564.

The discovery of a *Valvaster* at Mer, Murray Islands, in 1913 added a second species to the genus, originally monotypic, and revealed it as a member of the Australian fauna. Owing to their secretive habits and a habitat difficult of access, very few specimens of *Valvaster* have ever been taken, but there seems no reason to doubt that the unique Australian specimen is a different species from the genotype.

Valvaster spinifera

H. L. Clark, 1921. Ech. Torres Strait, p. 102; pl. 6, fig. 6 (colored); pl. 36, figs. 8, 9.

All that is known of this beautiful sea star is recorded in the reference given above. It appears to be quite distinct from Lamarck's species, but neither is yet sufficiently known to make any conclusion regarding them perfectly trustworthy. This *Valvaster* is at least a worthy rival of *Echinaster superbus* as Australia's most beautiful sea star.

Family PTERASTERIDAE

This remarkable family of several genera and many species is widely distributed all over the world, usually in deep water, rarely less than 100 fms. Only 2 genera have yet been found in Australia, and these are represented each by but a single species. The 2 genera are to be distinguished as follows:

Muscle bands of supradorsal membrane not conspicuous or regularly reticulated, but meandering or crisscrossing, usually very inconspicuous ..... *Pteraster*
Muscle bands conspicuous, regularly reticulated ..... *Retaster*

PTERASTER

Müller and Troschel, 1842. Syst. Ast., p. 128.

Genotype: *Asterias militaris* O. F. Müller, 1776, p. 234.

This large, widely distributed genus, with some 30 species, is poorly represented in Australia, where a single specimen of a single species is the only example yet

found. This is quite different from its nearest congeners and represents a well marked, possibly endemic species.

Pteraster tetracanthus

H. L. Clark, 1916. "Endeavour" rept., p. 67; pl. 18, figs. 1, 2.

The unique holotype, with R = 30 mm., is the only *Pteraster* yet taken in Australia, and, as has been suggested, is very possibly endemic, since it has distinctive specific characters. It was taken in 90–150 fms. southeast of Cape Everard, Victoria.

RETASTER

E. Perrier, 1878. Nouv. arch., ser. 2, vol. 1, p. 56.

Genotype: *Pteraster cribrosus* von Martens, 1867, p. 109.

As was pointed out in H. L. Clark, 1923, page 298, if we are to retain the genus *Retaster,* we must accept *cribrosus* as the type. Perrier's inclusion of *capensis* with *cribrosus* in his proposed genus was a mistake probably due to accepting Gray's misleading diagnosis. The *Pteraster* from "The Cape" is not a *Retaster* according with Perrier's brief definition. Fisher's (1919) designation of *capensis* as the type of *Retaster* is probably due to observance of the "first named" principle, but if insisted on makes *Retaster* simply a synonym of *Pteraster.* It seems best therefore to use the second species given by Perrier, namely *cribrosus* von Martens.

Retaster insignis

Sladen, 1882. Jour. Linn. Soc. (Zool.), vol. 16, p. 200.
——— 1889. "Challenger" Ast., p. 482; pl. 76, figs. 3, 4.

In life, this *Retaster* is one of the most extraordinary sea stars on the Australian coast. The characteristic reticulated character of the dorsal side, the brilliant red color, and the thick coat of transparent, colorless jelly in which the animal is enshrouded (at least on the abactinal surface) combine to make the living animal an oddly beautiful object. The smallest specimen seen has R = 14 mm., and the largest has R almost exactly 6 times as much (= 83 mm.). The small specimen is from Lindeman Island, Queensland, the big one from Shark Bay, Western Australia. Livingstone (1932) gives the southern limit of the range on the east coast as "probably Port Jackson," but the "Challenger" did not take it there, and Whitelegge (1889) gives it only with a question mark "*fide* Bell." As the "Endeavour" did not take any specimens, it is doubtful whether this *Retaster* belongs in the New South Wales fauna. On the west coast, Shark Bay is assuredly as far south as *Retaster* may be expected. To the northward the range extends to the Philippines.

Order FORCIPULATA

This order contains perhaps as many species as the preceding, but they are not nearly so strikingly differentiated. Only 3 families occur in the Australian fauna, and they are represented by relatively few species. The contrast in this respect between North America and Australia is striking. The families occurring in Australia are easily separated thus:

KEY TO THE FAMILIES OF FORCIPULATA

A. Deep-water forms with small, circular disk and slender, often deciduous arms, distinctly set off from it; adambulacral ossicles not compressed ..... Brisingidae

AA. Disk not circular or distinctly set off from slender arms; adambulacral ossicles compressed:

Only straight pedicellariae present; deep-water species with small disk and 5 slender, tapering rays ..... Zoroasteridae

Both straight and crossed pedicellariae present; often shallow-water forms and often with more than 5 rays ..... Asteriidae

Family BRISINGIDAE

Though this is a widespread family with many genera, it is represented in Australia by a single species, and that known only from 2 specimens taken by the "Endeavour."

ODINIA

E. Perrier, 1885. Ann. sci. nat., ser. 6, vol. 19, no. 8, p. 9.

Genotype: *Odinia semicoronata* Perrier, 1885, p. 9.[1]

This is a widely distributed genus occurring in deep water in the Atlantic, Pacific, and Indian oceans. Apparently it does not occur in the Antarctic deeps, but the "Endeavour" found the following species south of Australia.

Odinia australis

H. L. Clark, 1916. "Endeavour" rept., p. 75; pl. 27, figs. 1, 2.

This well marked species, the first *Odinia* taken in the southern hemisphere, was found southeast of Cape Everard, Victoria, in 200 fms. No other *Odinia* is known from so moderate a depth. The disk is about 25 mm. across, the 14 arms are only 100 mm. long. There is no record of the color in life.

Family ZOROASTERIDAE

This family is widespread in deep water, but apparently not found in the Antarctic. One species, however, another of the "Endeavour" 's prizes, has been found in the deep water south of Australia, far from any of its near relatives.

ZOROASTER

Wyville-Thomson, 1873. Depths of the sea, p. 154.

Genotype: *Zoroaster fulgens* Wyv.-Thomson, 1873, p. 154.

There are 10 or more species of *Zoroaster* in the Indo-Pacific region, yet none of them has been found near Australia. The following was found, however, on

[1] This species is listed by Perrier as *Brisinga semicoronata* in his preliminary paper (1885*a*, p. 442), but the name is little better than a *nomen nudum* and was not really valid until his description was published in the Ann. sci. nat.

the southern side of the continent by the "Endeavour," in the deepest water in which she took any echinoderms.

Zoroaster macracantha

H. L. Clark, 1916. "Endeavour" rept., p. 68; pl. 28, figs. 1, 2.

Three specimens of this interesting sea star were taken in the Great Australian Bight in 250–450 fms. The largest specimen has R = 160 mm., r = only 14 mm. The nearest relative of this *Zoroaster* is apparently the Hawaiian species *Z. spinulosus* Fisher, but there are differences which warrant keeping the two separate at least until more material is available.

Family ASTERIIDAE

This large and widely distributed family, so conspicuous a feature of the sea-star fauna of the northern hemisphere, is rather poorly represented in Australia, save for the single genus *Uniophora,* which is endemic there. Nevertheless 8 genera are distributed along the southern coasts of the continent, and 2 of these are quite common. The following key will show the characters on which the 8 genera are based and how they differ. It is known that another genus, *Coronaster* or something allied thereto, occurs on the southern coast of the continent, for there is a small, 6-rayed sea star, obviously immature, in the South Australian Museum and supposedly from St. Vincent or Spencer Gulf, which cannot be referred to any of the genera now known from Australia (see H. L. Clark, 1928, p. 398).

Key to the Genera of Asteriidae

A. Tube feet biserial; skeleton an open network with very small spines; crossed pedicellariae never in circlets about them nor present on adambulacral spines ..... *Pedicellaster*

AA. Tube feet quadriserial, at least basally:

B. Adambulacral spines without pedicellariae; rays 5 or more; abactinal and marginal spines prominent, spaced, styliform or acicular, wreathed with pedicellariae; one series of actinal plates:

C. Only the outer of the two inferomarginal spines (on each plate) carries cluster of pedicellariae; 7–12 rays:

Adambulacral plates diplacanthid ..... *Astrostole*

Adambulacral plates monacanthid ..... *Coscinasterias*

CC. Both inferomarginal spines with pedicellariae; adambulacral plates diplacanthid; rays 5 ..... *Australiaster*

BB. Adambulacral spines carry pedicellariae singly or in clusters; abactinal spines short, more or less blunt, tubercular or variously granuliform; actinal areas broad, generally with 2 or more series of plates:

D. Abactinal plates small, in network; not forming obvious longitudinal series ..... *Smilasterias*

DD. Abactinal plates in rather definite longitudinal series:

E. Actinal plates in single series, dominated by their inferomarginals, which form ventrolateral margin to ray ..... *Allostichaster*

EE. Actinal plates in 2 or more series forming actinolateral areas along ray:
Large unguiculate, straight pedicellariae; actinostome sunken; adoral carina long ..... *Cosmasterias*
No large, unguiculate pedicellariae; actinostome not sunken; adoral carina short ..... *Uniophora*

PEDICELLASTER

Sars, 1861. Oversigt af Norges Echinodermer, p. 77.

Genotype: *Pedicellaster typicus* M. Sars, 1861, p. 77.

Most of the known species of *Pedicellaster* are found in moderate depths in the Atlantic, but 2 occur in the Antarctic and at least 2 in the Pacific Ocean. The occurrence of the following species in Australian seas was hardly to be expected.

Pedicellaster reticulatus

H. L. Clark, 1916. "Endeavour" rept., p. 69; pl. 27, figs. 3, 4.

A single individual of this sea star was taken by the "Endeavour" east of Maria Island, Tasmania, in 78 fms. It has 6 rays, the longest 30 mm. long. It is unlike the Atlantic Pedicellasters but bears considerable resemblance to Ludwig's species *improvisus* from the Galápagos Islands.

ASTROSTOLE

Fisher, 1923. Ann. Mag. Nat. Hist., ser. 9, vol. 12, p. 255.

Genotype: *Margaraster* (?) *scaber* Hutton, 1872, p. 5.

This is a group confined to and characteristic of the southern Pacific, and its right to a place in the Australian fauna is due to the occurrence of an endemic species at Lord Howe Island.

Astrostole insularis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 191; pl. 8, fig. 1 (colored).

This handsome sea star is apparently not rare at Lord Howe Island, where it is found under and among coral fragments near low-water mark. The largest specimen has R = 70–110 mm. The color in life is unusual, as blue predominates, and blue is a rare color among echinoderms. Although it has not yet been reported from the Australian coast, it is possible that specimens have been taken and confused with the following species, which it resembles superficially.

COSCINASTERIAS

Verrill, 1867. Trans. Connecticut Acad., vol. 1, p. 248.

Genotype: *Coscinasterias muricata* Verrill, 1867, p. 249 = *Asterias calamaria* Gray, 1840, p. 179.

Fisher (1928) divides this genus into 2 subgenera, including the species from the southern hemisphere in *Coscinasterias s. s.* and placing the 2 related forms of

the northern hemisphere in a subgenus, *Stolasterias*. The latter may well be accepted as a genus itself. Whether *muricata* Verrill is a complete synonym of Gray's *calamaria* may still be debatable, but Mortensen, who has collected at both Mauritius and New Zealand, so regards it, and my own observations in Australia have led to the same conclusion.

Coscinasterias calamaria

Asterias calamaria Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 179.
Coscinasterias calamaria Perrier, 1894. Stell. "Travailleur" et "Talisman," p. 106.
Coscinasterias gemmifera (Perrier) H. L. Clark, 1916. "Endeavour" rept., p. 74; pls. 31, 32.

This is undoubtedly the commonest littoral sea star of the southern coasts of Australia, ranging from Lord Howe Island on the east to Rottnest on the west. The number of rays ranges from 7 to 11, full-grown adults usually having 11. The coloration is diversified and variable, but blue is a not uncommon shade, though greenish, grayish, and brown shades predominate as a rule. For further discussion see H. L. Clark, 1938, pages 189–190.

AUSTRALIASTER

Fisher, 1923. Ann. Mag. Nat. Hist., ser. 9, vol. 12, p. 253.

Genotype: *Coscinasterias dubia* H. L. Clark, 1909, p. 532.

The establishment of a monotypic genus as a resting place for this endemic sea star is a satisfactory solution of that matter, but just what its relationships are remains a problem, for it is certainly not very closely allied to any other Australian form, nor is it very near to any of the other genera in the subfamily Coscinasterinae.

Australiaster dubia

Coscinasterias dubia H. L. Clark, 1909. "Thetis" rept., p. 532; pl. 49, figs. 3, 4; pl. 50.
Australiaster dubia Fisher, 1923. Ann. Mag. Nat. Hist., ser. 9, vol. 12, p. 253.

Both the "Thetis" and the "Endeavour" found this endemic sea star fairly common in 20–70 fms. off the southeastern corner of the continent and near Tasmania. The "Endeavour" also took it in 200 fms. south of Gabo Island and at least once on "the southern coast of South Australia," but it is notable that Verco did not find it during his extensive dredging in St. Vincent and Spencer gulfs. It is a well marked species which cannot be confused with any other Australian sea star. It reaches a considerable size (R = 138 mm.), but nothing is recorded as to color or general appearance in life.

SMILASTERIAS

Sladen, 1889. "Challenger" Ast., p. 562 (as subgenus).

Genotype: *Asterias* (*Smilasterias*) *scalprifera* Sladen, 1889, p. 562.

The granting of generic rank to this group by Fisher seems quite justifiable, though the material of the Australian species is so scanty and poor that it is not certain whether it represents one species or more. Nor does this procedure give

assurance that these little sea stars from the southern coast of Australia are really congeneric with the material collected by the "Challenger" in subantarctic seas, on which Sladen based his subgenus.

Smilasterias irregularis

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 402; figs. 116*a, b.*

The holotype of this species, said to be from Spencer or St. Vincent Gulf, is in the South Australian Museum. It has but 3 rays, of which 1 is very small; the largest is 49 mm. long. A second specimen, symmetrically pentamerous with R = 25 mm., taken at Western Port, Victoria, is in the National Museum at Melbourne. As these 2 specimens have not been compared side by side, it is quite possible that they are not conspecific. In the Museum of Comparative Zoölogy there are 17 small sea stars, in very poor condition, taken at Western Port and in Port Phillip by J. Gabriel in 1915. The larger of these are apparently identical with the National Museum specimen, but whether they are identical with the one at Adelaide is very doubtful.

ALLOSTICHASTER

Verrill, 1914. Shallow water starfishes, N. Pacific coast, p. 363.

Genotype: *Asteracanthion polyplax* Müller and Troschel, 1844, p. 178.

This is a group of 5 species occurring in the waters around southern South America, New Zealand, and Australia, but not yet found in South Africa. The 2 species found in Australia may be easily distinguished thus:

Rays 6–9, usually 8; seldom symmetrical owing to continually repeated autotomy ..... *polyplax*
Rays 5, symmetrical; autotomy rare or wanting ..... *regularis*

Allostichaster polyplax

Asteracanthion polyplax Müller and Troschel, 1844. Arch. f. Naturgesch., vol. 10, no. 1, p. 178.
Allostichaster polyplax Verrill, 1914. Shallow water starfishes, N. Pacific coast, p. 363.
Koehler, 1920. Australasian Antarctic Exped.: Ech. Ast., p. 85; pl. 18, figs. 7–11.

This is one of the most common and characteristic of southern Australian sea stars, ranging as it does from Long Reef, Colloroy, New South Wales, to Rottnest Island, Western Australia. It also occurs in New Zealand and Tasmania, but oddly enough has not yet been found at Lord Howe Island. Very probably the water there is too warm. Full-grown, symmetrical specimens of *polyplax* are rare, for autotomy seems to continue long after maturity is reached. With R = 35–38 mm. maximum size seems to be attained. In its habits, this little sea star is secretive and sluggish, living in crevices or in dead shells, or on the under side of rocks. Its colors show considerable diversity; brown, greenish, cream color, orange, and red occur in many shades and arrangements, but are never bright and are very fugacious.

Allostichaster regularis

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 400; figs. 115*a, b*.

In its pentamerous symmetry and regularity, this species is in striking contrast with the preceding, but otherwise the differences are not conspicuous. The largest specimen has R = 30 mm. No information is available as to color or habits. All the known specimens are from St. Vincent and Spencer gulfs, South Australia.

COSMASTERIAS

Sladen, 1889. "Challenger" Ast., p. 562 (as subgenus).

Genotype: *Asteracanthion sulcifer* Perrier, 1869, p. 235.

This is another group of southern-hemisphere sea stars to which Verrill properly gave generic rank. A single species occurs in Australian seas, having been discovered by the "Endeavour."

Cosmasterias dyscrita

H. L. Clark, 1916. "Endeavour" rept., p. 71; pl. 29, figs. 1, 2.

A single specimen with R = 67 mm. is the only evidence that *Cosmasterias* is an Australian genus. It was taken by the "Endeavour" south of Gabo Island, Victoria, in 200 fms. Nothing was recorded as to its appearance in life.

UNIOPHORA

Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 288.

Genotype: *Uniophora globifera* Gray, 1840, p. 288 = *Asterias granifera* Lamarck, 1816, vol. 2, p. 560.

This is perhaps the most distinctively endemic genus of Australian sea stars, remarkable for the degree of speciation that has been attained in a relatively restricted habitat, for at least 5 and possibly 6 species occur in the waters of South Australia, centering in Spencer and St. Vincent gulfs. Moreover, the genus does not occur north of Port Jackson on the east coast and Fremantle on the west. No fewer than 9 species seem to be recognizable and distinguishable as follows:

Key to the Species of Uniophora

A. Large, straight pedicellariae rare or wanting except on inner end of oral plates:
  B. Dorsal spines conspicuously capitate, globose, or fungiform:
    Dorsal, lateral, and actinal spines fungiform, the dorsal crowded..... *fungifera*
    Spines more or less globose or capitate..... *granifera*
  BB. Dorsal spines of divers forms, often capitate, but not conspicuously so and never fungiform:
    C. Spines more or less numerous on dorsal surface as well as on marginal and actinal plates:
      D. Carinal series of plates and spines conspicuous and well defined:

E. Carinal series more or less zigzag, at least distally; dorsolateral plates generally with spines:
F. Carinal series conspicuously zigzag, except near disk, its spines capitate, particularly the large ones; carinal and dorsolateral spines marking a double series of large polygonal areas ..... *sinusoida*
FF. Carinal series zigzag only distally, or if zigzag proximally its spines not capitate; no double series of large polygonal areas on dorsal side of rays, but 2 series of small areas on each side of carinals:
Arms relatively short and stout; most dorsal spines small and capitate ..... *obesa*
Arms longer, tapering; dorsal spines numerous, long, not capitate ..... *multispina*
EE. Carinal series nearly or quite straight; not more than 1 spine to a plate; dorsolateral spines practically wanting ..... *uniserialis*
DD. Carinal series inconspicuous and incomplete; spines of inferomarginal and actinal plates flattened, with tips chisel-shaped, or deeply channeled on upper side or even divided into 2 or 3 short branches ..... *dyscrita*
CC. Spines relatively few, wanting dorsally and on marginals except near tip of ray; more or less numerous but often nearly wanting on actinal plates ..... *gymnonota*
AA. Large, straight pedicellariae numerous both in ambulacral furrow and external to adambulacral spines ..... *nuda*

Uniophora fungifera

Asterias fungifera Perrier, 1875. Arch. zool. exp., vol. 4, p. 338 (p. 74 of reprint).
Uniophora fungifera Fisher, 1926. Ann. Mag. Nat. Hist., ser. 9, vol. 18, p. 198 (not figured).

This remarkable sea star undoubtedly came from "Nouvelle Hollande" as its label says, but it has not been met with in recent years.

Uniophora granifera

Asterias granifera Lamarck, 1816. Anim. sans vert., vol. 2, p. 560.
Uniophora globifera Gray, 1840. Ann. Mag. Nat. Hist., vol. 6, p. 288.
Uniophora granifera Bell, 1881. Proc. Zool. Soc. London, p. 497.
H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 403; figs. 117*a, b.*

Nothing is recorded as to the distribution of this species, or its habits or appearance in life, save for the single record from Port Jackson which I reported in 1938 (p. 196). This individual was bright, deep carmine red, shaded on depressed areas with dusky. Aside from Port Jackson, no definite localities are known for this species, but it apparently occurs on the South Australian coast. The largest specimen noted has R = 55 mm.

Uniophora sinusoida

Asterias sinusoida Perrier, 1875. Arch. zool. exp., vol. 4, p. 338 (p. 74 of reprint).
Uniophora sinusoida Fisher, 1923. Ann. Mag. Nat. Hist., ser. 9, vol. 12, p. 597.
H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 411; figs. 121*a, b.*

The only specimens I have seen of this species are from Spencer or St. Vincent Gulf, South Australia. The largest has R = 75 mm. The original specimen was said to be from Hobart, Tasmania. Stach (1938) reports 2 specimens (the larger with R = 85 mm.) from the Posidonia bank off Lusby Island, Spencer Gulf, where, he says, the species is fairly common.

Uniophora obesa

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 409; figs. 120*a*, *b*.

There is nothing to add to the original account of this species. The types were from Kangaroo Island, South Australia, and had R = 62 mm. Some specimens in poor condition were larger, the largest with R = 100 mm.

Uniophora multispina

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 407; figs. 119*a*, *b*.

The original material, R = 52–82 mm., was all from the vicinity of Adelaide or at least St. Vincent Gulf. Stach (1938) reports 14 small Uniophoras from the Posidonia bank, Lusby Island, Spencer Gulf, of which he refers 4 to this species. The other 10 he considers representatives of the following species, which he treats as a subspecies of *multispina*. I do not see from either his remarks or his figures any evidence that he had any specimen of *uniserialis*. All his specimens seem to have been *multispina*, small specimens of which would of course have fewer and more regularly arranged dorsal spines than the adults. But young *uniserialis* would have very few dorsal spines indeed.

Uniophora uniserialis

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 413; figs. 122*a*, *b*.

There were only 3 specimens in the original lot, the largest having R = 65 mm. No further information about this species has come to light. Stach's (1938) report of specimens from Lusby Island, Spencer Gulf, is apparently due to a misunderstanding of the characteristic spines.

Uniophora dyscrita

H. L. Clark, 1923*a*. Jour. Linn. Soc. (Zool.), vol. 35, p. 244.

The holotype is still unique in spite of much collecting near the spot where it was taken—Garden Island, Fremantle. It has R = 55 mm. but is probably not full grown. Unfortunately it has never been figured.

Uniophora gymnonota

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 405; figs. 118*a*, *b*.

No further information is available concerning this species. It reaches a fairly large size (R = 75–88 mm.) and seems to be rather common in the vicinity of St. Vincent Gulf.

Uniophora nuda

Asterias nuda Perrier, 1875. Arch. zool. exp., vol. 4, p. 335 (p. 71 of reprint).
Uniophora nuda Fisher, 1926. Ann. Mag. Nat. Hist., ser. 9, vol. 18, p. 198.

The holotype of this species, from Port Lincoln, South Australia, is still unique. Fisher has examined it and places it in *Uniophora.* It has not been figured.

OPHIUROIDEA

The brittle stars make up a very considerable part of the echinoderm fauna of Australia, and in number of individuals probably exceed greatly any of the other classes. They are small, as a rule, when compared with the sea stars or the crinoids, and among them are to be found the smallest echinoderms known. The largest rarely have bodies more than 50 mm. across, but the arms are often excessively long, 20 times (or more) the body diameter. The colors are for the most part dull shades of gray, brown, olive, or buff, often prettily mingled in attractive combinations with or without white. Many species are, however, handsomely colored, and a few rank with the most beautiful of Australian marine invertebrates. Their habits and habitats are extremely varied, for whereas some live under and among coral slabs and rock fragments and move about quickly, many live on gorgonians and other invertebrates (even on crinoids) and are very inactive. Another large group live buried more or less deeply in sand or mud and are only to be seen when dug out. They are naturally most abundant in tropical seas and are a particularly notable feature of the Barrier Reef region, whence more than 75 species are known, and of the vicinity of Broome, where 60 species have been found. At Port Jackson about 30 species may be collected, with half a dozen or more additional in the deeper water outside, and about the same number have been found in Verco's extensive dredging in St. Vincent and Spencer gulfs. Not quite so many have yet been reported from the western coast near Fremantle. The entire ophiuran fauna of Australia includes 70 Recent and 11 fossil genera with 223 Recent and 14 fossil species.

The Extinct Ophiuroidea

The extinct ophiurans of Australia are, with a single exception, quite unlike the living forms. Indeed, their relationship to the present fauna is remote and there are no connecting links. Owing to the lack of any generally accepted classification and to differences of opinion regarding the interpretation of the structure of the Paleozoic forms, it is very difficult to draw up artificial keys for the identification of the fossils. Withers and Keble (1934*a*) have, however, published so admirable a review of the group that it is unnecessary to attempt here any key to the orders and families involved. This is fortunate, for the classification used by Schuchert (1915) in his great monograph on Paleozoic Stelleroidea has been greatly affected by Matsumoto's (1917) radical rearrangement of ophiuran groups and particularly by Spencer's (1925 et seq.) meticulous studies, and there is not at present a consistent usable classification of the ophiuran Asterozoa.

None of the principal writers on the fossil brittle stars (Auluroidea) had any firsthand knowledge of the Recent forms, and consequently the terminology they used is quite different from that used by Lyman, Lütken, and all later writers on the living ophiurans. This is too bad, as contradictory inconsistencies are bound to occur and it is consequently difficult to harmonize the literature and make a comprehensive and usable tabulation of the fossil and Recent groups. The only practicable course seems to be to give first a brief, condensed summary of Withers and Keble's work, beginning with the following very artificial key to the 10 genera which they recognize, and following it with the necessary bibliographical, geographical, and geological data for the species included in each.

Key to the Genera of Extinct Ophiuroidea

A. Arm spines short or wanting, or if elongated and slender, not serrate:
- B. Arms slender and flexible:
  - C. Ambulacral plates subtriangular, more or less alternate; arm spines 2, short and pointed ..... *Gregoriura*
  - CC. Not as above:
    - D. Many disk plates tumid and socketed for large spine ..... *Taeniactis*
    - DD. Disk plates not tumid and socketed:
      - Arms flattened, with arm spines equaling about 2 segments ..... *Lapworthura*
      - Arms very slender, with long, slender spines ..... *Eospondylus*
- BB. Arms short and stiff, either more or less cylindrical or terete, or relatively flat and wide, at least basally:
  - E. Very small; arms terete, not flattened and widened at base ..... *Aganaster*
  - EE. Arms flattened and often widened at base:
    - F. Disk large, with prominent marginal plates; arms wide at base, tapering rapidly to tip ..... *Crepidosoma*
    - FF. Not as above:
      - G. Ambulacral plates more or less halberd-shaped ..... *Sturtzura*
      - GG. Ambulacrals more or less boot-shaped, with rounded corners:
        - Small species with 5 short petaloid arms; side arm plates slightly curved, rounded distally; no arm spines ..... *Hallaster*
        - Not as above ..... *Furcaster*

AA. Arm spines, and similar ones on disk margin, long, slender, and serrate ..... *Sturtzaster*

*GREGORIURA

Chapman, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, p. 24.

Genotype: *Gregoriura spryi* Chapman, 1907, p. 25.

No further material having been discovered, the relationships of this genus remain obscure. There is, however, no reason to consider it closely related to any one of the following genera.

*Gregoriura spryi

Chapman, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, p. 25; pl. 6, fig. 1; pl. 8, figs. 1, 3.

The unique holotype of this species is in the National Museum at Melbourne. It was of moderate size, with arms 32 mm. long and a disk diameter of apparently 9 or 10 mm. It was found in the Melbournian series of the Silurian blue and ochraceous shale at South Yarra, Victoria.

*TAENIACTIS

Spencer, 1922. Brit. Pal. Ast., pt. 5, explanation of pl. 17.

Genotype: *Taeniactis wenlocki* Spencer, 1922, expl. of pl. 17.

Whether this generic name dates from 1922, when it was first used without a word of explanation by Spencer for a fossil echinoderm of which two photographic figures (but no diagnosis or description) were given, or from 1927 (pt. 7, p. 379), when it was actually published with a diagnosis and with the description of its then only known species, is a debatable question but fortunately purely academic. The figures on plate 17 do not reveal at all the characters on which the genus is based, nor are they adequate to distinguish the species, and I should therefore prefer to accept 1927 as the actual date for the name, but strict adherence to the International Code requires acceptance of 1922.

*Taeniactis yeringae

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 199; text fig. 1.

There are 2 specimens known of this species, found in the Yeringian series of the Silurian rocks of section 12, Parish of Yering, Victoria. The disk is about 12 mm. across and the longest arm fragment is only 17 mm. These measurements indicate a somewhat greater size than that of the Scotch genotype, but the resemblance between the two species seems fairly close.

*LAPWORTHURA

Gregory, 1897. Proc. Zool. Soc. London (1896), p. 1037.

Genotype: *Protaster miltoni* Salter, 1857, p. 330.

Besides the English genotype, Withers and Keble record an endemic Australian species in this genus. The two are distinguished thus:

Arms 25–30 mm. long, not petaloid ..... *miltoni*
Arms 10 mm. long, petaloid ..... *pulcherrima*

*Lapworthura miltoni

Protaster miltoni Salter, 1857. Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 330; pl. 9, fig. 4.
Lapworthura miltoni Gregory, 1897. Proc. Zool. Soc. London (1896), p. 1037.
Spencer, 1925. Brit. Pal. Ast., pt. 6, p. 302; pl. 20, figs. 2, 3; pl. 21, figs. 7, 8.

This is one of the best known of the British Paleozoic Auluroidea, and its occurrence in Australia is vouched for by Withers and Keble. In view of the

character of the material, the specific identity of the British and Australian specimens is open to question. The Australian material consists of a fairly well preserved individual showing the bases at least of all 5 arms, and a single incomplete arm, 30 mm. long. The former is from the Yarravian series, of the Silurian rocks at Collins Quarry, Kinglake West, Victoria. The single arm is from the same strata at Moonee Ponds Creek, Flemington, Victoria.

*Lapworthura pulcherrima

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 201; pl. 11, figs. 1, 2; text figs. 4, 5.

A single specimen of this little auluroid provides syntypes from the Yarravian series of the Silurian rocks at Dawson Street, West Brunswick, Victoria. Diameter of oral pentagon 2.5 mm.; arms about 10 mm. long.

*EOSPONDYLUS

Gregory, 1897. Proc. Zool. Soc. London (1896), p. 1039.

Genotype: *Ophiurella primigenia* Stürtz, 1886*a*, p. 77.

A single fossil from the Silurian of Victoria is considered a representative of this genus, known hitherto only from the Lower Devonian of Germany.

*Eospondylus tenuis

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 206; pl. 11, fig. 7; text fig. 12.

The unique holotype consists of "part of a disk and portions of each arm" seen from the oral side. The radius of the disk is said to be 7.5 mm., but the figure, said to be ×4, shows a radius of less than 6 mm.; presumably there is a typographical error. Perhaps 7.5 should read .75. The specimen was collected in the Yarravian series of the Silurian of Victoria at Moonee Ponds in 1926, by E. S. Hills.

*AGANASTER

Miller and Gurley, 1891. Sixteenth rept. Geol. Surv. Indiana, p. 372.

Genotype: *Protaster* (?) *gregarius* Meek and Worthen, 1869, p. 169.

All the specimens as yet referred to this genus are very small and are very possibly simply the young of some larger species, perhaps not yet known. They have been found in the Lower Carboniferous of Great Britain and of the United States, and Withers and Keble (1934*a*) refer certain very minute Victorian "stelleroids" to the same species.

*Aganaster gregarius

Protaster (?) *gregarius* Meek and Worthen, 1869. Proc. Acad. Nat. Sci. Philadelphia, vol. 21, p. 169.

Aganaster gregarius Miller and Gurley, 1891. Sixteenth rept. Geol. Surv. Indiana, p. 372; pl. 9, figs. 10, 11.

Spencer, 1925. Brit. Pal. Ast., pt. 6, p. 285; pl. 18, fig. 3; pl. 20, figs. 4–6.

Withers and Keble (1934*a*, p. 207) refer some small ophiuran-like fossils from a "hard, chocolate sandstone" in the Carboniferous rocks at Maindample Park, Mansfield, Victoria to this small and imperfectly known species. They have the disk about 1 mm. across and the arms about 3.5 mm. long. There are 3 specimens "not more than an inch away from each other," indicating a gregarious habit, and this is one of the reasons for referring the fossils to *Aganaster*. For obvious reasons, the probability that the British, American, and Australian fossils are the young of a single species is remote. That they are even congeneric is open to question.

*CREPIDOSOMA

Spencer, 1930. Brit. Pal. Ast., pt. 8, pp. 405, 430.

Genotype: *Crepidosoma wenlockensis* Spencer, 1930, p. 405 (*nomen nudum*) = *Crepidosoma wenlocki* Spencer, 1930, p. 430.

On page 405 of his monograph, Spencer gives the genotype as "*Crep. wenlockensis*" and lists 3 species, *wenlockensis, petri,* and *goslariensis*. The first 2 are *nomina nuda,* as neither is mentioned again, but under the genus *Urosoma* reference is made to a *Protaster petri* Salter, a MS name. As for *goslariensis,* on page 430 this is listed as a *Crepidosoma,* but with a question mark. Obviously, then, on page 405 *Crepidosoma* has no component species, but sufficient distinctive features are given to justify the name. On page 430, however, "the holotype of the genus" is given as "*wenlocki* n. sp.," and adequate description and figures validate the name. Withers and Keble have described a second species from Australia.

*Crepidosoma kinglakensis

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 200; pl. 11, fig. 3; text figs. 2, 3.

The 2 specimens known of this species were found in the Silurian strata of Collins Quarry, Kinglake West, Victoria. Disk about 5 mm. across; arms 7 or 8 mm. long. "All the essential features of Crepidosoma are present," but there are at least 6 marginal plates in each interradius instead of 3 as in the British species.

*STURTZURA

Gregory, 1897. Proc. Zool. Soc. London (1896), p. 1034.

Genotype: *Protaster brisingoides* Gregory, 1889, p. 22.

This genus is known as yet only from the type species, which has not been reported from outside Australia.

*Sturtzura brisingoides

Protaster brisingoides Gregory, 1889. Geol. Mag., n. s., dec. 3, vol. 6, p. 24; text figs. 1, 2.
Sturtzura brisingoides Gregory, 1897. Proc. Zool. Soc. London (1896), p. 1034.
Spencer, 1927. Brit. Pal. Ast., pt. 7, p. 366; text figs. 232*b*, 233*b*.

It is not clear how many specimens of this fossil have been collected, but as Withers and Keble (1934*a*) quote Chapman as saying (*in litt.*) he has "found

considerable variation in the mouth parts," he must obviously have had a number of specimens. Chapman himself (1907) speaks of an "extensive series." The only recorded localities are the Yarravian series of the Silurian, near Flemington, Victoria, and the Yeringian series, section 12, Parish of Yering, Victoria. Judging from Chapman's figures, the disk was about 5 mm. across and the arms were about 15 mm. long. Spencer's figures are from larger specimens, as the arms were 4 mm. wide.

*HALLASTER

Stürtz, 1886. Neues Jahrb. Min., vol. 2, p. 150.

Genotype: *Protaster forbesi* Hall, 1868, p. 293 = *Palaeocoma cylindrica* Billings, 1857, p. 292.

Spencer (1925) considers this genus monotypic in spite of the fact that the known material came from Canada, the United States, and Great Britain, and from strata ranging from Middle Ordovician to Lower Devonian. It is therefore of no little interest that a specimen has been found in Australia which apparently represents a second species.

*Hallaster parvus

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 203; pl. 11, figs. 5, 6; text figs. 8, 9.

A very small, but fairly well preserved individual (syntypes) was found in 1929 by E. S. Hills in the Silurian strata of Blue Hills, Taggerty, Victoria, which Withers and Keble refer to this genus but not to the long-known species. It is very small, the petaloid arms being only about 5 mm. long. No arm spines are visible, but the side arm plates are obvious and characteristic.

*FURCASTER

Stürtz, 1886. Palaeontographica, vol. 32, p. 79.

Genotype: *Furcaster palaeozoicus* Stürtz, 1886*a*, p. 79 = *Protaster leptosoma* Salter, 1857, p. 331.

Spencer (1925) discussed this genus so thoroughly that the 7 described species melted into one, to which he added a second valid form. Withers and Keble (1934*a*) have found that the genus occurs frequently in the Silurian rocks of Victoria, but the specimens seem to represent 3 distinct species, of which 2 are new. They may be distinguished thus:

Key to the Species of Furcaster

A. Ambulacrals hatchet-shaped; arms about 7 mm. long ..... *bakeri*
AA. Ambulacrals short, boot-shaped:
  Arms petaloid, elongated, 20 mm. long ..... *kilmorensis*
  Arms not markedly petaloid, 10 mm. long ..... *leptosomoides*

*Furcaster bakeri

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 204; pl. 11, figs. 9, 10; text figs. 10, 11.

Found in the Yarravian strata of the Silurian rocks near Dight's Falls, Studley Park, Victoria, on the east side of the new Yarra boulevard, this species is known only from its syntypes. It is apparently the smallest of the Australian Furcasters, and its describers stress the unusual shape of its ambulacrals.

*Furcaster kilmorensis

Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 205; pl. 11, fig. 8; text figs. 6, 7.

This is apparently the largest of the Australian Furcasters, having arms 20 mm. long. The number of specimens examined is not stated, but the sentence "Other specimens are only slightly smaller or slightly larger" indicates that there were several. Apparently all are from Silurian strata at Kilmore, Victoria.

*Furcaster leptosomoides

Sturtzura leptosomoides Chapman, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, p. 26; pl. 7; pl. 8, fig. 4.
Furcaster leptosomoides Withers and Keble, 1934*a*. Proc. Roy. Soc. Victoria, n. s., vol. 47, p. 206.

Nothing has been added to our knowledge of this species since Chapman's paper, though Withers and Keble have altered its generic position. As Chapman speaks of "specimens" and gives two figures, he seems to have had at least two, one of which (pl. 7, fig. 1) he says is the "type." Apparently no other material has been collected. Chapman gives the diameter of the oral pentagon as 2.5 mm. and the length of arm as 10 mm. The type locality is the Melbournian series, in the Silurian rocks of Moonee Ponds Creek, Flemington, Victoria.

*STURTZASTER

Etheridge, 1899. Rec. Australian Mus., vol. 3, p. 129.

Genotype: *Palaeocoma marstoni* Salter, 1857, p. 328.

The material on which the justification rests for including this genus here is not satisfactory, but there is no doubt that a *Sturtzaster*-like form of echinoderm occurs in both New South Wales and Victoria. Whether the fossils from these widely separated beds represent a single species is no doubt debatable, but as material is so scanty, I am including all under a single name.

*Sturtzaster mitchelli

Etheridge, 1899. Rec. Australian Mus., vol. 3, p. 129 (not figured).

The original material of this species is from the Upper Trilobite bed of the Wenlock series, Silurian strata, at Bowning, New South Wales. Two similar specimens, one from the Yarravian beds of the Silurian at Swanston Street, Mel-

bourne, the other from the Moonee Ponds district, Victoria, are thought by Withers and Keble (1934*a*) to be probably closely related to, if not identical with, Etheridge's species. Until we get better-preserved material, the question of the actual relationship of the two forms must be left undecided.

The Orders and Families of Recent Ophiuroidea

In spite of the large amount of taxonomic work that has been done on ophiurans, we still lack a well founded natural classification of even the Recent forms. Matsumoto (1915, 1917) made an excellent beginning, but his work has not been followed up; it needs a critical restudy including many more genera. No other writers on the group, however, have made careful or extensive comparative morphological studies of any considerable number of genera. For the present, therefore, we cannot do better than follow Matsumoto's proposed arrangement, which will do very well for the Australian fauna. Under this scheme his 4 orders and the 10 families found in Australia may be distinguished as follows:

Key to the Orders and Families of Ophiuroidea

A. Arms with dorsal plates rudimentary or wanting; side arm plates subventral or ventral in position; radial shields long and barlike, or more or less rudimentary ..... Phrynophiurida

B. Arms simple, not exceedingly long; side arm plates subventral; arm spines not confined to ventral side of arm ..... Ophiomyxidae

BB. Arms exceedingly long, when simple, but usually branched at least near tip; side arm plates ventral; arm spines confined to ventral side of arm, all serving as tentacle scales:

Teeth stout, in a single vertical series; oral and dental papillae not well developed; arms not annulated with rings of hook-bearing granules ..... Trichasteridae

Teeth and dental papillae, often also oral papillae, all similar, spiniform; arms annulated with double rows of hook-bearing granules ..... Gorgonocephalidae

AA. Arms simple, with dorsal, ventral, and side arm plates forming a well marked covering; radial shields usually well developed and not barlike:

C. Radial shields and genital plates articulated by means of simple face or transverse ridge without articular condyles or pits; disk covered by soft skin with or without fine scales or plates, usually beset with granules, tubercles, or spinules ..... Laemophiurida

This order is represented in Australia by the single family ..... Ophiacanthidae

CC. Radial shields and genital plates articulating by means of pits and condyles:

D. Single articular pit and condyle in connection with each radial shield and genital plate; oral papillae few, often wanting ..... Gnathophiurida

Oral papillae present; no vertical clump of small dental papillae at apex of jaw ..... Amphiuridae

Oral papillae absent; dental papillae present in dense oval vertical clump at apex of jaw ..... Ophiotrichidae

DD. 2 articular condyles and 1 pit on each radial shield and genital plate; oral papillae well developed, often numerous..... CHILOPHIURIDA
E. Disk covered with very fine, almost microscopic scaling, without granules; large supplementary upper arm plates present; 1 large, flat, circular tentacle scale..... Ophiochitonidae
EE. Not as above:
F. Dental papillae well developed in vertical clump at apex of jaw; arm spines big and conspicuous..... Ophiocomidae
FF. No dental papillae; arm spines usually small and appressed (big and flaring in *Ophiarachna*):
Disk closely covered with granules concealing scales..Ophiodermatidae
Disk covered with scales or plates, without granules...Ophiolepididae

Order PHRYNOPHIURIDA

Family OPHIOMYXIDAE

This small family is poorly represented in Australian waters, for only a single species is at all common; of the others, one has been taken half a dozen times in 30–200 fms., but the second has been met with only once. The 3 genera may be easily distinguished thus:

KEY TO THE GENERA OF OPHIOMYXIDAE

A. Teeth and oral papillae wide, with serrate, glassy margins..... *Ophiomyxa*
AA. Teeth and oral papillae spiniform or peglike:
Disk covered densely with minute acute spinelets; arm spines small and numerous ..... *Ophiobyrsa*
Disk naked; arm spines 3 or 4, long and slender..... *Ophioscolex*

OPHIOMYXA

Müller and Troschel, 1842. Syst. Ast., pp. 84, 108.

Genotype: *Ophiura pentagona* Lamarck, 1816, vol. 2, p. 546.

Some 20 species have been named in this genus, but only 4 of them occur in the southern hemisphere. Of these, 2 occur in South Africa (1 of these in South America) and 1 in New Zealand. The fourth is the following Australian species.

Ophiomyxa australis

Lütken, 1869. Add. ad hist. Oph., pt. 3, p. 99.
H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 168; pl. 1, figs. 1, 2.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 201; pl. 13, figs. 1, 2 (colored).

This species has a wide range, from Mauritius on the west to Fiji in the east, north to Japan and south to Tasmania. In Australia, it ranges from the west coast between Geraldton and Fremantle, along the southern coast to Tasmania, Port Jackson, and Lord Howe Island. It is not known from the tropical coasts of Australia except in the vicinity of Lizard Island, Queensland, where the Great Barrier Reef Expedition found it common. It is known, however, from Amboina and the East Indies, under the name *O. brevispina* von Martens. Under favorable

conditions it reaches a large size, up to 35 mm. in disk diameter, and arm length 140 mm. The color is very diversified, ranging through shades of brown, olive, and dull yellow, often with gray spots or markings; the arms are commonly more or less indefinitely banded. In habits, *Ophiomyxa* is secretive, living under rock slabs or hidden in crannies, but it is capable of rather fast movements when exposed.

Koehler in 1905 described an *Ophiomyxa* from the East Indies under the name *irregularis,* to which in 1930 he referred 4 specimens collected by Mortensen off southeastern New South Wales, in 83–160 fms. He makes no reference to *australis,* but he refers the rest of the Ophiomyxas collected by Mortensen in Australia to *brevispina,* which in my opinion is a synonym of *australis.* After examining a specimen of *irregularis* from Amboina, identified by Koehler himself, I doubt the validity of the species. In any case, it does not seem likely that 2 distinct species of *Ophiomyxa* are living together in deep water off Cape Howe, New South Wales.

OPHIOBYRSA

Lyman, 1878. Bull. Mus. Comp. Zoöl., vol. 5, p. 131.

Genotype: *Ophiobyrsa rudis* Lyman, 1878, p. 131.

Although monotypic when established, this genus has since been found to be widely distributed and half a dozen additional species have been described, but 2 have been segregated in a genus *Ophiobyrsella.* The following is the only one from the southern hemisphere.

Ophiobyrsa rudis

Lyman, 1878. Bull. Mus. Comp. Zoöl., vol. 5, p. 131; pl. 8, figs. 198–200.
——— 1882. "Challenger" Oph., p. 244; pl. 16, figs. 18–20.

The "Challenger" took but 2 specimens of this interesting form off Port Phillip, Victoria, in 38 fms. The "Thetis" failed to find it at all, but the "Endeavour" took 7 specimens at five stations off the southeastern corner of the continent and near Tasmania, in 30–200 fms. Mortensen took 3 specimens in the same region in 1914. One of the "Challenger" specimens was 28 mm. across the disk, but none of the "Endeavour" specimens was quite so large. Nothing is recorded as to the color in life; the preserved material is yellow-brown. Koehler's report (1930) of a specimen from the Kei Islands needs confirmation.

OPHIOSCOLEX

Müller and Troschel, 1842. Syst. Ast., pp. 84, 109.

Genotype: *Ophioscolex glacialis* Müller and Troschel, 1842, p. 109.

This genus is entitled to a place in this list, for a specimen which should undoubtedly be referred to it is in the South Australian Museum.

Ophioscolex sp.?

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 418 (not figured).

A very small *Ophioscolex,* 6 mm. across the disk and with arms 20 mm. long, was dredged by Verco in Spencer or St. Vincent Gulf. It is so much like a young

example of the North Atlantic species, *glacialis,* that it cannot be satisfactorily distinguished in its present condition. Probably adult specimens in good condition will prove to be distinguishable.

Family TRICHASTERIDAE

This small family is well represented in Australia, as there are 6 genera in the fauna, of which 3 are found on the tropical coasts and the other 3 only on the southern side of the continent, below 30° S. They may be distinguished thus:

Key to the Genera of Trichasteridae

A. Arms stout basally, repeatedly branched dichotomously ..... *Euryale*
AA. Arms slender, unbranched, elongated:
B. 3 or more arm spines; disk naked; radial shields flat, thin, conspicuous ..... *Asteronyx*
BB. Only 2 arm spines:
C. Side arm plates widely separated ventrally by an evident under arm plate; arms and disk naked; arm spines short:
Arms short, only 2–5 times disk diameter ..... *Ophiuropsis*
Arms long, many times disk diameter ..... *Astrobrachion*
CC. Side arm plates not separated ventrally by under arm plates; at least inner arm spines more or less elongated:
Hexamerous; no visible radial shields; flattened, circular or oval tentacle scale ..... *Astrogymnotes*
Pentamerous, normally; radial shields usually evident; no tentacle scales ..... *Ophiocreas*

EURYALE

Lamarck, 1816. Anim. sans vert., vol. 2, p. 535.

Genotype: *Euryale aspera* Lamarck, 1816, vol. 2, p. 535.

The conspicuous "basket fish" which compose this genus are among the most remarkable of the marine invertebrates of Australia. They live either entwined among the branches of gorgonian (or other) corals, or else exposed on sandy sea bottoms, lying with mouth up, the numberless terminal branches of the much divided arms in continual inward and outward movement, taking food to the mouth and going back to the periphery of the "basket" for more. There are apparently 2 species in Australia, but only 1 is adequately known.

Large spiniform tubercles of disk and arm bases 4 mm. or less in height, 1.5 mm. or less in diameter, often sharp-pointed ..... *aspera*
Large tubercles 5–7 mm. high, 2 mm. or more thick at base, blunt or clavate at tip ..... *euopla*

Euryale aspera

Lamarck, 1816. Anim. sans vert., vol. 2, p. 535.
Döderlein, 1911. Japan. Euryalae, p. 65; pl. 5, figs. 7, 7*a*.

This is a more or less common East Indian species often found on the coasts of tropical Australia, ranging from Double Island Point, Queensland, to Cape

Villaret, Western Australia. Large specimens may have the disk as much as 40 mm. across and the arms at least 150 mm. long when fully stretched out, as they may be when the animal is feeding. The very young are white but rapidly become pigmented, and the adults are more or less dark-colored in various shades of yellow, brown, red, or purple, often quite variegated.

Euryale euopla

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 203; pl. 23, fig. 1.

The specimens on which this species is based were labeled as from Bald Island, east of Albany, Western Australia, a most unexpected locality for a *Euryale*. No further material has been reported.

ASTERONYX

Müller and Troschel, 1842. Syst. Ast., pp. 85, 119.

Genotype: *Asteronyx loveni* Müller and Troschel, 1842, p. 119.

Although some half-dozen species have been named in this perplexing genus, it is difficult to distinguish any one of them clearly from the genotype, which seems to be well-nigh ubiquitous in cold water from 65 to 1650 fms. deep.

Asteronyx loveni

Müller and Troschel, 1842. Syst. Ast., p. 119; pl. 10, figs. 3–5.

Neither the "Challenger" nor the "Thetis" found this characteristically deep-sea ophiuran in Australian waters, but the "Endeavour" took half a dozen specimens in 65–200 fms. off the southeastern corner of the continent, and Mortensen took 11 in the same region, in 120–250 fms. These specimens were of moderate size and indistinguishable from specimens taken in the northern and eastern Pacific.

OPHIUROPSIS

Studer, 1884. "Gazelle" Ast., p. 55.

Genotype: *Ophiuropsis lymani* Studer, 1884, p. 55.

This genus, based on a single small trichasterid, is almost certainly invalid. The unique specimen is obviously immature, but as it is impossible to determine of what species it is the young, the genus must be admitted here. Koehler (1930) reports a somewhat similar trichasterid, but with arms much longer relatively, as taken by Mortensen off Cape Howe, New South Wales, in 100–150 fms., but believing the genus to be invalid he wisely refrained from giving it a name. Studer's species, however, having been named, must be included here.

Ophiuropsis lymani

Studer, 1884. "Gazelle" Ast., p. 55; pl. 5, figs. 12*a–d*.

The unique holotype of this puzzling form has the disk 6 mm. across, the arms about 12 mm. long. The color in life was rosy red. The error by which I attributed

(1915, 1923) this species to South Africa was corrected by Döderlein (1927) but repeated by Koehler (1930). The correct locality is southwest of Dirk Hartog Island, Western Australia, in 60 fms.

ASTROBRACHION

Döderlein, 1927. Abhandl. K. bayer. Akad. Wissensch., math.-naturwiss. Abt., vol. 31, pt. 6, p. 77.

Genotype: *Ophiocreas constrictum* Farquhar, 1900, p. 405.

Material for an adequate discussion of this genus is lacking, and as Mortensen (1924) has pointed out, the relations of several species and at least two genera cannot be determined until a much larger number of specimens of various ages and sizes, from both New Zealand and Australian stations, is available for study. For the present, it seems advisable to let the nominal species stand as they are.

Astrobrachion adhaerens

Ophiocreas adhaerens Studer, 1884. "Gazelle" Ast., p. 54; pl. 5, figs. 11*a–d*.
Astrobrachion adhaerens H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 202.

The original specimens of this species were taken by the "Gazelle" off northwestern Australia in 45 fms. What are apparently very young specimens of the same thing are in the Australian Museum from Port Molle, Queensland, 15 fms., and in the Museum of Comparative Zoölogy from Whitsunday Passage, 9 fms. Adult material is still lacking. When it is available, relationship between *adhaerens* and the New Zealand genotype will be better understood.

ASTROGYMNOTES

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 153.

Genotype: *Astrogymnotes catasticta* H. L. Clark, 1914, p. 154.

No other species of this endemic Western Australian genus have yet been discovered.

Astrogymnotes catasticta

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 154; pl. 22.

Ten specimens of this remarkable ophiuran were taken by the "Endeavour" in 1912, off Jurien Bay, Western Australia, in 80–100 fms., but it has not been found anywhere since. There are 6 or rarely 7 arms. Disk 9 mm. across; length of arms only about 5 times disk diameter. The color in life is not recorded, but in alcohol the general tint is yellow-brown, indistinctly speckled on radial areas of disk, and conspicuously spotted all over lower surface of disk and arms with pale yellowish white. In dry specimens the colors are dull, the spotting is not so noticeable, and calcareous granules give the upper surface of the arms a whitish cast.

OPHIOCREAS

Lyman, 1869. Bull. Mus. Comp. Zoöl., vol. 1, p. 347.

Genotype: *Ophiocreas lumbricus* Lyman, 1869, p. 347.

Some 20 species have been referred to this genus since it was established by Lyman, but Döderlein (1927) in his last revision listed only 16, and of several of these he was dubious. This doubt extends even to the 4 species here included in the Australian fauna. Growth changes are considerable, and as nearly all the species are from moderately deep water, material in museums is generally scanty. The Australian species may be separated by the characters given in the following key. It is possible, if not probable, that *melambaphes* and *rhabdotum* are color forms of a single species; it seems best, however, to keep both names in use until the actual relationship between the two forms is determined, as the difference in the basal tentacle pores is important. Doubt also shrouds *phanerum,* which Mortensen (1924) considers a synonym of *constrictum* Farquhar from New Zealand.

Key to the Species of Ophiocreas

A. Arm spines (or tentacle scales) begin at second tentacle pore:
  Arm spines relatively long, longest exceeding arm width; size large (disk more than 10 mm., arms more than 150 mm.) ..... *sibogae*
  Arm spines short, scarcely half arm width; size small (disk 5–7 mm., arms less than 100 mm.) ..... *rhabdotum*

AA. Arm spines begin at third tentacle pore:
  Teeth well formed, triangular, sharply pointed; arm spines well developed, subequal, stout, very thorny on terminal half; size large (disk 13–18 mm., arms over 250 mm.) ..... *phanerum*
  Teeth poorly developed, blunt, lowest often deformed; arm spines very small, inner somewhat larger, often somewhat capitate; size small (disk 6–8 mm., arms about 120 mm.) ..... *melambaphes*

Ophiocreas sibogae

Koehler, 1904*a*. "Siboga" Oph.: Mer prof., p. 165; pl. 36.

The occurrence of this East Indian species in deep water off the southern coast of Australia is perplexing, for it has not otherwise been found nearer to Australia than the Kei Islands. The "Endeavour" took 7 large specimens (largest, 25 mm. in disk diameter, with arms 610 mm. long) east of Flinders Island, and in the Great Australian Bight, in 80–300 fms. Comparison with a cotype of the species justifies the identification.

Ophiocreas rhabdotum

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 156 (not figured).

This species has been collected only once, and that by the "Endeavour" in 1912, off Jurien Bay (south of Geraldton), Western Australia, in 80–100 fms.; its status is unsatisfactory. Only 2 specimens were studied at the time of the description, but apparently a larger number were taken, for W. B. Alexander, the collector, says in a footnote to the original account (H. L. Clark, 1914, p. 156) that this species

and *melambaphes* were taken in "large quantities" (see further under *melambaphes,* below). The color is dull yellow, speckled and streaked on disk with blackish; a broad blackish stripe, finely speckled with yellowish, runs the length of the arm in the median line abactinally; on each side of the arm just above the arm spines is a very narrow and often indistinct blackish stripe. This notable coloration, the small size, and the presence of arm spines at the second tentacle pore seem to warrant the recognition of the species, though Alexander thought it only a color variety when he took it. It has not been figured.

Ophiocreas phanerum

H. L. Clark, 1916. "Endeavour" rept., p. 79; pl. 33, figs. 1, 2.

Mortensen (1924, p. 99) believes this species is identical with *constrictum* Farquhar. Not having a specimen of the New Zealand species for comparison with the large Australian *Ophiocreas* at hand, I cannot contradict him. But if that is the case, then the Australian species is not an *Ophiocreas* at all, but an *Astrobrachion,* and apparently identical with Studer's species *adhaerens.* Of this species, only very young ones are available, and they are so different from the big *phanerum,* it is hard to accept their identity. For the present, therefore, the Australian species taken by the "Endeavour" may retain its name. There is little doubt that it will ultimately be considered an *Astrobrachion* and perhaps identical with Studer's species; but a range from New Zealand to northwestern Australia is too unusual to accept without much better evidence than we have in this case. The "Endeavour" took 14 specimens of *phanerum* at four stations between Sandon Bluffs, New South Wales, 35–40 fms., and Cape Barren Island, Tasmania, 70 fms. East of Flinders Island, it was taken at 80–300 fms. The type was 18 mm. across the disk and had arms 380 mm. long. The color was deep red-purple.

Ophiocreas melambaphes

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 155.
——— 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 177; pl. 1, fig. 9.

At a casual glance this little species could well pass for a very young *phanerum,* but more careful examination shows such differences in the teeth and arm spines that no confusion is likely. It was taken with *rhabdotum* by the "Endeavour" in 1912, off Jurien Bay, Western Australia, in 80–100 fms., and the collector, W. B. Alexander (1915), thought the two were "probably color varieties of one species." They "were obtained together in large quantities attached to one particular species of Hydroid with which their arms were so much intertwined, it was very difficult to remove them, except in fragments." Until further collecting reveals larger specimens, it cannot be said whether these small ones are adults or not. They are less than 7 mm. across the disk and the arms are only about 120 mm. long. The color is a deep purple or purplish black, with the actinal surface much lighter, a dull cream color.

Family GORGONOCEPHALIDAE

This cosmopolitan family is well represented in Australia by a dozen species of 9 genera. Two of the genera, including 5 of the species, are endemic, 6 are Indo-

Pacific, and 1 is found in the West Indies, Japan, and New Zealand. None of the species are strictly littoral, but several occur in depths of only a few fathoms and are sometimes washed up on the beach. The usual habitat is between 50 and 300 fms. The genera may be distinguished thus:

Key to the Genera of Gorgonocephalidae

A. Arms long and unbranched:
  B. Annulations of arms not continued onto disk:
    Disk covered with low, hemispherical granules (0.30–0.90 mm. in diameter) with rough or prickly surface ..... *Astrothamnus*
    Disk covered with very irregular pavement of granules, diverse in size and form, large ones rounded, small ones angular ..... *Astrothrombus*
  BB. Annulations on arms continued onto disk so the latter is ornamented with concentric circles or pentagons ..... *Asteroporpa*
AA. Arms stout and branched:
  C. Tentacle scales (or papillae) present before first arm fork:
    D. Disk and upper surface of arm bases with big tubercles or stout spines:
      Each pair of radial shields forms a wedge scarcely separated from its neighbors ..... *Conocladus*
      All radial shields distinctly separated ..... *Astroconus*
    DD. Disk and arm bases with small spinelets or none ..... *Astrodendrum*
  CC. No tentacle scales before first arm fork:
    E. Tentacle scales begin near disk margin, after first or second arm fork ..... *Astrocladus*
    EE. Tentacle scales begin at or after fourth arm fork:
      Free arm near disk margin narrow, about as broad as high, with narrow lower surface ..... *Astroboa*
      Free arm near disk very broad and low, with flat, wide lower surface ..... *Astrochalcis*

ASTROTHAMNUS

Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 55.

Genotype: *Astrotoma echinacea* Matsumoto, 1912, p. 200.

Matsumoto included in his genus 3 East Indian species which Koehler described as *Astrotoma*. Döderlein (1927) removes these to "Incertae sedis," as well as my species of 1916 and 1923, but adds a fifth species from the Philippines. Koehler (1922, 1930) has added 2 more species from the East Indian region and 1 from southeastern Australia. This last appears to be identical with my species from the same region, the only Australian member of the genus.

Astrothamnus rugosus

H. L. Clark, 1916. "Endeavour" rept., p. 85; pl. 35, figs. 1, 2.
Astrothamnus furtivus Koehler, 1930. Vidensk. Medd., vol. 89, p. 6; pl. 1, figs. 1, 2.

It is strange, in view of the locality where his 2 specimens were taken, that Koehler overlooked the species taken by the "Endeavour" in the same region. Comparison of his description and figures with a paratype of *rugosus* fails to show

any ground for considering them distinct. The number of madreporites is of no importance; the holotype of *rugosus* has 2. Mortensen in 1914 took 2 specimens in 120–250 fms., with disks 10 and 15 mm. in diameter, and the "Endeavour" collection contained 4 specimens, 9–20 mm. across, from 80–300 fms. There are no notes in either collection regarding the color in life. Preserved specimens are "museum color." All the material has come from the eastern end of Bass Strait, near Cape Everard or Flinders Island.

ASTROTHROMBUS

H. L. Clark, 1909. "Thetis" rept., p. 548.

Genotype: *Astrothrombus rugosus* H. L. Clark, 1909, p. 548.

This genus was based on a single specimen, and nothing congeneric with it has yet been taken.

Astrothrombus rugosus

H. L. Clark, 1909. "Thetis" rept., p. 548; pl. 54, fig. 3.

The unique holotype of this remarkable ophiuran is only 7 mm. across the disk, and the arms are 4 or 5 times as much. It was taken by the "Thetis" at her station 48, off Wollongong, New South Wales, in 55–56 fms., on a bottom of "sand and mud to rock," and is now in the Australian Museum.

ASTEROPORPA

Lütken, 1856. Vidensk. Medd., p. 17.

Genotype: *Asteroporpa annulata* Lütken, 1856, p. 17.

This is a cosmopolitan genus indeed, with 2 species in the West Indies, 1 in Japan, 1 in New Zealand, and 1 in southern Australia. As might be expected, the New Zealand species is the one most nearly allied to the Australian form.

Asteroporpa australiensis

Astroporpa australiensis H. L. Clark, 1909. "Thetis" rept., p. 547; pl. 54, fig. 2.
Asteroporpa australiensis H. L. Clark, 1916. "Endeavour" rept., p. 80 (corrected spelling).

The "Thetis" took a single specimen of this handsome species off Wollongong, New South Wales, in 55–56 fms., on a bottom of "sand and mud to rock." The "Endeavour" took 10 specimens in Bass Strait and vicinity in 65–200 fms. The largest specimen was 18 mm. across the disk and the arms were more than 4 times as much. The colors are very light brown or dirty whitish, prettily annulated on arms and disk with bright brown; lower surface of arms brown. The Australian Museum has a large series of specimens, 5–17 mm. across the disk, trawled in 70–75 fms. off Cape Everard, Victoria, March 6, 1929. Koehler (1930) reports 3 specimens from Bass Strait collected by Mortensen. He also refers a specimen from Amboina to this species, but as it is only 2 mm. across the disk, we may well be skeptical of the identification.

CONOCLADUS

H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 131.

Genotype: *Conocladus oxyconus* H. L. Clark, 1909*a*, p. 132.

This is one of the most striking endemic genera in the Australian fauna, where it is represented by 3 well marked species. Döderlein (1927) regards it as among the most primitive of the Gorgonocephalidae and suggests that it is a "Stammform" for the family. The 3 species may be distinguished thus:

Key to the Species of Conocladus

A. Numerous (or few) large tubercles or stout spines on disk and arm bases:
  Disk with stout, pointed, tubercular spines ..... *oxyconus*
  Disk with big, rounded tubercles ..... *amblyconus*
AA. No large tubercles or stout spines on disk or arm bases; disk spines numerous but not very big ..... *microconus*

Conocladus oxyconus

Conocladus oxyconus H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 132; pl., figs. 1–3.
Astroconus annulatus Koehler, 1930. Vidensk. Medd., vol. 89, p. 16; pl. 1, figs. 8–10.

This species is apparently not common, as only 10 or a dozen specimens have been reported. These are all from off the coast of New South Wales, near or south of Port Jackson, in 15–50 fms., save 2 reported to be from off Cape Wiles, South Australia. It is not impossible that there is some mistake about this label, for no other examples have been found west of Bass Strait. The largest individual is about 40 mm. across the disk, but most of the specimens are much smaller. Nothing is recorded of the color in life, but dried specimens are very pale brown or dirty white with or without purplish markings. The big individual on which Koehler (1930) based his *Astroconus annulatus* was clear gray with purple markings on the disk and brown rings on the arms. The figures (particularly fig. 8) show clearly that this specimen was a *Conocladus,* apparently a very large *oxyconus.*

Conocladus amblyconus

H. L. Clark, 1909. "Thetis" rept., p. 549; pl. 55.

More than 40 specimens of this species have been taken, all from off the coast of New South Wales in 10–75 fms. They range from 3 to nearly 50 mm. in disk diameter. Nothing is recorded as to the color in life, but dry specimens are diversified, ranging from nearly white to fawn color or even darker, reddish brown or purplish brown.

Conocladus microconus

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 156; pl. 25, upper fig.

Only 2 specimens of this well marked species are as yet reported, and 1 of these had 6 rays. They were 27 and 35 mm. across the disk and are said to have been

in life dull brown. The dry specimens are a uniform light brown. They were taken in 80–120 fms., between Geraldton and Fremantle, Western Australia, by the "Endeavour," in June 1912.

ASTROCONUS

Döderlein, 1911. Japan. Euryalae, p. 36.

Genotype: *Astrophyton australe* Verrill, 1876, p. 74.

This interesting genus is also endemic in southern Australian seas, and approaches the preceding so closely that the line between them is difficult to maintain. Typical specimens are easily placed, but intermediates and young individuals are perplexing. It seems as though *Conocladus oxyconus* and *Astroconus australis* intergraded, but until much more material of the former is available, it is best to maintain the artificial distinction. Although the genotype of *Astroconus* is known from many specimens, the other 2 species are known from only 1 specimen each. The 3 forms are distinguishable thus:

A. Arms more or less slender (often stout in big specimens), not annulated basally and usually not until smaller distal branches are reached ..... *australis*

AA. Arms distinctly annulated from base:

Arms slender, annulations not extending onto radial wedges ..... *pulcher*

Arms stout, deeply annulated, annulations including distal part of radial wedges ..... *occidentalis*

Astroconus australis

Astrophyton australe Verrill, 1876. Bull. 3 U. S. Nat. Mus., p. 74.
Astroconus australis Döderlein, 1911. Japan. Euryalae, p. 37; pl. 5, figs. 2, 2*a*.

Both the Sydney and Adelaide museums contain good series of this notable species, and data concerning them have already been published (see H. L. Clark, 1916, 1928). The smallest specimen recorded is 6 mm. across the disk, with arms 20–25 mm. long. The largest is about 50 mm. in disk diameter; the arms were probably fully 200 mm. long when extended. Coloration is apparently very diversified, ranging, in preserved material, from nearly uniform pale gray or almost white to dark gray or brown, more or less heavily marked with dull red-purple or purplish. Nothing is recorded of the color in life. The range of *australis* is from the northeastern corner of Tasmania to Cape Wiles, South Australia, in 17–235 fms.

Astroconus pulcher

H. L. Clark, 1939*a*. Rec. S. Australian Mus., vol. 6, p. 207; pl. 18.

This handsome species is as yet known only from the holotype. The disk diameter is 35 mm., and the coloration, light ashy gray marked and variegated with brownish black, the arm spines yellow and oral papillae and teeth pale orange, is very striking. The specimen was taken in a "crayfish pot," in 20 fms., at Cape Dutton, South Australia.

Astroconus occidentalis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 205; pl. 23, fig. 2.

This notable "basket fish" was taken at North Beach, Fremantle, Western Australia, and no second specimen has as yet been found. It is 32 mm. across the disk, and the very stout arms probably exceeded 100 mm. when opened out. The dry specimen is purplish brown, lightest on tubercles and ridges, darkest in depressions and valleys; orally the contrast between light and dark is conspicuous, the brownish-yellow ground color being more or less freely marked with purple.

ASTRODENDRUM

Döderlein, 1911. Japan. Euryalae, pp. 28, 38.

Genotype: *Gorgonocēphalus sagaminus* Döderlein, 1902, p. 321.

This small Oriental genus is represented in Australia by only the following species.

Astrodendrum pustulatum

H. L. Clark, 1916. "Endeavour" rept., p. 84; pl. 34, figs. 1, 2.

This fine species is known only from the unique holotype, which was taken east of Flinders Island, Bass Strait, in 100–300 fms. It is 40 mm. across the disk and the much branched arms are about 125 mm. long. The color in alcohol is nearly uniform reddish flesh color.

ASTROCLADUS

Verrill, 1899*b*. Trans. Connecticut Acad., vol. 10, pt. 2, p. 369.

Genotype: *Euryale verrucosum* Lamarck, 1816, vol. 2, p. 537 = *Asterias euryale* Retzius, 1783, p. 243.

This small group is chiefly Oriental, 3 species occurring in Japan, but 1 is characteristic of South Africa and another has been found as yet only in the Tonga Islands. The following is the only Australian form.

Astrocladus granulatus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 206; pl. 23, fig. 3.

The single little specimen on which this species rests was collected at Lindeman Island, Great Barrier Reef, in 1934 by Melbourne Ward, the discoverer of many a fine invertebrate in the Barrier Reef region. It is only 11 mm. across the disk and hence is apparently young. The color is uniformly rich red-brown, but it may have been quite different in life. A very small gorgonocephalid, taken by Ward in the same region, may represent an early growth stage of this species. It is only 5–6 mm. across the disk and has developed so little pigment it is very pale cream color.

ASTROBOA

Döderlein, 1911. Japan. Euryalae, pp. 28, 50.

Genotype: *Astrophyton clavatum* Lyman, 1861, p. 85.

There are half a dozen or more species in this genus, which is confined to the Indian region from Zanzibar to the Sagami Sea, Japan. Only the following species enters the Australian fauna.

Astroboa ernae

Döderlein, 1911. Japan. Euryalae, p. 82; pl. 9, figs. 7–7*a*.
Astrophyton clavatum Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 254 (NON Lyman, 1882, p. 258).

This species was established for a single small gorgonocephalid from Shark Bay, Western Australia, 22 mm. across the disk, which Koehler identified as *Astrophyton clavatum* Lyman. It has since been taken half a dozen times in South Australia, the largest specimen being 50 mm. across the disk. The "Endeavour" took 3 specimens off Geraldton, Western Australia, in 29 fms., in June 1912, with disk diameter 15–40 mm. The color of these individuals in life is said to have been "buff or leaden." In alcohol they are a peculiar shade of purplish brown which becomes much paler, almost a dirty white, when dried. Bell's (1894) record of *Astrophyton clavatum* from Holothuria Bank, Western Australia, no doubt refers to this species.

ASTROCHALCIS

Koehler, 1905. "Siboga" oph. litt., p. 129.

Genotype: *Astrochalcis tuberculosus* Koehler, 1905, p. 130.

This genus includes but 2 species, 1 from the Philippines and 1 from the Dutch East Indies. The latter has been found in tropical Queensland waters.

Astrochalcis tuberculosus

Koehler, 1905. "Siboga" oph. litt., p. 129; pl. 16, figs. 1, 2.

The only Australian specimen of this "basket fish" that has yet been reported is in the museum in Sydney. It is a big individual, fully 75 mm. across the disk, which is purplish brown irregularly spotted and marked with dirty cream color. It was taken in 9–12 fms. on a gravelly bank in Albany Passage, northern Queensland.

Order LAEMOPHIURIDA

Family OPHIACANTHIDAE

This cosmopolitan family of more than 250 species is very poorly represented in Australia, as only 16 species are as yet recorded from that continent and nearly all are small, inconspicuous ophiurans. One is now extinct and is known only from Cretaceous rocks; most of the others are taken only by dredging, and several are deep-water forms. All are dull-colored and very few show any attractive or interesting markings. Only a single member of the family is known in the New Zealand fauna and only 10 in South Africa.

The Australian ophiacanthids are distributed in 6 genera, but only 1 of these is represented by more than a single species.

Key to the Genera of Ophiacanthidae

A. Arms in same plane as disk, not capable of being pulled back into vertical position so that tips meet over center of disk:
  B. Tentacle pores small, with single small tentacle scale or rarely 2 or none:
    C. Disk variously covered but never with close uniform coat of granules concealing radial shields:
      D. Disk formed of small plates covered by imbricating scales which bear granules or spinelets or both, or may be wholly naked:
        Tooth papillae single or wanting ..... *Ophiacantha*
        Tooth papillae several in a cluster; radial shields large and bare ..... *Ophiomitra*
      DD. Disk formed of "more or less angulated, pentagonal elements"; extinct, Cretaceous ..... *Ophioglyphoida*
    CC. Disk covered with coat of close-set uniform granules with no indication of radial shields; single large, flat, rounded tentacle scale ..... *Ophiocomina*
  BB. Tentacle pores large, the basal ones with 2 or 3 conspicuous large, sharp tentacle scales ..... *Ophioprium*
AA. Arms articulated at base so they can be erected into conical group over disk; in preserved material they are generally in that position ..... *Ophiothauma*

OPHIACANTHA

Müller and Troschel, 1842. Syst. Ast., pp. 84, 106.

Genotype: *Ophiacantha spinulosa* Müller and Troschel, 1842, p. 107 = *Asterias bidentata* Retzius, 1805, p. 33.

This large and heterogeneous group of more than 150 nominal species is in need of careful revision. Both Verrill (1899*a*, 1899*b*) and Matsumoto (1917) have attacked the problem, but the former made important use of unimportant characters and concerned himself chiefly with the rich and perplexing West Indian fauna, whereas Matsumoto dealt with the Japanese fauna. Fortunately the Australian species are few and unimportant, and it is possible to make a workable key for them without getting enmeshed with the multitude of species occurring in the East and West Indies. The Australian species are nearly all small and inconspicuous and differ chiefly in the character of the disk covering:

Key to the Species of Ophiacantha

A. Tentacle scale single (occasionally 2 on basal pores) or wanting:
  B. Arms not evidently moniliform, except in some species slightly so at tip:
    C. Disk covering, coarse granules and short blunt spinelets (often few), chiefly marginal:
      Arm spines (except long, dorsal pair on first segment) coarse, thorny, blunt ..... *clavigera*
      Arm spines slender, smooth, pointed ..... *heterotyla*

CC. Disk covering, spinelets or granules but not both:
D. Disk covering, spinelets:
E. Spinelets delicate, slender, forked or trifid at tip:
Oral papillae stout, erect, pointed; arm spines 7 or 8 ..... *confusa*
Oral papillae long, narrow, pointed; arm spines 9 or 10 ..... *tenuispina*
EE. Spinelets coarse, rough, thorny:
Arm spines coarse, cylindrical, smooth; oral papillae 5 on a side, long, blunt ..... *truncata*
Arm spines slender, tapering, acute; oral papillae 3 on a side, short, peglike ..... *discoidea*
DD. Disk covering, granules:
Granules mostly near center of disk, its marginal areas more or less bare; radial shields evident in rodlike pairs but not at all bare; arm spines long and pointed ..... *fidelis*
Granules smooth, uniformly distributed over disk; arm spines short, stout, blunt ..... *congesta*
BB. Arms more or less evidently moniliform:
Uppermost spine on each side of second arm segment very long and conspicuous ..... *gracilis*
Uppermost spines on second segment longer than others but not conspicuously so ..... *brachygnatha*
AA. Tentacle scales conspicuously 2 on each pore ..... *valenciennesi*

Ophiacantha clavigera

Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 247; figs. 1–3.

This little brittle star is common in Koombana Bay at Bunbury, Western Australia. It has also been taken in Cockburn Sound, near Fremantle, and a very young individual is reported from Broome. It is, then, so far as is known, endemic in Western Australia. The largest specimen yet reported is 3.5 mm. across the disk and the arms are about 14 mm. long. The color ranges from whitish to light brown, but the tips of the radial shields are rather conspicuously white.

Ophiacantha heterotyla

H. L. Clark, 1909. "Thetis" rept., p. 542; pl. 52, figs. 4–6.

Across the continent from the preceding, this equally small and inconspicuous ophiuran is endemic in New South Wales and Tasmania. The largest individual yet taken is 4 mm. across the disk; the arms are scarcely more than twice the disk diameter. The color is light brown becoming darker with age, and the largest individual has at the center of each mouth shield and of each of the first 2 under arm plates a nearly circular blackish spot with ill defined boundaries. The localities where *heterotyla* has been taken are all near or a little south of Port Jackson in 11–80 fms., except for one specimen obtained off Gordon, D'Entrecasteaux Channel, Tasmania, in 5 fms.

Ophiacantha confusa

Koehler, 1905. "Siboga" oph. litt., p. 59; pl. 7, figs. 9–11.

This little ophiacanthid is so ill known that it is not impossible that the 4 specimens recorded belong to 3 different species. The type was taken by the

"Siboga" in 20 fms. near Salibabu, Dutch East Indies, but was only 3 mm. across the disk and somewhat damaged. On the basis of Koehler's description and figures, I (1921) assigned 2 specimens of the same size from Mer, Murray Islands, to the same species. The following year, Koehler (1922) proposed that an ophiacanthid 6 mm. across the disk with arms 40 mm. long, from the Philippines ("Albatross" station 5420) in 127 fms., should be considered the type of the "Siboga" 's species. There is room for some doubt about the identity of the "Siboga" and "Albatross" specimens. Those from Mer are apparently more like the "Siboga" specimen, but, like it, are obviously young. They do not correspond very well to the description and figures of the Philippine ophiacanthid. The matter cannot be decided until more and better material is available. Meanwhile the appropriateness of the name *confusa* is beyond question.

Ophiacantha tenuispina

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 210 (not figured).

This species is known only from a single specimen in the Australian Museum from Queensland: off Gatecomb Head, Port Curtis, 9–12 fms. It is only 4.5 mm. across the disk and the arms are all broken. The colors are dull (yellowish brown, gray, and whitish) but the arm spines are glassy with a bluish tint and, in good light, appear marked or banded with dark transverse lines. It is not markedly different from *confusa,* but the differences in oral papillae and arm spines preclude uniting them under a single name.

Ophiacantha truncata

Koehler, 1930. Vidensk. Medd., vol. 89, p. 62; pl. 6, figs. 13, 14.

The 2 specimens on which this fine species is based were collected by Mortensen in September 1914, off southeastern Australia (38° 15′ S., 149° 20′ E.) in 150–260 fms. They were 9 and 10 mm. across the disk; the arms were all broken, but apparently they are 5 times the disk diameter or more. No reference is made to the color. One of the striking structural features is the shape of the oral shields, which are truncated triangular, but *the base* adjoins the adoral plates, the blunt apex pointing to the disk margin.

Ophiacantha discoidea

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 57.
——— 1882. "Challenger" Oph., p. 196; pl. 26, figs. 1–3.
H. L. Clark, 1921. Ech. Torres Strait, p. 105; pl. 12, fig. 4 (colored).

The "Challenger" took this species in the Arafura Sea, at a depth of 40 fms., but obtained only a single specimen, less than 5 mm. across the disk. The Carnegie Expedition to Torres Strait in 1913 took 4 specimens at Mer, Murray Islands, in 4–5 fms., the largest scarcely bigger than Lyman's type. Hedley and McCulloch took 2 small specimens at the Murray Islands in 1907. No other specimens have yet been recorded. The brown, bluish, and white coloration is fugitive, and preserved specimens are a dingy light brown.

Ophiacantha fidelis

Ophiomitrella fidelis Koehler, 1930. Vidensk. Medd., vol. 89, p. 72; pl. 7, figs. 4, 5.

Although Koehler preferred to place this brittle star in *Ophiomitrella,* there seem to be no satisfactory reasons for not ranking it as an *Ophiacantha.* The two genera are not sharply distinguished and both need redefining. For the present at least, no Australian ophiacanthids are well placed in *Ophiomitrella* as defined by Verrill. The present species is known only from the specimens taken by Mortensen off southeastern Australia in 1914 and at the Kei Islands in 1922. The Australian material was taken in 150–255 fms., south of Cape Howe, at two stations, at one of which 4 specimens were taken and at the other "quelques échantillons." The description gives the disk as 6–8 mm. in diameter, the arms 50–55 mm. long. Although Koehler says the arms are somewhat moniliform, one would not suspect it from the photographs given. Nothing is said as to the color of the specimens, so it is probably in no way distinctive.

Ophiacantha congesta

Koehler, 1904*a*. "Siboga" Oph.: Mer prof., p. 103.
Ophialcaea congesta (Koehler), 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 85; pl. 15, figs. 6, 7.

This species was taken in deep water in the East Indies and Philippines, but Mortensen took a small ophiacanthid in 30–50 fms. north of Cape Howe, New South Wales, which Koehler (1930) refers to it. It is smaller than his East Indian material, only 4 mm. across the disk, and some of the disk granules are elongated as in *heterotyla.* It seems not unlikely that it may be a representative of that species. The validity of the genus *Ophialcaea* is not so certain that it is advisable to list it in the Australian fauna on the basis of this one, young individual.

Ophiacantha gracilis

Ophiothamnus gracilis Studer, 1882. "Gazelle" Oph., p. 24; pl. 3, figs. 11*a–e*.
Ophiacantha dallasii Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 291; pl. 16, figs. 12, 12*a*.
Ophiacantha ameleta H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 209.

A single specimen of this little species is in the Australian Museum from the Murray Islands. The moniliform arms and the relatively huge uppermost arm spines on the second segment are unmistakable specific marks. Studer's unique holotype was from north of the Dampier Archipelago, Western Australia, in 50 fms. When correcting Döderlein's (1896, p. 291) error in identifying Semon's little ophiacanthid as Duncan's Korean species *dallasii,* I made the even worse error (1938, p. 209) of giving a new name to this species, adequately described and figured by Studer over fifty years earlier. Few specimens are as yet known, all from tropical Australia.

Ophiacantha brachygnatha

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 420; figs. 123*a, b*.

Only 2 specimens of this South Australian *Ophiacantha* are as yet known. They were taken by Verco in Spencer or St. Vincent Gulf. They are 4 and 6 mm. across

the disk and reveal a group of characters quite different from those of any other Australian brittle star. The dry specimens are nearly white.

Ophiacantha valenciennesi

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 57; pl. 15, figs. 408–410.
Koehler, 1909*a*. "Princesse Alice" Ech., pl. 6, fig. 2 (colored).

This easily recognized and very widespread brittle star is known in Australia from only one place. Koehler (1930) reports that Mortensen took a single specimen from off Cape Howe, New South Wales, in 100–153 fms., but he says nothing of its size or color. The pair of large scales guarding each tentacle pore is very distinctive among the Australian ophiacanthids.

OPHIOMITRA

Lyman, 1869. Bull. Mus. Comp. Zoöl., vol. 1, p. 325.

Genotype: *Ophiomitra valida* Lyman, 1869, p. 325.

The limits of this genus were so loosely drawn that no fewer than 20 species had been referred to it in the first thirty years after it was named; but in 1899, Verrill restricted it drastically to only 3 West Indian or western Atlantic species. In 1922, Koehler reported a fourth species as occurring in the Philippines, and a specimen of this was taken by the Great Barrier Reef Expedition.

Ophiomitra dives

Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 107; pl. 10, figs. 1–4.

The 2 specimens taken by the "Albatross" in the Philippines were 15–17 mm. across the disk. The Great Barrier Reef specimen was 14 mm. across, and the coloration was similar to that of the types, a dark gray longitudinal line on the upper side of the arm being the most striking feature. It was taken in 210 fms. just outside Cook's Passage, north Queensland.

*OPHIOGLYPHOIDA

Chapman, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 195 (as subgenus).

Genotype: *Ophiacantha* (*Ophioglyphoida*) *fosteri* Chapman, 1934, p. 195.

It seems wiser to recognize the generic status of this Cretaceous ophiuran than to bury it in the heterogeneous group called *Ophiacantha*. Additional material will probably reveal other characters to justify the isolation of this long extinct brittle star.

*Ophioglyphoida fosteri

Ophiacantha (*Ophioglyphoida*) *fosteri* Chapman, 1934. Proc. Roy. Soc. Victoria, vol. 46, p. 195; pl. 7, figs. 1–4.

Only a single specimen of this notable fossil has yet been found. It occurred in a dark gray carbonaceous mudstone, regarded as Cretaceous, and probably in the Tambo series. It was in No. 2 Bore, Gavin's Anticline, Cleave, near Longreach, Queensland, at a depth of 519 feet. Disk 6 mm. across; arms rather more than 30 mm. long. Arms without spines 1.6 mm. wide at base; spines 0.75 mm. long.

OPHIOCOMINA

Koehler *in* Mortensen, 1920. Vidensk. Medd., vol. 72, pp. 50, 53.

Genotype: *Asterias nigra* Abildgaard *in* O. F. Müller, 1789, p. 20, pl. xciii = *Asterias sphaerulata* Pennant, 1777, p. 63.

This genus was first published and to some extent discussed by Mortensen, but he states that the name is in process of publication by Koehler and credits it to him. In 1921 Koehler first published the name, but his real account of the genus and its relationship appeared in 1922 (p. 316; pl. 75). For a further discussion of the genus, its structural features and real relationships, see H. L. Clark, 1928, page 424. Only a single species was known until the discovery of the following Australian species by Verco.

Ophiocomina australis

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 422; figs. 124*a, b*.

As in the case of *Ophioscolex* referred to above (p. 171), we have here a species closely related to one known only from the seas of northwestern Europe, but in this instance we have sufficient material to enable us to see a definite specific difference between the two widely separated but very similar forms. The Australian *Ophiocomina* has but a single tentacle scale, whereas the European species has two. As yet the Australian species is known only from Spencer and St. Vincent gulfs, South Australia; it does not reach so large a size as its European congener, the largest individual being but 12 mm. across the disk; arms about 5 times disk diameter. The coloration is apparently somewhat diversified, for even the preserved material shows no little variety; the disk is light brown, or dull greenish brown or rosy or pinkish; the arms are shades of gray or brown with indications of banding; the arm spines too may show indistinct spots or bands. In all probability, living specimens are more or less prettily colored. The European species has no beauty of color, but, as its name (*nigra*) implies, is uniformly dark.

OPHIOPRIUM

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 214.

Genotype: *Ophiacantha cervicornis* Lyman, 1883, p. 257.

This seems to be a natural and well marked genus, but its place in the Australian list rests on a single small specimen of the following species. Adult specimens may reveal quite different relationships.

Ophioprium axiologum

Ophiopristis axiologus H. L. Clark, 1909. "Thetis" rept., p. 543; pl. 53, figs. 1–3.
Ophioprium axiologum H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 216.

The "Thetis" took a tiny brittle star, only 3 mm. across the disk, off Wata Mooli, New South Wales, in 54–59 fms., which is apparently best referred to this genus. Nothing like it has since been taken.

OPHIOTHAUMA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 211.

Genotype: *Ophiothauma heptactis* H. L. Clark, 1938, p. 216.

This is another brittle star known from only a single specimen, and in this case it is even more remarkable that it has no congeneric fellows. Moreover, it was taken, without being noticed at the time of its capture, in one of the most isolated spots in northern Australia.

Ophiothauma heptactis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 211 (not figured).

The unique specimen of this odd little brittle star was found in a jar of large, bristly ophiurans (*Macrophiothrix belli*) collected at Port Essington, Coburg Peninsula, Northern Territory. It was not noticed at the time the specimens were put in the jar, but the supposition is that it was living in such close association with the *Macrophiothrix* that it was entangled with one of them when it was taken. The possibility of its being commensal with *Macrophiothrix* as *Ophiomaza* is with *Comanthina* cannot be ignored. The single specimen is only 3 mm. across the disk, and the 7 arms range from 10 to 18 mm. They are folded back together in a closed group over the disk. The color of the dry specimen is very pale brown.

Order GNATHOPHIURIDA

Family AMPHIURIDAE

This large cosmopolitan family, including nearly a fourth of the known ophiurans, is well represented in Australia by more than 50 species, but they group themselves into few genera, since most of the species belong to *Amphiura* itself or to *Ophiactis*. Nearly all the members of the family are secretive and inactive, living buried in mud or sand or in the crannies of dead coral, shells, or irregular rock fragments. Some species frequent sponges, occurring often in great numbers together. Others live buried in mud together in almost incredible numbers. A few live singly and are capable of rapid movement under the surface of fine sand. The classification of the Amphiuridae is based primarily on the mouth parts, particularly the number, form, and position of the oral papillae, but the character of the disk covering, the form and relation of the upper and under arm plates, and the size and arrangement of the arm spines are all much used. Some 25 genera are currently recognized, but only 12 have been reported from Australia, and 7 of these have but a single representative each. They may be distinguished by means of the following key:

Key to the Genera of Amphiuridae

A. Jaws with pair of blocklike papillae at apex (which may appear as single block) and 1 or more papillae at distal end of mouth angle or along side of jaw, quite free from one another:

B. Distal oral papillae 1 on each side of distal end of mouth angle (rarely 2 or none):

C. Interbrachial areas below more or less covered like disk with scales, or if naked, disk is densely covered with minute scales and arms are not more than 10 times disk diameter:
D. Scales of disk without spinelets; tentacle scales present:
Distal oral papilla very large; tentacle scales 2, at base of arm, of which the one on side arm plate is big and circular, the other, on under arm plate, is twice as long as wide and lies so it is overlapped by larger; arm spines 10 ..... *Ctenamphiura*
Not as above ..... *Amphiura*
DD. Scales of disk with spinelets; tentacle scales wanting ..... *Ophiocentrus*
CC. Interbrachial areas below with thin, more or less naked skin; arms 15–25 times disk diameter; tentacle scales wanting .... *Ophionephthys*
BB. Oral papillae 3 or more on each side:
E. Outermost oral papilla conspicuously largest, long and low and more or less opercular (i.e., meeting its fellow of opposite side so as to close distal half of slit or more):
Disk scales smooth ..... *Amphipholis*
Some disk scales with relatively large, erect spines ..... *Amphistigma*
EE. Outermost oral papilla often largest, but rarely conspicuously so and never opercular:
F. Oral papillae 3 on a side, outermost usually widest:
Disk without spines ..... *Amphiodia*
Disk with spines or spinelets ..... *Ophiocnida*
FF. Oral papillae 4 or more on a side, outermost not usually notably biggest:
Disk without spines ..... *Amphioplus*
Disk with spines or spinelets ..... *Amphiacantha*
AA. Jaws with no blocklike papillae at tip, and only 1 or 2 (rarely 3) distal oral papillae, or 3 more or less fused together:
Oral papillae 1 or 2, rarely 3, at distal end of mouth slit ..... *Ophiactis*
Oral papillae 3 on each side, low, wide, more or less fused into a marginal piece bearing numerous minute spinules ..... *Ophiodaphne*

CTENAMPHIURA

Verrill, 1899*b*. Trans. Connecticut Acad., vol. 10, p. 306.

Genotype: *Amphiura maxima* Lyman, 1879, p. 19.

In his revision of the family Amphiuridae Verrill points out how different this big amphiuran is from its congeners and isolates it in this genus. No closely related species has yet been discovered.

Ctenamphiura maxima

Amphiura maxima Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 24.
——— 1882. "Challenger" Oph., p. 126; pl. 18, figs. 7–9.
Ctenamphiura maxima Verrill, 1899*b*. Trans. Connecticut Acad., vol. 10, p. 306.

The "Challenger" took 2 fine big specimens (disk diameter 15 mm.) of this notable amphiurid on muddy bottom, at station 188, near the western end of Torres

Strait, in 28 fms., just within the arbitrary boundary of Australia established for this report. It has not been met with since, but may be looked for anywhere along the northern coast of Australia.

AMPHIURA

Forbes, 1843. Trans. Linn. Soc. London, vol. 19, p. 149.

Genotype: *Amphiura chiajii* Forbes, 1843, p. 151.

Far more than a hundred species of brittle stars are still included in this genus, in spite of the large number that have been segregated into independent genera by Verrill (1899) and later writers. There is no doubt that it is still a heterogeneous group and a thoroughgoing revision is much needed. In Australian seas, 21 species are found, occurring on all sides of the continent and under very varied conditions. Owing to their small size and secretive habits they are easily overlooked, and it is probable that most of the species have a much wider range than is at present known.

Key to the Species of Amphiura

A. Tentacle scales single, 1 to each pore:
  B. Arms normally 5 (4 or 6 extremely rare):
    C. Tentacle scale attached only at base, free along its inner margin:
      D. Disk covered with very fine scales, coarsest near radial shields, which are very long and narrow, separated throughout by elongated narrow plates, parallel to shields; arm spines 3 (4 or 5 sometimes at very base of arm) ..... *trisacantha*
    DD. Not as above:
      E. Under arm plates wider than long; disk somewhat swollen, covered with close coat of thick, overlapping scales; outer oral papilla minute, peglike:
        Arm spines in bristling vertical series of 8–10 at base of arm, number dropping rapidly distally; color gray, arms not contrasting with disk ..... *catephes*
        Arm spines 6 (or 7), more or less appressed; disk light gray, arms cream white in contrast ..... *phrixa*
      EE. Under arm plates longer than wide:
        F. Disk covered with thick, dark skin with which light-colored radial shields and some scattered minute granules contrast markedly ..... *microsoma*
        FF. Disk covered with scales:
          G. Disk covering, countless minute scales and long, narrow radial shields:
            H. Arm spines 8 or more, flat, pointed, rather delicate, series at base of arm approaching each other closely on dorsal side ..... *stictacantha*
            HH. Arm spines 5–7:
              J. Arms short, about 4 times disk diameter; disk scaling very fine; upper arm plates broadly elliptical ..... *brachyactis*
              JJ. Arms longer, about 6 times disk diameter; disk scaling coarser:

Upper arm spines tapering, pointed ..... *septemspinosa*
Upper arm spines wide, blunt ..... *constricta*
GG. Disk covering, coarse overlapping scales and short, wide radial shields:
K. Arm spines 5, or 6 on basal joints; outer oral papilla large, flat, more or less circular:
Distal half of radial shields white in marked contrast with remainder of plate; tentacle scale very large, 3 times as long as wide, and nearly equal to under arm plate ..... *leucaspis*
Distal half of radial shields pale gray like rest of disk; tentacle scale small, about one-third as long as under arm plate ..... *magnisquama*
KK. Arm spines 4 or 3; outer oral papilla longer than wide ..... *micra*
CC. Tentacle scale as long as under arm plate and attached to it for its full length ..... *ptena*
BB. Arms normally 6, rarely 5; disk covered with minute scales; radial shields long and narrow, in contact only at distal tips; arm spines 4 or 5, short, flat, blunt or truncated, the third the largest, with hyaline tooth on each side of tip ..... *velox*
AA. Tentacle scales 2 to each pore:
L. Disk covered with naked skin except around radial shields ..... *diacritica*
LL. Disk covered with scales though they may be minute and thin:
M. Interbrachial areas below naked:
Arm spines 6; radial shields long and narrow, equal to one-third disk diameter ..... *ambigua*
Arm spines 8 or 9; radial shields very small, divergent, scarcely one-sixth disk diameter ..... *multiremula*
MM. Interbrachial areas below covered with scales:
N. Arm spines 3; 2 distal oral papillae on each side ..... *bidentata*
NN. Arm spines 5 or more; single oral papilla on each side distally:
O. Disk scaling coarse; distal oral papilla flat, thick, opercular ..... *dolia*
OO. Disk scaling very fine; distal oral papilla erect, not at all opercular:
P. Disk scaling very fine with no indication of primary plates; arms short, about 4 times disk diameter; arm spines flat, thin, more or less pointed; oral shields wider than long ..... *nannodes*
PP. Disk scaling not so fine; primary plates usually evident; arms longer, 4 to 6 times disk diameter; arm spines not so flat, blunt; oral shields as long as wide or longer:
Radial shields very small and indistinct, about twice as long as broad; arm spines flattened, tapering, bluntly pointed at tip ..... *acrisia*
Radial shields long and narrow, nearly parallel, 3 or 4 times as long as broad; arm spines flattened, broad, rounded, truncate at tip ..... *poecila*

Amphiura trisacantha

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 425; figs. 125*a, b*.

The holotype of this species is still unique. It is 9 mm. across the disk and has but 20 mm. of one arm still attached. It is in the South Australian Museum and was taken by Verco in either Spencer or St. Vincent Gulf.

Amphiura catephes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 221 (not figured).

This species is known only from 2 specimens taken in Port Jackson, off Middle Head, in several fathoms. Whether it is a southern species or one of the Barrier Reef amphiurans at the limit of its range southward remains to be shown. It is fairly large, 8 mm. or more across the disk, with the customary indefinite coloration of most Amphiuras.

Amphiura phrixa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 232 (not figured).

In Roebuck Bay, Western Australia, one of the common brittle stars is this amphiuran, whose bristling arm spines have suggested its name. It lives in the sandy mud of the bay, with which the gray disk and whitish arms harmonize well. Many specimens were taken there in 1932, the largest with the disk over 7 mm. in diameter. As yet it has not been taken elsewhere.

Amphiura microsoma

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 228; pl. 5, figs. 5–7.

Not since its discovery in 1913 has an adult specimen of this species been taken. Its secretive habits and commonly inaccessible habitat make the finding of specimens a matter of chance. But several young Amphiuras from the coast of Western Australia have been referred to it (H. L. Clark, 1938, p. 215); this assignment indicates a very extensive range along the whole tropical coast of Australia, as far south as Rottnest Island, near Fremantle, Western Australia. It is true that the identity of these young specimens is open to question, and only good series of specimens showing the growth stages can settle the matter. But it is quite probable that young individuals have scales on the disk which are resorbed with growth and the attaining of maturity. The adults are like *Ophionephthys* in the character of the disk, but otherwise they are more like *Amphiura*. The original specimens from Mer were about 5 mm. across the disk, the skin of which was (and still is) nearly black, with the radial shields very light. When kept alive in the laboratory for a few hours, they exhibited after dark, if disturbed, a conspicuous phosphorescence.

Amphiura stictacantha

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 234 (not figured).

This is another amphiuran characteristic of Broome, Western Australia, but as additional specimens have been taken at Rottnest Island near Fremantle, and at

Bunkers Bay near the southwestern corner of the continent, it probably ranges along the whole western coast. It is a small species, only 5 mm. in disk diameter, but the arms are long, 7 times the diameter of the disk. The coloration is, as usual in the genus, light, various shades of gray, brown (or blackish), and whitish leading to considerable diversity, but the only constant, distinctive feature is a speckling and streaking of the arm spines with brown, by which character the name was suggested.

Amphiura brachyactis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 220 (not figured).

Only from Broome are specimens of this species yet known, and their relationship to *microsoma* is sufficiently obvious to raise a question as to the validity of the species. But the short arms and general appearance of the disk give them such a different facies that it is best to keep them segregated under a separate name until larger collections enable us to understand the specific characters at all ages. The holotype of *brachyactis* is 5 mm. across the fully scale-covered disk, and the arms are scarcely 20 mm. long. The paratype is not essentially different.

Amphiura septemspinosa

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 231; pl. 4, figs. 13, 14.
——— 1921. Ech. Torres Strait, p. 106; pl. 13, fig. 3 (colored).

In 1938, Melbourne Ward collected at Cape Bedwell, Northern Territory, 2 specimens of this species, hitherto known only from the unique holotype from Mer, Murray Islands, which was very young, 2 mm. disk diameter. As Ward generously gave these specimens to the Museum of Comparative Zoölogy, it is possible to give further data here. The smaller one is 3.5 mm. across the disk, the larger is 4.5 mm. Both are a dingy pale brown in color. They agree with the holotype in most particulars very well, but with the much greater size the upper arm plates have increased in width and broadened their contacts with one another so that at the middle of the arm they are elliptical or quadrilateral with rounded corners, and much wider than long. The arm spines, too, are relatively bigger, and the middle ones are blunt or truncate. In the smaller specimen the outer oral papilla is spatulate as in the type, but in the larger specimen it is distinctly pointed.

Amphiura constricta

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 22.
——— 1882. "Challenger" Oph., p. 131; pl. 16, figs. 11–14.

Whether the scores of specimens referred to this common and widespread amphiuran (see H. L. Clark, 1938, pp. 213–215) are all really conspecific is open to some question, on account of differences in disk scaling and arm spines, but good series of *adult* specimens from several widely separated localities, as well as series showing growth stages from a disk diameter of 2 to 6 mm. or more, are essential for a real solution of the problem. The largest specimens as yet reported are 6 mm. across the disk. The colors are as usual in *Amphiura,* a grayish disk with arms of a different, usually lighter shade; the arms often show dusky crossbands,

and in very young specimens these bands may be reddish or even bright red in life; red shades seldom withstand preservation in alcohol. The range of *constricta* is from Port Curtis, Queensland, southward to New South Wales (including Lord Howe Island) and Tasmania, westward to Victoria (Port Phillip and Port Melbourne), South Australia (Kingston and Cape Martin, "Endeavour" collection), and Western Australia (Bunkers Bay and Bunbury), northward to Rottnest Island and Dongarra, and northeastward to Broome, Western Australia, and Darwin, Northern Territory. Apparently, then, this brittle star has a circumcontinental range, though it has not yet been found between Darwin and Port Curtis. Although *constricta* is related rather closely to *septemspinosa,* the species look less alike than might be supposed, the finer disk scaling of the northern species being noticeable. It is noteworthy, however, that *septemspinosa* is known only from that area between Port Curtis and Darwin.

Amphiura leucaspis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 226 (not figured).

At Broome, Western Australia, 3 specimens of this little species were taken in the two seasons of collecting, but it has not yet been taken elsewhere. It is obviously very uncommon, or else its small size (2–3 mm. across disk) leads to its being overlooked in the rich hauls of the dredge. The pure white distal part of the radial shields is a striking character in the living animal.

Amphiura magnisquama

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 227 (not figured).

Off Botany Bay, New South Wales, in 33–56 fms. is the only locality where this little species (3.5 mm. across disk) has been taken. Its small size and light color make it very inconspicuous, but as it was taken by both the "Thetis" and the "Goonambie," it is apparently not rare in that particular locality.

Amphiura micra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 228 (not figured).

The characters of the unique holotype of this tiny species (1.8 mm. in disk diameter with arms 6 mm. long) are clear and distinctive and warrant recognition, but its insignificant size and appearance militate against the determination of its relationships and range. The single known specimen was collected at Broome.

Amphiura ptena

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 233; fig. 15.

This strikingly characterized and easily recognized *Amphiura* was taken at Bunkers Bay, Western Australia, and has not been found elsewhere as yet. The holotype was 5.5 mm. in disk diameter, but the arms were all broken, so it is not known whether it is a long-armed species or not. The 2 paratypes are in even

worse condition. They were all found in muddy sand in intertidal pools. The color is, as usual in the genus, an indistinctive gray.

Amphiura velox

Koehler, 1910*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 33, p. 292; pl. 15, fig. 6; pl. 16, fig. 5.

This fine species is found on the northwestern coast of Australia in the Broome region, but is rather rare, as we took only 3 specimens, all in June 1932 (see H. L. Clark, 1938, p. 216). The coloration is more distinctive than in most Amphiuras, the light-colored, banded arms being in marked contrast with the pale gray disk. The Broome specimens were more than 5 mm. across the disk, somewhat larger than the types. Koehler had but 2 rather small specimens for his original account of the species from the Aru Islands, and failed to find it in either of the great East Indian collections on which he subsequently reported (1922, 1930). Both his specimens were hexamerous, as were 2 of the 3 specimens from Broome, but the fact that the third is perfectly pentamerous raises some question as to how large a percentage normally have but 5 arms.

Amphiura diacritica

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 222 (not figured).

Like *microsoma,* this species approaches the genus *Ophionephthys,* but seems on the whole more closely related to *Amphiura.* Only a single specimen, 6 to 7 mm. across the disk, is known; all the arms are broken and partly missing, but in life they were apparently about 10 times the disk diameter. The naked skin of the disk is very dark brown and the rest of the animal is nearly white. This interesting novelty was collected at Black Island, Whitsunday Passage, Queensland.

Amphiura ambigua

Koehler, 1905. "Siboga" oph. litt., p. 39; pl. 4, figs. 9–11.

Widely distributed in the East Indian region but apparently not very common, this long-armed amphiuran was taken several times at Darwin (see H. L. Clark, 1938, p. 213). The disk measures up to 6 mm. in diameter, with the arms 10 times as much. A distinctive feature of the rather plain coloration is the speckling and streaking of the nearly white arm spines with a more or less dark brown.

Amphiura multiremula

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 228 (not figured).

This well marked and quite specialized *Amphiura* is known only from Port Jackson and Long Reef at Colloroy, New South Wales. The 3 known specimens show so much diversity in coloration, there can be no doubt that increase in size (or age) causes considerable change in details of the color. There is change, too, in the form of the arm spines during growth, and the paddle-shaped upper spines are most striking in the holotype, which is 7 mm. in disk diameter.

Amphiura bidentata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 218; fig. 13.

The presence of 2 distal oral papillae on each side of each mouth slit is confusing, but the relationship to *Amphiura s.s.* is so obvious, there need be little hesitation in placing the specimens. Nevertheless, with more abundant material of the species having the character, it will probably appear that they form a distinct generic group. This species occurs along the tropical coast of the continent from Port Curtis, Queensland, to Broome, Western Australia. It is very small (3.5 mm. across disk), with short (10 mm.) arms. The pale gray and yellowish-white coloration is indistinctive. Only a dozen specimens are known, and 10 of these are from the Broome region, but the Port Curtis specimens are indistinguishable.

Amphiura dolia

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 224; fig. 14.

Port Jackson is the only locality where this well marked species has yet been taken. The big, flat outer oral papilla is very distinctive even in specimens only one-quarter grown. The large size (11–12 mm. across disk) and numerous arm spines (7 or 8, basally) set this species apart, when it is adult, from the other Australian Amphiuras, but the outer oral papilla conclusively marks specimens of any size. The light gray coloration is not distinctive.

Amphiura nannodes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 230 (not figured).

Rottnest Island, off Fremantle, Western Australia, is the only known locality for this tiny amphiuran with a disk diameter of less than 3 mm. It is of course possible that the 7 known specimens are all young, but as they were taken at two different times, some two years apart, it is hardly probable. The pale coloration is indistinctive, but the numerous arm spines, coarse disk scaling, and wide oral shields are good characters.

Amphiura acrisia

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 217 (not figured).

The rich marine fauna at Broome provides the only known specimens of this species, of which 2 examples were dredged in 5–7 fms. in June 1932. Disk 5 mm. across, arms 30 mm. long. The color is quite indistinctive.

Amphiura poecila

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 230; pl. 5, figs. 12, 13.
Amphiura rapida Koehler, 1930. Vidensk. Medd., vol. 89, p. 99.

The holotype of this brittle star, only 4 mm. across disk, was collected at Western Port, Victoria, in 2–5 fms. in 1911. In 1915 J. Gabriel sent 9 similar specimens to the Museum of Comparative Zoölogy from the same collecting ground. The variegated arms, pale cream color with dull purple markings, are probably a good recognition mark in life, but the colors fade out in preserved material. It seems beyond question that Koehler's unique type of *Amphiura rapida* is an adult *poecila*.

It was taken at "Port Western, Australia, 5–8 meters," apparently the same place whence the specimens of *poecila* have come.

OPHIOCENTRUS

Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 321.

Genotype: *Ophiocentrus aculeatus* Ljungman, 1867, p. 321.

This genus, long monotypic, expanded greatly when Matsumoto (1917) pointed out that Verrill's *Amphiocnida* (1899) was a synonym of Ljungman's name. The genus thus contained 9 species in 1922, when Koehler accepted Matsumoto's decision. Since then 3 species have been added, but the long-known European species has been made the type of a distinct genus. As at present known, *Ophiocentrus* is an East Indian genus, with 5 species occurring in Australian seas. They may be distinguished thus:

Key to the Species of Ophiocentrus

A. Upper arm plates longer than wide; arm spines very numerous (up to 10) in adults ..... *verticillatus*

AA. Upper arm plates wider than long, except perhaps on basal part of arm:

B. Upper arm plates thin, transparent, microscopically pitted, their lateral margins markedly concave; radial shields straight, narrow, about 6 times as long as wide; next to lowest arm spine bidentate at tip ..... *fragilis*

BB. Not as above:

C. Middle of arms much wider than base; upper arm plates very much wider than long; uppermost spine on middle part of arm short, thick, blunt ..... *dilatatus*

CC. Not as above:

Middle arm spines smallest, acute ..... *pilosus*

Middle arm spines largest, blunt or truncate with rough or hooked tip ..... *asper*

Ophiocentrus verticillatus

Ophiocnida verticillata Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 287; pl. 14, figs. 2, 2*a;* pl. 15, figs. 7, 7*a*.

Ophiocentrus verticillatus Matsumoto, 1917. Monog. Japan. Oph., p. 213.

This East Indian brittle star is fairly common at Broome, where it grows to a large size, 14 mm. across disk, arms up to 100 mm. at least. It has not been found elsewhere in Australian waters. For notes on color and habits see H. L. Clark, 1938, pages 237–238.

Ophiocentrus fragilis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 238 (not figured).

This is a well marked species, known from only a single specimen taken 22 miles east of Port Jackson Heads in 120 fms. The disk is but 5 mm. across, the arms about a dozen times as much. The whole appearance and structure is delicate, in striking contrast with the preceding species. The color is very light, a pale gray disk with white lower surface, arms, and arm spines.

Ophiocentrus dilatatus

Ophiocnida dilatata Koehler, 1905. "Siboga" oph. litt., p. 30; pl. 12, figs. 2–4.
Ophiocentrus dilatatus Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 199.

Originally found by the "Siboga" in the East Indies as far north as the Sulu Archipelago, this brittle star has been taken since at the Aru and Kei islands and at Mer Island, near the eastern entrance to Torres Strait. A specimen in the Museum of Comparative Zoölogy is from Mindoro, Philippine Islands. Its occurrence at Darwin (H. L. Clark, 1938, p. 236) extends the range considerably to the southwest. Full-grown specimens have the disk 9 mm. in diameter, arms about 8 times as much. The colors in life are rather pretty, buff, orange, brown, and violet (see H. L. Clark, 1921, pl. 16, fig. 7). The habits are very secretive, even the biggest specimens hiding themselves compactly in unbelievably small crannies in corals and rock fragments.

Ophiocentrus pilosus

Ophiocnida pilosa Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 32.
——— 1882. "Challenger" Oph., p. 153; pl. 19, figs. 7–9.
Ophiocentrus pilosus Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 199.

Material of this species is scanty and poor. The "Challenger" type specimen came from Bass Strait, southeastern Australia, in 38–40 fms., accompanied by a single, smaller paratype. Lyman also referred to his new species a single specimen taken by the "Challenger" near Zamboanga, Philippine Islands. If this latter specimen, which was probably *dilatatus,* were actually *pilosus,* it would appear that the species ranged throughout the East Indian and Australian regions from the Philippines to Bass Strait. Yet neither the "Siboga" nor the "Albatross" in their very extensive dredging and collecting took a single specimen. On the other hand, the "Thetis" in her dredgings off the New South Wales coast took 4 specimens, all in poor condition, at three stations. The "Endeavour" did not obtain any material of *pilosus* in her dredgings, nor did Mortensen or I meet with it. Apparently, like other members of the genus, it is so secretive that it escapes capture under ordinary conditions. The largest known specimen is only a little over 5 mm. across the disk; hence it is probable no adults have yet been taken. For the present, *pilosus* must be considered endemic in southeastern Australia.

In 1924, Mortensen discussed the occurrence of *pilosus* in New Zealand, concluding that it is a very variable species, as he had 8 specimens from Colville Channel and no 2 of them were exactly alike. He makes several references to New South Wales specimens, but does not indicate whence they came, save for the single one which Koehler (1930) identified as *asper.* In 1926, Gislen made an important and useful revision of the genus *Ophiocentrus* and established a new species, *novae-zelandiae,* for Mortensen's New Zealand material. To this species he also refers the "Thetis" specimens, which I consider *pilosus,* although I gave no data about them and he probably had not seen them. It is quite possible that the New Zealand specimens represent a species distinct from *pilosus,* but it is not clear why specimens from New South Wales should be referred to it. Mortensen considered his single Australian specimen an example of *pilosus.* Koehler later (1930) regards it as *asper,* though in regard to other species he agrees with Gislen. It is

evident that more and better material from Australia is necessary for clearing up the confusion among the three forms.

Ophiocentrus asper

Ophiocnida aspera Koehler, 1905. "Siboga" oph. litt., p. 29; pl. 2, figs. 11–13.
Ophiocentrus asper Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 199; pl. 62, figs. 7–9.

This species is included in the Australian fauna solely on the strength of Koehler's (1930) report of a single specimen from off Cape Howe, southeastern Australia, in 30–50 fms. Considering the locality and the close relationship of *asper* to *pilosus,* one cannot avoid the feeling that this specimen is simply a young, or possibly aberrant, individual of Lyman's species. Koehler makes no reference to this possibility, nor does he give any data concerning the specimen.

OPHIONEPHTHYS

Lütken, 1869. Add. ad hist. Oph., pt. 3, pp. 24, 25, 93, 98.

Genotype: *Ophionephthys limicola* Lütken, 1869, pp. 24, 25.

This genus contains half a dozen or more amphiurids remarkable for excessively long, slender arms and soft disks, with very little calcareous matter save the radial shields. They live, buried in soft sand or mud, a subterranean life to which they are specially adapted. The type species occurs in the West Indies, but all the others are found in Japan and the East Indies, ranging as far south as Sydney, New South Wales. Matsumoto (1917) and Koehler (1922) consider the genus superfluous and indistinguishable from *Amphiura.* In my opinion it is a well marked and highly specialized group, quite worthy of recognition. The Australian species, 3 of which were found at Broome, are easily distinguished thus:

A. Arm spines more than 6:
  Arm spines in series of 8 (or 9), not meeting on dorsal side of arm; uppermost spines very short and thick ..... *octacantha*
  Arm spines in series of 10, meeting on dorsal side of arm; uppermost spines slender, not notably short ..... *decacantha*
AA. Arm spines 6 or fewer:
  Disk covered with minute scales; arms about 17 times disk diameter ..... *perplexa*
  Disk naked except around radial shields; arms about 25 times disk diameter ..... *tenuis*

Ophionephthys octacantha

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 239; pl. 9, figs. 9, 10.
——— 1921. Ech. Torres Strait, p. 106; pl. 15, fig. 3 (colored).

The holotype of this peculiar but in life quite prettily colored brittle star was found in the sand under a stone at Friday Island, Torres Strait. A second specimen, much larger and more complete, was found in the sandy mud of the jetty flat at Broome, nineteen years later. In it the disk was well over 10 mm. across in life and the arms were about 200 mm. long; the dimensions of the dry specimen are much less. The colors even in life were not so bright as in the Friday Island specimen, but near the tips the arms showed some signs of banding.

Ophionephthys decacantha

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 240 (not figured).

A single specimen of this very delicate ophiuran was sifted out of the sandy mud near the jetty at Broome in 1929, and in 1932 also a single specimen was taken, this time in dredging. The arms are so slender and the disk so soft, the fragility of the specimens is excessive, and the preserved specimens are sorry sights. In life the body was 6 mm. or more in diameter and the arms undoubtedly exceeded 100 mm. The body is brown in life, the arms pale cream color without bands or other markings.

Ophionephthys perplexa

Ophiolepis perplexus Stimpson, 1855. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, p. 386.
Amphiura perplexa Lyman, 1865. Illus. cat. Mus. Comp. Zoöl., no. 1, p. 12 (not figured).

This species has not been met with since Stimpson's day so far as we have any record. He speaks of its having been found in mud at Port Jackson, and of its habit of shedding the disk and tangling the arms. Apparently Lyman saw Stimpson's types, for he adds (1882, p. 124) two important characters: the absence of tentacle scales and the more or less naked character of the interbrachial areas below. Stimpson says there are 5 short, thick, pointed arm spines. He says of the color: "Disk above dark greyish; arms purplish-brown, darker and lighter alternately; below reddish." He gives no measurements.

Ophionephthys tenuis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 241 (not figured).

This excessively specialized brittle star is common in the sandy mud of Roebuck Bay, near the jetty at Broome, where it lives in company with *Ophiocentrus verticillatus*. The disk is 6 or 7 mm. across, light yellowish brown in life, and the white arms are excessively long and slender, probably 25 times the disk diameter. The habit of living deep in the mud, communicating with the surface only by means of the slender and sensitive arms, makes it almost impossible to secure this brittle star by dredging. Hence the determination of its geographic range will be well-nigh impossible, for there are few places where conditions for collecting such animals are as favorable as at Broome.

AMPHIPHOLIS

Ljungman, 1866. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 6, p. 165.

Genotype: *Amphipholis januarii* Ljungman, 1866, p. 165 = *Ophiolepis gracillima* Stimpson, 1852, p. 224.

Some 25 or 30 amphiurans are referred to this genus, but specific limits are not always clear, and a careful revision would be very useful. The genus is not well represented in Australia, but the small size and secretive habits of these little brittle stars are great obstacles to collecting them, and obtaining satisfactory series is a real problem. Only a single species, one of cosmopolitan distribution, is known

from Australia as yet. The attempt which I made in 1909 to distinguish Australian specimens from those of the northern hemisphere under the name *australiana* proves, in the light of abundant material, to be futile.

Amphipholis squamata

Asteria squamata Delle Chiaje, 1828. Mem. anim. senza vert. Napoli, vol. 3, p. 74.
Amphipholis squamata Verrill, 1899*b*. Trans. Connecticut Acad., vol. 10, pt. 2, p. 312.
H. L. Clark, 1904. Bull. U. S. Fish Comm. (1902), p. 560; pl. 6, figs. 33, 34; pl. 7, figs. 43, 44.
Amphipholis australiana H. L. Clark, 1909. "Thetis" rept., p. 540; pl. 52, figs. 1–3.

With a disk 3–5 mm. across and arms rarely more than 20 mm. long, this little brittle star hides itself in crannies of rock and coral fragments, in and around the holdfasts of kelp and other coarse algae, among coralline algae and some sponges, and often within a half-shell of a dead bivalve mollusk. It is sometimes found in coarse sand or fine gravel, when these are sifted through a sieve, but it is not certain that normally the brittle star lives free in such a shifting environment. It ranges from between tides out to 200 fms. or even more. The color in life is inconspicuous, but the distal half of the radial shields is white, and this little patch of white at the base of each arm usually stands out against the gray of the disk as a helpful recognition mark.

In Australia, *Amphipholis* has been found wherever intensive shore collecting has been undertaken. At Lord Howe Island; at Hobart, Tasmania; at Port Willunga, South Australia; at Rottnest Island and Dongarra, and at Broome, Western Australia; at Darwin, Northern Territory; at Mer, near the northern extremity of the Barrier Reef; and at Long Reef, Colloroy, New South Wales, it occurs in greater or less abundance, showing clearly that its distribution is continuous along the entire coast of the continent. No other echinoderm is so ubiquitous. As it occurs in similar manner in South Africa, St. Helena, Tobago, Bermuda, the northeastern United States, and northern Europe, not to mention Japan, Hawaii, Society Islands, and New Zealand, it obviously is of no value in connection with the question of the origin and relationships of the Australian fauna.

AMPHISTIGMA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 244.

Genotype: *Amphistigma minuta* H. L. Clark, 1938, p. 245.

One of the endemic echinoderms of Lord Howe Island, *Amphistigma* is so small that its discovery was due largely to the fact that the results of dredging near Goat Island were so poor, all the material that was obtained, vegetable as well as animal, was set away in basins over night in the hope that something of interest would be found in the morning. *Amphistigma* was the reward.

Amphistigma minuta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 245; fig. 16.

Lord Howe Island furnished us with many novelties; this was the smallest, yet one of the most interesting. Only equally thorough search elsewhere will reveal the

limits of its distribution. The living animal is prettily variegated with browns and whites and some red, generally on the arms only. It is only 1.5 mm. across the disk, and the arms are but 6 mm. long.

AMPHIODIA

Verrill, 1899*a*. Bull. Univ. Iowa, n. s., vol. 1, no. 6, p. 25.

Genotype: *Amphiura pulchella* Lyman, 1869, p. 337.

This well defined genus of more than 40 species is represented by only a single species in Australia. That one is an East Indian form which has extended its range not only to Darwin and Broome, but southward to Victoria and thence westward to St. Vincent and Spencer gulfs. It was first described by Brock in 1888, but received another name in 1896 and a third in 1915.

Amphiodia ochroleuca

Amphiura ochroleuca Brock, 1888. Ztschr. f. wissensch. Zool., vol. 47, p. 484.
Amphiura brocki Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 286; pl. 15, figs. 6, 6*a*.
Amphiodia mesopoma H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 247; pl. 6, figs. 11, 13.
Amphiodia ochroleuca H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 250.

This East Indian brittle star has been taken at Thursday Island and at Badu in Torres Strait, at Darwin and Broome in tropical Australia, at Western Port, Victoria, and at St. Vincent and Spencer gulfs, South Australia. It reaches a considerable size, disk 7–9 mm. in diameter, arms 6 or 7 times as much. In smaller specimens the arms are relatively shorter. There is apparently considerable diversity in color, but the arms are often if not always banded. For a fuller discussion of the growth changes and coloration see H. L. Clark, 1938, pages 247–249. Obviously much more material is required.

OPHIOCNIDA

Lyman, 1865. Illus. cat. Mus. Comp. Zoöl., no. 1, p. 133.

Genotype: *Ophiolepis hispida* LeConte, 1851, p. 318.

This is an American genus of half a dozen species (4 West Indian), of which 1 is known from the Philippine Islands and the East Indies. A single small *Ophiocnida* taken by the Great Barrier Reef Expedition in 20–25 fms., in Papuan Pass, Queensland, is probably the young of the East Indian species.

Ophiocnida echinata

Ophiophragmus echinatus Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 316.
Ophiocnida echinata Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 230; pl. 4, figs. 22, 23.

As the Great Barrier Reef Expedition took but a single small specimen (4 mm. across disk; adults are 10 mm. or more), it is obvious that more material is necessary before the status of *Ophiocnida* as an Australian genus can be regarded as satisfactorily established.

AMPHIOPLUS

Verrill, 1899*a*. Bull. Univ. Iowa, n. s., vol. 1, no. 6, p. 25.

Genotype: *Amphiura tumida* Lyman, 1878*a*, p. 225.

This big genus of more than 60 species is represented in Australia by a scant half-dozen. Of these, 2 reach a considerable size (10 mm. disk diameter), but the others are small mud-loving species. Only 1 (*depressus*) is known from any considerable number of specimens, and few of those specimens are adult, the great majority being less than 5 mm. across the disk. The following key is compiled from the available data, but more adult specimens are essential for a proper understanding of the species.

Key to the Species of Amphioplus

A. Disk without scales, except around long, narrow radial shields; under arm plates usually longer than wide; 2 small tentacle scales; oral shields longer than wide; arm spines 5–8 at base of arm but dropping to 3 distally ..... *lucidus*

AA. Not as above:

B. Radial shields wide, appressed along inner margins ..... *depressus*

BB. Radial shields not wide and appressed, but usually long, narrow, and well separated:

C. Radial shields very small, about one-tenth disk diameter ..... *parviclypeus*

CC. Radial shields long and narrow, one-sixth to one-fourth disk diameter:

D. Arm spines 6, subequal, a little longer than a segment ..... *lobatus*

DD. Arm spines 3–5:

Arm spines 3, with a fourth, small and peglike, dorsally at base of arm; adoral plates meet within ..... *didymus*

Arm spines 4 or 5 basally; adoral plates do not meet within ..... *stenaspis*

Amphioplus lucidus

Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 176; pl. 68, figs. 6–10.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 249.

Were the mouth parts of this brittle star like those of *Amphiura,* instead of being so typically like *Amphioplus,* it would naturally be assigned to *Ophionephthys,* so similar to that genus is the character of the disk covering and the general habitus. When more and better material is available, this and one or two allied forms will properly be grouped in a genus of their own having the same relation to *Amphioplus* that *Ophionephthys* has to *Amphiura.*

As yet *lucidus* has been found at only two places in Australia: Broken Bay, New South Wales, in 2–4 fms., and Broome, Western Australia, in equally shallow water. In the East Indies, the "Albatross" found it in slightly deeper water, 16–83 fms. Koehler has given a very detailed account of the arms and mouth frame, and in my 1938 account I have given a description of the disk and some details as to coloration. With (or even without) the disk, the species is not likely to be confused with any other. Its occurrence at diagonally opposite corners of the continent would indicate that it may be found anywhere along the northern and eastern coasts.

Amphioplus depressus

Amphipholis depressa Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 312.
Amphioplus depressus H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 254.
Amphiura relicta Koehler, 1898. Bull. sci. France et Belgique, vol. 31, p. 68; pl. 4, figs. 37, 38.
Amphioplus relictus H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 256.
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 179; pl. 71, figs. 4–8.

After prolonged consideration and comparison of many specimens and such figures as there are, I am forced to the conclusion that Koehler's species is the same as Ljungman's. Koehler said in his original description that it could not be the same, as the oral shields were so different. His figures (1922), however, show diversity in this character, and the Australian material at hand (15 specimens) confirms its unreliability. Other specimens from Amboina and 5 from the Philippines identified as *depressa* by Lyman indicate the inadvisability of resting specific difference on this one character. Moreover, Koehler relies on the accuracy of Lütken's (1872) figure; this, however, is drawn from a specimen which the Danish zoologist says he believes to be Ljungman's species, but which is evidently not one of Ljungman's specimens. The details of the oral papillae in this figure are so inaccurate, we cannot feel sure that the outlines of the oral shields are accurately drawn. In the light of these facts, it appears that Ljungman and Koehler were dealing with the same species of *Amphioplus,* one which is widespread in the East Indian region and along the tropical coast of Australia. It is apparently common in the Philippines. Koehler records it from as far north as Kagoshima, Japan, and Lyman (1882) from as far east as Fiji. Nearly all Australian specimens are young, and none that I have seen could be called full grown. A curious feature is that in most very young specimens the arms are much longer relatively than in the adults, and are more filiform. The Australian material is from Torres Strait, near Goode Island; Darwin, Northern Territory; Broome, and Point Peron, south of Fremantle, Western Australia. Full-grown specimens are 11 mm. across the disk, but the largest Australian individual I have seen is only 6 mm.

Amphioplus parviclypeus

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 255; pl. 7, figs. 5–8.

The holotype of this fine species is still unique, as we did not meet with it in either 1929 or 1932. The type is 10 mm. across the disk; the radial shields measure only 1 mm. in length and 0.25–0.30 mm. in width. It was found on the under side of a coral fragment in 5–6 feet of water at Badu Island in Torres Strait.

Amphioplus lobatus

Amphipholis lobata Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 315.
Amphioplus lobatus H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 258.
Koehler, 1927. Ark. Zool., vol. 19*a,* no. 2, p. 19; pl. 3, figs. 5, 6.

The unique holotype of this species has been well figured by Koehler, and no specimen corresponding exactly to it has yet been reported. But 2 amphiurids (one

diskless) taken at Papuan Pass, northern Queensland, in 20–25 fms., in the collections of the Great Barrier Reef Expedition, were referred to this species by me (H. L. Clark, 1932), though the disk scaling is coarser than in Koehler's figure and the oral shields are not closely similar to those of the type. There are two diskless amphiurids in the collection of the Museum of Comparative Zoölogy from Lindeman Island, Queensland, taken by Melbourne Ward, which seem to be identical with those from Papuan Pass, but the oral shields are more like Koehler's figure of *lobatus*. Until more material is available, however, the identification of these Queensland specimens must be considered tentative. The original *lobatus* was recorded as from Sydney, New South Wales.

Amphioplus didymus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 252; fig. 17.

Only 2 specimens of this species are known, 1 from Darwin and 1 from Broome. They were about 5 mm. across the disk, with the arms 50 mm. long or more. In life the arms were bright yellow with bright red markings, but these fine colors are fugacious. The 3 short arm spines and the very large tentacle scales are good distinctive characters.

Amphioplus stenaspis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 254; figs. 18, 19.

All the 9 known specimens of this brittle star were found in a single rock fragment at Darwin in 1929. Even in life they were dull-colored, not very different from the grays and browns of the dried specimens. The holotype is 6 mm. across the disk and the arms are about 50 mm. long. The very secretive habits and the inconspicuous coloration make the discovery and collection of specimens largely a matter of chance.

AMPHIACANTHA

Matsumoto, 1917. Monog. Japan. Oph., p. 177.

Genotype: *Amphioplus acanthinus* H. L. Clark, 1911, p. 168.

As Matsumoto said, this genus contains the *Amphioplus*-like amphiurans which have spinelets on the disk. This is not a very fundamental character, but it segregates conveniently some 9 or 10 species, 1 of which has been once reported from Australia.

Amphiacantha sexradia

Ophiocnida sexradia Duncan, 1887. Jour. Linn. Soc. (Zool.), vol. 21, p. 92; pl. 8, figs. 10, 11.
Amphiacantha sexradia Matsumoto, 1917. Monog. Japan. Oph., p. 178.

This East Indian species is included in the Australian fauna solely on the basis of a specimen only 2.5 mm. across the disk taken in 1905, by Michaelsen and Hartmeyer, at Surf Point, Shark Bay, Western Australia, and identified by Koehler (1907*a*) as Duncan's species, which is still imperfectly known.

OPHIACTIS

Lütken, 1856. Vidensk. Medd., p. 12.

Genotype: *Ophiactis krebsii* Lütken, 1856, p. 12 = *Ophiolepis savignyi* Müller and Troschel, 1842, p. 95.

This well-nigh cosmopolitan genus is represented in Australia by at least a dozen species besides a few others whose status is open to doubt. They are all small brittle stars living in and among sponges, corals, and bryozoa, or in holes and crannies in rock fragments or shells. Few of them exceed 8 mm. in disk diameter. They show considerable diversity in color, but in general the color within the species is fairly constant and hence coloration or color markings may be an important, distinctive species character.

Key to the Species of Ophiactis

I. Upper arm plates more or less fan-shaped, oval, or triangular, proximal angle more or less truncate if plates are in contact:
  A. Disk covered with coarse, flat scales, between which or on corners or edges are low, conical tubercles which become short, sharp spinelets near disk margin; oral papillae apparently 2 on a side ..... *symbiota*
  AA. Not as above; oral papilla single:
    B. Disk scales very small and numerous; radial shields small, not one-fourth of disk diameter; oral papilla very large:
      Disk covered by smooth coat of small, rounded scales; radial shields very small, not much larger than some of disk scales; disk usually purplish rose color and arms variegated but not banded ..... *laevis*
      Disk scales larger and less smooth; radial shields considerably larger; disk grayish or dirty yellowish; arms normally banded with pinkish white, rosy red, and dull blue ..... *tricolor*
    BB. Disk scales large, thin, overlapping; radial shields relatively large, one-fourth or more of disk diameter:
      C. Adoral plates large, meeting fully within; colors dull ..... *profundi*
      CC. Adoral plates not meeting at all or only slightly in 1 or 2 areas:
        D. Interbrachial areas below without scales ..... *macrolepidota*
        DD. Interbrachial areas covered with coarse scales:
          E. Arms 5, relatively short; disk variegated with shades of green and yellow (latter often wanting) ..... *luteomaculata*
          EE. Arms 6:
            Basal upper arm plates triangular, about as long as broad, barely overlapping; arm spines short and stout, basal thickness about half length, which does not exceed that of segment ..... *delicata*
            Basal arm plates much wider than long, broadly overlapping; arm spines, some exceeding segment and 3–4 times as long as basally thick ..... *acosmeta*
II. Upper arm plates transversely elliptical or tetragonal, width 1.3–4 times length, broadly in contact:
  F. Upper arm plates more or less swollen, with small dark spot on each side, either on distal margin or on line between plates; this spot

often associated with notch in distal margin of plate, so that plates have slightly trilobed appearance; arm spines 5 or 6, short; colors usually variegated green and white ..... *savignyi*

FF. Not as above:

G. Oral papilla single:

Upper arm plates 3–4 times as wide as long ..... *modesta*

Upper arm plates 1.5–2 times as wide as long ..... *fuscolineata*

GG. Oral papillae 2 on each side:

H. 7 (or 6) arms; radial shields short and well separated ..... *hirta*

HH. 5 or 6 arms:

J. 7 or 8 arm spines, upper ones very slender, short, pointed ..... *hemiteles*

JJ. Arm spines 5 or 6:

Oral shields longer than wide; adoral plates very large ..... *brevis*

Oral shields much wider than long; adoral plates not very large ..... *resiliens*

Ophiactis symbiota

H. L. Clark, 1916. "Endeavour" rept., p. 88; pl. 36.

The unique specimen of this interesting species was taken by the "Endeavour," east of Flinders Island, Bass Strait, in 100–300 fms. As it was clinging closely to the oral surface of a comatulid, it was apparently commensal therewith, but there is no proof that this is the normal habit of the brittle star. The specimen was rather more than 6 mm. across disk; arms about 26 mm. long. The dry specimen is brownish white.

Ophiactis laevis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 268 (not figured).

Ophiactis lütkeni Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 245 (NON Marktanner-Turneretscher, 1887, p. 298).

This is one of the most notable of the smaller brittle stars of southwestern Australia. It is common in Koombana Bay, Bunbury, in 5–8 fms. of water, and the color and unusually stocky form make it a striking feature of the fauna there. Although it is not often more than 5 mm. across the disk and the length of the arms is only 4 times as much, the remarkably smooth disk with its innumerable slightly convex plates and small radial shields is very distinctive, especially if it is of the usual purplish-rose color. For a full account of the habits and distribution, see the original description.

Ophiactis tricolor

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 427; fig. 126.

The red, white, and blue arms of this pretty species are its most obvious recognition mark. It is apparently not rare in Spencer and St. Vincent gulfs, and it is also known from near Kangaroo Island. It has not yet been taken elsewhere. It reaches a comparatively large size for an *Ophiactis,* 7 mm. across the disk, but the arms are short, scarcely 4 times the disk diameter.

Ophiactis profundi

Lütken and Mortensen, 1899. Mem. Mus. Comp. Zoöl., vol. 23, p. 140; pl. 6, figs. 4–6.

A tiny (2.5 mm. across disk) *Ophiactis* taken off Eden, New South Wales, in 25–30 fms., and now in the Australian Museum, requires a name. As it is so similar to the form which Mortensen (1924, p. 128; fig. 13) has called *profundi* var. *novae-zelandiae* that comparison side by side with cotypes of that form reveals no differences worth noting, it must for the present bear that name. The status of *profundi, plana,* and several other forms is very unsatisfactory. Whether they represent distinct species or not is still an unanswerable question. Mortensen holds to the opinion that several species are involved, whereas I am inclined to believe we are dealing with a single protean species like *savignyi.* Mortensen does not think that 5-armed adults arise from 6-armed young, a fact for which I hold there is abundant evidence.

Ophiactis macrolepidota

Marktanner-Turneretscher, 1887. Ann. K. K. Naturhist. Hofmus. Wien, vol. 2, p. 298; pl. 12, figs. 12, 13.

This little *Ophiactis,* based on a single small specimen, is said to be from "Sydney," which is supposed to mean Sydney, New South Wales. On the strength of that assumption, the species is included here, but Whitelegge (1889) does not include it in his list of Port Jackson's invertebrate fauna. If there is really an absence of scales on the interbrachial areas below, the species should be easily identified, whenever and wherever it may be rediscovered.

Ophiactis luteomaculata

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 263; pl. 11, figs. 7, 8.

The type locality for this species is at Mer, Murray Islands, at the eastern end of Torres Strait. The "Endeavour," however, took 11 specimens near Ballina, New South Wales, and we found it common in the Broome region in both 1929 and 1932. It is one of the species of brittle star that have convinced me that 6-armed young give rise to 5-armed adults, not only occasionally, but in various species as a regular thing. At Broome, the large series taken in winter (June) are all 5-rayed, but of the 11 specimens taken in spring (August and September), 3 are 6-rayed and have recently undergone division. The largest specimen is 4 mm. across the disk, with arms about 10 mm. long. The coloration is very diversified in the more than 100 specimens examined, and the orange-yellow on the radial shields, which in 1915 suggested the specific name, is more frequently absent than present. The spot on the upper side of the arm spines is also lacking in some individuals.

Ophiactis delicata

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 260; pl. 11, figs. 9, 10.

This *Ophiactis* was, like the preceding species, found but once at Mer, Murray Islands, on the southwestern reef flat near extreme low-water mark. The unique holotype is only 2 mm. across the disk, and the 6 arms are about 13 mm. long. In

life it was variegated with orange and brown, but in the dry specimen the colors are dulled, pale yellow and reddish purple. It was living on a comatulid when found, and hence is possibly a commensal.

Ophiactis acosmeta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 262 (not figured).

Like *profundi* in its dull brownish-gray coloration, this is an insignificant member of the genus, only 2–3 mm. across the disk. It has 6 arms, 12–14 mm. long. In spite of the 6 arms, several specimens, including one or two of the largest, have only 5 pairs of radial shields, which may be construed as further evidence that 5-armed adults come from 6-armed young. Apparently the range of *acosmeta* includes the whole coast of tropical Australia, from Lord Howe Island on the southeast to Rockingham, Western Australia, on the southwest, but most of the material was secured at Broome, Western Australia.

Ophiactis savignyi

Ophiolepis savignyi Müller and Troschel, 1842. Syst. Ast., p. 95.
Ophiactis savignyi Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 323.
Ophiactis reinhardtii Lütken, 1859. Add. ad hist. Oph., pt. 2, pl. 3, figs. 7*a–b*.

There is little room for doubt that this is the most common brittle star in the world. It is tropicopolitan in distribution, and may range down to 283 fms. (Koehler, 1922, Philippine Islands). It does not occur, so far as is now known, on the southern coast of Australia, but from Rottnest Island, near Fremantle, on the west to Lord Howe Island and Port Jackson on the east, it may be expected anywhere on the warmer coasts. Very large adults may be 7–8 mm. across the disk, with arms 5 or 6 times as long. Large specimens nearly all have 5 arms and very small ones have 6; intermediates have either 5 or 6. There is no reason whatever to doubt that the egg gives rise normally to a 6-armed young and that repeated divisions with a steady increase in size result in an indefinite number of asexual generations. As sexual maturity is attained, after a normal division, the 3-armed half-ophiuran regenerates only 2 jaws and 2 arms, and the normal 5-armed adult appears. But apparently internal and probably external conditions check or hasten the process so that it does not occur uniformly at a given stage in any group of young. Young and half-grown individuals often occur by the hundred in a sponge or some equally protective and suitable spot, and various steps in the asexual process may be traced. Large adults usually occur singly, seldom in company with large hosts of young. The color is normally variegated green and white, often quite handsome, but the green shades may be very dingy and are sometimes brown or yellowish. The most striking color form seen in Australia was in a tide pool at Quail Island, west of Darwin, Northern Territory, where living in a pure white sponge were a dozen or more *Ophiactis* with bright brown disks and yellow arms. The name var. *lutea* (H. L. Clark, 1938, p. 262) has been given to this form, which even in the dry condition after preservation is distinguishable from normal specimens by its pallid, almost bleached appearance. Whether this variety would survive transportation and, living in a different region, would breed true is an open and interesting question.

Ophiactis modesta

Brock, 1888. Ztschr. f. wissensch. Zool., vol. 47, p. 482.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 285; pl. 15, figs. 5–5*b*.

Döderlein first reported this *Ophiactis* from Australia when he recorded 2 specimens from Torres Strait. It has not yet been found any farther south on the Queensland coast, but in 1929 and 1932 we found it at Darwin, at Cape Leveque, at Broome, and in Lagrange Bay. Large specimens have the disk 7–8 mm. across and the arms 60 mm. long. As in the preceding species, the young are hexamerous, the adults pentamerous. The colors are green and white, prettily variegated, but the green is usually much more blue than in *savignyi* and occasionally the variegation is definitely blue and white. Except at the type locality, Amboina, this *Ophiactis* had been reported only on the tropical Australian coast; it is now known to occur in the Hawaiian Islands, and specimens from Oahu are in the Museum of Comparative Zoölogy (Ely, 1942, p. 40).

Ophiactis fuscolineata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 266 (not figured).

This is a characteristic brittle star of the tropical coast of Australia, from the Coburg Peninsula to Broome. Although easily mistaken in the field for *savignyi* or *modesta,* it is really quite distinct. It differs from both in the entire lack of a hexamerous stage in its development, all the 65 specimens at hand being pentamerous, even the very small ones. Its coloration lacks greens and blues, but is made up of light and dark grays, yellowish, and white. Preserved material retains the variegation well, but the shades are duller. The disk may reach 5 mm. in diameter and the arms 8 times as much.

Ophiactis hirta

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 39.
——— 1882. "Challenger" Oph., p. 118; pl. 20, figs. 4–6.

The "Challenger" took a 7-armed specimen, less than 5 mm. across the disk, at her station 164a, off the coast of New South Wales in 400 fms. The color was gray mottled with pale brown. No other specimen is known save a 6-armed individual only 2.5 mm. in disk diameter taken in 120 fms. in Cook Strait, New Zealand, which Mortensen (1924, p. 126; fig. 12) believes to be identical with the New South Wales specimen.

Ophiactis hemiteles

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 262; pl. 10, figs. 7, 8.
——— 1921. Ech. Torres Strait, p. 108; pl. 16, fig. 1 (colored).

The unique specimen on which this aberrant species rests was extricated from a fragment of coral rock at Mer, Murray Islands. The gray and brown disk was over 5 mm. across, the white arms, with brown dorsal spots, were 40–50 mm. long. The appearance and habit indicated an *Amphiura;* the mouth parts and lower surface show it to be an aberrant *Ophiactis.* The dry specimen has lost all its beauty, and the white arms are now reddish buff.

Ophiactis brevis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 264 (not figured).

This is still another species resting on a single small specimen, only 3 mm. across the disk. It was collected at Darwin, Northern Territory, near the Shell Islands, in 3–6 fms., but at the time was not distinguished from the *savignyi* with which it was taken. The disk was apparently regenerating, and we cannot therefore feel sure that the big radial shields are a species character. But the dull coloration, the short arms, the form of the upper arm plates, and the 2 big oral papillae show conclusively that it is different from *savignyi*.

Ophiactis resiliens

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 36.
——— 1882. "Challenger" Oph., p. 115; pl. 20, figs. 7–9.

Unlike most of the preceding species, this *Ophiactis* is a characteristic member of the temperate fauna of southern Australia. It ranges from Lord Howe Island and the coast of New South Wales through Bass Strait (there are no records apparently from Tasmania) to Victoria, South Australia, Great Australian Bight (90 fms.), and Western Australia at Rottnest Island. That it also occurs in New Zealand has been demonstrated by Mortensen (1924), who shows that the supposed New Zealand species *nomentis* Farquhar is not distinguishable from Australian specimens. In size *resiliens* ranks among the larger species, with a disk 7–9 mm. in diameter and arms exceeding 40 mm. The color in life is a more or less deep greenish gray or grayish green, with some light variegation. Some individuals are brown rather than green, especially on the arms; the distal tips of the radial shields are usually white or whitish, a helpful recognition mark in fresh material. In preserved specimens (especially in alcohol) the green shades are more or less completely lost, unless particular pains are taken in killing and drying the material. The arms are often distinctly banded, but this is not a constant character.

OPHIODAPHNE

Koehler, 1930. Vidensk. Medd., vol. 89, p. 129.

Genotype: *Ophiodaphne materna* Koehler, 1930, p. 129.

This extraordinary genus is as yet but imperfectly known from very few specimens, all of which are for the present referred to a single species.

Ophiodaphne materna

Koehler, 1930. Vidensk. Medd., vol. 89, p. 129; pl. 16, figs. 3–8.
Mortensen, 1933. Vidensk. Medd., vol. 93, p. 183.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 270.
——— 1939. John Murray Exped.: Oph., p. 82.

The references given above contain all that has yet been published concerning this remarkable little brittle star, of which only half a dozen specimens are as yet known, 4 from the Kei Islands, 1 from Broome, Western Australia, and 1 from the Arabian coast. The Kei Islands material was taken in 136 fms., but the Australian and Arabian specimens, both youthful, were collected in 5–16 fms. Adult females are 5 mm. across the disk; the associated males 2 mm. or less.

Family OPHIOTRICHIDAE

More than 150 species have been referred to this family, five-sixths of them to the old genus *Ophiothrix,* which is now in process of dismemberment. Nearly all are tropical ophiurans associated with corals and sponges, but a few species extend the range of the group into the warm-temperate seas. Some species are widely distributed in the Indo-Pacific region, but most have fairly restricted ranges. More than 20 of the Australian species seem to be endemic. The classification of the family is still in a highly unsatisfactory state, and the following key to the Australian genera is particularly artificial. Many of the species are very diversified in coloration, hence color is unsatisfactory as a distinguishing character; and yet some particular color feature such as transverse lines or bands, or one or more longitudinal lines on the arm, may be distinctive. The absence of oral papillae and the presence of a compact oval group of dental papillae at the tip of each jaw make the mouth parts of little use to the taxonomist. The character of the arm plates and arm spines and the nature of the disk covering provide the best features.

Key to the Genera of Ophiotrichidae

A. Disk covered with many plates or with thick skin; arm spines 4 or more:
- B. Disk plates present, small and numerous:
  - C. Disk plates carry spines, spinelets, thorns, or granules:
    - D. Upper arm plates smooth or with scattered, minute, low thorns or spinelets:
      - E. Radial shields more or less concealed; not in conspicuous large pairs:
        - Radial shields small, with few or many spinelets or thorns; upper arm plates smooth; arms 4 or 5 times disk diameter (rarely much more) ..... *Ophiothrix*
        - Radial shields large but concealed by close covering of low spinelets; upper arm plates with minute spinelets scattered over them; arms 9 times disk diameter ..... *Amphiophiothrix*
      - EE. Radial shields in conspicuous, large pairs:
        - F. Disk with spines or spinelets or low, thorny stumps:
          - G. Arms very long, usually 9–20 times disk diameter, but in a few cases only 6–8 times; radial shields with at least a few stumps ..... *Macrophiothrix*
          - GG. Arms less than 9 times disk diameter:
            - Basal arm spines free, not united into vertical series by thin membrane ..... *Placophiothrix*
            - Basal arm spines united into vertical winglike series by thin membrane ..... *Ophiopteron*
        - FF. Disk with coat of crowded granules only ..... *Ophiocnemis*
    - DD. Upper arm plates with knobs, warts, or irregular grains, more or less obscuring plate outlines ..... *Ophiothela*
  - CC. Disk plates smooth, without spinelets or granules:
    - H. Radial shields small and scarcely in contact, length not half disk radius; arm spines long and very slender, longest 4 times arm width ..... *Lissophiothrix*

HH. Radial shields large, more or less in contact, length much more than half disk radius; arm spines rather stout, seldom more than 2 times arm width:
Upper arm plates not short and wide; arm spines more or less thorny ..... *Ophiotrichoides*
Upper arm plates short and wide; arm spines smooth and opaque ..... *Ophiomaza*
BB. Disk covered by loose skin; no scales or plates obvious, except distal ends of radial shields ..... *Ophiogymna*
AA. Very small, with disk covered mainly by primary plates and radial shields; arm spines 2, the lower a hook ..... *Ophiophthirius*

OPHIOTHRIX

Müller and Troschel, 1840. Ber. Verhandl. K. preuss. Akad. Wissensch., Apr., p. 20.

Genotype: *Ophiura rosula* Fleming, 1828, p. 289 = *Asterias pentaphylla* Pennant, 1777, p. 64.

Although this genus has never contained as many species as *Amphiura* (*sens. lat.*), it is a much more difficult group to break up into natural genera, as the mouth parts and oral frame are essentially the same in all the species assigned to it. No thoroughgoing dismemberment has yet been made, but a few groups have been segregated and named. Their exact limits and their natural relationships to one another and to *Ophiothrix s.s.* have not, however, been worked out. A complete revision of the whole family is much needed, but it is particularly desirable in the present genus. Some half-dozen species of the roughly restricted genus are reported from Australia, but the following key will reveal to some extent how intangible and unsatisfactory specific limits are. Koehler (1930, p. 152) records 2 specimens of *Ophiothrix vitrea* Döderlein from "Port Western, Victoria," but they were only 4 mm. or less across the disk and obviously immature. They are, I believe, probably the young of one of the Australian species rather than representatives of a tropical species not otherwise known from south of the Kei Islands.

Key to the Species of Ophiothrix

A. Arms 4–6 times disk diameter:
B. Disk with more or less numerous slender, pointed spines among thorny stumps; upper arm plates with distal end somewhat swollen and produced ..... *acestra*
BB. Disk often without true spines, but some thorny stumps may be elongated to thick spinelets, and in adults these may be very numerous:
C. Under arm plates wide and short, with distal margin conspicuously notched in middle ..... *exigua*
CC. Under arm plates not so wide and not notched:
Upper arm plates wide, often wider than long on basal half of arm ..... *caespitosa*
Upper arm plates not so wide, often longer than wide even near base of arm ..... *stelligera*
AA. Arms 9 times disk diameter ..... *dyscrita*

Ophiothrix acestra

H. L. Clark, 1909. "Thetis" rept., p. 544; pl. 53, figs. 4, 5.

The status of this species, which is known as yet only from the eastern half of Australia, west to Spencer Gulf perhaps, is still a problem (see H. L. Clark, 1928, 1938). There is no question that *acestra, caespitosa,* and *stelligera* intergrade more or less. The proper interpretation of this fact must, however, be attempted in Australia, where living material in large quantities can be studied. At present, with only museum material available, it is hopeless to draw lines of distinction which will hold. Typical *acestra* is easily recognized by the disk spines and upper arm plates, but many specimens are indefinite in one or the other of these characters. Until some critical study of growth stages is undertaken, we shall continue in the dark. Large specimens of *acestra* are 7–8 mm. across the disk. There is very great diversity of color, as in the allied species, and it is doubtful whether there are any reliable color characters.

Ophiothrix exigua

Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 236; pl. 4, figs. 24–26.

Lyman describes the notched under arm plates, but does not figure them. They serve as the most reliable species character, but the general appearance of this *Ophiothrix* is more delicate than that of its near allies. Its diversity of color is so great that it would be futile to attempt any description. The type locality is in the Philippine Islands, but it ranges throughout the East Indian region and along the tropical coast of Australia from Port Curtis, Queensland, to Broome, Western Australia. Koehler, who has given some fine pictures of *exigua* (1922, pl. 40, figs. 1–4), records (1930, p. 139) a specimen from Disaster Bay, New South Wales, but it seems likely that the specimen is an aberrant *caespitosa,* or else a mistake in the locality has been made. Koehler (1922, p. 229) says *exigua* is known to occur in the Red Sea. The John Murray Expedition did not find it there, however. We did not find any *Ophiothrix* at the Murray Islands in 1913 which could be referred to *exigua.* It is a small species, the largest specimen noted being only 5 mm. across the disk, with arms about 4–5 times the disk diameter.

Ophiothrix caespitosa

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 53.
——— 1882. "Challenger" Oph., p. 218; pl. 26, figs. 12–14.
Ophiothrix hartmeyeri Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 248; figs. 4–6.

Port Jackson is the type locality for this, the common *Ophiothrix* of temperate Australia. It is now known to range from southern Queensland around southeastern Australia, westward to St. Vincent and Spencer gulfs, South Australia, to Bunkers Bay and thence northward to Shark Bay, Western Australia. It is a small, rather short-armed species, the disk rarely exceeding 8 mm. in diameter, with arms about 4 to 6 times as much. The colors are diversified, pink or reddish, purplish gray, brownish yellow, or even lighter. Typical specimens are easy to recognize, but variants toward *acestra* and *stelligera* are confusing. Koehler (1930, p. 142) has recorded a specimen of *koreana* Duncan from Port Hacking, New South Wales.

It seems very probable that this specimen should be referred to *caespitosa,* as I doubt if *koreana* ranges farther south than the Kei Islands. The actual relationships between *caespitosa, koreana, stelligera, hartmeyeri,* and *acestra* cannot be determined save by critical study of large numbers of living or freshly and carefully killed individuals of all sizes.

Ophiothrix stelligera

Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 237; pl. 3, figs. 15–20.
H. L. Clark, 1921. Ech. Torres Strait, p. 114; pl. 16, fig. 8 (colored).
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, pp. 267–277; pl. 53, figs. 1–5; pl. 54, figs. 1–6; pl. 55, figs. 1–4; pl. 56, figs. 4–7; pl. 102, figs. 2, 3.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 273.
Ophiothrix melanogramma Bell, 1884. "Alert" rept., p. 145.

This is one of the most abundant and diversified species of brittle star to be found in Australia. The references given above reveal something of its diversity. Koehler's figures are particularly illuminating, but it seems to me possible, even probable, that more than a single species is included in this bewildering lot of photographs. The species is small, rarely exceeding 8 mm. in disk diameter; it is gregarious in habit, and of astonishing diversity in color and in the character of arm and disk spines. It is reported from Zanzibar on the west to Fiji on the east and from the Gulf of Siam on the north to Koombana Bay, Western Australia, on the south, but it is very probable that these reports concern several species and cannot be trusted as indicators of the actual range of *stelligera.* On the Australian coast, it ranges from Koombana Bay northward and eastward to the Murray Islands at the northern end of the Barrier Reef and thence southward to an unknown limit. Koehler has pointed out that the types of *Ophiura ciliaris* Lamarck are undoubtedly the same species as *stelligera* Lyman, but he shrinks from using the older name. I refrain from making the change here simply because *stelligera, acestra,* and *caespitosa* may prove to be identical, or critical study of abundant fresh material may enable us to draw the lines between them more clearly. Meanwhile it seems best not to disturb the nomenclature unduly.

The extraordinary diversity of color shown by *stelligera* led me (1938, p. 274) to name two of the most striking cases forma *atra* and forma *atrolineata.* It now develops that the latter is identical with the *Ophiothrix* described by Bell (1884, p. 145) as *Ophiothrix melanogramma.* It is not strange that he did not recognize it as closely allied to *stelligera.* Had I not found them living in the same sponges, along with "connecting links," it would not have occurred to me that the two could be a single species. As it is, my forma *atrolineata* must be known as forma *melanogramma* (Bell).

Ophiothrix dyscrita

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 271; pl. 13, fig. 3.

This species rests on a tiny specimen only 2 mm. across the disk, but with arms about 20 mm. long. It was collected at Mer, Murray Islands, in 1913. That it is adult seems improbable. It will very possibly prove to be the young of some species of *Macrophiothrix,* perhaps *longipeda.*

AMPHIOPHIOTHRIX,[1] gen. nov.

Disk covered with a loose skin bearing countless scales, carrying minute low stumps which terminate in 2 or more sharp, glassy thorns, the length of which seems to decrease with age. Upper arm plates with similar but much smaller stumps; in some cases there are but 3 or 4 such stumps on a plate, but in many specimens there are large numbers, though they are rarely crowded. Arms relatively long, about 10 times disk diameter. Radial shields rather large, but more or less completely concealed.

Genotype: *Ophiothrix demessa* Lyman, 1861, p. 82.

This genus is apparently monotypic, but it is quite possible that when larger series are available for comparison the widespread genotype will resolve itself into 2 or more species. It is clearly not an *Ophiothrix s.s.,* but it is even more obviously not congeneric with any of the groups that have recently been segregated from the old genus. Koehler (1905, p. 92) thinks *O. mauritiensis* de Loriol is entitled to recognition as a second species, but more material is absolutely necessary to make a reliable conclusion possible.

Amphiophiothrix demessa

Ophiothrix demessa Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 82.
Koehler, 1905. "Siboga" oph. litt., p. 91; pl. 9, figs. 5, 6.

Although this brittle star has been recorded at various places from Madagascar to the Red Sea on the west to the Society Islands and Hawaii on the east, it seems to be far from common. The "Siboga" took but 2 specimens in all her collecting, the "Albatross" did not meet with it in the Philippines, and Mortensen did not come across it in all his East Indian collecting. We found it at Mer, Murray Islands, but Semon did not take it in Torres Strait, and the "Alert" as well as the "Challenger" failed to bring home even one specimen. No doubt this absence of specimens is in part due to its secretive, amphiuran-like habits. Of the single specimen collected at Hilo, Hawaii, my field notes say: "Supposed to be an amphiuroid when taken; habit and habitat most un-Ophiothrix-like." It was found on the "underside of a rock fragment on the shore reef." This individual was very different in color from those found in Torres Strait, for its general appearance was reddish, whereas theirs was more nearly purple or dull bluish. In all specimens, the disk tends to be unicolored, the arms more or less variegated. We did not find *demessa* in either 1929 or 1932. Large specimens are 8–10 mm. across the disk, with arms 9–12 times as much. De Loriol's specimens of *mauritiensis* were considerably larger than this, 13–14 mm. across the disk.

MACROPHIOTHRIX

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 278.

Genotype: *Ophiura longipeda* Lamarck, 1816, vol. 2, p. 544.

This genus, created for the very long-armed species of *Ophiothrix,* is still "in the rough" and undoubtedly needs improved delimiting and defining. The Australian

[1] The name is given because of a certain similarity in form and habits to brittle stars of the genus *Amphiura.*

species, however, give little difficulty if material is adult and in good condition; little attention has been given to growth stages, and young individuals can seldom be identified with certainty. The arm spines are usually blunt and thorny and tend to lie in the same plane as the rather flat arms, so that the latter appear even more flattened than they are. Some 13 species[1] occur in Australian waters which may for the present rest in this genus, and they may, when adult, be distinguished by means of the following key, but it is almost certain that *capillaris* is not congeneric with the others. It is, furthermore, certain that the other species are not all equally valid, but that with more critical study, dissociated from the disadvantages of hurried collecting, the natural specific limits will be more accurately drawn.

Key to the Species of Macrophiothrix

A. Color gray, blue, lavender, or purple, with or without more or less yellowish or white; upper arm plates often spotted or marked with dark shades:
  B. Upper arm plates smooth, occasionally roughly granular or prickly at sides:
    C. Oral shields large, nearly as long as wide, with spinelets of interbrachial areas extending onto distal part:
      D. Upper arm plates perfectly flat, 3 times as wide as long, with sides almost completely rounded; proximal and distal margins straight and nearly equal; each plate has several (1–12) large, more or less circular, very dark spots on light blue-gray background ..... *sticta*
    DD. Not as above:
      E. Under arm plates wider than long, with convex lateral margins, straight or slightly convex distal margin, and all corners rounded; tentacle scale exceptionally large, rounded, scalelike ..... *megapoma*
      EE. Not as above:
        Arms and arm spines very flat, uppermost spine very small, flat, and blunt, the following longer; then 2 or 3 long and horizontal; lowest 2 very small and circular; color light bluish gray or lavender, with or without yellowish ..... *spinifera*
        Arms and arm spines less flat, uppermost and lowest less differentiated from others; color of large adults very dark ..... *scotia*
  CC. Oral shields with no spinelets on distal part:
    F. Under arm plates with broad longitudinal white line at least on distal part of arm:
      Colors dark and light purple and brownish yellow, single distinct longitudinal light stripe on upper side of arm; large arm spines rather long, tapering, not widened and truncate at tip, though blunt ..... *lampra*
      Colors light purple or lavender and pale yellow or whitish; 3 more or less interrupted light stripes on arm, or none except one distally; arm spines rather short, truncate or widened at tip ..... *rhabdota*

[1] A fourteenth species, *galateae*, is listed by Koehler (1907, as *galatheae*) on the strength of a specimen in the Paris Museum, said to be from Torres Strait. It is probably either *longipeda* or *belli*. Koehler gives no data, and *galateae* is a dubious species at best.

FF. No white stripe on lower surface of arm:
G. Upper arm plates with distal lateral angles very sharp; proximal margin much shorter than distal, which is typically straight or concave but often bending back a little at each end; if distal margin is convex, lateral angles of plate are nevertheless far distal to middle of plate; width of plate twice length or more:
Disk covered with thorny stumps and radial shields with coarse granules; arm spines not clavate ..... *longipeda*
Disk covered with rough spinelets; radial shields nearly bare or with a few scattered, pointed granules; most of large arm spines strongly clavate ..... *belli*
GG. Upper arm plates not as above:
H. Upper arm plates elliptical or tetragonal or hexagonal with strongly rounded corners ..... *callizona*
HH. Upper arm plates with distinct lateral angles:
Arms short, much less than 10 times disk; radial shields rather uniformly covered by minute thorny stumps like those on disk ..... *calyptaspis*
Arms 10 times disk or more; radial shields more or less bare; under arm plates with conspicuously thickened, convex distal margin ..... *michaelseni*
BB. Upper arm plates with entire surface rough with minute prickly granules ..... *rugosa*
AA. Color pink or reddish or nearly white with dark red longitudinal line on upper side of arm; arm spines long, more or less aciculate, very finely thorny ..... *capillaris*

Macrophiothrix sticta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 304; fig. 24.
Ophiothrix hirsuta Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 252 (NON Müller and Troschel, 1842, p. 111).

This notable and handsome species was collected in 6–8 fms., northwest of Middle Bluff, Shark Bay, Western Australia, in 1905 by Michaelsen and Hartmeyer. Presumably the 7 specimens taken in Shark Bay, at Turtle Island, and at Port Hedland, Western Australia, by the German zoologists and identified by Koehler as *hirsuta* are identical with the one now in the Museum of Comparative Zoölogy and made the type of *sticta;* Koehler was too good a worker to have mixed specimens of ordinary *Macrophiothrix* with so distinctively marked a species as *sticta,* which we did not find anywhere on the entire West Australian coast. Holotype 15 mm. across disk, arms apparently 10–12 times as much.

Macrophiothrix megapoma

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 297; fig. 22.

This species, long concealed under the name *longipeda,* was first taken by the "Challenger" near Cape York, but was not recognized as different from Lamarck's species for more than half a century. It was taken again by the Barrier Reef Expedition in Penguin Channel, north Queensland, 12–14 fms., but was again confused with *longipeda* (see H. L. Clark, 1932, p. 204). It was only when an

attempt was made to separate the species of *Macrophiothrix* that this very distinct and well marked species was recognized. It is as yet known only from northern Queensland. The specimens are 18–23 mm. across the disk; the arms, all broken, were probably 10 times as much or more. The lavender-gray coloration with the broad white stripe on the lower side of the arms is probably characteristic.

Macrophiothrix spinifera

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 302; pl. 24, fig. 3.

This is a common and conspicuous big brittle star of the Broome region from Cape Leveque to Lagrange Bay, but when young (less than 10 mm. across disk) it is difficult to distinguish from youthful congeners. In adults, 20 mm. or more across disk, the arms are very long, up to 300 mm. at least. The coloration is light, grayish lavender above with more or less yellowish, and white, cream color, or yellowish beneath save near tips of arms, where violet becomes evident. Young specimens are easily confused with young *belli, longipeda,* and *scotia.*

Macrophiothrix scotia

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 300; pl. 24, fig. 2.

Adult specimens of this very large and notable species have been taken as yet only in the Broome region, but young ones were taken at Darwin which seem to belong here. They are distinguishable from their nearest relatives by the presence of spinelets on the oral shields (distal end) and slender spines here and there on the disk; the latter are not always present. Adults of *scotia* are 23–25 mm. across disk, with arms up to 15 or more times disk diameter. The color, bright blue and white in the very young, becomes increasingly darker and more uniform in adults, and full-grown specimens are uniformly dark purple, almost black, with only faint indications of banding on the arms.

Macrophiothrix lampra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 296; fig. 21.

It is very probable that this species has long been confused under old names, for it is certain that specimens of *Ophiothrix* from Port Jackson have been incorrectly recorded at various times as *fumaria, ciliaris,* etc. It is more than probable also that small specimens of *lampra* (and big ones too perhaps) have been identified as *Ophiothrix spongicola* Stimpson, as this long-known species has never been adequately described. At present, *lampra* is definitely known only from Port Jackson and from Long Reef, Colloroy, New South Wales. It reaches a large size (20 mm. across disk) and a handsome coloration, but as yet we know nothing of youth stages or color development.

Macrophiothrix rhabdota

Ophiothrix rhabdota H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 278; pl. 13, fig. 4.

——— 1921. Ech. Torres Strait, p. 113; pl. 15, figs. 6, 7 (colored).

Macrophiothrix rhabdota H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 286.

This species has a very dubious status, for few specimens have been taken and the supposed specific characters are few and hazy. The Murray Islands at the northern end of the Barrier Reef is the type locality, and the only other known specimen comes from Port Galera, Mindoro, Philippine Islands. Disk 13–15 mm. across, arms 150–180 mm. long. The longitudinal stripes on the arm are not always as evident as could be desired.

Macrophiothrix longipeda

Ophiura longipeda Lamarck, 1816. Anim. sans vert., vol. 2, p. 544.
Ophiothrix longipeda Müller and Troschel, 1842. Syst. Ast., p. 113.
H. L. Clark, 1921. Ech. Torres Strait, p. 110; pl. 15, fig. 5 (colored); pl. 33, fig. 1.
Macrophiothrix longipeda H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 288.

Because of its extraordinary length of arms, this is one of the most striking brittle stars on the Australian coast. Owing to the fact that several long-armed species have been confused under the name *longipeda* (and possibly still are), it is difficult to say what the geographical range is, but it appears to be from East Africa to the Society Islands, north to Kominato, Japan, and south to Port Curtis, Queensland. On the Australian coast it ranges from Port Curtis northward to Torres Strait, and westward along the Coburg Peninsula, to Darwin and to Broome. It does not seem to occur much farther to the southwestward. It grows to a surprisingly large size, for although most museum specimens are less than 25 mm. across the disk and have arms about 400 mm. long, specimens taken in Torres Strait show a maximum disk diameter in life of 37 mm. and arms 625 mm. long. The general coloration is variegated purple and yellow, with considerable diversity in the shade and amount of each color. Usually the arms show no longitudinal stripes or conspicuous cross-banding. In habit, the animal is secretive, hiding in crevices and holes, extending the elongated arms out for surprising distances, and retracting them when alarmed into even more surprisingly small cavities.

Macrophiothrix belli

Ophiothrix belli Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 292; pl. 14, figs. 5*a*, *b*; pl. 16, figs. 14, 14*a*.
Macrophiothrix belli H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 287.

All that is known of this species is recorded in the references given above. It has not been reported from outside tropical Australia, where its range seems to coincide with that of *longipeda*. The possibility that the two supposed species may be the two sexes of one cannot be ignored.

Macrophiothrix callizona

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 293; pl. 24, fig. 1.

The only known specimens of this brittle star were taken at Broome, Western Australia, 1 in 1929 and 1 in 1932. Disk about 10 mm. across, length of arms 10–12 times as much. The color is pale gray, spotted (disk) or banded (arms) with deep purple; under arm plates cream color speckled and occasionally blotched with deep purple. Apparently the species is very secretive and seldom dredged or found along shore. It is one of the handsomest members of the genus.

Macrophiothrix calyptaspis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 294; pl. 25, fig. 3.

Of this species also, only 2 specimens are known, also found at Broome. They were taken in 1929, probably under rocks at the rich collecting grounds on Entrance Point. The disk is about 10 mm. across and the arms are relatively short, only about 7 or 8 times as much. It is justifiable, therefore, to question the propriety of including the species in *Macrophiothrix,* but the character of both disk and arms counterbalances the brevity of the latter.

Macrophiothrix michaelseni

Ophiothrix michaelseni Koehler, 1907*a*. Fauna Südwest-Australiens, vol. 1, p. 250; figs. 7–10.
Macrophiothrix michaelseni H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 290.

Only 4 specimens of this species have as yet been recorded. Of Koehler's 2 specimens, 1 was "en mauvais état," and the other was only 9 mm. across the disk. The 2 specimens in the Museum of Comparative Zoölogy are 13 and 15 mm. in disk diameter and agree well in most characters, but the smaller has the arm spines notably more slender and hence less like Koehler's type. The latter was from Shark Bay, the poorer one from Koombana Bay, Bunbury. The larger M.C.Z. specimen is from Bunkers Bay (some distance south of Bunbury), and the smaller is from Garden Island, near Fremantle. Apparently *michaelseni* is an endemic species of Western Australia.

Macrophiothrix rugosa

Ophiothrix hirsuta H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 272 (NON Müller and Troschel, 1842, p. 111).
——— 1921. Ech. Torres Strait, p. 109.
Macrophiothrix rugosa H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 299; fig. 23.

A single long-armed *Ophiothrix* from Mer, Murray Islands, northern Queensland is the unique holotype of this species. It is 16 mm. across the disk and the length of the arms is more than 10 times that. The disk is nearly uniform purple, but the arms are rather evidently banded, lighter and darker purple alternating.

Macrophiothrix capillaris

Ophiothrix capillaris Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 51.
——— 1882. "Challenger" Oph., p. 222; pl. 21, figs. 5–8.

It is only after much hesitation that I include this handsome East Indian species here. In the first place, I am skeptical as to its occurrence in the Australian region. Koehler (1930) reports 5 specimens from southeastern Australia in 83–200 fms., but he makes no comment on them. As he had studied many specimens from the Philippines (1922), his identification should be indubitable, but it seems strange that the "Thetis" and the "Endeavour" should have failed to find so conspicuous a species, though they collected in the same region.

In the second place, granting that *capillaris* does extend its range thus far south of Torres Strait, the inclusion of the species in *Macrophiothrix* is open to serious

objection. The arms, although very long, are not at all like those of *longipeda* and its relatives, and the arm spines are wholly different. But until more material is available it seems unwise to establish a new genus here. On the strength of Koehler's identification of the specimens taken by Mortensen off Cape Howe, *capillaris* is included in the Australian fauna, and purely for convenience it is temporarily included in *Macrophiothrix*.

PLACOPHIOTHRIX

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 309.

Genotype: *Ophiothrix melanosticta* Grube, 1868, p. 45.

Like *Macrophiothrix,* this genus is undoubtedly a natural group, but it is as yet ill defined and needs critical study and revision. The Australian species are for the most part well marked and easily recognized, but several need careful study of good series of specimens. Color markings seem to be fairly constant and are useful for specific distinctions in several cases, but the genotype reveals one of the most extraordinary cases of diversity of color to be found in the whole echinoderm phylum. It became perfectly comprehensible, however, as soon as sufficient material of all ages was available for study.

Many of the species referred to this genus pass through a stage when quite small (disk diameter less than 5 mm.) in which the arm spines of each side arm plate at base of arm are united by a vertical membrane as in *Ophiopteron.* Perhaps the possession of an *Ophiopteron* stage should be considered an essential character of the genus. See Mortensen, 1932*a,* on the genus *Ophiopteron.*

Key to the Species of Placophiothrix

A. Disk lacking conspicuous centrodorsal plate:
  B. Disk with spines, or spinelets of considerable length:
    C. Disk spines fairly numerous, not exceedingly slender:
      D. Disk spines rather short, smooth, acute, not very numerous; upper arm plates quadrilateral, wider than long, distal margin convex, broadly in contact; color very diversified but never with unbroken white or colored line on upper surface of arms ..... *melanosticta*
    DD. Not as above:
      Upper arm plates diamond-shaped, slightly in contact; broad but often ill defined white stripe, bordered with deep rose-colored lines, on upper side of arms ..... *aristulata*
      Upper arm plates hexagonal, broadly in contact; narrow white line on upper side of arm bordered with deep blue ..... *lineocaerulea*
  CC. Disk spines exceedingly slender and not very numerous (save in some large specimens):
    E. Upper arm plates prettily marked with spots of deep blue,[1] frequently so numerous as to form 2 broken parallel lines ..... *striolata*

[1] In life, the colors are brown and pale green, which undergo great changes either in alcohol or when dried.

EE. Upper surface of arm with 1 or more narrow but distinct lines:
Single narrow black line on each arm ..... *elegans*
3 narrow dark lines separated by 2 narrow white lines ..... *trilineata*
BB. Disk with thorny stumps, low, rough spines, or pointed granules:
F. Center of disk as thickly covered with stumps or low spinelets as interradial areas:
G. White (or yellow) longitudinal line on dorsal side of arm:
General coloration violet or purple with narrow longitudinal white stripe (yellow in life) on both upper and under surfaces of arm ..... *virgata*
Disk yellowish white; radial shields bluish white in definite contrast; upper surface of arm with broad white stripe faintly bounded with yellowish brown or gray ..... *albostriata*
GG. No white stripe on arm ..... *spongicola*
FF. Center of disk smooth, without spinelets or granules, which are however numerous on interradial areas especially at margin:
Arms rather short, 5–6 times disk diameter; no white lines on arms ..... *plana*
Arms rather long, 7–8 times disk diameter; longitudinal white lines along middle of each surface of arm ..... *albolineata*
AA. Disk with large centrodorsal plate; size very small ..... *megaloplax*

Placophiothrix melanosticta

Ophiothrix melanosticta Grube, 1868. Jahresber. Schles. Gesellsch., Breslau, vol. 45, p. 45.
Koehler, 1905. "Siboga" oph. litt., p. 77; pl. 8, figs. 4–6.
Placophiothrix melanosticta H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 311; pl. 12, figs. 3–5 (colored).

Among all the brittle stars of Australia, none compares with this for diversity of color and growth changes. It is abundant at Broome and thus it was possible to discover and work out these changes to an unusual degree. The incredible idea that black, white, and parti-colored big brittle stars, 15–20 mm. across the disk, could all develop from red, green, and black young became perfectly comprehensible when the extreme tides of September laid bare the bottom of the harbor at Broome, exposing thousands of *melanosticta* for our examination (see H. L. Clark, 1938). The only Australian records for this brittle star aside from Broome are a single small specimen recorded by Koehler (1907) from Port Hedland, Western Australia; a single very young one which we took at Darwin in 1929; another, still smaller, which we took in Torres Strait in 1913; and Bell's laconic record (1894), "northwestern Australia, 38 fms." Apparently adults have not been found as yet anywhere in Australia, save in Roebuck Bay.

Placophiothrix aristulata

Ophiothrix aristulata Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 50.
——— 1882. "Challenger" Oph., p. 223; pl. 21, figs. 9–12.
Placophiothrix aristulata H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 310.

A very handsome brittle star found by the "Challenger" first off South Africa and later off southeastern Australia, *aristulata* has since been found widely distributed

in the Indian and western Pacific areas from the Gulf of Aden to New Zealand, in water 65–345 fms. deep. It has not yet been taken off Western Australia. It reaches a considerable size, 18 mm. in disk diameter, with arms 6–8 times width of disk. The coloring is normally pink and white, the white stripe on the upper side of the arm being conspicuous, but in preserved material the rosy shades tend to fade and specimens become dingy white or yellowish, with the white line on the upper side of the arm no longer conspicuous.

Placophiothrix lineocaerulea

Ophiothrix lineocaerulea H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 432; fig. 129.
Placophiothrix lineocaerulea H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 310.

This is one of the handsomest and most characteristic brittle stars of the Broome region, where it is quite common. We did not find it at Cape Leveque, but we did no dredging in that vicinity. It has not been taken west or south of Lagrange Bay. It is odd that the unique holotype should be in the South Australian Museum without any locality label. Full-grown specimens are 20 mm. across the disk and have arms 7–8 times as much. The blue and white coloration is very fine and in all essentials it is remarkably constant. There are of course differences between young and adult specimens, and there is considerable diversity in the amount of blue on the lower surface.

Placophiothrix striolata

Ophiothrix striolata Grube, 1868. Jahresber. Schles. Gesellsch., Breslau, vol. 45, p. 45.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 295; pl. 17, figs. 22, 22*a*.
H. L. Clark, 1921. Ech. Torres Strait, p. 114; pl. 15, fig. 1 (colored).
Placophiothrix striolata H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 314.
Ophiopteron puncto-caeruleum Koehler, 1905. "Siboga" oph. litt., p. 114; pl. 12, figs. 5–7; pl. 15, fig. 6.

Mortensen (1932*a*) has demonstrated beyond cavil that Koehler's pretty little brittle star which he considered a new species of *Ophiopteron* is in reality the young of this East Indian species, which, though frequently reported, does not seem to be common or well known. Bell (1884) lists it among the species taken by the "Alert" in Torres Strait, but gives no information whatever. Döderlein (1896) says that Semon brought many specimens from Thursday Island up to 11–13 mm. in disk diameter. We took a single small specimen at Friday Island in 1913, but did not meet with the species in either 1929 or 1932. Melbourne Ward sent a small specimen to the Museum of Comparative Zoölogy from Lindeman Island, Queensland, in 1934, and the Great Barrier Reef Expedition took a single small specimen at Linden Bank in 1928. There are no other Australian records save Koehler's (1907*a*) 2 small specimens from Western Australia, which are probably young *spongicola*. Apparently, therefore, *striolata*, which is common in the Philippines, reaches the southern limit of its distribution in the northern Barrier Reef region and does not occur west of Torres Strait. Mortensen did not find it at the Kei Islands.

The maximum size appears to be 15 mm. across the disk, with arms 5–6 times the disk diameter. There is considerable diversity in the number and slenderness of the disk spines. The coloration of *striolata* apparently is very different when

living from what it is in preserved material. The latter is dirty white or pale buff spotted or marked with short lines of deep but bright blue, very striking and attractive especially under a lens. In the largest specimen (15 mm. across disk) in the Museum of Comparative Zoölogy, there is very little indication of blue, but whether this is a case of senescence or merely fading due to the age of the specimen (probably over 80 years), we have no means of knowing. For the color in life, the only record is of the young specimen which we took at Friday Island in 1913. It was only a little over 5 mm. across the disk, with arms about 5 times as much. The colors were brown, of two shades, and pale yellowish green. On being placed in formalin and corrosive sublimate, prior to drying, it became purple and yellow, and on drying, it slowly assumed the dirty white and blue color of our other museum specimens. Further observations on these color changes are greatly to be desired.

Placophiothrix elegans

Ophiothrix elegans Lütken, 1869. Add. ad hist. Oph., pt. 3, pp. 57, 99.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 110; figs. 82–86.

Judging from the 2 specimens in the Museum of Comparative Zoölogy, 1 from the Philippines and 1 from the Pelew Islands, this species, long but very imperfectly known, certainly belongs in *Placophiothrix*. Koehler re-examined and figured Lütken's type in 1904. In 1922, he reported a specimen 5 mm. across the disk from the Philippines; his figures show a specimen that can hardly be placed in *Placophiothrix,* but is apparently what I (1938) have called *Ophiothrix stelligera* forma *atrolineata,* and now recognize as Bell's *Ophiothrix melanogramma* (see p. 216). As Bell gave no figures, it is not strange that Koehler failed to recognize the species when working on the "Albatross" 's huge collection of brittle stars from the Philippines. In 1930, Koehler reports a very small specimen, 3 mm. across disk, from Disaster Bay, New South Wales, in 29–32 fms., which seems more like Lütken's species but which I strongly suspect is a young *Ophiothrix acestra.* Since, however, *elegans* may well occur in Australian seas, I include it here on the strength of Koehler's certainly dubious record.

Placophiothrix trilineata

Ophiothrix trilineata Lütken, 1869. Add. ad hist. Oph., pt. 3, pp. 58, 100.
H. L. Clark, 1921. Ech. Torres Strait, p. 115; pl. 16, figs. 4–6 (colored); pl. 33, figs. 4, 5.
Placophiothrix trilineata H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 315.

This species of brittle star would seem to be very local in its distribution; it ranges across the East Indian region and is abundant at Mer at the northern end of the Great Barrier Reef, but occurs also at Lord Howe Island far south of the Reef's end. Only a single specimen has as yet been reported from between the two islands: a small individual collected at Bott Reef near Cairns. It is not known from the mainland coast anywhere, nor is it found west of Torres Strait nor at the Aru or Kei islands. Bell (1894) lists it from northwestern Australia in 20–35 fms., but gives no data. It is a relatively small species with short arms, 4–5 times the disk diameter, which rarely exceeds 8 mm. For a discussion of its color and habits at Mer see H. L. Clark, 1921, page 115.

Placophiothrix virgata

Ophiothrix virgata Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 82.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 80; figs. 36–40.

This is apparently a rather rare species, for there are but few records even in the East Indies. In Australia it is known only from Mer, and my notes published in 1921 comprise all that we know of its habits and appearance in life. The most interesting fact in its coloration is that the conspicuous white stripes on the upper and lower surfaces of the arm in preserved material are yellow in life.

Placophiothrix albostriata

Ophiothrix albostriata H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 429; fig. 127.

A single specimen, 10 mm. across the disk, with arms 50–55 mm. long, is the only known representative of this species. It is in the South Australian Museum and is said to be from the Great Australian Bight.

Placophiothrix spongicola

Ophiothrix spongicola Stimpson, 1855. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, p. 385.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 97; figs. 64–68.
Placophiothrix spongicola H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 314.

One of the most characteristic echinoderms of southern Australia, this handsome brittle star ranges from Broken Bay, New South Wales, along the southern coasts of the continent (there seem to be no records from Tasmania) to Dongarra, Western Australia, and the Abrolhos Islands. Large specimens may be 20 mm. across the disk. The variegated coloration, red and blue in life, is quite handsome, but is much dulled in preserved specimens. The shades may be very dark in large individuals.

Placophiothrix plana

Ophiothrix plana Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 238.
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 255; pl. 38, figs. 3–5.
Placophiothrix plana H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 313.

This little East Indian brittle star, 6–7 mm. across the disk with arms 35–40 mm. long, is very common on the northern coast of Australia, particularly at the Shell Islands near Darwin and at Entrance and Gantheaume points, Broome. It has not, however, been found in Torres Strait or in the Barrier Reef area. The diversity of color is very great, the disk being usually some shade of gray but sometimes yellowish, brownish, or reddish purple, more or less variegated with whitish and finely speckled with black. It probably is not really a *Placophiothrix,* as it does not have the general facies of species of the genus, and it lacks an *Ophiopteron* stage in development, even the small specimens having no membrane connecting the arm spines.

Placophiothrix albolineata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 315; fig. 26.

This species rests upon a single brittle star, 11 mm. across the disk, taken at Lord Howe Island in 1932. It is very similar to *P. virgata* of the same size, but the arm spines are more slender and the character of the disk covering is notably different, *albolineata* being very nearly an *Ophiotrichoides* in this respect. If *virgata* had been taken within two thousand miles of Lord Howe, the present specimen might well be treated as an aberrant member of that species. As it is, it may for the present be considered a representative of a species peculiar to Lord Howe.

Placophiothrix megaloplax

Ophiothrix megaloplax Koehler, 1930. Vidensk. Medd., vol. 89, p. 170; pl. 9, figs. 8, 9.

This supposed species is based on 4 small specimens collected by Mortensen off Cape Howe, southeastern Australia, in 75–83 fms. These 4 little brittle stars, 4 mm. or less across the disk, are probably the young of a larger and as yet unknown *Ophiothrix,* perhaps a *Placophiothrix.* The color of the types in alcohol was yellowish gray.

OPHIOPTERON

Ludwig, 1888*a*. Ztschr. f. wissensch. Zool., vol. 47, p. 459.

Genotype: *Ophiopteron elegans* Ludwig, 1888*a,* p. 459.

For a most important discussion of this interesting little group, consult Mortensen (1932*a,* pp. 11–20). Its limits are fairly definite, but the number of species is still uncertain. Only one, however, is as yet known from Australia, and that is the genotype.

Ophiopteron elegans

Ludwig, 1888*a*. Ztschr. f. wissensch. Zool., vol. 47, p. 459; pl. 35, figs. 1–11.

The type locality for this remarkable brittle star is Amboina, that well known hotbed of echinoderms, but it has been taken as far north as the Philippines and as far west as the Maldives. The only record for Australia is that of a single specimen in the Australian Museum, taken 20 miles north-northeast of Double Island Point, Queensland, in 30 fms. It is not in good condition, but the generic position is indubitable and there is no particular reason to question the species. Koehler (1922) has given some good photographs of this remarkable brittle star (pl. 60, figs. 1, 2, 5).

OPHIOCNEMIS

Müller and Troschel, 1842. Syst. Ast., pp. 83, 87.

Genotype: *Ophiura marmorata* Lamarck, 1816, vol. 2, p. 543.

This genus is supposed to contain 3 species, but 1 of these, listed as from Liberia, is open to question, and another from Singapore needs elucidation with more material. The following is the only well known species.

Ophiocnemis marmorata

Ophiura marmorata Lamarck, 1816. Anim. sans vert., vol. 2, p. 543.
Ophiocnemis marmorata Müller and Troschel, 1842. Syst. Ast., p. 87.
Döderlein, 1888. Zool. Jahrb., Abt. syst., vol. 3, pl. 32, figs. 6*a–c*.

This handsome brittle star is common at Broome, where it frequents in great numbers the fine sandy areas in Roebuck Bay. It grows to a considerable size, 21 mm. disk diameter, and is very gregarious in habit. It lives just below the surface of the sand, with which its gray and white colors (upper surface) harmonize wonderfully. The lower surface is uniformly white, in rather marked contrast with the sand, in which the ophiurans live so closely together that the arms more or less overlap one another. *Ophiocnemis* has not been found at any other locality on the Australian coast, but it occurs more or less generally from Zanzibar to the Philippines where local conditions are favorable.

OPHIOTHELA

Verrill, 1867. Trans. Connecticut Acad., vol. 1, p. 269.

Genotype: *Ophiothrix* (*Ophiothela*) *mirabilis* Verrill, 1867, p. 268.

Even more than *Ophiothrix,* this little genus, to which 9 species have been referred, needs a careful revision, for the extent of individual diversity is very great and the specific characters are poorly worked out. The Australian specimens referred by Koehler to Verrill's species *danae* are better considered identical with the species from Torres Strait and the eastern coast of the continent, and all Australian material is therefore here referred to the following species, including the specimens from Sir Edward Pellew group, Gulf of Carpentaria, which were recorded by McNeill and Livingstone (1926) as *Ophiothela* sp. and which I then said were probably referable to *O. danae.*

Ophiothela hadra

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 284; pl. 14, fig. 2.
——— 1921. Ech. Torres Strait, p. 117; pl. 13, fig. 5 (colored).

This little, very diversified, apparently symbiotic brittle star has been found southeast of Ballina, New South Wales, in 27–29 fathoms, on the spines of the sea urchin *Prionocidaris;* at Port Curtis, Queensland (host not noted); at Mer, Torres Strait, in 18 fms., on a sponge; at Shell Islands, Darwin, in 3–6 fms., on a sponge; and repeatedly in the Broome region, in 5–8 fms., on gorgonians and once on a holothurian. Koehler's specimens (1907*a*), which he called *danae,* were from Shark Bay and Albany, Western Australia. The latter station seems highly improbable. As already stated, McNeill and Livingstone's specimens (1926) from the Gulf of Carpentaria, on "alcyonarian" stems, are probably *hadra.*

The disk of this species is 3 mm. in diameter or less, and the arms are hardly 4 times as much. Adults have 6 arms, but most specimens have only 2, 3, or 4, as they seem to be constantly in process of reproduction by fission. The colors in life are diversified, but orange-yellow and green are frequent, changing rapidly to red and blue after preservation. My Darwin field notes say that the coloration was extraordinarily bizarre—black, white, red, yellow, and dull green quite irregularly

massed. The general impression of a group of specimens together was red and green but not bright. The disk of the larger specimens at Broome was deep purplish red, and the dried specimens retain that color, but the small specimens show little trace of it. In the dry condition, most of the specimens are pale brown or variegated with dull shades of blue, red, and whitish. In all details of structure, such as the granules on disk and arms, the arm spines, and the various plates of the oral surface, there is great diversity. There are no recorded observations as to whether the diversities in color and details of structure are correlated with the character of the host on which the specimens are living.

LISSOPHIOTHRIX

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 275.

Genotype: *Lissophiothrix delicata* H. L. Clark, 1938, p. 276.

This is at present a monotypic genus, known only from tropical Australia west of Torres Strait.

Lissophiothrix delicata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 276 (not figured).

There is nothing further to be added to the original account of this delicate little brittle star. Adults are 5 mm. across the disk and have arms 25–30 mm. long. The colors, both in life and when preserved, are light but varied; specimens from Darwin tend to be green, but Broome material is light—grayish or yellowish white—with no evidence of green. Quite possibly this color difference is associated with a difference in the character of the bottom from which they are taken.

OPHIOTRICHOIDES

Ludwig, 1882. Brasil. Echinod., p. 20.

Genotype: *Ophiotrichoides lymani* Ludwig, 1882, p. 21.

This genus, long monotypic, appears to be represented in the Indo-Pacific region by a considerable number of species. Of these, 8 occur in the Australian region and several are highly characteristic species. At least half of these are notable for the beauty of their coloration, which is frequently constant and distinctive. These Australian species may be distinguished as follows, but it should be noted that 3 are known from only a single specimen each:

Key to the Species of Ophiotrichoides

A. Upper arm plates in uniform series, not individually peculiar:
  B. Upper surface of arm with distinct longitudinal colored line, or 2 narrow, closely parallel lines:
    Longitudinal line on arm narrow, deep blue or almost black; large light area on one side or the other of each plate (in life, orange or deep yellow); these light (or orange) areas alternating right and left with notable regularity the whole length of arm ..... *martensi australis*

Longitudinal line on arm double, deep nile green or blue, space between them more or less nearly white (or yellow), outer margin of each line usually very indefinite ..... *smaragdina*

Longitudinal line pale brownish or gray, not uniform but slightly widened at distal end of each plate, bordered by white lines, outer margins of which are limited by narrow dark line; white lines generally evident, colored lines may be much broken up ..... *liodisca*

BB. Upper surface of arm without longitudinal line:

C. Upper arm plates with conspicuous color markings:

Each upper arm plate with transverse (to arm) orange or yellow line, fading to nearly white ..... *nereidina*

Each upper arm plate blotched and variegated but with no definite transverse lines ..... *propinqua*

CC. Upper arm plates unicolor or with single minute dusky spot:

Arm spines 7 or 8, uppermost 3 or 4 united (on basal arm segments) by membrane ..... *hymenacantha*

Arm spines 6, not united by membrane ..... *pulchra*

AA. Upper arm plates irregular and unlike ..... *irregularis*

Ophiotrichoides martensi australis

Ophiothrix martensi Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 234 (*partim*).
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 291; pl. 16, figs. 13, 13*a*.
Ophiothrix martensi australis H. L. Clark, 1921. Ech. Torres Strait, p. 111; pl. 15, fig. 4 (colored).
Ophiotrichoides martensi australis H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 305.

This is a very handsome brittle star, common on the tropical coasts of Australia. It is almost unique among ophiurans as an apparently definite color form monopolizing a distinct geographical area and not occurring elsewhere, and hence is entitled to recognition as a subspecies. Large adults are 15 mm. across the disk, with arms 100 mm. and more in length. The purple and orange or yellow coloring is very fine, except in the darkest specimens. The range of *australis* is from Port Curtis, Queensland, on the east coast, to Cossacks, Western Australia, on the northwest. It is one of the few echinoderms that are common at both Darwin and Broome.

Ophiotrichoides smaragdina

Ophiothrix smaragdina Studer, 1882. "Gazelle" Oph., p. 26.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 92; figs. 60–63.
Ophiotrichoides smaragdina H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 307.

This is one of the few echinoderms with such beautiful coloration and delicate grace of form that the adjective "exquisite" is no exaggeration. No other known brittle star exceeds it in attractiveness. It seems to be peculiar to the northwestern coast of Australia from Darwin, where it is common, to Lagrange Bay, Western Australia, where it appears to be rare. The type locality is "off northwestern Australia, 50 fms." Large specimens are 9–10 mm. across the disk, with the slender arms some 10 times as much. The amount and shade of green on the upper side of the arms show considerable diversity. The amount ranges from a well defined narrow line on each side of the median white (rarely yellow) stripe

to an ill defined covering of much of the surface of the dorsal plates. The shade ranges from robin's-egg blue to emerald green. The youngest specimens seen are all in the *Ophiopteron* stage, the web on the basal arm spines being very obvious.

Ophiotrichoides liodisca

Ophiothrix liodisca H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 273; pl. 12, fig. 3.

The only Australian specimen yet taken of this interesting little brittle star is the holotype from Mer, Murray Islands, but in the Museum of Comparative Zoölogy there are a dozen specimens taken in 10–12 fms. at Port Galera, Mindoro, Philippine Islands. They range from 4 to 7.5 mm. across the disk and in their structural features correspond well to the holotype. In color, however, there is great diversity. Several are light gray, the color pattern corresponding well to that of the Australian specimen; but the young specimens are a dull reddish brown and show little or no dorsal stripe, but some faint variegation on the dorsal arm plates. The large brown specimens are also variegated on the arms, but the color pattern of the striped form is more or less evident under the lens. The "Albatross" does not seem to have taken *liodisca* during its extensive Philippine cruise, and we did not find it on the Australian coast in either 1929 or 1932. Apparently it is somewhat rare and local and probably very secretive in its habits.

Ophiotrichoides nereidina

Ophiura nereidina Lamarck, 1816. Anim. sans vert., vol. 2, p. 544.
Ophiothrix nereidina Müller and Troschel, 1842. Syst. Ast., p. 115.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 293; pl. 16, figs. 16, 16*a*.
H. L. Clark, 1921. Ech. Torres Strait, p. 112; pl. 15, figs. 2, 8, 9 (colored).
Ophiotrichoides nereidina H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 306.

This very handsome East Indian ophiuran does not seem to have reached the Australian coast west of Torres Strait, but on the northeastern side it has been taken at Mer, at Lizard Island, at Lindeman Island, and at Fraser Island on the Queensland coast. It is a very handsome species, with its finely banded arms (purple or lavender and orange, yellow, or whitish) and prettily marked disk, and reaches a considerable size, 15 mm. across disk, with arms more than 100 mm. long.

Ophiotrichoides propinqua

Ophiothrix propinqua Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 83.
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 256; pl. 38, figs. 1, 2.

Apparently this brittle star should be included in *Ophiotrichoides,* but its type of coloration distinguishes it easily from the other Australian species. It does not reach a large size, specimens 10 mm. across the disk being near the maximum. The variegated coloration (dull blue or purplish, whitish, and often, but not always, rosy or dull red) seems to be quite constant, and specimens showing such but with a well defined longitudinal color line on the upper surface of the arm (see Koehler, 1930, p. 147) are almost surely some other species. At Mer, Murray Islands, *propinqua* is fairly common, but it is not known from south of that point, nor did

we find it at either Darwin or Broome. Koehler (1907) records one specimen from Shark Bay, Western Australia, but this identification is almost certainly erroneous, as the species is an Indo-Pacific form, not otherwise known from south of lat. 10° S.

Ophiotrichoides hymenacantha

Ophiothrix hymenacantha H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 431; fig. 128.

This species is known from only a single specimen, which is in the South Australian Museum. It is recorded as from the "Great Australian Bight," but there is a possibility that it is from the northwestern coast of the continent. It is 8 mm. across the disk and of an almost uniformly pale grayish-white color, with the arm spines and mouth parts yellowish white. Of course the specimen may be more or less bleached, but even in that case, the absence of notable markings would be distinctive. The persistence of an *Ophiopteron* stage at the base of the arms is a remarkable feature.

Ophiotrichoides pulchra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 309 (not figured).

The only known specimen of this species is the holotype, taken on the under side of a rock, at Entrance Point, Broome, Western Australia. It is 8 mm. across disk; arms 55–60 mm. The color in life was bright yellowish orange without lines or markings. The preserved specimen (dry) is yellowish with little trace of orange, and with a faint dusky spot, very small, on each upper arm plate.

Ophiotrichoides irregularis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 308; fig. 25.

It is difficult to decide whether the unique holotype of this species is simply a freak or is representative of a valid species. It is very similar to *martensi,* but the color of the disk is a dull purplish gray without markings, and the light gray upper arm plates have often a longitudinal white streak on one side or the other of the median line. A broken, irregular, narrow black line occurs on a considerable number of the dorsal arm plates, in many cases looking like a crack. The lower surface of the arms has a broad but ill defined median white stripe running the whole length of the arm. The upper arm plates are peculiar in that they are unequal in size and form and usually the distal margin is concave. Moreover, some are cracked into two or three pieces, and others have irregular, cracklike black lines. This very curious specimen was taken at Port Curtis, Queensland, and is in the Australian Museum. It is 10 mm. across disk; arms 50–60 mm. long.

OPHIOMAZA

Lyman, 1871. Illus. cat. Mus. Comp. Zoöl., no. 6, p. 9.

Genotype: *Ophiomaza cacaotica* Lyman, 1871, p. 9.

This is a very remarkable small group of ophiurans which live symbiotically with or parasitic on comatulids. They grow to considerable size, and there is no indication

that their presence hampers or injures the comatulid in any way. Of the 4 species which have been described, 3 occur in tropical Australia, but 1 is known from only a single specimen. They may be distinguished thus:

KEY TO THE SPECIES OF OPHIOMAZA

A. Interbrachial areas below covered by rough skin with only small scattered plates or none:
  Unicolor (chocolate brown), or variegated brown and white or cream color, or light color may predominate, sometimes very markedly so; interradial areas of disk covered by a single series of thick, quadrilateral plates ..... *cacaotica*
  Black or blackish or olive brown, sometimes more or less prettily marked with olive yellow (markings may be very faint in dry specimens); interradial areas of disk covered by several series of long, narrow, thin plates ..... *obscura*
AA. Interbrachial areas below covered by regular pavement of smooth plates .... *cataphracta*

Ophiomaza cacaotica

Lyman, 1871. Illus. cat. Mus. Comp. Zoöl., no. 6, p. 9.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 298; pl. 17, figs. 26, 26*a*.
H. L. Clark, 1921. Ech. Torres Strait, p. 116; pl. 16, fig. 3 (colored).

This is one of the most interesting of the tropical Australian ophiurans, as it has become so admirably adapted to its symbiotic life with large comatulids that it is doubtful whether it could live separated from its partner. The curious diversity of coloration shows that its success in life does not depend at all on protective resemblance. Not only is there no correlation in color between the commensal and its host, but the fact that the conspicuous and bizarre black and white individuals grow as large as the unicolored ones indicates that concealment is not necessary for safety. Koehler (1895) suggested the varietal name *picta* for the black and white form, and the name may be used for convenience, but the form is in no true sense a variety, and the line between it and the unicolor form cannot be drawn sharply.

Widely distributed from Zanzibar to New Caledonia, this *Ophiomaza* occurs on the tropical Australian coast presumably wherever large comatulids occur. Accordingly, we found it at Mer but not at Darwin, and it was common at Broome. It has been taken as far south as Port Curtis, Queensland, and Bell (1894) records it from "northwestern Australia, 8–20 fms." Full-grown specimens are 18–23 mm. across disk; length of arms only about 3 times as much.

Ophiomaza obscura

Ophiocnemis obscura Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 333.
Ophiomaza obscura Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 233.
H. L. Clark, 1921. Ech. Torres Strait, p. 116; pl. 16, fig. 2 (colored).

This seems to be a much rarer species than the preceding, for we found only 3 specimens at Mer in 1913 and none at any point in 1929 or 1932. Since Ljungman's day, this brittle star has apparently been met with very rarely. There was no specimen in the Museum of Comparative Zoölogy until 1914, and evidently Lyman never saw

one. Koehler also, in spite of the huge East Indian collections that have passed through his hands, does not record *obscura.* Bell alone has had a specimen (or specimens) to study, and he merely reports (1894) *Ophiomaza obscura* Lyman from "North-west Australia" in 9 fms. We therefore lack information as to the size and color, whether on a comatulid or not, and locality. There are at present 4 specimens in the M.C.Z., for besides those collected at Mer in 1913, there is the large specimen, 18 mm. across the disk, from the Philippine Islands recorded by me in 1921. Since only one of these specimens shows the ornamental markings shown in my colored figure, it may be inferred that, just as in *cacaotica* the normal coloration is uniform chocolate brown and individuals with light markings are exceptional variants, so in *obscura* the normal coloration is uniform deep olive brown or blackish and individuals with yellowish lines are exceptional.

Ophiomaza cataphracta

Lütkenia cataphracta Brock, 1888. Ztschr. f. wissensch. Zool., vol. 47, p. 522.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 114; figs. 92, 93.
Ophiomaza cataphracta H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 283.

As this species is still known from the unique holotype only, there is some possibility that Brock was right in giving it generic rank, but he could not call the genus *Lütkenia,* since that name is preoccupied by *Lütkenia* Duncan (1878), also proposed for an ophiuran, but abandoned as a synonym of *Ophiopleura.* Brock states the facts correctly, but concludes that since Duncan himself abandons the name, it may be used for some other group. This, of course, is not permissible under the International Code.

Judging from Koehler's figures, the holotype of *cataphracta* cannot be referred to *cacaotica,* for whereas the dorsal surface indicates identity, the lower surface of the interbrachial areas is essentially different. Were the unique specimen very small, this might be interpreted as a youthful condition, but the specimen is 9.5 mm. across the disk. The locality is given by Brock as Cape York, Queensland.

OPHIOGYMNA

Ljungman, 1866. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 6, p. 163.

Genotype: *Ophiogymna elegans* Ljungman, 1866, p. 163.

Koehler (1922, pp. 281–296) has given an admirable account of this genus with a very valuable discussion of the component 6 species which he recognizes. All are East Indian, and 5 of them he found (1930) in Mortensen's big collection, 4 from the Kei Islands. His description of the morphological peculiarities, particularly of the arms, is very important. Only a single specimen of *elegans* has been found in Australian waters, and no example of any other of the known species has been taken, but at the Low Isles on the Barrier Reef a seventh species occurs. As yet the genus is not known from northern or western Australia. The two Barrier Reef species may be easily distinguished by their color markings alone, but there are important structural differences also.

Arms irregularly spotted, or transversely imperfectly banded, or unmarked.....*elegans*
Arms with distinct narrow, longitudinal white stripe on upper surface.....*lineata*

Ophiogymna elegans

Ljungman, 1866. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, p. 163.
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 5, p. 281; pl. 43, figs. 3–8.

Although this brittle star is widely distributed in the East Indies, from Hong Kong to the Kei Islands, it is apparently rare in Australia, for the only record is that of a single small specimen in the Australian Museum, dredged off Norwest Islet, Great Barrier Reef, Queensland. Fully grown specimens may be 9 mm. across the disk and the long arms may be 10–15 times the disk diameter. Koehler says the color in alcohol is pinkish, tending more or less toward yellow, with red dots on the disk, and the arms showing annulations formed of small red dots. In old specimens the colors are seldom conspicuous, and most large individuals are light-colored, more or less nearly cream white. Usually, however, rosy or red-violet markings can be detected with a lens.

Ophiogymna lineata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 320 (not figured).

This little species is known from only 4 specimens, but it seems to be distinct from the other known members of the genus. The white line on the arm is an easily seen character. The specimens, 4 mm. or less across the disk, were taken on a mud and alcyonarian bottom, in 6–8 fms., west of Low Isles, Great Barrier Reef, Queensland. The Great Barrier Reef Expedition to the Low Isles found no specimens.

OPHIOPHTHIRIUS

Döderlein, 1898. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 486.

Genotype: *Ophiophthirius actinometrae* Döderlein, 1898, p. 486.

The extraordinary little brittle stars to which so long a name is attached were discovered by Döderlein (1898) among the cirri of *Comatula solaris* from Torres Strait. Similar specimens have not been met with since. It is not impossible that we are dealing with very young stages of *Ophiomaza,* but very young examples of *O. cacaotica* (3 mm. in disk diameter) show no resemblance to Döderlein's figures.

Ophiophthirius actinometrae

Döderlein, 1898. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 486; pl. 37, figs. 4–4*a*.

Of this curious little brittle star Döderlein says there were "many specimens," but as he also reports "many specimens" of *Comatula solaris,* we do not know whether there were "many specimens" of *Ophiophthirius* on one comatulid or not. If there were, the opinion that we are dealing with very young ophiurans would be strengthened, but the fact that *Ophiophthirius* is not at all like the smallest young Ophiomazas available, even though they are three or four times as large, is disconcerting. The types of *Ophiophthirius* were less than 1 mm. in disk diameter, and the arms were less than 2 mm. long, having but 7–10 joints.

Order CHILOPHIURIDA

Family OPHIOCHITONIDAE

A small group of not more than half a dozen genera, all from tropical or subtropical seas, this family is represented in Australia by only a single genus, but that one is common and represented on all coasts of the continent.

OPHIONEREIS

Lütken, 1859. Add. ad hist. Oph., pt. 2, p. 110.

Genotype: *Ophiura reticulata* Say, 1825, p. 148.

Wherever shore collecting is at all worth while on the Australian coast, north, south, east, or west, some representative of this genus will be found. Most of the species are small and several have very distinctive color markings. The presence of supplementary arm plates and of a single big tentacle scale are characteristic features of the genus. The 8 species on the Australian coasts may be distinguished as follows:

Key to the Species of Ophionereis

A. Oral shields and adoral plates well defined, not obscured by skin:
  B. Arms 5; interambulacral areas below scale-covered, or at least not sharply set off from upper surface of disk:
    C. Margins of genital slits, at least near oral shield, with spinelets or rounded teeth:
      D. Supplementary upper arm plates conspicuous; no longitudinal dark line on arms:
        Arm spines 4 at base of arm; interbrachial areas adjoining oral shield more or less free of scales but with spinelets like those on margin of genital slits; inner end of oral shield blunt and rounded ..... *schayeri*
        Arm spines 3 only; interbrachial areas with scales usually quite up to end of oral shield; marginal papillae on genital slits rounded, rather granuliform; inner end of oral shield more or less pointed ..... *porrecta*
      DD. Supplementary upper arm plates small and obscure; conspicuous longitudinal dark line on upper side of each arm ..... *lineata*
    CC. Margin of genital slits smooth or slightly wrinkled, with no spinelets or papillae:
      Disk reticulated; conspicuous dark brown mark (often more or less Y-shaped) on disk at base of each arm, usually including radial shields ..... *stigma*
      Coloration varied but never as above ..... *dubia*
  BB. Arms 6; interbrachial areas below naked ..... *hexactis*
AA. Oral shields and adoral plates more or less obscured by thick skin:
  Oral shields white, obvious but otherwise with indistinct boundaries; center of disk usually with blotch of dark red-brown or brownish purple ..... *semoni*
  Oral shields quite obscured; disk irregularly, coarsely reticulated ..... *tigris*

Ophionereis schayeri

Ophiolepis schayeri Müller and Troschel, 1844. Arch. f. Naturgesch., vol. 10, no. 1, p. 182.
Ophionereis schayeri Lütken, 1859. Add. ad hist. Oph., pt. 2, p. 110.
H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 289; pl. 13, figs. 1, 2.

This is one of the common brittle stars of southern Australia and one of the largest species in the genus. Full-grown specimens have the disk 20–25 mm. across and the arms 5 or 6 times that. The disk is generally gray or grayish brown, sometimes very light but often quite dark, seldom conspicuously marked. The arms are commonly darker than the disk and are usually conspicuously cross-banded. Specimens from Port Jackson have, in life, a decidedly reddish cast and look quite different from the grayer specimens of the west coast; but in preserved material the reddish tinge is not retained. The range of *schayeri* is from the Abrolhos Islands and Dongarra on the western coast, south to Bunbury and Bunkers Bay, thence eastward to Tasmania and New South Wales, and northward only to Long Reef at Colloroy. It, or a closely related species, *fasciata* Hutton, occurs in New Zealand, but oddly enough neither has been found at Lord Howe Island. For a discussion of the relation between the Australian and New Zealand forms, see Mortensen, 1924, pages 164–168, and H. L. Clark, 1928, pages 435–436. In 1938 (p. 321) I inadvertently referred to the occurrence of *schayeri* in New Zealand, but the identity of the Australian and New Zealand forms is still open to debate.

Ophionereis porrecta

Lyman, 1860. Proc. Boston Soc. Nat. Hist., vol. 7, p. 260.
H. L. Clark, 1921. Ech. Torres Strait, p. 117; pl. 12, fig. 6 (colored); pl. 33, figs. 2, 3.

Apparently this handsome brittle star reaches the Australian region only at its northeast corner, the Murray Islands, where it is fairly common.[1] For a discussion of its occurrence there and the peculiarities of its known distribution, see H. L. Clark, 1921. It is not quite so large as *schayeri,* as the maximum disk diameter would seem to be about 15 mm. The colors are brighter than in the southern species, having more yellow and less gray in their composition.

Ophionereis lineata,[2] sp. nov.

Disk not very flat, but more or less convex, about 8.5 mm. in diameter, covered by a coat of rather coarse scales, 3 or 4 to a millimeter; a centrodorsal plate is evident, and 4 of the radial plates, about the same size, can also be made out, but there are at least 3 other plates equally large and not symmetrically arranged. Otherwise, largest scales are near radial shields and along disk margin, smallest are in interradii near center of disk. Radial shields small, but evident, about twice as large as largest scales; they are widely separated by several coarse scales. Upper arm plates about twice as wide as long, distal margin nearly straight, distinctly longer than proximal; all four corners rounded, but distal ones only slightly so, proximal decidedly. Supplementary upper arm plates very small and difficult to make out, as they are not well set off from upper ends of side arm plates.

[1] The record of specimens from the Abrolhos Islands (H. L. Clark, 1923*a*) is an error, since those specimens are undoubtedly *schayeri.*

[2] *lineatus* = marked with a line, in reference to the conspicuous coloration of the arms.

Interbrachial areas below thickly covered, clear to oral shields, by scales similar to those of dorsal surface. Edges of genital slits with small, crowded but distinct, rounded papillae. Under arm plates quadrilateral or somewhat bell-shaped, distal margin slightly convex, its length equal to that of plate; lateral margins markedly concave; proximal margin nearly straight but its lateral corners slightly rounded; plates broadly in contact throughout arm length. Arm spines 3, thick and blunt, middle one distinctly longest and evidently longer than arm segment. Tentacle scale single, large, nearly circular but tending to be longer than wide. Oral shields rounded pentagonal, longer than wide, inner end rounded, distal (except of madreporite) pointed. Adoral plates relatively small, somewhat triangular, lying wholly at side of oral shields, but their outer corners in contact with first under arm plate, which is much smaller than they are. Oral papillae 5 on each side, closely set, next to outermost largest.

Color of dry specimen: disk grayish white, speckled and mottled with darker, purplish gray; upper arm plates similar grayish white with very minute dusky spots, scarcely visible without lens; about every fifth (third to seventh) plate has large blotch or spot on one side or the other of deep dull purple (or purplish gray); very few plates have both sides dark; the arrangement gives the arms the appearance of very imperfect cross-banding. Along entire length of arm is a conspicuous broad line (⅓ mm. wide) of very dark purplish gray, crossing upper arm plates in middle; briefly, this most striking feature of the coloration would be described as "a broad, nearly black line along middle of upper side of each arm." Arm spines yellowish white, and mouth parts similar but less yellow. Under arm plates whitish with many minute speckles and a very few scattered blotches of dark purplish gray.

Holotype: M.C.Z. no. 5829, from Lindeman Island, Great Barrier Reef, Queensland; Melbourne Ward, collector.

This very distinct and unmistakable *Ophionereis* warrants description and inclusion here in spite of the intention that no "new species" were to be described in this volume. No figure is necessary, for the general appearance is obviously that of an *Ophionereis* and the very small supplementary plates confirm this; the coloration is unusually distinctive. Apparently it is most closely related to *porrecta.*

Ophionereis stigma

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 325 (not figured).

This small, secretive species occurs under rocks near low-water mark at Broome, at False Cape Bossut, and at Cape Leveque, but we did not find it east thereof. At both Entrance and Gantheaume points, Broome, it occurred with *O. semoni,* but the distinctive coloring made it easy to separate the two. The "stigmata" on the disk of the present species form a very useful recognition mark. The largest specimen found had the disk 7 mm. across, but few were over 5 mm.; arms 7 or 8 times as much.

Ophionereis dubia

Ophiolepis dubia Müller and Troschel, 1842. Syst. Ast., p. 94.
Savigny, 1809. Descr. de l'Egypte (Audouin), Rayonnes, pl. 1, figs. 3^1–3^{10}.
Ophionereis dubia Lyman, 1865. Illus. cat. Mus. Comp. Zoöl., no. 1, p. 149.

It is very doubtful whether this species occurs in Australian waters. Bell (1884) records it as having been taken by the "Alert" at four stations, but since he gives no information about the specimens, one may properly believe that they were in reality *semoni*. The same is true of his record (1894) from Holothuria Bank, Western Australia, 8–36 fms. Koehler records *dubia* from the Aru and Kei islands (1910*a*) as well as from Singapore and other East Indian points (1930). He also records (1907*a*) 1 specimen from Shark Bay, Western Australia, and it is on the strength of that record that the species is admitted here. Koehler was a far more careful and reliable worker than Bell, but in 1907 he had had little experience as compared with what he acquired in the following twenty years. It is therefore quite possible that his Shark Bay *Ophionereis* was really *semoni,* which is common at Broome and would be more likely to occur in Shark Bay than would *dubia.* The latter species is appropriately named, for its status is more unsatisfactory than that of any other member of the genus. Of the specimens catalogued as *dubia* in the Museum of Comparative Zoölogy, not one is full grown; the largest is but 5 mm. across the disk. They show much diversity of color, but lack papillae on the margin of the genital slits and have no skin obscuring the oral shields. They come from the Red Sea, East Africa, the Maldives, Japan, and the Philippines. No Australian specimens are similar. Australian specimens formerly catalogued as *dubia* have proved to be *semoni,* and it seems very probable that all the Australian records really refer to Döderlein's Torres Strait species.

Ophionereis hexactis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 324 (not figured).

This, the smallest member of the genus, is an endemic Australian species, known as yet only from Darwin and Lord Howe Island, but probably present through all the Barrier Reef region. It is so small (4 mm. or less across the disk) and delicate that it would be very easily overlooked in the course of ordinary shore collecting. The arms are white and threadlike and extremely fragile. They may have 9 or 10 narrow dark cross-bands. The disk is gray or brown. The number of arms is constantly 6, and none of the specimens seen show any evidence of schizogony.

Ophionereis semoni

Ophiotriton semoni Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 288; pl. 15, figs. 8, 8*a*.
Ophionereis semoni Koehler, 1905. "Siboga" oph. litt., p. 54.

Semon collected this little brittle star first, and Döderlein was so impressed with the apparent lack of scales in the skin of the disk that he made it the type of a new genus. Subsequent collecting and study has led to the general adoption of Koehler's (1905) view that no sharp line can be drawn separating it from *Ophionereis.* The discovery of other closely related species indicates, nevertheless, the possibility that *Ophiotriton* may be someday a useful generic name. For the present, however, *Ophionereis* well accommodates these little secretive ophiurans.

The range of *semoni* would seem to be the tropical coast of Australia from Broome eastward to Darwin and thence eastward and southward to Lindeman Island on the Barrier Reef. It also seems to be common on the South Australian

coast, though it is not known from the Peronian Province (see p. 468). All the specimens which I recorded in 1915 from Torres Strait and Queensland as *dubia* prove to be *semoni* (see H. L. Clark, 1921). On the coast of Western Australia, it has been taken at Dongarra and even as far south as Point Peron. As stated above, the *Ophionereis* from Shark Bay recorded by Koehler (1907*a*) as *dubia* was probably *semoni*. The largest specimen reported has the disk 9 mm. in diameter, but 7 mm. is the normal maximum. There is considerable diversity in the arm bands and disk markings, but the white oral shields seem to be a very constant feature.

The 2 specimens from the west coast, south of Shark Bay, are very different in color from each other and from typical *semoni*. As each, however, has the oral shields white, it seems best to consider them merely as varieties. The one from Dongarra has the disk chocolate brown with a few small whitish spots, and the interradial areas below dusky brown, each with 8–10 rounded, whitish spots. In reference to this brown coloring, the specimen is known as *O. semoni* var. *badia* (H. L. Clark, 1938, p. 324). The other *semoni* from the west coast was taken at Point Peron, south of Fremantle, and is even more deeply colored. The ground color of the disk both above and below is black (hence the varietal name *nigra* H. L. Clark, 1938, p. 323), but there are many spots and blotches of white or yellowish, making a very unusual and quite handsome brittle star. The further collecting of *semoni* on both the western and southern coasts of Australia should prove very interesting.

Ophionereis tigris

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 327.

The Barrier Reef area has produced at Norwest Islet, Queensland, a striking offshoot from *semoni* even more bizarre than the two varieties just mentioned. In this case, however, a structural change justifies the recognition of a new species. The skin of the oral region is so thick as to conceal the plates, and not even the oral shields are distinguishable. The pale yellow disk, irregularly reticulated with purplish brown, and the distinctly banded whitish and purple-brown arms are very characteristic. Only a single specimen (not quite 5 mm. across disk) is known.

Family OPHIOCOMIDAE

This is perhaps the most striking group of brittle stars on the eastern coast of Australia, particularly at the northern end of the Barrier Reef, where 16 species are found. Their generally large size, their usually conspicuous coloration, their shallow-water habitat, and their unusually great activity (with few exceptions) when alarmed combine to attract the attention of all sorts of collectors. But elsewhere in Australia only a few species occur. At Lord Howe Island, which has practically a depauperate Barrier Reef fauna, 5 species of *Ophiocoma* are found, all of them occurring also at the Murray Islands. On the southern coast of the continent only 2 species occur, both Ophiocomas. In the Perth region, 3 other Ophiocomas join these, but farther north even Ophiocomas become rare, for at Broome we found none, either in 1929 or in 1932. At Cape Leveque we found *Ophiocoma parva,* which also occurs at Rottnest Island, Western Australia, and at

Lord Howe Island, New South Wales. In 1907, Koehler reported three Ophiocomas from Shark Bay, but the identifications seem open to serious question. It is possible and perhaps probable that his specimens listed as *brevipes* are *insularia* var. *variegata,* which occurs at the Abrolhos Islands; his single small *scolopendrina* is probably a *parva,* and his *wendtii* is apparently *occidentalis.* Further collecting in Shark Bay is essential to the correct understanding of his identifications. Aside from these few species of *Ophiocoma,* the only members of the family occurring anywhere on the Western Australian coast are the very widely distributed Indo-Pacific *Ophiarthrum elegans,* taken at Augustus and Champagny islands in the far north by Beresford E. Bardwell in 1933, and the apparently endemic and very rare *Ophiomastix notabilis,* the only known specimen of which was taken by us at Cape Leveque in 1929. Of the 5 genera known in the family, only 3 occur in Australia, and these are easily distinguished by means of the following key. A complete revision of the entire family as it was known in 1920, with keys and synonymy for all genera and species (except *Ophiopsila,* which does not occur in Australia, although found among the Kei Islands), was published in H. L. Clark, 1921.

Key to the Genera of Ophiocomidae

A. Disk covered with scales bearing either granules or spinelets or both:
  Disk closely covered with granules, but interbrachial areas below often bare ..... *Ophiocoma*
  Disk covered with scattered spinelets, sometimes with granules also .... *Ophiomastix*
AA. Disk covered with smooth, naked skin, without either granules or spinelets ..... *Ophiarthrum*

OPHIOCOMA

L. Agassiz, 1835*a*. Mem. Soc. sci. nat. Neuchâtel, vol. 1, p. 192.

Genotype: *Ophiura echinata* Lamarck, 1816, vol. 2, p. 543.

This genus of fine, usually big brittle stars is well represented in Australia by no fewer than 11 species, which have a rather characteristic facies but are well distinguished by various structural features, usually associated with some fairlv definite color shades or markings, as shown in the following key:

Key to the Species of Ophiocoma

A. Disk granules nearly or quite spherical and of more or less uniform size:
  B. Disk granulation coarse, 9–64 granules per sq. mm., covering only part of oral interbrachial areas:
    C. Tentacle scales 2 (distally there may be but 1):
      D. Disk granulation coarse, 9–36 granules per sq. mm.:
        Coloration variegated; under arm plates, at least proximally, with more or less whitish ..... *scolopendrina*
        Coloration nearly or quite uniformly black or very dark ..... *erinaceus*
      DD. Disk granulation finer, 36–64 per sq. mm.:
        E. About 49–64 granules per sq. mm.; adoral plates small; disk deep brown beautifully marked with yellow ..... *pica*

EE. About 30–48 granules per sq. mm.; adoral plates big; no yellow:
Arm spines not banded; under side of arm with broad median white stripe ..... *canaliculata*
Arm spines beautifully banded; under arm plates prettily marked with various shades of purplish or brownish and white ..... *pulchra*
CC. Tentacle scale single (often 2 on first 6–8 arm segments):
Coloration rich brownish black; side arm plates with shagreen-like surface in marked contrast with smooth under arm plates ..... *schoenleinii*
Coloration chocolate brown or deep claret red (in life), more or less variegated with whitish; side arm plates not with shagreen-like surface ..... *occidentalis*
BB. Disk granulation finer, 64–100 per sq. mm., covering interbrachial areas below clear to oral shield; tentacle scales 2:
F. Prevailing coloration green or greenish and white or pale yellowish in life (green shades may be lost on preservation) ..... *brevipes*
FF. Prevailing coloration dark (gray, brown, or black) marked or variegated with white:
Disk handsomely marked with large, white-encircled dark brown spots; arms conspicuously and regularly cross-banded ..... *delicata*
Not as above ..... *insularia* var. *variegata*
AA. Disk granules, at least near disk margin, higher than thick, becoming spiniform; arms usually 6; tentacle scale single ..... *parva*

Ophiocoma scolopendrina

Ophiura scolopendrina Lamarck, 1816. Anim. sans vert., vol. 2, p. 544.
Ophiocoma scolopendrina Müller and Troschel, 1842. Syst. Ast., p. 101.
H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 293; pl. 14, figs. 10, 11.

This large *Ophiocoma* has an extended range in the Indo-Pacific region, from East Africa to Hawaii and the Paumotu Islands. It apparently enters the Australian fauna only at the northern end of the Great Barrier. Bell's record (1884) from Port Molle, Queensland, is suspect—he gives no data—but the Barrier Reef Expedition found it at the Low Isles and it is very common at the Murray Islands. It has not been found west of there on the Australian coast, Koehler's report (1907*a*) of a single small specimen from Shark Bay being (as already stated) probably based on a 5-rayed example of *parva*. My record (1909) from Lord Howe Island was based on confusion with *erinaceus*. In size *scolopendrina* is one of the largest species, and in color one of the dullest. Adults have the disk 25–30 mm. in diameter, with the long arms sometimes 7–8 times as much. But there is considerable diversity in arm length, for it is not unusual to find individuals with arms only 5–6 times the disk diameter. The coloration is always dull, dark gray or dark brown, rarely quite black, more or less tinged or variegated with whitish or yellowish. Evidence of light coloration may be quite lacking on the upper surface, but is apparently always to be found around the mouth and on the basal under arm plates. For an account of habitat and habits see H. L. Clark, 1921, pages 125–126.

Ophiocoma erinaceus

Müller and Troschel, 1842. Syst. Ast., p. 98.
H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 291; pl. 15, figs. 5, 6.

This species has been so frequently confused with the preceding that the limits of its range in the Indo-Pacific area are unknown. In Australia, it is very common at the Murray Islands and at Lord Howe Island, but there are no records between these two points or elsewhere in Australia. It reaches a disk diameter of 28 mm. and the arms are commonly about 5 times as much. The absence of white or very light shades in the coloration, even on the lower surface, is a distinguishing feature. It is a more active species than *scolopendrina* and often lives among the dead or dying branches of coral colonies.

Ophiocoma pica

Müller and Troschel, 1842. Syst. Ast., p. 101.
H. L. Clark, 1921. Ech. Torres Strait, p. 127; pl. 13, fig. 8 (colored).

As with the preceding species, the Australian records for this beautiful brittle star, although the general range is from Zanzibar to Hawaii, are confined to the Murray Islands and Lord Howe. It is not abundant at either place, but its apparent scarcity is probably due to its very secretive habits, living as it does in the crannies of large coral heads and colonies where it is difficult to reach. The handsome brown and yellow livery is very striking and distinctive, especially in big specimens, which may be 25–26 mm. across the disk. The arms, however, are only 3–4 times as much, which is unusually short for an *Ophiocoma*.

Ophiocoma canaliculata

Lütken, 1869. Add. ad hist. Oph., pt. 3, vol. 17, pp. 46, 99.
Koehler, 1904. Mém. Soc. zool. France, vol. 17, p. 75; figs. 30–32.
H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 437; figs. 130*a, b*.

An endemic species, this is one of the most characteristic brittle stars of temperate Australia. It ranges from Shell Harbor, New South Wales, to Rottnest Island, Western Australia, but has not yet been reported from Tasmania. It is not a large species, the maximum disk diameter being 21 mm. The arms are relatively short, scarcely equal to 4 times the disk and often little more than 3. In color there is great diversity, but most dried specimens are a dingy brown, sometimes very dark, or have a definite reddish cast, sometimes very pale. The white stripe on the under side of the arm is distinctive, but is usually most evident on the basal half of the arm and in large specimens may be indistinct even there. In life, the specimens from the west coast are very much lighter (pale olive or light brown) than those from the east (very dark, with a reddish or reddish-purple tint), but do not seem to differ otherwise. Occasionally, small specimens have the distal part of the arms cross-banded with white, but this seems to be unusual. The arm spines are never cross-banded.

Ophiocoma pulchra

Ophiocoma canaliculata var. *pulchra* H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 439; figs. 131*a, b*.

Ophiocoma punctata Koehler, 1930. Vidensk. Medd., vol. 89, p. 205; pl. 14, figs. 2–5.
Ophiocoma pulchra H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 333.

The above references give all the data at present available concerning this pretty species. Koehler's specimens were collected by Mortensen in Port Jackson. Mine came from Long Reef, Colloroy, New South Wales (above Port Jackson), and from Shell Harbor (below Port Jackson), and also from South Australia (Spencer and St. Vincent gulfs) and Western Australia (Bunkers Bay). The range thus coincides with that of *canaliculata,* and the two species occur together at Shell Harbor and at Bunkers Bay. They are of about the same size, though 18 mm. across the disk is the maximum for *pulchra* so far as is now known. The ground color in the two species is not constantly different, for although my specimens of *pulchra* are lighter or else much redder than *canaliculata,* some of Mortensen's were very dark. So too with reference to the minute speckling with light granules on which Koehler based his name *punctata.* In the dark-colored individuals this shows up well, but in light-colored ones it is far from obvious. On the whole, the handsome cross-banding of the spines and the variegated under arm plates are the most obvious and constant characters shown by *pulchra.* The fact that the two species may be found in the same places and have the character of the arm spines and other morphological features essentially the same makes the actual relationship of the two forms still an open question.

Ophiocoma schoenleinii

Müller and Troschel, 1842. Syst. Ast., p. 99.
H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 293; pl. 15, figs. 1, 2.

Little has been added to our knowledge of this species since my discussion of its status in 1921 (p. 128) and 1938 (p. 336). We did not meet with it either in 1929 or in 1932. Paradice took 2 specimens at High Island, Frankland Group, in 1924, and Melbourne Ward has sent a specimen to the Museum of Comparative Zoölogy from Lindeman Island, just north of Mackay, Queensland—the farthest south for this *Ophiocoma.* It is somewhat smaller than *erinaceus,* the largest specimens noted being 20–22 mm. across the disk. The arms are some 4 or 5 times the disk diameter. The color is uniformly black, though at the very tips of the arms narrow, white bands may be present.

Ophiocoma occidentalis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 334; pl. 25, fig. 1.

No further data concerning this species have been obtained since the original description was published. It is a large species (26 mm. across disk), with short, stout arms, and the color in life, deep red, is very distinctive. So far as is yet known, *occidentalis* is endemic to Western Australia, in the vicinity of Fremantle; Rottnest Island and Point Peron are the only well authenticated localities. Probably the 4 specimens from Shark Bay which Koehler (1907*a*) listed as *Ophiocoma wendtii* are really *occidentalis,* but as he says nothing about arm spines or color, we cannot know.

Ophiocoma brevipes

Peters, 1851. Monatsber. K. preuss. Akad. Wissensch., p. 465.
H. L. Clark, 1921. Ech. Torres Strait, p. 129; pl. 13, fig. 7 (colored); pl. 34, figs. 3, 4.

The light coloration (green or greenish yellow or light yellowish brown, more or less variegated with white or whitish) is the distinguishing feature of this rather short-armed species. The photographic figure (pl. 34, fig. 3) given in my Torres Strait Report (1921) indicates a nearly black disk, but the actual color, both in life and now as a dried specimen, is a light brown. The secretive habits of *brevipes,* particularly the drawing in of the arms and folding them closely around the body as the animal hides in some hole or cranny among corals or coralline algae, are very characteristic (see H. L. Clark, 1938, p. 328). Adult specimens are 15–18 mm. across the disk, with arms appreciably less than 5 times the disk diameter. The range of the species is not clearly defined, but apparently includes the whole Indo-Pacific area. In Australia, it is found at the Murray Islands and Lord Howe, but has rarely been taken at intermediate points, the only record being from Green Island, near Cairns, Queensland.

Ophiocoma delicata

H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 7, p. 206; pl. 1, figs. 1–3.

Nothing is known further of this handsome little brittle star than is recorded in the original publication. The holotype was 9 mm. across the disk and the long, slender arms were about 60 mm. in length. The handsome coloration, light brown, dark brown, and white, curiously variegated, is unique in the genus. The 2 known specimens were taken by the Great Barrier Reef Expedition at their stations XIV and XVII, in 19 fms. on *Halimeda* bottom, in the vicinity of Lizard Island, northern Queensland.

Ophiocoma insularia var. variegata

Ophiocoma insularia Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 80.
Ophiocoma variegata E. A. Smith, 1876*a*. Ann. Mag. Nat. Hist., ser. 4, vol. 18, p. 39.
——— 1879. Philos. Trans., vol. 168, p. 565; pl. 1, figs. 2–2*c*.
Ophiocoma brevipes var. *variegata* H. L. Clark, 1921. Ech. Torres Strait, p. 130.
Ophiocoma insularia var. *variegata* H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 330.

The status of the various forms of *Ophiocoma* to which the names *brevipes, brevispinosa, insularia, ternispina, dentata* (of Lütken, NOT of Müller and Troschel), *marmorata, tenuispina, longispina,* and *döderleini* have been applied is still open to discussion. That *brevipes* and *brevispinosa* refer to the same species admits of little doubt, and that it is distinct from the form called *variegata* by E. A. Smith was demonstrated to me by collecting at Lord Howe Island. But what the interrelationships of the other 7 forms are is not as yet clear. Since Lyman's name *insularia* has many years' precedence over any of the others, it must be used for the form (or forms) occurring at the Hawaiian Islands, but whether *variegata* is constantly distinguishable is still very doubtful. Typical *insularia* does not occur in Australia, but *variegata* certainly does. Von Martens' *ternispina* appears to be identical with *insularia,* but the coloration of the arms suggests *variegata.* There is little doubt that Marktanner-Turneretscher's *marmorata* is based on a half-grown *brevipes.* Obviously de Loriol's *tenuispina* is a typographical error for *ternispina.* As for Lütken's *dentata* and de Loriol's *döderleini,* they are easily recognized but seem to be unquestionably mere color forms of *variegata.* The

possible connection of these and similar color forms with sex is a point that deserves but has never received careful investigation. At present it seems best to restrict the name *insularia* to unicolored specimens and use the term "variety *variegata*" for all the forms which have disk and arms in any way mottled, spotted, or marked with lighter or darker shades. With this understanding, we find that *insularia s.s.* has not yet been taken in Australia, but var. *variegata* is well known from Lord Howe Island and from several islands at the northern end of the Barrier Reef. Dakin found it at the Abrolhos Islands (see H. L. Clark, 1923*a*), which makes it seem likely that Koehler's (1907*a*) record of *brevipes* from Shark Bay probably rests on specimens of *variegata*. It is difficult to account for the fact that tropical species seemingly absent from the Broome region occur at the Abrolhos, but more intensive collecting in Shark Bay, near Northwest Cape, and in the Dampier Archipelago will probably throw much light on the problem.

Large specimens of *variegata* measure up to 34 mm. across the disk. The arms are 4–6 times as much. The diversity of color is very great. See H. L. Clark, 1921, page 130; 1938, page 330.

Ophiocoma parva

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 292; pl. 14, figs. 8, 9.
——— 1921. Ech. Torres Strait, p. 132; pl. 13, fig. 4 (colored).

This little species is a puzzle. None larger than 7 mm. across the disk have been found, and nearly all of those found at Lord Howe Island were undergoing autotomy, whereas at Mer this was not so evident. The colors in life are green and brown at Mer, but at Lord Howe there was little trace of green. Preserved material is yellow-brown with more or less evident banding of the arms. That *parva* is the young of some larger species seems very probable, but there is no clue as yet to the adult. At Mer and Lord Howe Island, this small *Ophiocoma* is common. It seems to be rare elsewhere, for only a single specimen was found at Port Essington, only 2 at Cape Leveque, and only 6 at Rottnest Island. A. H. Clark (1939) has proposed to make *parva* a member of a genus *Ophiocomella,* but in my opinion this genus is made up wholly of young Ophiocomas and has no validity.

OPHIOMASTIX

Müller and Troschel, 1842. Syst. Ast., pp. 84, 107.

Genotype: *Ophiura annulosa* Lamarck, 1816, vol. 2, p. 543.

This is the finest group of ophiurans at the Murray Islands, and its practical absence west of Torres Strait or south of Ellison Reef, Queensland, adds interest to the remarkable occurrence of no fewer than 7 species at Mer. Their large size, fine colors, and notable activity make them an unusually interesting group. Moreover, their constancy in color as well as in structural features makes them easy to identify even when young, and puzzling specimens are rare. Besides the species found at Mer, a single specimen of a species hitherto known only from the Paumotus was taken by the Great Barrier Reef Expedition near Lizard Island, and we found at Cape Leveque, Western Australia, a single specimen of a well marked new species. These 9 Australian species are to be distinguished as follows:

Key to the Species of Ophiomastix

A. Tentacle scales present:
  B. Disk covered with granules some of which are elongated into spinelets; arms relatively short, about 5 times disk diameter:
    Tentacle scale single, except on basal pores; colors black (dark gray) and white (whitish) ..... *asperula*
    Tentacle scales 2; color in life uniformly deep red; preserved specimens orange to grayish ..... *mixta*
  BB. Disk bare but with more or less numerous scattered spinelets and sometimes a few coarse granules:
    C. Tentacle scales 2:
      D. Arms long, 7–12 times disk diameter:
        Disk spines rather blunt, not acicular, white usually more or less clearly banded with dark brown ..... *annulosa*
        Disk spines more or less acicular, unicolor, never banded; general coloration black and dark yellow ..... *janualis*
      DD. Arms short, about 5 times disk diameter:
        Upper arm plates broadly fan-shaped, distal half and distal half of side arm plates white or whitish; proximal halves very dark brown ..... *caryophyllata*
        Upper arm plates broadly diamond-shaped (twice as wide as long), uniformly light gray or fawn color, in marked contrast with dark side arm plates ..... *corallicola*
    CC. Tentacle scale single, except often on basal pores:
      Arm spines 4, sometimes 5, often only 3; colors, black and white ..... *notabilis*
      Arm spines alternating 3 and 2; color, dull olive brown, with distal part of arms banded with dirty whitish ..... *bispinosa*
AA. Tentacle scales wanting; no granules, but some scattered spinelets on disk; arm spines 3 and 2 ..... *flaccida*

Ophiomastix asperula

Lütken, 1869. Add. ad hist. Oph., pt. 3, p. 43.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 290; pl. 15, figs. 9, 9*a*.
Koehler, 1905. "Siboga" oph. litt., p. 66; pl. 6, figs. 11, 12.
H. L. Clark, 1921. Ech. Torres Strait, p. 134; pl. 14, fig. 1 (colored).

This is a large species, and beautiful, though the colors are dark gray, black, and white. The disk may be 20 mm. across and the arms about 90 mm. long. Few specimens have ever been taken. The "Albatross" did not find it in her Philippine collecting, the "Siboga" met with it but once, and Mortensen took but 1 specimen. The type locality is Fiji, and it is known from Amboina. We took but 3 specimens at Mer, all under coral fragments on the southeastern reef flat.

Ophiomastix mixta

Lütken, 1869. Add. ad hist. Oph., pt. 3, p. 42.
Matsumoto, 1917. Japan. Oph., p. 348; figs. 97*a–c*.
H. L. Clark, 1921. Ech. Torres Strait, p. 135; pl. 14, fig. 2 (colored).

The type localities for this interesting and somewhat aberrant species are Fiji and Samoa. It is apparently common at Misaki, Japan, and at Amboina. The

"Albatross" found but 1 small specimen in the Philippines, and Mortensen did not meet with it. It is fairly common at Mer, and Paradice collected a specimen on the reef flat at High Island, Frankland Group, Queensland. There are no other Australian records. Large specimens are 15–28 mm. across the disk, but the arms are short, about 5 times the disk diameter. The beautiful deep red color is extremely fugacious, and all efforts to retain it were completely futile. Preserved specimens are yellowish, pale brownish, or white.

Ophiomastix annulosa

Ophiura annulosa Lamarck, 1816. Anim. sans vert., vol. 2, p. 543.
Ophiomastix annulosa Müller and Troschel, 1842. Syst. Ast., p. 107.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 289; pl. 16, fig. 11.
H. L. Clark, 1921. Ech. Torres Strait, p. 135; pl. 14, fig. 6 (colored).

One of the largest and commonest members of the genus, *annulosa* occurs throughout the East Indian region from Ceylon to the Loyalty Islands and northward to the Ryukyu Islands. On the Australian coast it has been taken as far south as Ellison Reef, Queensland. Full-grown specimens may be 30 mm. across the disk and have arms 250 mm. long. The red, black, and white coloring is distinctive, but several more or less albino specimens were found at Mer. It is a very active brittle star and moves rapidly from one shelter to another when pursued.

Ophiomastix janualis

Lyman, 1871. Illus. cat. Mus. Comp. Zoöl., no. 6, p. 14; pl. 1, figs. 13, 14.
H. L. Clark, 1921. Ech. Torres Strait, p. 136; pl. 14, fig. 5 (colored).

This is certainly one of the finest and most striking of brittle stars. Its large size, long arms, attractive colors, and great activity make it the royal prince of ophiurans on the reef flat at Mer. Strangely enough, not only is it unknown from any other place in Australia, but even though specimens are in the Museum of Comparative Zoölogy from the Philippines, neither the "Siboga" nor the "Albatross" nor Mortensen met with *janualis* anywhere in the East Indian region. It reaches a disk diameter of 28 mm., and the long, attenuate arms may be 10 times as much. The deep yellow markings on the brownish-black ground color make a handsome livery in the brilliant sunlight on the broad reef flat, east of Mer. The graceful but vigorous arm movements make the capture of an uninjured specimen something of a feat.

Ophiomastix caryophyllata

Lütken, 1869. Add. ad hist. Oph., pt. 3, p. 43.
Döderlein, 1896. Semon's Oph., *in* Jena Denkschr., vol. 8, p. 290; pl. 15, figs. 10, 10*a*.
H. L. Clark, 1921. Ech. Torres Strait, p. 137; pl. 14, fig. 4 (colored); pl. 36, fig. 10.

The only known Australian locality for this handsome species is Mer, Murray Islands, where it is quite common in the dead parts of coral colonies on the southeastern reef. The question of its normal coloration is made debatable by Brock (1888) and Koehler (1905), but there has probably been some confusion of species in these two papers. Certainly at Mer the coloration was both constant and distinctive (see H. L. Clark, 1921, p. 137). The species is not large, less than

20 mm. across the disk, but it is prettily colored, and its great activity when disturbed adds to its interest. The type locality for *caryophyllata* is at the Fiji Islands, but it has been taken at several places in the East Indian region and as far southeast as New Caledonia.

Ophiomastix corallicola

H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 294; pl. 16, figs. 1, 2.
——— 1921. Ech. Torres Strait, p. 137; pl. 14, fig. 3 (colored); pl. 36, fig. 11.

This handsome brittle star is known only from the type locality, the southeastern reef flat at Mer, where it occurs with other species of *Ophiomastix,* with which, however, there is no evidence of intergrading. It is one of the smaller species, the maximum disk diameter so far as observed being 18 mm. The coloration, a mixture of dark brown, light brown, and pale gray or whitish, is handsome and distinctive.

Ophiomastix notabilis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 337; fig. 27.

As this striking black and white brittle star is known from only a single specimen, there is no further light to be thrown upon it. It was found deeply hidden in a coral mass at Cape Leveque, Western Australia, and is actually the only individual *Ophiomastix* [1] known from west of Torres Strait, south of Timor. It is only 13 mm. across the disk and has arms about 65 mm. long. The general color is shining black with more or less white or light yellow on the arms.

Ophiomastix bispinosa

H. L. Clark, 1917*a*. Bull. Mus. Comp. Zoöl., vol. 61, p. 442; pl. 2, figs. 1, 2.

This species was based on a single specimen from Makemo, in the Paumotu Islands, only 5 mm. across the disk, but the Great Barrier Reef Expedition took a second specimen at Lizard Island, Queensland, in 19 fms., which is about 3 times as large. Apparently the presence of only 2 arm spines on many basal arm segments is a youthful character, for in the adult specimen the basal arm segments have 3 or 4, occasionally only 2; distally there are never 4 but frequently only 2. The disk spinules increase greatly in number with age and are rather uniformly short and sharp. In both the known specimens the colors are dull, olive or olive brown, and the arms are banded distally at intervals of 4–6 segments with dull cream color or dirty whitish. Some of the arm spines are annulated, at least faintly, with dusky or pale olive.

Ophiomastix flaccida

Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 226; pl. 6, figs. 14, 15.
H. L. Clark, 1921. Ech. Torres Strait, p. 138; pl. 13, fig. 2 (young, colored).

[1] The statement in the original description (1938, p. 338) that it is "the only specimen of the Ophiocomidae which we took on the whole northern coast of Australia" is of course an error, as, on p. 332, *Ophiocoma parva* is reported from both the Coburg Peninsula and Cape Leveque.

Although Koehler (1930) had at his disposal a number of specimens of this peculiar and little-known species, he gave no data about them and makes no comment on the desirability of recognizing Smith's (1878) proposed genus *Acantharachna* for its reception. As the only known Australian material consists of a single specimen (very young, scarcely 4 mm. across disk) from Mer, Murray Islands, it is not advisable to enter into a discussion of the question here. This Murray Islands specimen was very brightly colored in life, bluish and orange-red on the disk, yellow, green, and white on the arms, but Studer (1883) says the species is purplish red in life. Lyman and Smith each refer to the color of their unique specimens, but in each case the "museum color" is obviously what is described.

OPHIARTHRUM

Peters, 1851. Monatsber. K. preuss. Akad. Wissensch., p. 463.

Genotype: *Ophiarthrum elegans* Peters, 1851, p. 464.

Only 3 species are as yet known in this Indo-Pacific genus, and 2 of these occur in Australia but only on the tropical coasts, particularly near the northern end of the Barrier Reef. Of 1 of these 2 a peculiar form has been taken near Lizard Island, Queensland, and also at Waigeu Island, New Guinea, to which a varietal name has been given. The 3 forms may be distinguished thus:

Key to the Species of Ophiarthrum

A. Disk beautifully marked in life with white, yellow, and gray (usually lost in preserved specimens; those carefully dried retain pattern but not shades); arms with more or less distinct median dark line on upper side ..... *pictum*

AA. Not as above:

Disk very dark at center, more or less light at margin, the contrast marked; arms, including spines, light, often nearly white, finely speckled with black or blackish, and commonly more or less banded with dark ..... *elegans*

Disk almost uniformly brown; arms dark, indistinctly banded with lighter ..... *elegans* var. *unicolor*

Ophiarthrum pictum

Ophiocoma picta Müller and Troschel, 1842. Syst. Ast., p. 102.
Ophiarthrum pictum Lyman, 1874. Bull. Mus. Comp. Zoöl., vol. 3, p. 225; pl. 7, figs. 2–4.
H. L. Clark, 1921. Ech. Torres Strait, p. 140; pl. 12, fig. 1 (colored).

This is one of the most beautiful of brittle stars in life, but most of its beauty disappears on preservation. It grows to a large size, up to 30 mm. across the disk with arms 200 mm. long, more or less. The delicacy of the coloring is baffling to the artist. The published figure is accurate for that particular specimen, but there is much individual diversity, and without the five long, graceful, exquisitely marked arms, the remarkable beauty of the animal as a whole can hardly be imagined.

Under large coral fragments on the southeastern reef flat at Mer, Murray Islands, *pictum* is fairly common, and it is not uncommon farther south at the Low Isles. The "farthest south" record seems to be at Lindeman Island, rather more than 21° S. It has not been taken elsewhere in Australia. It is reported from Timor, northward to the Philippines, and eastward to the Pelew Islands, but it is apparently not often taken.

Ophiarthrum elegans

Peters, 1851. Monatsber. K. preuss. Akad. Wissensch., p. 464.
Koehler, 1898. Bull. sci. France et Belgique, vol. 31, p. 108; pl. 3, figs. 25, 26.
H. L. Clark, 1921. Ech. Torres Strait, p. 139; pl. 13, fig. 1 (colored).

This is a smaller and more active species than the preceding, and does not vie with it in beauty; nevertheless, the dark shades of the disk contrast prettily with the lighter margins and the speckled arms. There is considerable individual diversity in color, but the variations do not seem to be associated with any particular locality or habitat. In size, *elegans* is not so large as *pictum,* the maximum disk diameter reported being 23 mm. The arms are 5.5–8 times the width of the disk. In its distribution, this species far outstrips the preceding, for it ranges from Mozambique and Zanzibar to Tahiti and northward to the Ryukyu Islands. On the Australian coast, it occurs in Torres Strait and far to the west at Augustus Island, Western Australia. To the south along the Queensland coast, it reaches at least to Lindeman Island.

Two unusual specimens from near Lizard Island, Queensland, taken by the Great Barrier Reef Expedition in 19 fms., have the entire disk above and below a dull brown. The arms also are brown, indistinctly banded at intervals of 2–5 segments with dull cream color. They seem to be worthy of a distinguishing name and hence have been designated as *Ophiarthrum elegans* var. *unicolor* (H. L. Clark, 1932, p. 208). In the discussion of these specimens, reference was made to "a specimen in the M.C.Z. from New Guinea" which resembles them in certain respects. There is good reason for believing that this specimen is from the Philippines and not from New Guinea. The true status of *unicolor* must await more extensive material.

Family OPHIODERMATIDAE

This widely distributed family stands in marked contrast with the preceding because of the entire absence of dental papillae. As a rule, too, the arm spines tend to lie appressed to the side arm plates, so that the arms have a more or less terete appearance like that of the tail of a snake, justifying the name ophiuroids or ophiurans, now applied to the whole class. The family is represented in Australia by more than 20 species grouped in 8 genera. These may be distinguished as follows:

Key to the Genera of Ophiodermatidae

A. Arm spines longer than arm segment, usually more or less flaring, at least at base of arm:
  Teeth narrow, bluntly pointed, not hyaline ..... *Ophiarachna*
  Teeth wide, with broadly curved, hyaline margin ..... *Ophiurodon*

AA. Arm spines shorter than segment, usually closely appressed to arm:
B. Oral shields bare and conspicuous, often with supplementary plate at distal end:
C. Radial shields covered by granulation of disk:
Disk more or less notched at insertion of arm; marginal scales not enlarged or visible through granulation ..... *Pectinura*
Disk not notched at insertion of arm; marginal scales enlarged, conspicuous underneath granulation ..... *Ophiopezella*
CC. Radial shields not covered by granulation of disk:
Radial shields very large, interradial space between 2 little wider than radial; interbrachial areas orally narrower than arm bases ..... *Ophiochasma*
Radial shields small or of moderate size, interradial space between 2 much wider than radial; interradial areas (orally) wider than arm bases ..... *Ophiarachnella*
BB. Oral shields concealed by granules (easily rubbed off when dry):
No granules on arm plates ..... *Cryptopelta*
Upper arm plates more or less concealed by granules ..... *Ophiodyscrita*

OPHIARACHNA

Müller and Troschel, 1842. Syst. Ast., pp. xiii, 84, 104.

Genotype: *Ophiura incrassata* Lamarck, 1816, vol. 2, p. 542.

This is a small genus of large ophiurans, of which only 2 occur in Australia. They were formerly associated with *Ophiocoma,* on account of their general appearance, habits, and habitat. But in reality they are much nearer to *Pectinura.* The 2 Australian species differ thus:

Radial shields concealed by granules; arm spines more or less conspicuously banded ..... *incrassata*
Radial shields naked but small; arm spines unicolor ..... *megacantha*

Ophiarachna incrassata

Ophiura incrassata Lamarck, 1816. Anim. sans vert., vol. 2, p. 542.
Ophiarachna incrassata Müller and Troschel, 1842. Syst. Ast., p. 104.
H. L. Clark, 1921. Ech. Torres Strait, p. 140; pl. 34, figs. 1, 2.

Of all big, simple-armed ophiurans, this is the largest, specimens 50–57 mm. across the disk being known. In such specimens, the arms, which are relatively short and stout, measure up to 200 mm. in length, with a width of 8 mm. exclusive of the spines. The color in life is very beautiful, for the disk is brilliant grass green, on which are white spots encircled with black, and occasional black spots and markings. The arm spines are handsomely annulated with black and white. The green, however, is very fugacious and becomes pale brown or dirty yellowish in preserved specimens. The range of this magnificent brittle star is from Zanzibar to the Caroline and Fiji islands and from the Ryukyu and Bonin islands in the north to about 19° S. on the Queensland coast. It is common at Mer, Murray Islands, living under large rock fragments and coral slabs on the southeastern reef.

Ophiarachna megacantha

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 341; figs. 28–30.

Since the original description was published, Ward has sent, from Lindeman Island, a very much larger specimen than any of the original 3. It is 27 mm. across the disk and the arms are about 130 mm. long. The colors are much duller than in the types, but the banding of the arms is very well marked. The disk is a uniform dark brown, and the bare radial shields of the same color are not conspicuous. The lowest arm spines are up to 7 mm. in length, but do not show that contrast with other spines which is so marked in the holotype. On some basal joints there are 6 spines. The oral papillae are notably big, but in number and arrangement do not differ from those of the smaller specimens. Apparently this *Ophiarachna* replaces *incrassata* on the reefs south of 20°.

OPHIURODON

Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 86.

Genotype: *Ophioconis grandisquama* Koehler, 1904, p. 11.

This is a small group of little ophiurans whose relationships have been so misunderstood that they have been placed in the Ophiacanthidae or in the Ophiodermatidae with about equal frequency. As material has slowly accumulated, however, their position in the latter family has become fairly well assured. The curious wide, semicircular teeth are the most characteristic feature and make the genus easy to recognize. There are about half a dozen named species, of which 3, and a color variety, are reported from Australia. They may be distinguished thus:

Key to the Species of Ophiurodon [1]

A. Arm spines slender, more or less hyaline, upper ones at least, slender and acute:
  B. Margin of disk usually with small spinelets either singly or in groups; inner tentacle scale very large, nearly or quite equal to under arm plate (at least near middle of arm), acutely pointed:
    Disk without conspicuous dark area or areas; arms banded with dark gray ..... *cinctum*
    Disk with conspicuous dark mark and arms banded with dark brown ..... *cinctum* var. *pulchellum*
  BB. Margin of disk without spinelets and with no dark markings; inner tentacle scale blunt, not much more than half under arm plate ..... *cupidum*
AA. Arm spines (at least upper ones) flat, opaque, blunt or truncate ..... *opacum*

[1] Specific names in this genus were first given a feminine ending. Later both feminine and neuter were used. In 1922, Koehler used feminine endings at first (p. 15) but later (p. 351) adopted a masculine termination. In 1930, however (p. 277), he adopts the neuter form, and in a footnote he says the neuter seems to him "plus correct." The matter may well rest here.

Ophiurodon cinctum

Ophioconis cincta Brock, 1888. Ztschr. f. wissensch. Zool., vol. 47, p. 480.
Ophiurodon cincta Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 84.
Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 3, p. 15.
Ophiurodon cinctus Koehler, 1922. Bull. 100 U. S. Nat. Mus., vol. 3, p. 351; pl. 81, fig. 5.
Ophiurodon cinctum Koehler, 1930. Vidensk. Medd., vol. 89, p. 277.

This is a secretive little brittle star, 5–6 mm. across the disk with arms about 3–4 times as much, but few specimens seen were full grown. The dull colors harmonize well with the algae, bryozoa, and sponges among which the ophiurans live, and hence specimens are not easy to find. We took only 3 at Darwin, but at Broome we were more fortunate. The Western Australian specimens, however, were so much more handsomely colored that the name *Ophiurodon cinctum* var. *pulchellum* has been proposed for them (see H. L. Clark, 1938, pp. 339–341). The color of the typical form is a pale yellow-brown without any noticeable markings, but the specimens collected at Broome were made conspicuous, when in hand, by red-brown markings on the disk. No structural characters were associated with this coloring, however; hence the form can be given only varietal status. The range of *cinctum* is still imperfectly known, but it has been taken in the Sulu Archipelago and the Philippines, at Amboina, at the Kei Islands, and near Timor. It is not known from Torres Strait or the Barrier Reef area.

Ophiurodon cupidum

Ophioconis cupida Koehler, 1905. "Siboga" oph. litt., p. 15; pl. 1, figs. 19, 20.
Ophiurodon cupida Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 84.

This species is very similar to the preceding, and abundant material may show they are identical. In size and color there are no essential differences. It is very difficult to separate specimens of *cinctum* which lack marginal spines from specimens of *cupidum* of the same size. The geographical distribution of *cupidum* is wide, as it has been found in the Red Sea and in the Philippines and southward to the Kei Islands. The "Siboga" found it at three stations, but the "Albatross" did not meet with it. The only justification for including it in the Australian fauna is a single *Ophiurodon* in badly damaged condition taken by the Great Barrier Reef Expedition in 1929 "outside Cooks Passage, Queensland," in 210 fms.

Ophiurodon opacum

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 440; figs. 132*a*, *b*.

This is a well marked species, the arm spines being notably different from those of its congeners. The disk granulation is coarser and the whole makeup more robust. It is geographically isolated, as none of its congeners occur south of 20° S. and its home is in St. Vincent Gulf. It is no exaggeration to say it is at least 2500 miles by sea from its nearest relative. It is large for the genus, up to 7.5 mm. across the disk, with the arms fully 3 times that much. As only 2 specimens are known and they differ in color, we cannot consider that character distinctive.

PECTINURA

Forbes, 1843. Trans. Linn. Soc. London, vol. 19, p. 144.

Genotype: *Pectinura vestita* Forbes, 1843, p. 145.

The type of this small genus is known from only a single specimen taken in the Aegean Sea, off the coast of Lycia, Asia Minor, in 100 fms., a century ago. All the other members of the genus occur south of the equator from Zanzibar to New Zealand, and only 2 or 3 of them have been found in the East Indies. One cannot help feeling skeptical concerning the real relation of this unique Mediterranean brittle star to the 5 Australian forms here considered congeneric with it. These are relatively small and dull-colored (with one exception), and not one is known from really adequate material. Only a single *Pectinura,* and that the unique type of a new species, was met with by me during my three visits to Australia.

Key to the Species of Pectinura

A. Arm spines blunt or slightly acute, lower ones longest; arms more or less terete, not evidently widened or keeled at base:
  B. Arm spines few (4–8):
    Color light (varied); arm spines 6–8, lowest conspicuously largest..... *dyscrita*
    Color black in life, very deep purple when dried; arm spines 4–6, lowest not conspicuously largest..... *nigra*
  BB. Arm spines numerous, 9–14 in adults:
    Upper arm plates not twice as wide as long; supplementary oral plates well marked..... *arenosa*
    Upper arm plates 3 times as wide as long; supplementary oral plates often wanting..... *assimilis*
AA. Arm spines 5–10 (according to age), sharp, middle ones evidently longest (near base of arm upper ones may be as long); arms flattened, widened, slightly keeled at base..... *yoldii*

Pectinura dyscrita

H. L. Clark, 1909. "Thetis" rept., p. 534; pl. 49, figs. 5–7.

This brittle star was first collected by the "Thetis," but the "Endeavour" took more and larger specimens. The range includes the southeastern corner of Australia from Wata Mooli, New South Wales, to Gabo Island, Victoria, and the northeastern corner of Tasmania. The bathymetrical range is 55–300 fms. Obviously it is not a littoral form. It grows to a fairly large size, with a disk diameter of 20 mm. and arm length of 7 times as much. The diversity of color in the preserved material is considerable, but the living animal is supposed to be white, dull yellow, or pale brown with rose-purple markings. The specimen listed by me (1914) as taken by the "Endeavour" between Fremantle and Geraldton was in poor condition and its identity is open to question.

Pectinura nigra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 344 (not figured).

As only a single specimen of this species is known, there is nothing to add to the original account. It was taken in 5–8 fms. in Koombana Bay, Bunbury, Western

Australia. It is obviously young (6.5 mm. across disk), and the appearance of the genital slits confirms this conclusion. The black color made it conspicuous in the dredge haul that brought it up, but all efforts to locate a second specimen were in vain.

Pectinura arenosa

Lyman, 1879. Bull. Mus. Comp. Zoöl., vol. 6, p. 48.
——— 1882. "Challenger" Oph., p. 15; pl. 23, figs. 10–12.

The "Challenger" took this species in Bass Strait, in 38 fms., and the collection of the South Australian Museum reveals it as a common species in the vicinity of Spencer and St. Vincent gulfs. Döderlein (1896) reports a specimen from Torres Strait, but the probability that either the label or the identification is wrong seems to me great. Koehler's (1898) record from Ceylon seems to me even more open to question, as he himself had some doubt. He did not find *arenosa* in the extensive collections made by Mortensen and by the "Albatross" in the East Indian region, but he records a number of small specimens taken by the "Siboga" as this species. Of these too I am skeptical, for I believe that *arenosa* is really a species of temperate Australian waters. It does not reach a large size, about 11–12 mm. being the maximum, but it does have a large number of arm spines, and Pectinuras with fewer than 9 arm spines on the basal arm segments should be referred to *arenosa* only after very critical study and comparison. The material in the South Australian Museum indicates that *arenosa* is not brightly colored in life and apparently lacks the rose-purple tints which the following species shows. The usual tints are browns or grays and the arms are often distinctly cross-banded.

Pectinura assimilis

Ophiopeza assimilis Bell, 1888*a*. Proc. Zool. Soc. London, p. 282; pl. 16, fig. 5.
Pectinura assimilis H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 118.

This species is imperfectly known, and far more material is needed to enable us to delimit it properly. The original specimen was said to be from Port Jackson, New South Wales, but all other specimens (save the very large one in the Museum of Comparative Zoölogy from "South Australia") are from the South Australian Museum and were taken in Tumby Bay and St. Vincent and Spencer gulfs. The largest of these has the disk 21 mm. across, but in the M.C.Z. specimen it is 25 mm. Most of the known specimens have more or less rose-purple color in markings on disk, arms, oral shields, or basal under arm plates, but we have no reliable information as to the colors in life. Bennett gave me, at Perth, 3 specimens of a *Pectinura* with disks 12–15 mm. across, which were supposed to have been picked up somewhere on the Fremantle beaches. But the condition is so poor, the occurrence of *assimilis* in Western Australia needs confirmation.

Pectinura yoldii

Ophiopeza yoldii Lütken, 1856. Vidensk. Medd., p. 9.
——— 1859. Add. ad hist. Oph., pt. 2, pl. 1, fig. 9.
Ophiopeza conjungens Bell, 1884. "Alert" rept., p. 137.
Ophiopeza exilis Koehler, 1905. "Siboga" oph. litt., p. 12; pl. 2, figs. 5, 6, 8.
Pectinura yoldii H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 119.

Widely distributed in the East Indies, this brittle star ranges southward to eastern Victoria. It has been found in Torres Strait, and Bell (1894) records it from Holothuria Bank, northwestern Australia, in 38 fms. It has been taken also at several points on the Queensland coast. The "Challenger" took a specimen off Twofold Bay, New South Wales, in 120 fms., but the most southern record is from south of Cape Howe, New South Wales and Victoria, in 70–83 fms.; here Mortensen took 1 specimen in 1914, which Koehler (1930, p. 270) lists as *Pectinura exilis*.

The arm spines are very distinctive, for although the number may range from 5 to 10, they are always sharp-pointed and the middle ones (except at base of arm) are conspicuously longer than those above or below. Large specimens have the disk 25–26 mm. across and the arms about 75 mm. long, but in most museum material the disk is 10–15 mm. across and the arms about 4 times as much or even more. Colors of preserved material are dull, young specimens being gray or light brown with the arms more or less distinctly banded with darker, and older individuals dark brown (the oral surface lighter) with the banding of the arms less distinct.

It is a surprise to find that the name *exilis* is simply a synonym of *yoldii*. Koehler apparently did not compare the two species, although in his original description he says that *exilis* may be distinguished from *conjungens* Bell by the form of the upper arm plates. Koehler's types were very small and Bell's about three times as big, so that this comparison is invalid. The Museum of Comparative Zoölogy has cotypes of Bell's species, and a specimen of *exilis* from Macassar identified by Koehler himself, and I can find no way to distinguish the species from each other or from the much longer-known *yoldii* of Lütken.

OPHIOPEZELLA

Ljungman, 1872. Öfvers. K. Vetensk.-Akad. Förh., vol. 28, no. 5, p. 639.

Genotype: *Ophiarachna spinosum* Ljungman, 1867, p. 305.

This genus contains but 2 species, 1 from Mauritius and 1 from the East Indies. The latter extends its range northward to the Philippines, eastward to Tahiti, and southward to Torres Strait.

Ophiopezella spinosa

Ophiarachna spinosum Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 305.
"*Ophiopezella spinosa* Ljn." Lyman, 1882. "Challenger" Oph., p. 17.
Ophiopezella Lütkeni de Loriol, 1893. Rev. suisse zool., vol. 1, p. 392; pl. 13, figs. 1–1*e*.

The conspicuous, though covered, marginal scales and the large number (12–14) of small sharp arm spines make this little brittle star easy to recognize. It is widely distributed among the islands of the Pacific, but does not seem to occur in the Indian Ocean, although it has been found at a number of islands in the Philippines and East Indies. It is common at the eastern end of Torres Strait and at Mer, Murray Islands, but has yet to be found elsewhere in Australia. The largest specimens are less than 10 mm. across the disk and the arms are 5 or 6 times that diameter. The color ranges from very pale to dark brown or deep gray, and the

arms are distinctly banded in small specimens but may be entirely unicolor in adults. It is an inactive species, living in the sand under rocks and slabs of coral in shallow water.

OPHIOCHASMA

Grube, 1868. Jahresber. Schles. Gesellsch., vol. 45, p. 45.

Genotype: *Ophiochasma adspersa* Grube, 1868, p. 45 = *Ophiarachna stellata* Ljungman, 1867, p. 305.

This is a monotypic genus widespread in the East Indian region, easily recognized by the large, bare radial shields and the wide arm bases.

Ophiochasma stellatum

Ophiarachna stellata Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 305.
Ophiochasma adspersa Grube, 1868. Jahresber. Schles. Gesellsch., vol. 45, p. 45.
Ophiopinax stellatus Bell, 1884. "Alert" rept., p. 136; pl. 8, fig. C.
Ophiochasma stellata H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 121.
Ophiochasma stellatum H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 304.

An East Indian species occurring as far north as the Gulf of Siam, this handsome, sand-loving brittle star occurs along the tropical coast of Queensland, as far south at least as Lindeman Island near Mackay. It occurs in Torres Strait, but west of there it has been found only in the region of Broome, where it is quite common. When adult (20–30 mm. across disk) it is pure white underneath, but the upper surface is beautifully variegated with white, gray, and light brown, matching remarkably well the sandy bottom of Roebuck Bay.

OPHIARACHNELLA

Ljungman, 1872. Öfvers. K. Vetensk.-Akad. Förh., vol. 28, no. 5, p. 640.

Genotype: *Ophiarachna gorgonia* Müller and Troschel, 1842, p. 105.

This is apparently the largest genus of the family, with more than 20 species, of which 9 occur in Australia, on all sides of the continent. Most of the Australian forms are relatively small, but 2 or 3 of them may be 25 mm. or more across the disk. The genus is tropicopolitan, with at least 1 West Indian species, 1 South African, and 1 ranging eastward into the Pacific as far as Fiji and the Gilberts, but most of the species are East Indian. The range in depth is noteworthy, for although most of the species are strictly littoral, several are found in deep water, down to 260 fms. The 10 representatives of this genus which occur in Australia are inadequately known and more or less ill defined. The validity of several is open to serious question.

Key to the Species of Ophiarachnella

A. Radial shields more or less elongate, not conspicuous because of dark color; arm pores wanting or not more than 3 pairs visible:
  B. Arm spines numerous, 8–13:
    C. Entire disk granulated except radial shields; arm pores present:
      D. Size small or moderate (up to 20–22 mm. disk diameter); colors generally light, especially below, often green on

disk, never very dark or with conspicuous rose-red or yellow areas ..... *gorgonia*

DD. Very large, up to 35 mm. disk diameter:

Colors dark, sometimes almost black on upper surface; lower surface usually abruptly light in well marked contrast; frequently rose-red shades or markings on disk or arm bases ..... *ramsayi*

Color very bright, yellow, pink, yellow-brown, light gray, etc. ..... *ramsayi* var. *pulchra*

CC. Besides radial shields, some other plates are bare, usually only a few near base of each arm:

E. Many disk scales bare and swollen, making disk surface rough; arm spines very short and thick but pointed ..... *rugosa*

EE. Only a few disk scales near base of each arm or along interradial margins are bare:

At least 3 large bare plates between radial shields, and other bare plates often present; area of each oral shield greater than combined areas of adjoining adoral plates ..... *infernalis*

Only 2–4 small bare plates between radial shields; oral shields small, with area of each one less than combined areas of adoral plates ..... *similis*

BB. Arm spines 4–7 (sometimes 8):

F. Arm spines more than 4:

Radial shields small, widely separated, with 1–3 large bare plates between ..... *sphenisci*

Radial shields large and conspicuous; distance between 2 of a pair less than width of 1; no bare disk plates ..... *megaloplax*

FF. Arm spines 4, small and pointed; disk very sparsely granulated ... *paucigranula*

AA. Radial shields very small, circular, conspicuous because of very dark color; more than 4 pairs of arm pores usually visible ..... *septemspinosa*

Ophiarachnella gorgonia

Ophiarachna gorgonia Müller and Troschel, 1842. Syst. Ast., p. 105.
Ophiarachnella gorgonia H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 123.
——— 1921. Ech. Torres Strait, p. 141; pl. 12, fig. 5 (colored); pl. 35, figs. 4, 5.

Although this is a common and widespread brittle star, it is impossible at present to define it with any degree of distinctiveness. In spite of actual collecting and study in tropical Australia and the examination of scores of specimens from many localities, the present writer is unable to delimit the species satisfactorily. In 1909 I united 5 supposed species with *gorgonia* to make a single widespread unit. Koehler (1922, 1930) accepted this action as conclusive. My first visit to Australia and the collecting of living material, however, shook my own faith badly, and in 1915 I restored *ramsayi* and *marmorata* to good specific standing. Subsequent visits to Australia have only increased my perplexity. In 1926 (see McNeill and Livingstone, 1926, p. 195) I considered five Ophiarachnellas from the coast of the Northern Territory as *marmorata,* thus bringing that name back into usage and establishing it as an Australian species. In 1929 and 1932, collecting at Broome again left me uncertain as to both *marmorata* and *gorgonia.* In 1938, I recognized *gorgonia* and

ramsayi as distinct and described a very striking color variety of *ramsayi,* and that seems to be the most nearly satisfactory conclusion possible with the available material and data.

Typical *gorgonia* occurs in Torres Strait and on the Queensland coast. Passing westward, we find fairly typical material at Darwin and even at Augustus Island, but at Cape Leveque and especially at Broome a much larger and coarser form occurs, although still with the essential characters of *gorgonia.* Koehler (1907*a*) reports 2 specimens from "Turtle Island," northeast of Port Hedland, near the western limit of the Broome area. On the other hand, as one passes southward on the Queensland coast, *gorgonia* occurs in the vicinity of Cairns (Green Island) and the Low Isles, but there are no records south of there until we reach New South Wales. At Long Reef, Colloroy, at Port Jackson, and at Shell Harbor occurs an *Ophiarachnella* which Bell (1888*a*) first designated as *Pectinura ramsayi.* It grows much larger than typical *gorgonia* and has a different general appearance and coloration, but it is exceedingly difficult if not impossible to find a single structural feature which will separate it from northern specimens of *gorgonia* of approximately similar size. Nevertheless, it is desirable to indicate in some way that this southern form is not really identical with *gorgonia,* and we may therefore use for it Bell's name *ramsayi,* without asserting whether the distinction is specific, subspecific, or varietal only. As we pass westward along the southern coast of the continent, this ophiuran develops in size and bright coloration until in the vicinity of Fremantle we find a huge, handsomely colored form which should have some sort of designation to distinguish it from the dull-colored Ophiarachnellas of the southeastern coast. No better course seems open than to use the name *gorgonia* for the form occurring on the coasts of tropical Australia from Cairns, Queensland, to Port Hedland, Western Australia, regardless of size and coloration, and the name *ramsayi* for the form occurring on the temperate coasts of southern Australia, recognizing as a named variety the brightly colored *Ophiarachnella* of Western Australia. This course is adopted for this monograph.

Typical *gorgonia* is widely distributed in the Indo-Pacific region from Natal and Zanzibar to Ceylon, southern Japan, Fiji, and Samoa. Apparently it has not reached Tahiti, New Zealand, or Lord Howe Island. But it has reached New Guinea and New Caledonia and thus the Great Barrier Reef. As the "Siboga" found it on the southern side of Timor, it probably reached northern and northwestern Australia by that route. At Broome it reaches a large size (20–22 mm. across disk), but in the Torres Strait region and on the Barrier Reef, 10–15 mm. is the normal maximum. The young are often, if not always, prettily colored with green and white (H. L. Clark, 1921, pl. 12, fig. 5), but as they increase in size the colors become more dull and more varied, the green tends toward gray or brown, and the dark banding of the arms is commonly conspicuous. In very large individuals dark blotches and spots are usually evident on the disk.

Ophiarachnella ramsayi

Pectinura ramsayi Bell, 1888*a*. Proc. Zool. Soc. London, p. 281; pl. 16, figs. 1, 2.
Ophiarachnella ramsayi H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 305.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 347.

The line between this brittle star and *O. gorgonia* is faint indeed, but *ramsayi* ranges from Long Reef, Colloroy, New South Wales, to Rottnest and to Triggs

islands, Western Australia, via Kangaroo Island and other South Australian points. There seem to be no records for Tasmania. Large specimens may be 30 mm. across the disk or a little more, and the arms about 4 times as much. The colors are for the most part dull, grays or browns predominating. There is sometimes a greenish tint, and even rose red may appear. Broad but not sharply defined light bands are more or less conspicuous on the arms. The uniformly light-colored (white, cream color, or yellowish) lower surface of the disk (mouth parts and basal part of each interbrachial area) is sharply marked off from the distal parts. Sometimes the sharp boundary line runs across the interbrachial area midway between the oral shield and the margin, but often it is more distal and it may be just below the actual margin of the disk. In dried material, this line may be completely obliterated either by staining or by bleaching, but when visible it seems to be a good species character.

On the coast of Western Australia, north of Fremantle, remarkably bright-colored specimens of large size (31–35 mm. across the disk) occur which are so different in appearance that they require a name, and I have called them variety *pulchra* (H. L. Clark, 1938, p. 348; pl. 14, fig. 1). The ground color is a slightly orange yellow with pink radial shields and broad whitish or light gray bands on the arms. The limits of these bands are indicated by bright brown transverse lines. As intermediate specimens occur with less yellow and more gray, it is better for the present to give this form merely a varietal designation.

Ophiarachnella rugosa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 352; figs. 32–34.

At Broome, there occurs, but not at all commonly, a remarkable *Ophiarachnella* in which the plates of the disk are nearly all slightly swollen and bare at the center, making a rough, pebbly surface. The arms are short, about 3 times the disk diameter, which in the largest specimen is 15 mm. The colors are light gray and brown, 1 or 2 large spots on the disk and 4–6 broad bands on each arm being of the darker color. The lower side is white or pale cream color, but in the smaller specimens the dark arm bands extend across as dull purplish bars. The relationship to *gorgonia* (as it occurs at Broome) is obvious, but aside from the very different disk, the shorter, stouter arms, sharper arm spines, and different upper arm plates give a different facies to *rugosa*.

Ophiarachnella infernalis

Ophiarachna infernalis Müller and Troschel, 1842. Syst. Ast., p. 105.
Pectinura infernalis Koehler, 1905. "Siboga" oph. litt., p. 7; pl. 1, figs. 1–3.
Ophiarachnella infernalis H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 124.

A dull-colored, gray and brown brittle star, this common East Indian species ranges south on the Australian coast as far as Port Molle and westward on the northern coast at least to Broome. Full-grown specimens exceed 15 mm. in disk diameter, with arm length about 4 times as much. There is some diversity in form, for specimens from Sorong, New Guinea, have a flatter disk and more slender arms than most Australian material, but the group of bare plates on the disk, at the base of each arm, is very distinctive.

Ophiarachnella similis

Pectinura similis Koehler, 1905. "Siboga" oph. litt., p. 6; pl. 1, figs. 4–6.
Ophiarachnella similis H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 306.

This dubious species is admitted to the Australian fauna on the basis of a single specimen from Lindeman Island, near Mackay, Queensland. This specimen may be an aberrant *infernalis,* however, for I am by no means satisfied that *similis* is a valid species, in spite of Koehler's assertions (1922, 1930). In the Queensland specimen, the radial shields are not nearly so bare as they should be in *similis,* but the adoral plates are very big. Koehler seldom if ever undertook to make artificial keys to the species of a large genus, and in consequence he was not always very clear and definite as to the distinguishing characters of his species. I am accepting *similis,* however, on the strength of its author's general reliability.

Ophiarachnella sphenisci

Pectinura sphenisci Bell, 1894. Proc. Zool. Soc. London, p. 406; pl. 25, figs. 7–9.
Ophiarachnella sphenisci H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 124.

The type locality of this little species is Holothuria Bank, northwestern Australia, and no other Australian specimens have been reported. Koehler (1905, p. 10) reports specimens from three well separated East Indian localities. The validity of the species seems dubious.

Ophiarachnella megaloplax

Pectinura megaloplax Bell, 1884. "Alert" rept., p. 134 (not figured).
Ophiarachnella megaloplax H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 125.

Bell's original material was from Port Molle, but a later record was from Holothuria Bank. No other worker on brittle stars has seen the material and no figures have been published. Hence the validity of the species must still be considered dubious. The type was 19 mm. across the disk and the arms were 83 mm. long. The very large radial shields and the small number of arm spines would seem to be fairly diagnostic.

Ophiarachnella paucigranula

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 351; figs. 31*a, b*.

The unique specimen on which this odd little species is based was taken by the Great Barrier Reef Expedition off North Direction Island, Queensland, in 19 fms. It is 7 mm. across the disk and the arms are about 27 mm. long. The disk is variegated light and dark brown, and the light gray arms have 4 broad, almost blackish crossbands.

Ophiarachnella septemspinosa

Ophiarachna septemspinosa Müller and Troschel, 1842. Syst. Ast., p. 105.
Ophiarachnella septemspinosa H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 126.

Rather more than usually handsome, this large species (30–36 mm. in disk diameter) barely enters the Australian fauna. It ranges from Zanzibar to Fiji, but

reaches Australia only at the Murray Islands, where it is not uncommon, and at Augustus Island, Western Australia, where Bardwell took 4 specimens in 1933. These specimens are unusually dark-colored, and the arm spines lack the usual light tips.

CRYPTOPELTA

H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 130.

Genotype: *Ophiopeza aster* Lyman, 1882, p. 12.

Only 4 species of this genus have yet been discovered, all in the Indo-Pacific region. Of these, 2 have been taken in Australia: 1 on the Barrier Reef, 1 on the northwest coast. The 2 are easily distinguished thus:

Arms flattened distally but more cylindrical near base; arm spines slender, acute, lowest distinctly longest and more than half segment length; arms rather faintly banded, bands not evident on lower surface ..... *granulifera*

Arms flattened throughout; arm spines short, stout, pointed, lowest not evidently longest and not half segment length; arms conspicuously banded, as much so ventrally as dorsally ..... *callista*

Cryptopelta granulifera

H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 131.
——— 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 307; pl. 17, figs. 6, 7.
——— 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 7, p. 209.

All that is known of this apparently rare brittle star is to be found in the papers referred to above. It occurs in Mauritius and along the Great Barrier Reef. It should therefore occur throughout the East Indian region, but neither the "Siboga," the "Albatross," nor Mortensen met with it. It grows to a considerable size, 12–13 mm. across the disk, with the arms about 5 times as much. In dried specimens the arms are light olive gray, broadly but rather faintly banded with darker; the bands are not present on the lower side of the arm. The disk is conspicuously and abruptly lighter, pale brown or dirty cream color.

Cryptopelta callista

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 354; pl. 14, fig. 2 (colored).

This unusually pretty brittle star is known only from the Broome region. It was first taken in 1929 at Cape Leveque, but later it was found in Lagrange Bay and at Entrance Point on Roebuck Bay. In 1932, additional material was dredged in the vicinity of Broome. But it is not very common, as only 8 specimens were taken in all. They were very similar in color, the disk bright orange, the arms pale brown banded conspicuously with darker. In preserved material the bright shades are wholly gone; the disk is a dirty cream color, the arms nearly white banded with a dull purplish black. On the lower side of the arms the bands are as conspicuous as dorsally, but are a dark gray. The largest specimens are 10–11 mm. across the disk, with arms about 4 times that.

OPHIODYSCRITA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 355.

Genotype: *Ophiodyscrita acosmeta*. H. L. Clark, 1938, p. 356.

The validity of this genus is open to question, as it is quite possibly based on a very young individual of some *Ophiarachnella* or *Pectinura*. The similarity to *Ophioncus* and *Ophiocryptus* is obvious, but we do not know enough about the young stages of East Indian and Australian Ophiodermatidae to enable us to place accurately this little brittle star. Not one of the members of that family which occur at Broome has any such combination of characters as would warrant considering it the adult of *Ophiodyscrita*.

Ophiodyscrita acosmeta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 356 (not figured).

A single ophiuran, 5 mm. across the disk, with arms about 20 mm. long, dredged at Broome in June 1932, is the sole known representative of this species. The disk is pale fawn color, becoming white on the bases of the arms, which are banded with dark purplish gray on a pale gray or whitish ground color. The arm spines are the same color as the segment which bears them. The dark bands encircle the arm.

Family OPHIOLEPIDIDAE

This large family of some 300 species is represented in Australia by only about 20 species, divided among a dozen or more genera. The scale-covered or plated disk and the small, appressed arm spines give the species a characteristic facies, but the great diversity shown in disk scaling, arrangement of arm plates, spines, tentacle pores, and scales results in many genera. Very few of the species occur along shore, nearly all being collectible only by dredge or trawl in water over 5 fms. deep. They are for the most part relatively small, few exceeding 20 mm. in disk diameter, and fewer still show any beauty of coloring. The Australian genera may be distinguished as follows:

Key to the Genera of Ophiolepididae

A. Arms abnormally widened at base; disk margin in each interradius made up of 1 big plate dorsally and a pair of thick, somewhat 4-sided plates orally ..... *Ophiomisidium*

AA. Arms not abnormally widened at base; interradial margin not as above:

B. Upper arm plates normally of 1 piece:

C. Tentacle pores present on basal half or more of arm:

D. Tentacle scales wholly wanting ..... *Haplophiura*

DD. Tentacle scales present:

E. Radial shields large, in contact proximally, separated distally by large triangular plate; margins of these plates, and of that part of radial shields in contact with them, provided with a close-set series of minute papillae ..... *Ophiocrossota*

EE. Radial shields widely separated proximally but in contact or slightly separated distally:
F. Genital plates with upper end large and conspicuous, separating radial shields from large triangular plate at base of arm; on margins of this basal plate and adjoining margins of genital plates are well developed combs of numerous minute papillae ..... *Dictenophiura*
FF. No such arrangement of genital plates, radial shields, and papillae:
G. Tentacle scales 3 or more, placed on both sides of pore, at least on basal arm segments:
Basal under arm plates broadly in contact; disk high, with thick plates among which primaries are conspicuous; oral shields very large, often covering most of oral interbrachial areas ..... *Amphiophiura*
Basal under arm plates broadly triangular, little or not at all in contact; disk low and flat, primary plates not very conspicuous as a rule; oral shields usually not covering half of interbrachial area ..... *Ophiura*
GG. Tentacle scales 2, more or less completely closing pore:
H. Marginal plates of disk greatly swollen, forming rampart around disk ..... *Ophioteichus*
HH. No such rampart around disk:
No supplementary upper arm plates ..... *Ophiozonella*
Supplementary upper arm plates present ..... *Ophiolepis*
CC. Only 2 pairs of tentacle pores, or none ..... *Ophiomusium*
BB. Upper arm plates divided into 5 or more pieces ..... *Ophioplocus*

OPHIOMISIDIUM

Koehler, 1914. Bull. 84 U. S. Nat. Mus., p. 32.

Genotype: *Ophiomisidium speciosum* Koehler, 1914, p. 34.

The occurrence of this odd little genus on the coast of New South Wales in relatively shallow water is quite remarkable, as the other members of the genus are found in the South Atlantic at depths of 100 fms. and more. It was originally collected by the "Challenger," and no second species has been found in Australian seas.

Ophiomisidium flabellum

Ophiomusium flabellum Lyman, 1878. Bull. Mus. Comp. Zoöl., vol. 5, p. 120.
——— 1882. "Challenger" Oph., p. 98; pl. 3, figs. 4–6.

The "Challenger" took but a single specimen of this interesting little ophiuran "off Port Jackson, 30–35 fms.," and subsequent collecting has not produced many. The "Thetis" and one or two other vessels have taken a few specimens, but neither the "Endeavour" nor Mortensen found any. All the material so far collected has come from between Cape Three Points on the north and Crookhaven River on the

south of Port Jackson in 11–18 fms. Disk commonly about 3 mm. across; arm length about equal to disk diameter. There is no record as to color in life. Preserved specimens are more or less nearly white.

HAPLOPHIURA

Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 76.

Genotype: *Ophiozona gymnopora* H. L. Clark, 1909, p. 535.

This is a monotypic genus peculiar to the coast of New South Wales. Its geographical and bathymetrical range is similar to that of *Ophiomisidium,* but it seems to be much more common, though it was not taken by the "Challenger," the "Endeavour," or Mortensen.

Haplophiura gymnopora

Ophiozona gymnopora H. L. Clark, 1909. "Thetis" rept., p. 535; pl. 51, figs. 1–3.
Haplophiura gymnopora Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 76.

One of the "Thetis" ' most interesting discoveries, this tiny brittle star has a range very similar to that of the preceding. It is of about the same size but grows a bit bigger, as the largest specimen taken is 4.5 mm. across the disk and the arms are of about the same length. It is apparently more common than *Ophiomisidium,* as several hundred specimens have been taken. Nothing is recorded as to the color in life, but preserved material is pale "museum color."

OPHIOCROSSOTA

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 450.

Genotype: *Ophiocrossota heteracantha* H. L. Clark, 1928, p. 451 = *Ophioglypha multispina* Ljungman, 1867, p. 307.

Lyman, though he had material of the remarkable brittle star on which this genus is based, in the "Challenger" collection from Port Jackson, gave no data about the specimens save the depth at which they were taken. When examining the rich material in the South Australian Museum collection, I overlooked the "*Ophioglypha multispina* Ljn." in the Museum of Comparative Zoölogy collection, from the "Challenger" material, being confident that this interesting ophiuran would never have been put in *Ophioglypha* or *Ophiura* by anyone familiar with brittle stars. Hence I was sure I was dealing with a new species for which a new genus was necessary. I still consider the new genus valid and important, but my proposed specific name is superfluous. The genus is monotypic and endemic in Australia, and apparently confined to the southeastern coasts of the continent.

Ophiocrossota multispina

Ophioglypha multispina Ljungman, 1867. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, p. 307.
Ophiocrossota heteracantha H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 451; figs. 136*a, b.*

Port Jackson is the type locality for this very interesting brittle star, and it has been taken there since the original collecting, not only by the "Challenger," but more than once by local collectors. Yet it was not taken by the "Thetis," the "Endeavour," or Mortensen. Apparently it is, then, either rare or local. In Spencer and St. Vincent gulfs, South Australia, it is apparently common, for Verco obtained more than 50 specimens for the South Australian Museum. The largest of these were 10–12 mm. across the disk, with arms about 3 times as much. The color of museum specimens is variegated light brown and white, the upper surface with darker brown markings; the arms appear banded with the darker brown, but the lower surface is uniformly whitish or pale brown. The depths at which Verco took his material are not known, but specimens in the Museum of Comparative Zoölogy from Port Jackson come from 4–9 fms., and Lyman gives the "Challenger" depths as 30–35 fms. (1878) or 2–10 (1882).

DICTENOPHIURA

H. L. Clark, 1923. Ann. S. African Mus., vol. 13, p. 361.

Genotype: *Ophiura carnea* Lütken, 1858, p. 41.

This little genus of 3 or 4 species has an unusual distribution. The type species occurs in the northern Atlantic and the Mediterranean at depths of 30–700 fms.; 1 or 2 related species occur in the southeastern Atlantic on the African coast (22–118 fms.); and of the following 2 species, 1 is common on the northwestern coast of Australia and in the East Indian region in shallow water (5–55 fms.), and the other is known only from the coast of New South Wales. The 2 are easily distinguished thus:

Disk somewhat arched, with several interradial plates at margin; oral shields very large, much longer than wide, more or less swollen ..... *ctenophora*
Disk very flat, with single big, somewhat swollen marginal plate in each interradius; oral shields flat, wider than long ..... *stellata*

Dictenophiura ctenophora

Ophiura ctenophora H. L. Clark, 1909. "Thetis" rept., p. 537; pl. 51, figs. 4–6.
Amphiophiura ctenophora H. L. Clark, 1915. Mem. Mus. Comp. Zoöl., vol. 25, p. 310.

Challenger 870 fms in 100 fathoms Jan 1960 JB

This well marked species has been taken several times off the coast of New South Wales in 3–120 fms., the specimens being 3–14 mm. in disk diameter. The arms are short, only 2–3 times the disk. The dry specimens are a light gray-brown with a purplish tinge, becoming more or less nearly cream color or white beneath. The primary plates are obvious and the centrodorsal has a central tubercle, conspicuous in the smallest specimen but detectable even in the largest.

Dictenophiura stellata

Ophioglypha stellata Studer, 1882. "Gazelle" Oph., p. 11; pl. 2, figs. 5*a–b*.
Dictenophiura stellata H. L. Clark, 1923. Ann. S. African Mus., vol. 13, p. 361.

One of the common brittle stars of the Broome region, this species ranges to the northeast at least as far as Augustus and Champagny islands, but its occurrence

southwest of Mermaid Strait is doubtful. Studer in his account of the species says it was taken at "Ausgang der Naturaliste Channel (West-Australien)," but his labels on the material in Berlin say it came from Mermaid Strait, which is 300 miles nearer Broome and hence more probable. Full-grown specimens are 11 mm. across the disk. In life, the upper surface is prettily variegated with shades of gray and sometimes brown, harmonizing well with the sand in which it occurs, and the under side is pure white. We did not find it near low-water mark, but in 5–8 fms.

AMPHIOPHIURA

Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 77.

Genotype: *Ophioglypha bullata* Wyville Thomson, 1873, p. 400.

This is a large genus of more than 50 nominal species, widely distributed in nearly all seas at depths ranging from 10 to 3353 fms. But it is very poorly represented in the vicinity of Australia, where only the 2 following species have been taken, both rare and imperfectly known. They may be distinguished thus:

Arm comb of low, triangular papillae; 2 outer oral papillae wide and notched ..... *colleta*
Arm comb of peglike, spaced papillae; outer oral papillae not peculiar ..... *urbana*

Amphiophiura colleta

H. L. Clark, 1916. "Endeavour" rept., p. 93; pl. 37, figs. 1, 2.

The unique type of this rather fine species was taken by the "Endeavour," east of Babel Island, Bass Strait, in 60–80 fms. It is 17 mm. across the disk, with the arms well over 50 mm. but all more or less broken. The color (dry) is yellowish white.

Amphiophiura urbana

Ophioglypha urbana Koehler, 1904*a*. "Siboga" Oph.: Mer prof., p. 50; pl. 7, figs. 10–12.
Amphiophiura urbana Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 77.

Except for the holotype and a single paratype, this species is practically unknown. It was taken by the "Siboga" near Waigeu, New Guinea, in 260 fms. The described specimen was 14 mm. across the disk, and the arms, all of which were broken, exceeded 35 mm. The reason that *urbana* is included in the Australian fauna is that Koehler (1930, p. 226) reports a specimen 16 mm. across the disk taken by Mortensen in 83–145 fms. off Cape Howe, southeastern Australia. This is so near the locality where *colleta* was taken by the "Endeavour" that the suspicion arises at once that either the two species are identical, or Koehler has mistaken a specimen of *colleta* for his own species, *urbana*. Careful comparison of the descriptions of the two show that they are very much alike, but as the figures of *urbana* are conventional, whereas those of *colleta* are photographs, it is impossible to determine whether the species are identical. Only more material can settle the question, for the type of *colleta* is in Sydney, of *urbana* in Amsterdam, and it is very unlikely they can ever be compared.

OPHIURA

Lamarck, 1816. Anim. sans vert., vol. 2, p. 540.

Genotype: *Ophiura texturata* Lamarck, 1816, vol. 2, p. 542 = *Asterias ophiura* Linné, 1758, p. 662.

Long known under the name *Ophioglypha,* to which Lyman always clung, this genus had become so unwieldy, with nearly 150 species, that Matsumoto's (1915) breaking it up into 4 genera was an important and welcome forward step. Segregation of 2 other genera has reduced the old genus to more satisfactory and more natural size, but it still contains some 60 or more nominal species. Of these, however, only 2 have reached Australia, both down the east coast from the north. These 2 are easily distinguished almost at a glance by the shape of the upper arm plates:

Upper arm plates quadrangular or somewhat pentagonal, wider than long, broadly in contact ..... *kinbergi*
Upper arm plates oval, longer than wide, scarcely or not in contact ..... *oöplax*

Ophiura kinbergi

Ljungman, 1866. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 6, p. 166.
Ophioglypha kinbergi Lyman, 1882. "Challenger" Oph., p. 38.
Ophioglypha ferruginea Lyman, 1882. "Challenger" Oph., p. 38; pl. 4, fig. 7.
Ophiura kinbergi H. L. Clark, 1911. Bull. 75 U. S. Nat. Mus., p. 37; fig. 9.

This is a widely distributed brittle star in the East Indian region, ranging from Japan to Australia. It occurs as far south as Bass Strait on the eastern coast, and west to St. Vincent and Spencer gulfs. It has not been taken on the coast of northern and western Queensland (Gulf coast), nor in the waters of the Northern Territory. At Broome it occurs in both Roebuck and Lagrange bays, though it is not very common and no adults were taken. Apparently it does not occur on the western side of the continent. It is a pretty little ophiuran with a variegated upper surface and a white lower side. Large individuals may be 10 mm. across the disk, but few Australian specimens reach that size.

Ophiura oöplax

Ophiocten oöplax H. L. Clark, 1911. Bull. 75 U. S. Nat. Mus., p. 99; figs. 37*a–c*.
Ophiura oöplax Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 81.

This is also a species occurring in Japanese waters and ranging south to St. Vincent and Spencer gulfs, South Australia. It is not known from northern and western Australia, nor does it occur, so far as is yet known, in the East Indies, though Koehler (1930) has recorded 1 specimen from the Philippines. It is hard to account for its presence in southeastern Australian seas and also in Japanese waters, without the assumption that it is to be found in suitable places among the East Indies. It is a small, pale or dull-colored brittle star with a maximum disk diameter of 10 mm. and arms about 6 times as much. It is found in water 83–275 fms. deep.

OPHIOTEICHUS

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 360.

Genotype: *Ophioteichus parvispinum* H. L. Clark, 1938, p. 362.

This extraordinary genus is one of the most bizarre of all Australian echinoderm genera. Since it is known as yet from only 2 specimens, each representing a conspicuously distinct species, little can be said as to its relationships, but the lower surface of the arms and the arrangement of the tentacle scales is very suggestive of *Ophiolepis,* and the marginal knobs recall the big tubercles of *Ophiolepis nodosa.* The 2 species are easily distinguished by the arm spines:

Arm spines numerous, 12 or more, flat, fragile, pointed, upper ones longest. . . *multispinum*
Arm spines 4 (rarely 5), very short and thick. . . . . *parvispinum*

Ophioteichus multispinum

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 360; pl. 25, fig. 5.

This remarkable brittle star was collected by Melbourne Ward at Lindeman Island, near Mackay, Queensland, in 1934, under a piece of dead coral. It is about 15 mm. across the disk, with arms only 25 mm. long. The general color is a pale purplish brown above and white below; there are several light bands on the arms, but they are inconspicuous and ill defined.

Ophioteichus parvispinum

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 362; pl. 15, fig. 2 (colored); pl. 25, fig. 4.

This little brittle star was found at Lord Howe Island in April 1932; it was the first species of the genus brought to light, and hence should be considered the genotype. It is 6 mm. across the disk, with arms about 11 mm. long. The color in life was pearl gray, white, and bright yellow-brown. The dry specimen is somewhat duller but not essentially different. For a full account of the finding of this remarkable novelty, see the original description.

OPHIOZONELLA

Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 82.

Genotype: *Ophiozona longispina* H. L. Clark, 1908*a,* p. 290.

This is a group of more than 20 species, widely distributed in the warmer parts of the northern hemisphere but with only a very few representatives south of the equator, and only 1 of these in Australia.

Ophiozonella elevata

Ophiozona elevata H. L. Clark, 1911. Bull. 75 U. S. Nat. Mus., p. 31; figs. 6*a–c*.
Ophiozonella elevata Matsumoto, 1915. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, p. 82.

No further data are available concerning the occurrence of this Japanese species in Australian seas, since the account was published (H. L. Clark, 1928) of those

in the South Australian Museum from St. Vincent (or Spencer) Gulf. Nor is there any further light on the relation between *elevata* and *bispinosa*. Only considerably more material can determine whether we are dealing with a single somewhat heterogeneous species, or 2 well differentiated forms.

OPHIOLEPIS

Müller and Troschel, 1842. Syst. Ast., pp. 83, 89.

Genotype: *Ophiolepis superba* H. L. Clark, 1915*a*, p. 89 = *Ophiura annulosa* Blainville, 1834, pl. 24 (NON Lamarck, 1816, vol. 2, p. 543).

This is a small group of sand-loving brittle stars, of which 4 species have been taken in Australia. There is considerable diversity in size and form, but the chief generic characters seem to hold well. A West Indian species seldom exceeds 5 mm. in disk diameter. The largest East Indian species may be 30 mm. or more. The Australian species are easily distinguished by the arm spines, disk plates, and color pattern:

Key to the Species of Ophiolepis

A. Disk plates often thick and stout, but never with conspicuous knobs and tubercles:
  B. Large (15–30 mm. disk diameter), with thick arms (3.5–6 mm.); arm spines 6 (5–8):
    Arms conspicuously banded with dark ..... *superba*
    Unicolor; arms not banded ..... *unicolor*
  BB. Small (5–15 mm. disk diameter), with slender arms (2–3 mm.); arm spines 3–4 (rarely 5) ..... *cincta*
AA. Many disk plates and most basal upper arm plates with relatively big knobs or tubercles ..... *nodosa*

Ophiolepis superba

H. L. Clark, 1915*a*. Spolia zeylanica, vol. 10, p. 89.
Ophiolepis annulosa Lütken, 1859. Add. ad hist. Oph., pt. 2, p. 100; pl. 2, figs. 5*a–b* (colored).

This heavy and inert but rather handsome ophiuran is fairly common at the Murray Islands and is reported from Torres Strait, the Gulf of Carpentaria, and as far west as Darwin. On the eastern coast it is common at the Low Isles and occurs at Port Douglas. South of there, satisfactory records are lacking, yet Whitelegge (1889) includes it without comment in his Port Jackson list, and Koehler (1930) reports, also without comment, that in Mortensen's collection there were 4 specimens from "Port Jackson. 22 October 1914." In the South Australian Museum there are half a dozen specimens labeled "Spencer Gulf." This seems incredible, but if the species really does occur in Port Jackson there is no *a priori* reason why it should not be found in Spencer Gulf. I have seen no specimens from south of the Low Isles region. Outside of Australia, *superba* is found from Zanzibar to the Marshall Islands.

The color in life ranges from a rather light buff to a deep brown or olive, but is commonly a rich yellow-brown. Whatever the ground color, there is a large blotch

of deep purple (becoming almost black) on the disk; usually a central blotch and a wide branch running out toward the interradial margin; usually also the central blotch has a large light area at center. In a few cases, the dark markings are reduced to 5 interradial blotches. The arms are almost always conspicuously banded with the dark color; commonly there are 5–7 more or less well formed bands, but specimens occur in which only 1 or 2 bands, and these imperfect, are evident. In 1 specimen, which has a conspicuous disk mark, only 1 arm has any dark pigment, and on that arm is a single very imperfect band. Small specimens of *superba* seem to be seldom found; the smallest I have seen is 15 mm. across the disk, with arms 32–35 mm. long but 3.5 mm. wide at base. The color markings are notably symmetrical. It is regrettable that Koehler refused to recognize the fact that the name *annulosa* is preoccupied.

Ophiolepis unicolor

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 364; pl. 25, fig. 2.

Similar to the preceding in all details of structure, this interesting form replaces it on the northwestern coast of Australia from Augustus Island to Turtle Island, below Port Hedland. It is not abundant, but seems to be very constant in its unicolor condition. The range apparently includes Ceylon (see H. L. Clark, 1915*a*, p. 89). The shade shows some diversity, but in life a red-brown was usual. The deep buff, chocolate brown, and dark olive brown of preserved specimens may not be the color that the living animal showed. All our specimens were found under stones near low-water mark, none being obtained by dredging. This is equally true of the *superbas* I have collected.

Ophiolepis cincta

Müller and Troschel, 1842. Syst. Ast., p. 90.
Lütken, 1859. Add. ad hist. Oph., pt. 2, p. 101; pl. 2, figs. 6*a–b*.
Ophiolepis garretti Lyman, 1865. Illus. cat. Mus. Comp. Zoöl., no. 1, p. 61; pl. 2, fig. 4 (colored).

This is a typical Indo-Pacific brittle star, ranging from Mozambique and the Red Sea on the west to the Society Islands on the southeast; on the north it reaches Japan, and on the south, the eastern coast of Australia. It occurs in Torres Strait and is common at Mer. There are 2 specimens in the Museum of Comparative Zoölogy labeled "Port Jackson," but Whitelegge (1889) does not include it in his list and there are no other records for the eastern coast of Australia. The largest specimen at hand is 15 mm. across the disk and comes from the Red Sea. Australian specimens do not exceed 10 mm. and are mostly smaller. They are greenish gray above (variegated) and nearly white beneath. Their color in life was not at all like Lyman's figure of *garretti,* and this can hardly have been due to youthfulness.

Ophiolepis nodosa

Duncan, 1887. Jour. Linn. Soc. (Zool.), vol. 21, p. 86; pl. 8, figs. 1–3.

The occurrence of this remarkable brittle star in Australia was discovered by W. E. J. Paradice during his collecting on little-known parts of the Barrier Reef in July 1924. On the reef flat off High Island, in the Frankland Group, between 17°

and 19° S., he found a single specimen, 13 mm. across the disk, with arms 16–18 mm. long. The color of the preserved specimen is dull orange-brown above, dull grayish brown below (owing to numerous minute brown dots on a dirty whitish background). The arms have half a dozen narrow, indefinite crossbands of purplish brown. The only other specimen yet known of this unusual *Ophiolepis* is the unique holotype, from Elphinstone Island, Mergui Archipelago, 4000 miles northwest of the Frankland group.

OPHIOMUSIUM

Lyman, 1869. Bull. Mus. Comp. Zoöl., vol. 1, p. 322.

Genotype: *Ophiomusium eburneum* Lyman, 1869, p. 322.

This is another large, widely distributed genus of 30 species or more which is poorly represented in Australia. The 3 Australian species are all from the southern and southeastern coasts, no representative of the genus occurring west, north, or east of the continent (within the arbitrary limits set for this work) or even in New Zealand waters. There are a score or more species in the East Indies, and 10 of these are known from the vicinity of the Kei Islands, but apparently shallow water has barred them from Australia. The Australian species are well marked and quite unlike one another. They may be distinguished thus:

Key to the Species of Ophiomusium

A. 2 pairs of tentacle pores obvious:
  Interbrachial areas below covered by single large, flat plate distal to oral shield, with genital plate on each side ..... *anisacanthum*
  Interbrachial areas below covered by 3 more or less swollen plates, of which 2 form disk margin, as seen from below ..... *simplex*
AA. Tentacle pores wanting or at best very difficult to make out (probably present beside second under arm plate and possibly by third) ..... *aporum*

Ophiomusium anisacanthum

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 446; figs. 133*a, b.*

Verco took 5 specimens of this well marked species during his collecting in Spencer and St. Vincent gulfs, but left no record of exact locality or depth. As most members of the genus are known from depths of 200–2000 fms. and very few from less than 100, it would be interesting to know at what depth *anisacanthum* is found. The original specimens are 9–13 mm. across the disk, with the slender, rather rigid arms 3 or 4 times as much. Their color is pale gray or nearly white.

Ophiomusium simplex

Lyman, 1878. Bull. Mus. Comp. Zoöl., vol. 5, p. 115.
——— 1882. "Challenger" Oph., p. 93; pl. 1, figs. 7–9.

This species, which attains a disk diameter of 14 mm., is found throughout the East Indian region from southern Japan to the Kei Islands in depths of 54–180 fms. It is quite unexpected, therefore, in the South Australian gulfs, but Verco took 1

full-grown adult (14 mm. across the disk). We have, however, no clue to the depth at which it was taken. It has certain peculiarities which justify considering it a variety to which the name *australe* has been given (H. L. Clark, 1928, p. 449), but it may be only an individual variant. More material must be obtained before a satisfactory decision is possible.

Ophiomusium aporum

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 447; figs. 134*a, b*.
Ophiomusium incertum Koehler, 1930. Vidensk. Medd., vol. 89, p. 245; pl. 18, fig. 8; pl. 19, figs. 3, 4.

Koehler was working over Mortensen's East Indian and Australian collections while my report on the collections of the South Australian Museum was in press. Neither of us knew that this was the case, and his report was completed and in press before it was possible for him to see a copy of my report. There are consequently several cases where we independently came upon and named an Australian novelty. This *Ophiomusium* is such a case. There were but 2 specimens in the South Australian Museum collection, both collected by Verco in "Spencer and St. Vincent Gulfs," depth unknown. The holotype was 9 mm. across the disk, the paratype but 4. Satisfied that they were undescribed, I named them *aporum,* in view of the apparent lack of tentacle pores. Koehler, with 7 specimens, all less than 5 mm. across, from southeastern Australia in 70–220 fms., decided they represented a new species, which he called *incertum* because of some doubts about its relationships. It is evident we were dealing with the same brittle star, which must bear the earlier name. Koehler's figures are of great value in making clear the characters of this little *Ophiomusium.* In addition to the 7 specimens from Australia, Koehler included a single specimen from the Kei Islands. This identification seems questionable; some confusion of labels or some other mishap may explain this unexpected occurrence.

OPHIOPLOCUS

Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 75.

Genotype: *Ophiolepis imbricata* Müller and Troschel, 1842, p. 93.

Easily recognized among the genera of Ophiolepididae, *Ophioplocus* is known by its fragmented upper arm plates. It does not occur in the Atlantic, but ranges from Zanzibar to California in the Indo-Pacific and eastern Pacific regions. Of the 5 species, 2 occur in Australia. They are easily distinguished thus:

Arm spines 3; upper arm plates in 10–12 pieces ..... *imbricatus*
Arm spines 2; upper arm plates in 6 (4–8) pieces ..... *bispinosus*

Ophioplocus imbricatus

Ophiolepis imbricata Müller and Troschel, 1842. Syst. Ast., p. 93.
Ophioplocus imbricatus Lyman, 1861. Proc. Boston Soc. Nat. Hist., vol. 8, p. 75.
H. L. Clark, 1921. Ech. Torres Strait, p. 143; pl. 12, fig. 8 (colored); pl. 35, figs. 1–3.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 365.

This is a common brittle star at the northern end of the Barrier Reef, but it was not taken by the Great Barrier Reef Expedition at Low Isles, nor is it reported from any station south of these on the Queensland coast. Nevertheless, it is not rare at Lord Howe Island, where the individuals have the light sandy coloration of many individuals from Mer and Erub. Westward, although it is not known from Torres Strait, it occurs at Darwin, at Augustus Island, Cape Leveque, Broome, Shark Bay, and Houtman's Abrolhos (Long Island). It ranges up to 25 mm. in disk diameter, with arms about 3–5 times as long. The color shows great diversity, ranging from light yellowish or gray to deep gray or olive brown, often, perhaps usually, with conspicuous dark markings on the disk. The arms are almost always banded, and in light-colored individuals the bands are often bright brown, numerous and conspicuous. Some specimens from northwestern Australia are tinted with red-orange, particularly on the lower surface, and others are distinctly violet. These tints may, however, be artificial, associated with the method of killing and preserving. Outside the Australian region *imbricatus* ranges from Zanzibar to the Gilbert Islands and northward to the Ryukyu Islands.

Ophioplocus bispinosus

H. L. Clark, 1918. Bull. Mus. Comp. Zoöl., vol. 62, p. 337; pl. 4, fig. 2.

This species is still known only from the original 7 specimens taken by Joseph Gabriel at Philip Island, Western Port, Victoria, in May 1915. It was not found by Verco in all his dredgings in South Australian waters. We did not find it at Port Willunga, nor did Mortensen collect it in New South Wales. The Western Port specimens are all small, about 9 mm. across the disk, with arms scarcely 3 times as much. The color of the dry specimens is pale olive gray above, and uniformly light buff beneath. The arms are very faintly and irregularly banded.

ECHINOIDEA

The sea urchins of Australia are a large and unusually interesting group, notable for the great percentage that are known only as fossils. Of the 191 species included in this report, 56, nearly 30 per cent, are fossil only, and several of the 135 Recent forms occur as Quaternary fossils also. These figures emphasize further how unusually well represented echini are in the Australian fauna, a fact to which attention was first called in the report on the "Endeavour" collection (H. L. Clark, 1916, p. 95). Of some 1700 species of living ophiurans known, rather more than 200 occur in Australia, or about 12 per cent; of 1200 sea stars, not including fossils, 190 are Australian, or about 16 per cent; but of rather more than 600 Recent echini, 135, or 22 per cent, are to be found in the Australian region. Why this should be so is hard to determine or even to imagine, but it is a striking and interesting fact. Another notable point is that whereas nearly all the fossil crinoids, asteroids, and ophiuroids are from Paleozoic strata, the extinct echini are almost all Mesozoic and Cenozoic, a very large proportion belonging to genera still occurring in Australian seas.

Of the Recent species, rather more than half occur in shallow water (10 fms. or less), and most of these will be found, now and then at least, near extreme low-water mark. Most of the echini are inert and sedentary creatures, but a few species can move with at least visible speed; *Arachnoides* was noted at Darwin as moving an inch in 5 minutes or thereabouts, and *Lovenia* followed an outgoing spring tide at Broome at a very perceptible speed, at least a yard a minute. The littoral regular echini live either among or under coral fragments or rocks, or on so-called "grassy" bottoms, and though they are seldom handsomely colored, many species, especially among the smaller ones, may show no little beauty in both form and coloring. The clypeastroids and spatangoids rarely show any beauty of coloring, as they live for the most part buried in sand or mud, to a greater or less extent.

The classification of the echini is at present in a state of flux, and there is no universally accepted arrangement. Everything depends on the basis chosen from which to make a start. Jackson (1912), in his magnificent work "The Phylogeny of the Echini," taking the little Ordovician fossil from Russia, *Bothriocidaris* of Eichwald, as his starting point, developed a logical, natural, and convenient arrangement, which is consistent with both the geological history and the course of postlarval development of all known echini. Mortensen, on the other hand, having become convinced that *Bothriocidaris* is not an echinoid and that the echini have developed from forms having the skeletal plates irregularly arranged but ultimately pluriseriate, is working out a system of classification which is

still in process of development, in his great monograph on the Echinoidea, the publication of which began in 1928. Convinced as I am that stages in development are our surest guide, and not being convinced that either geological or embryological facts warrant the adoption of Mortensen's classification, I believe it the wisest course to use in this volume the classification which has been used in my previous publications on Australian echinoderms and in my "Catalogue of the Recent Sea-Urchins" (1925). Ultimately the geological history of echini and the postlarval development of all the chief genera will be sufficiently well known to make a natural classification universally accepted. Meanwhile there will be some confusion in the sequence and arrangement of certain families and larger groups, but the nomenclature of genera and species will be little affected. Mortensen's refusal to abandon the old and wrong generic name "*Diadema*" and to adopt Jackson's most appropriate and needed name *Centrechinus* leads to a little confusion in a family and an ordinal name, but there seems to be no help for this at present.

In spite of my inability to adopt his classification and nomenclature, I must express here my admiration for Mortensen's great monograph and acknowledge my debt to it and to him for the inestimable help they have given. The illustrations are superb, and the keys and synonymies of the greatest value. Constant references to them (as far as published) will be found in the following pages.

The class Echinoidea is divided into 7 orders, of which, however, only 3 contain species now living; but 1 of the other 4 is represented in Australia by a single fossil genus and species. The 4 Australian orders are easily recognized thus:

Key to the Orders of Echinoidea

A. Plates of interambulacra in more than 2 vertical series in each area; extinct ..... Perischoechinoida

AA. Plates of each interambulacrum in 2 vertical series:

B. Periproct within oculogenital ring at or near apex of test:

Ambulacral plates simple; perignathic girdle made up of apophyses only; no pit in top of each pyramid of lantern; primary spines with cortical layer ..... Cidaroida

Ambulacral plates compound (very rarely simple); perignathic girdle with auricles and apophyses; pit in top of each pyramid of lantern; no cortical layer on primary spines .... Centrechinoida

BB. Periproct outside oculogenital ring in posterior interambulacrum, usually near margin of test and often below ambitus ..... Exocycloida

Order *PERISCHOECHINOIDA

This order contains, according to Jackson's classification (1912), 4 families, but only 1 is represented in Australia, so far as we yet know.

Family *ARCHAEOCIDARIDAE

According to Jackson (1912), this family contains 3 genera, of which 2 are monotypic and the third includes more than 50 species. Of these, 14 are so imperfectly known that their true status is debatable. One of this group is the following species, undoubtedly, however, an

*ARCHAEOCIDARIS

McCoy, 1849. Ann. Mag. Nat. Hist., ser. 2, vol. 3, p. 252.

Genotype: *Cidaris urii* Fleming, 1828, p. 478.

Although Etheridge (1892) considered it probable that the material which he had in hand represented 2 different species, he named but 1, and Jackson (1912) holds that the differences are merely such as to indicate unlikeness of age, not of species. In this I have no doubt Jackson is right, and accordingly all Australian material referable to *Archaeocidaris* is included here under the name proposed by Etheridge.

*Archaeocidaris selwyni

Archaeocidaris (?) *selwyni* Etheridge, 1892. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pt. 2, p. 67; pl. 15, figs. 1–3; pl. 22, fig. 1.
Archaeocidaris selwyni Lambert and Thiéry, 1910. Ess. nomen. éch., fasc. 2, p. 125.
Jackson, 1912. Phyl. ech., p. 447.

This was a large sea urchin, having the test fully 115 mm. in diameter at ambitus. Additional material is badly needed, as no spines are known. It is the only Paleozoic echinoid from Australia, and has been found only in the Upper Marine series of the Permocarboniferous of New South Wales; first at Nowra, Shoalhaven River, County St. Vincent, and again at a point 5 miles south of West Maitland, County Northumberland. The second specimen was smaller than the first, and owing to differences in the shape of the plates, Etheridge thought they represented a second species, but Jackson thinks the difference is simply a matter of age.

Order CIDAROIDA

This small but important order contains only a single family, a large and easily recognized group, for the primary spines are much larger than the secondaries, and there is but 1 to a plate. The species are commonly of moderate or large size and of conspicuous appearance.

Family CIDARIDAE

This large and widely distributed family contains more than 120 species now living, and the extinct forms referred to it are legion. Many of the latter are, however, based on isolated primary spines, and their validity is open to serious question. In Australia, 9 genera and 26 species are recorded; 3 of these genera lack Recent species in Australian seas, and of the 26 species 9 are extinct and known only from Australia and from scanty material. The 9 genera are to be distinguished thus when Recent material is in hand:

Key to the Genera of Cidaridae

A. Pores horizontal or nearly so, distant; surface of interval flat or with groove connecting pores, never elevated:

B. Primary spines cylindrical or terete, sometimes with longitudinal series of small serrations but never with thorns, or projecting ridges, or spotted collar; if subambital primaries are flaring at tip, they are very stout, only 3–7 times as long as thick; large globiferous pedicellariae very rare or wanting ..... *Phyllacanthus*

BB. Primary spines with more or less numerous projecting thorns or ridges, at least near base or near tip, or with spotted collar; or if relatively smooth, and collar unspotted, some subambital spines are flaring at tip but are 9–12 times as long as thick:

Interambulacral areas very wide, densely covered with minute tubercles bearing miliary spines or small globiferous pedicellariae; primary spines with large thorns or ridges ..... *Chondrocidaris*

Interambulacral areas not conspicuously widened and not densely clothed with miliaries and small pedicellariae; primary spines very diverse but not as in *Chondrocidaris* ..... *Prionocidaris*

AA. Pores near together, more or less oblique, often separated by elevation, never connected by shallow groove:

C. Globiferous pedicellariae present:

D. Ambulacra not very wide, about one-third of interambulacra or less; median ambulacral and interambulacral areas without bare depressed pits, lines, or areas:

E. Large globiferous pedicellariae with conspicuous end tooth ..... *Cidaris*

EE. Large globiferous pedicellariae without conspicuous, single end tooth:

F. Large globiferous pedicellariae with tips of valves turned inward, with large terminal opening and no end tooth:

Primaries short, usually about equal to test diameter, rather stout, often very stout and even swollen; areolae little or not sunken; actinostome generally larger than abactinal system ..... *Eucidaris*

Primaries 1–3 times test diameter, more or less slender and pointed, sometimes prickly, or even thorny or ridged; areolae more or less deeply sunken; actinostome generally smaller than abactinal system .... *Stylocidaris*

FF. Large globiferous pedicellariae with straight valves and small terminal opening ..... *Stereocidaris*

DD. Ambulacra very wide, 35–55 per cent of interambulacra; in both areas, more or less evident development of sunken, bare pits, spaces, or lines along sutures ..... *Goniocidaris*

CC. No globiferous pedicellariae; primary spines long, straight, usually cylindrical, often thorny, more or less white and shining (unless stained) ..... *Histocidaris*

Obviously the above key is worthless for fossils, which often lack spines and almost never have pedicellariae. Moreover, specific names have been given in certain cases to spines alone. As a result it is impossible to make a key which will cover both Recent and fossil forms. As regards the Australian Cidaridae, however, the problem is solved by the invaluable report on "The Cainozoic Cidaridae of

Australia" by Chapman and Cudmore (1934). The clarity of both text and figures in this paper makes the identification of nearly all extinct Australian Cidaridae a simple matter. The one exception is *Cidaris comptoni* Glauert, which, being from Cretaceous strata, is not included in Chapman and Cudmore's paper. There were no spines connected with Glauert's unique type, but he says that spines from the same strata might be referred to *Cidaris, Dorocidaris,* or *Typocidaris.* There is no reason, then, why his reference of his specimen to *Cidaris* should be questioned, save that all the living species of that genus occur in the Atlantic and the presence of the genus in the Australian Cretaceous seas is improbable. His figure resembles rather closely a *Stylocidaris,* and it is more likely that the species belongs in that genus, but the test alone will not serve to determine the point. As Mortensen (1928*a*, p. 288) has well said, "We may, or rather must, go on designating such fossil forms as Cidaris." Hence the presence of the name *Cidaris* among the Australian Cidaridae.

PHYLLACANTHUS

Brandt, 1835. Prodr. descr. anim., p. 67.

Genotype: *Cidarites* (*Phyllacanthus*) *dubia* Brandt, 1835, p. 68.

Mortensen (1928*a*) recognizes 6 species in this genus, 5 of which occur in Australia. Chapman and Cudmore (1934) add a sixth species to the Australian list, but it is known only as a fossil. It is, however, well characterized by its unusually broad and finely tuberculated interambulacral areas. The species are all large and characteristically rigid. The long, stout primary spines serve presumably as a protection against attacks from fishes and other predators, but they are also of use in very sluggish locomotion and in holding the animal rigidly in place in nooks and hollows of coral reefs and among rocks. Only a single species (*imperialis*) is widespread in the Indo-Pacific region (including tropical Australia); it does not range east of Tonga, but extends northward to the Ryukyu Islands. The type species (*dubia*) is known as yet only from the Bonin Islands. The remaining 4 species are all peculiar to Australia and occur on all sides of the continent.

Key to the Species of Phyllacanthus

A. Coronal plates of adults (50–70 mm. h.d.) 6 or 7 in each column:
  B. Primary spines short, normally less than test diameter:
    Interambulacral median areas very wide and closely covered with small tubercles; extinct ..... *duncani*
    Interambulacral median areas not wider than entire ambulacrum ..... *imperialis*
  BB. Primary spines, as a rule, considerably longer than test diameter, rather slender, and usually tapering somewhat ..... *longispinus*
AA. Coronal plates 8–10:
  C. Oral primaries flaring at tip ..... *magnificus*
  CC. Oral primaries not flaring:
    Spinelets on apical system pointed; marginal series of ambulacral tubercles more or less irregular ..... *irregularis*
    Spinelets on apical system broad and scalelike; marginal ambulacral tubercles very regular, of uniform size ..... *parvispinus*

*Phyllacanthus duncani

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 131; pl. 12, figs. 7–9; pl. 15, fig. 33.

Fragmentary specimens and spines of this big sea urchin are found in the rocks of Victoria, Tasmania, South Australia, and southern Western Australia, in rocks of Upper Oligocene and Lower Pliocene age. The notably wide and finely tuberculated interambulacral areas suggest that it is not a primitive member of the genus. It seems to be somewhat nearer to the widespread species *imperialis* than to any one of the other Australian species of the genus, but in the broad, finely granulated interambulacral areas it is strikingly suggestive of the Western Australian species *magnificus*.

Phyllacanthus imperialis

Cidarites imperialis Lamarck, 1816. Anim. sans vert., vol. 3, p. 54.
Phyllacanthus imperialis Brandt, 1835. Prodr. descr. anim., p. 68.
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 504; pl. 54, fig. 4; pl. 57, fig. 3; pl. 74, fig. 6; pl. 88, figs. 4–10.

This is the widespread species of the genus, ranging from Zanzibar and the Red Sea on the west to the Ryukyu and Tonga islands on the east. It is fairly common at the Murray Islands, but its favorite habitat (on the outer side of the reef below low-water mark) is rather inaccessible, so that specimens are not easily obtained save by a diver. It has been taken elsewhere in the Torres Strait region, but is replaced west of that area by the following species. It reaches a large size, 80 mm. h.d., with spine length somewhat less, or the longest spines may be somewhat more. The general color is very dark purple with the primaries lighter and often with a greenish tint; in many cases some or all of the primaries have one or more light rings (yellowish or whitish) of considerable breadth near the tip, but the number, width, and position of these show great diversity. Döderlein and Mortensen have suggested varietal or "form" names for individuals showing or lacking such color bands, but there seems to be neither constancy nor consistency in the matter, and the material at hand does not warrant using special names. Between Torres Strait and Moreton Bay, southern Queensland, there are no records of *Phyllacanthus,* which would seem to indicate that the ranges of *imperialis* and *parvispinus* do not meet on the eastern Australian coast—"important, if true."

Phyllacanthus longispinus

Mortensen, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 9, p. 4; pl. 1; pl. 2; pl. 3, fig. 2; pl. 5, fig. 15.
——— 1928*a*. Mon. Ech., vol. 1, p. 517; pl. 63, figs. 7, 8; pl. 74, fig. 9.

This is the species occurring on the northern coasts of Australia, its known range being from Port Essington, on the Coburg Peninsula, to Cape Jaubert, northwestern Australia. The largest specimen is 90 mm. h.d., with the longest spine scarcely exceeding the diameter. The primary spines are so obviously more slender and tapering than in *imperialis* that the two species need not be confused. Even the largest specimens live in crevices in masses of coral (see H. L. Clark, 1938, p. 374).

Phyllacanthus magnificus

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 158; pl. 26, upper fig. (inverted).
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 518; pl. 61, fig. 2; pl. 62.

This fine species is known as yet only from the 2 specimens taken by the "Endeavour" in her trawling between Fremantle and Geraldton, Western Australia, in 19–120 fms. The larger was 92 mm. h.d. and 72 mm. v.d., with the longest primary about 75 mm. long. The actinal primaries are conspicuously short and stout with flaring tips. The general color of the test and its minor appendages is deep red-brown; young primaries and the collar of large ones, yellow-brown; mature primaries dark, with an evident purplish-red shade, but covered for the most part with bryozoa, sponges, and other organisms.

Phyllacanthus irregularis

Mortensen, 1928. Vidensk. Medd., vol. 85, p. 74.
——— 1928*a*. Mon. Ech., vol. 1, p. 520; pl. 58; pl. 59; pl. 60; pl. 61, fig. 1.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 372.

This is the largest and apparently the most variable (or diversified) species of the genus, and the name chosen by Mortensen is doubly appropriate. Fully grown specimens are 110 mm. h.d., 70–73 mm. v.d., and have primaries 50–70 mm. long. The usual color is a dark purplish brown, but the primaries are generally of different tint, sometimes lighter, sometimes darker. A young specimen in the Perth Museum is yellowish brown orally, becoming purplish brown apically. The aboral primaries are dull purple with a narrow encircling band near the middle, and the neck, light; the collar is dull brown.

The range of *irregularis* is from Fremantle and Rottnest Island, Western Australia, to Port Willunga, South Australia, along the southwestern and southern coasts of the continent. There is much individual diversity, particularly in the length and form of the primary spines, but the acute or acuminate miliaries are generally diagnostic. Cotton and Godfrey (1942, p. 216; pl. 12) have recognized the South Australian form as a subspecies of *irregularis* to which they have given the name *kimberi*. This may be desirable if the slight distinguishing features prove to be constant.

Phyllacanthus parvispinus

Tenison-Woods, 1879. Proc. Linn. Soc. N. S. Wales, vol. 4, p. 286; pl. 14 (the feminine form *parvispina* was the original spelling).
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 513; pl. 63, figs. 1–3; pl. 64, fig. 3.

The question of distinguishing the Port Jackson *Phyllacanthus* from *imperialis* is debatable, but in view of the wide gap along the Queensland coast which separates the known ranges of the two forms, it is reasonable to follow Mortensen's lead and treat them as distinct species. It will not be surprising, however, if larger series of specimens prove their intergradation.

The Port Jackson form is best known from the coast of New South Wales in the region north of Cape Howe, but it is said to occur in Tasmania and at Moreton Bay in southern Queensland. The record from the Kermadec Islands is accepted by Mortensen, but that from Lord Howe Island he properly rejects. It is now very

sure that the large cidarid from Lord Howe is *Prionocidaris australis* and not a *Phyllacanthus* at all.

The differences between *parvispinus* and *irregularis* of southwestern Australia seem to be fairly obvious and quite constant. The southeastern species does not reach so large a size as *irregularis,* 92 mm. being the maximum diameter given by Mortensen. There are no constant and reliable differences in color.

CHONDROCIDARIS

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 18.

Genotype: *Chondrocidaris gigantea* A. Agassiz, 1863, p. 18.

This is an old, rare, and widespread genus known today from Mauritius, Sumatra, the Loyalty Islands, Samoa, and Hawaii, but only a dozen specimens of the 2 recognized species are to be found in all the museums of the world. In various places (Madagascar, India, Java) spines of fossil cidarids have been found that resemble those of *Chondrocidaris gigantea* more or less. Similar spines, associated with tests, justifying reference to this genus, have been found in Australia.

*Chondrocidaris clarkii

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 141; pl. 13, figs. 15–17; pl. 15, fig. 31.

If the spines figured were really associated in life with the smaller of the types, there is justification for placing the species in *Chondrocidaris,* for the ridges and projections on them are indeed similar to those shown in the type species of that genus, and the broad, closely tuberculated interambulacra confirm the association. All the material has been obtained in the Murray River valley in Victoria, more particularly from the cliffs at Morgan and at Overland Corner, in Upper Oligocene to Miocene strata. The larger test (from below Overland Corner) was 62 mm. h.d. and 33 mm. v.d.; the one from Morgan was only 36 mm. h.d. The Recent species of *Chondrocidaris* are not much larger than this (50–85 mm. h.d.), but the spines are so much stouter as to raise the question of the actual relationship of the Australian and the Indo-Pacific forms. Until much more material is available, however, the matter may rest as it is.

PRIONOCIDARIS

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 18.

Genotype: *Cidarites pistillaris* Lamarck, 1816, vol. 3, p. 55.

This genus was soon disavowed by its founder, but was revived by Mortensen (1909), and in the light of our present-day knowledge seems a relatively natural group. It is made up of half a dozen species ranging throughout the Indo-Pacific region from East Africa to Hawaii. The species of which many specimens are known show great diversity in the character of the primary spines but remarkable constancy in some detail of color, which serves to define the species. They are all of moderate size and shallow-water habitat. In the Australian region we find 5

species, 1 of which is now extinct and another is so common and so diversified in the character of the primary spines that it seems permissible at least to recognize several nominal varieties.

Key to the Species of Prionocidaris

A. Spinelets and projections on primary spines not arranged in whorls, sometimes wanting:
  B. Collar of primaries more or less conspicuously spotted; in extreme cases only a few spots present, many collars having no spots:
    Spots on collar white ..... *australis*
    Spots on collar purple, violet, or crimson ..... *baculosa*
  BB. Collar of primaries not spotted:
    Coronal plates large and few, 7 in a specimen 75 mm. h.d.; primary spines long and thorny; extinct ..... *scoparia*
    Coronal plates more numerous, 9–11 in specimens 70–75 mm. h.d.; primary spines short and thorny or long, more or less slender, with spinelets or thorns at base or at tip or throughout or often wholly wanting ..... *bispinosa*
AA. Spinelets and projections on primary spines arranged in several conspicuous whorls ..... *verticillata*

Prionocidaris australis

Phyllacanthus australis Ramsay, 1885. Cat. Ech. Australian Mus., pt. 1, p. 44; pls. 1, 1*a*, 1*b*.
Prionocidaris australis H. L. Clark, 1916. "Endeavour" rept., p. 97.
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 456; pl. 52; pl. 53, fig. 12.

This fine species is characteristic of the southeastern coasts of Australia from Fraser Island, Queensland, to Bass Strait. It also occurs at Lord Howe Island, the only cidaroid as yet known occurring there. It ranges up to 70 mm. h.d.; the primary spines show considerable diversity in relative length, which ranges from less than the test diameter to more than twice that. It is a strikingly handsome species, as is shown in Mortensen's splendid plate 52. There is considerable diversity in color, but the secondary and abactinal spines are commonly red, very bright in life. The white spotting of the collar of the primaries is noticeable. The color of the primaries themselves is deep brown, becoming more and more grayish or completely obscured with the development of the coating of anastomosing cortical hairs and of the barnacles, bryozoa, sponges, and other zoological specimens which tend to settle upon them.

Prionocidaris baculosa

Cidarites baculosa Lamarck, 1816. Anim. sans vert., vol. 3, p. 55.
Prionocidaris baculosa Mortensen, 1909. Ech. Deutsch. Südpolar-Exped., p. 50.

The remarkable diversity shown in the length, form, and character of the primary spines by this common and widespread species of the Indian Ocean and East Indies has been the source of much confusion, which has, however, been well cleared up by Mortensen (1928*a*). The only justification for including the species in the Australian fauna is the occurrence of an extreme variety in the coastal waters of Western Australia, south of 28° S. This variety is distinguished by its long, more

or less banded, and nearly or quite smooth (that is, without thorns or spinelets) primaries, and narrow, light-colored secondaries with a brown median stripe. A similar but less extreme form was recognized by Lamarck as a distinct species, and the essential synonymy is as follows:

Cidarites annulifera Lamarck, 1816. Anim. sans vert., vol. 3, p. 55.
Prionocidaris baculosa var. *annulifera* H. L. Clark, 1923*a*. Jour. Linn. Soc. (Zool.), vol. 35, p. 248.
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 443 (pp. 437–438 for full synonymy); pls. 45, 46.
Prionocidaris bispinosa var. *laevis* H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 371; pl. 26, fig. 1.

Only 2 authentically Australian specimens of this handsome sea urchin seem to be known, and both are in the Museum of Comparative Zoölogy. The larger, 56 mm. h.d., collected near Garden Island, Fremantle, Western Australia, in 1914, was presented to the Museum by E. W. Bennett. As most of the primaries had unspotted collars, this specimen was identified as *Prionocidaris bispinosa,* but owing to its striking peculiarities, it was named as a new variety, *laevis*. Recently, comparison with the specimen, 49 mm. h.d., taken by Dakin at the Abrolhos Islands, identified (H. L. Clark, 1923*a*, p. 248) as *P. baculosa* var. *annulifera,* has brought out the fact that the two are identical. The name *laevis* had therefore better be discarded for the present, but should further collecting on the coast of Western Australia demonstrate that all the *baculosa* of that area have the primary spines as smooth as in these specimens, those of the lower mid-zone conspicuously expanded at the tip, the general coloration as light, and the collars sparsely (or not at all) spotted with crimson, there would be adequate ground for maintaining the varietal name *laevis*.

*Prionocidaris scoparia

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 134; pl. 12, figs. 10, 11; pl. 15, figs. 28–30.

This interesting species has been found at several localities in Victoria and South Australia in strata from the Upper Oligocene to the Miocene. The well preserved specimen figured is 75 mm. h.d. and 64 mm. v.d. The primary spines are more or less cylindrical and thorny. They apparently may exceed the test diameter.

Prionocidaris bispinosa

Cidarites bispinosa Lamarck, 1816. Anim. sans vert., vol. 3, p. 57.
Prionocidaris bispinosa Döderlein, 1911*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 34, p. 240.
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 468; pl. 44, fig. 2; pl. 47, fig. 1; pl. 53, figs. 1–3.

This fine sea urchin is very common on the northwestern coast of Australia, particularly in the vicinity of Broome. Mortensen considers its "centre of distribution" to be in the "Java-Philippine and Moluccan seas," but it ranges as far west as Ceylon and as far south as Port Denison, Queensland. It was taken by the "Challenger" in Torres Strait, but A. Agassiz listed the specimens as *Phyllacanthus annulifera*. Along the northern coast of Australia it is found as far to the southwest as Shark Bay and even the Abrolhos Islands. It reaches a considerable size (78 mm.

h.d.) and shows an astonishing diversity in the length and character of the primaries, and to a lesser degree in coloration. Mortensen's admirable account (1928*a*, pp. 468–475) should certainly be consulted. He lists 5 named varieties, all of which occur on the Australian coast. Briefly, they are as follows:

1. Var. *ramsayi* Döderlein, from Queensland, has the primary spines distinctly more than h.d., slender, not tapering, with thorns only near the widened, crown-shaped tip.
2. Var. *chinensis* Döderlein, from the China Sea, but also occurring on the coast of Western Australia as far south as the Abrolhos Islands, has the primaries long and tapering, without thorns or with a few long thorns near the tip.
3. Var. *aruana* Döderlein, from the Aru Islands and from Augustus Island, northern Western Australia, has very long primaries (up to 3 times h.d.) with few or no thorns, but the tip may be expanded into a small crown.
4. Var. *elegans* Mortensen, from northwestern Australia, has very short primaries (two-thirds h.d.) and white secondaries with a sharply limited red-brown mid-line.
5. Var. *nigro-brunnea* Mortensen, from Cape Jaubert and Shark Bay, has the secondary spines (at least those surrounding the primaries) very dark, sometimes "almost black," and the primaries "more or less dark violet," about equal to or less than h.d. Somewhat similar specimens occur also on the Queensland coast.

Though these varieties are interesting as showing the possibilities of diversity within a single species, they are, as Mortensen says, "of very little real value." That is, they do not seem to be correlated with any particular geographical or ecological factors and presumably they do not "breed true." As stated above (p. 286), the variety *laevis* named by me in 1938 is better regarded as an extreme variant of *baculosa* var. *annulifera*.

Prionocidaris verticillata

Cidarites verticillata Lamarck, 1816. Anim. sans vert., vol. 3, p. 56.
Prionocidaris verticillata Döderlein, 1911*a*. Abhandl. Senckenb. Naturforsch. Gesellsch., vol. 34, p. 242.
Plococidaris verticillata Mortensen, 1909. Ech. Deutsch. Südpolar-Exped., pp. 51, 53.
——— 1928*a*. Mon. Ech., vol. 1, p. 428; pl. 51, figs. 3–7.

Mortensen (1928*a*, p. 433) says this sea urchin is "distributed all over the Indo-Pacific region from Zanzibar . . . [to] Samoa (also recorded from Hawaii) and from Japan . . . to the Australian East coast (exact localities unknown)." The Hawaiian record is dubious, and the Australian report was supported only by A. Agassiz's brief statement (1881, p. 40) that the "Challenger" took *verticillata* at her station 186 in Torres Strait. No specimen of the "Challenger" 's collecting was in the British Museum in 1924. The Barrier Reef Expedition, however, took a fine specimen on the Low Isles reef in 1929 (H. L. Clark, 1932, p. 211). The species is small, with 30–40 mm. as the maximum horizontal diameter. The color is generally definitely green, but this shade may be obscured by gray or brown, and in some specimens at least there are indications of red and yellow shades. In spite of its wide distribution, specimens are not common, and good series will probably reveal considerable diversity in color. At present, *verticillata* must be considered one of the rarest of Australian echini.

As I pointed out in 1932, the name *Plococidaris*, in the use of which Mortensen persists, is untenable, as it is a pure synonym of *Prionocidaris*. The author of a genus has no more right to change the type species after publication than has any

other writer. The name *Plococidaris* is also superfluous, as *verticillata* is merely a *Prionocidaris* with an unusually constant type of primary spines. The other supposed characters are too trivial and too much dependent on size, age, and condition of the specimen to warrant giving them generic weight.

CIDARIS

Leske, 1778. Add. ad Klein, pp. xvii, 61.

Genotype: *Cidaris papillata* Leske, 1778, p. xvii = *Echinus cidaris* Linné, 1758, p. 664 (as limited in 1761, p. 513).

It is extremely doubtful whether this genus, as typified by the Recent species, really occurs in Australia, but the species assigned to it by Glauert may for the present remain therein. Possibly further and better material may warrant giving it a different generic status, but, as stated above (p. 281), until such material is available we must continue to use the inclusive name *Cidaris*.

*Cidaris comptoni

Glauert, 1923. Jour. Roy. Soc. W. Australia, vol. 9, pt. 1, pp. 48–52; pl. 3.

The type specimen is incomplete, but was apparently about 35 mm. h.d. and 20 mm. v.d. The large scrobicular areas, the coarse tuberculation, the elevated, narrow interporiferous areas, and the depressed, zigzag, narrow areas between the columns of interambulacral tubercles are distinctive features. This specimen was found in the chalk of the Gingin beds, Western Australia. Apparently no spines were definitely associated with it, but numerous spines, "quite in accord with those of the genus Cidaris," have been found in the same Cretaceous beds, and some at least of these probably represent the same species as the test. Obviously more material is much to be desired.

EUCIDARIS

Pomel, 1883. Class. méth. éch., p. 109.

Genotype: *Cidarites metularia* Lamarck, 1816, vol. 3, p. 56.

This is an interesting little genus, widespread in the tropics but barely entering the Australian region. The number of species included depends on the degree of differentiation which is allowed in those recognized. Mortensen (1928*a*) accepts 4 and a variety which he considers may well be accepted as a fifth. In my judgment, this is a rather extreme grouping and makes too little allowance for the normal diversity within a species. There are 3 well marked forms occurring in well separated areas, 1 in the Atlantic, 1 in the eastern tropical Pacific, and 1 in the vast Indo-Pacific area. The last is said to occur in Australia. Typical examples of a fourth species occurring at St. Helena and Ascension in the southeastern Atlantic are very striking and seem to justify recognition of *clavata* Mortensen.

Eucidaris metularia

Cidarites metularia Lamarck, 1816. Anim. sans vert., vol. 3, p. 56.
Eucidaris metularia Döderlein, 1887. Japan. Seeigel, p. 42.
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 386; pl. 41, figs. 1–8.

This small and usually pretty cidarid has a very wide range, from Mozambique on the west to Hawaii on the east, north to the Gulf of Suez and southern Japan, and south to the shoals of northern Australia. The actual occurrence on the Australian coast seems to be open to question. I have seen no Australian specimens save in the British Museum, and the only specimens there with definite locality are from Evans and Flinders banks off the northwestern coast. We found none in the Broome region, and Bardwell did not find any farther east at Augustus and Champagny islands. Specimens more than 30 mm. h.d. are not common, and the longest primaries do not often exceed the test diameter. In young specimens, the colors are usually red and white (often a bright, light red) with the spines distinctly banded. With growth, the red becomes more and more purplish brown and the light shades more gray, yellowish, or dusky, so that the adults are not nearly as pretty as the young.

STYLOCIDARIS

Mortensen, 1909. Ech. Deutsch. Südpolar-Exped., p. 52.

Genotype: *Cidaris affinis* Philippi, 1845, p. 351.

This large and widely distributed genus is represented in Australia by but 2 species, quite unlike each other in appearance and in the region they inhabit. They may be easily distinguished thus:

Collar of primaries with red spots ..... *bracteata*
Collar of primaries unspotted ..... *conferta*

Stylocidaris bracteata

Dorocidaris bracteata A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 197.
Stylocidaris (?) *bracteata* Mortensen, 1909. Ech. Deutsch. Südpolar-Exped., p. 52.
——— 1928*a*. Mon. Ech., vol. 1, p. 359; pl. 39, figs. 1–6.

This is a handsome East Indian sea urchin which was taken by the "Endeavour" between Fremantle and Geraldton, Western Australia, in June 1912, in 60–100 fms. Two specimens, each 35 mm. h.d., were obtained. The primaries are about 50 mm. long, somewhat flattened near the base, where they are 4 mm. wide, with prominent dentate ridges, and longitudinal series of red-brown spots, especially on the collar. No other Australian specimens are as yet known, but more extensive dredging off northwestern Australia in moderately deep water will probably show that the range is continuous from Amboina to Geraldton.

Stylocidaris conferta

Cidaris conferta H. L. Clark, 1916. "Endeavour" rept., p. 100; pl. 38.
Stylocidaris conferta Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 351; pl. 37, figs. 3–7.

Known as yet only from rather deep water (80–260 fms.) off the southeastern corner of Australia, this well marked species would seem to be endemic. It was taken twice by the "Endeavour" and twice by Mortensen (1914), and Mortensen (1928*a*) reports other specimens from off Port Jackson in 250 fms. It reaches 45 mm. h.d., with the primary spines 60–70 mm. long. There is apparently considerable diversity of color, ranging from white to yellowish brown or dull reddish; secondary

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spines usually with a longitudinal line of some dull shade; primary spines more or less white, with a yellow-brown collar. In young primaries there may be 2 or 3 narrow reddish bands, but fully grown spines usually lack them.

STEREOCIDARIS

Pomel, 1883. Class. méth. éch., p. 110.

Genotype: *Cidaris cretosa* Mantell, 1835, p. 205.

This is a large genus, notable for the fact that it has an exceptional geological range, including species long since extinct, as well as more than a dozen species and several named varieties occurring in Recent seas. The earliest species are found in the Cretaceous and Eocene strata. The Recent species are nearly all found in the Indo-Pacific, more particularly in its western half. None has yet been found in Australian seas, but the following species has long been known from Tertiary deposits of Victoria and South Australia.

*Stereocidaris australiae

Leiocidaris australiae Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 45; pl. 3, figs. 1, 2.
Cidaris (*Stereocidaris*) *australiae* Tate, 1898. Jour. Roy. Soc. N. S. Wales, vol. 31, p. 411.
Stereocidaris australiae Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 127; pl. 1; pl. 2, figs. 1–3, 5–6*b*; pl. 15, figs. 32*a*, 34–36*c*.

Considerable material of this interesting species, apparently a typical *Stereocidaris*, has been collected at several points in Victoria and South Australia, ranging from Upper Oligocene to Miocene. Large specimens were apparently nearly 40 mm. h.d. in life, and the height was definitely more than half as much. The primary spines were nearly or quite twice the test diameter. Chapman and Cudmore have given a full account of this cidarid, but their figure 4, plate 12, is not the test of a *Stereocidaris*. It is much more like *Stylocidaris* and probably represents an undescribed species of that or a related genus. It also seems improbable that all the spines which they assign to this species are really referable to *Stereocidaris*. I am particularly skeptical about those shown in figure 36 of plate 15.

GONIOCIDARIS

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 337.

Genotype: *Cidarites tubaria* Lamarck, 1816, vol. 3, p. 57.

Few genera among echini have caused so much discussion among students of the group as has this East Indian genus of Cidaridae. It ranges from Japan to New Zealand and Tasmania, but half of the 14 Recent species recognized by Mortensen (1928*a*) are known only from the East Indies. Of the species here included as Australian, 4 are known only from fossil remains, and their relation to the 2 Recent species is still in need of critical study, especially since one of these two is the type of the genus and shows great diversity in both test and spines. A single Recent species is known from New Zealand, and Mortensen has seen a badly damaged sea urchin from South Africa which is apparently a *Goniocidaris*. The Australian forms may be distinguished as follows, but the lines are hazy and require further elucidation.

KEY TO THE SPECIES OF GONIOCIDARIS

A. No basal disk on primary spines; secondary spines rather thick and more or less clavate; no green on test:
  B. Large (up to 60 mm. h.d.), with conspicuous bare sunken areas on test, vertical or horizontal or both, and often pits at corners of plates; spines very diversified, usually coarse, thick, more or less thorny:
    C. Poriferous areas sunken, and "longitudinal ridge of tubercles marginal" to them very pronounced; primary spines not very thorny, "often terminating in tiny, cup-shaped flares"; extinct ..... *mortenseni*
    CC. Not as above:
      A conspicuous broad, vertical bare area in both ambulacra and interambulacra ..... *tubaria*
      No bare vertical areas, narrow horizontal areas often forming ladder-like columns ..... *tubaria* var. *impressa*
  BB. Smaller, not over 30 mm. h.d.; primary spines less stout:
    D. No bare areas on test, though median interambulacral sutures are sunken; extinct ..... *prunispinosa*
    DD. Narrow, sunken median vertical bare areas in both ambulacra and interambulacra:
      Bare areas of interambulacra more or less ladder-like; extinct ... *murrayensis*
      Bare areas of interambulacra not ladder-like; extinct ..... *pentaspinosa*
AA. Basal disk on primary spines more or less developed (at least on some spines); secondary spines flattened; more or less green on upper half of test ..... *australiae*

*Goniocidaris mortenseni

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 139; pl. 14, figs. 23, 27.

This species, obviously close to the common living species *tubaria,* is based on test fragments and spines from the Lower Pliocene rocks of Aldinga, South Australia. For stratigraphical purposes, it may be well to accept the species, but sufficient well preserved material would probably show that the specific characters are hardly sufficient to warrant separation from *tubaria.*

Goniocidaris tubaria

Cidarites tubaria Lamarck, 1816. Anim. sans vert., vol. 3, p. 57.
Goniocidaris tubaria Lütken, 1864. Vidensk. Medd. (1863), p. 137.
McCoy, 1885. Prodr. zool. Victoria, dec. 10, p. 33; pl. 100 (colored).
Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 156; pl. 12, figs. 1–7.

This, the largest species of the genus, is a common urchin in shallow water along the coasts of New South Wales, Victoria, South Australia, and Tasmania. Its range extends to southwestern Australia, even north of Fremantle, but it is not common along that coast, and specimens in the British Museum labeled from "northwestern Australia" do not justify the conclusion that it occurs north of Geraldton. Mortensen's (1918) record of 2 specimens from "Cape Jaubert" is to me incredible, and must be due to a misplaced locality label; his later statement (1928*a,* p. 160) that *tubaria* "appears to be distributed all round Australia except probably the North Coast"

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gives an erroneous idea of its distribution, for it is distinctly a southern form and avoids the warmer coasts north of 28°. Its absence from Lord Howe Island is worthy of note. It occurs most commonly in depths of 10–80 fms., but is sometimes found along shore and occasionally down to depths of 150 fms. When fully grown the test is 50–60 mm. h.d., and the spines show great diversity in length, stoutness, and thorniness. The colors are usually dull shades of gray, brown, and red, but show much diversity. Some individuals are quite handsome. Another feature which shows extraordinary diversity is the degree to which the ambulacra and interambulacra are devoid of small tubercles. Ordinarily they are quite bare, at least in the median areas, but often they tend to be more or less covered except along the horizontal sutures. Extreme examples look very unlike typical specimens; they were long regarded as a distinct species and were called "*geranioides* Lamarck." Mortensen (1928*a*) has shown, however, that Lamarck's "*geranioides*" is unrecognizable but was not a cidarid; hence the name can no longer be used. Instead, a specific name proposed by Koehler has been adopted by Mortensen as a valid varietal name and is therefore the proper one to be used, if the form is recognized at all. The essential synonymy is as follows. References prior to the "Revision of the Echini" are omitted.

Goniocidaris geranioides A. Agassiz, 1872*a*. Rev. ech., p. 131; pl. 1*g*, figs. 3, 4 (NON *Cidarites geranioides* Lamarck, 1816, vol. 3, p. 56).
Goniocidaris impressa Koehler, 1926. Ech. Australasian Antarct. Exped., p. 24; pls. 91, 92.
Goniocidaris tubaria var. *impressa* Mortensen, 1928*a*. Mon. Ech., vol. 1, p. 163; pl. 12, figs. 8, 9.

In its extreme development this is an easily recognized sea urchin. It is most frequent in Bass Strait and on the Tasmanian coast, but occurs as far west as St. Francis Island and Kangaroo Island, South Australia. It is not yet reported from New South Wales or Western Australia. The genus *Adelcidaris* proposed by Cotton and Godfrey (1942) seems quite superfluous, as Mortensen's clearing up of the nomenclatural difficulties is entirely satisfactory.

*Goniocidaris prunispinosa

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 135; pl. 13, figs. 12–14.

This rather small species (29 mm. h.d.) has been found at many places in both Victoria and South Australia in Upper Oligocene to Miocene beds. It is possibly not a *Goniocidaris,* but there seems good reason for regarding it as a primitive member of the genus.

*Goniocidaris murrayensis

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 138; pl. 14, figs. 20–22.

This is a small and apparently rather rare cidarid, but the holotype is well preserved, though no spines are associated with it. It is rather less than 14 mm. h.d., and only 6.25 mm. high. It was found at the Lower Murray Cliffs in South Australia. The only other known specimens are fragments of the test found at Neumerella,[1] Longford, and Flinders, Victoria, and at Morgan, Wongulla, and

[1] An interambulacral fragment from Neumerella was previously figured (Chapman and Cudmore, 1928, pl. 11, fig. 74*g*) as *G. pentaspinosa.*

Aldinga, South Australia. No spines have yet been found. The known material is from beds of Upper Oligocene to Miocene age.

*Goniocidaris pentaspinosa

Chapman and Cudmore, 1934. Mem. Nat. Mus. Victoria, no. 8, p. 137; pl. 14, figs. 18, 19.

This is another small species, with the test less than 20 mm. in diameter and its height more than half as much. The test is described as "very depressed," which apparently means, to judge from the figure, that the upper side is flattened. The greatest circumference is thus above the equator. No complete test has yet been found. The primary spines, which have not yet been found still attached to the test, are long (they may exceed twice the test diameter), rather slender, and not thorny or irregularly spiniferous, but may show parallel series of coarse serrations near the base. The species is rather widespread and fairly common in Upper Oligocene to Miocene strata in Victoria and South Australia.

Goniocidaris australiae

Goniocidaris clypeata H. L. Clark, 1916. "Endeavour" rept., p. 102 (NON Döderlein, 1885, p. 82).
Goniocidaris australiae Mortensen, 1928. Vidensk. Medd., vol. 85, p. 68.
——— 1928*a*. Mon. Ech., vol. 1, p. 201; pl. 15, figs. 1–7.

Mortensen's opinion that Australian examples of a small *Goniocidaris,* which were referred by me to Döderlein's East Indian species *clypeata,* are not the same but represent a distinct species which he calls *australiae,* is here accepted because he has had far more experience with the perplexing small cidarids included in *Goniocidaris* than has any other worker, and his careful work and keenness of observation entitle his decisions to respect. He is, however, inclined to draw specific lines between groups which seem to me to intergrade more or less definitely, and has almost certainly recognized more species of "Goniocidarina" than exist in nature, barring of course any which have not yet been taken. The differences on which he relies to separate the 6 species of the subgenus *Aspidocidaris* are trivial and subject to great diversity. Moreover, all these forms save *australiae* are found in the seas of southern Japan and the East Indies, and fewer than 25 specimens of the 5 supposed species are as yet known. Obviously far more material is needed before their status can be determined.

Meanwhile, however, the relatively isolated (so far as we yet know) Australian form, of which more than 20 specimens seem to have been taken, may be recognized under the name *australiae.* The fact that neither Koehler (1926) nor I (1916) was able to identify all our specimens correctly, according to Mortensen's judgment, indicates how difficult it is to identify the species of *Goniocidaris* and justifies some skepticism as to the validity of some of the lines which Mortensen draws. All the material has been taken in the vicinity of Tasmania or northward to Cape Howe in 20–260 fms., a fact which indicates a relatively restricted range. The largest specimens are scarcely 25 mm. h.d., but are apparently fully mature. The longest primaries are half again as long as the test diameter and in smaller specimens may even be twice as long. The green color or tinge on the upper side of the test and on the oral primaries is apparently quite a constant character.

HISTOCIDARIS

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 22.

Genotype: *Porocidaris elegans* A. Agassiz, 1879, p. 198.

Like the preceding, this genus finds its chief center of distribution in the East Indies and ranges from southern Japan to southeastern Australia. It occurs also in the eastern tropical Pacific and in the West Indies, but seems to be local and uncommon, and specimens are rare. As in the case of *Goniocidaris,* Mortensen (1928*a*) has multiplied the species on the basis of relatively little material. Of the 14 species he recognizes, he is the author of 8, and of all these together only 13 specimens are known; 6 are known from only a single specimen of each. He records only 3 from Australian seas, and distinguishes these as follows:

Key to the Species of Histocidaris

A. Primary spines uniformly serrate:
  Primary spines slender, cylindrical ..... *elegans*
  Primary spines thick, fusiform ..... *crassispina*
AA. Primary spines of aboral side with scattered larger thorns mainly in basal part ..... *australiae*

All the material known of these 3 forms was collected off the southeastern corner of the continent in 80–410 fms., probably below 150 fms. in all cases. The conditions here are such that there is no reason to suspect any environmental difference leading to specific differentiation in such an animal as *Histocidaris.* I feel very sure that the collection of any considerable number would show intergradation between these forms, but in deference to Mortensen's authority, I list the 3 supposed species here.

Histocidaris elegans

Porocidaris elegans A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 198.
Histocidaris elegans Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 2.
——— 1928*a*. Mon. Ech., vol. 1, p. 72; pl. 1, figs. 1–5; pl. 2.

This very striking sea urchin was first taken by the "Challenger" at her station 164b, off the coast of New South Wales, south of Sydney, in 410 fms. It was subsequently taken by the "Endeavour" at the eastern end of Bass Strait in 80–300 fms., and apparently by Mortensen himself off New South Wales (referred to by him as "off Sydney"). The primary spines are (in preserved specimens) more or less white and often shining, but are said to have been yellow in life in some cases. The secondaries are brownish yellow or yellowish brown. Full-grown specimens may exceed 60 mm. h.d., and the longest primaries are nearly or quite twice the h.d.

Histocidaris crassispina

Mortensen, 1928. Vidensk. Medd., vol. 85, p. 66.
——— 1928*a*. Mon. Ech., vol. 1, p. 77; pl. 10, figs. 4, 5.

The unique holotype of this supposed species was taken by the "Challenger" at her station 164b, with the original specimens of the preceding species. Mortensen's emphasis on its distinguishing features would be more convincing if they were not

all subject to individual, as well as age, diversity, in regard to the extent of which we have not nearly sufficient material to form an opinion.

Histocidaris australiae

Mortensen, 1928. Vidensk. Medd., vol. 85, p. 66.
——— 1928*a*. Mon. Ech., vol. 1, p. 91; pl. 10, figs. 1, 2; pl. 11, figs. 1–5.

Although 5 specimens of this supposed species are known, its validity seems to me even less certain than that of the preceding form. The specimens are all large (62–75 mm. h.d.) and the primary spines are for the most part wanting or broken. It seems almost certain that were a hundred specimens of *Histocidaris* to be dredged off southeastern Australia, it would be evident that *australiae* is merely the old and probably senescent *elegans*.

Order CENTRECHINOIDA

This large and diversified order is well represented in Australian waters by more than 60 species grouped in 9 families. Only half a dozen fossil species have yet been found. The 9 families may be distinguished as indicated in the following key:

Key to the Families of Centrechinoida [1]

A. Teeth grooved (i.e., without keel or longitudinal, median ridge on concave inner surface); primary tubercles perforate; periproct with many small plates or granules or more or less leathery:
  Test more or less rigid; peristome with 5 pairs of buccal plates; other small, more fragile plates, without definite order, may also be present ..... Centrechinidae
  Test usually more or less flexible; peristome well covered with series of ambulacral plates ..... Echinothuriidae
AA. Teeth keeled on inner concave surface; primary tubercles almost always imperforate; periproct covered with 4 or 5 subequal plates, or with several to many plates, one of which (suranal) may be much the largest:
  B. Epiphyses of lantern narrow, not meeting in suture over foramen magnum:
    Periproct with permanent large suranal, or 2 or more large plates and small anal plates ..... Saleniidae
    Periproct with only 4 or 5 (rarely 3) subequal more or less triangular plates ..... Arbaciidae
    Periproct with many small plates; each group of 4 or 5 ambulacral plates in mid-zone overgrown and bound together by one large primary ambulacral tubercle ..... Stomopneustidae
  BB. Epiphyses of lantern wide, meeting in suture over foramen magnum:
    C. Pits or sculpturing in coronal plates dorsally more or less evident ..... Temnopleuridae

[1] Based largely on Jackson, 1912, pp. 202–203. It is unfortunate that the fundamental characters separating these families are found in the lantern. As a consequence, one specimen must be seriously damaged to determine the family positively; but as a rule a very little experience enables one to recognize the family from the general appearance and external characters of a specimen.

CC. No pits or sculpturing in coronal plates:
D. Ambitus circular:
Ambulacral plates with 3 (very rarely 2) elements.....Echinidae
Ambulacral plates with 4–10 elements.....Strongylocentrotidae
DD. Ambitus obliquely elliptical.....Echinometridae

Family CENTRECHINIDAE

(DIADEMATIDAE Peters, 1855, *et auct. seq.*)

This is a relatively small family of 9 or 10 Recent genera and an unknown number of extinct forms, grouped in 10 or a dozen ill defined and very incompletely known genera. None of the fossil forms are as yet reported from Australia, but 6 of the Recent genera occur in the tropical and subtropical seas. None is known from the southern coasts (Cape Howe to Cape Leeuwin) or from Tasmania.[1] All are shallow-water genera and most of them occur along shore. Owing to the large size (50–150 mm. h.d), the long, usually sharp and slender spines, and the conspicuous (often black or very dark) coloration, the Australian centrechinids are a notable group.

Key to the Genera of Centrechinidae [2]

I. Tube feet in single linear series or in arcs of 3, none with large, umbrella-like disks:
A. Test subhemispherical, rigid:
B. Primary ambulacral tubercles large, in 2 regular series; ambulacral spines not peculiar:
No spines on buccal plates.....*Centrechinus*
Numerous small spines on buccal plates.....*Centrostephanus*
BB. Primary ambulacral tubercles very small; aboral ambulacral spines very slender, retrorsely barbed distally.....*Echinothrix*
AA. Test low, more or less flattened, flexible in life:
Pore pairs on oral surface in distinct arcs of 3.....*Astropyga*
Pore pairs on oral surface in single linear series.....*Chaetodiadema*
II. Tube feet in double series, the outer series (at least aborally) with large, umbrella-like disks.....*Micropyga*

CENTRECHINUS

Jackson, 1912. Phyl. ech., p. 28.

Genotype: *Echinometra setosa* Leske, 1778, p. 36.

There is room for debate as to the type species of this important tropical genus, for whereas Jackson designates Leske's species as his type, he gives Key West, Florida, as the type locality. It is now generally agreed that the Florida *Centrechinus* is not Leske's species, so it is possible to claim that the type of the genus is *C. antillarum* Philippi. The question is purely academic, as there is not the remotest possibility that *setosus* and *antillarum* are not congeneric. It is regrettable that Mortensen persists in using the incorrect and preoccupied name *Diadema* for this

[1] Mortensen (1940, p. 325) gives the range of *Centrostephanus rodgersii* as being from "Queensland to Tasmania." There is no reliable record from Tasmania.

[2] Museum specimens commonly have the primary spines badly broken and the colors much less striking than in life. Spots and lines of blue, green, red, or white are particularly apt to be inconspicuous or altered in color in preserved material.

common and widespread genus, which is represented everywhere in the tropics wherever there are coral reefs. Owing to the large size, the black color, and the long, very poisonous primary spines, these urchins are known and dreaded by fishermen and others who have occasion to work around or collect upon the reefs and reef flats. Under favorable conditions great numbers of *Centrechinus* may be found on reef flats, sometimes flocking together regardless of protection from the tropical sun, but commonly seeking shelter beneath overhanging rocks or underneath coral heads and fragments. Two species are found on Australian reef flats, and are easily distinguished thus:

Much white around mouth; 5 conspicuous white spots on aboral surface; orange or reddish ring around anus ..... *setosus*
No white; no ring around anus ..... *savignyi*

Centrechinus setosus

Echinometra setosa Leske, 1778. Add. ad Klein, p. 36.
Centrechinus setosus Jackson, 1912. Phyl. ech., p. 28.
H. L. Clark, 1921. Ech. Torres Strait, p. 164; pl. 17, figs. 3, 4 (colored).
Diadema setosum Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 256; pls. 50, 56.

This sea urchin is a striking feature of the marine fauna along the tropical Australian coast wherever coral-reef flats are well developed, but its distribution is erratic and it is absent from some areas which would seem well adapted to it. Owing to the fact that until 1904, when Mortensen's report on echini from Siam was published, the species of *Centrechinus* were badly confused, the distribution of the now recognized species is not exactly known. The 2 Australian species sometimes occur on the same reef flat, as at Mer, Murray Islands, but apparently each species flocks by itself. The present species occurs at Lord Howe Island, but is not abundant. That is undoubtedly the southeastern limit of its range. On the western coast of the continent it has been taken at the Abrolhos Islands, which are not quite so far south as Lord Howe. Between these two extremes the distribution of *setosus* is very erratic. We did not find it at or near Port Essington or Darwin, nor at Cape Leveque or Broome, but Bardwell found it at Augustus Island, where he says "they were very plentiful in pure coral pools." On the Queensland coast, this urchin has been found at the Low Isles, at Port Molle, and at several other rather widely scattered points, in addition to Prince of Wales Island, Torres Strait, and the Murray Islands. It may be expected wherever there is luxuriant coral growth. The black color, with the sharply contrasting colored ring around the anus and the conspicuous white marks both above and below, makes the species easy to recognize in life, but in preserved specimens the white and bright-colored features are often much obscured. Young specimens have the primary spines banded with white, and the ground color has a dull reddish or purplish tint. Misidentifications are therefore very common. Full-grown specimens may be 100 mm. h.d., with primary spines sometimes twice as much.

Centrechinus savignyi

Diadema savignyi Michelin, 1845. Mag. zool., vol. 7, p. 15 of reprint.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 265; pl. 52, fig. 1.
Centrechinus savignyi H. L. Clark, 1921. Ech. Torres Strait, p. 145; pl. 17, figs. 1, 2 (colored).

The absence of white makes this species less conspicuous than the preceding, and preserved specimens have been and are frequently confused with it. The present species is generally somewhat smaller than *setosus,* but specimens 85–100 mm. h.d. have been recorded. The distribution is even less clearly delimited than is that of *setosus,* for although Dakin found *savignyi* at the Abrolhos Islands, Western Australia, there are no reliable records from elsewhere on that half of the continental coast. On the Queensland reefs, we found it at Mer much more common than *setosus,* but nowhere else in my three Australian excursions has *savignyi* been observed. The Great Barrier Reef Expedition found it, however, at the Low Isles, and Paradice collected it "between 17° and 19°S on the outer Barrier Reef." The latter is the southernmost station as yet reported on the Queensland coast. But its range in the Indo-Pacific region is enormous, from Natal and Zanzibar on the west to Easter Island on the east and north to Cape Gardafui and Japan.

CENTROSTEPHANUS

Peters, 1855. Abhandl. K. preuss. Akad. Wissensch. (1854), p. 109.

Genotype: *Cidaris* (*Diadema*) *longispina* Philippi 1845, p. 354.

This is a tropicopolitan genus of 7 or 8 species, showing great diversity in size and color but well characterized by the spines on the buccal plates. The Australian species stand somewhat apart from the others in lacking abactinal claviform spines and in having the primaries stout, unicolor, and not distinctly verticillate. They may be distinguished thus:

Primary spines very stout; genital and ocular plates with secondary tubercles but lacking larger ones ..... *rodgersii*
Primary spines much more slender; each genital and ocular plate has at least 1 definitely larger tubercle ..... *tenuispinus*

Centrostephanus rodgersii

Thrichodiadema rodgersii A. Agassiz, 1863*a*. Proc. Acad. Nat. Sci. Philadelphia, p. 354.
Centrostephanus rodgersii A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 98.
——— 1873. Rev. ech., pt. 3, p. 412; pl. 3*b*, figs. 1–3.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 320; pl. 35, figs. 6, 13–15; pl. 37, figs. 3–8; pl. 38.

One of the characteristic echini of southeastern Australia, this big sea urchin attains a test diameter of 100 mm. or more, though the stout primary spines are only two-thirds as much or even less. In very small specimens (20 mm. h.d.) the spines may be 2 or 3 times the test diameter. The color in life is a deep wine red or red-purple, almost crimson in young individuals, but becoming very dark in the full-grown adults, nearly black in poor light. A greenish iridescence may be noted in the living specimens in bright light. In very young individuals (15–25 mm. h.d.) the spines may be prettily banded with white as in young *Centrechinus,* but the bands disappear rapidly with increasing size. The favorite habitat of *rodgersii* is in the crannies and hollows of the reefs and rocks along shore, where it is frequently so well ensconced as to be inaccessible to the collector. The range of this species is as yet very imperfectly known. It is common at Port Jackson and Botany Bay,

but there are no records from south of Cape Howe, and apparently no reliable records from south of Jervis Bay. North of Sydney records are few and unsatisfactory. A young individual in the British Museum is said to be from Port Denison, Queensland, but all reports from Queensland need verification. Ramsay, who gives an interesting account (1885, p. 44) of this sea urchin, knew it only from the coast of New South Wales. It is not rare at Lord Howe Island, but may have reached there on foul ship bottoms from Port Jackson. A very small specimen, 13 mm. h.d., which we took at Lord Howe in 1932 had the spines unicolor as in the adult, a rather remarkable difference from the young ones described by Ramsay.

Centrostephanus tenuispinus

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 162; pl. 26.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 326; pl. 39, figs. 2, 3.

This is a smaller species than the preceding, and the more slender spines give it a different facies. The color in life is similar but perhaps a little more brilliant—"rich royal purple with the membranous parts a brilliant crimson" (H. L. Clark, 1938, p. 378). The largest specimen yet reported is 84 mm. h.d. So far as is now known, the range is restricted to the coast of Western Australia, between Fremantle and Geraldton. It has not yet been taken south of Fremantle, but Dakin obtained specimens at Pelsart and Long islands in Houtman's Abrolhos off Geraldton. As no *Centrostephanus* is known from either the northern or the southern coast of Australia, the isolation of *tenuispinus* would seem to be complete.

ECHINOTHRIX

Peters, 1853. Monatsber. K. preuss. Akad. Wissensch., p. 484.

Genotype: *Echinus calamaris* Pallas, 1774, p. 31.

This is an Indo-Pacific genus of only 2 species. Typical examples of the two are easily distinguished, but full-grown adults are often perplexing. Mortensen (1940, p. 295) thinks the 2 species are "very distinct," and even suggests that they might be placed in different genera. And yet, of the eight characters which he uses to distinguish them, there is none that can be relied on always to serve as distinctive. The most reliable seem to be found in the primary spines, the structure and colors of which are usually characteristic. Those of the ambulacra are sharp and barbed and very slender. They apparently secrete a strong poison, the wounds they cause being as painful as those from *Centrechinus* spines. The features of the test listed by Mortensen in his key to the 2 species are subject to too much diversity to justify complete confidence, although the smaller interambulacral tubercles of *calamaris* may be a helpful character in some cases. The 2 species often, if not generally, occur together, the geographical ranges and habitats being identical. The most reliable distinctions between them may be stated as follows:

Primary interambulacral spines distinctly verticillate, whorls close together; spines relatively brittle, inner cavity more than half diameter of spine; larger spines commonly banded ..... *calamaris*
Primary interambulacral spines distinctly striated, without whorls, relatively stout, inner cavity less than half diameter; unicolor ..... *diadema*

Echinothrix calamaris

Echinus calamaris Pallas, 1774. Spic. zool., vol. 1, pt. 10, p. 31.
Echinothrix calamaris Peters, 1853. Monatsber. K. preuss. Akad. Wissensch., p. 485.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 285; pl. 39, fig. 1; pl. 40; pl. 41; pl. 42; pl. 43, fig. 3.

When in perfect condition, in its undimmed natural colors, this is one of the few sea urchins which may properly be called beautiful; indeed, it might be called the most beautiful of sea urchins. The primary interambulacral spines are handsomely banded with white and a greenish, brownish, purplish, or even reddish color; the more or less bare abactinal interradial areas are green, and the very slender and crowded ambulacral spines are more or less greenish yellow or light brown. Adult specimens exceed 100 mm. h.d. (the largest is in the Copenhagen Museum and measures 130 mm.), but the primary spines of such specimens are considerably less than the test diameter. In young and even in half-grown specimens, the primaries considerably exceed h.d. Although this sea urchin ranges throughout the Indo-Pacific region, from Natal and the Red Sea to Hawaii and Tahiti, it barely enters the Australian fauna, as it is known only from the Low Isles and Murray Islands at the northern end of the Great Barrier Reef. At Mer, Murray Islands, it is not abundant, but occurs on the southeastern reef flat with the following species and *Centrechinus*.

Echinothrix diadema

Echinus diadema Linné, 1758. Syst. Nat., ed. 10, p. 664.
Echinothrix diadema Lovén, 1887. Ech. Linn., p. 137.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 290; pl. 43, fig. 2; pl. 44, fig. 1; pl. 45; pl. 46, fig. 4.

This species has the same range as the preceding and occupies the same habitat, but does not grow so large (maximum as yet known, 110 mm. h.d.), and except when young is not nearly so handsome. In small specimens the primaries may be banded as in *calamaris* and even with shades of greenish and purplish, but with increase of size they tend to become unicolor and ultimately black or blackish. The slender ambulacral primaries are often rusty brown, sometimes in marked contrast with the larger spines. As yet, *diadema* is known in Australia only at the Murray Islands at the northern end of the Barrier Reef. It is common there in company with the preceding species and with *Centrechinus*. It is remarkable that, although *Centrechinus* has extended its range southward on the Queensland coast even to Lord Howe Island, and westward and southward to Houtman's Abrolhos, Western Australia, *Echinothrix* has secured a foothold only at the northern end of the Barrier Reef. And yet habits and habitat seem to be virtually identical.

ASTROPYGA

Gray, 1825. Ann. Philos., vol. 26, p. 426.

Genotype: *Cidaris radiata* Leske, 1778, p. 52.

A genus of only 3 or 4 species, *Astropyga* is tropicopolitan save for its apparent absence from the eastern Atlantic. The species occurring in tropical Australia is the most wide-ranging and the longest-known.

Astropyga radiata

Cidaris radiata Leske, 1778. Add. ad Klein, p. 52.
Astropyga radiata Gray, 1825. Ann. Philos., vol. 26, p. 426.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 187; pls. 10–12, *et al.*

From Natal to Hawaii, throughout the tropical parts of the Indo-Pacific region, this big flattened sea urchin may be expected in shallow water. It barely reaches Australia on the north. It becomes very large when full grown, 150–180 mm. h.d., though the height is commonly only one-fourth to one-third the diameter. The normal coloration is fundamentally red, bright in the young, deep and often dull in adults, with more or less evident white or reddish-white markings. Conspicuous blue spots are more or less evident, scattered over both the abactinal and actinal surfaces. In adults the ground color may be very dark and tinged with dull greenish, and the banding of the primary spines may be very faint or nearly wanting. Young specimens, 25–30 mm. h.d., are very pretty.

Astropyga is rare in Australia, for there seem to be but two reliable records. A. Agassiz (1881) lists "*A. pulvinata*" from "Challenger" station 188, but there are no Astropygas now in the British Museum from Torres Strait. Tenison-Woods (1878) records 4 large specimens of *A. radiata* taken by the "Chevert" off Darnley Island (Erub), Torres Strait, in 10–20 fms. on sandy mud. He describes the color as "dull whitish-green and reddish brown. The anal system and bare median interambulacral space are reddish with spots of violet. The spines slender, generally red." The "Endeavour" took 2 adult specimens 25 miles southeast of Double Island Point, Queensland, in 33 fms., but in recording these (1916) I forgot Tenison-Woods' record and said that *Astropyga* had "not hitherto been found" in Australia. The "Endeavour" specimens were 110 and 145 mm. h.d.; the larger was dull dark red, the primaries with a greenish cast; the smaller was reddish white and rose red. Blue abactinal spots were much more evident in the smaller specimen.

CHAETODIADEMA

Mortensen, 1903*a*. Vidensk. Medd., p. 1.

Genotype: *Chaetodiadema granulatum* Mortensen, 1903*a*, p. 1.

Although this genus contains half a dozen species, widespread in the Indo-Pacific region, it was not until well into the twentieth century that it was recognized and named. It is obviously near to *Astropyga*, but the oral ambulacra are so different, it is strange that the 2 genera were long confused. To Mortensen is due the credit of making clear their differences. *Chaetodiadema* ranges throughout the Indo-Pacific region from South Africa to Hawaii. It enters the Australian fauna, however, on the eastern side of the continent only, extending south to New South Wales. The 2 Australian species may be distinguished thus:

Primary spines not hollow; distinct blue spots on abactinal surface of test..... *granulatum*
Primary spines hollow; blue of abactinal surface in vertical lines, 1 on each column of interambulacral plates..... *tuberculatum*

Chaetodiadema granulatum

Mortensen, 1903*a*. Vidensk. Medd., p. 1.
——— 1940. Mon. Ech., vol. 3, pt. 1, p. 218; pls. 29–31.
de Meijere, 1904. "Siboga" Ech., p. 54; pl. 11, fig. 101 (colored).

This is the type species of the genus, and the only one known from a considerable number of specimens from an extensive area. The distribution centers in the Malay Archipelago, but extends from the Maldive Islands to Macclesfield Bank and southward to Queensland. The "Challenger" took it at her stations 188 and 190, north of Australia, in 28–49 fms., and the "Endeavour" obtained a single large specimen (115 mm. h.d.) 20 miles northeast of Double Island Point, Queensland, in 29–30 fms. The test is quite flat, the vertical diameter being one-fourth to one-third the horizontal. The upper surface is brownish or brownish olive and the primary spines are pink or brownish red. On each of the bare median parts of the aboral interambulacra is a series of large, more or less triangular blue spots, one to each plate. There is also a large spot on each genital plate and smaller ones scattered over the whole abactinal side. The oral surface, both test and spines, is whitish.

Chaetodiadema tuberculatum

H. L. Clark, 1909. "Thetis" rept., p. 554; pls. 56, 57.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 235; pl. 33, figs. 1, 2.

This species is known only from the 2 original specimens, 45 and 55 mm. h.d. The color of the preserved specimens was purplish brown above and light brown below. The abactinal primary spines were greenish or lavender, the tubercles greenish yellow. A deep blue line over 1 mm. wide runs from the second interambulacral plate to ambitus in the middle of each column of interambulacral plates. Both specimens were taken off Wata Mooli, New South Wales, but one was found on a soft mud bottom in 52–71 fms., and the other on a bottom of "fine sand to mud" in only 28–42 fms. The nearest relative of this *Chaetodiadema* would seem to be the species *africanum,* from Natal and East Africa.

MICROPYGA

A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 200.

Genotype: *Micropyga tuberculata* A. Agassiz, 1879, p. 200.

The relationships and systematic position of this genus seem to be open to some question. Mortensen (1940, p. 136) considers it so unique, he still puts it in a family by itself, "Micropygidae," as he did in 1904 when he first discussed the family "Diadematidae." Of the six characters which he lists, the first would be weighty if it were distinctive, but all the Centrechinidae have perforate tubercles, and crenulation is not a very important feature. The other supposedly distinctive characters are all microscopic and of little genetic significance. They help to characterize the genus, but it is hard to believe they indicate any real phylogenetic distinction. The general appearance of *Micropyga* is very similar to that of *Astropyga* and *Chaetodiadema,* and the microscopic details which Mortensen stresses may well be associated with its more abysmal habitat. It seems best, therefore, to include the genus in the Centrechinidae. Although 2 species of *Micropyga* are known, only 1 has been found in Australian waters.

Micropyga tuberculata

A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 200.
Mortensen, 1940. Mon. Ech., vol. 3, pt. 1, p. 147; pls. 4–6.

The justification for including *Micropyga* in the Australian fauna rests on a single specimen of this species taken by the Great Barrier Reef Expedition at their station XV, ½ mile outside Cooks Passage, northern Queensland, in 210 fms. It is 70 mm. h.d. and light reddish purple in color.

Family ECHINOTHURIIDAE

This interesting family is widespread in the deeper waters of all oceans and in the shallow waters of the East Indies. The relationships of the family are still in doubt, for Mortensen (1935) considers it closely related to the Paleozoic Lepidocentroida and not allied to any echini now living, whereas Jackson (1912) places it in the Aulodonta, closely allied to the Centrechinidae. The latter position seems to me more probably correct. The family includes about 50 species in 10 or 12 genera, but only 2 species have yet been taken in Australia. These represent 2 different though rather closely allied genera, to be distinguished, according to Mortensen, by characters of the spines and pedicellariae which are difficult to make out, especially in dried material. The 2 Australian species are, however, easily separated thus:

Large primary tubercles scattered on aboral surface ..... *Araeosoma*
No large primary tubercles on aboral surface ..... *Asthenosoma*

ARAEOSOMA

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 53.

Genotype: *Calveria fenestrata* Wyv. Thomson, 1872, p. 494.

This is much the largest genus in the family, including more than a dozen species. They are large (115–200 mm. h.d.) and of conspicuous appearance, and occur in moderately deep water (100–500 fms.) in nearly all seas, rarely in more shallow water (40–100 fms.). The single Australian species occurs off the southeastern corner of the continent and is also known from off the northern island of New Zealand.

Araeosoma thetidis

Asthenosoma thetidis H. L. Clark, 1909*a*. Bull. Mus. Comp. Zoöl., vol. 52, p. 134.
Araeosoma thetidis A. Agassiz and H. L. Clark, 1909. Mem. Mus. Comp. Zoöl., vol. 34, no. 3, p. 175; pls. 68–70.

The distribution of this big sea urchin is still imperfectly known. Aside from the specimens taken by the "Terra Nova" 7 miles east of North Cape, New Zealand, in 70 fms., identified by Bell as *Astropyga radiata* but redetermined by Mortensen as this *Araeosoma,* all known material has come from the original haul of the "Thetis" in 79–80 fms. off Botany Bay (see H. L. Clark, 1909, p. 555) or from various hauls by the "Endeavour" in the vicinity of Cape Howe, in 70–200 fms. It is evidently more or less gregarious, as the "Thetis" took between "two and three hundred examples" off Botany Bay. The wounds inflicted by the spines are very painful. The largest individuals were more than 200 mm. h.d. in life, but nothing has been recorded as to the color. Mortensen, who twice collected specimens while on the "Endeavour," gives no hint as to the appearance of the living animals.

Sydney Challenger Jan 1960

ASTHENOSOMA

Grube, 1868. Jahresber. Schles. Gesellsch., vol. 45, p. 42.

Genotype: *Asthenosoma varium* Grube, 1868, p. 42.

The discovery of this genus on the Queensland coast was one of Melbourne Ward's most interesting contributions to our knowledge of Australian echinoderms. The 3 previously known species were found in the Malay Archipelago, from the Kei Islands northward to the Sagami Sea, Japan, the type species extending its range westward to the Gulf of Suez.

Asthenosoma intermedium

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 378; pl. 26, figs. 2, 3.

The discovery of this typical *Asthenosoma* on the reef near Lindeman Island, Queensland, extends the geographical range of the genus far to the south. The specimens taken were 90 and 120 mm. h.d. and were deep brown with a purplish tint. The spines were light greenish more or less tinted, especially basally, with brown, and often rather definitely banded at least near the tip.

Family SALENIIDAE

This small but interesting family is made up for the most part of sea urchins, nearly all small, long since extinct. It first appears in the Upper Jurassic, reaches its maximum development (perhaps 75–85 species) in the Cretaceous, and then rapidly dies out until only about a dozen species are now known to be living, all in deep waters of the Atlantic, Indian, and Pacific oceans. No Recent species has yet been found in Australian seas, but 2 supposedly distinct forms have been found in the Tertiary rocks of the Aldinga Cliffs, South Australia. Both are to be referred apparently to the same genus.

*SALENIDIA

Pomel, 1883. Class. méth. éch., p. 94.

Genotype: *Salenia gibba* L. Agassiz, 1838, p. 13.

This is a small group of about 10 species considered by Mortensen to be the most primitive of saleniids having an eccentric periproct. The ambulacra consist of single plates, each with a primary tubercle. The 2 Australian forms are found at the same place in the same strata, but Tate considered them distinct species, separable by the following characters:

Test rather low and flattened, v.d. about 0.50–0.60 h.d. ..... *tertiaria*
Test more globose, v.d. 0.75 h.d. ..... *globosa*

*Salenidia tertiaria

Salenia tertiaria Tate, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 258; figs. 2*a–c*.
Salenidia tertiaria Lambert and Thiéry, 1911. Ess. nomen. éch., fasc. 3, p. 212 (see also p. 567).

The type locality for this species is in Oligocene strata, at the Aldinga Cliffs, on the east side of St. Vincent Gulf, some distance south of Adelaide. Tate (1891) also reports it from Wilson Bluff, Great Australian Bight. It is a small species, with 17.5 mm. the maximum h.d. He reports having had "very many specimens."

*Salenidia globosa

Salenia globosa Tate, 1891. Trans. Roy. Soc. S. Australia, vol. 14, p. 279 (no figure).

This species is based on 2 specimens having h.d. 18 mm. and v.d. 13.5 mm. This almost globose shape indicates a valid specific difference from the common species of *Salenidia,* also occurring at the Aldinga Cliffs. This shape is accompanied by an additional primary tubercle in each interambulacral column, there being 7 in *globosa* and 6 in *tertiaria.* Why Lambert and Thiéry (1911, p. 212) fail to list *globosa* among the species of *Salenidia* is not easy to understand, but possibly it was overlooked. It is clearly congeneric with *tertiaria.*

Family STOMOPNEUSTIDAE

This is a very small family with only a single species now living. More than a dozen genera are recognized among the fossil echini of the Jurassic and Cretaceous periods, but apparently they died out completely.

STOMOPNEUSTES

L. Agassiz, 1841*a*. Mon. éch.: Obs. prog. réc. hist. nat. éch., p. 7.

Genotype: *Echinus variolaris* Lamarck, 1816, vol. 3, p. 47.

No description or diagnosis was given by Agassiz at the time the name was first proposed, but as he designated a definite and indisputable type species, the status of the genus has never been questioned, nor has the name, though confusion with *Heliocidaris* occurred for a few years. Only a single species has been recognized, though Tenison-Woods (1881) thought the Australian form different from the East Indian and suggested another name (*atropurpurea*) for it. It is now generally agreed that the genus is monotypic.

Stomopneustes variolaris

Echinus variolaris Lamarck, 1816. Anim. sans vert., vol. 3, p. 47.
Stomopneustes variolaris L. Agassiz, 1841*a*. Mon. éch.: Obs. prog. réc. hist. nat. éch., p. 7.
Mortensen, 1935. Mon. Ech., vol. 2, p. 507; pl. 71, figs. 3–5; pl. 72.

This big, dark-colored, stout-spined sea urchin is known from Australia only in the Barrier Reef region. It grows to a large size, 100 mm. h.d., with primary spines 60–65 mm. long. A single specimen is recorded from the Murray Islands and 2 from the Low Isles. All other Australian specimens are from Trinity Bay and Port Denison in northern Queensland (see Tenison-Woods, 1881*a*, pp. 198–199). In the tropical Indo-Pacific region, *Stomopneustes* ranges from Durban, South Africa, to the Samoan Islands.

Family ARBACIIDAE

This is a small family of 8 Recent and 14 fossil genera, represented in Australia by a single genus, of which 1 fossil and 1 Recent species are known. As these species are each known from only a single specimen, it is obvious that the arbaciids are a very unimportant element in the Australian echinoid fauna. The genus is widely distributed in tropical seas and in geological strata since the Eocene. The occurrence in the Cretaceous is open to serious question.

COELOPLEURUS

L. Agassiz, 1840. Cat. syst. ectyp. Ech., p. 19.

Genotype: *Cidaris coronalis* Leske, 1778, p. 72.

Although this genus is known today from the West Indian region and from South Africa, its real center of occurrence is in the Malay Archipelago. The extinct species are well distributed throughout the northern hemisphere. The 2 Australian species are thus on the very edge of the known distribution of the genus. They are easily distinguished thus:

Primary tubercles in abactinal, interambulacral areas conspicuous; Recent ..... *australis*
Primary tubercles in abactinal, interambulacral areas wanting; extinct, Miocene ..... *paucituberculatus*

Coelopleurus australis

H. L. Clark, 1916. "Endeavour" rept., p. 107; pl. 43, fig. 1.

The only specimen of this species as yet known was taken by the "Endeavour" at the eastern end of Bass Strait in 60–112 fms. It was 40 mm. h.d., with the longest primaries more than twice as much. The ground color was light brownish, but there were vermilion-red, lavender or rose-purple, and reddish-brown markings on the abactinal side; the primary spines were light gray-brown, apple green, and bright red; the lower surface of the big primaries was white, as were the actinal primaries. The occurrence of a *Coelopleurus* at the southeastern corner of Australia is remarkable, as there is no other member of the genus living within some 2000 miles.

*Coelopleurus paucituberculatus

Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 486; pl. 14, figs. 4, 5.

The only specimen of this echinoid as yet described was collected in Miocene strata (Middle Murravian) at Morgan, South Australia. Gregory states that the specimen is in the Ipswich Museum. It is an incomplete but fairly good individual, 19 mm. h.d. by 12 mm. v.d. That other specimens are known is implied by Tate (1891, p. 274), who refers to a MS name of his and gives the locality as "River Murray Cliffs near Blanchetown."

Family TEMNOPLEURIDAE

This is a large family including more than 30 genera, of which at least 16 contain Recent species. They fall into two subfamilies, distinguished by the character of

the ornamentation of the test, more particularly of the abactinal half. Nine of the genera occur in Australia, but 1 is known only as a fossil. Of the others, 2 are particularly characteristic of the southern coasts of the continent, where they have become differentiated into a number of species which are among the most distinctive of Australian echini. The 9 genera are to be distinguished from each other by the test sculpturing, tuberculation, and features of the actinostome and periproct. Unfortunately Mortensen's (1943) great monograph dealing with the Temnopleuridae and related families was not available in this country until this volume had gone to press. As many of his conclusions seem to me open to question, no attempt is made here to harmonize our views.

Key to the Genera of Temnopleuridae

A. Test without pits on sutures or at angles of coronal plates, but more or less extensively ornamented with grooves, depressions, ridges, or knobs, sometimes greatly reduced:
  Ambitus rounded pentagonal; sculpturing of test marked; fossil only ..... *Paradoxechinus*
  Ambitus circular; sculpturing of test slight; living ..... *Genocidaris*
AA. Test not sculptured, or rarely so, but with pits on sutures or at angles of coronal plates:
  B. Primary tubercles distinctly crenulated:
    Coronal plates, at least abactinally, with deep and more or less conspicuous pits at sutural angles; these pits usually extended more or less distinctly along horizontal sutures; each interambulacral plate at ambitus with 1 or 3 (very rarely 4) primary tubercles ..... *Temnopleurus*
    Coronal plates with small sutural pits or none; if pits are large enough to form furrow along horizontal suture, interambulacral plates at ambitus each carry 4–9 subequal primary tubercles in a horizontal series ..... *Salmacis*
  BB. Primary tubercles not crenulated (or faintly so in some large individuals):
    C. Every ambulacral plate with primary tubercle close beside poriferous area:
      D. Coronal plates with deep, conspicuous, usually oblong pits at sutural angles and on horizontal sutures; poriferous areas narrow, pore pairs in an approximately vertical series ..... *Temnotrema*
    DD. Coronal plates with small sutural pits or none:
      E. Median abactinal interambulacral areas (and usually ambulacral also) more or less extensively bare, free from spines and tubercles:
        Interambulacral plates low and numerous (21 or 22) in each column in specimens 20 mm. h.d.; pore pairs distinctly biserial ..... *Mespilia*
        Interambulacral plates high and few, not more than 18 in largest specimens; pore pairs usually monoserial ..... *Microcyphus*
      EE. Median abactinal interambulacral areas not bare but more or less covered by secondary or miliary spines . *Amblypneustes*
    CC. Only every second or third ambulacral plate, at and above ambitus, with primary tubercle close beside poriferous area . . . *Holopneustes*

*PARADOXECHINUS

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, p. 186.

Genotype: *Paradoxechinus novus* Laube, 1869, p. 186.

This genus was based on a single South Australian fossil echinoid, but apparently the same type of small temnopleurid was found in the Miocene rocks of France, and on that material Cotteau based a genus *Coptechinus*. Duncan (1889) and Lambert and Thiéry (1909–1925) are agreed that the French and Australian specimens are congeneric. At any rate, they cannot be distinguished until much better-preserved material is available. Duncan (1877) described a small fossil echinoid from Australia as a *Temnechinus,* but ten years later he made it the type of a new genus. Chapman considers it identical with Laube's species, and I can find no ground on which to question his opinion.

*Paradoxechinus novus

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, p. 186; fig. 2.
Temnechinus lineatus Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 46; pl. 3, figs. 3–5.
Ortholophus lineatus Duncan, 1887*a*. Quart. Jour. Geol. Soc. London, vol. 43, p. 415.

The scanty material on which the above names rest was found in South Australia, at the Murray Cliffs at Mannum and in the beds at Aldinga Cliffs; and in Victoria, at Mordialloc, Kalimnan, and Beaumaris. Tate (1891) lists these fossils as from Eocene strata, but Duncan and Lambert and Thiéry say they are Miocene, and Chapman (*in litt.*) calls them Oligocene, Miocene, and Lower Pliocene. The unique holotype is 13 mm. h.d. and 6.5 mm. v.d. The apical system is wanting.

GENOCIDARIS

A. Agassiz, 1869. Bull. Mus. Comp. Zoöl., vol. 2, no. 9, p. 262.

Genotype: *Genocidaris maculata* A. Agassiz, 1869, p. 262.

The occurrence of this genus in Australia is still open to question, for although many specimens of the supposed species were found, not one had either the periproctal plates or the buccal membrane present, and without those features, the genus cannot be positively determined. The close resemblance of these little urchins to the West Indian genotype justifies calling them congeneric therewith, but until specimens are found with the test intact and spines and pedicellariae present, the occurrence of *Genocidaris* in Australia must be regarded as open to question.

Genocidaris incerta

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 457; figs. 137*a–c*.

Verco, whose extensive marine collections so enriched the South Australian Museum, took 63 specimens of this little sea urchin off Cape Borda, Kangaroo Island, 60 fms.; off Cape Jaffa, South Australia, 90–300 fms.; and off Beachport, South Australia, 110–200 fms. Unfortunately all are dead tests, and no spines, pedicellariae, periproctal plates, or buccal membranes are present. The largest specimen is 6 mm. h.d., with height one-half as much or a little more. The bare

tests are greenish and whitish or very pale yellow. A certain resemblance to *Genocidaris maculata* of the West Indies is obvious, but Mortensen (1943), after critical study of South Australian specimens, doubts that the two are congeneric.

TEMNOPLEURUS

L. Agassiz, 1841*a*. Mon. éch.: Obs. prog. réc. hist. nat. éch., p. 7.

Genotype: *Cidaris toreumatica* Leske, 1778, p. 155.

This is a small but interesting genus ranging from Korea and Japan, along the southern coast of Asia to Karachi and Muscat. It has been reported from Delagoa Bay, South Africa, but does not seem otherwise to have reached the African coast. On the south, it reaches Queensland on the east coast of Australia, and a well marked endemic species occurs in large numbers on the southwestern and southern coasts of the continent from Fremantle to eastern South Australia. The 2 Australian species are easily distinguished thus:

Large, up to nearly 60 mm. h.d.; spines rather coarse, usually banded near tip; pits along sutures usually conspicuous; primary tubercles very large, occupying 60–100 per cent of height of coronal plates ..... *toreumaticus*
Small, less than 30 mm. h.d. (usually 15–20 mm.); spines slender, not banded; pits along sutures shallow, except at plate corners, and often indistinct; primary tubercles small, only about half height of plate ..... *michaelseni*

Temnopleurus toreumaticus

Cidaris toreumatica Leske, 1778. Add. ad Klein, p. 155.
Temnopleurus toreumaticus L. Agassiz, 1841*a*. Mon. éch.: Obs. prog. réc. hist. nat. éch., p. 7.
A. Agassiz, 1873. Rev. ech., pt. 3, pl. 7*a*, figs. 4, 5.

This is a common Japanese species, but occurs throughout the East Indian region and extends its range to the Queensland coast. It has not been found in Torres Strait, but isolated specimens are known from various points between 15° and 23° S. These show considerable diversity of color and give room for difference of opinion as to the identity. One in the British Museum from Port Curtis seems to me a possible albino. With sufficient material available, we may find that there is a Queensland *Temnopleurus* not *toreumaticus*, but a distinct species, for which Tenison-Woods (1881) proposed the name *cavernosa*. As regards the few specimens I have seen, however, I find no satisfactory reason for not calling them identical with the Japanese species, as Mortensen (1943) also believes. He considers Tenison-Woods' species a *Temnotrema*.

Temnopleurus michaelseni

Salmacis michaelseni Döderlein, 1914. Fauna Südwest-Australiens, vol. 4, p. 454; fig. 1.
Temnopleurus australis H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 458; figs. 138*a–d*.
Temnopleurus michaelseni H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 380.

A full account of this interesting endemic species of southwestern Australia is given in H. L. Clark, 1938. It is commonly less than 25 mm. h.d., but shows con-

siderable diversity of form, as v.d. ranges from 0.50 to over 0.70 h.d. There is much variety in the color also, as the test may be light or dark gray, often mottled with cream color; or it may be cream color or whitish with spots or blotches of dark gray. The periproctal plates are often quite green, and that color may tint the whole upper surface. In extreme cases the spines are green, with dark bases and light tips, and this form has been designated as variety *viridis*. Mortensen's (1943, p. 108) statement that he is "unable to see how it differs from the usual typical form" merely shows inattention to the brief but perfectly definite description. Ordinarily the color of the spines shows much diversity, but as a rule the larger ones are dark red or red-brown at base, dull light red in middle, becoming green distally and tipped with white. The small spines are more or less pure white. This little urchin is common at Cottesloe Beach and near Garden Island, Fremantle. It extends south to Bunbury and appears again on the South Australian coast, where it is very common in Spencer and St. Vincent gulfs in 14–22 fms.

SALMACIS

L. Agassiz, 1841*b*. Mon. éch.: Préf. Anat. Echinus, p. viii.

Genotype: *Salmacis bicolor* L. Agassiz, 1841*b*, p. viii.

The line between this genus and the preceding is difficult to draw, but the species of *Salmacis* are larger and have a different facies, and there is as a rule little practical difficulty in recognizing them. They occur throughout the Indian Ocean region from Zanzibar to eastern Australia and the Philippines. Apparently they do not reach Japan or New Zealand; their farthest east seems to be Ugi, Solomon Islands. There are 5 species on the Australian coast, and 1 of these has a well marked variety. The following key will help in distinguishing these usually handsome sea urchins:

Key to the Species of Salmacis

A. V.d. exceeds one-half h.d.; all oculars exsert; each ambulacral plate with primary tubercle close to poriferous area (*Salmacis s. str.*):
  B. Primary spines not banded, greenish or light-colored at base, becoming reddish or purple distally (or for most of length) but sometimes with light tips:
    Coronal plates separated by distinct sutures, edges of which may be slightly beveled ..... *virgulata*
    Coronal plates separated by deep horizontal furrows, sides of which are more or less vertical ..... *virgulata* var. *alexandri*
  BB. Primary spines banded, usually conspicuously so:
    Primaries distal to green base rose red; actinal primaries noticeably widened at tip; gill cuts insignificant ..... *belli*
    Primaries distal to green base not rose red; actinal primaries not specially widened at tip; gill cuts deep ..... *sphaeroides*
AA. V.d. less than one-half h.d.; ocular I usually insert or nearly so; only every other ambulacral plate (at least in mid-zone) with primary tubercle beside poriferous area (*Salmaciella* Mortensen):
  Number of ambulacral plates in column 0.52–0.62 more than interambulacral; colors white, greenish white, and olive green, no red or purple ..... *oligopora*

Number of ambulacral plates in column 0.70–0.87 more than interambulacral; colors diversified, tending to be dull, but spines often white, banded with purple or reddish ..... *dussumieri*

Salmacis virgulata

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 359.
Döderlein, 1903. Semon's Ech., *in* Jena Denkschr., vol. 8, pl. 62, figs. 2, 2*a*.

There seems to be some doubt whether typical *virgulata* (a species of southern Asia and the East Indies) occurs in Australia, but a very good specimen is in the Museum of Comparative Zoölogy collection, labeled as from the Queensland coast, 25 miles southeast of Double Island Point, in 33 fms. As this specimen was received from the Australian Museum, there is no reason to doubt the accuracy of the label. But I have seen no other indubitable *virgulata* that was certainly from Australia. The form to which Bell gave the name *alexandri* is the characteristic *Salmacis* of Australia from Port Jackson north and westward to Broome, Western Australia. It was described as *Salmacis alexandri* Bell (1884, p. 118), but was reduced to the status of a variety of *virgulata* by Döderlein (1903, p. 712; pl. 62, figs. 1, 3–7), and called a subspecies by the same writer in 1914. In 1925, I considered it a variety, and until more material is available I am inclined to continue it in that category. This variety is very common on the northwestern coast and is to be found under rocks near low-water mark as well as in depths of 5–10 fms. It shows extraordinary diversity in color, and the extremes are so unlike it is hard to believe they are really the same species, but connecting links are too numerous to permit any doubt. At one extreme is the lovely purple and white urchin called "*Temnopleurus scalaris*" by Mortensen (1918), which may well bear the name "forma *scalaris*," and at the other extreme are the green or green and white individuals which I have called "forma *viridis*." This *Salmacis* is recorded from Shark Bay and Geraldton on the western coast, and from Long Island in the Abrolhos, but apparently it does not occur in the Fremantle region or on the southern coasts of the continent. It grows to a large size (70–80 mm. h.d.) on both the eastern and western sides of Australia, but the largest we found at Broome was 65 mm. The remarkable type specimen of *Salmacis woodsii* of Ramsay (1885) is undoubtedly a malformed individual of *virgulata*.

Salmacis belli

Salmacis rarispina A. Agassiz, 1881. "Challenger" Ech., p. 113 (*partim*).
Salmacis sphaeroides var. *belli* Döderlein, 1903. Semon's Ech., *in* Jena Denkschr., vol. 8, p. 718; pl. 64, figs. 1–1*c*.
Salmacis belli Mortensen, 1904. Ech. (1) Danish Exped. Siam, p. 68.

This very lovely sea urchin is found on the northern coasts of Australia from Lindeman Island and Port Molle, Queensland, to Holothuria Bank off northern Western Australia. It is not known elsewhere. It grows to be 74 mm. h.d., but most of the rather few known museum specimens are 10–40 mm. h.d. The test is light-colored (cream to fawn) and the long primaries are banded rose red and green, with one or two whitish bands near the tip. In large specimens the spines are not notably long, but the colors are very distinctive and the oral primaries are conspicuously wide and flat distally. The insignificant gill cuts are also a good character.

Salmacis sphaeroides

Echinus sphaeroides Linné, 1758. Syst. Nat., ed. 10, p. 664.
Salmacis sphaeroides Lovén, 1887. Ech. Linn., p. 69.
Döderlein, 1903. Semon's Ech., *in* Jena Denkschr., vol. 8, p. 716; pl. 63, figs. 1–4.

This is a typically East Indian sea urchin, ranging south to Western Australia and the Solomon Islands. Along the Australian coast it occurs from Lord Howe Island and Double Island Point, Queensland, north and west to Broome, Western Australia. At Broome, it does not occur along shore, but lives in 5–10 fms. of water. It grows to be 80–90 mm. h.d., and shows considerable diversity in color. Shades of green, red-purple, and brownish red mingle with white or very light tints in great variety, some specimens being light and others dark-colored. Ordinarily the spines are green at base but white distally, with 3–8 narrow and distinct bands of red-purple. In some cases the red shades approach vermilion.

Salmacis oligopora

H. L. Clark, 1916. "Endeavour" rept., p. 113; pl. 42; pl. 43, fig. 2.

Nothing further is known of this endemic species from southeastern Australia beyond what is given in the original account. The "Endeavour" took 8 specimens, 60–81 mm. h.d., off New South Wales and in Oyster Bay, Tasmania, in 20–50 fms. The colors are white, greenish, and olive green, with no hint of red or purple anywhere.

Salmacis dussumieri

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 359.
Döderlein, 1903. Semon's Ech., *in* Jena Denkschr., vol. 8, p. 715; pl. 63, figs. 5–5*c*.

Widely distributed on the coasts of southern Asia and in the Malay Archipelago, this well marked species of *Salmacis* ranges southward on the eastern coast of Australia to Port Curtis, Queensland. Mortensen (1943) questions the validity of this record, and those from New South Wales probably refer to the preceding species. The literature referring to this *Salmacis* makes no reference to the size of full-grown specimens. The largest in the Museum of Comparative Zoölogy is 65 mm. h.d.

TEMNOTREMA

A. Agassiz, 1863*a*. Proc. Acad. Nat. Sci. Philadelphia, p. 358.

Genotype: *Temnotrema sculpta* A. Agassiz, 1863*a*, p. 358.

This little genus of small but often beautiful shallow-water sea urchins is well represented in Australia, but owing to their secretiveness and insignificance they are not often collected in any numbers, and hardly one of the species is known from more than a few specimens. Although Temnotremas have been taken on the tropical coasts of Australia from Queensland to the southwestern corner of the continent, during my three visits to those coasts I found but 10 specimens—8 of 1 species and 1 each of 2 others. The 5 Australian species may be distinguished thus:

KEY TO THE SPECIES OF TEMNOTREMA

A. Pits between coronal plates large, distance between the two of any one horizontal suture less than length of one:
  B. Anus central or nearly so; no conspicuous suranal plate on periproct; test high; valves of globiferous pedicellariae with lateral tooth on each side, near tip:
    Genital plates not abruptly depressed at outer end, at genital pore; test dark (olive or olive gray); bands on primaries bright scarlet ..... *bothryoides*
    Genital plates abruptly depressed at outer end, at genital pore; test greenish white; bands on primaries violet-red ..... *elegans*
  BB. Anus excentric; distinct suranal plate present; valves of globiferous pedicellariae without lateral teeth ..... *siamense*
AA. Pits between coronal plates small, seldom as long as space between two:
  Color dull purplish red and dull purple; spines bright red with tips more or less white ..... *phoenissa*
  Colors greenish and white; no red ..... *notium*

Temnotrema bothryoides

Temnopleurus bothryoides Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 360.

Temnotrema bothryoides H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 317. (See Mortensen, 1943. Mon. Ech., vol. 3, pt. 2, p. 254.)

Döderlein (1903) says he had many small examples of *Pleurechinus bothryoides* from Thursday Island, Torres Strait; the largest whose measurement he gives was 21 mm. h.d. In 1914, he reports the species from Shark Bay, Western Australia, but gives no information as to the specimen or specimens. There is little doubt, however, that it was the following species (*elegans*). In 1925, I listed 19 specimens of *bothryoides* (as *Temnotrema decorum*) as in the British Museum, all from the tropical coast of Australia; the largest was 20.5 mm. h.d. The large pits in the test and the bright red rings on the spines make the species easy to recognize. In 1932, I recorded specimens 23–26 mm. h.d. and 15–18 mm. v.d. as in the collections of the Barrier Reef Expedition from northern Queensland, and in 1938 I reported a very fine specimen in the Australian Museum, from off Peak Point, northern Queensland, 3–6 fms., also a small bare test from Darwin. The "Challenger" and the "Alert" both took *bothryoides* in Torres Strait, and there are specimens in the British Museum from Holothuria Bank and Baudin Island (125° 36′ E., 14° 8′ S.), Western Australia. This handsome little echinoid probably occurs in the East Indian region, but data are lacking. West of King Sound it is apparently replaced by the following species.

Temnotrema elegans

Mortensen, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 9, p. 12; fig. 2; pl. 4, figs. 4–6; pl. 5, fig. 3.

This pretty little urchin was described from 7 specimens taken in 15 fms., west-southwest of Cape Jaubert, Western Australia, considerably west of Broome. The largest was 15 mm. h.d. by 9.5 mm. v.d. We also took 7 specimens in the Broome region in 5–8 fms., 3 in 1929 and 4 in 1932. The largest is 26 mm. h.d. and 19 mm. v.d.; none of the others is relatively nearly as high. In the Western Australian

Museum is a half-grown specimen from Rottnest Island. Döderlein's (1914) *Temnotrema* from Shark Bay, reported by him as *decorum,* is very probably *elegans,* which apparently ranges from Broome to Fremantle. The coloring distinguishes the two species easily.

Temnotrema siamense

Pleurechinus siamensis Mortensen, 1904. Ech. (1) Danish Exped. Siam, p. 79; pl. 1, figs. 2, 7, 11, 20; pl. 2, figs. 2, 9, 14, 15, 22.
Temnotrema siamensis H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 318.
Temnotrema sculpta H. L. Clark, 1921. Ech. Torres Strait, p. 150; pl. 17, fig. 5 (colored).

This East Indian species reaches northeastern Australia, but only 2 specimens are as yet reported. The first was found at Mer, Murray Islands, in 1913. It is 8 mm. h.d. and shows very little red on the spines. It was wrongly identified as *T. sculpta.* The second and much larger specimen (11 × 6 mm.) is in the Australian Museum and is said to have been taken at the same time and place (in 1928, off Peak Point, Queensland, in 3–6 fms.) as the fine *Temnotrema bothryoides* referred to above. Specimens from Holothuria Bank, northwestern Australia, identified by Mortensen are in the British Museum, so it will not be surprising if *siamense* occurs along the whole northern coast of Australia.

Temnotrema phoenissa

H. L. Clark, 1926. Rec. Australian Mus., vol. 15, p. 188; fig. 1 (2 figures).

This species is known as yet only from the single specimen collected by W. E. J. Paradice from a coral fragment taken in 8 fms., off Ellison Reef, outer Great Barrier, Queensland, and now in the Australian Museum. It was in company with two small Parasalenias. It is only 6.5 mm. h.d. and 3 mm. v.d. The dull purplish-red color is simply dull purple in the interambulacral areas abactinally; the spines are bright red, with more or less of the tip white. The relationship of this form to *notium* and *sculpta* is obvious.

Temnotrema notium

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 387; pl. 26, fig. 5.

This is another species based on inadequate material, but at least there are 2 specimens of this dull-colored form. They were taken together in King George's Sound, near Albany, Western Australia, by Troughton, of the Australian Museum. One is 9 mm. h.d., the other 7, but they agree in all essentials. The dull greenish and white coloration makes them easily confusable with young *Temnopleurus michaelseni* of the same region.

MESPILIA

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 357.

Genotype: *Echinus globulus* Linné, 1758, p. 664.

Whether this genus contains more than a single species is still open to question, but if there is but one, it shows considerable diversity of color and tuberculation, as there are at least 3 named varieties.

Mespilia globulus

Echinus globulus Linné, 1758. Syst. Nat., ed. 10, p. 664.
Mespilia globulus Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 358.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 477; pl. 8*a*, figs. 13, 14.

In 1938 (p. 388) I said this sea urchin was "not hitherto known from Australia." My attention has been called to the fact that Tenison-Woods, who reported it from Lady Elliot Island, Queensland, in 1878, and in 1880 withdrew the record, in 1881 again vouched for its occurrence on the Queensland coast, having found a specimen at Trinity Bay. Obviously it either is rare or lives only in inaccessible habitats, for no one else has taken a specimen on the east coast.

In 1933, however, Beresford E. Bardwell obtained 5 specimens from under rocks along shore at Augustus and Champagny islands, Western Australia, a most interesting extension of the known range of *Mespilia*. But the most remarkable feature of this discovery was that the specimens are not ordinary *globulus*, but are typical examples of the interesting color variety *pellocrica* (H. L. Clark, 1912, p. 322), known from the islands of the western Pacific and the Philippines, which lacks all red tints in its coloration. The usual red and green *Mespilia* ranges north to Japan and south to New Guinea and, as already mentioned, to northern Queensland. Adult specimens of *Mespilia* are 40 mm. or more h.d.

MICROCYPHUS

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 358.

Genotype: *Microcyphus maculatus* Agassiz and Desor, 1846, p. 358.

This is a characteristic genus of southern Australia, and only 2 species are known from elsewhere. The species are all notable for the beauty of their tests and their pretty coloration, but none of the Australian forms are sufficiently common for us to know how constant the color characters are. For the present they afford the best means of distinguishing the species.

Key to the Species of Microcyphus

A. Margins of all test plates, except near peristome, broadly white; entire surface of uppermost coronal plates white with reddish tinge; lowermost plates and central part of others, except uppermost, rich reddish brown; upper ends of ambulacra dull reddish brown merging into grayish brown of abactinal system ..... *pulchellus*

AA. Coloration not as above:

B. Spines light, greenish at base, white at tip broadly encircled by band of red; bare interambulacral areas broad and very light-colored ..... *annulatus*

BB. Spines not banded:

Bare interambulacral spaces narrow and dark-colored (yellowish brown in young, almost black in adults); spines deep red ..... *zigzag*

Bare interambulacral spaces narrow and rose red; spines pale reddish ..... *compsus*

Microcyphus pulchellus

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 462; figs. 139*a–b*.

Not only is this species based on a bare test, but the holotype is unique. It was collected in Spencer Gulf, South Australia, and is now in the South Australian Museum. It is nearly spherical, only 12.5 mm. h.d. and 11 mm. v.d.

Microcyphus annulatus

Mortensen, 1904. Ech. (1) Danish Exped. Siam, p. 101 (no figure).

Some 30 specimens of this pretty little sea urchin are now known, half of them having been collected by Verco in South Australian waters in depths down to 20 fms. The other half have come from near Port Phillip, Victoria, and from Bass Strait; 1 small specimen was taken in 40–50 fms. off Schouten Island, Tasmania. The specimens taken by the "Challenger" at her stations 161 and 162 were identified and published as *M. zigzag*. The largest specimens are 19 mm. h.d., and the height ranges from 0.75 to nearly 0.90 h.d. The type specimen of *annulatus* was described by Mortensen as 14.8 mm. long and only 12.8 mm. wide, but no other of the 30 known specimens has an elliptical ambitus. When the material in the British Museum was examined by me in 1924, all the 5 specimens from station 162 had the ambitus circular, ranging from 12 to 17 mm. h.d. It is evident that Mortensen's holotype was not seen by me, but it is also quite certain that the elliptical ambitus is not, as he thought probable, "really a specific character." The colored ring on the primaries is not always present on all the large spines; in some specimens only a few show it.

Microcyphus zigzag

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 358.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 469; pl. 8*c*, figs. 11–13.

This is apparently a rather rare species, for although there are 11 specimens in the Museum of Comparative Zoölogy, several are old, with dubious locality labels (the specimens said to be from Japan and the "Philippines" were purchased long ago in Hamburg, and of course the locality label is not to be trusted), and the remainder are recent acquisitions, 2 from Tasmania and 4 from Western Port, Victoria. There are 6 specimens in the British Museum from Port Phillip Heads and Bass Strait. Verco took but 1 small bare test during his extensive dredging in South Australian waters. The largest known specimen is 25 × 23 mm., a bare test from an unknown locality (labeled "Philippines").

Microcyphus compsus

Microcyphus elegans Mortensen, 1904. Ech. (1) Danish Exped. Siam, p. 100 (specific name preoccupied).
Microcyphus compsus H. L. Clark, 1912. Mem. Mus. Comp. Zool., vol. 34, p. 322 (no figure).

Besides Mortensen's types in the British Museum (4 specimens from Port Phillip Heads), the only reported specimens are the 5 collected by Verco, at five different

stations in South Australian waters, 23–130 fms. (or less). These range from 8 to 15 mm. h.d. The smallest has the red shades not at all rosy, and approaches *zigzag* in its general appearance.

AMBLYPNEUSTES

L. Agassiz, 1841*b*. Mon. Ech.: Préf. Anat. Echinus, p. ix.

Genotype: *Echinus ovum* Lamarck, 1816, vol. 3, p. 48.

This is one of the most characteristic of the endemic genera of Australian echini. It ranges westward from Tasmania and Bass Strait to Geraldton, Western Australia. Records from New South Wales and New Zealand need verification, as dead tests may occasionally wash up on coasts far from the habitat in life. These sea urchins usually occur in large numbers on "grassy" or "weedy" bottoms in rather shallow water (5–10 fms.), and the bare tests are often washed up on the adjoining beaches in considerable quantities. As a result, the great majority of specimens in museums lack spines and pedicellariae, and frequently the buccal membrane and periproctal plates also. Consequently, at least 8 species names have been proposed, most of them without adequate material in good condition. Owing to the lack of perfect specimens and the individual diversity in shape and color of test, and form and color of spines, species lines are still hazy, and areas of distribution are very imperfectly delimited. The whole problem needs to be attacked *de novo* by a zoologist who can collect material and work out its interrelationships on the southern coasts of Australia. Meanwhile, an abbreviated form of the key offered in my British Museum Catalogue (1925) will serve here:

Key to the Species of Amblypneustes

A. Periproctal plates small and thin, with no spines; primary spines red, purple, or green, with secondaries different; zigzag markings of interambulacra (or some sort of color ornamentation) usually conspicuous; poriferous areas narrow:
  Primary spines bright red; test usually dark, with lateral parts of interambulacra often noticeably darker than middle; tuberculation of test rather coarse ..... *formosus*
  Primary spines pale red, purple, lavender, or green, with secondaries lavender or nearly white; test light-colored; tuberculation of test notable for small size of tubercles ..... *pallidus*

AA. Periproctal plates coarse, some at least bearing spines; primary spines not bright-colored, often darkest at base and light- or even white-tipped; ornamental patterns on interambulacra indistinct or wanting; poriferous areas narrow or wide, often notably wide with 3 vertical series of pore pairs:
  Miliary spines much shorter than half length of primaries, with spherical white tips; v.d. about 0.90 h.d.; primary spines green or brown ..... *leucoglobus*
  Miliary spines at least half as long as primaries; tips not spheroidal; primary spines dull or pale ..... *ovum*

Amblypneustes formosus

Valenciennes, 1846. Voy. "Venus": Zooph., pl. 2, fig. 2.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 479; pl. 8*c*, fig. 1.

Typical examples of this species are easy to recognize, even though the anal plates and spines may be missing, the coarse tuberculation and handsomely marked interambulacra being distinctive. Most specimens are under 25 mm. h.d., and the height is less than the diameter, but the largest specimen in the British Museum is 36 mm. h.d. and 37 mm. v.d. The distribution of *formosus* is imperfectly known, but apparently it may be found anywhere between Bass Strait and Fremantle.

Amblypneustes pallidus

Echinus pallidus Lamarck, 1816. Anim. sans vert., vol. 3, p. 48.
Amblypneustes pallidus Valenciennes, 1846. Voy. "Venus": Zooph., pl. 2, fig. 1.
Döderlein, 1914. Fauna Südwest-Australiens, vol. 4, p. 460; pl. 9, figs. 1–3.

This delicate and beautiful sea urchin is very common in Koombana Bay, Bunbury, Western Australia. The test is some shade of lavender or purple, and the primary spines range from light green, more or less reddish at tip, to bright orange-red, greenish only at base; the secondary spines are commonly bright lavender, but may be very pale, almost white, or quite brown with little indication of lavender. This diversity of color does not seem to be associated with size or age. The largest specimen is 36 mm. h.d., height 0.80–0.90 h.d. A specimen in the British Museum, 34 mm. h.d., is 36 mm. high, but this is a rare variant. A specimen in the South Australian Museum is 48 mm. h.d. and 50 mm. v.d., the largest specimen on record. In several South Australian specimens, the ambitus is above the equator, resulting in a noticeably ovoid form. In very young specimens (3–6 mm. h.d.), v.d. is only 0.50–0.60 h.d., so that they seem quite flattened. The range of *pallidus* appears to be chiefly along the southwestern coast of the continent between Port Willunga, South Australia, and Dongarra, Western Australia. A single specimen in the Museum of Comparative Zoölogy is said to be from "Victoria." Mortensen's (1943) variety *subglobosus* seems to me without value or significance.

Amblypneustes leucoglobus

Döderlein, 1914. Fauna Südwest-Australiens, vol. 4, p. 463; pl. 9, figs. 8, 9.

This is a dubious species, as its relationship to the following (*ovum*) is not clear. It is apparently a Western Australian form, and is common on that coast from Geraldton to Bunbury. But it is not yet sure that the characters supposed to distinguish it from *ovum* are constant. It does not grow to as large a size apparently as *ovum,* the maximum being 44 mm. h.d. The coloration is not distinctive.

Amblypneustes ovum

Echinus ovum Lamarck, 1816. Anim. sans vert., vol. 3, p. 48.
Amblypneustes ovum L. Agassiz, 1841*b*. Mon. Ech.: Préf. Anat. Echinus, p. ix.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 480; pl. 8*c*, figs. 3, 4.

This name has been used for a very large number of *Amblypneustes* from all parts of the southern coasts of Australia, but as most of them are bare tests, often lacking the periproctal plates, we are still in the dark as to whether they represent 1 very variable species or 2 or more distinct species confused because of our in-

adequate material. The geographical range is also in question, but if we call all the Western Australian specimens *leucoglobus* and deny the correctness of the two or three supposed records from New South Wales, we may say that *ovum* ranges from Tasmania and Bass Strait westward to Spencer Gulf. The named forms may be distinguished by the unsatisfactory characters of size, form, and tuberculation, thus:

Test high and often large; diameter up to 60 mm. and height 0.92–1.18 h.d.; tuberculation of test fine, often very fine; colors diverse but usually dull, brownish, yellowish, or dirty white spines on gray, brown, or greenish test; pedicels often dark-colored in marked contrast ..... *ovum*

Test lower, more hemispherical or even somewhat flattened, height 0.60–0.80 h.d.; tuberculation coarse:

Very large, up to 85 mm. h.d.; poriferous areas very narrow, the two together forming one-third or less of ambulacrum; test and primaries pale brown, dull pale red, or dirty whitish ..... var. *grandis*

Smaller, 40–45 mm. h.d.; poriferous areas one-half ambulacrum or nearly so; primary tubercles very large, especially in ambulacra, where marginal series is very conspicuous; test dull green or brown; primaries dull green, often dark, especially at base, whitish at tip; small spines often very light, sometimes nearly white ..... var. *pachistus*

HOLOPNEUSTES [1]

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 364.

Genotype: *Holopneustes porosissimus* Agassiz and Desor, 1846, p. 364.

This is another typical, endemic genus of the southern coast of Australia, easily distinguished from the preceding, yet constantly confused with it, the general facies is so similar. Owing to the peculiar habits and habitat of *Holopneustes* (see H. L. Clark, 1938, p. 392), which live among the distal fronds of large kelp, they may be transported long distances, and their occurrence as bare tests on the shores of New Zealand is no evidence that they belong to the fauna of that country. Mortensen's (1921) inclusion of *Holopneustes* in the list of New Zealand echini is therefore unwarranted. On the other hand, his conclusion that Hutton's *Echinus elevatus* is based on a specimen of *Holopneustes inflatus* seems to me quite reasonable. Hutton's specimen still had some of the spines attached to the test when he collected it, but this would be no evidence that it was then living. It is quite improbable that either *Amblypneustes* or *Holopneustes* lives in New Zealand seas. There seem to be 3 species of *Holopneustes,* but the lines between them are not sharply drawn. Most specimens may be distinguished thus:

Key to the Species of Holopneustes

A. Interambulacral plates fairly numerous (22–25 in specimens 22 mm. h.d., about 46 in specimens 48 mm. h.d.), their tubercles small; areolae of primaries occupying only about half plate but forming a well spaced vertical series on each side of interambulacrum:

Ambulacra decidedly wider than interambulacra; primary spines greenish, more or less extensively tipped with red ..... *porosissimus*

[1] See H. L. Clark, 1912, p. 332 for a discussion of the genotype.

Ambulacra not appreciably wider than interambulacra and usually distinctly narrower; primary spines range from very pale brown to reddish purple ..... *inflatus*

AA. Interambulacral plates very numerous (30 in specimen 22 mm. h.d., 40–50 in specimens over 36 mm. h.d.), their tubercles large; areolae of primaries occupying nearly whole height of plate and hence forming more or less crowded vertical series on each side of interambulacrum; primary spines whitish or cream color or pale purplish or greenish, often tipped with lighter or darker; ambulacra usually distinctly wider than interambulacra, at least in adults ..... *pycnotilus*

Holopneustes porosissimus

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 364.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 484; pl. 8*c*, figs. 9, 10.

This handsome and usually brilliantly colored sea urchin ranges from Dongarra, Western Australia, southward and eastward to Port Phillip Heads, Victoria. Tenison-Woods (1878) reports it from Bass Strait and Tasmania, but these records need verification. Large specimens exceed 50 mm. h.d.; the height is normally 0.75–0.80 h.d. The usual coloration is dull greenish, with the larger spines more or less bright, almost vermilion red. Duller-colored individuals occur which may be hybrids with the following species, for the two are sometimes found together. E. W. Bennett found both occurring "plentifully" at Cape Leeuwin, Western Australia, and sent the Museum of Comparative Zoölogy 4 specimens perplexingly intermediate between the two species (see H. L. Clark, 1938, p. 394).

Holopneustes inflatus

A. Agassiz, 1872. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, p. 56.
——— 1873. Rev. ech., pt. 3, p. 485; pl. 8*c*, figs. 5, 6 (as *H. purpurescens*).

This is the common *Holopneustes* from Fremantle to Tasmania and the eastern end of Bass Strait. It is reported from Port Jackson, but verification of these records is needed. As stated above, its occurrence in New Zealand is probably only in the form of dead tests washed up on beaches. It is very common on the southwestern coast of Australia, notably at Point Peron and Bunbury. It reaches a diameter of over 60 mm., and in large specimens the height equals the diameter. The color ranges from gray or pale brown to deep red-purple. For an account of habitat and habits see H. L. Clark, 1938, pages 392–393.

Holopneustes pycnotilus

H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 334; pl. 104, fig. 4; pl. 112, figs. 6–9.

This species is still imperfectly known, but is apparently confined to the coasts of New South Wales. Most of the known material is supposed to be from Port Jackson. The largest specimen yet recorded is 58 mm. h.d., with the height 56 mm. The test is light brown, with the spines, particularly the primaries, a dull, pale pink. It was taken at Shell Harbor, New South Wales. Nothing is yet known as to habits or habitat in life.

Family ECHINIDAE

This large and widely distributed family is well represented in the Australian fauna, for 6 of the dozen more or less recognizable genera are recorded from the continent. Few of the species, however, occur in any abundance, and several are known from very inadequate material. One is known only as a fossil from the Tertiary rocks of Victoria and South Australia. The following key will help to place specimens of the family, but it is based on too little material to be infallible.

Key to the Genera of Echinidae

A. Periproct approximately central; if 2 oculars reach it, they are typically I and V:
  B. Buccal membrane more or less heavily plated; ocular I insert ..... *Lytechinus*
  BB. Buccal membrane not plated, but naked, or may have scattered small plates besides 5 pairs of primordial ambulacrals:
    C. Gill slits, if present, shallow and not sharply defined:
      D. Ocular plates small, completely exsert; primary spines much longer and primary tubercles much bigger than secondaries; size large, h.d. in adults up to 80 mm. ..... *Dermechinus*
      DD. Ocular I usually, and V not rarely, insert; primary spines and tubercles not conspicuous; size small, rarely exceeding 40 and usually under 30 mm. h.d.
        Valves of globiferous pedicellariae, so far as known, with conspicuous lateral tooth, normally on left side; Recent or Tertiary ..... *Pseudechinus*
        Valves of globiferous pedicellariae with no lateral teeth; Recent ..... *Nudechinus*
    CC. Gill slits deep and sharply defined; pore pairs in 3 more or less well separated vertical series ..... *Tripneustes*
AA. Periproct excentric at right, with oculars I and II insert ..... *Gymnechinus*

LYTECHINUS

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 24.

Genotype: *Cidaris variegatus* Leske, 1778, p. 85.

This circumtropical genus of half a dozen or more species barely enters the Australian region at the northeast corner, only a single specimen of one species having as yet been taken.

Lytechinus verruculatus

Psammechinus verruculatus Lütken, 1864. Vidensk. Medd., p. 166.
Echinus verruculatus de Loriol, 1883. Mém. Soc. phys. hist. nat. Genève, vol. 28, no. 8, p. 21; pl. 3, figs. 3*a–f* (several in colors).
Lytechinus verruculatus H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 253.

The only specimen of this little sea urchin reported from Australia is the one taken by me at Green Island, off Cairns, Queensland, September 6, 1913. It is only 10 mm. h.d., but agrees in all details with a specimen of the same size from the Hawaiian Islands. As the species ranges from Mauritius to Hawaii, its occurrence in northern Queensland is not extraordinary, but Mortensen (1943) has

overlooked or ignored the Green Island record. The variegated coloring, particularly the green blotches on the test, is quite characteristic. I have never seen specimens as yellow as de Loriol's figures, but it is not unlikely that more or less diversity of color is shown by specimens of different ages, besides such differences as localities widely separated might produce. The largest specimen in the Museum of Comparative Zoölogy is 26 mm. h.d. De Loriol refers to one 27 mm.

DERMECHINUS

Mortensen, 1942. New Echinoidea. Vidensk. Medd., vol. 106, p. 231.

Genotype: *Echinus horridus* A. Agassiz, 1879, p. 203.

The establishment of a distinct genus for this very remarkable sea urchin is amply justified in view of its distribution, as well as its morphological characters. Whether more than one species should be recognized remains to be determined when more material is available.

Dermechinus horridus

Echinus horridus A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 203.
H. L. Clark, 1916. "Endeavour" rept., p. 109; pls. 39, 40.
——— 1924*a*. Fish. and Marine Biol. Surv. S. Africa, rept. 4, special rept. 1, p. 7.

The "Challenger" collected at her station 308, off southern Chile, in 175 fms. on a muddy bottom, several unbroken small specimens and fragments of much larger ones of an *Echinus*-like sea urchin notable for the form of the test, which in adults had v.d. 1.25–1.40 h.d. Early in the present century the "Valdivia" took what was apparently a half-grown specimen of the same extraordinary urchin off Mossel Bay, South Africa, in 276 fms. Some years later the "Endeavour" collected what is virtually the same thing in 100–300 fms. at the eastern end of Bass Strait; and not long afterward, the South African Fisheries Board brought to light a considerable series of specimens collected off South Africa in 200–300 fms. Though the South African material shows some slight differences from the "Challenger" specimens and the Australian material has some slight peculiarities of its own, it is obvious that whether we call it all one species or a species with two varieties, or three closely related species, we are dealing with a single remarkable biological unit common to the southern tips of the three southern continents. It is the most conspicuous case of an echinoderm common to the three and not known from anywhere else in the world. The added fact that the habitat is on the continental slope in each case makes the situation even more interesting.

The material collected by the South African Fisheries Board proves conclusively that when young this remarkable urchin has the form, size, and general appearance of a typical *Echinus,* but with growth the vertical axis elongates disproportionately, and the adult animal has v.d. greatly in excess of h.d. The largest specimen taken is one from South Africa which is 110 mm. h.d. and 127 mm. v.d., but the proportionately highest one is from Australia and measures 80 mm. h.d. and 115 mm. v.d. In this case the height is 1.43 times the diameter. The color in life is more or less vermilion or orange-red, with the primary spines smooth and shining.

PSEUDECHINUS

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 106.

Genotype: *Echinus albocinctus* Hutton, 1872, p. 12.

The inclusion of this genus in the Australian fauna rests on a very slight foundation; furthermore, the living species are based on very small individuals and only one of each is known. The inclusion of a Tertiary echinid originally described as a *Psammechinus* seems amply justified, but cannot be proved correct, since not one of the three fundamentally important structures (the periproctal plates, the buccal membrane, and the pedicellariae) is to be found in the fossil material. Mortensen (1943) is convinced that *Pseudechinus* should be regarded as a temnopleurid, but the Australian species, so far as known, throw no light on this question. The 2 Recent forms may be distinguished from each other thus:

Test with numerous spines and tubercles, primaries not very conspicuously bigger; periproct covered by about 30 plates; globiferous pedicellariae with long, slender valves, blade longer than base ..... *notius*

Test with relatively few spines and tubercles, primary tubercles conspicuously bigger especially abactinally; periproct covered by very large suranal and a few other narrow plates; globiferous pedicellariae with short, wide valves, blade shorter than base ..... *hesperus*

Pseudechinus notius

Parechinus notius H. L. Clark, 1916. "Endeavour" rept., p. 111; pl. 41.
Pseudechinus notius Mortensen, 1921. Vidensk. Medd., vol. 73, p. 167.

As Mortensen considers this species to be very nearly related to *Pseudechinus huttoni,* and to represent that genus in Australia (see H. L. Clark, 1938, p. 397), I am transferring it thereto. Only a single specimen of *notius* is known, the one taken by the "Endeavour," southeast of Cape Everard, Victoria, in 70–80 fms. It is 28 mm. h.d., pale brown with white spines.

Pseudechinus hesperus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 395; fig. 35; pl. 27, fig. 1.

The unique holotype of this urchin, 7.5 mm. h.d., was collected in the cove at the northeastern end of Rottnest Island, off Fremantle, Western Australia. The test is light lavender-brown, the abactinal system and poriferous areas light yellow-green in rather evident contrast; spines very pale green or white, lightest distally.

*Pseudechinus woodsi

Psammechinus woodsi Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, p. 185; figs. 1–18.
? *Psammechinus humilior* Bittner, 1892. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, p. 337; pl. 1, fig. 3.

As Tate (1892) has explained clearly how Bittner was misled by scanty material into describing a superfluous species, it seems proper to consider all the small fossil *Psammechinus*-like urchins of the River Murray and Aldinga cliffs a single species.

Comparison of the figures given with specimens of the various Recent genera of small Echinidae has satisfied me that the fossils are best referred to the genus *Pseudechinus*. A comparison of Laube's figure 3 with a specimen of *Ps. albocinctus* of about the same size is quite convincing. The fossils occur in Oligocene and Lower Miocene strata. They are up to 22 mm. in diameter and show considerable diversity in the relative height, v.d. 0.57–0.80 h.d., but Tate says the low and high forms intergrade completely.

NUDECHINUS

H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 276.

Genotype: *Nudechinus scotiopremnus* H. L. Clark, 1912, p. 277.

This small genus of half a dozen species is made up of little, rather secretive echini of which 4 species occur in Australian waters. Their structural differences are not very evident, but the diversity of color and color patterns indicates specific distinctions. The following key emphasizes these:

Key to the Species of Nudechinus

A. Primary spines not distinctly banded, either unicolor or with colored basal part:
  Test green or yellowish green or light with green blotches; spines white or whitish, green or brown at base ..... *scotiopremnus*
  Test whitish, yellowish, or dusky; spines white distally, violet or brownish basally; in some cases violet or brown forms broad band, with actual base of spine white or light-colored; rarely in young specimens spines are wholly white ..... *darnleyensis*

AA. Primary spines more or less distinctly banded, but color fades with time and bands may become very faint; test with more or less green:
  Test gray-greenish with some deep green blotches or spots; primaries grayish white with 1, 2, or 3 bands or rings of dull pink, clear rose, or brownish rose ..... *gravieri*
  Test variegated with white, light, and dark green; primaries light-colored with 2–4 narrow, not sharply defined dusky bands, which may have a violet tinge ..... *multicolor*

Nudechinus scotiopremnus

H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 277; pl. 97, figs. 4–6.

The discovery of this urchin at Broome was one of the great surprises of collecting in Roebuck Bay. The subsequent discovery near Fremantle and the occurrences at Dongarra and Shark Bay and, as a fossil or semifossil, in the Quaternary deposits on Rottnest Island were also unexpected. For details of these occurrences see H. L. Clark, 1938, pages 401–402. This is one of the few cases of an echinoderm common to northwestern Australia and the Red Sea, which is not also known in the East Indian or South African areas. Mortensen (1943) thinks the Australian form may well be regarded as a separate variety, *australiensis*.

Nudechinus darnleyensis

Echinus darnleyensis Tenison-Woods, 1878. Proc. Linn. Soc. N. S. Wales, vol. 2, p. 165.
Nudechinus darnleyensis H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 277 (not figured).

This little sea urchin is a characteristic species of the tropical coasts of Australia from Moreton Bay, southern Queensland, to 45 miles west-southwest of Cape Jaubert, Western Australia, in 3–11 fms. It seldom exceeds 25 mm. h.d., but shows no little diversity of form, v.d. ranging from 0.44 to 0.58 h.d. The great diversity in the relative amounts of white and violet (or pale brown) renders a description of the coloration difficult, but in H. L. Clark, 1938 (pp. 398–399), some attempt has been made.

Nudechinus gravieri

Gymnechinus gravieri Koehler, 1905*a*. Bull. Mus. hist. nat., vol. 11, no. 3, p. 185; fig. 1.
Nudechinus gravieri H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 277.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 400.

This little sea urchin is very inadequately known, and it is doubtful whether the specimens from Western Australia are identical with Koehler's 2 specimens from the Red Sea. All the known material is made up of young individuals, 13 mm. or less in diameter. The "John Murray" Expedition failed to find any specimens of *Nudechinus* in the very region where they should be found.

Nudechinus multicolor

Echinus multicolor Yoshiwara, 1898. Annot. zool. japon., vol. 2, no. 2, p. 60.
Nudechinus multicolor H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 276 (not figured).

This is another very imperfectly known small echinoid, based on a single specimen, 14 mm. h.d. This individual was taken in southern Japan, and no others have yet been taken in that region. The Great Barrier Reef Expedition took 2 small echini, 5 and 8 mm. h.d., at Low Isles and at Three Isles, which appear to be identical with the Japanese urchin. No other specimens of *multicolor* have been reported and until much more material is available, the status of the species is uncertain.

TRIPNEUSTES

L. Agassiz, 1841*b*. Mon. Ech.: Préf. Anat. Echinus, p. viii.

Genotype: *Echinus ventricosus* Lamarck, 1816, vol. 3, p. 44.

This is a tropical genus of large sea urchins, common in shallow water, more particularly on grassy bottoms, up to low-water mark. One species is common in the West Indian region and is reported from several of the Atlantic islands, and even from the western coast of Africa. A very closely related species occurs on the western coast of tropical America. The most widespread species is found throughout the Indo-Pacific region, from the Red Sea to Delagoa Bay on the eastern coast of Africa, to Hawaii, Clarion Island, and the Paumotus in the eastern tropical Pacific. This is naturally the species occurring in Australia, where it has, however, a rather peculiar distribution.

Tripneustes gratilla

Echinus gratilla Linné, 1758. Syst. Nat., ed. 10, p. 664.
Tripneustes gratilla Lovén, 1887. Ech. Linn., p. 77.
H. L. Clark, 1921. Ech. Torres Strait, p. 148; pl. 17, fig. 6 (colored).

Although this big sea urchin is common on the Barrier Reef from the Murray Islands southward even to Lord Howe Island and Port Jackson, it has not been taken in Torres Strait or the Arafura Sea or anywhere on the northern coast of Australia; yet it does occur in Western Australia, at Shark Bay, in the Abrolhos, and even at Rottnest Island. This curiously discontinuous distribution still lacks an explanation. Full-grown specimens are 140–145 mm. h.d. and are more or less handsomely colored: the test deep purple, the spines white, more or less tipped with deep orange, and the tube feet white with black or deep red crossbands. In very young individuals, little pigment is present and the general coloration is pure white, with some dusky pigment or with a pinkish tinge in the abactinal interambulacral areas. Tenison-Woods' (1883, p. 94) supposed variety *alba* is, I think, based on immature, though relatively large, individuals. Pigmentation shows a good deal of individual diversity, and its absence hardly warrants a varietal name. Apparently it normally increases with age, and there is also some local diversity. The orange of the spines is a fugitive color and soon disappears in preserved specimens, either dry or alcoholic or in formalin.

GYMNECHINUS

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 115.

Genotype: *Echinus robillardi* de Loriol, 1883, p. 23.

This is a small and interesting genus of half a dozen species occurring in the Indian region from Mauritius and the Persian Gulf to Siam and northeastern Australia. They are easily recognized by the notably excentric periproct. The single Australian species is the following.

Gymnechinus epistichus

H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 289; pl. 102, figs. 4, 5.

The finding of this interesting sea urchin near Lizard Island, Queensland, by the Great Barrier Reef Expedition (see H. L. Clark, 1932, p. 214) definitely settles the question concerning its position in the Australian fauna. The specimens from "Australia" sent to Agassiz by Tenison-Woods were undoubtedly from Darnley Island, even though we did not collect any specimens in that region in 1913. Mortensen (1943) records specimens from Bowen, Queensland.

The type specimens are about 26 mm. h.d. and rather dingy in their dull gray and dull violet shades, but those taken by the Barrier Reef Expedition, of which the largest is 30 mm. h.d., have the test light gray or purplish apically, with the abactinal system greenish white; large spines light dull orange fading to nearly white at base and tip; the orange more or less tinged with purple, especially distally, where some spines are distinctly violet; small spines and pedicellariae, white.

Family STRONGYLOCENTROTIDAE

This rather large and widely distributed family is not very common in the Australian region, but is represented by 4 genera, of which 1 is monotypic and endemic, and only 1 occurs outside the Indo-Pacific area. These genera may be distinguished as follows:

Key to the Genera of Strongylocentrotidae

A. Test with ambitus above equator; not more than 4 pore pairs in each arc; ocular plates fully exsert; primary spines longest on flat abactinal surface ..... *Echinostrephus*

AA. Test with ambitus at or below equator (if above, there are more than 4 pore pairs in an arc, and 1, at least, of oculars is insert):

B. Test thin, with deep gill cuts having very prominent flange ("lip" or "tag") on interradial side; plates of buccal membrane carry both spines and pedicellariae ..... *Pseudoboletia*

BB. Test seldom thin; gill cuts without prominent flange and usually shallow; no spines on plates of buccal membrane:

Test thick, heavily tuberculated; pore pairs 4, rarely 5, in an arc ..... *Pachycentrotus*

Test not notably thick and heavily tuberculated; pore pairs 7–10 in an arc ..... *Heliocidaris*

ECHINOSTREPHUS [1]

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 20.

Genotype: *Echinostrephus aciculatus* A. Agassiz, 1863, p. 20.

This little genus of curious rock-boring sea urchins is characteristic of coral-rock areas in the Indo-Pacific region from Zanzibar to Hawaii. There are but 2 species, and both occur in the Australian seas, though not in the same area. They are readily distinguished thus:

Pore pairs in arcs of 3; ambitus more or less pentagonal; genital and ocular plates with tubercles only on outer margin ..... *molare*

Pore pairs in arcs of 4; ambitus circular; genital and ocular plates with more or less numerous tubercles ..... *aciculatum*

Echinostrephus molare

Echinus molaris de Blainville, 1825. Dict. sci. nat., vol. 37, p. 88.
Echinostrephus molare A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 119.
Echinostrephus molaris de Loriol, 1883. Mém. Soc. phys. hist. nat. Genève, vol. 28, no. 8, p. 31; pl. 4, figs. 2–2*c*.

This odd little sea urchin is common at the Murray Islands and has been taken as far south as the Low Isles, but it is not otherwise known from Australia. The test,

[1] Mortensen (1943, p. 310) protests "emphatically" against my use of the neuter terminations for the species names in this genus, asserting that the name *Echinostrephus* is "clearly masculine." It may be apparently masculine, but the Greek noun *στρέφος* is neuter, not masculine. The neuter terminations for the specific names in *Echinostrephus* are therefore correct, as A. Agassiz indicated in 1872.

less than 25 mm. h.d., is usually quite green on the abactinal side, but the spines are purplish brown, generally very dark but occasionally light. For an account of the remarkable habits, see H. L. Clark, 1921, page 150.

Echinostrephus aciculatum

Echinostrephus aciculatus A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 20.
——— 1873. Rev. ech., pt. 3, pl. 5*a*, figs. 10–12 (as *E. molare*).

The fact that the *Echinostrephus* at Lord Howe Island is not the species occurring on the Barrier Reef, but is the Hawaiian species, is most surprising, but is authenticated by many specimens (see H. L. Clark, 1938, p. 402). It grows larger than *molare* (up to 29 mm. h.d.) and shows more diversity in color and in the length of the primary spines, but its habits seem to be the same. Mortensen (1943) reports *aciculatum* from the Gilbert and Society islands and does not consider its occurrence at Lord Howe Island so remarkable as it still seems to me.

PSEUDOBOLETIA

Troschel, 1869. Sitzungsber. Niederrhein. Gesellsch. Bonn, p. 96.

Genotype: *Pseudoboletia stenostoma* Troschel, 1869, p. 96 = *Toxopneustes indianus* Michelin, 1862, p. 5.

This is a widely distributed but small genus of only 3 or 4 species, and a single specimen is the justification for including it in the Australian fauna. Apparently very local in its distribution, it may possibly occur in any part of the tropics, though it has not yet been taken in the eastern Pacific along the American coast.

Pseudoboletia indiana

Toxopneustes indianus Michelin, 1862. Ech. et stel., annexe A *in* Maillard, Réunion, p. 5.
Pseudoboletia indiana A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 153.
de Loriol, 1883. Mém. Soc. phys. hist. nat. Genève, vol. 28, no. 8, p. 28; pl. 3, figs. 4–4*f* (4, 4*a* colored).

A single specimen, 50 mm. h.d., was dredged by Dakin off Long Island, in Houtman's Abrolhos, Western Australia. No other Australian specimen is known, but the species ranges from Mauritius to Hawaii and might be expected anywhere in tropical Australia. At Mauritius it grows to 100 mm. h.d., and its colors in life are shown by de Loriol as rather striking—yellow, bluish green, and pink. But the Abrolhos specimen, as preserved, is a dirty white.

PACHYCENTROTUS

H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 349.

Genotype: *Sphaerechinus australiae* A. Agassiz, 1872, p. 55.

This is a monotypic, endemic genus known only from southeastern Australia. Its exact relationships are obscure, but probably it is nearer to *Heliocidaris* than to any other genus in the family. Superficially, however, it is not at all like that genus.

Pachycentrotus australiae

Sphaerechinus australiae A. Agassiz, 1872. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, p. 55.
Pachycentrotus australiae H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 349; pl. 98, figs. 5–8.

Although neither the "Thetis" nor the "Endeavour" met with this sea urchin, Verco found it rather common in St. Vincent and Spencer gulfs, and the largest specimen in the South Australian Museum is from the northern coast of Kangaroo Island. No specimens are yet recorded exceeding 40 mm. h.d. The height of the test is 0.55–0.60 h.d. The coloration is diversified green, violet, and brownish (see H. L. Clark, 1928, p. 468). *Pachycentrotus* has been taken not only at the South Australian localities, but also at Port Phillip, in Bass Strait, and in Tasmania. It is not yet reported from New South Wales.

HELIOCIDARIS

Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 371.

Genotype: *Echinus omalostoma* Valenciennes, 1846, pl. 6, fig. 2 = *Echinus tuberculatus* Lamarck, 1816, vol. 3, p. 50.

As it now seems evident that *Toxocidaris crassispina* A. Agassiz from Japan is not congeneric with *Echinus tuberculatus* Lamarck, and that *Heliocidaris stenopora* H. L. Clark is based on a specimen of *Echinometra vanbrunti* having a circular ambitus and very coarse tubercles and spines, it develops that *Heliocidaris* is a genus of the southern hemisphere, including only 2 species, 1 characteristic of the southern coasts of Australia, and 1 found rarely on the eastern coast, very common at Lord Howe Island, and apparently occurring, though rarely, in northern New Zealand and at the Kermadec Islands.[1] These 2 species differ quite obviously in general appearance, but the differences are not easy to formulate. The best distinction is in the number of pore pairs in an arc.

Pore pairs 7 or 8 in an arc, rarely 9 ..... *erythrogramma*
Pore pairs 9 or often 10 in an arc ..... *tuberculata*

Heliocidaris erythrogramma

Echinus erythrogrammus Valenciennes, 1846. Voy. "Venus": Zooph., pl. 7, fig. 1.
Heliocidaris erythrogramma Agassiz and Desor, 1846. Ann. sci. nat., Zool., ser. 3, vol. 6, p. 371.

This is probably the most common regular sea urchin from Port Stephens, New South Wales, along the southern coast of Australia to the Abrolhos Islands and Shark Bay on the western side of the continent. It reaches 86 mm. h.d. The test is usually about 0.50 h.d. in height, rarely more, but may be much less; some specimens in the British Museum have the height only 0.32–0.38 h.d. There is very great diversity in the length and character of the primary spines and in coloration, and several species and varieties have been named. The validity and value of these varietal names is a matter of opinion, but 2, representing extremes in the stoutness of the primaries, *armigera* and *parvispina,* may be useful. For an extended

[1] These conclusions are also reached by Mortensen, 1943.

discussion of the matter see H. L. Clark, 1938, pages 404–406. The recognition of *armigera* as a valid species by Cotton and Godfrey (1942) seems to me indefensible. They are justified, however, in declining to recognize *parvispina* as a valid subspecies, since it is only an extreme variant. The remarkable, abbreviated development from the egg of this common Australian sea urchin was discovered by Mortensen in 1914 and promptly reported (1915) to the Linnean Society of New South Wales, under the name *Toxocidaris erythrogrammus.*

Heliocidaris tuberculata

Echinus tuberculatus Lamarck, 1816. Anim. sans vert., vol. 3, p. 50.
Strongylocentrotus tuberculatus A. Agassiz, 1873. Rev. ech., pt. 3, p. 449; pl. 5*b*, figs. 4, 5.
Heliocidaris tuberculata H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 282.

This big sea urchin is very common at Lord Howe Island, but its occurrence elsewhere is erratic. Specimens in the British Museum are said to be from "Sydney" and "Port Philip Heads, Victoria." Whitelegge (1889, p. 203) lists "*Strongylocentrotus tuberculosus*" as "Rare, Shark Point, P. J. (Mr. Hunt)," and Mortensen (1943, p. 342) says he found it at Port Jackson Head. Tenison-Woods (1878, p. 158) says he has seen a specimen from Port Stephens, but two years later (1880, p. 288) he lists *tuberculatus* as from "Australia, habitat unknown." Neither the "Thetis" nor the "Endeavour" met with it, and there are no specimens in the South Australian Museum. Mortensen (1921, p. 174) reports it from Mokohinau with the remark that "This appears to be the only New Zealand locality from which it is known with certainty." There is no doubt, however, of its occurrence at Raoul Island and apparently elsewhere in the Kermadecs. At Lord Howe Island, it is particularly common on the reef flat near Mount Lidgbird, where it grows to a large size, 100–106 mm. h.d. It shows considerable diversity in the length of the primary spines and also in their relative stoutness and form. The color in life is bright brown with a red tinge to test and pedicels, and with the tips of the spines markedly greenish.

Family ECHINOMETRIDAE

This is a rather well marked tropical family of some 5 genera and a dozen or more species, but it is poorly represented in Australian seas by a few species of 3 genera which have a very scattered and disconnected distribution on the tropical coasts. They are easily distinguished thus:

Key to the Genera of Echinometridae

A. Pore pairs in arcs of 3; periproct covered by 4 (rarely 5) subequal anal plates ..... *Parasalenia*
AA. Pore pairs 4 or more; periproct covered by numerous unequal plates:
Pore pairs 4–8; primary spines not excessively stout ..... *Echinometra*
Pore pairs 10 or more; primary spines excessively stout ..... *Heterocentrotus*

PARASALENIA [1]

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 22.

Genotype: *Parasalenia gratiosa* A. Agassiz, 1863, p. 22.

The question whether there is more than a single species in this genus is still open to debate, for adequate material is not yet available. Parasalenias are secretive in their habits and live, as a rule, well concealed among the branches of corals or hidden in crevices and crannies or under slabs of coral rock. They are also small, and the longest test diameter does not reach 40 mm. The 2 recognizable forms are distinguishable as follows:

Periproct large, long diameter about one-half long diameter of abactinal system; each genital plate with at least 1 well developed tubercle; no red in coloration; genital 3 not excluded from periproct ..... *gratiosa*
Periproct small, about one-fourth diameter of abactinal system; no tubercles on genital plates; more or less red in coloration; genital 3 often excluded from periproct ..... *pöhlii*

Parasalenia gratiosa

A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 22.
——— 1873. Rev. ech., pt. 3, p. 435; pl. 3*d*, figs. 1, 2.

Mature specimens of this urchin are very dark, more or less nearly black, with the milled ring of the primary spines pure white in striking contrast. They are 30–36 mm. long, with the height generally less than half as much and the width 0.70–0.90 of the length. The longest primary spines are nearly or quite equal to the long diameter. The species ranges from Zanzibar to the Paumotu Archipelago and north to the Bonin Islands and southern Japan. On the Australian coast it has been found as far south as Green Island, off Cairns, Queensland, and as far west as Augustus and Champagny islands, Western Australia, but it is apparently rare and local.

Parasalenia pöhlii

Pfeffer, 1887. Verhandl. Naturwiss. Ver. Hamburg, vol. 6, p. 110 (not figured).

Whether this species is valid or not is still debatable, but Mortensen (1943) maintains it. I am still very skeptical, but a specimen in the South Australian Museum from Cairns, Queensland, clearly a *Parasalenia,* is apparently not *gratiosa* and may better be referred to *pöhlii* than made the basis for a new name, even though there is no red in the coloration. It is 16×13×7 mm. and hence is fully half grown. There are 5 subequal anal plates, each one opposite an ocular. There are no other specimens from Australia referred to *pöhlii,* so far as I know.

[1] Mortensen (1943) makes a family, the Parasaleniidae, to include this genus and a superficially very different Eocene form, which he calls *Diplosalenia,* a quite unnecessary procedure.

ECHINOMETRA

Gray, 1825. Ann. Philos., vol. 26, p. 426.

Genotype: *Echinus lucunter* Linné, 1758, p. 665.

This very abundant tropicopolitan genus is represented in Australia by at least 1 species and possibly 2, but the distribution is peculiar. Döderlein (1914) records "*Mortensenia oblonga*" from Shark Bay, Western Australia, but gives no information as to the character or size of the specimens. He does, however, indicate that they were not characterized by the short, stout spines which alone make *oblonga* a recognizable species. It therefore seems best to refer all the known Australian material to the common and very widespread Indo-Pacific species, which shows so much diversity in color, form, and spinulation as to make the distinguishing of even so long recognized a species as *oblonga* very difficult and unsatisfactory. Typical specimens of *oblonga* are not known from Australia.

Echinometra mathaei

Echinus mathaei de Blainville, 1825. Dict. sci. nat., vol. 37, p. 94.
Echinometra mathaei de Blainville, 1830. Dict. sci. nat., vol. 60, p. 206.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 431; pl. 4*b*, fig. 4 (as *lucunter*).
H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 373; pl. 114, figs. 5, 6 (as *picta*).

Probably the most abundant sea urchin in the world, this wide-ranging Indo-Pacific species occurs in very great numbers on the reefs and reef flats where it occurs at all. It is a great rock borer, and thrives on surf-beaten reefs and areas where other echini have to seek shelter under large slabs of rock or in protected pools. It shows great diversity in color and character of spines, and several striking forms have received names as separate varieties. The distribution of *mathaei* in Australia is peculiar, for whereas it occurs abundantly at Lord Howe Island and on the northern part of the Great Barrier Reef, above Port Molle, it is wanting along the whole northern coast of the continent west of Thursday Island, save for a single record from the Gulf of Carpentaria (McNeill and Livingstone, 1926). And yet local conditions at many places would seem to be particularly suited to its needs. On the western side of Australia, however, *mathaei* is again found at Shark Bay, at the Abrolhos Islands, and even as far south as Rottnest Island, where it occurs at the southwest corner "in thousands" (see H. L. Clark, 1938, pp. 408–410). The Shark Bay material was identified by Döderlein as *oblonga,* but as he gives no data about spines or color, it is impossible to determine whether that name was correctly used. In view of the occurrence of *mathaei* at the Abrolhos and Rottnest and the complete absence of true *oblonga* from Australia otherwise, it seems almost certain that the Shark Bay *Echinometra* is *mathaei.*

Under favorable conditions, this urchin grows to a notable size, and specimens from the Red Sea in the Museum of Comparative Zoölogy collection show great diversity of form when fully grown. The largest is 87 mm. long, 73 mm. wide, and 42 mm. high; the width is thus 0.84 h.d. and the height 0.48. But there is another specimen 72 mm. long, in which the width is 66 mm. (0.91 h.d.) and the height only 31 mm. (0.43 h.d.), and a third individual in the same lot is 75 mm. long, only 60 mm. wide (0.80 h.d.), but 41 mm. high (0.54 h.d.). Australian specimens are not known to reach so large a size, but probably show just as great

diversity in proportions. As for color, the diversity is equally great; the test is usually blackish, but the spines range (in different specimens) from dull pinkish, brownish red, or dull purple (almost black at times) to green (more or less olive) or light gray; they are sometimes abruptly tipped with white, making very handsome specimens, strikingly different at first sight from the duller-colored individuals.

HETEROCENTROTUS

Brandt, 1835. Prodr. descr. anim., p. 65.

Genotype: *Echinus mamillatus* Linné, 1758, p. 667.[1]

This extraordinary genus, comprising the so-called "slate pencil" urchins, includes but 2 species, which range widely over the Indo-Pacific region from East Africa to the Paumotus and north to the Bonin Islands and Hawaii. In the Pacific, one species seems to be found north of the equator, the other only to the south thereof, but in the Indian region both species occur. The species of the northern Pacific reaches Australia, but neither reaches New Zealand.

Heterocentrotus mammillatus

Echinus mamillatus Linné, 1758. Syst. Nat., ed. 10, p. 667.
Echinus mammillatus Gmelin, 1791. Linné: Syst. Nat., ed. 13, vol. 1, pt. 6, p. 3175.
Heterocentrotus mamillatus Brandt, 1835. Prodr. descr. anim., p. 66.
Heterocentrotus mammillatus A. Agassiz, 1863. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, p. 17.
H. L. Clark, 1912. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, p. 378; pls. 115–117.

Southwestge Heron rev Aug 61.

This big and inert sea urchin has been taken once at Lord Howe Island and once at the Murray Islands, at the northern end of the Barrier Reef. It is therefore but little entitled to a place in the Australian fauna. Owing to the very heavy primary spines, which may exceed the longer diameter of the test and have a diameter of 8–10 mm., the genus is unmistakable. Full-grown specimens have the longer diameter of the test 100 mm. or more. There is considerable range in color, from dull purplish to bright brown, with the big primaries often distinctly cream color, though they may be dark. In some individuals, the primaries are conspicuously marked on the distal half with 1, 2, or 3 broad bands of white or pale cream color. The short, blunt secondary spines often contrast in color markedly with the primaries; in some individuals they are very light, but in others they are very dark, and this may occur in specimens from the same spot, so it seems to be purely a matter of individual diversity.

Mortensen (1918) lists a single dried specimen of this species from Cape Jaubert, but I feel sure this is a case of an erroneous locality label, as in the case of "*Goniocidaris tubaria*" from the same locality.

Order EXOCYCLOIDA

This is a very heterogeneous group of "irregular echini," so called because the shape of the test is so different from that of those called regular. The change in

[1] The spelling "mamillatus" used by Linné in 1758 is an obvious error which was corrected by Gmelin in the 13th edition of "Systema Naturae." The attempted return to the spelling of the 10th edition is to be regretted.

shape is associated with a change in the position of the periproct away from the center of the abactinal surface, opposite to the mouth, into interambulacrum 5, which thus indicates the posterior end of the animal. As the mouth in the more specialized groups moves forward into ambulacrum III, a superficial bilateral symmetry is assumed, obscuring the still fundamentally radiate symmetry. These changes have gone on extensively during the Mesozoic and subsequent eras, and the fossil species of Exocycloida are numerous and varied. The order breaks up into 6 suborders, which are to be distinguished thus:

Key to the Suborders of Exocycloida

A. Interambulacrum 5 not essentially different from others orally:
  B. Test usually depressed, often markedly flattened; anus in posterior interambulacrum, generally near margin of test, usually on oral surface, sometimes quite near mouth; jaws and auricles present but peristomal gills wanting; ambulacra markedly petaloid abactinally, except in certain small forms where they are greatly reduced ..... Clypeastrina
  BB. Not as above:
    C. Ambulacra narrow, not at all petaloid; pore pairs uniserial, with minute pores; peristome oblique ..... Echinoneina
    CC. Ambulacra more or less petaloid or at least subpetaloid:
      Pores of petals dissimilar ..... Nucleolitina
      Pores of petals similar and normally conjugate ..... Cassidulina
AA. Interambulacrum 5 modified orally to form sternum:
  Labrum followed by single plate ..... Urechinina
  Labrum followed by pair of plates, large and equal or nearly equal ..... Spatangina

Suborder Clypeastrina

This suborder includes the largest of the shield urchins as well as the smallest members of the Exocycloida. They show great diversity of form, but remarkable similarity of habits and habitats, for all are shallow-water echini living on or just below the surface of sandy bottoms. They are frequently gregarious and often occur in large numbers in favorable places. The group is well represented in Australia by 4 families, which may be distinguished thus:

Key to the Families of Clypeastrina

A. Auricles separate, each placed more or less clearly on ambulacrum ..... Clypeastridae
AA. Auricles fused into single piece on interambulacrum:
  B. Test seldom discoidal and never with marginal slits or lunules; aboral end of each interambulacrum consists of single large plate adjoining genital; ambulacral furrows on oral surface short and indistinct or wanting:
    Petals more or less perfect; madreporic pores numerous; size moderate to large, 15–150 mm. in length ..... Laganidae
    Petals reduced and often rudimentary; often only 1 madreporic pore; size small, rarely up to 20 mm. in length ..... Fibulariidae
  BB. Test flat and usually discoidal, often with marginal slits or lunules; aboral end of each interambulacrum with usual pair of small plates adjoining genital; ambulacral furrows distinct on oral surface, at least the posterior reaching margin ..... Scutellidae

Family CLYPEASTRIDAE

So abundant are the members of this family both in Recent seas and in Tertiary rocks that something like 300 species have been named, of which more than 250 are fossils. The group is in need of a careful revision, more particularly of the fossil forms. Only about a dozen species are known from Australia, most of which are living. One genus of these, *Arachnoides,* occurring also in the East Indian region and New Zealand, has long been considered so different from *Clypeaster* as to warrant separation in a family by itself, but in recent years 2 additional genera have been discovered on the coasts of South and Western Australia which obliterate the supposed lines of distinction and require the recognition of 6 genera in the present family. It may be mentioned in passing that Lambert and Thiéry (1914) name 15 genera and list scores of Clypeasters which they are unable to place in any of these groups. It is quite impossible to make use of their classification. The 6 genera of Clypeastridae which occur in Australia may be recognized with the aid of the following key:

Key to the Genera of Clypeastridae

A. Test rarely discoidal, usually not flat; anus marginal or inframarginal; genital pores 5:
  Poriferous areas of petals divergent, not incurved distally; anus marginal ..... *Anomalanthus*
  Poriferous areas more or less incurved distally; anus inframarginal ..... *Clypeaster*
AA. Test more or less discoidal or flat; genital pores 4:
  B. Test longer than wide; petals small, sharply defined, slightly narrowed and rounded distally; periproct inframarginal; fossil ..... *Monostychia*
  BB. Not as above:
    C. Test very flat, markedly discoidal; petals with poriferous areas short and very divergent; periproct marginal or supramarginal ..... *Arachnoides*
    CC. Not as above; periproct on oral surface:
      Test distinctly longer than wide, moderately arched; poriferous areas divergent, not curved inward at tip ..... *Hesperaster*
      Test discoidal, length and breadth about equal; very flat; poriferous areas with outer margin rounded so they appear to curve inward at tip ..... *Ammotrophus*

ANOMALANTHUS

Bell, 1884*a*. Proc. Zool. Soc. London, p. 43.

Genotype: *Echinanthus tumidus* Tenison-Woods, 1878, p. 169.

This well marked genus was fully described by Bell and excellent figures of the type species are given. Its relationship to *Clypeaster* is obvious, but its distinctness is equally evident. Only a single species is known.

Anomalanthus tumidus

Echinanthus tumidus Tenison-Woods, 1878. Proc. Linn. Soc. N. S. Wales, vol. 2, p. 169.
Anomalanthus tumidus Bell, 1884*a*. Proc. Zool. Soc. London, p. 43; pls. 2, 3.

This remarkable species is known from only a single specimen in the Australian Museum, supposed to have been taken on the Australian coast, presumably near or in Port Jackson. It is 140 mm. long, 115 mm. wide, and 63 mm. high. I can find no basis for Lambert and Thiéry's (1914, p. 310) statement that the species belongs to the "Pliocène d'Australie." There is every indication that it is a Recent species.

CLYPEASTER

Lamarck, 1801. Syst. anim. sans vert., p. 349.

Genotype: *Echinus rosaceus* Linné, 1758, p. 665.

Considering the scores of Tertiary fossils that have been referred to this genus, it is very poorly represented in Australia, by a single fossil and 4 Recent species. Owing to their habit of living more or less buried just below the surface of the sand, they are easily overlooked by divers, and a dredge or trawl usually passes over them. Often a fragment is broken off, tangible evidence of their presence but very unsatisfactory as a specimen. Occasionally, however, they occur in such numbers that several will be taken by a dredge. Bare tests are not rarely found on beaches or under rocks on reef flats. The 5 Australian species may be distinguished by the following key:

Key to the Species of Clypeaster

A. Test rather high, with thick margins; lower surface concave or deeply sunken only near mouth; lateral petals more or less widely open:
  Tuberculation of test crowded, miliary granules very numerous and relatively high; ridges between pores usually with numerous (9–12) primary tubercles crowded by miliaries ..... *australasiae*
  Tuberculation of test more sparse, miliary granules rather flat and uncrowded; ridges between pore pairs with 6 or more primary tubercles but usually without miliaries; fossil ..... *gippslandicus*

AA. Test rather low and flat; lower surface flat or gradually concave:
  B. Primary tubercles numerous, small; 6 or more on ridges between pore pairs; anterior petal long, with converging poriferous areas:
    Primary tubercles evidently bigger than miliaries, well spaced; miliaries flattened ..... *humilis*
    Primary and miliary tubercles not sharply differentiated, but crowded together ..... *telurus*
  BB. Primary tubercles scattered, rather large; not more than 4, often 1 or none, on ridges between pore pairs of unpaired petal; anterior petal short, with diverging poriferous areas ..... *virescens*

Clypeaster australasiae

Echinanthus australasiae Gray, 1851*a*. Proc. Zool. Soc. London, p. 34.
Clypeaster australasiae H. L. Clark, 1914*a*. Mem. Mus. Comp. Zoöl., vol. 46, p. 32; pl. 134; pl. 135, fig. 6.

This is the commonest of the Australian Clypeasters, having been taken at many points between Brisbane Water, Queensland, and Port Phillip Heads, Victoria, as well as at Lord Howe Island, from low-water mark down to 71 fms. It grows to

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a large size, a specimen in the Museum of Comparative Zoölogy measuring 150 mm. in length and 125 in width. Its color is very dark, nearly black, but smaller specimens are more of a gray-brown. The specimen from Lord Howe Island in the M.C.Z. is notably flattened, with the poriferous areas exceptionally narrow and the tuberculation of the ridges between the pore pairs very coarse as in *gippslandicus*. A good series of specimens from Lord Howe might prove very interesting in studying the relationship between that species and *australasiae,* for it is by no means sure that the two are distinct.

*Clypeaster gippslandicus

McCoy, 1879. Prodr. palaeontol. Victoria, dec. 6, p. 33; pl. 59.

The excellent figures and description of this species leave no doubt as to its specific characters, and it is almost certain that if it is really distinct from *australasiae,* it is the ancestor of that species. McCoy says it is very common in Miocene strata of Bairnsdale and other localities in Gippsland. He mentions several other Miocene localities and one in the Lower Pliocene. He says the average specimen is 3½ inches long, with the width 0.88 of the length, and the height, 0.27.

Clypeaster humilis

Echinanthus humilis Leske, 1778. Add. ad Klein, p. 121.
Clypeaster humilis A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 100.
H. L. Clark, 1914*a*. Mem. Mus. Comp. Zoöl., vol. 46, p. 36; pl. 137; pl. 138, fig. 4.

This is a wide-ranging species, known from Mauritius to the Red Sea and eastward to the Philippine Islands and Queensland. Its right to a place in the Australian fauna rests on a very large specimen (150 × 135 × 25 mm.) taken by the "Alert," which Bell identified as *humilis* and says is from "Port Molle, 4 fms." The specimen is in the British Museum but bears a label saying that it is from Port Denison—not a very important difference. The possibility that this specimen is a very large and stout example of the following species cannot be ignored, and renders the position of *humilis* in the Australian fauna uncertain.

Clypeaster telurus

H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 166; pl. 23.

This species is remarkable for occurring both at Broome, Western Australia, and farther south near Fremantle, and also at Fraser Island, Queensland, directly across the continent. Although closely allied to *humilis,* it is less stout, and the difference in the tuberculation of the test is rather striking. At Broome it is fairly common, as we took specimens in both 1929 and 1932. They ranged from 77 to 157 mm. in length, and the width was uniformly 0.92 or 0.93 as much. The smallest specimen was purplish brown, but others were yellowish brown and the adults were bright dark brown. The Fraser Island specimens are large adults, up to 145 × 135 mm., and are purplish brown. They were taken by the "Endeavour," and their identity with the specimens from Western Australia seems complete.

Clypeaster virescens

Döderlein, 1885. Arch. f. Naturgesch., vol. 51, no. 1, p. 102.
H. L. Clark, 1914*a*. Mem. Mus. Comp. Zoöl., vol. 46, p. 39; pl. 139, fig. 4; pl. 140, figs. 1, 2.

This is a second species of *Clypeaster* whose right to a place in the Australian fauna rests on a single specimen, taken by the "Endeavour" in Shoalhaven Bight in 15–45 fms. It is an adult, 105 mm. long and 95 mm. wide, and shows no characters to distinguish it from Japanese specimens. The fact that the "Terra Nova" took 2 specimens of *virescens* "off New Zealand," which are now in the British Museum, gives support to the idea that this Japanese species really does belong in the Australian fauna.

*MONOSTYCHIA

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 69, p. 188.

Genotype: *Monostychia australis* Laube, 1869, p. 190.

The fossils on which this genus is based seem to be rather common, and show enough variety of structure to make it doubtful how many species there are and in how many genera they belong. Duncan (1877), McCoy (1879), Johnston (1877, 1878), and Tate (1893) have all added to the confusion, and there is still room for difference of opinion as to the true status of the named forms. There is no reason to question Laube's account or figures given in 1869. Duncan (1877) and Johnston (1877) suggested new names for closely related forms, but McCoy (1879) reduced Duncan's *Arachnoides loveni* to the status of a variety of *Monostychia australis,* and Johnston decided that his *Micraster etheridgei* is really a *Monostychia.* In 1893, Tate proposed an *Arachnoides incisa* which is apparently closely related to *Monostychia,* but the similarity of the general facies to that of *Arachnoides* cannot be ignored. Consequently the genus *Monostychia* now includes 2 species, so diverse in form that several varietal names, already proposed, might be used if only the forms showed sufficient constancy to permit definition. The 2 apparently distinct species may be separated thus:

Outline rounded pentagonal, distinctly longer than wide; ambital margin not thickened ..... *australis*
Outline narrow oblong oval, broadest behind, narrowing to the somewhat produced, shortly rounded anterior end; ambital margin tumid ..... *etheridgei*

*Monostychia australis

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 69, p. 190; figs. 3–3*c*.
Arachnoides loveni Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 47; pl. 3, figs. 6, 7.
Arachnoides elongatus Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 48; pl. 3, fig. 8.

This is a very common fossil in several localities in South Australia and Victoria. The small series of specimens at hand shows enough diversity to make one

suspicious of varietal names, and Duncan's descriptions are so indefinite that the diagnostic characters of his proposed species are not at all clear. Laube's species is unmistakable, and it is improbable that the forms named by Duncan represent anything constantly distinct. The dimensions given for the type, 46.5 × 42 mm., are not quite equaled by any of the specimens at hand. The strata in which *australis* occurs are stated to be Oligocene, Miocene, and Lower Pliocene. Some of the localities are Murray River Cliffs and Mount Gambier, South Australia, and Mordialloc, Beaumaris, and Curdies Inlet, Victoria.

*Monostychia etheridgei

Micraster etheridgei Johnston, 1877. Proc. Roy. Soc. Tasmania (1876), p. 116.
Monostychia etheridgei Johnston, 1888. Proc. Roy. Soc. Tasmania (1887), p. 169 (not figured).

This inadequately described species, occurring in the Lower Miocene of Tasmania, would seem to be distinct from the preceding, but it might be mentioned here that a *Monostychia* in the Museum of Comparative Zoölogy from the Murray River Cliffs has the anterior end noticeably narrowed as described for *etheridgei*. The ambital margin, however, is not tumid, and it is probably only an individual variant from the normal form of *australis*.

ARACHNOIDES

Leske, 1778. Add. ad Klein, p. 154.

Genotype: *Arachnoides echinarachnius* Leske, 1778, p. 154 = *Echinus placenta* Linné, 1758, p. 666.

This is a small group of very flat, discoidal echini occurring in the East Indian region, northern Australia, and New Zealand. A single fossil species is known from Victoria which seems to be a connecting link with *Monostychia*. Specimens in the British Museum indicate that the New Zealand species occurs at Flinders Island in Bass Strait and at Cape Upstart on the Queensland coast. The characters of the New Zealand species by which it is distinguished from the widespread *placenta* have been made clear only in recent years, by Mortensen (1921). It is not impossible that the species occurs along the whole eastern coast of Australia, but if so, it must be very local, for there are few records for *Arachnoides* on the Queensland coast and none south of Moreton Bay. Except the specimens in the British Museum from "Cape Upstart," all the known Queensland material is *placenta*. On the whole, it seems best to include all the known Recent species in the Australian list. These and the Victorian fossil species are to be distinguished by the form of the test, the relative width of ambulacra and interambulacra at test margin, and the position of the periproct:

Key to the Species of Arachnoides

A. Ambitus sharp, deeply incised at ends of ambulacral grooves, between which it is undulose; periproct supramarginal; fossil ..... *incisa*
AA. Ambitus circular or slightly undulose, not incised in ambulacra:

B. Interambulacra at edge of test about half as wide as ambulacra; 2 or 3 pairs of interambulacral plates in each area on oral surface; no groove on oral surface in interambulacrum 5 ..... *zelandiae*

BB. Interambulacra at edge of test only one-fourth to one-third as wide as ambulacra; only 1 pair of interambulacral plates (rarely a second plate on one side) in each area on oral surface:

Test moderately stout; periproct marginal; naked groove on oral surface in interambulacrum 5 ..... *placenta*

Test delicate, with thin margins; periproct distinctly supra-marginal; no groove in interambulacrum 5 ..... *tenuis*

*Arachnoides incisa

Tate, 1893. Jour. Proc. Roy. Soc. N. S. Wales, vol. 27, p. 192; pl. 13, fig. 3.

This seems to be a well marked species, suggestive of *Monostychia* but quite evidently more like *Arachnoides*. The type was 54.4 mm. long, 56.5 wide, and 6.5 high. There were 3 specimens, found at Red Bluff and beyond Meringa, Gippsland Lakes, Victoria. Tate says the strata were Miocene, but Chapman writes me that they are Lower Pliocene.

Arachnoides zelandiae

Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 14; pl. 2, fig. 2.
Mortensen, 1921. Vidensk. Medd., vol. 73, p. 180; pl. 6, figs. 24, 25.

Mortensen's account of this species is adequate and leaves no doubt of its validity—another proof of the keen and unusually reliable systematic sense of Gray. Whether it belongs to the Australian fauna is, as stated above, open to considerable question. It was so long confused with *placenta* that it quite possibly has a wider range than has yet been suggested. It grows to a very large size, a specimen presented to Mortensen, taken in Wellington Harbor, being 128 mm. in length. Nothing has been recorded as to its distribution in New Zealand; Mortensen mentions only Napier and Wellington. Specimens in the British Museum are said to be from Massacre Bay. The reported Australian localities are Cape Upstart, Queensland, and Flinders Island, Bass Strait.

Arachnoides placenta

Echinus placenta Linné, 1758. Syst. Nat., ed. 10, p. 666.
Arachnoides placenta L. Agassiz, 1841. Mon. Ech.: Scut., p. 94.
Mortensen, 1921. Vidensk. Medd., vol. 73, pl. 6, figs. 26, 27.

This "sand shilling" is very common in suitable localities on the northern coast of Australia. It is recorded from Torres Strait and from a few points on the Queensland coast, of which the most southern is Moreton Bay. At Lindeman Island conditions must suit it well, as the largest specimen recorded, 96 mm. in diameter, is from there. It is very abundant at Darwin, and some observations on its habits are recorded in H. L. Clark, 1938, page 415. North of Australia it ranges to the Andaman Islands and the Philippines. The color in life is a dull gray-purple which changes, on drying, to gray or yellow-brown with or without a greenish cast.

Arachnoides tenuis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 415; pl. 27, figs. 3, 4.

This fragile species replaces *placenta* on the coast of Western Australia, at least west of Cape Leveque. Dead tests are excessively abundant west of Broome on some of the sandy beaches, but living specimens are not easy to discover. It is a small species, no individuals over 50 mm. in diameter being noted. The color in life is purplish brown, with the ambulacral areas darker than the interambulacral.

HESPERASTER

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 411.

Genotype: *Hesperaster arachnoides* H. L. Clark, 1938, p. 411.

This remarkable genus is endemic in Western Australia so far as we know, but there seem to be 2 species there, of which our knowledge and material are very scanty. Its relationship to *Clypeaster* is obvious in size and form, but structurally it is probably nearer to *Arachnoides*. The 2 species differ thus:

Height of test about 0.15 h.d.; petals short and wide; margin of test thin.....*arachnoides*
Height of test about 0.25 h.d.; petals longer and narrower; margin of test thick.....*crassus*

Hesperaster arachnoides

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 411; pl. 27, fig. 2.

An adult individual 130 mm. long × 121 mm. wide, and a young one, 31 × 30 mm., were dredged between Rottnest Island and Fremantle, October 19, 1929. The adult had the test "grayish light brown," which has not changed greatly in the dry specimen. The upper surface of the young one had a purple tinge; the lower side was light yellow, blotched with a darker shade.

Hesperaster crassus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 413; fig. 35A.

The somewhat damaged type of this species is in the Western Australian Museum at Perth, having been found in a Quaternary deposit near the salt lake on Rottnest Island. It measures 35 mm. long, 30 mm. wide, and 8 mm. high. The fact that it is semifossil does not indicate that the species is extinct, for all the other echinoids found in this deposit on Rottnest are now living in Western Australian seas. Further dredging will probably produce living specimens of this interesting species.

AMMOTROPHUS

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 471.

Genotype: *Ammotrophus cyclius* H. L. Clark, 1928, p. 471.

This endemic genus from the coast of South Australia is notable for several reasons, of which one is the superficial resemblance to *Echinarachnius*, a northern genus of Scutellidae which has been reported several times from Australia. It now seems probable that specimens of *Ammotrophus* are the basis for such reports. The genus is also interesting as being a close ally of *Arachnoides*, which has always been

considered quite an isolated genus. There seem to be 2 species of *Ammotrophus,* but as one is based on a single specimen, more material is indispensable for a correct determination of its status. The 2 species are distinguished thus:

Test nearly circular; petal in ambulacrum III nearly twice as long as wide; ambulacral furrow on oral surface in III just as conspicuous as in other ambulacra ..... *cyclius*
Test distinctly wider than long; width of petal in ambulacrum III about 0.80 length; ambulacral furrow in III, orally very indistinct ..... *platyterus*

Ammotrophus cyclius

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 471; figs. 140*a, b.*

This "sand shilling" is so much like the American "sand dollars" of the genus *Echinarachnius* of the family Scutellidae, it is hard to believe they are not very nearly related. Apparently the South Australian species is confined to that state, as no specimens have yet been reported save those in the South Australian Museum, and most of those lie to the credit of Verco, whose industrious dredging has contributed so much to our knowledge of Australia's marine fauna. The series of specimens in Adelaide ranges from 15 to 59 mm. in diameter. They are remarkably constant in the nearly circular form. The color in life is not recorded, but preserved specimens are rather bright yellow-brown, sometimes with a reddish tinge. The localities are Spencer Gulf, St. Vincent Gulf, and Encounter Bay.

Ammotrophus platyterus

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 474; figs. 144*a, b.*

Although this species rests on a single bare test taken in St. Vincent Gulf, its characters are so well marked there can be little doubt that it is a distinct species. The type is a perfectly bare test, bleached white, hence we know nothing as to spines or appearance in life. The form of the test is striking, for although it is 29.5 mm. wide, it is only 27 mm. long. Mouth longer than wide, and back of center of test; periproct little more than its own diameter from test margin.

Family LAGANIDAE

This small family, containing but 2 genera, is widely distributed in shallow water in the Indo-Pacific region. It does not occur in the Atlantic or in the eastern Pacific, but it is well represented on the coasts of Australia. The 2 accepted genera are arbitrarily distinguished by the number of genital pores, but it is not yet demonstrated whether this represents a natural or an artificial grouping.

Genital pores 5 or 6, present in all interambulacra ..... *Laganum*
Genital pores 4, wanting in posterior interambulacrum ..... *Peronella*

LAGANUM

Gray, 1825. Ann. Philos., vol. 26, p. 427 (*Lagana,* by error).

Genotype: *Echinodiscus laganum* Leske, 1778, p. 140.

Half a dozen or more species make up this genus, of which 3 occur in Australian seas. One of these, the type species, is unmistakable, but its geographical distribution

is still imperfectly known. The other two are closely related, and their ranges in Australia are not distinct, both being known from the northern part of the Barrier Reef area. The 3 species may be distinguished as in the following key. It may be mentioned here that Gregory's (1892) *Laganum decagonale* var. *rictum* is not a *Laganum,* but a *Peronella.*

Key to the Species of Laganum

A. Periproct midway between posterior margin of test and mouth, longitudinally elongated; test thick, with depressed petaloid area and swollen margins ..... *laganum*

AA. Periproct nearer margin than mouth, usually transversely elongated; test with petaloid area more or less elevated and margins not swollen:

Width of test 0.80–0.85 length; periproct 0.20 test length from margin; petaloid area about 0.60 test length; covering of test not made up of long, slender, crowded spines like coat of fur, and not dull purplish brown in color ..... *depressum*

Width of test 0.90–0.95 length; periproct only 0.12 test length from margin; petaloid area about 0.70 test length; covering of test made up of long, slender, crowded spines like coat of fur, purplish brown in color ..... *dyscritum*

Laganum laganum

Echinodiscus laganum Leske, 1778. Add. ad Klein, p. 140.
Lagana laganum de Blainville, 1830. Dict. sci. nat., vol. 60, p. 196.
Laganum bonani A. Agassiz, 1873. Rev. ech., pt. 3, p. 517; pl. 13*e*, figs. 6, 7.

This is a well marked species, for besides the distinctive characters of the test already mentioned, many specimens show the very characteristic spotting of the dorsal side shown in Agassiz's figure. The largest recorded specimens, 63 × 63 mm. and 65 × 62 mm., are in the Queensland Museum; most known specimens are little more than half this size. It is not known whether these big individuals were collected on the Queensland coast or not. The species occurs as far south as Tasmania; at least, specimens so labeled are in the Museum of Comparative Zoölogy. It is also known from the Philippines, the Carolines, and New Guinea. Specimens in the British Museum are labeled "Timorlaut" and "West Australia, Dirk Hartog Island," but the latter is almost surely an error. It is very unlikely that this species occurs on the western side of the continent.

Laganum depressum

L. Agassiz, 1841. Mon. Ech.: Scut., p. 110; pl. 23, figs. 1–7.

With a geographical range from Zanzibar and the Red Sea to the Marshall and Samoan islands, Tongatabu, and New Caledonia, this is the most common and widely distributed member of the genus. Most specimens in museum collections are 30–50 mm. long, but large individuals reach 70–80 mm. The largest recorded is in the British Museum, from Mauritius, and measures 80 × 72 mm. There is considerable diversity in the solidity of the test, many specimens having a relatively light test with thin margins, and many others having a stout test with thick, though

seldom swollen, margins. There are no published notes on the color or appearance in life, but museum specimens show great diversity, ranging from light gray or pale cream color, with the petals almost black in marked contrast, to light brown, gray-brown, yellow-brown, or dull greenish yellow. Probably most of this diversity is due to the different methods of killing and preserving. In Australia, *depressum* is confined to Torres Strait and the northern Barrier Reef region. We did not find it at the Murray Islands, but it is reported from the neighboring Darnley Island.

Laganum dyscritum

H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, no. 7, p. 216; pl. 1, figs. 5–9.

That this species is closely related to the preceding is beyond question, but the much shorter and wider test and the more posterior periproct seem to be constant characters, and intermediate specimens are lacking. There is also an obvious difference in color and in texture of the coat of spines. As yet *dyscritum* is known only from the vicinity of the Low Isles, and the largest specimen is but 40 × 38 mm.

PERONELLA

Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 13.

Genotype: *Laganum peronii* Agassiz, 1841, p. 123.

The absence of a genital pore in interambulacrum 5 is a convenient recognition mark for this group of "sand shillings," but may not really be indicative of any important morphological difference between it and *Laganum*. The genus includes 8 or more species, of which 6 occur in Australia, one of them being the largest member of the family. They may be distinguished as follows:

Key to the Species of Peronella

A. Genital pores in interambulacra at considerable distance from madreporite ..... *peronii*
AA. Genital pores at proximal ends of interambulacra more or less close to madreporite:
  B. Periproct near posterior margin of test, its distance therefrom less than 0.30 long radius of test:
    C. Petaloid area more than half test length; margin of test thick, about 0.2 test length:
      Width of test about 0.80 length; petaloid area 0.66 test length ..... *ricta*
      Width of test about 0.85–0.95 length; petaloid area 0.54–0.60 test length ..... *orbicularis*
    CC. Petaloid area about half test length; margin of test thin, about 0.07 test length ..... *lesueuri*
  BB. Periproct more than 0.30 long radius of test from posterior margin:
    Petals short, wide near base, acutely pointed; fossil ..... *platymodes*
    Petals rather long, moderately wide, not at all acutely pointed ..... *tuberculata*

Peronella peronii

Laganum peronii Agassiz, 1841. Mon. Ech.: Scut., p. 123.
Laganum (*Peronella*) *peronii* Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 13.

Peronella peronii A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 149.
——— 1873. Rev. ech., pt. 3, p. 522; pl. 13*e*, figs. 4, 5.

This is an unmistakable laganid, as indicated by the unusual position of the genital pores. Most of our museum specimens are under 25 mm. in length, but full-grown individuals are almost double that. There is one in the British Museum 44×40 mm., and in the Queensland Museum is one still larger, 45×43 mm. The color of dry specimens is light brown, rarely deep brown; very young specimens are pale buff. The species is endemic in southeastern Australia in shallow water, ranging from southern Queensland to Tasmania and west to Spencer Gulf, South Australia, from low-water mark to 80 fms.

Peronella ricta

Laganum decagonale var. *rictum* Gregory, 1892. Geol. Mag., n. s., dec. 3, vol. 9, p. 433; pl. 12, figs. 1*a*–1*c*.

The specimen on which Gregory based his "variety" of *Laganum decagonale* was a "Cainozoic" fossil from Shark Bay, Western Australia. It is carefully described and well figured, and is obviously a *Peronella,* resembling *orbicularis* in certain particulars. In the Museum of Comparative Zoölogy collection there is a bare test, in excellent condition, of a Recent *Peronella* which is evidently identical with Gregory's specimen, though not quite so large. It has no locality label, but one label with it shows it has been in the M.C.Z. since 1864. It has a label "*Laganum elongatum* Ag.??," but has been catalogued as *Peronella orbicularis.* It is, however, much larger than any specimen of that species (the maximum for which is 37×35 mm.) at hand, is more elongate, and has very different petals. It is 61×51×11 mm., and Gregory's type is 68×55×12. The species is probably nearest *orbicularis.* It is certainly not *Laganum elongatum* Agassiz, which is a synonym of *Peronella lesueuri,* nor can it well be considered *Laganum rostratum* Agassiz, said to be from New Zealand, a statement rightly doubted by Mortensen (1921). A good series of specimens might show that the marked differences in the height and form of the test are within the limits of specific diversity, but until more material is available both *ricta* and *rostrata* must be considered Peronellas whose specific limits and geographical distribution are not satisfactorily known.

Peronella orbicularis

Echinodiscus orbicularis Leske, 1778. Add. ad Klein, p. 144.
Laganum orbiculare Agassiz, 1841. Mon. Ech.: Scut., pl. 22, figs. 16–20.
Peronella orbicularis A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 149.

This is a small, widely distributed species, which has been ill defined and with which young individuals of larger species have been frequently confused. Typical specimens are unmistakable, but there is a good deal of individual diversity. The maximum size for *orbicularis* seems to be 37×35 mm., but very few specimens exceed 25 mm. in length. The width is often almost as great, and these nearly circular individuals with their characteristic pointed petals are unmistakable. The species is characteristically tropical Australian, but apparently occurs throughout the East Indies. On the Australian coast, it ranges from Cape Upstart, Queensland, to Shark Bay, Western Australia. It is very common at both Darwin and Broome.

In life, the test is rose red or pink, with the spines white or colorless, or the spines may be brown of some shade, in which case the red is masked. Dry specimens show great diversity of color, from greenish yellow to purplish brown or to distinct rose red.

Peronella lesueuri

Laganum lesueuri Agassiz, 1841. Mon. Ech.: Scut., p. 116; pl. 24, figs. 3–6.
Laganum elongatum Agassiz, 1841. Mon. Ech.: Scut., p. 117; pl. 24, figs. 1, 2.
Peronella lesueuri A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 148.
Peronella decagonalis A. Agassiz, 1881. "Challenger" Ech., p. 120 (*partim*).
Peronella aphnostina H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 167; pl. 24.

This is the largest species in the genus, sometimes exceeding 150 mm. in length. The largest recorded specimen is in the British Museum and measures 168 × 136 mm.; it has no locality label. The largest of the Australian specimens is 157 × 136 mm. There is great diversity of form, and the supposed Western Australian species *aphnostina* has no validity. In comparison with the size, the thickness of the test margin is remarkably slight; it averages about 0.07 test length, but may be as little as 0.03 even in big specimens. Occasionally it is more than 0.09. The proportion of width to length reaches its extreme in the variety called *Polyaster elegans* by Michelin, in which width exceeds length (see H. L. Clark, 1925, p. 160, pl. 8). In life the color is distinctive, ranging from old rose to Indian red (see H. L. Clark, 1938, pl. 15, fig. 3, colored), but the color is fugacious, and dried specimens are brown or yellowish. Like *orbicularis,* this *Peronella* is characteristic of the tropical Australian coast, ranging from Port Molle, Queensland, to Fremantle, Western Australia. It extends its range northward through the East Indian region to southern Japan.

*Peronella platymodes

Laganum platymodes Tate, 1893. Jour. Proc. Roy. Soc. N. S. Wales, vol. 27, p. 193; pl. 13, fig. 4.

This little laganid is clearly a *Peronella,* reminding one of *orbicularis.* It is of about the same size as that species, an average specimen being 34 mm. long, 31 mm. wide, and 6 mm. high. Tate says it is common in Miocene strata of Hallett's Cove and Aldinga Cliffs, east side of St. Vincent Gulf, South Australia. Chapman writes me that the strata are Lower Pliocene.

Peronella tuberculata

Mortensen, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 9, p. 16; pl. 4, figs. 10, 11.

Though this species is closely allied to *orbicularis,* the differences are sufficiently evident and constant to justify the separation. Both occur in abundance in the vicinity of Broome, Western Australia, and may even be taken together in the same dredge haul, though they do not necessarily live together on the same spot. In size, *tuberculata* slightly exceeds *orbicularis,* as specimens in excess of 40 mm. are not rare; the longest is 46 × 44 mm. As a rule, the width of the test is about 0.90 of its length. The color in life is purplish gray, with the poriferous areas of the petals distinctly darker. The lower surface is rather more purple than the upper. As yet *tuberculata* is known only from the Broome region.

Family FIBULARIIDAE

This small family of little echini consists, like the preceding, of only 2 Recent genera. All the species are densely covered with minute spines, which conceal the generic and specific characters completely, but the spine coat is lost after death with apparent speed and completeness, and probably at least 90 per cent of our museum specimens are perfectly bare tests which reveal specific characters readily. The essential generic distinction, however, is internal, and is difficult to see without injury to the test. But as it is more or less associated with the form of the test, a little familiarity with the structure of a specimen from each genus enables one to distinguish between the two at a glance with a fair degree of accuracy. In life, the species of both genera apparently live just below the surface of the rather firm, sandy mud where they are found, but the European species of *Echinocyamus* is said to prefer a bottom of coarse sand or even gravel. Both genera are said to be used considerably by fish for food.

Besides the 2 Recent genera, there are some half-dozen genera known only from fossils. Of these, 2 occur in Australia, in the Oligocene and Miocene rocks of South Australia and Victoria. The 4 genera are distinguishable as follows:

Key to the Genera of Fibulariidae

A. Test rather high, sometimes markedly so, without internal radiating walls, except posteriorly, where they may be more or less indicated..... *Fibularia*

AA. Not as above:

B. Periproct inframarginal:

Test flattened but arched or barely convex dorsally, margins not swollen ..... *Echinocyamus*

Test flat, with swollen margins; extinct..... *Sismondia*

BB. Periproct marginal or supramarginal; extinct..... *Scutellina*

FIBULARIA

Lamarck, 1816. Anim. sans vert., vol. 3, p. 16.

Genotype: *Fibularia trigona* Lamarck, 1816, vol. 3, p. 16 = *Echinocyamus craniolaris* Leske, 1778, p. 150.

There are half a dozen or more Recent species of this genus, and many fossils, but owing to the confusion caused by Lambert's and other paleontologists' refusal to accept the genus as it was understood by Agassiz and other zoologists, only a very careful revision of the fossil species can determine how many extinct forms should be referred to *Fibularia.* Five species, of which 1 is apparently extinct, occur in Australia. They may be distinguished as follows:

Key to the Species of Fibularia

A. Petals present, though they may be ill formed:

B. Pores of distinctly formed petals smaller than genital pores; test high, more or less ovoid:

Poriferous areas nearly or quite parallel in each petal..... *craniolaris*

Poriferous areas diverging; extinct..... *gregata*

BB. Pores of ill formed petals few and as large as or larger than genital pores:
Petals short, with 40–120 pores in whole petaloid area; test about half as high as long ..... *volva*
Petals with fewer than 40 pores in whole area; test much less than half as high as long ..... *plateia*
AA. Petals wanting; dorsal surface of female sunken to form brood pouch ..... *nutriens*

Fibularia craniolaris

Echinocyamus craniolaris Leske, 1778. Add. ad Klein, p. 150.
Fibularia craniolaris de Blainville, 1820. Dict. sci. nat., vol. 16, p. 512.
Fibularia ovulum A. Agassiz, 1873. Rev. ech., pt. 3, p. 507; pl. 13*e*, figs. 1–3.

The distribution of this species is very imperfectly known, but the South Australian Museum has scores of specimens from nine or ten places or areas on the coast of that state. They were chiefly collected by Verco in 12–45 fms., and all but 9 or 10 are bare tests. They range from 2.5 to 11.5 mm. in length and reveal great diversity of form; thus, one specimen 9 mm. long is 8 mm. wide and 7 mm. high, and the largest is 11.5 mm. long, scarcely 8 mm. wide, and only 6.5 mm. high. There is also great diversity in the relative size of the ambulacral and genital pores. I erroneously said (1928, p. 477) that the small genital and large ambulacral pores led me to call the specimens *craniolaris*. In this species, according to my own key (1914, p. 57), the ambulacral pores are smaller than the genitals.

*Fibularia gregata

Tate, 1885. Southern Science Rec., n. s., no. 1, p. 4.
Bittner, 1892. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, pt. 1, p. 347; pl. 2, figs. 1–3.

Tate (1892, p. 190) pointed out that Bittner's variety *orbiculus* and new species *tatei* have no validity, being based on variants of a common species which shows great diversity. Tate is doubtless right, and I am even inclined to doubt whether there is any valid, constant difference between *gregata* and *craniolaris*. Tate (1892) lists half a dozen places where his species occurs, all in South Australia and all in Eocene strata. Chapman writes me that it also occurs in the Oligocene of South Australia and in the Lower Miocene of Victoria and Tasmania.

Fibularia volva

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 7, p. 142.
H. L. Clark, 1921. Ech. Torres Strait, p. 152; pl. 35, figs. 6–9.

This species occurs all along the northern coast of Australia from Torres Strait to Cape Jaubert, west of Broome, Western Australia, and the range extends northward to India and probably to China; a specimen in the British Museum is said to be from "Korea." There is a bare test in the Museum of Comparative Zoölogy given to me by E. W. Bennett, at Perth, said to be from Middleton Beach, near Albany, Western Australia. The specimens from Broome have 8–10 or more madreporic pores, but apparently many specimens have but a single pore; this may

be a youthful condition. The color in life is pale brown, which becomes more or less yellowish on drying. Full-grown specimens are 10 mm. long, with a width of 8 and a height of 6 mm.

Fibularia plateia

H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 477; figs. 142*a–c*.

There is a large series of this well marked species in the South Australian Museum, taken by Verco at nine stations on the South Australian coast in 15–130 fms. There are also specimens from off Bunbury, Western Australia, indicating that the whole southwestern corner of the continent is the home of the species. Nearly all the known specimens are young, 2–4 mm. in length. The holotype alone is apparently adult, and measures 6.25 × 4.8 × 2.35 mm.; but it is a bare test.

Fibularia nutriens

H. L. Clark, 1909. "Thetis" rept., p. 557; pl. 58, figs. 1–11.

This remarkable little echinoid, of which 85 specimens were taken by the "Thetis" off Cape Three Points, New South Wales, in 41–50 fms., and 2 more off Wata Mooli in slightly deeper water, has since been taken off Port Hacking in 55 fms. The bottom was muddy at all stations. The extraordinary sexual dimorphism shown is unique among clypeastroids, though several spatangoids show the same peculiarity and a very few regular echini have a similar tendency. The females of this little *Fibularia* are larger than the males, but they are only a little over 3 mm. long. The color is a very pale brown.

ECHINOCYAMUS

Leske, 1778. Add. ad Klein, p. 149.

Genotype: *Echinocyamus angulosus* Leske, 1778, p. 151 = *Echinus minutus* Pallas, 1774, p. 34.

A dozen or more Recent species of this genus are known from nearly all parts of the world, but only 4 are as yet recorded from Australia, and 3 of these are known only from the southern and southeastern coasts. The fourth is found at the opposite corner of the continent. These species may be distinguished thus:

Key to the Species of Echinocyamus

A. Petals well formed, with 6 or more pore pairs on each side:
- Upper surface arched; periproct close to margin ..... *provectus*
- Upper surface flattened, with slightly arched petaloid area only a little elevated over somewhat tumid margin of test, from which it is more or less evidently separated by barely depressed area; periproct separated from margin by more than its own width ..... *planissimus*

AA. Petals more or less imperfect, with 1 to 5 (rarely 6) pore pairs on each side:
- Surface of broad, flat test very rough, with numerous high, rounded or bluntly pointed tubercles ..... *scaber*
- Surface of exceedingly flat test with few, low, rounded tubercles ..... *platytatus*

Echinocyamus provectus

de Meijere, 1903. Tijdschr. Nederlandsche Dierk. Ver., ser. 2, vol. 8, p. 6.

Specimens of *Echinocyamus* taken by the "Thetis" off Cape Three Points and Wata Mooli, New South Wales, in 41–59 fms., the largest 8 mm. long, were referred to this species without much doubt. A single specimen from southeastern Tasmania, off Schouten Island, 40–50 fms., is apparently the same thing. Much more material from both Australia and the East Indies must be compared before their identity can be assured.

Echinocyamus planissimus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 422; pl. 27, figs. 5–8.

This species is known only from the vicinity of Broome, where it was taken in both 1929 and 1932. The largest specimen is $8 \times 7.25 \times 1.5$ mm. The color of the living animal was light brown.

Echinocyamus scaber

de Meijere, 1903. Tijdschr. Nederlandsche Dierk. Ver., ser. 2, vol. 8, p. 5.
——— 1904. "Siboga" Ech., p. 108; pl. 6, figs. 46, 47; pl. 17, figs. 301–305.

This species is admitted here on the basis of a single specimen (a bare test) in the British Museum, taken by the "Challenger" in Port Jackson, New South Wales, and originally identified as *Fibularia australis*. It is certainly not that species, but its identity with de Meijere's East Indian species is by no means beyond dispute. The very scabrous character of the test surface, however, justifies assigning it to that form.

Echinocyamus platytatus

H. L. Clark, 1914*a*. Mem. Mus. Comp. Zoöl., vol. 46, p. 63; pl. 127, figs. 1–6.

The original specimens on which this species is based are bare tests, the largest 8×7 mm., from Port Phillip, Victoria. The "Endeavour" took what is apparently the same thing between Devonport and Launceston, Tasmania. The South Australian Museum collection revealed scores of this species, the largest 9.5×8 mm. Only 4 specimens showed any spines, and even these were apparently dead when collected. The localities whence this notable series of specimens came extend from Cape Jaffa to King Georges Sound and Hopetown, Western Australia. The depths range from "beach" down to 200 fms. Obviously *platytatus* is the common *Echinocyamus* of the southern coast of Australia, and a strictly endemic species.

*SISMONDIA

Desor, 1858. Syn. éch., p. 225.

Genotype: *Scutella occitana* DeFrance, 1827, p. 231.

More than 20 supposed species of small echini from Eocene and Miocene rocks are now referred to this genus, and 1 of these is reported from Australia.

*Sismondia murravica

Tate, 1893. Trans. Proc. Roy. Soc. N. S. Wales, vol. 27, p. 193; pl. 13, fig. 5.

This small, flat echinoid occurs in the Murray River Cliffs of South Australia in what Tate calls Eocene strata. Chapman writes me that they are Miocene. The type was 19 mm. long, 16.5 wide, and 7 high. It looks more like a laganid than a fibulariid, but the petals are more like *Fibularia.*

*SCUTELLINA

L. Agassiz, 1841. Mon. Ech.: Scut., p. 98.

Genotype: *Scutellina nummularia* L. Agassiz, 1841, p. 99.

A dozen or more small scutellids from the Tertiary are referred to this genus, one of which is known from Australia.

*Scutellina patella

Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 279.
T. S. Hall, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 20, pt. 2, pp. 140–142 (figured).

Tate says nothing as to the age of the strata in which these fossils occur, but he lists three localities thus: "Calciferous sandstones of the River Murray Cliffs (common); white polyzoal limestone at Mt. Gambier; polyzoal sands, Muddy Creek." His specimens were 22–24 mm. long, 21–22.5 mm. wide, and 6–7.5 mm. high. T. S. Hall (1908) describes an actinal depression on the lower surface of certain specimens which he collected at the mouth of the Glenelg River, Victoria. He believed such specimens to be females and the depression to be a brood pouch; his view is justified by his figures. Hall also pointed out that *S. morgani* Cotteau (1891) is a synonym of Tate's *patella.*

Chapman tells me that in 1874, McCoy used the manuscript name "*Scutella tamboensis*" for this species, and it is possible that the name is to be found on labels or in some notes of McCoy's. Chapman further says the species occurs in the Oligocene of South Australia and the Lower Miocene of Victoria.

Family SCUTELLIDAE

So far as Recent species are concerned, this is decidedly a family of the northern hemisphere, for of the 7 genera only 1 is found in Australia, and that is also the only genus found in South Africa; none occurs in South America or New Zealand.

ECHINODISCUS

Leske, 1778. Add. ad Klein, p. 131.

Genotype: *Echinodiscus bisperforatus* Leske, 1778, p. 192.

This is clearly a genus of the Indian Ocean, as it occurs all along the East African coast from Suez to Mossel Bay, Cape Colony, and eastward to New Hebrides and New Caledonia. It does not seem to have extended its range as yet into the Pacific

except as it reaches Ousima, Japan, on the north. Two species occur in Australia, but only on the tropical coasts. The two differ thus:

Posterior ambulacra each with deep, narrow marginal slit; no lunules.....*auritus*
Posterior ambulacra each with lunule distal to petal.....*tenuissimus*

Echinodiscus auritus

Leske, 1778. Add. ad Klein, p. 138.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 531; pl. 13*c*, figs. 1, 2.

The discovery of this fine scutellid at Broome was a great surprise, as it is not known otherwise from the Australian coast. The largest specimen in the British Museum is 183 × 178 mm., but at Broome the largest taken is 138 × 134 mm. The color in life was deep yellow-brown; on drying, a purple tint became evident. Smaller specimens are distinctly red-violet, and retain this color more or less in drying, even when as much as 120 mm. in length. These scutellids lie just below the surface of firm, sandy mud and are likely to be more or less badly damaged by a dredge; a trawl simply passes over without dislodging them.

Echinodiscus tenuissimus

Lobophora tenuissima Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 7, p. 136.
Echinodiscus tenuissimus Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 30.
Döderlein, 1903. Semon's Ech., *in* Jena Denkschr., vol. 8, p. 723; pl. 65, figs. 4, 5 (as *E. auritus* var. *tenuissimus*).

This very flat and fragile scutellid is easily distinguished from the preceding species, with which Döderlein confused it in spite of its closed lunules. The only record from Australia is from Torres Strait near Thursday Island, where Semon obtained the specimens on which Döderlein reported. From here the known range extends northward to Japan and eastward to the New Hebrides. A very large specimen in the British Museum from New Caledonia is 115 mm. long by 120 mm. wide, but it is unusual for the width to exceed the length. A normal specimen in the Museum of Comparative Zoölogy, also from New Caledonia, is 125 mm. long by 118 mm. wide.

Suborder Echinoneina

This is a very small group, perhaps the last surviving remnant of the Holectypoida. There are but 2 living genera, and only 1 of these occurs in Australia.

Family ECHINONEIDAE

This family contains the 2 living genera, only 1 of which has as yet been found in Australia.

ECHINONEUS

Leske, 1778. Add. ad Klein, p. 109.

Genotype: *Echinoneus cyclostomus* Leske, 1778, p. 109.

Of the 3 living species now recognized in this genus, only 1 occurs in Australia. The others are as yet inadequately known from very few specimens. Both occur

only in the Indo-Pacific region, but the species found in Australia is tropicopolitan. A second species, now extinct, is reported from the Lower Miocene of Victoria. It is very similar to the Recent species, the only tangible difference being in the form of the test.

Test three-fourths as wide as long; Recent ..... *cyclostomus*
Test two-thirds as wide as long; extinct ..... *dennanti*

Echinoneus cyclostomus

Leske, 1778. Add. ad Klein, pl. 109.
Westergren, 1911. Mem. Mus. Comp. Zoöl., vol. 39, no. 2, pp. 35–68; pls. 1–5.

This species has been so exhaustively monographed by Westergren that little need be said of its form and structure. It is apparently to be found in all parts of the tropics where conditions are suitable. It lives buried in sand under rock fragments or coralline algae, and is apparently quite inert. The largest reported specimens are 1 in the British Museum, said to be from the West Indies, and 1 in the Museum of Comparative Zoölogy from Lord Howe Island. They measure 44 × 36 × 21 mm. and 44 × 36 × 19 mm., respectively. The Lord Howe specimen in life was 45 × 38 × 20 mm. The color in life shows no little diversity, ranging from very pale brown to deep red-brown, with the ambulacral appendages bright red, contrasting prettily with the light shades of brown. Dried specimens show great diversity in color, due no doubt to differences in the killing agent and the method of drying.

*Echinoneus dennanti

T. S. Hall, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, p. 47; pl. 13, figs. 1, 2.

This species is based on a single specimen, 21 mm. long, 14 mm. wide, and 7 mm. high, from the Lower Miocene of Victoria. The specimen is said to be "somewhat obliquely crushed" and that may account for its unusual narrowness. In the light of what we know, or at least have reason to believe, concerning the antiquity of *Echinoneus,* it seems to me highly improbable that *dennanti* is distinct from *cyclostomus,* but more material must be obtained before the matter can be settled.

Suborder Nucleolitina

As in the preceding suborder, only a single family occurs in the fauna of Australia, and this family adds but 1 Recent species to the list. It does, however, add 2 fossil species of a second genus.

Family NUCLEOLITIDAE

Scores of fossils referable to this family are known from many parts of the world, but living species are few indeed. Only 1 occurs in Australia, but there are 2 fossil species of an allied genus which occur in Victoria and South Australia. The two genera differ thus:

Anal sulcus long and narrow, reaching more than halfway to apex; extinct ..... *Nucleolites*
Anal sulcus short and wide, not reaching halfway to apex; Recent ..... *Apatopygus*

*NUCLEOLITES

Lamarck, 1801. Syst. anim. sans vert., p. 347.

Genotype: *Nucleolites clypeatus* Lamarck, 1801, p. 347.

Lamarck names only 2 species in *Nucleolites* in 1801, *oviformis* and *clypeatus,* and in 1816, he removes *oviformis* to *Clypeaster,* leaving *clypeatus* alone as the type of *Nucleolites.* In 1816 he lists 4 species of *Nucleolites* but *clypeatus* is not one of them, nor have I been able to ascertain what has become of it. A. Agassiz, in the "Revision," dates *Nucleolites* from Edwards 1836, ignoring Lamarck's connection with the name altogether until 1873 (Rev. ech., pt. 3, p. 557), when he gives merely a casual reference to it. Lambert and Thiéry (1921, p. 344) give Lamarck credit for the name from 1801, but designate his *scutatus* as the genotype. Now if it can be shown that *scutatus* and *clypeatus* are the same thing and that *scutatus* is the earlier name, the whole problem is solved. As I have not been able to learn anything about *clypeatus,* I leave the matter as it is, only remarking that the name *Nucleolites* stands or falls with *clypeatus,* and as long as the generic name is used there must be a *clypeatus* for the type, though its correct name (i.e., earlier) may be *scutatus.* But *Nucleolites* will very likely have to be abandoned. The two Australian fossils referred to it differ thus:

Ambitus definitely elliptical ..... *australiae*
Ambitus ovate subpentagonal ..... *vincentinus*

*Nucleolites australiae

Echinobrissus australiae Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 50; pl. 3, fig. 11.

The specimen on which this species is based was found in the Lower Miocene strata of Cape Otway, Victoria. It is about 30 × 22.5 × 10 mm., and the definitely elliptical form sets it apart from the relatively common following species, which, however, was not named and described until some years later. Additional specimens are much to be desired.

*Nucleolites vincentinus

Echinobrissus vincentinus Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 280 (not figured).

The holotype of this species measures 28.5 × 23 × 12 mm. and has the "apical disk" posterior to the center of the test. Specimens are said to be common in glauconitic limestones of Aldinga Bay. The same fossil also occurs at Muloowurtie in the Yorke Peninsula. Chapman records it (*in litt.*) from Upper Oligocene to Miocene, South Australia to Victoria. It is interesting to speculate as to the possible relation between these 2 species of *Nucleolites* and the New Zealand and Western Australian species of the following genus, but far more material of all must be obtained before such speculation can be profitable. Records of *Apatopygus recens* from the Australian Tertiary are no doubt based on specimens of *Nucleolites.*

APATOPYGUS

Hawkins, 1920. Geol. Mag., vol. 57, p. 396.

Genotype: *Nucleolites recens* Milne-Edwards, 1836.

When established, this was a monotypic genus, but the discovery of a Western Australian species in 1929 shows that the group ranges at least from New Zealand westward along the southern coast of the entire Australian continent. It makes the possibility of its occurrence in Madagascar, as a British Museum specimen is labeled, more credible, except that that specimen is apparently the New Zealand species and not the Western Australian.

Apatopygus occidentalis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 425; pl. 28, figs. 1–3.
Apatopygus recens H. L. Clark, 1928. Rec. S. Australian Mus., vol. 3, p. 478.

This extraordinarily interesting sea urchin is known as yet only from the 2 youthful specimens discussed in the references given above. The smaller is but 10 mm. long, the larger, 17 mm.

Suborder Cassidulina

Something like 60 genera, grouped in 2 families, comprise this suborder, but very few of them contain any Recent species and these are all members of a single family. All the Australian fossil cassiduloids are also members of this same group.

Family CASSIDULIDAE

Only 2 representatives of this family are living today in Australian seas, but no less than 8 others occur in the Upper Oligocene and Lower Miocene strata of Victoria and South Australia. These 10 species belong to 7 genera, distinguished from one another largely by characters of the periproct, petals, and peristome, which are usually quite obvious.

Key to the Genera of Cassidulidae

A. Periproct distinctly supramarginal:
  B. Periproct wider than long, in transverse depression; extinct ..... *Cassidulus*
  BB. Periproct circular or longer than wide, in longitudinal depression:
    Poriferous zones diverging, not definitely petaloid; no conspicuous floscelle; anal sulcus nearly terminal ..... *Oligopodia*
    Poriferous zones not diverging, forming distinct petals; floscelle very conspicuous; anal sulcus well above margin; extinct ..... *Australanthus*
AA. Periproct not supramarginal:
  C. Periproct small, terminal, well up on truncate and somewhat overhanging rear end of test; extinct ..... *Studeria*
  CC. Periproct inframarginal:
    D. Periproct nearly or quite circular; extinct ..... *Pygorhynchus*
    DD. Periproct much wider than long:
      Petals and phyllodes ill defined; extinct ..... *Plesiolampas*
      Petals and phyllodes more or less well defined ..... *Echinolampas*

*CASSIDULUS

Lamarck, 1801. Syst. anim. sans vert., p. 349.

Genotype: *Cassidulus cariboearum* Lamarck, 1801, p. 349.

Lambert and Thiéry (1921) list more than 30 species in this genus, but only 1 of these is known from Australia, and this one is apparently rare.

*Cassidulus florescens

Gregory, 1892. Geol. Mag., n. s., dec. 3, vol. 9, p. 435; pl. 12, figs. 2–4.

Gregory described 2 specimens of this fossil without designating either as the holotype. They are 19.5–22 mm. long and 15.5–17 mm. in maximum width. They were taken at Fyans Ford hill, Moorabool River, 1½ miles northwest of Geelong, Victoria, in strata then considered Upper Eocene. Chapman, however, tells me the strata are now considered Lower Miocene.

OLIGOPODIA

Duncan, 1889. Jour. Linn. Soc. (Zool.), vol. 23, p. 176.

Genotype: *Nucleolites epigonus* von Martens, 1865*a*, p. 143.

This genus is allotted but 2 species by Lambert and Thiéry (1921), one the genotype, a Recent species, and the other from the Eocene. The Recent species is known from several places in the East Indies and apparently enters the Australian fauna. Owing to the fragility of the test and the habit of living more or less buried in the muddy bottom, whole specimens are very difficult to secure. Consequently suitable material for study is definitely lacking.

Oligopodia epigonus

Nucleolites epigonus von Martens, 1865*a*. Monatsber. K. preuss. Akad. Wissensch., p. 143.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 558; pl. 19*b*, figs. 4–6.

In the "Revision," Agassiz reports (p. 147) specimens of this species in the British Museum from "Lord Hood's Island." When I studied the collection in 1924, I read the label as Lord Howe Island and so published it. But intensive collecting at Lord Howe failed to reveal the species there, nor are there specimens in the Australian Museum. I did not include the species, therefore, in my list of the echinoderms of Lord Howe Island (1938, pp. 559–561), and am doubtful of its right to a place in the Australian fauna. The specimen figured by Agassiz is a bare test, from an unknown locality, 20 mm. long, and I know of none larger. The largest of the specimens in the British Museum is $17 \times 15.5 \times 8.5$ mm. It is possible that these British Museum specimens came from one of the two "Lord Howe's" Islands north of the New Hebrides. It is very unlikely that they came from Lord Hood's Island in the Paumotus. There is no doubt that *epigonus* is a rare sea urchin, known as yet only from a few East Indian localities.

*AUSTRALANTHUS

Bittner, 1892. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, pt. 1, p. 20.

Genotype: *Cassidulus longianus* Gregory, 1890, p. 482.

In 1892, Gregory accepted Bittner's proposed genus as a subgenus, but it seems worthy of recognition as a generic group. Lambert and Thiéry (1921) accept it and assign 4 other species to it, besides the type. But only the type is known from Australia.

*Australanthus longianus

Cassidulus longianus Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 482; pl. 13, figs. 1–3.
Australanthus longianus Bittner, 1892. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, pt. 1, p. 20; pl. 3, fig. 2.

The material on which Gregory based his species was collected at Willunga, near Adelaide, South Australia, in strata regarded as Upper Oligocene. Bittner gives no other locality, and apparently the genus has not yet been found elsewhere in Australia. The original specimens were 43–67 mm. in length; the largest was 56 mm. wide and 30 mm. high. Bittner's specimens were not quite so large, but to judge from his figures they were in very fine condition. This is natural, since they were specially selected by Tate.

*STUDERIA

Duncan, 1889. Jour. Linn. Soc. (Zool.), vol. 23, p. 185.

Genotype: *Catopygus elegans* Laube, 1869, p. 190.

The limits and components of this genus have been so juggled about by Lambert and Thiéry (1924, 1925) that it may be well to get back to Duncan's monotypic genus. Although he refers to both Recent and Eocene species, *elegans* is the only one named. As this is also the only one occurring in Australia, it is not necessary to attempt to clear up here the confusion which exists in the group.

*Studeria elegans

Catopygus elegans Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, p. 190; figs. 8–8*c*.
Studeria elegans Duncan, 1889. Jour. Linn. Soc. (Zool.), vol. 23, p. 185.

Apparently rather common in the River Murray Cliffs in South Australia, this species was made the type of his new genus by Duncan, and only three years later Bittner (1892) gave it still another generic name. It is a small echinoid, seldom much more than 25 mm. long; width four-fifths length; height a trifle more than half length. Chapman (1908) also reports *Studeria* from the Spring Creek beds at Torquay, Victoria. All the localities are Upper Eocene or Lower Miocene.

*PYGORHYNCHUS

L. Agassiz, 1839. Ech. foss. Suisse, pt. 1, p. 53.

Genotype: *Catopygus obovatus* L. Agassiz, 1836, p. 136.

Something like 20 species have been referred to this genus, but its limits are still hazy. A single one is reported from Australia and has been identified as indistinguishable from one found in Malta. Under that name it is still listed.

*Pygorhynchus vassali

Wright, 1864*a*. Quart. Jour. Geol. Soc. London, vol. 20, p. 22; figs. 6*a–c*.

The Maltese and South Australian fossils are very similar, but I am skeptical as to their being identical. Nevertheless, until differences have been pointed out, the name *vassali* must be used for both. The fossils have been found in the Lower Miocene of both Victoria and South Australia, but apparently are rare. No data concerning them have been published. Wright's specimen from Malta was 30 × 21 × 15 mm., but Duncan gives no figures for the Glenelg specimen, nor does Tate for his from Mannum, South Australia.

*PLESIOLAMPAS

Duncan and Sladen, 1882. Foss. Ech. W. Sind, Palaeontol. indica, ser. 14, pp. 9, 54.

Genotype: *Plesiolampas elongata* Duncan and Sladen, 1882, p. 10.

This genus was based on fossils from India, but a notable echinoid from Tasmania seems to be congeneric with the Indian species. It was, however, originally called *Conoclypeus,* with the suggestion that perhaps it was nearer to *Plesiolampas.*

*Plesiolampas rostrata

Conoclypeus rostratus Tate, 1893. Jour. Proc. Roy. Soc. N. S. Wales, vol. 27, p. 194; pl. 13, fig. 1.
Plesiolampas rostratus Tate, 1897. Jour. Proc. Roy. Soc. N. S. Wales, vol. 31, p. 412.

Apparently this striking species is still known only from the holotype, which was collected at Table Cape, Tasmania, in Eocene (Tate) or Lower Miocene (Chapman) strata. Tate (1897) refers to "additional specimens" having enabled him to determine that the species is a *Plesiolampas,* but he gives no data about them. Tate does not even say that his additional material is from Table Cape, but as he elsewhere refers to a visit to that spot, presumably the species is still known only from Tasmania. The holotype is 57 × 54 × 24 mm.; periproct 8 mm. across.

ECHINOLAMPAS

Gray, 1825. Ann. Philos., vol. 26, p. 429.

Genotype: *Echinanthus ovatus* Leske, 1778, p. 127.

Recent species of this genus occur in many of the warmer seas, some 9 species being recognized, but extinct species abound, something like 200 forms having been

given names. In Australia, however, the genus is modestly represented by a single living form and 2 from the Tertiary rocks of Victoria and South Australia. The 3 may be distinguished as follows:

KEY TO THE SPECIES OF ECHINOLAMPAS

A. Test notably high, vertical diameter about 0.60 length; petals wide and conspicuous; extinct ..... *gambierensis*

AA. Test about half as high as long:

Petals small, narrow, not well defined; mouth small, twice as wide as long; extinct ..... *posterocrassa*

Petals large, moderately wide, well defined; mouth large, not nearly twice as wide as long; Recent ..... *ovata*

*Echinolampas gambierensis

Tenison-Woods, 1867, figs. 1*a–c* (*fide* Tate, 1891).
Echinolampas australis Tenison-Woods, 1867 (*fide* Tate, 1891).
Echinolampas ovulum Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, p. 191.
Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 483; pl. 13, figs. 7, 8.

There is some confusion in regard to the correct name for this species, but Tate (1891) regards Tenison-Woods' 2 nominal species as being the same and Laube's species as being based on a specimen of the same thing. Gregory's use of Laube's name (*ovulum*) is not correct if Tate is right in considering it synonymous with Tenison-Woods' earlier *gambierensis*. Tenison-Woods' paper has not been available, and I have accepted Tate's views. This is a large species, up to 64 mm. in length and conspicuously high. It is known from the Upper Oligocene and Lower Miocene of Victoria and South Australia.

*Echinolampas posterocrassa

Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 483; pl. 13, figs. 4–6.

Apparently only a single specimen of this species was known to Gregory when he wrote. It was collected at Willunga, near Adelaide, South Australia, and measured 43×36×21 mm. E. V. Clark (1900) reports specimens from the same region. The form of the test is rather striking and suggests the name. Tate (1891, p. 276) intimates that he had specimens from the "glauconitic limestone, of Aldinga Cliffs," but he gives no information about them. Later (1892, p. 193) he says that specimens were sent to Vienna, and he protests against Bittner's "reckless" species-making, by which a new genus "*Progonolampas*" with a type species "*Novae-Hollandiae*" is discovered in a trio of specimens of Gregory's *Echinolampas*. Certainly a comparison of Bittner's and Gregory's figures (none of which are photographs) does not justify a generic distinction. Chapman writes me that *posterocrassa* is known from the Lower Miocene of Victoria.

Echinolampas ovata

Echinanthus ovatus Leske, 1778. Add. ad Klein, p. 127.
Echinolampas ovata Döderlein, 1906. "Valdivia" ech., p. 240.
H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, p. 114; pl. 153, figs. 1, 2.

This is a distinctly Indian Ocean species, whose range extends from India to northwestern Australia and eastward to the East Indian islands. The "Challenger" took a specimen at the Kei Islands. The "Siboga" took an *Echinolampas* near Saleyer which de Meijere identified as the West Indian species, *depressa*. It is probably *ovata*. In the waters of northwestern Australia, *ovata* ranges from Lewis Island, Dampier Archipelago, near long. 117° E., to Augustus Island, near 125° E. No doubt it will be found between Augustus Island and the Kei Islands. It is fairly common near Broome in 5–8 fms. In life the color is at first a light wood brown, but becomes a dark yellowish brown or even a deep chestnut brown with increased size or age. The largest specimens are about 70 mm. long, width 0.83–0.90 length, height 0.50–0.66 length. The Recent species of *Echinolampas* have been so confused that it is not certain whether *ovata* occurs in the Red Sea or on the East African coast, but it would be rather strange if it does not.

Suborder Urechinina

There are 4 families in this suborder, but only 1 occurs in Australia, and that is represented only by fossil species. Nearly all Recent species occur only in deep water, so it is not strange that they have not yet been found near the Australian coast. The fossil species are from the Tertiary rocks of Victoria and South Australia.

Family ANANCHYTIDAE

Although this family comprises more than 20 genera (only 1 is now living), the Australian species represent but 2. These are distinguished thus:

Ambitus more or less heart-shaped, with conspicuous depression in ambulacrum III; marginal fasciole may be present ..... *Cardiaster*
Ambitus more nearly oval, with very slight depression in ambulacrum III; no marginal fasciole ..... *Duncaniaster*

*CARDIASTER

Forbes, 1850. Ann. Mag. Nat. Hist., ser. 2, vol. 6, p. 442.

Genotype: *Spatangus excentricus* Woodward, 1833, p. 37.

Lambert and Thiéry (1924, p. 406) designate as the type of this genus a species which is not even mentioned by Forbes, and hence, of course, cannot be the genotype. The first species Forbes mentioned, which has been satisfactorily figured and is well known, is obviously the one he considered typical and should be considered the genotype. There are 2 species from Australian strata which apparently belong in *Cardiaster,* but they are strikingly different in form and cannot be confused with each other.

Length greater than width; height much more than half length ..... *tertiarius*
Length less than width; height much less than half length ..... *latecordatus*

*Cardiaster tertiarius

Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 484; pl. 14, figs. 2, 3.

Although Gregory had but a single imperfect specimen, his description and figures are adequate. A typographical error in his description makes the width

only 21 mm., whereas his figure shows the actual width to be about 41 mm. This specimen was from Willunga, near Adelaide, South Australia. Bittner (1892, p. 360) reports that Tate sent 2 specimens to Vienna, 1 of which was 70 mm. long, but no definite locality is given. Tate (1891, p. 277) records many specimens in a "good state of preservation" from "glauconitic limestone, Aldinga Cliffs," South Australia, and adds one descriptive sentence: "There is no lateral fasciole." Chapman writes me that the locality is "Upper Oligocene."

*Cardiaster latecordatus

Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 280 (not figured).

This big, flat species occurs in the same glauconitic limestone at Aldinga Cliffs, South Australia, in which the preceding species is found. The measurements given by Tate are 82×87×35 mm., much greater than those of the largest reported *tertiarius*.

*DUNCANIASTER

Lambert, 1896. Bull. Géol. soc. France, ser. 3, vol. 24, p. 317.

Genotype: *Holaster australiae* Duncan, 1877, p. 51.

Apparently this is an endemic, monotypic genus, related to *Cardiaster* but lacking the deeply sunken (at ambitus) anterior ambulacrum as well as the marginal fasciole. Tate (1891) says that the latter feature is lacking in *Cardiaster tertiarius*, which suggests that the line between the two genera is not of very great morphological significance.

*Duncaniaster australiae

Holaster australiae Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 51; pl. 3, figs. 12, 13.
Duncaniaster australiae Lambert, 1896. Bull. Géol. soc. France, ser. 3, vol. 24, p. 317.

Tate (1891) intimates that this is a common fossil in the Tertiary rocks of Victoria and South Australia, and says it is very variable in shape, showing great diversity in the vertical diameter as compared with the length and width. Duncan's original description and figures give an adequate idea of the general appearance. The type was approximately 40×37×20 mm. Chapman writes me that *Duncaniaster* occurs in the Upper Oligocene and Lower Miocene rocks of Victoria and South Australia. Tate (1891) lists five localities.

Suborder Spatangina

This large group of more than 100 genera arranged in 5 families is well represented in Australia, but the more than 20 genera are, with one exception, divided between the 2 families usually ranked as the most typical spatangoids. The one exception belongs to a somewhat more primitive family of deep-water forms. The 3 families are easily distinguished thus, though the division may be more convenient than natural:

KEY TO THE FAMILIES OF SPATANGINA

A. No fascioles; ambulacra flush, not petaloid or only slightly so.....Palaeopneustidae
AA. Fascioles present; some or all ambulacra petaloid and more or less sunken:
Subanal fasciole wanting.....Hemiasteridae
Subanal fasciole present.....Spatangidae

Family PALAEOPNEUSTIDAE

This rather ill defined family of 25 or more species, grouped in about a dozen genera, is represented in Australia by only a single species, recently discovered in moderately deep water off the southeastern corner of the continent.

ARCHAEOPNEUSTES

Gregory, 1892*a*. Quart. Jour. Geol. Soc. London, vol. 48, p. 163.

Genotype: *Palaeopneustes hystrix* A. Agassiz, 1880, p. 82.

This genus, with 1 species in the West Indian seas and 2 in the Indian Ocean, is entitled to a place here because one of the East Indian forms has recently been taken in Australia.

Archaeopneustes niasicus

Palaeopneustes niasicus Döderlein, 1900. *In* Chun: Aus Tief. Welt., figs. p. 360.
Archaeopneustes niasicus Koehler, 1914*a*. Indian Mus. Spat., p. 52.

As was reported in H. L. Clark, 1938 (p. 429), this big spatangoid (147 mm. long) has been found in 70 fms. off Cape Everard, eastern Victoria. It must be rare and local, for the "Endeavour" did not obtain a specimen, nor did the "Siboga" take even one in all her East Indian dredging.

Family HEMIASTERIDAE

This family is represented in Australia by 9 genera, but 3 of these are known only as fossils, and in another, 2 of the 3 species are extinct. One of the extinct genera is very ill defined, yet 5 species are here referred to it. Moreover, much fossil material is so poorly preserved that the presence or absence of fascioles is difficult and often impossible to determine, not to speak of tracing their course. The following keys, therefore, are offered with diffidence and must not be relied on as unfailing guides.

KEY TO THE GENERA OF HEMIASTERIDAE

A. Marginal fasciole complete and separate:
Abactinal system nearly or quite central.....*Pericosmus*
Abactinal system excentric anteriorly; extinct.....*Prenaster*
AA. No true marginal fasciole present:
B. Abactinal system ethmophract; genital pores 4; no lateroanal fasciole present .....*Hemiaster*

BB. Abactinal system ethmolytic:
C. Genital pores 4; lateroanal fasciole more or less completely developed:
D. Apex subcentral or anterior:
Ambulacrum III narrow, not petaloid or sunken.....*Protenaster*
Ambulacrum III wide, petaloid, sunken; extinct.....*Linthia*
DD. Apex more or less posterior.....*Paraster*
CC. Genital pores 2 or 3:
E. Peripetalous fasciole runs across interambulacra 1 and 4 at some distance from apical system:
Lateroanal fasciole incomplete or wanting.....*Hypselaster*
Lateroanal fasciole complete and distinct.....*Schizaster*
EE. Peripetalous fasciole closely follows margins of all petals; these are very deeply sunken and enterable only by narrow slits .....*Moira*

PERICOSMUS

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 19.

Genotype: *Micraster edwardsii* Agassiz, 1840, p. 2 (*nomen nudum*) = *Schizaster agassizii* Sismonda, 1841, p. 23.

Although more than 40 species have been referred to this genus, only 2 or 3 are Recent and only 1 of these occurs in Australia. Of the fossil forms none is Australian, but several now included under *Linthia* have been referred to *Pericosmus* by different authorities at various times. The difficulty of determining the position and course of the fascioles in most fossils makes their assignment to genera and species very unreliable and leaves wide room for differences of opinion as to their true relations. Both Chapman (1908) and Pritchard (1908) seem to be satisfied that none of the Australian fossils referred to *Pericosmus* belong in that genus, but should be treated as Linthias. Hence the following is the only Australian species of *Pericosmus*.

Pericosmus macronesius

Koehler, 1914*a*. Indian Mus. Spat., p. 133; pl. 12, figs. 1–5.

The discovery that this rare spatangoid is a member of the Australian fauna was one of the notable results of the deep-water dredging done by the Great Barrier Reef Expedition (see H. L. Clark, 1932, p. 217). Only a single specimen was taken, but it is a very fine one, 61 × 57 × 37 mm., bright purple in color. It was taken in 210 fms., ½ mile outside Cook's Passage, near Lizard Island, north Queensland. The only other known specimens were taken by the "Investigator," in rather more shallow water (55 fms.) on the eastern side of the Bay of Bengal, near the Andaman and Moscos islands.

*PRENASTER

Desor, 1853. Act. Soc. helvét. sci. nat., vol. 38, p. 279 (p. 12 of reprint).

Genotype: *Prenaster alpinus* Desor, 1853, p. 279 (12) (*nomen nudum*); 1858, p. 401.

Lambert and Thiéry (1925) list 20 species in this genus, 2 of which are from Australian strata. One of these is considered a *Linthia* by Chapman, but the other seems to be a very typical member of Desor's genus.

*Prenaster aldingensis

T. S. Hall, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, p. 48; pl. 13, figs. 3, 4.

This interesting species is based on a single small specimen, 21 × 18.5 × 14 mm., having the posterior end hidden by the matrix. The position of the small apical system and the character of the very narrow fascioles warrant assigning the species to *Prenaster*. The type was found in the Upper Oligocene rocks at Aldinga, South Australia.

HEMIASTER

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 16.

Genotype: *Spatangus bufo* Brongniart, 1822, p. 389.

Lambert and Thiéry (1924) list some 200 Hemiasters, grouped in 7 sections, to which are appended 4 subgenera. Fortunately only 1 of this vast, heterogeneous horde is listed from Australia, so it is neither necessary nor desirable to discuss here the status of the proposed groups.

*Hemiaster planadeclivis

Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 488; pl. 14, figs. 6, 7.

The unique holotype of this well marked species was collected at Morgan, South Australia, in the "Middle Murravian," according to Gregory. Tate (1891) lists the species from the "River Murray Cliffs" and the "Aldinga Cliffs." Chapman writes that it occurs in the Lower Miocene of Victoria. Adult specimens are about 30 × 27 × 22 mm. and show the generic characters and usual facies very well.

PROTENASTER

Pomel, 1883. Class. méth. éch., p. 36.

Genotype: *Desoria australis* Gray, 1851, p. 132.

Lambert and Thiéry (1925) recognize this group as only a "section" of *Linthia,* but its leading characters are so well marked, it is well worth recognition. There are at least 2 Recent species, and 1 of these is apparently endemic in Australia. It is still relatively rare in collections, and there is some reason to think that possibly 2 species are now confused under the one name. It is also possible that the species is not endemic, for there are 2 specimens in the British Museum said to be from the Philippine Islands.

Protenaster australis

Desoria australis Gray, 1851. Ann. Mag. Nat. Hist., ser. 2, vol. 7, p. 132.
Protenaster australis Pomel, 1883. Class. méth. éch., p. 36.

This fine and easily recognized spatangoid seems to be fairly common near the southwestern corner of Australia, whence it ranges northward to Cottesloe. It is also known from Tasmania and Flinders Island, and a specimen is in the Museum of Comparative Zoölogy from Western Port, Victoria. But Verco did not meet with

it in South Australian waters, nor do there seem to be records from New South Wales. The largest specimen reported is in the British Museum and measures 76×64×44 mm. For a discussion of the appearance in life, the pedicellariae, and the color, see H. L. Clark, 1938, page 429.

*LINTHIA

Desor, 1853. Act. Soc. helvét. sci. nat., vol. 38, p. 278 (p. 11 of reprint).

Genotype: *Linthia insignis* Desor, 1853, p. 278 (11).

More than 70 species have been assigned to this ill defined genus. The very few living forms are now placed in other genera, but the fossils make up a heterogeneous group whose limits are very vague. Fortunately only 5 Australian species have to be distinguished, but the lines between these are by no means clear. However, the following vague and arbitrary grouping may be of some help:

Key to the Species of Linthia

A. Test high, height about one-half length or more:
- Apex slightly anterior; ambulacrum III deeply depressed at margin ..... *gigas*
- Apex slightly anterior; ambulacrum III but little depressed at margin ..... *antiaustralis*
- Apex and petaloid area markedly anterior; ambulacrum III little depressed ..... *nelsoni*

AA. Test depressed and very wide; ambulacrum III deeply depressed at margin:
- Petals short and straight; height of test about two-fifths length; slope of test from apex anteriorly not marked ..... *compressus*
- Petals rather long; anterior pair curved; height of test about three-tenths length; slope of test from apex anteriorly very marked .... *mooraboolensis*

*Linthia gigas

Pericosmus gigas McCoy, 1882. Prodr. palaeontol. Victoria, dec. 7, p. 15; pls. 64, 65.
Linthia gigas Pritchard, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 21, pt. 1, p. 396.

This very large spatangoid is found, usually only in fragments, in the Lower Miocene rocks of Victoria and South Australia. It attained a length of 175 mm. or more, with the height nearly or quite half as much.

*Linthia antiaustralis

Tate, 1885. Southern Science Rec., n. s., no. 1, p. 4.
Chapman, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 20, pt. 2, p. 215; pl. 19.
Pritchard, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 21, pt. 1, p. 397.

Pritchard is skeptical as to whether Chapman's specimen from Curlewis, Victoria, is identical with Tate's type from the Murray River Cliffs. Both are from Lower Miocene strata. Until more material is collected and studied, the present species is dubious indeed. Tate's specimen was 60×50×40 mm., and Chapman's was (according to the figures given, said to be natural size) 42–45.5×37–39×27 mm. The Victorian specimen is a trifle flatter, but on the whole the proportions are very similar.

*Linthia nelsoni

Pericosmus nelsoni McCoy, 1882. Prodr. palaeontol. Victoria, dec. 7, p. 17; pl. 66; pl. 67, fig. 1.
Linthia nelsoni Pritchard, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 21, pt. 1, p. 399.

The known material of this species is from the Waurn Pond quarries, Victoria, in Lower Miocene strata, but Chapman says (*in litt.*) that it also occurs in the Lower Miocene of South Australia. Pritchard's account is wholly comparative and says nothing as to the number, size, or proportions of his specimens.

*Linthia compressus

Megalaster compressus Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 62; fig. 1.
Pericosmus compressus McCoy, 1882. Prodr. palaeontol. Victoria, dec. 7, p. 21; pl. 67, figs. 2, 2*a;* pl. 68.
Pericosmus McCoyi Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 485.

Owing to the great diversity in the condition of the fossils referred to this species, there is wide difference of opinion as to its generic position, but on the whole its obvious relationship to the following species warrants placing it in the same genus. It is known from the River Murray Cliffs and from Spring Creek, near Geelong, and the strata are listed as Lower Miocene. The measurements of the holotype are given by Duncan as $4\frac{3}{4} \times 4\frac{1}{2} \times 2$ inches, but McCoy's specimens were larger. Pritchard (1908) makes no reference to the species, but whether that is because he did not know of its occurrence in Victoria or because he did not think it a *Linthia,* cannot be said.

*Linthia mooraboolensis

Pritchard, 1908. Proc. Roy. Soc. Victoria, n. s., vol. 21, pt. 1, p. 394; pls. 22, 23.

The large size and depressed form of this species are very striking. The holotype is $195 \times 185 \times 55$ mm. Fragments and crushed specimens occur in large numbers in the polyzoal limestones of the Filter Quarries at Batesford, Moorabool Valley, Victoria, in Balcombian strata, but complete specimens are very rare. Pritchard says the strata are Eocene, but Chapman (*in litt.*) calls them Lower Miocene. The ambulacral petals in *mooraboolensis* are remarkably narrow and the anterior pair are definitely curved, being thus very different from those of *compressus.* The sunken ambulacrum III cuts a narrower and much deeper notch at the anterior end of the test than is found in the related species.

PARASTER

Pomel, 1869. Rev. éch., p. xiv.

Genotype: *Schizaster gibberulus* Agassiz and Desor, 1847, p. 22.

This genus includes an indefinite number of fossil forms and several Recent species, but only the following is a member of the Australian fauna.

Paraster savignyi

Schizaster savignyi Fourtau, 1904. Bull. Inst. égypt., ser. 4, vol. 4, p. 436.
Paraster savignyi Koehler, 1914*a*. Indian Mus. Spat., p. 172; pl. 8, figs. 4, 6, 12, 15; pl. 9, figs. 3, 11.

The inclusion of this spatangoid in the Australian fauna rests on the specimens taken by the "Challenger" at her station 188, in 28 fms., at the eastern end of the Arafura Sea. These specimens were all young, except one, 53×46×35 mm., and their identity is not beyond question, as the line between *savignyi* and *gibberulus* is not well defined and young *Schizaster lacunosus* is not very different. More material is obviously necessary to enable us to determine the true relation of these forms, and to decide which one is found in Australia.

HYPSELASTER

H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 185.

Genotype: *Schizaster* (*Periaster*) *limicola* A. Agassiz, 1878, p. 193.

The 2 Australian species referred to this genus are probably congeneric, but that they belong in the same genus with *limicola* is certainly open to question. Far too little material of one is available, and of the other more specimens, particularly young ones, would be useful. The two may be distinguished thus:

Apex slightly posterior; petaloid area large ..... *dolosus*
Apex slightly anterior; petaloid area small ..... *fragilis*

Hypselaster dolosus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 430; pl. 28, figs. 4–7.

This interesting spatangoid is common at Broome, Western Australia, and also occurs farther northeast at Augustus Island. The superficial resemblance to *Schizaster lacunosus* is striking. It reaches a length of about 50 mm., with the width 0.70–0.88 thereof and the height 0.64–0.72, and is thus not quite so wide or high relatively as typical *lacunosus*.

Hypselaster fragilis

Periaster limicola A. Agassiz, 1881. "Challenger" Ech., p. 204 (NON A. Agassiz, 1878, p. 293).
Periaster fragilis Agassiz and Clark, 1907. Bull. Mus. Comp. Zoöl., vol. 51, p. 138.
Hypselaster fragilis H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 189.
——— 1925. Cat. Recent sea-urchins Brit. Mus., p. 208.

The unique holotype of this spatangoid was taken by the "Albatross" in 391 fms., southwest of Koshika Islands, Japan. The only other specimens referred to the same species are in the British Museum and were collected many years apart, 1 at Cape York by Jukes, 1 by the "Challenger" in 28 fms. at her station 188 at the western end of Torres Strait, and 1 by the Great Barrier Reef Expedition near Howick Island in 10 fms. The Cape York specimen is 60×52 mm., with the posterior end 42 mm. high, the anterior end only three-fourths as much. As this

is nearly 4 times the size of the holotype, the identity of the two is obviously dubious, but the "Challenger" and Barrier Reef specimens are intermediate and give some warrant for calling all these specimens by one name. Until considerably more material is available the matter must rest here.

SCHIZASTER

L. Agassiz, 1835*a*. Mém. soc. sci. nat. Neuchâtel, vol. 1, p. 185.

Genotype: *Schizaster studeri* Agassiz, 1835*a*, p. 185.

Scores of fossil spatangoids in Tertiary rocks have been assigned to this genus, but living species are very few. There are only 3 Schizasters in the Australian fauna, 1 living and 2 fossil. Thanks to T. S. Hall's (1907) excellent figures, they are distinguishable without difficulty.

Key to the Species of Schizaster

A. Test broadly ovoid, sloping gradually from posterior apex to anterior end; ambulacrum III not very deeply sunken at ambitus; mouth well back from anterior margin:
  Test high, truncate or rounded posteriorly; petals I and V very small, about one-third as long as II and IV; Recent ..... *lacunosus*
  Test not so high, broadly ovate, roundly pointed posteriorly; petals I and V large, about half as big as II and IV; extinct ..... *abductus*
AA. Test ovate, depressed markedly in front of apical system; ambulacrum III deeply sunken at ambitus, with mouth very near anterior margin; extinct ..... *sphenoides*

Schizaster lacunosus

Echinus lacunosus Linné, 1758. Syst. Nat., ed. 10, p. 665.
Schizaster lacunosus Lovén, 1887. Ech. Linn., p. 168.
Schizaster japonicus A. Agassiz, 1881. "Challenger" Ech., p. 202; pl. 36, figs. 8–13.

This spatangoid is found in the Indian seas from the Maldives to Kobe, Japan, and south to northern Australia, where it has been taken in Torres Strait and near Turtle Isles, northern Queensland. It also occurs on the East African coast as far south as Natal, but on the Western Australian coast it is replaced by *Hypselaster dolosus*. Large specimens exceed 50 mm. in length, breadth about 0.90 and posterior height 0.75 length. The color is similar to that of the sandy mud in which the animals live.

*Schizaster abductus

Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 281.
T. S. Hall, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, p. 52; pl. 15, figs. 9, 10; pl. 16, fig. 11.

This species reaches about the same size as the preceding, but is not nearly so high, the height being about 0.60 length. It has been found in the Lower Miocene rocks of South Australia, Victoria, and Tasmania.

*Schizaster sphenoides

T. S. Hall, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, p. 51; pl. 14, figs. 7, 8; pl. 16, fig. 12.

This *Schizaster* is known as yet only from the Lower Miocene rocks of Victoria. Hall gives the type locality as the "base of cliffs at mouth of Sherbrooke River," where, he says, specimens are common but usually crushed. He adds that most of the specimens have patches of spines still attached. This is the largest of the 3 Australian Schizasters, the biggest of Hall's specimens measuring 66 × 60 × 38 mm.

MOIRA

A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 146.

Genotype: *Spatangus atropos* Lamarck, 1816, vol. 3, p. 32.

The highly specialized spatangoids of this group are widely distributed in the warmer seas, 1 species occurring in the West Indian region, 1 in the eastern Pacific along the American coast, 1 in Japan, and 1 in the Indian Ocean from Suez to the Andaman Islands and Australia. Owing to their habit of living more or less deeply buried in mud or fine sand, they are not often taken by the general collector and good specimens are rare in museums. The West Indian species apparently occurs in great numbers in certain localities along the southeastern coast of the United States, and the dead tests may sometimes be gathered in quantity. Apparently this is not the case with the Australian species, which is rare everywhere so far as at present known.

Moira stygia

Moera stygia A. Agassiz, 1872. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, p. 58.
Moira stygia A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 147 (not figured).

Although this curious spatangoid has never been figured, it is unmistakable among the Australian members of the Spatangina. It seems to occur most commonly on the Queensland coast, where it reaches maximum size, a specimen in the museum at Brisbane measuring 49 × 44 × 37 mm. It is known, however, from both Broome, Western Australia, and Port Willunga, South Australia, so it may well be looked for anywhere on the Australian coast. For details with reference to Australian specimens, see H. L. Clark, 1938, page 432.

Family SPATANGIDAE

The exact limits of this family are either very hazy or arbitrarily determined by the presence of the subanal fasciole. Lambert and Thiéry (1914–1925) ignore the name as well as the group here recognized, owing to their misuse of the old name *Spatangus*. Duncan (1889) goes to the other extreme and uses the name for all but 3 or 4 of the genera here included in the suborder Spatangina. Rearrangement of the genera of spatangoids is almost sure to occur with increase in our knowledge of them, but at present, the family Spatangidae seems a natural and useful group of some 40 or more genera, of which about half have living representatives. Twelve of the latter genera and 3 of those known only from extinct species are represented

in the Australian fauna. These 15 genera may be distinguished as follows, but it must not be forgotten that some lines of division are very arbitrary and some very hazy.

Key to the Genera of Spatangidae

A. No true internal fasciole (peripetalous fasciole may cut across very tips of petals):
- B. Peripetalous fasciole present:
  - C. At least 4 petals well formed and in adults more or less depressed:
    - D. Ambulacrum III more or less sunken and petaloid abactinally ..... *Brissopsis*
    - DD. Ambulacrum III not at all sunken nor definitely petaloid:
      - E. Peripetalous fasciole very narrow, angularly subcircular, commonly incomplete; anterior petals, II and IV, much longer than posterior; extinct ..... *Cyclaster*
      - EE. Peripetalous fasciole normally wide and complete; anterior petals shorter:
        - F. Distinct anal fasciole on each side of periproct:
          - Subanal plastron not projecting like snout beyond periproctal area ..... *Metalia*
          - Subanal plastron projecting, snoutlike, beyond periproctal area ..... *Rhynobrissus*
        - FF. No anal fascioles:
          - G. Subanal fasciole complete, surrounding definite subanal plastron:
            - Subanal plastron projecting, snoutlike, beyond periproctal area ..... *Cionobrissus*
            - Subanal plastron not thus projecting ..... *Brissus*
          - GG. Subanal fasciole incomplete, subanal plastron not sharply defined ..... *Meoma*
  - CC. At least 4 petals flush, not sunken, and often not distinctly petaloid:
    - Posterior petals widest near middle, tips cut off by peripetalous fasciole; extinct ..... *Gualtieria*
    - Peripetalous fasciole does not cross tips of posterior petals ..... *Eupatagus*
- BB. No peripetalous fasciole:
  - H. Sternum well developed, much longer than wide, fully covered with tubercles:
    - Subanal plastron projecting beyond periproctal area; periproct visible from above; extinct ..... *Micraster*
    - Not as above ..... *Gonimaretia*
  - HH. Sternum small, wide, with conspicuous tubercles confined to posterior half ..... *Maretia*

AA. Internal fasciole definitely present around abactinal system:
- J. Peripetalous fasciole present ..... *Breynia*
- JJ. Peripetalous fasciole wanting:
  - Large, deeply sunken primary tubercles present; labrum long and narrow ..... *Lovenia*
  - No large, deeply sunken primary tubercles; labrum short and wide ..... *Echinocardium*

BRISSOPSIS

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 14.

Genotype: *Brissus lyrifer* Forbes, 1841, p. 187.

This group of some 8 or more Recent species is found widespread in the northern hemisphere, but 1 Atlantic species ranges southward to South Africa and 1 Indo-Pacific species just enters the Australian fauna in the Torres Strait region. There are, however, dozens of nominal Tertiary species, and 1 of these is found in Victoria. The 2 Australian forms are closely related, but are to be distinguished thus:

Ambulacra I and V on oral surface bare but wide, wider than half sternum; no tubercles on labrum ..... *luzonica*
Ambulacra I and V orally narrow, bare area less than half sternum; tubercles of sternum anteriorly rather coarse, extending up onto labrum; extinct ..... *tatei*

Brissopsis luzonica

Kleinia luzonica Gray, 1851. Ann. Mag. Nat. Hist., ser. 2, vol. 7, p. 133.
Brissopsis luzonica A. Agassiz, 1872*a*. Rev. ech., pt. 1, p. 95.
H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, pl. 155, figs. 2, 3.

This widespread Indo-Pacific species occurs around the northeastern corner of Australia, having been taken by the "Challenger" at her station 188, at the western end of Torres Strait, in 28 fms.; by the Great Barrier Reef Expedition off Linden Bank, Queensland, in 114 fms.; and by Melbourne Ward off Lindeman Island, near Mackay, Queensland, in shallow water. Full-grown specimens are 60 mm. or more in length, but most of the known Australian specimens are much smaller, under 40 mm.

*Brissopsis tatei

T. S. Hall, 1907. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, p. 49; pl. 13, figs. 5, 6.

Hall found his "numerous" specimens in the cliffs at the mouth of the Sherbrooke River, Victoria, and at various localities along the neighboring coast. Chapman considers these strata Lower Miocene. The type specimens were 46–47 × 41 × 23–24 mm. They are thus relatively wider than specimens of *luzonica* of the same length. Hall refers also to slight differences in the posterior petals and in the "less pointed posterior end." It is very doubtful whether these differences are constant and reliable, for *luzonica* shows considerable individual diversity in these characters.

*CYCLASTER

Cotteau, 1856. Bull. Soc. géol. France, ser. 2, vol. 13, p. 345.

Genotype: *Cyclaster declivus* Cotteau, 1856, p. 345.

Duncan (1889) considers this group a subgenus of *Brissopsis,* but Lambert and Thiéry (1924) recognize it as a valid genus containing some 20 or more species, all of which are extinct. One of these occurs in Australia and apparently warrants recognition. Its generic position has been changed several times, however, in ac-

cordance with the condition of the specimens examined or the relative weight given to the various characters by the paleontologist studying the material. If only the specimens were as fine as Cotteau's notoriously beautiful figures, we should have less diversity of opinion, but nature rarely provides such specimens.

*Cyclaster archeri

Hemiaster archeri Tenison-Woods, 1867. Proc. Philos. Soc. Adelaide (*fide* Tate, 1891).
Micraster brevistella Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, pt. 1, p. 192; figs. 7 (not 8, as stated), 7*a*, 7*b*.
Brissopsis archeri Tate, 1884. Trans. Roy. Soc. S. Australia, vol. 7, p. 41.
Cyclaster morgani Cotteau, 1889. Mém. Soc. zool. France, vol. 2, p. 330; pl. 15, figs. 6–10.
Micraster archeri Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 277.
Cyclaster lycoperdon Bittner, 1892. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, p. 360; pl. 4, figs. 1, 2.
Cyclaster archeri Tate, 1892. Trans. Proc. Roy. Soc. S. Australia, vol. 15, p. 194.

This much described, discussed, and figured fossil is one of the most widespread of the Tertiary echini of Australia. It is known from the Lower Miocene strata of South Australia, Victoria, and Tasmania. Mature specimens measure 40–54 mm. in length, with breadth 0.90 or more, and height 0.70–0.80 of length.

METALIA

Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 51.

Genotype: *Spatangus sternalis* Lamarck, 1816, vol. 3, p. 31.

This is a group of 5 or 6 Recent species confined to the Indo-Pacific region. The 2 which occur in Australia are easily distinguished thus:

Petals I and V not at all confluent; primary tubercles at dorsal proximal end of interambulacrum 5 ..... *spatagus*
Petals I and V more or less confluent; no primary tubercles at dorsal proximal end of interambulacrum 5 ..... *sternalis*

Metalia spatagus

Echinus spatagus Linné, 1758. Syst. Nat., ed. 10, p. 665.
Metalia maculosa A. Agassiz, 1873. Rev. ech., pt. 3, p. 598; pl. 21*b*, figs. 8, 9.
Metalia spatagus Lovén, 1887. Ech. Linn., p. 162.

The Great Barrier Reef Expedition brought back 3 specimens of this big spatangoid from the Low Isles, but there are no data with them. One is the largest specimen of the species yet recorded, measuring 110×93×52 mm. Although the species ranges throughout the Indo-Pacific region from Suez to Mexico, there do not seem to be any other Australian records save the "Challenger" 's station 188, in Torres Strait, 28 fms.

Metalia sternalis

Spatangus sternalis Lamarck, 1816. Anim. sans vert., vol. 3, p. 31.
Brissus (*Metalia*) *sternalis* Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 51.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 600; pl. 21*a*, figs. 4, 5; pl. 21*c*, figs. 5–9.

This big spatangoid is widely distributed in the Indo-Pacific region from Zanzibar to Hawaii and the Society Islands. Specimens in the British Museum are more than 180 mm. long, 160 mm. wide, and over 100 mm. high. There is at least 1 specimen there from "northeastern Australia," and Agassiz lists 1 in the "Revision" from Port Essington. The Great Barrier Reef Expedition took 2 small, bare, bleached specimens at "Low Island. Off Port Douglas, Queensland." But it has not yet been found in Torres Strait nor on the northern or northwestern coasts of the continent.

RHYNOBRISSUS

A. Agassiz, 1872. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, p. 58.

Genotype: *Rhynobrissus pyramidalis* A. Agassiz, 1872, p. 58.

Only 5 species are referred to this striking genus, and 3 of them occur on the northern coast of Australia. They are seldom collected, and specimens are rare in museums; the British Museum (in 1925) had 3, representing 2 species, and the Museum of Comparative Zoölogy has today only 26 specimens of the 5 species, 17 of these representing the commonest and most widespread form. The Australian species may be distinguished as follows:

Key to the Species of Rhynobrissus

A. Test sloping forward markedly from back of apical system; posterior end of sternum and subanal plastron projecting conspicuously beyond periproct; ambitus rounded pentangular ..... *pyramidalis*

AA. Test highest in front of abactinal system or at least but little lower than posteriorly; posterior end of sternum and plastron project but little; ambitus elliptical:

Petaloid area relatively small, 0.70–0.75 test length, peripetalous fasciole not nearly reaching ambitus anteriorly ..... *hemiasteroides*

Petaloid area very large, about 0.90 test length, peripetalous fasciole nearly coinciding with ambitus anteriorly ..... *macropetalus*

Rhynobrissus pyramidalis

A. Agassiz, 1872. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, p. 58.
——— 1873. Rev. ech., pt. 3, p. 590; pl. 23*a*, figs. 4–6.

Until 1938, the only justification for including this unusually handsome East Indian spatangoid in the Australian fauna was a small individual, 16 mm. long, in the British Museum, taken on Holothuria Bank in 10 fms. This specimen is so young that its identity is dubious. But in 1938, Melbourne Ward, the well known Australian zoologist and collector, obtained a superb adult near Darwin, "on a sand spit about one mile off West Point," which "dries only at very low water." The collection was made "at night, Feb. 5, 1938." Ward has generously presented this specimen to the Museum of Comparative Zoölogy. It is fully clothed with very slender and delicate light purple or lavender spines, which attain a length of 10–12 mm. along the sides of the oral surface, particularly posteriorly. The test is about 50 mm. long, by 45 mm. wide just back of the mouth; 35 mm. back of the anterior margin, it is about 30 mm. high, but at the apical system, which is 23 mm. from the anterior margin, the height is only 25 mm. All these measurements are inaccurate owing to the dense coat of spines.

Rhynobrissus hemiasteroides

A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 211.
——— 1881. "Challenger" Ech., p. 186; pl. 35*b*, figs. 12–15.
Hemiaster (*Rhynobrissus*) *apicatus* Tenison-Woods, 1880. Proc. Linn. Soc. N. S. Wales, vol. 4, p. 283; pl. 13.

This species ranges from Tahiti and Hawaii on the east to Queensland and northwestern Australia on the west. The largest specimen from Broome is 49 × 44 × 26 mm.; one in the Brisbane Museum and supposed to be from the Queensland coast is 65 × 58 × 38 mm. For a discussion of differences between the Broome and Queensland material, see H. L. Clark, 1938, page 433. There is no doubt that the Queensland material is the form named *R. apicatus* by Tenison-Woods, and there are apparently no characters by which it can be distinguished from Agassiz's Tahitian type.

Rhynobrissus macropetalus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 434; pl. 28, figs. 8, 9.

Since the description of the unique and badly damaged holotype was published, Bardwell has collected, and generously given to the Museum of Comparative Zoölogy, a superb specimen of this rare spatangoid. It was found by him at extreme low water on the "central banks" in Roebuck Bay, in September 1941. It is 67 × 58 × 43 mm. and entirely covered with a dense coat of rather coarse yellow-brown spines, very different from the slender, almost silky spines of *pyramidalis*. The petals are very straight, narrower and rather more sunken than in the type. The ventral ambulacra bounding the straight, narrow sternum are densely covered with miliary spines and a few pedicellariae. The test is not elevated in front of the abactinal system as it is in *hemiasteroides*, but the posterior interambulacrum is well elevated above the limiting petals.

CIONOBRISSUS

A. Agassiz, 1879. Proc. Amer. Acad., vol. 14, p. 206.

Genotype: *Cionobrissus revinctus* A. Agassiz, 1879, p. 206.

Though this genus resembles *Rhynobrissus* in its most obvious character, the projecting subanal plastron, the entire absence of an anal fasciole is a conspicuous difference. Only 2 species are known, both from the western end of the Torres Strait region and both collected by the "Challenger." But the type species was taken only in very deep water, 800 fms., near the Kei Islands, and the second was not discovered until 45 years after the first was described, although it was taken at practically the same time, in much shallower water, nearer the Australian coast.

Cionobrissus regularis

H. L. Clark, 1925. Cat. Recent sea-urchins Brit. Mus., p. 221; pl. 10, figs. 6, 7.

The unique holotype of this species is a well preserved specimen, 40 × 33 × 22 mm., in the British Museum. It was taken by the "Challenger" at her station 188, in 28 fms., at the western end of Torres Strait, but was hastily labeled "*Metalia maculosa*," a spatangoid it superficially resembles. It is readily distinguished from its deep-

water congener by its lower, stouter test and much lighter coloration. More important is the fact that ambulacrum III is not at all depressed and hence there is no notch in the ambitus anteriorly.

BRISSUS

Leske, 1778. Add. ad Klein, p. xx.

Genotype: *Spatangus brissus unicolor* Leske, 1778, p. xx.

There are but 2 Recent species of this genus, one occurring in the Mediterranean, eastern Atlantic, and West Indian region, the other in the Indo-Pacific from Zanzibar to Panama. The latter occurs in Australia, at least along the eastern coast, but does not seem to be very common. The 2 species are not very distinct, and young or half-grown specimens are easily confused.

Brissus latecarinatus

Spatangus brissus var. *latecarinatus* Leske, 1778. Add. ad Klein, p. 185.
Brissus latecarinatus H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 219.

This spatangoid's habit of living buried in sand under rock fragments leads to its being often overlooked by collectors, and small specimens are more commonly found than adults. The British Museum has a number of specimens from Australian localities, chiefly in the Torres Strait region. The locality farthest west is Port Essington on the Coburg Peninsula. The species ranges south on the Queensland coast, and Whitelegge (1889) includes it in the fauna of Port Jackson. It certainly occurs at Lord Howe Island, for we took 2 adult specimens on the reef flat near Mount Lidgbird. Ramsay and Tenison-Woods both say it is common on the coasts of eastern and southern Australia, but there have been none in any Australian collection I have studied. It may occur on the New South Wales coast, but the record needs verification; yet Cotton and Godfrey (1942) report it from Port Lincoln, South Australia. The largest specimen noted is from Hawaii and measures $130 \times 108 \times 74$ mm. There is much diversity of form, ranging from rather flattened, wide, low individuals to narrower, high forms with a marked keel in interambulacrum 5 dorsally. In some cases there is an evident keel on the lower side, and frequently the posterior end of the test is almost pointed. In life, the color is pale brownish, sometimes with a lavender tinge. Often, if not always, the big globiferous pedicellariae with their black glandular heads stand out as black spots among the light-colored spines.

MEOMA

Gray, 1851. Ann. Mag. Nat. Hist., ser. 2, vol. 7, p. 132.

Genotype: *Meoma grandis* Gray, 1851, p. 132.

The spatangoids composing this genus are definitely American, 1 species occurring on the western coast of Mexico and 1 in the West Indies. A Pliocene species from South Carolina is probably identical with the latter. A Miocene species has been described from Java, but it is improbable that it is congeneric with the Recent species. The following species from Australia can hardly be very closely related to the American forms, but I leave it where Tate and Dennant (1896) last placed it. More and better material will surely show it is not a *Meoma*.

*Meoma decipiens

Eupatagus decipiens Tate, 1891. Trans. Proc. Roy. Soc. S. Australia, vol. 14, p. 282.
Pericosmus compressus Gregory, 1890. Geol. Mag., n. s., dec. 3, vol. 7, p. 485; pl. 14, fig. 1 (NON McCoy, 1882, p. 21).
Macropneustes decipiens Gregory, 1892. Geol. Mag., n. s., dec. 3, vol. 9, p. 436.
Meoma decipiens Tate and Dennant, 1896. Trans. Proc. Roy. Soc. S. Australia, vol. 20, p. 130.

Although Gregory at first considered this fossil a *Pericosmus* (in spite of there being no marginal fasciole), he later gave it more careful study and decided it was not a *Pericosmus,* nor a *Eupatagus* as Tate thought, but should be considered a *Macropneustes.* Tate objects to this, and puts his much shifted species in *Meoma,* where I am sure it does not belong. Gregory's specimen is about 100 mm. long and nearly as wide. Chapman writes me that the species is found in the Lower Miocene of Victoria and the Miocene of South Australia.

*GUALTIERIA

Desor, *in* Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 10.

Genotype: *Gualtieria orbignyana* Agassiz, *in* Agassiz and Desor, 1847, p. 10.

It seems to be agreed that the following Australian species is congeneric with the European species which Desor made the type of his genus, and Tate (1892) accepts it as "an interesting addition to the Echinoid fauna of the Australian Eocene" but adds that it is not represented in his collection.

*Gualtieria australiae

Cotteau, 1889. Mém. Soc. zool. France, vol. 2, p. 328; pl. 15, figs. 4, 5.

This interesting fossil is said by Cotteau to be "très rare" in the "Eocène" of Mount Gambier, South Australia. The unique type was 55 × 45 × 25 mm. Chapman assigns the strata to the Lower Miocene.

EUPATAGUS

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 9.

Genotype: *Eupatagus valenciennesii* Agassiz and Desor, 1847, p. 9.

Lambert and Thiéry (1924) abandon this long-used name, replacing it with a pre-Linnaean term, but by whatever name the group is called, it is an unnatural assemblage of forms associated together largely because the lack of distinctive characters is an obstacle to placing them elsewhere. Only 2 species are now living, both Australian. One is the type of the genus; the other is very different, and when adequate material is available will undoubtedly be placed in another, probably as yet unnamed, genus. The more than 100 fossil species from the Tertiary rocks of the world are grouped by Lambert and Thiéry in 5 sections, and they make a sixth section for the Recent species belonging to the perfectly good genus *Gymnopatagus* of Döderlein. Only 5 Australian fossil species have been relegated to *Eupatagus,*

and 1 of these, *Eupatagus coranguinum* Tate, is apparently a *nomen nudum,* as I have been unable to locate either a word of description or a figure. The 2 Recent and 4 Tertiary Australian species are not so heterogeneous a group as might be feared, but it is fairly certain that sufficient well preserved material would show they are not congeneric.

KEY TO THE SPECIES OF EUPATAGUS

A. Test high, vertical diameter about half length or more:
  B. Apex of test posterior to center of abactinal surface:
    Test flattened at apex and anterior thereto; width of test about 0.80 length; extinct ..... *murrayensis*
    Test highly arched at apex and anterior thereto; width of test nearly equal to length; extinct ..... *rotundus*
  BB. Apex of test nearly central or anterior thereto:
    Apex near center of abactinal surface; many enlarged tubercles within peripetalous fasciole; extinct ..... *wrightii*
    Apex anterior to center; no large tubercles within peripetalous fasciole; Recent ..... *dyscritus*
AA. Test low, vertical diameter about 0.35 length:
  Width of test about 0.90 length; many enlarged tubercles within peripetalous fasciole; extinct ..... *laubei*
  Width of test about 0.80 length; very few enlarged tubercles within peripetalous fasciole; Recent ..... *valenciennesii*

*Eupatagus murrayensis

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, no. 1, p. 196; fig. 6.

This seems to be one of the characteristic fossils of the Murray River Cliffs, but little has been published concerning it since Laube wrote. His type was 40 × 34 × 20 mm. Chapman says (*in litt.*) "Lower Miocene of Victoria and South Australia," but does not specify any Victorian locality.

*Eupatagus rotundus

Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 53; pl. 3, figs. 14–17.

Duncan says (1877, p. 68) that this is an "exceedingly beautiful" species, which would seem to indicate that his specimen (or specimens) was (or were) in fine condition. The measurements, translated into the metric system, are about 70 × 67 × 38 mm.; the figured specimen, said to be natural size, is a trifle higher and considerably narrower. Duncan gives the locality for his specimens as Tertiaries of the Murray River (South Australia). Tate also says River Murray Cliffs. Chapman (*in litt.*) says "Lower Miocene, Victoria."

*Eupatagus wrightii

Laube, 1869. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, no. 1, p. 196; fig. 5.

Practically nothing of importance has been published about this species since Laube's paper appeared. He had 2 specimens, of which 1 was young. The type was 39 × 36 × 22.5 mm. The locality is given simply as Murray Cliffs, South Australia.

Chapman says the species occurs in the Lower Miocene of Victoria and South Australia.

Eupatagus dyscritus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 436; pl. 28, figs. 10, 11.

All that is known of this remarkable spatangoid, supposed to be from somewhere on the coast of Victoria, is given in the original account. That it is really a *Eupatagus* is more than doubtful, but there is no better genus to accommodate it temporarily. The holotype was at least 85 mm. long and 70 mm. wide, and the height must have been 45 mm. or more.

*Eupatagus laubei

Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 55; pl. 3, fig. 18.

The unique holotype of this apparently small species measured about 40 × 36 × 15 mm. Though the depressed form seems to ally it with the following Recent species, the tuberculation and the petals are very different. It was found in the lower part of a cliff a mile west of the mouth of the Sherbrook River, Victoria. Chapman says the strata are Lower Miocene.

Eupatagus valenciennesii

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 9.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 572; pl. 15*a*, figs. 3, 4.

This is a very characteristic endemic spatangoid which is either rare or local, for although the British Museum has 42 specimens, the Museum of Comparative Zoölogy has but 7 and these are all old material. I have not met with a specimen in my Australian collecting, nor has there been a specimen in any collection submitted to me for study. All the British Museum material is from the southeastern part of Australia, chiefly Tasmania. The recorded range is from Port Jackson to South Australia, but it is noteworthy that Verco did not find it in his extensive South Australian collecting. The largest of the British Museum specimens is 57 × 47 × 20 mm. The color ranges from brownish white to pale gray or brown.

*MICRASTER

L. Agassiz, 1835*a*. Mém. Soc. sci. nat. Neuchâtel, vol. 1, p. 184.

Genotype: Not designated. Lambert and Thiéry (1924) designate "*Spatangus coranguinum* Klein," which, being pre-Linnaean, has no validity. Agassiz and Desor (1847, p. 23) list "*Echinites coranguinum* Gmelin" (1791), "p. 3195, vars. b, c, d, e" as their first species "*cor-anguinum* Agass.," and that may therefore be accepted as the genotype.

A single species of this genus is recorded from Australia, but not from the Tertiary strata of the southeastern part of the continent. It is much older than they and even more imperfectly known.

*Micraster sweeti

Etheridge, 1892*a*. *In* Jack and Etheridge: Geol. and palaeontol. Queensland, p. 559.

A single incomplete specimen from Upper Cretaceous strata of Queensland was briefly and inadequately described with the promise that a figure would be published. The promise does not seem to have been fulfilled, nor have further specimens been discovered.

GONIMARETIA

H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 240.

Genotype: *Gonimaretia tylota* H. L. Clark, 1917, p. 241.

The distribution of this genus is interesting, for the type is from the Kei Islands region in 129–800 fms., a second species is from Western Australia in 5–30 fms., and the third is from San Clemente Island, California, in 60 fms. Of none of the species is adequate material known, but that from the Kei Island area, collected by the "Challenger," is represented by 9 specimens in the British Museum.

Gonimaretia interrupta

Lonchophorus interruptus Studer, 1880. Monatsber. K. preuss. Akad. Wissensch., p. 880; pl. 2, figs. 2–2*c*.
Gonimaretia interrupta H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 245.

This very interesting spatangoid is known from only 3 specimens: Studer's unique holotype in Berlin, about 30 mm. long; a well preserved, nonpentamerous variant in the South Australian Museum, some 26 mm. long; and a poor semifossilized, bare test, about 27 mm. long. Studer's specimen was taken in "30 fms., West Australia"; the Adelaide specimen has no locality label but there is reason to believe it is from southwestern Australia; and the third specimen we dredged in 1929, off Lagrange Bay, Western Australia, in 5–7 fms. It is thus probable that the species is endemic to Western Australia.

MARETIA

Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 48.

Genotype: *Spatangus planulatus* Lamarck, 1816, vol. 3, p. 31 = *Spatangus ovatus* Leske, 1778, p. 188.

This genus consists of a dozen or more species, of which about half are extinct. The Recent species are all Indo-Pacific, chiefly from south of 20° N. Two of them occur in Australia and 1 of the fossil species is also Australian. The 3 may be distinguished as follows:

Key to the Species of Maretia

A. Test very broad, 0.90 length or more; primary tubercles of dorsal surface very large; anterior petals short; extinct ..... *anomala*
AA. Test not so wide, about 0.80–0.85 length; primary tubercles much smaller and more numerous:

Anterior petals normally well formed, reaching nearly to ambitus; no large primary tubercles in interambulacrum 5 dorsally; Recent ..... *ovata*

Anterior petals imperfect, but posterior series of pore pairs is fairly distinguishable; large primary tubercles in interambulacrum 5 dorsally; Recent ..... *peloria*

*Maretia anomala

Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 52; pl. 4, figs. 1–4.

Comparison of Duncan's figures with those given by A. Agassiz for the following species causes one to disagree with Duncan's statement that the Australian fossil's resemblance to the following species is "perfect with the exception of the partial and extremely small fasciole." The differences in form, tuberculation, shape of anterior petals, and position of mouth are all conspicuous. Duncan's description of a supposed fasciole is brief and unsatisfactory. If a peripetalous fasciole is really present, the fossil cannot be referred to the genus *Maretia*. The only locality Duncan or Tate (1891) gives for *Maretia anomala* is the mouth of the Sherbrooke River, but Chapman (*in litt.*) says that the fossil occurs in the "Upper Oligocene of South Australia" and the "Lower Miocene of Victoria."

Maretia ovata

Spatangus ovatus Leske, 1778. Add. ad Klein, p. 188.
Maretia ovata Hamann, 1904. Bronn's Klass. Ord. Thierreichs, vol. 2, pt. 3, bk. 4, p. 1397.
Maretia planulata A. Agassiz, 1873. Rev. ech., pt. 3, p. 570; pl. 19*b*, figs. 7–12.

Widely distributed in the Indo-Pacific region from Zanzibar to the Fiji Islands, this attractive spatangoid occurs on the Australian coast from Cooktown southward to Port Jackson. As it is not known from the Torres Strait region or west thereof, it is a typical case of an echinoderm which has reached Australia around the eastern end of New Guinea. It shows considerable diversity in color (see H. L. Clark, 1925, p. 227) and is often almost handsome. Fully grown specimens are 60–70 mm. long. It is apparently gregarious and local, for the Barrier Reef Expedition found it very common at the Low Isles and northward, the "Alert" took many specimens at Flinders Island, and Paradice found it common near Port Denison, yet in all the Australian collections I have made or examined there has never been even one specimen, save those from the Barrier Reef Expedition. Melbourne Ward has, however, sent specimens to the Museum of Comparative Zoölogy from Lindeman Island, near Mackay, where he reports it as common.

Maretia peloria

H. L. Clark, 1916. "Endeavour" rept., p. 121; pl. 44, figs. 1–3.

Although this large and well marked species was fully described and figured when named, Lambert (in Lambert and Thiéry, 1924, p. 458) lists it as "espèce provisoire établie sur un pédicellaire." Apparently he ignored my original account of the species and assumed that it rested on my brief reference to the remarkable globiferous pedicellariae, figured in H. L. Clark, 1917 (p. 248; pl. 146, fig. 25). No further material has been reported since that collected by the "Endeavour."

BREYNIA

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 12.

Genotype: *Spatangus crux-andreae* Lamarck, 1816, vol. 3, p. 31 = *Spatangus australasiae* Leach, 1815, p. 68.

Although there are supposed to be 2 species in this genus, the northern one, from the Andaman Islands, is still little known, and the type is now well recognized as the typical spatangoid of Australia.

Breynia australasiae

Spatangus australasiae Leach, 1815. Zool. misc., vol. 2, fig. 68.
Breynia australasiae Gray, 1855. Cat. Recent Ech. Brit. Mus., p. 46.
A. Agassiz, 1873. Rev. ech., pt. 3, p. 578; pl. 15*a*, figs. 7–9.

From Lord Howe Island on the southeast to the Abrolhos Islands on the west, this is the common and characteristic spatangoid of tropical Australia. On the mainland coast, it does not seem to reach Port Jackson; indeed, I can find no record from south of Port Denison. Tenison-Woods, however (1878), says "Cape York to Port Jackson." On the west coast, it is sometimes found on Fremantle Beach, but apparently the Abrolhos Islands are the southern limit for the living animals. It reaches the maximum size at Lord Howe Island, where specimens 110–116 mm. long occur. In these large specimens the width of the test is 0.82–0.86 length; the height, 0.40–0.48. There is great diversity of color, the fundamental shade being gray or light brown. In young specimens, red and purple occur (see H. L. Clark, 1925, p. 228; 1938, p. 438).

LOVENIA

Agassiz and Desor, 1847. Ann. sci. nat., Zool., ser. 3, vol. 8, p. 10.

Genotype: *Lovenia hystrix* Agassiz and Desor, 1847, p. 11 = *Spatangus elongatus* Gray, 1845, p. 436.

Although based on a Recent and well marked species, this genus now includes about as many Tertiary as living forms. In Australia there is 1 very well marked and common fossil species and apparently 2 living forms on the tropical coasts. These 3 species are to be distinguished thus:

Key to the Species of Lovenia

A. Periproctal region markedly sunken into posterior end of test; test broad and flat, its width exceeding 0.75 length:
  Test highest at or anterior to apical system; 6–10 large pore pairs on each side of subanal plastron; Recent ..... *elongata*
  Test highest back of apical system; only 4 or 5 large pore pairs on each side of subanal plastron; Recent ..... *camarota*
AA. Periproctal region little or not at all sunken; test wide and flat; extinct ..... *forbesi*

Lovenia elongata

Spatangus elongatus Gray, 1845. Eyre's Jour. Expl. Australia, vol. 1, p. 436; pl. 6, figs. 2–2*b*.
Lovenia elongata Gray, 1851. Ann. Mag. Nat. Hist., ser. 2, vol. 7, p. 131.

An Indian Ocean species, this *Lovenia* occurs on the northern coast of Australia from Broome to Lindeman Island, near Mackay, Queensland. It ranges from South Africa to Aden and eastward to Misaki, Japan. Large specimens are 85–90 mm. in length. The long spines are often handsomely banded with purple and yellow, and red-violet or even brick-red coloring occurs in some cases. The colors are brightest in young specimens, and full-grown adults may be simply light brown or gray.

Lovenia camarota

H. L. Clark, 1917. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, p. 253; pl. 161, figs. 1–4.

This is an endemic species of tropical Australia, ranging only from Holothuria Bank, 34 fms., eastward to Torres Strait, 10 fms. The known specimens were taken by either the "Alert" or the "Challenger." All are relatively small, the holotype being only 53 mm. long. The colors are light gray or brown, with the primary spines unbanded.

*Lovenia forbesi

Spatangus forbesi Tenison-Woods, 1862. Geol. Obs., p. 75; fig.
Lovenia forbesi Duncan, 1877. Quart. Jour. Geol. Soc. London, vol. 33, p. 59; pl. 4, figs. 5–8.

This is one of the commonest fossils in the Tertiary rocks of southern Australia. Tate (1891, p. 278) says: "Generally distributed; in polyzoal limestone and calciferous sandstone formations of Eocene age in South Australia, Victoria and Tasmania." Most specimens are 30–40 mm. long, with the width 0.80–0.90 as much. The largest specimen in the Museum of Comparative Zoölogy is 45 × 38 × 17 mm., but another of the same width is only 38 mm. long. At the other extreme is a specimen 31 mm. long but only 25 mm. wide.

ECHINOCARDIUM

Gray, 1825. Ann. Philos., vol. 26, p. 430.

Genotype: *Spatangus pusillus* Leske, 1778, p. 166 = *Echinus cordatus* Pennant, 1777, p. 58.

Some 25 or more species are now referable to this specialized group, but only 8 are living forms and only 1 occurs in Australia.

Echinocardium cordatum

Echinus cordatus Pennant, 1777. Brit. zool., vol. 4, p. 69.
Echinocardium cordatus Gray, 1848. Brit. rad., p. 6.
A. Agassiz, 1872*a*. Rev. ech., pt. 2, p. 349; pl. 20, figs. 5–7.
Echinocardium australe Gray, 1851. Ann. Mag. Nat. Hist., ser. 2, vol. 7, p. 131.

This well-nigh cosmopolitan sea urchin is abundant on the western and southern coasts of Australia in shallow water (7–10 fms.). It is reported also from Tasmania, Port Jackson, and Flinders Island, Queensland, not to mention New Zealand. As noted in H. L. Clark, 1925 (p. 233), the specimens from the southern hemisphere attain only about half the size of those from Great Britain, rarely exceeding 45 mm. in length.

HOLOTHURIOIDEA[1]

The holothurians, often called sea cucumbers or by less elegant names, differ so much from the other classes of echinoderms, in their body form and texture, that the average person finds it hard to believe they are really closely related to sea stars or sea urchins. A few species are bright-colored or have some beauty of form, but the great majority are dull-colored and unattractive and some are undoubtedly repulsive. They are nevertheless an interesting group and amply repay observation and study. They are a common feature of marine life on the coasts of Australia, more particularly in the tropics, but owing to the absence of anything like a shell or firm skeleton, they are usually ignored by the average collector. For the same reason, they are ill adapted for preservation as fossils, and only one extinct species is yet known from Australia. In both Europe and America, micropaleontologists have discovered and figured a considerable number of calcareous spicules of varied form which can be referred with some accuracy to certain genera of holothurians, but only one observation of this sort has as yet been made in Australia (see *Chiridota ingens,* p. 458).

The holothurians are the least-known class of echinoderms, the difficulties in the way of preserving them well in museums, and the notable unattractiveness of the preserved specimens, being serious handicaps. As a result, it is probable that more undescribed species remain to be discovered than in any other class of the phylum. In Australia, the littoral forms are now pretty well known, so that the percentage of Australian holothurians to the whole number of known species is about as high as in the echini. But the total number of known species is undoubtedly nearer the number of existing species among echini than among holothurians.

The classification of holothurians is still unsatisfactory in all details. Though the 5 orders commonly recognized are fairly well defined and almost universally accepted, their subdivision is not yet agreed upon. The calcareous ring around the esophagus and the calcareous particles in the body wall afford characters of great importance for distinguishing species and even genera, but they are subject to growth changes and senescence, not to mention considerable individual diversity, probably associated with differences in the sea water or other environmental factors. The appendages, both tentacles and those of the body wall (pedicels and papillae), are subject to marked changes in form and often in number with increasing maturity and again with senescence. As all the appendages and the body wall itself are capable of extraordinary extension and

[1] In the preparation of this section of the present volume, I am under great obligations to Dr. Elisabeth Deichmann, whose exceptional knowledge of the class has been freely drawn upon to help solve the numerous problems presented. I extend to her herewith my sincerest thanks.

contraction, preserved specimens show a great deal of diversity in size and form, even though in life they may have been of very similar appearance.

The holothurians are the only echinoderms which have any direct economic value, barring a few echini whose gonads are used, when fresh, for food in several widely separated areas. The injury done by sea stars to oyster beds in the northern hemisphere is on the other side of the ledger. Long ago the Chinese, and possibly other Orientals, discovered that palatable and perhaps nourishing soups could be made from the body wall of many of the larger species of holothurians, when properly prepared. This preparation consists in eviscerating and briefly boiling the animals, then spreading them open and smoking them over a wood fire (mangrove preferred) for 24 hours or until they are thoroughly dry. They are then quite hard, the better grades being as hard as, and much like, dry glue. For an account of the Torres Strait industry and traffic in these smoked holothurians, known to the trade as "bêche-de-mer" or "trepang" (a Malay name), see H. L. Clark, 1921, pages 156–158. When we were in Torres Strait in 1913, the traffic with China in bêche-de-mer was flourishing, and many thousands of pounds were exported annually from Thursday Island, the best grades bringing as much as three shillings a pound. The first World War seriously hurt this traffic, but subsequently the Chinese demand exhausted the supply that was easily accessible in the Torres Strait region, and there is little doubt that the traffic can only be restored to its former importance by governmental action and careful supervision.

In their habits and habitats, holothurians show less diversity than the more active brittle stars and sea stars. They are more like the echini, which are equally sluggish. The largest holothurians, which may be nearly a meter long (and extensile beyond that), and (in less extensile forms) 100–125 mm. in transverse diameter, live more or less exposed on the sea bottom, particularly on open areas near or among rocks and coral heads. Smaller species also live in the open, especially on eelgrass areas or among rock fragments. Still smaller forms, and some species 150 mm. long, live under rock fragments or among dead coral, often burying themselves deep in the sand and withdrawing out of sight when disturbed. A few of the small species live on horny corals or in sponges, sometimes in great numbers, but most of the species under 50 mm. long live buried in the sand or mud, and some are extremely difficult to collect. Various small species, less than 35 mm. long, live closely appressed to the lower surface of rock fragments or large dead shells, and others live concealed in patches of coralline algae. Some of these latter may be quite gregarious. Elongated, slender forms with very thin body walls often live like worms in tubes in the mud or sand, and a number of larger but very thin-walled species live buried in soft mud. The colors are mostly brown or gray of some shade, or white, sometimes with bright red or bright yellow areas or markings. Some

species, however, are handsomely colored, usually with shades of red or yellow or both. Mottled, blotched, and variegated forms are common, but unicolored species are not rare. Some are so dark as to appear quite black; others are very dark green or purple. The tentacles are frequently in contrast with the body color, as black where the body is for the most part brown, or cream-colored when the animal itself is black.

The 4 orders of holothurians occurring in Australia are represented by 158 species, grouped in only 41 genera of 8 families. The classification is based on the character of the tentacles, the number and arrangement of the appendages, and the body form. There are also important internal structural differences which, though less convenient for a key, are of fundamental importance. Within the orders, the families are based on body form and characters of various internal organs. Genera are based for the most part on the tentacles, pedicels, papillae, and external details, but the calcareous ring and the spicules are also important. Species are distinguishable for the most part only by the microscopic calcareous particles in the body wall. As a consequence, identification is almost hopeless if the specimen has been killed or preserved in a fluid at all acid. Formalin not only damages the calcareous particles, but tends to swell and distort the tissues. It should never be used as a killing agent or preservative for holothurians.

Key to the Orders of Holothurioidea

A. Pedicels and papillae present:
  Tentacles dendritic; retractor muscles present ..... Dendrochirota
  Tentacles peltate or peltato-digitate; retractor muscles wanting ..... Aspidochirota
AA. Pedicels and papillae wanting:
  Body relatively short and plump, usually with an evident caudal part; respiratory trees present ..... Molpadonia
  Body slender, usually elongated, often vermiform; no respiratory trees ..... Apoda

Order DENDROCHIROTA

This order includes more Australian holothurians than any of the others, but the Aspidochirota are a close second. Indeed, in the Torres Strait region there are twice as many aspidochirotes as dendrochirotes, and at Lord Howe Island only one dendrochirote was found. But at Broome there were 28 dendrochirotes and only 10 aspidochirotes, and farther southwest there were 10 and 4 respectively. Obviously the dendrochirotes are strikingly predominant in Western Australia. The species of this order are easily grouped in 2 families, distinguished by the body form. No doubt a more extended knowledge will justify the recognition of additional families.

Body more or less cylindrical, not flattened ventrally into a creeping sole ..... Cucumariidae
Body broad, flattened, ventral surface a well defined, thin-walled creeping sole ..... Psolidae

Family CUCUMARIIDAE

Nearly all dendrochirotes are grouped in this family, but we are only beginning to understand their interrelationships, and it is quite possible that at least 2 families are confused here, perhaps more. The Australian species are now arranged in 17 genera, but the lines between them are not too clear, and young individuals are often hard to place. The number of tentacles seems to be the most obvious character and may well serve as the starting point for a key to the genera.

Key to the Genera of Cucumariidae

A. Tentacles 10:
- B. Pedicels (or papillae) confined to ambulacra, at least on ventral surface:
  - C. Dorsal appendages mostly developed as pedicels; at least ventrally, pedicels may be confined to ambulacra:
    - Body not elongated and more or less curved, not pentagonal, not encased in firm body wall ..... *Cucumaria*
    - Body elongated, curved, pentagonal, encased in firm body wall ..... *Leptopentacta*
  - CC. Dorsal appendages mostly developed as papillae or tubercles (sometimes wanting); pedicels on ventral ambulacra:
    - Body wall more or less rigid, with calcareous deposits ..... *Pentacta*
    - Body wall with little calcareous matter; body short and stout in adults ..... *Pseudocolochirus*
- BB. Pedicels or papillae not confined to ambulacra, at least on ventral surface:
  - D. Body wall firm with crowded deposits, without conspicuous papillae or tubercles save for a series of large, pointed tubercles along each side; pedicels very numerous all over body ..... *Apentacta*
  - DD. Not as above:
    - E. Body wall hard with crowded deposits, covered all over with numerous rounded, hard, white calcareous tubercles, each perforated by a pedicel ..... *Acolochirus*
    - EE. Not as above:
      - F. Body quadrangular; pedicels crowded ventrally; double series of tubercles and many pedicels dorsally; body wall not hard with crowded deposits, but with small tables having 2 rods in spire, and disk with few perforations ..... *Pentathyone*
      - FF. Not as above:
        - G. Calcareous ring of 10 distinct loosely united pieces with no posterior prolongations; no calcareous particles in body wall ..... *Orbithyone*
        - GG. Not as above:
          - Calcareous particles usually not abundant, consisting of stout cruciform plates and more or less numerous minute rosettes, with or without slender rods ..... *Staurothyone*
          - Not as above ..... *Thyone*

AA. Tentacles more than 10, usually 20:
H. Pedicels confined to ambulacra in youth, but tending with growth to extend into interambulacra:
K. Papillae in dorsal interradii; 20 tentacles ..... *Actinocucumis*
KK. No papillae in dorsal interradii; usually more than 20 tentacles in adults:
L. Chief calcareous particles big lenticular plates covered with low, sharp points ..... *Discucumaria*
LL. No such plates:
Chief calcareous particles slender acicular rods, sharp at one end, wide and perforated at other ..... *Pseudocucumis*
Chief calcareous particles more or less developed tables ..... *Mensamaria*
HH. Pedicels more or less distributed over whole body:
M. Calcareous particles more or less abundant in body wall:
Calcareous particles tables, more or less incomplete or reduced, though stout, with or without rosettes ..... *Phyllophorus*
Calcareous particles rods, more or less enlarged and either perforate or spinous at one end; tables may also be present ..... *Urodemas*
MM. Calcareous particles in body wall practically wanting ..... *Lipotrapeza*

CUCUMARIA

de Blainville, 1830. Dict. sci. nat., vol. 60, pp. 173, 176.

Genotype: *Holothuria pentactes* Gmelin, 1791, p. 3139.

Scores of species have been placed in this genus, and many suggestions have been made toward segregating them in smaller groups, but no really serious and careful study has yet been made of the heterogeneous assemblage. It is world-wide in its distribution, but is represented in Australia by only about half a dozen species, of which 4 are found on the southern coasts and 2 in the tropics. All but 1 are small, 50–60 mm. or less in length. All are dull-colored, but 1 or 2 show an interesting contrast between the ambulacra and the interambulacral spaces. The 6 species may be distinguished by characteristic calcareous deposits in the body wall. Ekman (1918, p. 42) gives figures (pl. 4, fig. 35) of calcareous particles from a small holothurian which he calls "Cucumaria sp. juv." This is quite as likely a young *Thyone,* as it is only 8 mm. long.

Key to the Species of Cucumaria

A. Chief spicules in form of tables:
B. Tables with 10–12 holes in base and only 2 short rods for spire ..... *mirabilis*
BB. Tables with long, narrow base with few holes, and high, tapering, 2-pointed spire:
Accessory spicules irregular plates with 8–10 holes of unequal size ..... *striata*
Accessory spicules regular, elliptical or more or less circular plates with about 4 holes of considerable size ..... *bicolor*
AA. Chief spicules not in form of tables:
Spicules ellipsoidal frames of smooth curved rods ..... *semperi*
Spicules delicate, spinous baskets overlying thick perforated plates ..... *squamatoides*
Spicules flat, rather delicate perforated plates, of diverse sizes, few and scattered ..... *adela*

Cucumaria mirabilis

Théel, 1886. "Challenger" Hol., p. 61; pl. 9, figs. 5*a–f*.

This little holothurian was described from a single specimen, 12 mm. long, taken at Cebu, Philippine Islands, in 100 fms., and confirmed by a second specimen from Port Jackson, New South Wales, 6–15 fms., in which the length was only a trifle more. The "Thetis" took 2 specimens from off Cape Three Points, New South Wales, in 41–50 fms. No data were published in connection with the "Thetis" specimens, presumably because they threw no new light on the species. Deichmann thinks the species is invalid, based on young Thyones.

Cucumaria striata

Joshua and Creed, 1915. Trans. Roy. Soc. S. Australia, vol. 39, p. 18; pl. 3, figs. 2*a–d*.

The 2 specimens on which this species is based were collected in 1888 in the Great Australian Bight by W. J. Howard, and are in the South Australian Museum. They are about 25 mm. long and 12 mm. in diameter. The interradial areas are smoky black, and the ambulacra dirty white. No additional specimens have as yet been taken. The resemblance to the following species in color is notable, but the calcareous particles are obviously different. The improbability that the same species occurs in the Bight and in King Sound is so great, it would be unwise to treat *striata* as a synonym of *bicolor*. Deichmann thinks the former may be identical with *Pseudocucumis intercedens* Lampert. Though this is possible, it does not seem to me probable.

Cucumaria bicolor

Bell, 1887*a*. Proc. Zool. Soc. London, p. 532; pl. 45, fig. 2.

The 2 specimens on which this species is based are said to be from King Sound, Western Australia. They were 36 × 20 mm. and 25 × 12. The interambulacra were chocolate or black, the ambulacra quite white. The calcareous particles were relatively few, but if Bell's figures are to be trusted they were different from those of *striata*.

Cucumaria semperi

Bell, 1884. "Alert" rept., p. 147; pl. 9, fig. A.

This species was originally described from Port Denison, Queensland, and from Torres Strait. Vaney (1912) records it without comment from the Aru Islands. It is not a typical *Cucumaria,* but might well be made the type of a distinct genus. It proves to be common at Broome, where it grows to be 45–50 mm. long. In some individuals the body curves upward at each end, but this is not the rule. Most of our specimens were dredged in about 7 fms., but some were found in shallow water, and the largest was in a tide pool, above low-water mark. Small specimens are light brown or whitish with tentacles and pedicels purplish, but large specimens are dull flesh red or reddish white with long pedicels dusky or purplish black.

Cucumaria squamatoides, nom. nov.

Cucumaria squamata Joshua and Creed, 1915. Trans. Roy. Soc. S. Australia, vol. 39, p. 17 (NON Ludwig, 1898, p. 27).

Deichmann has given me the following notes on this species, to which I fully subscribe: "From what we know about the restricted distribution of the majority of the cucumariids, one can be almost positive that Joshua and Creed have erred in referring a single specimen from Encounter Bay, South Australia, to Ludwig's species from Kerguelen. We must assume that the specimen which Joshua and Creed examined agrees at least roughly with Ludwig's description and that such a holothurian does occur in South Australia, but critical study would undoubtedly reveal very definite differences from Ludwig's species. As the Australian writers give no hint as to the size, color, or general character of their specimen, it remains for some future investigator to point out the real differences between this type, which is presumably in the South Australian Museum, and the description and figures of *squamata*."

Cucumaria adela,[1] nom. nov.

Cucumaria japonica Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 39; pl. 4, figs. 32–34 (NON Semper, 1868, p. 236).

Deichmann has called my attention to the fact that this holothurian, 97 mm. long and exceptionally stout, collected by Mjöberg 45 miles southwest of Cape Jaubert, Western Australia, in 11 fms., cannot be properly referred to Semper's Japanese species, but almost surely represents an undescribed form. As Ekman has given a full description and several figures, no further account need be given here, but a new name is of course necessary, and is herewith suggested.

LEPTOPENTACTA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 453.

Genotype: *Leptopentacta grisea* H. L. Clark, 1938, p. 453.

This is a small group of possibly half a dozen species occurring in the East Indian region, 1 of which is a member of the Australian fauna. They are easily distinguished by the slender, pentagonal, more or less curved form, with its firm body wall.

Leptopentacta grisea

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 453; fig. 37.

This is one of the most easily recognized of the holothurians occurring at Broome. It was not taken elsewhere, presumably because no other mud flat was so diligently searched as the one around the jetty in Roebuck Bay. Full-grown specimens are 75 mm. in length and 7 or 8 mm. in diameter. They are notably inert, and no movements were ever noted. The color is the same as that of the sandy mud in which they live: gray, with the ventral side of the middle of the body white or

[1] ἄδηλος = uncertain, since the status of this species is doubtful.

whitish. The animal is so rigidly curved that the mouth and anus are at the surface of the mud at the same time, and apparently are but very slightly contractile, save to close the openings.

PENTACTA

Goldfuss, 1820. Handbuch der Zool., pt. 1, p. 177.

Genotype: *Actinia doliolum* Pallas, 1766, p. 152.

This is a characteristic group of holothurians, widely distributed and ill defined, long recognized under the later name *Colochirus*. It is particularly characteristic of the tropical coasts of Australia, and more than a dozen species have been recorded from the continent. Ekman (1918) has given a careful account of the material brought back from northwestern Australia by Mjöberg in 1913, listing 8 species, all from shallow water, 45 miles southwest of Cape Jaubert, which is about 80 miles southwest of Broome. One of his 8 species (also taken at Broome) is now assigned to *Pseudocolochirus,* and 2 others are described as new. During my two visits to Broome, we collected scores of Pentactas and examined many more, but there did not seem to be more than 4 species living in the region. One of the most common is *tuberculosa,* which Erwe (1913) records from Port Hedland and Shark Bay, but Ekman does not include it among the species from Cape Jaubert. Evidently Ekman's and my identifications are not consistent, and this fact illustrates how imperfect our knowledge is of the specific characters and limits in the genus. After prolonged study, it seems best to remove 2 species from the Australian list, making each the type of a new genus, since they are very different and cannot be treated as Pentactas without making the definition of the genus too vague and unsatisfactory. There remain, however, 11 nominal Pentactas, and the making of an accurate, reliable key is a hopeless task. The following is offered merely as a starting point from which a satisfactory arrangement may ultimately be worked out. Meanwhile, reference to the descriptions and figures of Selenka, Semper, Théel, Ekman, and Erwe will be necessary.

Key to the Species of Pentacta

(Note: In this key, *australis* appears twice)

A. Conspicuous dorsal papillae, at least along angles of more or less quadrangular body:
  B. Dorsal papillae in more or less evident longitudinal series on ambulacra:
    C. Pedicels numerous (4–8 longitudinal series) in each ventral ambulacrum:
      Dorsolateral papillae long and tapering ..... *quadrangularis*
      Dorsolateral papillae short and blunt ..... *jagorii*
  CC. Pedicels in only 1–3 series in each ventral ambulacrum:
      Calcareous "baskets" in skin, of 1 kind, about 0.06 mm. across ..... *australis*
      Baskets of 2 sorts, smaller about 0.05 mm. across, larger about 0.09 mm. ..... *minuta*
  BB. Dorsal papillae irregularly scattered on both ambulacra and interambulacra:
    D. Very large, heavy, reticulate spheroids in dermis ..... *robustoides*

DD. No such bodies present:
E. Small baskets shallow or reduced to plates, but with knobs of more or less considerable size:
Baskets stout, nearly as wide as long, with large knobs ..... *crassa*
Baskets rather delicate, often much longer than wide, even reduced to plates, with small knobs ..... *robusta*
EE. Small baskets deep and without knobs:
Large flattened, reticulate, spheroidal or ellipsoidal bodies present ..... *cucumis*
No such bodies present ..... *tuberculosa*
AA. No conspicuous dorsal papillae:
Body elongated, smooth, tapering posteriorly ..... *dispar*
Body quadrangular, sides and back uneven and lumpy ..... *trimorpha*
Body quadrangular, not uneven and lumpy ..... *australis*

Pentacta quadrangularis

Colochirus quadrangularis Troschel, 1846. Arch. f. Naturgesch., vol. 12, no. 1, p. 64 (NON *Holothuria quadrangularis* Lesson, 1830, p. 90).
Colochirus coeruleus Semper, 1868. Holothurien, p. 59; pl. 11, fig. 1 (colored); pl. 13, fig. 18.
Pentacta coerulea H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 227.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 449; pl. 16, fig. 4 (colored).

Ekman (1918) pointed out that Lesson's *quadrangularis* is an aspidote holothurian and hence could not be a *Colochirus,* but he ignored or overlooked Troschel's (1846) recognition of that fact and his deliberate use of the same name for a *Colochirus.* Misled by Ekman, I (1932) adopted Semper's name, *coerulea,* for this common dendrochirote holothurian, which should of course bear the appropriate name Troschel gave it. A *Holothuria quadrangularis* does not invalidate a *Colochirus quadrangularis.*

This is one of the commonest holothurians of northwestern Australia, ranging south on the west coast to Albany. East of long. 125° E. it seems to be rare, but the Great Barrier Reef Expedition found it on the Queensland coast, and it is difficult to account for its apparent absence at the Murray Islands and in Torres Strait. It is well known from the East Indies. Large specimens exceed 100 mm. in length, the width and height of the more or less quadrangular body being one-fifth or even one-fourth as much. The diversity of color is great, and many individuals are very handsome; compare Semper's and my colored figures. An extreme case of bright red coloring was found at Broome, and as the brilliant shade was associated with certain peculiarities of form and tuberculation, it seemed desirable to regard it as a namable variety; accordingly it was designated in H. L. Clark, 1938 (p. 451; pl. 16, fig. 5, colored) as *Pentacta coerulea* var. *rubra,* which should be designated henceforth as *Pentacta quadrangularis* var. *rubra.*

Pentacta jagorii

Colochirus jagorii Semper, 1868. Holothurien, p. 60.
Pentacta jagorii H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 228.

The inclusion of this dubious species in the Australian fauna on the basis of a single small specimen collected by the Great Barrier Reef Expedition is necessary,

but until adequate material is obtained, it is very doubtful whether *jagorii* is a valid species, and whether the Barrier Reef specimen is *jagorii*. In my discussion of the Australian specimen, I assert that Théel's opinion that *jagorii* is identical with *quadrangularis* does not seem "probable," but I do not designate clearly a single feature by which the two may be distinguished. The character of the dorsolateral papillae is doubtless subject to much individual diversity.

Pentacta australis

Colochirus australis Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 88.
Colochirus doliolum Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 351; pl. 5, figs. 1*a–b*.
Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 29; pl. 2, figs. 2, 3; pl. 3, figs. 20–22.
Pentacta australis H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 229.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 445.

This is a very common holothurian on many parts of the Australian coast, and may apparently be expected anywhere, though it has not yet been taken at Lord Howe Island, the Murray Islands, or Darwin. Typical specimens are 50–65 mm. long when adult, and are usually gray of some shade. The dorsal papillae may be very inconspicuous, especially in small specimens; hence the occurrence of *australis* twice in the key (p. 390). For a detailed discussion, see H. L. Clark, 1938, pages 445–449.

Pentacta minuta

Colochirus minutus Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 89; pl. 6, fig. 16.
Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 356; pl. 5, figs. 4*a–d*.
Pentacta minuta H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 229.

This species, of which described specimens range from 20 to 70 mm., is very imperfectly known. The type locality is Bowen, Queensland, and the Great Barrier Reef Expedition took it at two of their dredging stations. Ekman (1918) does not list it, but Erwe (1913) reports it, surprisingly enough, from Albany, Western Australia. I have not met with it at any of my collecting stations. Its validity as a species and its relationships within the genus cannot be determined without critical study of much more and better material.

Pentacta robustoides

Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 18; pl. 1, figs. 5, 6; pl. 3, figs. 10–12.

Ekman reports 4 specimens, 37–72 mm. long, taken by Mjöberg, in 18 fms., 45 miles west-southwest of Cape Jaubert, Western Australia. His account and figures are detailed, but the validity of the species needs verification by additional material. None of the scores of Pentactas taken at Broome have as yet been identified as *robustoides*, but many specimens have not had the calcareous particles critically examined. They are apparently *quadrangularis, crassa,* or *tuberculosa,* when not the obviously different *australis*.

Pentacta crassa

Colochirus crassus Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 6; pl. 1, figs. 1–4; pl. 3, figs. 1–7.
Pentacta crassa H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 451; pl. 16, fig. 1 (colored).

This is the largest of the Pentactas found on the northwest coast, reaching a length of 145 mm. It is not very common; Mjöberg collected 4 specimens and we took only 8. The dull coloration, gray becoming more or less salmon red ventrally, makes the very inert animal inconspicuous. No specimens have yet been reported outside the Broome region.

Pentacta robusta

Colochirus robustus Östergren, 1898*a*. Zool. Anz., vol. 21, no. 552, p. 134.
Colochirus squamatus Sluiter, 1901. "Siboga" Hol., p. 101; pl. 8, fig. 3, no. 6.
Colochirus robustus Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 14; pl. 3, figs. 8, 9.

It is with no little hesitation that I include this *Pentacta* in the Australian fauna. Only my respect for Ekman's work induces me to accept his identification of a holothurian from southwest of Cape Jaubert with Östergren's species from Korea. His belief that Sluiter's East Indian species is the same as Östergren's is also hard for me to accept. The Cape Jaubert specimen, which is 51 mm. long, may be identical with Sluiter's from the East Indies, but even this needs verification.

Pentacta cucumis

Colochirus cucumis Semper, 1868. Holothurien, p. 58; pl. 13, fig. 17; pl. 14, fig. 16.
Pentacta cucumis H. L. Clark, 1921. Ech. Torres Strait, p. 171.

Sluiter (1894) identified one of the holothurians collected by Semon in Torres Strait as *cucumis,* and I (1932) have called a specimen collected by the Great Barrier Reef Expedition at their station 16 by the same name. On this very uncertain basis, the species is here included in the fauna of Australia.

Pentacta tuberculosa

Holothuria tuberculosa Quoy and Gaimard, 1833. Voy. "Astrolabe," vol. 4, p. 131.
Colochirus tuberculosus Semper, 1868. Holothurien, p. 239.
Colochirus anceps Semper, 1868. Holothurien, p. 57; pl. 12, fig. 1 (colored).
Pentacta tuberculosus H. L. Clark, 1921. Ech. Torres Strait, p. 171.
Pentacta tuberculosa H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 230.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 452; pl. 16, fig. 2 (colored).

This is one of the commonest species of the genus, ranging from southern Japan throughout the East Indian region to Port Jackson, New South Wales. On the tropical coasts of Australia, it is found from northern Queensland westward to Shark Bay. It is one of the common holothurians at Broome, occurring with *P. crassa* around the timbers of the jetty, but easily distinguished by its bright red and yellow colors. Full-grown specimens exceed 100 mm. in length. It is odd that Ekman (1918) did not find *tuberculosa* among the holothurians collected southwest of Cape Jaubert by Mjöberg, where 7 species of *Pentacta* were taken.

Pentacta dispar

Colochirus dispar Lampert, 1889. "Gazelle" Hol., p. 820.
Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 32; pl. 3, fig. 25; pl. 4, fig. 26.

Lampert's material consisted of 3 specimens, 42–50 mm. long, from Mermaid Strait on the northwestern coast of Australia. Ekman had a single specimen 45 mm. long from southwest of Cape Jaubert, some 300 miles east of Mermaid Strait. No further specimens have been reported. Possibly *dispar* is only a form of *australis*.

Pentacta trimorpha

H. L. Clark, 1921. Ech. Torres Strait, p. 171; pl. 37, figs. 1–8.

This species rests on a single small specimen, only 10 mm. long, taken at the Murray Islands in 1913. The color in life was purplish brown, the tentacles much darker. The calcareous particles seem to be distinctive, but of course a single specimen proves nothing.

PSEUDOCOLOCHIRUS

Pearson, 1910. Proc. Zool. Soc. London, p. 172.

Genotype: *Colochirus violaceus* Théel, 1886, p. 78.

So few holothurians referable to this genus have yet been taken, and their distribution is so scattered, it is by no means certain whether there are 4 species as now listed, or only 2. There is no doubt, however, that 1 occurs on the northwestern coast of Australia.

Pseudocolochirus axiologus

Colochirus axiologus H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 171; pl. 25.
Pseudocolochirus axiologus H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 456.

The types of this extraordinary holothurian were taken at Port Hedland, Western Australia, and are in the Perth Museum, but additional material taken by Mjöberg at Cape Jaubert and Broome and carefully described by Ekman (1918, p. 26; pl. 2, fig. 1; pl. 3, figs. 16–19) contributed much to our knowledge. In 1932, 3 additional specimens, 1 of which was a huge adult, were taken at Pender Bay, northeast of Broome, and the following year Bardwell took 3 specimens still farther east, at Augustus Island. Owing to the peculiar shape of the animal, the length along the mid-ventral ambulacrum is 2.5–3 times the length of the mid-dorsal interambulacrum. In life the largest specimen was 125 mm. dorsally, but 325 mm. ventrally. Preservation in alcohol, however, caused a shrinkage to 75 and 150 mm. respectively. The coloring in life is surprisingly bright for a holothurian: yellow, blue (on interambulacra), and bright red (on ambulacra). The tentacles are white, brown, and orange. Preserved specimens are rose-purple, dull purplish gray, violet, reddish, or yellowish buff, giving little indication of the brilliant colors of the living animal.

in aquarium Green Sp. Aug. 1968. (photo. keeper 9/38)

APENTACTA, gen. nov.

Body form intermediate between *Pentacta* and *Thyone,* resembling the former in the 5 oral valves, but lacking the firm body wall with its 3 characteristic layers of calcareous deposits and its tendency to a quadrangular form. The resemblance to *Thyone* is in the pliable body wall, with numerous pedicels all over the body, not in longitudinal series. From both genera, *Apentacta* differs in the presence of a longitudinal series of 3–7 or more conical, more or less calcareous processes on each side of the body.

Genotype: *Holothuria spinosa* Quoy and Gaimard, 1833, p. 118.

In order that the line between *Pentacta* and *Thyone* may be definitely drawn, the curious, endemic holothurian discovered by the "Astrolabe" at Port Jackson must be placed in a genus by itself. Monotypic genera are often a nuisance, but certainly cannot always be avoided.

Apentacta spinosa

Holothuria spinosa Quoy and Gaimard, 1833. Voy. "Astrolabe," vol. 4, p. 118; Zoophytes, pl. 7, figs. 1–10.
Colochirus spinosus Selenka, 1868. Ztschr. f. wissensch. Zool., vol. 18, p. 117.
Théel, 1886. "Challenger" Hol., p. 76; pl. 6, fig. 12; pl. 14, figs. 3, 4.
Stereoderma validum Bell, 1884. "Alert" rept., p. 150; pl. 9, figs. E*a–f*.

This interesting holothurian is well known from Port Jackson and the neighboring coast to the north, but does not seem to have been taken elsewhere in Australia, save for Joshua's report (1914) of 5 specimens in the National Museum of Melbourne, supposed to be from "Victorian waters." In 1915, Joshua kindly presented to the Museum of Comparative Zoölogy a small holothurian taken at Point Cooke, Victoria, which he had labeled *Colochirus spinosus.* As it is only 12 mm. long, and strongly contracted, its identity is very doubtful. Bell reports his *Stereoderma validum* as from "China" and from "between Balls Head and Goat Island." It will be an interesting fact if the species is really confined to the vicinity of Port Jackson. It is a small form, 50–80 mm. long, and the color, as shown by Quoy and Gaimard, is dull gray (beneath?) and reddish.

ACOLOCHIRUS, gen. nov.

Body elongate, quadrangular, with 5 oral valves at anterior end. Body wall hard, leathery, almost inflexible (in preserved specimens), covered with numerous small, rounded, white, hard, calcareous protuberances, each penetrated by a minute retractile pedicel. Ventral pedicels not in defined series, except on mid-ventral radius.

Genotype: *Colochirus challengeri* Théel, 1886, p. 80.

As in the case of *Apentacta,* it has been necessary to establish a separate genus for this peculiar holothurian, in order to give definite limits to *Pentacta* and *Thyone.* It is endemic in tropical Australia and has no near allies.

Acolochirus challengeri

Colochirus challengeri Théel, 1886. "Challenger" Hol., p. 80; pl. 6, fig. 11; pl. 14, figs. 1, 2.

Although Théel considered this holothurian nearly related to the preceding (*spinosus*), the differences are so obvious and striking, they can hardly be denied. The "Challenger" took 3 specimens in 8 fms. in Torres Strait, and the "Siboga" took 1 large specimen in 31 fms. near the Aru Islands. Preserved specimens are dark brownish gray with lighter bands along the ambulacra. The size is notably large, 150 mm. from mouth to anus.

PENTATHYONE

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 458.

Genotype: *Thyone mirabilis* Ludwig, 1874, p. 93.

This is a monotypic genus also, but very different from either of the preceding, as the body wall contains relatively little calcareous matter.

Pentathyone mirabilis

Thyone mirabilis Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 93; pl. 6, fig. 18.
Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 362; pl. 5, fig. 8.
Cucumaria areolata Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 35.
Pentathyone mirabilis H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 459; pl. 16, fig. 3 (colored).

This well marked species is common on the tropical coast of Australia from Port Curtis, Queensland to Shark Bay, Western Australia. In life, large specimens exceed 100 mm. in length, but they are only 60–80 mm. when preserved. There is very great diversity of color, but adults are commonly brown of some shade, with the tips of the papillae bright red. For more details see H. L. Clark, 1938, pages 458–461.

ORBITHYONE

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 473.

Genotype: *Orbithyone megapodia* H. L. Clark, 1938, p. 473.

Still another monotypic genus is this, and based on a single specimen. But the characters are so well marked, it would be too bad to include the specimen in any known species or genus.

Orbithyone megapodia

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 473 (not figured).

The single specimen on which this species is based was collected at Broome, on a muddy bottom in 5–7 fms., in June 1932. It is only about 15 mm. long and 7 mm. in diameter. The pedicels are very large and numerous, with large end plates, but there are no supporting rods, nor are there calcareous particles in the body wall. On the other hand, the tentacles are richly supplied with rods both large and small.

STAUROTHYONE

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 474.

Genotype: *Staurothyone distincta* H. L. Clark, 1938, p. 475.

Five species are referred to this genus, of which 3 are from Australia. A fourth (*Thyone sargassi* Lampert) is known only from a single specimen, found floating in *Sargassum,* off northwestern Australia just outside the artificial limits of this work. As material in the genus is scanty and widely scattered, there is no certainty that more than 3 species exist. The Australian forms are distinguished by their calcareous particles, thus:

Key to the Species of Staurothyone

A. Cruciform particles longer than wide, terminal branches not rounded at tips:
  Cruciform particles with no vertical thorns rising from surface; associated with numerous slender rods and rosettes ..... *inconspicua*
  Cruciform particles with vertical thorns rising near corners; not associated with slender rods, but rosettes occur ..... *vercoi*
AA. Cruciform bodies large, as wide as long, terminal branches rounded at tips ..... *distincta*

Staurothyone inconspicua

Cucumaria inconspicua Bell, 1887. Proc. Zool. Soc. London, p. 532; pl. 45, fig. 3.
Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 3.
Staurothyone inconspicua H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 475.

Bell's specimens, averaging 17×6 mm., came from Port Phillip Heads, Victoria, but Joshua (1914) reports numerous specimens from Flinders. The following year he and Creed reported 3 specimens in the South Australian Museum taken by Verco, presumably in St. Vincent Gulf. Joshua thinks the species is very close to the Chilean species *Cucumaria parva* Ludwig, but the latter does not seem to be a *Staurothyone.* It is nevertheless interesting to note that both species have a brood-sheltering habit. Joshua refers to *inconspicua* as "little," but he gives no information as to size, color, or structure. Bell's account of the calcareous ring is vague and unsatisfactory; the word "fine" occurring in it is probably a misprint for "five." Apparently, however, it is the ring of a *Staurothyone.* Thanks to Joshua's generous kindness, there are specimens of *inconspicua* in the Museum of Comparative Zoölogy, and dissection of one shows that the calcareous ring is similar to that of *Staurothyone distincta.*

Staurothyone vercoi

Thyone vercoi Joshua and Creed, 1915. Trans. Roy. Soc. S. Australia, vol. 39, p. 19; pl. 2, figs. 2–4; pl. 3, figs. 1, 4.

Only a single specimen of this perplexing form is known. It was collected by Verco and hence probably came from St. Vincent Gulf. It is 36 mm. long, thickly covered with pedicels not arranged in rows, but perhaps less numerous dorsally. The calcareous ring is stout, the radial pieces prolonged posteriorly. The tentacles are

10 in number, the dorsal 2½ times as long as the ventral. The calcareous particles are minute cruciform bodies with small vertical spines, and a few rosettes. Numerous "digitiform bodies" crowded full of rosettes are dependent on the inner surface of the anterior part of the pharynx. These may be pathological. Thanks to the kindness of Joshua, beautifully prepared slides, one showing the cruciform bodies, and one, several of the pharyngeal appendages, are in the Museum of Comparative Zoölogy collection. They leave little room for doubt as to the validity of the species, but it is probably not a *Staurothyone*. Deichmann thinks it is identical with *Lipotrapeza vestiens*.

Staurothyone distincta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 475; figs. 44*a–c*.

Although only 2 specimens of this holothurian were taken, its distinctiveness is outstanding. The smaller specimen was 25 mm. long, the larger 40. The latter had evident anal teeth; in the former they were not visibly developed. In the smaller specimen the tips of the pedicels are dark brown, in marked contrast with the gray-brown body wall, but in the larger the tips are yellowish brown, in very little contrast with the body color. Both specimens were taken at Broome in 1932.

THYONE

Oken, 1815. Lehrb. Naturgesch., pt. 3, p. 351.

Genotype: *Holothuria fusus* O. F. Müller, 1776, p. 232.

This is a large and heterogeneous group badly in need of a careful revision. Its representatives occur in all parts of the world, with rather more than a dozen in Australia. As a rule, they live on muddy or sandy bottoms, but some species are associated with rocks or corals. The species are for the most part small, in only a few cases exceeding 100 mm. in length. The color ranges from white to almost black but is never notable in any way. The Australian forms show considerable diversity, but the validity of some is still open to question. At present, they are distinguishable as follows:

Key to the Species of Thyone

A. Calcareous particles more or less abundant in body wall:
  B. Calcareous particles very numerous, skin crowded with very small plates, mostly smooth and flat with 2–30 perforations, but some thick, prickly, and without perforations ..... *perissa*
  BB. Calcareous particles not as above:
    C. Calcareous ring with more or less elongated and jointed posterior prolongations on radial pieces:
      D. Calcareous particles more or less well formed tables:
        E. Tables with 4 large, symmetrically placed perforations in disk, and spire of 2 vertical rods:
          Disk of tables about as wide as long, usually with 4 small holes alternating with the large ones ..... *papuensis*
          Disk about twice as long as wide, without supplementary perforations ..... *micra*

EE. Tables usually with more than 4 perforations in oblong, elliptical, or roughly circular, more or less irregular disk:
F. Tables with oblong or squarish disks with 6–10 small perforations, stout spire with spiny, oblong top, and conspicuous half-ring on lower surface ..... *axiologa*
FF. Tables not as above:
G. Tables with roughly circular disk, with 20–30 perforations ..... *perforata*
GG. Tables stout, with more or less elongated oval or elliptical disks with 5–15 holes; radial pieces of calcareous ring with short, abruptly tapered posterior prolongations ..... *grisea*
GGG. Tables with irregularly oval or triangular disks with 6–12 perforations; radial pieces of calcareous ring with long, slender posterior prolongations:
White, with pedicels cream color ..... *alba*
Deep purplish black, with white pedicels ..... *nigra*
DD. Calcareous particles not tables, but knobbed buttons:
Buttons very numerous, with many knobs on one side and often with vertical half-circle or arch on one side or both ..... *buccalis*
Buttons not crowded, with fewer knobs and no arch ..... *minuta*
CC. Calcareous ring stout, with relatively short projections on radial pieces:
Calcareous particles stout tables or plates with spiny projections horizontally ..... *sluiteri*
Calcareous particles knobbed buttons and delicate baskets ..... *gazellae*
AA. No calcareous particles in body wall, but terminal plates in pedicels ..... *okeni*

Thyone perissa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 471; fig. 43.

The holotype is as yet the only recorded specimen of this remarkable *Thyone*. In life it was undoubtedly well over 100 mm. in length. The color was yellowish white with the numerous pedicels brown-black in sharp contrast. It was collected by a diver from "a hole in a rock," off Cape Villaret, Western Australia, in 5 fms. Deichmann thinks it is probably a *Phyllophorus,* and in that case identical with *P. magnus* Ludwig.

Thyone papuensis

Thyone fusus var. *papuensis* Théel, 1886. "Challenger" Hol., p. 92; pl. 7, fig. 1.
Thyone castanea Lampert, 1889. "Gazelle" Hol., p. 836.
Thyone papuensis H. L. Clark, 1921. Ech. Torres Strait, p. 167.

The "Challenger" took a single specimen in Torres Strait in 8 fms. The "Gazelle" took 3 specimens in Mermaid Strait, Western Australia, in 2–3 fms. The Great Barrier Reef Expedition took 3 specimens in the Low Isles region on the Queensland coast, 1 of which when extended was 100 mm. long. At Broome, we obtained 8 specimens, from 12 to 75 mm. in length. Apparently, this *Thyone* may be expected anywhere on the tropical coasts of Australia where local conditions are suitable, but

it is obviously not abundant, or possibly its chief habitats are such that it is not easily taken. The color ranges from yellowish brown to dull brown.

Thyone micra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 468; fig. 41.

This little *Thyone* was collected in 5–7 fms. on sandy mud at Pearl Shoal near Broome, and farther southward near or in Lagrange Bay. Only 9 specimens were taken, all less than 20 mm. in length. They were pale brown, often with 5 darker longitudinal lines which may indicate the interambulacra. The larger tentacles are blackish brown, much darker than the yellowish-brown small pair. All tentacles have minute white spots on the inner surface, due to accumulations of calcareous rosettes.

Thyone axiologa

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 465; fig. 39.

A single specimen of this well marked species was taken at Broome in 1929. In 1932, we looked for it in vain. It was found clinging to the under side of a rock near low-water mark at Entrance Point. It is 35 mm. long, the spindle-shaped body 8 mm. in diameter near the middle. The color is light gray, with yellowish tentacles, and many pedicels faintly red or rust color at tip.

Thyone perforata

H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 222; figs. 1–3.

Like several other Thyones in the Australian list, this species is based on a single specimen. The calcareous tables are very distinctive, but as the unique holotype is less than 20 mm. long, it is probably immature, and the tables in the adult may be quite different. At station XII, in "Penguin Channel, 10–15½ fms., rock and shell gravel, mud on edges of pit," this little holothurian was taken by the Barrier Reef Expedition. The color is light gray with dark brown tentacles.

Thyone grisea

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 467; fig. 40.

This is a fairly common holothurian at Broome and southwestward along the coast. In habitat and habits it is much like *buccalis,* and the two are associated on the jetty flat at Broome. Full-grown specimens of *grisea* exceed 50 mm. in length. The color is gray-brown, ranging from light to dark; some individuals are a dull purplish, others more of a red-brown. The tentacles are commonly darker than the body wall.

Thyone alba

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 464; fig. 38.

This species rests on a single specimen, 21 mm. long, taken in sandy mud on the jetty flat at Broome, near normal low-water mark, in August 1929. Repeated efforts

during the following month and in 1932 failed to find another specimen. In life, it was "pure white, rather Cucumaria-like, long pedicels." It is now white, with pedicels cream color and posterior tip of the body grayish.

Thyone nigra

Joshua and Creed, 1915. Trans. Roy. Soc. S. Australia, vol. 39, p. 20; pl. 3, figs. 3, 4.

This species also rests on a single specimen, taken by Verco, presumably in St. Vincent Gulf, South Australia, and now in the South Australian Museum. The describers say nothing as to the size of the animal, but it must be very small, for they say that the Polian vessel, 3 mm. long, is "very large in proportion to the size of the animal." The calcareous ring is notable and probably a good species character.

Thyone buccalis

Stimpson, 1855. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, p. 386.
Stolus sacellus Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 355; pl. 20, figs. 115, 116.
Thyone rigida Semper, 1868. Holothurien, p. 66; pl. 13, fig. 23.
Stereoderma murrayi Bell, 1883. Proc. Zool. Soc. London, p. 61; pl. 15, fig. 6.
Thyone sacellus Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 360.

With a distribution ranging from Delagoa Bay to Aden on the west and from Port Jackson to Japan on the east, this is one of the commonest holothurians of the Indian Ocean. It occurs on the tropical coasts of Australia from Shark Bay to Queensland and south even to Port Jackson. At Broome it is one of the holothurians most abundant on the jetty mud flat, especially in the soft mud around groups of partially buried rocks. Commonly 75–90 mm. long, it sometimes reaches 110 mm. The color ranges from bright yellow-brown, red-brown, or seal brown to purplish black, with the tentacles much darker, often nearly black.

One specimen, collected on the jetty flat at Broome, was so conspicuously different from all the others seen that it was supposed to be a different species, but critical study showed it to be different only in coloration. It was pure white with light brown tentacles. It is perhaps simply an albino, but for convenience of reference it seemed best to call it var. *pallida,* and it has been described and discussed under that name (H. L. Clark, 1938, p. 462). The preserved specimen is still a clear cream white.

Thyone minuta

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 470; fig. 42.

This curious little holothurian, usually less than 30 mm. long, is locally very common at Broome but seems to be wanting from many apparently just as suitable places. It occurs in great numbers on the inner side of Pearl Shoal, where there are many dead shells on a sandy-mud bottom; a habitat it shares with the much rarer *T. micra.* The color is white with more or less numerous minute blotches and spots of some shade of brown. When these are few, the color appears white; when they are abundant, the general effect is light brown.

Thyone sluiteri

Lampert, 1889. "Gazelle" Hol., p. 838; pl. 24, figs. 9*a–c*.

Lampert was unwilling to open the unique holotype in order to count and examine the tentacles, so he indicated the genus with a question mark, and until more material is available the status of this interesting holothurian must remain obscure. Deichmann thinks it is a *Phyllophorus* and probably identical with Bell's *P. proteus*. The holotype, taken in Mermaid Strait, northwestern Australia, was only 25 mm. long.

Thyone gazellae

Colochirus gazellae Lampert, 1889. "Gazelle" Hol., p. 823; pl. 24, figs. 5*a–c*.
Sluiter, 1901. "Siboga" Hol., p. 98; pl. 2, fig. 4 (colored).

The Museum of Comparative Zoölogy has 3 of the "Gazelle" specimens and 2 collected by the "Siboga," and I am obliged to disagree with my European colleagues as to the generic position of this holothurian. As is well shown by Sluiter's colored figure, the general appearance is surely that of a *Thyone* and not at all that of a true *Pentacta* (= *Colochirus*). Moreover, the calcareous particles in the relatively flaccid body wall are obviously not those of *Pentacta*. The 5 oral valves are an indication of a *Pentacta* relationship, but there are Thyones in which such valves are indicated if not fully formed.

Both the "Gazelle" and the "Siboga" took large numbers of specimens, but only at a single station each: the "Gazelle," in Mermaid Strait in 2.5–7.5 fms.; the "Siboga," on the east coast of Sumbawa in 20 fms. Obviously this holothurian is local and gregarious. It grows to a length of 80 mm., and its brilliant vermilion-red coloring is very striking.

Thyone okeni

Bell, 1884. "Alert" rept., p. 149; pl. 9, fig. II.

This is an endemic holothurian of obvious rarity, easily recognized by the absence of calcareous particles from the body wall, though end plates are present in the numerous pedicels. Bell's types are supposed to have been taken in Port Jackson, but no other report of the species has come from there. The only other known specimen of *okeni* is the one taken near Thursday Island, by the Carnegie Expedition to Torres Strait in 1913 (see H. L. Clark, 1921, p. 167). This individual was brownish in life, the pedicels with a reddish tint. Bell says his specimens were 62 and 85 mm. long and very dark brown.

ACTINOCUCUMIS

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 91.

Genotype: *Actinocucumis typica* Ludwig, 1874, p. 91.

This genus was monotypic when established; a second species was added by Bell in 1884 but not generally accepted as valid. Ludwig's material was from Bowen, Queensland, Bell's from Albany Island, Torres Strait. Pearson (1903) added a third species from Ceylon, but as it is based on a defective specimen only 15 mm.

long, it cannot be accepted as an *Actinocucumis* at all. That the genus has been reported from several places along the southern and southeastern Asiatic coast is beyond question, nevertheless it is notable that the "Siboga" took but 2 small specimens in the East Indies, and the "Investigator" failed to obtain any in Indian seas. Even if it is not endemic in Australia, there is no doubt that the tropical coasts of that continent are the real home of *Actinocucumis*. Apparently 4 species occur there; particularly at Broome, *Actinocucumis* is common. A discussion of the occurrence, validity, and characteristics of 3 of the species will be found in H. L. Clark, 1938, pages 477–481. The fourth has been found as yet only on the Queensland coast. Material is so scanty, there is room for much difference of opinion as to the number of species that may wisely be recognized. Deichmann inclines to think there is but 1 or possibly 2 species, whereas I am disposed to recognize 4, and I offer the following tentative key to these:

Key to the Species of Actinocucumis

A. Large, 75–135 mm. long when adult; pedicels rather short and thick, especially dorsally, few and short around anus; supporting tables in pedicels stout; no delicate biperforate plates in skin:
  B. Color brown with reddish tinge, not darker on interambulacra; small, imperfect pedicels numerous dorsally, but relatively few around anus; acorn-shaped spicules abundant ..... *typicus*
  BB. Color white or whitish, or purplish gray, often darkest on interambulacra; small, imperfect pedicels not numerous dorsally:
    Color tending to purplish gray, darkest on interambulacra; pedicels numerous around anus; body wall firm but not rigid; acorn-shaped particles many ..... *difficilis*
    Color nearly or quite white; pedicels few around anus; body wall more or less rigid; no truly acorn-shaped particles .... *quinquangularis*
AA. Small, 50–80 mm. long; pedicels long and slender, even dorsally and particularly so around anus; supporting rods in pedicels few and slender; delicate biperforate plates common, particularly in and near pedicels ..... *longipedes*

Actinocucumis typicus [1]

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 91; pl. 7, fig. 24.

The largest specimen taken of this species was 175 mm. long in life, but is only 135 mm. in its preserved condition (in alcohol). Unlike all the other specimens seen, it was dull purplish in color, not the normal walnut brown. Although the range of *typicus* is from Bowen, Queensland, to Shark Bay, Western Australia, it is not so common in the Broome district as the following species, and was never collected living near low-water mark. The records from Karachi, Amoy, and other Asiatic points need confirmation.

Actinocucumis difficilis

Bell, 1884. "Alert" rept., p. 148; pl. 9, fig. C.

Bell does not say how many specimens he had, but only that they came from Albany Island, which is at the southeastern entrance to Torres Strait. No later

[1] Ludwig used the feminine form, *typica,* but *cucumis* is a masculine noun.

writer has considered Bell's species valid, but at Broome it is apparently common and definitely different from *typicus*. It may reach a length of 100 mm. in life, but is usually smaller. Although it was occasionally taken at extreme low-water mark, most specimens were dredged in 5–7 fms.

Actinocucumis quinquangularis

Pseudocucumis quinquangularis Sluiter, 1901. "Siboga" Hol., p. 108; pl. 6, figs. 9*a–f*.
Engel, 1933. Mém. Mus. roy. hist. nat. Belgique, hors sér., vol. 3, fasc. 13, p. 13; figs. 13, 14.

The status of this species is open to serious question. If Engel's identification and figures are correct, as seems probable, then "*quinquangularis*" is better placed in *Actinocucumis* than in *Pseudocucumis,* as the spicules indicate. Two large specimens from Lindeman Island, Queensland, collected by Melbourne Ward and presented by him to the Museum of Comparative Zoölogy, have very similar spicules and might be considered adults of Sluiter's species, but Deichmann thinks them an unnamed form. They are about 100 mm. in length, nearly pure white in color, and the pedicels are pretty uniformly scattered over the body as in *Phyllophorus*. But the spicules are like *Actinocucumis,* and for the present these specimens may be associated with that genus.

Actinocucumis longipedes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 480; fig. 45.

This species, known as yet only from the Broome region, was taken when dredging in 5–7 fms., off Roebuck Bay or along the neighboring coast. It is smaller than either of the preceding, usually 50–70 mm. in length. The color is commonly deep purplish brown or brownish purple, with the tentacles very dark, sometimes almost black. The long pedicels are the distinguishing character.

DISCUCUMARIA, gen. nov.

Genotype: *Cucumaria africana* Semper, 1868, p. 53.

No other holothurian having been found with the big, rough, lenticular plates so characteristic of *africana,* it is necessary to recognize a monotypic genus for that species.

Discucumaria africana

Cucumaria africana Semper, 1868. Holothurien, p. 53.
Pseudocucumis théeli Ludwig, 1887. Sitzungsber. K. preuss. Akad. Wissensch., vol. 54, p. 1236; pl. 15, figs. 12–16.
Pseudocucumis africana Ludwig, 1888. Zool. Jahrb., Abt. syst., vol. 3, p. 815.

This is a widely distributed little holothurian, dull purplish or nearly black in life, becoming brown or even yellowish brown in alcohol. It rarely exceeds 50 mm. in length, and alcoholic specimens are much less. The large, rough plates in the skin (well figured by Ludwig) are very distinctive and can easily be seen with a hand lens. The species has a wide range, from the east coast of Africa to southern Japan and the East Indies. On the tropical coasts of Australia it is found from

Queensland to northwestern Australia. It is common at Low Isles, at the Murray Islands, and at Broome. The little animals live in the crevices and crannies of rocks and coral fragments, whence it is sometimes difficult to dislodge them.

PSEUDOCUCUMIS

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 90.

Genotype: *Cucumaria acicula* Semper, 1868, p. 54.

It is an interesting fact that although 15 species or more have been assigned to this genus, not one of them has calcareous spicules in any degree like those of the genotype. It seems best, therefore, to consider *Pseudocucumis* monotypic, containing only Semper's species. Deichmann considers the relationship to *Urodemas* of Selenka so close she would unite the two genera under the latter (earlier) name, but I am quite unable to agree to this.

Pseudocucumis aciculus

Cucumaria acicula Semper, 1868. Holothurien, p. 54; pl. 15, fig. 11.
Pseudocucumis acicula Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 90.
H. L. Clark, 1921. Ech. Torres Strait, p. 169; pl. 19, fig. 2 (colored).

Although its range extends from Mauritius to Fiji, this handsome holothurian does not seem to be common anywhere, but a number of specimens were taken at the Murray Islands by the Carnegie Expedition in 1913. Nowhere else in Australia has it yet been found, nor was it met with by the "Siboga" in the East Indies, although it certainly occurs in the Philippines. Semon took a specimen at Amboina in 1893. Large individuals when extended are 80–100 mm. in length, but contract to about half that size. They are normally brown-orange or orange-brown; when the brown pigment is excessively developed they may be nearly black, whereas if it is little developed they are bright orange. The tentacles are brown, more or less variegated with whitish.

MENSAMARIA,[1] gen. nov.

Tentacles 20 or usually more, often of diverse sizes. Pedicels more or less confined to ambulacra. Calcareous particles more or less abundant, including tables of some sort, though these may have either the disk or the spire or both more or less asymmetrical or irregular.

Genotype: *Pseudocucumis intercedens* Lampert, 1885, p. 254.

There is room for difference of opinion as to how many of the species supposed to be *Pseudocucumis* are congeneric with *intercedens,* but for the present, it seems best to let the 2 New Zealand species remain in this association. Probably, however, they will ultimately be removed, as the differences are obvious. Engel's careful work (1933) is an excellent start in analyzing the group as at present known, but far more material is essential.

[1] *Mensa* = a table, in reference to the characteristic deposits.

KEY TO THE SPECIES OF MENSAMARIA

A. Tables numerous, for the most part with symmetrical circular or elliptical bases perforated by 4 large and 4 small (alternating) holes ..... *bicolumnata*
AA. Tables with irregular, asymmetrical disks, often with 10 or more holes:
Spire of tables high, equal to long diameter of disk ..... *intercedens*
Spire of tables low and often imperfect, equal to about one-half disk length ..... *thomsoni*

Mensamaria bicolumnata

Pseudocucumis bicolumnatus Dendy and Hindle, 1907. Jour. Linn. Soc. (Zool.), vol. 30, p. 106; pl. 11, fig. 6; pl. 12, figs. 13, 14.

The admission of this New Zealand species to the Australian fauna is due to the statement of Joshua and Creed (1915) that "there is an excellently preserved and very typical specimen" in the South Australian Museum, collected by Verco. Dendy and Hindle had but a single specimen, only 35 mm. long and fully contracted; the Australian authors did not give even the size and color of their specimen. As Mortensen did not meet with the species in New Zealand, it is obvious that it is a rare form and still very imperfectly known.

Mensamaria intercedens

Pseudocucumis intercedens Lampert, 1885. Seewalzen, p. 254.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 482; pl. 16, fig. 6 (colored).
Pseudocucumis eurystichus H. L. Clark, 1921. Ech. Torres Strait, p. 169; pl. 37, figs. 9–19.

There is no doubt that the holothurian which I collected at Friday Island in Torres Strait in 1913 and called *eurystichus* is identical with Lampert's species, based on a specimen from an unknown locality. The matter is amply discussed in H. L. Clark, 1938, pages 482–484. In life, this is a very handsome holothurian with its red and dark blue-violet coloration. Nearly all known specimens are less than 75 mm. long, but an adult from Broome is 115 mm. The range of the species is from King Sound, Western Australia, northward to Amoy, China, eastward to Torres Strait, and along the tropical coast of Australia to Penguin Channel and Direction Island, northern Queensland.

Mensamaria thomsoni

Cucumaria thomsoni Hutton, 1879. Trans. Proc. New Zealand Inst. (1878), vol. 11, p. 307.
Cucumaria mutans Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 4; pl. 1, figs. 1*a–d*.
Pseudocucumis thomsoni Mortensen, 1925. Vidensk. Medd., vol. 79, p. 355; figs. 38–40.

The right of this New Zealand species to a place in the Australian fauna is based on 3 relatively young specimens collected in 5 fms. in Tasmania by T. T. Flynn, and in 90 fms. in Western Australia, at the western end of the Great Australian Bight, by D. L. Serventy. But there can be little question that the material on which Joshua based his supposedly new *Cucumaria mutans* is really made up of young and adult specimens of a *Mensamaria*. This might seem incredible, but Joshua kindly sent 4 specimens of his proposed species to the Museum of Com-

parative Zoölogy, and Deichmann, noting that Joshua's figure of the calcareous ring indicated a polychirote form, discovered that the specimens have 20 (±) tentacles. Further investigation has convinced us that the specimens are "*Pseudocucumis thomsoni* Mortensen," which also was first described (by Hutton) as a *Cucumaria.* Joshua has given interesting information regarding size and color of both young and adult specimens. He says the color is at first "deep blue-black" "during life (and generally in alcohol)," but with increasing size this color disappears, and mature specimens are "nearly white." He gives the size as "length 60 mm., greatest width, 20 mm." The specimens sent the M.C.Z. were scarcely half so big. Joshua says it "is perhaps one of our commonest holothurians—the young forms being met with between tide-marks in all the localities in which I have collected." It has not yet been reported from east of Western Port, except in Tasmania and New Zealand, but it occurs at Bunkers Bay, southwestern Australia, and even northward to Cottesloe Beach, Western Australia (see H. L. Clark, 1938, p. 444). Further study of this holothurian in New Zealand, Victoria, and Western Australia may show that at least 2 and possibly 3 species are at present confused under one name.

PHYLLOPHORUS

Grube, 1840. Act. Ech. und Würm. des Adriatischen, etc., p. 38.

Genotype: *Phyllophorus urna* Grube, 1840, p. 39.

This widely distributed group includes more than 30 species of varying degrees of validity. That it is a heterogeneous assemblage is beyond question, but Ludwig (1887) considered it better to include them all under one name than to attempt to distinguish two or more groups on the lines that had been suggested. Deichmann (1930) intimated that a distinction between *Phyllophorus* and *Thyonidium* might be made, but added that our knowledge is still too imperfect to permit such a division. The situation is no better today in the Indo-Pacific area, although a number of new species have been added. Deichmann's (1938, 1941) important revisions of American species will no doubt be of assistance when adequate Oriental and Australian material is available.

Seven Australian holothurians are referred to *Phyllophorus,* but not one is known from adequate material; of only 1 have a dozen specimens been taken; of 2, 6 or 7 were available; of the others, 5 or fewer. None is based on a single specimen, but much of the material studied is youthful or in very poor condition. The species here recognized are distinguishable by their calcareous rings, and particles in the skin, and these suggest that at least 2 genera are represented.

Key to the Species of Phyllophorus

A. Disk of calcareous tables in skin irregular or elongate, not approximately circular:
  B. Disk cruciform or reduced to a bar forked at each end or quite irregular, usually with 4 large perforations, or so reduced only 2 or no perforations are enclosed; stout, sharp projections on disk margin and sometimes on surface:
    Tables with spire ..... *holothurioides*
    Tables with central spike or very imperfect spire ..... *brocki*

BB. Disk of tables not so stout, elongate, with 4 symmetrical perforations and 2 blunt points in different planes on margin, outside each one ..... *proteus*

AA. Disk of tables approximately circular, though margin may have projecting angles and points:

C. Disk symmetrical, more or less circular, with 8 marginal perforations and no projecting points ..... *cebuensis*

CC. Disk more irregular, usually with marginal projections:

D. Calcareous ring very broad; radial pieces 10 mm. high, with posterior prolongations only 5 mm. ..... *thyonoides*

DD. Calcareous ring not nearly so broad and stout:

Radial pieces of ring with posterior prolongations more than twice height of ring (as 8 to 3) ..... *parvipedes*

Radial pieces not so much prolonged (as 8 to 5) ..... *trapezus*

Phyllophorus holothurioides

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 96; pl. 6, fig. 23.
Ekman, 1918. K. svenska Vetensk.-Akad. Handl., vol. 58, no. 6, p. 50; pl. 2, fig. 12; pl. 5, figs. 47–51.

The unique holotype of this species is from an unknown locality. Three specimens have been reported from the East Indies, at wide intervals. Mjöberg took 1 small specimen southwest of Cape Jaubert, Western Australia, and the Great Barrier Reef Expedition took 2 very small specimens off the coast of northern Queensland. In view of the small size and contracted condition of most of this material, it is open to serious question whether a single species is represented, or 2 or more. Obviously a series of adults and young from a single locality is a *sine qua non* in determining the growth changes and the reliable specific characters. Ludwig's holotype, 75 mm. long, was white speckled with brown and with small irregular black blotches. Apparently Mjöberg's specimen, 33 mm. long, was similar, but the Barrier Reef specimens, only 25 mm. long, were unicolor, one dark gray, the other light brown. Deichmann is satisfied that Mjöberg's specimen is *proteus* Bell, and the Barrier Reef material also.

Phyllophorus brocki

Ludwig, 1888. Zool. Jahrb., Abt. syst., vol. 3, p. 813; pl. 30, figs. 21–25.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 485; fig. 46.

Only 4 specimens of *brocki* are known from Australia, all from Augustus Island, Western Australia. A full account of these in comparison with Ludwig's and Sluiter's specimens is given in H. L. Clark, 1938. This is perhaps the largest of the Australian species, with a length much in excess of 100 mm. The color of preserved specimens is brown, and the pedicels have the tips noticeably darker and the walls white-dotted with little heaps of calcareous rosettes.

Phyllophorus proteus

Bell, 1884. "Alert" rept., p. 150; pl. 9, figs. F, F′.
H. L. Clark, 1921. Ech. Torres Strait, p. 168.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 488.

This is apparently an endemic species ranging from Port Molle, Queensland, northward to Torres Strait and thence westward to Darwin, Augustus Island, and Broome. Bell gives no hint as to the number of specimens in the "Alert" collection, but one of them is now in the Museum of Comparative Zoölogy, so it has been possible to compare it with the material from Darwin and Western Australia. The largest was one of those from Darwin, 100 mm. long in life, about 60 mm. in alcohol. The brown-red color in life was "masked by dusky blotches and fine sprinkling." It is now dirty white masked by very fine, irregular transverse lines of brown; the pale brown pedicels are whitish at base but blackish at tip. Other specimens are brown, dark gray, or dull purplish.

Phyllophorus cebuensis

Thyonidium cebuense Semper, 1868. Holothurien, p. 67; pl. 12, fig. 5 (colored); pl. 13, fig. 25; pl. 15, fig. 8.
Phyllophorus cebuensis Ludwig, 1892. Bronn's Klass. Ord. Thierreichs, vol. 2, pt. 3, bk. 1, p. 347.

To Semper's 3 specimens may be added 1 taken by the "Siboga" and 1 by the "Gier," in the East Indies, and 1 from Dongarra, Western Australia, in the Museum of Comparative Zoölogy. In view of this scanty and apparently youthful material, the status of the species is very uncertain. There is nothing distinctive about Semper's figures, but the specimen from Dongarra resembles them in all essentials. Nevertheless the identity is open to question.

Phyllophorus thyonoides

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 492; fig. 48.

The material on which this species is based was washed up on the beach at Cottesloe, Western Australia, in 1926, in company with large numbers of *Lipotrapeza vestiens.* There were only 5 *Phyllophorus,* the largest 42 mm. long. Their color was brown, with fragments of a much darker epidermis here and there. Naturally the condition of the specimens is poor, but it is reasonable to believe that in life this holothurian is 75–80 mm. long and nearly black.

Phyllophorus parvipedes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 489; fig. 47.

Only in the vicinity of Broome has this species been taken. The 4 known specimens range from 16 to 90 mm. in length. The small ones are light gray; the smaller was "translucent white" in life. The larger ones are darker, the holotype being gray, tinted with yellowish brown, with numerous irregular blotches of red-brown or blackish brown; the paratype has the blotches dusky purplish. The smallest specimen was taken at Beagle Bay, north of Broome, in 5 fms.

Phyllophorus trapezus

H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 224; figs. 4–9.

This species has been taken as yet only by the Barrier Reef Expedition, at the Low Isles, and south of Cape Kimberley, in 4 fms. The calcareous tables are very

characteristic, the tall, well developed spire being especially noticeable. The known specimens are all small, less than 50 mm. long, and it is possible that all are young. In that case, it might be that the adult would have the tables less regular and with a more or less resorbed spire. The color is a light yellowish brown in the holotype, darker in the other specimens.

URODEMAS

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 352.

Genotype: *Urodemas perspicillum* Selenka, 1867, p. 352.

Although established so many years ago, this genus was not recognized by Ludwig or Théel, and only in the past few years has its validity been appreciated. It is a group of East Indian and Australian species, related closely to *Phyllophorus* but easily distinguished by the remarkable rods in the body wall. Of the 4 species now known, 3 have been taken in Australia, the fourth only at Hong Kong. Deichmann thinks that *Urodemas* and *Pseudocucumis* are identical and that the former name, which is some years older, should replace the latter. This seems to me unlikely, since the type species of the two genera are so different in general characters.

Key to the Species of Urodemas

Calcareous rods minute, smooth, perforate at one end or both; in adults no other particles present, but in young, small tables and very irregular perforated plates also present ..... *perspicillum*

Calcareous rods long, perforated at inner end but terminating distally in spinous knob ..... *schmeltzii*

Calcareous rods more table-like, inner end like disk with 4 perforations, outer end showing much diversity but often like spiked club ..... *hamatum*

Urodemas perspicillum

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 352; pl. 20, figs. 110, 111.

For the complete synonymy and discussion of this big holothurian, characteristic of Port Jackson and not certainly known from elsewhere, see H. L. Clark, 1938, page 499. Adult specimens are 150–200 mm. long, and owing to the habit of contracting the oral end and swelling the body greatly, they are known to the dredgers as "footballs." Bell's (1884) bare reference of holothurians from the Queensland coast to "*Orcula perspicillum*" requires confirmation. The only information we have as to color is Théel's statement: "Color in alcohol, brown, lighter round the pedicels; ends of pedicels, black."

Urodemas schmeltzii

Thyonidium schmeltzii Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 94; pl. 6, fig. 20.
Urodemas schmeltzii H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 501.

Few holothurians are so easily recognized from their spicules as is this tropical Australian species, which ranges from Port Curtis, Queensland, to "45 miles, west

southwest of Cape Jaubert," Western Australia. This westernmost record is based on a specimen taken by Mjöberg, misidentified by Ekman (1918) as "*Phyllophorus hamatus* Sluiter." Ekman seems to have overlooked *schmeltzii*. At Broome, this holothurian is common, the series we obtained ranging in length from 8 to 85 mm. In life, they were of course considerably larger. The color was an unreliable factor, as it ranged from yellow or flesh red, through brown or olive to blackish. Alcoholic specimens range from light brown to deep purplish brown, sometimes almost black. Young specimens were found under rocks and among corals near low-water mark, but adults were more commonly dredged in 5–7 fms.

Urodemas hamatum

Phyllophorus hamatus Sluiter, 1914. Contr. Fauna Indes Néerl., vol. 1, p. 17; pl. 1.
Urodemas hamatum H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 502.

This species is very imperfectly known, and its right to a place in the Australian fauna rests on a single specimen, only 15 mm. long, taken at Broome in 1932. There are notable differences between this specimen and those of Sluiter, but it is much smaller than Sluiter's and the differences may be due only to the difference in age.

LIPOTRAPEZA

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 494.

Genotype: *Phyllophorus vestiens* Joshua, 1914, p. 5.

For species of *Phyllophorus* which lack calcareous particles in the body wall (not including the caudal end) this genus was instituted, and 3 Australian species are included therein. All 3 occur on the southern coast between Bass Strait and Cottesloe Beach, Western Australia. Probably the New Zealand species will ultimately be relegated to a genus of its own, but for the present it may remain here. Deichmann considers *dearmatus* to be a true *Phyllophorus,* and *ventripes* to be identical with *vestiens,* for which she would retain the generic name *Lipotrapeza.* The 3 nominal species here recognized are distinguishable thus:

Key to the Species of Lipotrapeza

A. Calcareous ring very high, polyplacous, with long posterior prolongations on radial pieces ..... *dearmatus*
AA. Calcareous ring not so high, stout, made up of relatively few pieces and with short prolongations on radial pieces:
  Pedicels abundant on middle of lower surface, much less abundant anteriorly and posteriorly, and nearly or quite wanting on middle of back ..... *ventripes*
  Pedicels very numerous all over body, with little distinction between dorsal and ventral surface ..... *vestiens*

Lipotrapeza dearmatus

Phyllophorus dearmatus Dendy and Hindle, 1907. Jour. Linn. Soc. (Zool.), vol. 30, p. 103; pl. 11, figs. 7, 8; pl. 12, fig. 15; pl. 13, fig. 20.
Mortensen, 1925. Vidensk. Medd., vol. 79, p. 353; figs. 36, 37.

This New Zealand holothurian has been reported from several places on the coast of Victoria, but has not yet been found farther west. Although Joshua (1914) lists the localities of the Victorian specimens, he gives no information about them. The holotype was 60 mm. long and there were "red-brown" spots on the tentacles, but no further hint as to color is given. Mortensen studied 2 New Zealand specimens but gives no hint as to size or color. Obviously more information is needed before the best generic position of this interesting holothurian can be determined. After examination of the specimens received by the Museum of Comparative Zoölogy from Joshua, Deichmann thinks that these are not identical with the New Zealand species, but should be referred to *Thyone*.

Lipotrapeza ventripes

Phyllophorus ventripes Joshua and Creed, 1915. Trans. Roy. Soc. S. Australia, vol. 39, p. 19; pl. 2, fig. 1; pl. 3, fig. 5.
Lipotrapeza ventripes H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 495.

During his extensive collecting on the South Australian coast, Verco took "several" specimens of this notable holothurian, probably in St. Vincent Gulf. They are 50–60 mm. long, with numerous pedicels, especially crowded on the mid-ventral surface. The color is light brown with the pedicels whitish. The original description requires some modification, but there is little doubt as to the validity of the species. It has not yet been met with elsewhere.

Lipotrapeza vestiens

Phyllophorus vestiens Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 5; pl. 1, figs. 2*a–f*.
Lipotrapeza vestiens H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 496.

With a known range from Wynyard, Tasmania, to Cottesloe Beach, Western Australia, this species is the commonest member of the genus. It is also much the largest, some of the individuals from Western Australia being 200–240 mm. long, even in their present contracted condition. It is likely that in life such individuals would be nearly or quite a foot long. Apparently the color in life is some shade of brown, but it is possibly reddish or reddish brown. Preserved material, if not bleached, is some shade of light brown. Nothing is known as to habits or habitat, but since specimens are washed up on beaches in considerable numbers after a storm, it is probable that the animals live more or less gregariously, just below the surface, on muddy bottoms in relatively shallow water, 2–5 fms. In heavy storms, wave action would wash them out and up onto the beach.

Family PSOLIDAE

This is a small group of only 5 or 6 genera, of which but 3 occur in Australia. The Australian forms are all inconspicuous animals, mostly small (less than 25 mm. in length), living on the under side of rock or coral fragments, or on the inner surface of the valves of dead bivalve mollusks, or even on the outer side of pearl shell. The genera are distinguished by the number of tentacles and the presence or absence of pedicels on the dorsal side; but the latter character is, on account of the

very small size of the contracted pedicels, difficult to make out. The Australian species, however, are sufficiently different in general appearance or in the calcareous particles in the skin so that they will not be confused with one another, in life or when well preserved.

Key to the Genera of Psolidae

A. Tentacles 15 ..... *Stolinus*
AA. Tentacles 10:
Dorsal surface without pedicels ..... *Psolus*
Dorsal surface with at least a few pedicels ..... *Psolidium*

STOLINUS

Selenka, 1868. Ztschr. f. wissensch. Zool., vol. 18, p. 110.

Genotype: *Stolinus cataphractus* Selenka, 1868, p. 110.

This genus is still very imperfectly known, and few specimens have been available for study during the past half-century. The figures published leave no room for doubt that the genus is warranted and easily recognized, but whether there is more than one species and just where they occur are still to be determined. The types and occasionally some other specimens are said to be from "Australia." Erwe (1913) describes the largest reported individual and figures calcareous particles, but there was no definite locality label (only "West Australia") with the specimen.

Stolinus cataphractus

Selenka, 1868. Ztschr. f. wissensch. Zool., vol. 18, p. 110; pl. 8, figs. 1, 2.
Psolus (*Hypopsolus*) *ambulator* Bell, 1882. Proc. Zool. Soc. London, p. 648; pl. 48, figs. 2*a–b*.
Théelia ambulatrix Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 358; pl. 5, figs. 6*a–b*.

The occurrence of a specimen, supposedly from Western Australia, in the Perth Museum warrants including the species here. The specimen is 85 mm. long, 35 mm. wide, 40 mm. high anteriorly, and only 20 mm. high at the posterior end. The type of Bell's species is nearly as large. It was said to be from Australia, as is supposed to be the case with the specimens studied by Selenka. Studer (1877) described a supposedly similar holothurian from Kerguelen, but it is very doubtful whether it is even congeneric with the Australian species.

PSOLUS

Oken, 1815. Lehrb. Naturgesch., pt. 3, p. 352.

Genotype: *Holothuria phantapus* O. F. Müller, 1776, p. 231.

Oken listed 3 species in his proposed genus, but Jaeger (1833) ignored one of these and put *squamatus* in a genus *Cuvieria.* Hence we must accept *phantapus* as the type of *Psolus,* although most of the species now included in the genus are much more like *squamatus.* Ultimately they will probably be called *Cuvieria.* It is to this group that the 2 Australian species belong. They are easily distinguished by the spicules in the sole:

Spicules of sole, baskets and plates with projecting teeth or knobs on margin ..... *minutus*
Spicules of sole, flat plates somewhat cruciform or more often with 4 symmetrical perforations, and knobs distal to them on plate surface near margin ..... *spinuliferus*

Psolus minutus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 507; figs. 51, 52.

This tiny species, less than 10 mm. long in life, is not rare at Lord Howe Island, where it occurs on the under side of rock fragments near low-water mark. The color is pure white both in life and in alcohol, though the tentacles tend to be yellowish. It is probable that this little *Psolus* will ultimately be found on the coast of New South Wales or Queensland.

Psolus spinuliferus

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 509; fig. 53.

This species, about twice the size of the preceding, is known from a single specimen, 20 mm. long in life, found on the outer surface of a pearl shell off Eighty-Mile Beach near Broome, in 10–12 fms., June 9, 1932. The color was pure, translucent white in life; now it has more of a yellowish tinge, especially at the ends. It is entirely different from the Lord Howe *Psolus,* and surprisingly like the European species, *squamatus.*

PSOLIDIUM

Ludwig, 1886. Zool. Jahrb., Abt. syst., vol. 2, p. 9.

Genotype: *Psolidium dorsipes* Ludwig, 1886, p. 9.

When Ludwig established this genus, it was monotypic, but a number of species have been transferred to it from *Psolus* and in the past few years half a dozen new species have been described. Among the latter are 2 from Australia. A third Australian species is listed by Joshua (1914), who considered it identical with one known otherwise only from the Magellanic region of South America. These 3 species may be distinguished thus:

Key to the Species of Psolidium

A. Relatively large, 30 mm.; color very dark gray, almost black; triradiate cuplike spicules in epidermis ..... *nigrescens*
AA. Small, under 20 mm.; color light; no triradiate cuplike spicules:
Dorsal scales numerous, conspicuous, each bearing up to 6–8 coarse granules; sole sharply defined ..... *granuliferum*
Not as above ..... sp.?

Psolidium nigrescens

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 505; fig. 50.

This very well marked species rests on a single specimen, 32 mm. long, very dark-colored, taken in November 1929 at Gunnamatta Bay, Port Hacking, New South

Wales. It was very *Psolus*-like in appearance and clung closely to its rock fragment as *Psolus* does. It was not until it was critically studied in the museum that the numerous dorsal pedicels were noted.

Psolidium granuliferum

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 503; fig. 49.

Like the preceding, this species is known from a single specimen. It was taken in Koombana Bay, Bunbury, Western Australia, in 5–8 fms., October 26, 1929. It is only 15 mm. long and is light gray above, with the sole distinctly white. The dorsal pedicels are few and apparently rudimentary, but seem to warrant putting the species in *Psolidium*. It may, however, prove to be a young *Psolus,* with adults lacking dorsal pedicels altogether.

Psolidium sp.?

Cucumaria convergens Joshua, 1914, p. 6 (NON Hérouard, 1901, p. xliii).
Psolidium convergens R. Perrier, 1904. Bull. Mus. hist. nat. Paris, vol. 10, p. 15.
——— 1905. Ann. sci. nat., Zool., ser. 9, vol. 1, p. 38; figs. D, E, F; pl. 2, figs. 2–4.
Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 6.

Through the kindness of Joshua, one of the 3 psolids which he took at Flinders, Victoria, is now in the Museum of Comparative Zoölogy. It is mounted whole, in balsam, on a microscope slide, and measures 9 mm. long by 5 mm. wide. There is no reason that I can see for considering it identical with Hérouard's species. Joshua seems not to have realized that the supposed discovery of so remarkable a Magellanic holothurian on the coast of Victoria demanded full data on the 3 specimens he collected. It is impossible from the mounted specimen at hand to determine anything distinctive about it, save that the pedicels are obvious and apparently occur dorsally as well as ventrally, thus justifying its being placed in *Psolidium*. But I am sure it is not *convergens*. The condition does not admit of any description justifying a new name. I agree with Deichmann (1941, p. 142) that *convergens* Hérouard is not a *Psolidium*.

Order ASPIDOCHIROTA

This order of holothurians is well marked by its peltate tentacles, well developed respiratory trees, and conspicuous pedicels (or papillae). It includes the largest holothurians and many of the most strikingly colored. All the forms that are of commercial importance belong here. Deichmann (1930) recognizes 3 families, which she distinguishes as follows:

Key to the Families of Aspidochirota

A. Tentacle ampullae absent; "rete mirabile" usually absent and respiratory trees free ..... Synallactidae
AA. Tentacle ampullae present; left respiratory tree entangled in a "rete mirabile":
Genital tubules in 2 tufts, 1 on each side of dorsal mesentery ..... Stichopodidae
Genital tubules in tuft on left side only of mesentery ..... Holothuriidae

Family SYNALLACTIDAE

Nearly all the members of this family are deep-sea forms, many occurring only at depths of 2000 fathoms (or more) and very few in water less than 300 fathoms deep. One of the latter group has been taken off eastern Australia, and no doubt others will be found when more dredging is done on the continental slope.

MESOTHURIA

Ludwig, 1894. Mem. Mus. Comp. Zoöl., vol. 17, no. 3, p. 31.

Genotype: *Mesothuria multipes* Ludwig, 1894, p. 31.

Although this genus was monotypic when established, about a dozen species are now included in it, and one of these was met with by the Great Barrier Reef Expedition.

Mesothuria parva

Mesothuria murrayi var. *parva* Théel, 1886. "Challenger" Hol., p. 186; pl. 9, fig. 2; pl. 16, figs. 4, 5.
Mesothuria parva Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 686; pl. 71, figs. 2A–C.

The Great Barrier Reef Expedition took 3 specimens of this holothurian at its station XV, ½ mile outside Cook's Passage in 210 fms., on a bottom of clean sand and coral debris. They measure 55–150 mm., as alcoholic specimens, and are pale gray, with the tentacles darker. The species was previously known from the Hawaiian Islands in 192–429 fms. and from near the Admiralty Islands in 150 fms.

Family STICHOPODIDAE

This group consists of 4 genera, of which 1, *Parastichopus,* occurring on the coasts of Scandinavia, Japan, and California, is perhaps better placed in the preceding family. A second is known only from the West Indian region, but the remaining 2 occur in Australia. They may be distinguished thus:

Calcareous particles in skin in form of tables or at least perforated plates..... *Stichopus*
Calcareous particles only innumerable, minute granules..... *Thelenota*

STICHOPUS

Brandt, 1835. Prodr. descr. anim., p. 50.

Genotype: *Stichopus* (*Perideris*) *chloronotos* Brandt, 1835, p. 50.

Although 50 species have been named in this genus, careful revision (H. L. Clark, 1922) reduces the number of valid forms to about 20. Of these, 7 occur in Australia and make up a conspicuous feature of the holothurian fauna. They are found along shore and in shallow water on all the coasts of the continent and Tasmania also. Three of them occur in the Torres Strait region, but elsewhere it is unusual to find more than one. In spite of their large size, they seem to be of practically no value for bêche-de-mer, although some individuals of the common *variegatus* are apparently included occasionally in the making of "curry fish," one of the least valuable forms marketed.

KEY TO THE SPECIES OF STICHOPUS

A. No buttons among calcareous deposits:
  B. Few rosettes or none among calcareous deposits, but tables present:
    C. Tables with regular spires and smooth disk margins:
      D. Spire of table more or less expanded and open at top:
        C-shaped bodies present, about 40 microns long ..... *chloronotus*
        No C-shaped bodies ..... *mollis*
      DD. Spire of table not expanded, but more or less conical; no C-shaped bodies ..... *ellipes*
    CC. Tables asymmetrical, with more or less deformed spires and often spiny margins ..... *ludwigi*
  BB. Rosettes present:
    E. Large tables with heavy, smooth, conical spires in dorsal papillae ..... *horrens*
    EE. No large tables with conical spires:
      Color fundamentally brown, light (with or without pink or red tinge) or dark or mottled ..... *variegatus*
      Color whitish gray, wisteria mauve, and pale ochre yellow .. *variegatus* var. *pallidus*
AA. Buttons among calcareous deposits ..... *paradoxus*

Stichopus chloronotus [1]

Stichopus (*Perideris*) *chloronotos* Brandt, 1835. Prodr. descr. anim., p. 50.
Stichopus chloronotus Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 315; pl. 17, figs. 20–24; pl. 18, fig. 25.
Kent, 1893. Great Barrier Reef, chromo pl. 12, fig. 3.
H. L. Clark, 1921. Ech. Torres Strait, p. 186; pl. 18, fig. 2 (colored).

Although this is a common holothurian on the Barrier Reef and is widespread in the Indo-Pacific region, it does not seem to occur in Australian seas either west of Torres Strait or south of Queensland. In life its dark green color is very constant and distinctive. It is not a large species, seldom exceeding 300 mm.

Stichopus mollis

Holothuria mollis Hutton, 1872. Cat. Ech. New Zealand, p. 15.
Stichopus mollis Dendy, 1897. Jour. Linn. Soc. (Zool.), vol. 26, p. 46.
Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 387.
Mortensen, 1925. Vidensk. Medd., vol. 79, p. 327; fig. 22.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 511.
Stichopus simulans Dendy and Hindle, 1907. Jour. Linn. Soc. (Zool.), vol. 30, p. 97.
Stichopus simultans Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 388.

Mortensen (1925) has I think shown satisfactorily that *simulans* cannot be wisely distinguished from *mollis,* but must be recognized only as a form of that species, if at all. He says nothing as to the size of the New Zealand specimens, but in Tasmania, *mollis* reaches a length of 250 mm. For a discussion of its diversified coloring see H. L. Clark, 1938, page 311. Joshua (1914) says *mollis* is common in

[1] Whether this name ends in *-us* or *-os* seems to be a matter of opinion. Except Ludwig (1892), modern writers beginning with Selenka and Semper have used *-us*. Brandt used the name but once, and the *-os* in that case may be a slip of the pen or a typographical error. There is no obvious reason for it.

Port Phillip, Victoria, and Erwe (1913) records specimens from near Albany and from Rottnest Island, Western Australia. It is common at Hobart, Tasmania. It would seem, therefore, to occur from southern New Zealand (south of 44° S.) to Tasmania, Victoria, and southern Western Australia (south of 31°).

Stichopus ellipes

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 514; fig. 54.

A single perplexing holothurian taken at Broome in 1929 is the basis for this species, and no more specimens are yet known. It was probably less than 200 mm. long and 35 mm. in diameter in life. The color is brownish gray, with faint blotches of a darker gray on back and sides. Hundreds of minute dark (almost black) dots are scattered irregularly over the animal, chiefly on the dorsal side. The absence of C-shaped bodies and rosettes is notable, and the large tables with many (20 or more) perforations in the disk are very characteristic. Deichmann considers them juvenile tables retained.

Stichopus ludwigi

Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 388; pl. 8, figs. 24*a–f*.

Based on 3 specimens from an unknown locality in southwestern Australia, this species seems to be well characterized by its calcareous particles, especially the tables, as shown in Erwe's admirable figures. The types were 100–110 mm. long and the ground color was reddish gray, more or less spotted, blotched, and marked with brown or blackish. Joshua and Creed (1915) record a specimen from Verco's collections in South Australian waters. It is 120 mm. long, and the color is "fawn, darker dorsally," with the papillae dark brown.

Stichopus horrens

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 316; pl. 18, figs. 27–29.
H. L. Clark, 1921. Ech. Torres Strait, p. 187; pl. 18, fig. 4 (colored).

This appears to be definitely a species of the western Pacific Islands from Hawaii to the Philippines and south to the Tonga Islands, Torres Strait, and Queensland as far south as Low Isles at least. It is fairly common at Mer and Erub under rocks on the reef flats. Adult specimens may be 300 mm. long, and the big tubercles and irregular body form give an "irregular, soft and almost repulsive" appearance. The coloration is usually variegated with white, gray, brown, and blackish, but in some cases it is more uniformly dark and then tends to be dull green of two or more shades.

Stichopus variegatus

Semper, 1868. Holothurien, p. 73; pl. 16 (colored); pl. 17 (colored); pl. 30, figs. 1, 2, 6.

This is the largest species in the genus, with a reported length of 900 mm. and a diameter of 200. It is usually 300–700 mm. long and correspondingly stout. It shows great diversity of color, and Semper's fine colored plates perpetuate two types, but neither represents an Australian form. In my reports (1921, 1938), I have

discussed the great diversity of color and form shown by Australian specimens. The range of *variegatus* is from Zanzibar and the Red Sea to the Caroline and Samoan islands, north to southern Japan and south to Lord Howe Island and southwestern Australia. It is not definitely known on the eastern coast of Australia, south of the Capricorn Islets, Queensland, nor has it yet been taken between Torres Strait and Augustus Island, but it occurs at the latter point and at Broome, at Shark Bay, and even in southwestern Australia (Erwe).

The *Stichopus* of Western Australia need a careful resurvey, for it is probable that several distinct forms occur there. One of these has been named *Stichopus variegatus* var. *pallidus* (H. L. Clark, 1938, p. 514). The unique specimen on which this name rests was dredged in 1929 about 20 miles south of Cape Jaubert, in 5–8 fms., and is now 135 mm. long and 30 mm. in diameter. Color notes made at the time of capture say that "almost equal sized patches of whitish-gray, wisteria-mauve and pale ochre yellow" made up the coloration of the upper surface and sides, and the ventral side was "semi-transparent grayish-white." Probably more material will warrant separating one or more species from the northwestern and western forms of *Stichopus* here included under the broad term *variegatus*.

Stichopus paradoxus

Lampert, 1885. Seewalzen, p. 247; figs. 14, 17, 27.

This species is based on a single specimen, 140 mm. long, in the Stuttgart Museum. The color is uniformly brown. Lampert's description is apparently careful and detailed and indicates a very distinct species. The locality is said to be New Holland, but no information as to time of collection is given. No similar specimen has since been reported, and the specific status must necessarily be considered dubious. Deichmann inclines to the opinion that Lampert's supposedly new *Stichopus* is based on a specimen of *Holothuria leucospilota*. Only a re-examination of the type in Stuttgart can settle the matter.

THELENOTA

Brandt, 1835. Prodr. descr. anim., p. 53.

Genotype: *Trepang ananas* Jaeger, 1833, p. 24.

This genus (see H. L. Clark, 1921, pp. 183–186) was monotypic for eighty-five years or more, but a second species was found at the Murray Islands in 1913, though not named or described until 1921. These rank as the largest known holothurians, although *Stichopus variegatus* is of nearly the same size when fully grown. Unlike that holothurian, these are of great value for bêche-de-mer and hence are of commercial importance. The two species are utterly unlike in external characters and color, but agree in their internal anatomy and spicules. They are easily distinguished thus:

Dorsal side with numerous big pointed or blunt papillae; general coloration orange-brown or brownish orange-red ..... *ananas*
Dorsal side without big papillae; not brownish orange; lower surface white with crowded pedicels ..... *anax*

Thelenota ananas

Trepang ananas Jaeger, 1833. De Hol., p. 24; pl. 3, fig. 1.
Holothuria (*Thelenota*) *ananas* Brandt, 1835. Prodr. descr. anim., p. 53.
Stichopus ananas Semper, 1868. Holothurien, p. 75.
Sluiter, 1901. "Siboga" Hol., p. 30; pl. 2, fig. 1 (colored).
Mitsukuri, 1912. Actin. Hol., p. 150; fig. 25; pl. 1, figs. 6–8.
Thelenota ananas H. L. Clark, 1921. Ech. Torres Strait, p. 184; pl. 18, fig. 2 (colored).

Okinawa, Japan, is the farthest north for this huge East Indian holothurian, and the northern end of the Great Barrier Reef is the farthest south. It has not yet been found west of Java and Torres Strait, but it reaches the Marshall and Society islands on the east and southeast. It grows to a large size, possibly a meter in length; the largest recorded measurements are 750 mm. long, 115 mm. wide, and 85 mm. high. When prepared for market, where they are called "prickly redfish," these huge individuals lose about 60 per cent or more of their bulk and are nearly black. The big dorsal papillae persist as hard, sharp projections; hence the qualifying adjective in the market name. The color in life has been well likened, by Mitsukuri, to that of a ripe tomato. Owing to the great demand, the supply of *Thelenota* in northern Australia has seriously diminished, but possibly the recent war will give a new lease on life to the fishery, as present conditions have probably completely stopped bêche-de-mer collecting.

Thelenota anax

H. L. Clark, 1921. Ech. Torres Strait, p. 185; pl. 18, fig. 3 (colored).

This remarkable holothurian has not been met with, so far as published records show, since its original discovery at the Murray Islands, and all that is known about it is recorded with the original description. Though it is superficially very different from the preceding species, the calcareous particles in the body wall require its being placed in *Thelenota*.

Family HOLOTHURIIDAE

The natural classification of this family has yet to be discovered. It is a large group with scores of species, but the attempts to break it up into genera have as yet proved unsatisfactory. The genus *Actinopyga* is apparently a natural group, and its species are easily recognized. *Labidodemas* is much less satisfactory, and the number of component species is doubtful. The rest of the family are best retained in the old genus *Holothuria*. Pearson (1913–1914) started out on the task of breaking up the genus, but he made little progress and his work has never been continued. Panning (1929–1935) attacked the problem *de novo* and gave promise of reaching some helpful conclusions, but he was diverted into a different line of work and his results were incomplete. Neither Pearson nor Panning had access to sufficient material to enable him fully to meet the problems, and it seems best to continue using the name *Holothuria* in the old wide sense until someone with access to at least half the named species can concentrate on the problem.

The Australian members of this family represent all 3 genera, and these may be distinguished thus:

KEY TO THE GENERA OF HOLOTHURIIDAE

A. No large, conspicuous calcified anal teeth (though anal papillae may be calcified, and in *Holothuria difficilis* seem like such teeth):
  Pedicels in a double series mid-ventrally, less clearly so in lateral ambulacra; calcareous tables with spires terminating in 5 (or 4) long, nearly horizontal points ..... *Labidodemas*
  Pedicels not in longitudinal series, but more or less generally scattered, often transformed into papillae; calcareous tables not as above ..... *Holothuria*
AA. Five large, conspicuous calcified teeth surrounding anus ..... *Actinopyga*

LABIDODEMAS

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 309.

Genotype: *Labidodemas semperianum* Selenka, 1867, p. 309.

Monotypic when established, this genus still contains 1 well validated species.[1] Semper, Ludwig, and Sluiter have each proposed another, but not one of these is well defined and properly validated. The type species is still very imperfectly known, but it has been reported twice from Australia and hence is included here.

Labidodemas semperianum

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 309; pl. 17, figs. 1–3.

Ranging from the Andaman Islands to Tahiti, this holothurian has been found at the Murray Islands, east of Torres Strait, and at Norwest Islet, Capricorn group, Queensland. The Murray Island specimens were found buried in the sand under rock fragments. They were 200–250 mm. long and about one-tenth of that in diameter. The color was a delicate, transparent pink, and the papillae and pedicels were notably long. The preserved specimens are of course much contracted and quite opaque. The Norwest Islet specimen is about 85 mm. long, with diameter ranging from 12 to 28 mm., dull gray becoming almost black anteriorly. Neither the form of the calcareous tables nor the distribution of the pedicels is as distinctive as could be desired, but both characters warrant recognition. There is little doubt that the species is valid, but the status of the genus is rather dubious, and much more material is needed before we can be sure what its real characters are and what its true relationship to *Holothuria* is.

HOLOTHURIA

Linné, 1791. Syst. Nat., ed. 13, vol. 1, pt. 6, p. 3138.

Genotype: *Holothuria tubulosa* Linné, 1791, p. 3138.

In the opinion of the International Commission on Zoological Nomenclature (see Opinion 80, Smithsonian Misc. Coll., vol. 73, no. 2, p. 17), it is best, in order to avoid most disturbing changes in the use of several well known generic names, to

[1] Deichmann's *Labidodemas americanum* (1938) from the west coast of Costa Rica lacks the very characteristic tables of *semperianum*, and I am skeptical as to the two being congeneric.

ignore Linné's use of *Holothuria* in 1758 and date the name from 1791. This official opinion has been unanimously agreed to. But, although the name is no longer debatable, the limits and contents of the genus are vague in the extreme, for there is no doubt that in the broad sense, used here, several genera are confused under *Holothuria*. Since the Australian species, although numerous, make up only about one-third of those already named, this is not the place to undertake a revision of the genus. The following key therefore ignores the great majority of known Holothurias and will serve only for identification of the Australian forms. Nevertheless it is possible that some of the main divisions here recognized may ultimately serve as nuclei for useful genera.

Key to the Species of Holothuria

A. Tentacles 20:
- B. No tables among calcareous deposits, except possibly in juveniles:
  - C. Calcareous particles more or less incomplete rosettes:
    - Dorsal side with large brown elliptical or circular spots encircled with white ..... *argus*
    - No conspicuous spots, though irregular dark blotches may occur ..... *marmorata*
  - CC. Calcareous particles not rosette-like:
    - D. Calcareous particles in form of rods, usually branched or enlarged at ends:
      - Rods short and wide, with irregular projections, more or less flattened and smooth ..... *erinaceus*
      - Rods long, narrow, with irregular branched ends and granulated surface ..... *moebii*
    - DD. Calcareous particles in form of minute irregular plates, with or without a few perforations and knobs ..... *michaelseni*
- BB. Tables among calcareous deposits:
  - E. Tables only ..... *modesta*
  - EE. Tables accompanied by accessory particles:
    - F. Accessory particles small plates or rods; tables reduced, with simple annular disk:
      - G. Accessory particles small irregular plates, usually perforated:
        - Pedicels and papillae well developed, numerous both dorsally and ventrally; unicolor; disk of tables fairly well developed; accessory particles, small plates with about 4 perforations or slits, many reduced ..... *atra*
        - Pedicels and papillae small, not very numerous; upper surface brown, lower rose red in life, dirty whitish in alcohol; disk of tables reduced to ring; accessory particles also reduced, often only X-shaped granules ..... *edulis*
      - GG. Accessory particles rods:
        - Rods slightly curved and finely granulated ..... *cinerascens*
        - Rods irregular, not granulated, often flattened, with loops or perforations along side ..... *pervicax*

FF. Accessory particles perforated plates or buttons or more complicated bodies:
H. Accessory particles fenestrated ellipsoids; commonly without plates:
Color black, with white or yellowish tentacles; fenestrated bodies short and thick, not twice as long as wide ..... *coluber*
Color yellowish brown, lighter ventrally; fenestrated ellipsoids 3 times as long as wide ..... *axiologa*
HH. Accessory particles buttons or flat perforated plates:
I. Buttons, at least in large part, with knobs or rough surface:
J. No smooth buttons:
K. No true pedicels, body covered above and below with papillae of some sort:
L. Papillae of back more or less white or light-colored, encircled at base by dark brown ring, often surrounded by outer white ring or area:
Tables with capitate thorny tops; no large tables with spire drawn out into long, simple point; elongated narrow buttons with 5 or more pairs of holes present ..... *ocellata*
Tables with low, squarish tops having few coarse teeth; large tables, with spire drawn out into long, simple point, present in papillae; no very elongated narrow buttons ..... *spinifera*
LL. Papillae not thus encircled:
M. Tables not peculiar, spire low, made up of 4 rods and only 1 or 2 crossbars ..... *scabra*
MM. Tables markedly peculiar:
Tables with high, somewhat tapering spire of 4 rods and 4–7 crossbars ..... *martensii*
Tables with 6–10 vertical rods capped with large, hemispherical spiny top ..... *albiventer*
KK. Pedicels present but sometimes few and very small:
N. Tables greatly reduced, spire seldom complete, but indicated only by 4 vertical rods ..... *notabilis*
NN. Tables not reduced, but often hypertrophied:
O. Tables of 2 kinds, the larger with spire fused into a simple, blunt, conical point ..... *fusco-olivacea*
OO. Tables of only one kind:
P. Spire of table more or less conical, with 3–6 crosspieces ..... *conica*
PP. Spire of table low, with more or less expanded tip and only 1 crosspiece; disk more or less convex:

Spire of table with 4–8 vertical rods, tending to become spiny hemispheres; buttons very knobby, often with 5–8 pairs of holes ..... *rigida*

Spire of table with 4 rods, and tending to become reduced; buttons not so knobby, with commonly 3 pairs of holes ..... *inhabilis*

JJ. Some smooth buttons without knobs, with 3–7 pairs of holes ..... *bowensis*

II. Buttons smooth, often reduced, with only 2–4 holes:

Q. Papillae all over body ..... *impatiens*

QQ. Papillae present only dorsally or wanting:

R. Papillae on dorsal side:

S. Tables of 2 kinds: ordinary, with smooth, flat disk having 8 marginal perforations; larger and rarer, with cruciform disk, tip of each branch expanded and perforated; buttons stout but smooth and regular ..... *altimensis*

SS. Tables all of one kind, but diverse in size and details:

T. Spire of 4–6 rods; disk with dentate margin; buttons short and wide, with 3–6 pairs of holes ..... *rugosa*

TT. Spire of 4 rods only; disk margin smooth:

U. Spire more or less incomplete; often vertical rods are not united and number may be reduced to 3 or 2; buttons thin and flat and usually with only 1 pair of slitlike perforations ..... *fuscocinerea*

UU. Spire normal; buttons with 3 or more pairs of perforations:

V. Buttons long and narrow, with 3–6 pairs of slitlike perforations .. *macroperona*

VV. Buttons shorter and wider, with 1–3 pairs of perforations:

Color uniformly brown; ventral pedicels more or less crowded, not in 3 longitudinal series; top of table-spire with many (20–30) teeth; anal papillae calcified, appearing like anal teeth ..... *difficilis*

Color not uniformly brown; ventral pedicels more or less evidently in 3 longitudinal series; spire of table with fewer (12–16) teeth; no indication of anal teeth ..... *monocaria*

RR. No papillae; pedicels all over body:
W. Tables of 2 kinds: mostly of usual type, spire of 4 rods and 1 crossbar, terminating in about 12 thorns; larger ones with elongated spires having 3 or 4 transverse bars and terminating in 4 thorns ..... *remollescens*
WW. Tables all of one kind, though there may be much diversity in size and details:
X. Buttons in little circles or heaps:
Disk of tables with marginal teeth ..... *pardalis*
Disk of tables without marginal teeth ..... *cumulus*
XX. Buttons not in heaps:
Y. General form very *Stichopus*-like, ventral surface well set off from dorsal; color gray, more or less variegated or marked with brown, or uniformly brown; supporting rods of ventral pedicels, elaborated buttons with 10 or more holes ..... *hartmeyeri*
YY. Not as above:
Z. Dorsal pedicels with spinous rods tapering toward ends ..... *leucospilota*
ZZ. Dorsal pedicels without spinous rods:
Buttons small, flat, with 1 or 2 pairs of slitlike holes, or with pair of long slits, at each end of which is small circular hole ..... *homoea*
Buttons regular, with 3 pairs of holes ..... *arenicola*
AA. Tentacles 25–30 ..... *verrucosa*

Holothuria argus

Bohadschia argus Jaeger, 1833. De Hol., p. 19; pl. 2, fig. 1.
Holothuria argus Semper, 1868. Holothurien, p. 80; pl. 30, fig. 11.
Kent, 1893. Great Barrier Reef, chromo pl. 12, fig. 7.

Although this very strikingly colored holothurian has a range in the Indo-Pacific region from the Seychelles to Tahiti and northward to the Ryukyus, it enters the Australian region only at the northern end of the Barrier Reef. It is not uncommon at the Murray Islands, and has been reported from Cooktown, but it has not been taken in Torres Strait, nor did the Barrier Reef Expedition meet with it in the Low Isles region. It grows to a length of a foot or more and is quite plump. It would seem admirably adapted for bêche-de-mer, but is not greatly esteemed for that purpose. The market names are "leopard fish," "spotted fish," and "tiger fish." In life the ground color is brown, dull gray, or purplish of some shade, with the conspicuous white-encircled spots of a different and contrasting shade of brown. This striking coloration is fairly well retained in alcoholic material, and may even be detected in some bêche-de-mer of the market.

Holothuria marmorata

Bohadschia marmorata Jaeger, 1833. De Hol., p. 18; pl. 3, fig. 9.
Holothuria marmorata Semper, 1868. Holothurien, p. 79; pl. 30, fig. 10.

This is one of the largest species of *Holothuria* found in the Australian region, where it occurs on both the northeastern (Low Isles, Murray Islands) and the northwestern coasts (Broome). Its known range is from Mauritius to Fiji and north to the Ryukyus. It grows to a length of 400 mm. or more, with a diameter about one-fourth as much. It is collected largely for bêche-de-mer, but is graded and sold under two different names, "sand fish" and "chalky fish." The color in life is pale or yellow-brown above, lighter (sometimes white) beneath, usually with 2 or 3 large, irregular brown blotches on the upper side; the pedicels are darker than the body wall, and the tentacles are gray-brown, darker than the body.

Holothuria erinaceus

Semper, 1868. Holothurien, p. 91; pl. 30, fig. 24.

Originally described from the Philippines, Fiji, and Port Mackay, Queensland, this holothurian has not been reported since save by the Great Barrier Reef Expedition, which took a small specimen in 1929 at the Low Isles. Semper gives the length as 18–20 cm. and the color as gray-brown. It is rather remarkable that, although the "Siboga" took 38 species of *Holothuria* in the East Indian region, *erinaceus* was not among them.

Holothuria moebii

Ludwig, 1883. Ber. Oberhess. Gesellsch. Nat.- u. Heilk., p. 171.
Mitsukuri, 1912. Actin. Hol., p. 92; fig. 19.

In 1938 (p. 526, footnote), I expressed my disagreement with Mitsukuri's opinion that *moebii* is a variety of Selenka's Panamic species *lubrica*. The Indian species was described from Hong Kong and has since been reported from Mauritius, the Philippines, southern Japan, the New Hebrides, and Lord Howe Island. Semon did not find it at Amboina, nor did the "Siboga" take it in the East Indies. The color in life is brown with the feet yellowish, and preservation in alcohol alters it little. The ventral surface, with crowded pedicels, is markedly set off from the dorsal. The Lord Howe specimen is 110 mm. long by 30 in diameter. Deichmann reports scattered tables in young *moebii* (see *H. cinerascens*).

Holothuria michaelseni

Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 384; pl. 7, figs. 20*a–c*.

The remarkable black and white coloration makes this endemic holothurian of Western Australia easy to recognize, and the calcareous particles are equally characteristic. Only 5 specimens are as yet known, all from northwestern Australia between Shark Bay and Pender Bay (inclusive). Adult individuals are 100–125 mm. long in life. Deichmann thinks juveniles would have tables, but such juveniles are not yet known.

Holothuria modesta

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 106; pl. 7, fig. 26.

Described from Cape York and subsequently reported from Port Curtis and islands in Torres Strait, this holothurian is now known to be common in the Broome region. It also occurs in the East Indies, but records from the Red Sea and from the vicinity of Fremantle are based on poor material and need verification. Adult specimens are 100–125 mm. long. The color is dull gray or more or less variegated with shades of brown, purple, and gray, or even whitish. The tentacles are notably short, yellow or cream color. The animal is inert and clings closely to the under side of rock fragments in shallow water. The flatter ventral side is supplied with rather numerous pedicels in 3 more or less ill-defined series, and usually contrasts with the convex dorsal side, which has fewer and more irregularly distributed pedicels. Deichmann has found scattered rosettes as well as tables in some cases.

Holothuria atra

Jaeger, 1833. De Hol., p. 22.
Semper, 1868. Holothurien, p. 88; pl. 26 (colored).
Théel, 1886. "Challenger" Hol., p. 181; pl. 7, fig. 4.

From Mozambique to Tahiti and northward to tropical Japan is the range of this common and very widespread species. The calcareous particles are relatively simple, not very variable, and quite characteristic. The color is dark brown or black; in life the tips of the papillae and pedicels and occasionally the margin of the periproct may be light, even white, but this is not evident in alcoholic material. The usual size for an adult is 200–300 mm., but large individuals are sometimes 600. In Australia, *atra* ranges from Lord Howe Island on the southeast, northward to the Murray Islands and westward to Augustus Island in the northwest, but we did not find it at Darwin. Records from "Adelaide" and other points on the southern coast are almost certainly mistakes. See H. L. Clark, 1921, page 174, and 1938, page 517, for observations on appearance and habits in life and its use as bêche-de-mer, under the name "lolly fish."

Holothuria edulis

Lesson, 1830. Cent. zool., p. 125; pl. 46, fig. 2.
H. L. Clark, 1921. Ech. Torres Strait, p. 177; pl. 19, fig. 4 (colored).

This species ranges from Aden and Mozambique to the Philippines and the Ryukyus on the north and to the Caroline and Fiji islands on the east. In Australia, it is known only from the eastern coast between the Murray Islands and the Capricorn group. It is not large, usually less than 300 mm. in length, though occasionally one reaches 400. Its coloration is handsome and distinctive, brown above and rose red ventrally. The rose color is fugacious, and the lower surface is dirty whitish in alcoholic specimens. The calcareous particles have not been well figured, but Selenka's figures of the particles which he refers to *fuscocinerea* (1867, pl. 19, fig. 86) are considered by Semper and Théel to be those of *edulis*.

Holothuria cinerascens

Stichopus (*Gymnochirota*) *cinerascens* Brandt, 1835. Prodr. descr. anim., p. 51.
Holothuria pulchella Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 329; pl. 18, figs. 61, 62.
Holothuria cinerascens Lampert, 1885. Seewalzen, p. 82.
Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 654; pl. 68, figs. 1*a–f*.
Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 377; pl. 6, figs. 15*a, b*.

Only the respect due to Erwe's excellent work leads to the inclusion of this widely distributed Indo-Pacific holothurian in the Australian fauna. He records 1 specimen from an unknown station in southwestern Australia. Though it is very probable that there is some mistake about the locality label of this specimen, the species is so widely distributed throughout the islands of the Indian and Pacific oceans, its occurrence in tropical Australia is quite likely. It is, according to Fisher, reddish purple to brownish purple when living; the alcoholic specimens are purplish brown, lighter below. It grows to a length of about 160 mm. Deichmann thinks *cinerascens* and *moebii* have been confused, for when the tables are scarce, specimens of *cinerascens* are very hard to distinguish from *moebii*.

Holothuria pervicax

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 327; pl. 18, fig. 54.
H. L. Clark, 1921. Ech. Torres Strait, p. 181; pl. 19, fig. 1 (colored).
Holothuria fuscocinerea Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 379; pl. 6, figs. 16*a–d*.

As was stated in 1938 (p. 529), Erwe's action in uniting Selenka's well marked species with Jaeger's more dubious one is ill advised, as the 2 species seem to be quite readily separable. There is little doubt that Erwe's specimen from Shark Bay is a typical *pervicax,* but its occurrence in Shark Bay is unexpected, since the species has not yet been found elsewhere west of Torres Strait. It is common at Erub and the Murray Islands, but is as yet unknown between that region and Lord Howe Island, far to the south (where it is fairly common), except for the single specimen dredged southeast of Lizard Island, in 19 fms., by the Barrier Reef Expedition in 1928. Apparently it is local in occurrence, and possibly it prefers the tantalizing area along the outer side of reefs and shores between 10 and 100 fms., where collecting is well-nigh impossible. It is a rather handsome species in life, with a variegated brown back and a white ventral surface and translucent white tentacles. Full-grown specimens are 300 mm. long. The species is widely distributed from the Red Sea and Zanzibar to Hawaii and Tahiti.

Holothuria coluber

Semper, 1868. Holothurien, p. 90; pl. 28 (colored); pl. 30, figs. 28*a, b*.

This is one of the most noticeable of the holothurians found in the Torres Strait region, the contrast between the white (or yellowish) tentacles and the black body being very striking. Semper's colored figure is admirable. Adult specimens are 500–600 mm. long and the body wall is firm and rather thick, yet it is rejected as a source of bêche-de-mer. The distribution of *coluber* is peculiar, for though it was originally

found in the Philippines, and occurs in Torres Strait, the "Siboga" failed to find it in the East Indies (save for 1 specimen at Lumu-Lumu in the Strait of Macassar), nor did Semon find it at Amboina. The "Challenger" failed to collect it, nor is it known from Japan. We failed to obtain a specimen anywhere in Australia in 1929 or 1932, but in 1913 it was very common at Mer, and we also found it at Thursday Island and Erub. Kent (1893) found it "common on inshore reefs" of tropical Queensland, but we do not know how far south. The Great Barrier Reef Expedition took a single specimen at the Low Isles, but there are no other definite records from the Queensland coast.

Holothuria axiologa

H. L. Clark, 1921. Ech. Torres Strait, p. 175; pl. 38, figs. 1–13.

No further specimens of this big holothurian have been taken since the unique holotype (600 mm. long, 100 mm. wide, 75 mm. high) was found at Mer, Murray Islands, in 1913. In life, the color was yellowish brown dorsally with dark brown pedicels, whitish with yellow pedicels ventrally and on the sides. The color in alcohol shows a loss of yellow tints. Deichmann thinks Jaeger's *fuscopunctata* may have been based on a specimen of *axiologa,* but as his name was previously used by Quoy and Gaimard for another species (probably *monocaria* Lesson), the name *axiologa* must be used.

Holothuria ocellata

Bohadschia ocellata Jaeger, 1833. De Hol., p. 19.
Holothuria ocellata Semper, 1868. Holothurien, p. 80.
Théel, 1886. "Challenger" Hol., p. 178; pl. 7, fig. 11; pl. 16, fig. 1.

This strikingly marked holothurian seems to be quite a rarity. Jaeger's type was from the Celebes, the "Challenger" took 1 specimen at the western end of Torres Strait in 28 fms., and the Barrier Reef Expedition took 1 large specimen in 10 fms. off Howick Island, Queensland. The last was referred to *ocellata* by me (1932), but a more critical examination may show it should be referred to *spinifera.* Erwe (1919) reports *ocellata* from the Red Sea, and Pearson (1910*a*) from the Mergui Archipelago, but these identifications need to be verified in the light of our present knowledge of *ocellata.*

The "Gier" took "zahlreiche Exemplare" of a holothurian, at various stations in the Java Sea, which Sluiter (1914) referred to *Holothuria squamifera* Semper. Special reference is made to specimens from 6° 28′ S. by 112° 39′ E., at 60 m., in which the tubercles and papillae were extraordinarily large and the coloration was unusually striking. One of these specimens is now in the Museum of Comparative Zoölogy and has been critically studied by Deichmann, who believes it is Jaeger's *ocellata,* a conclusion resting on the belief that Théel's description and figures in the "Challenger" report represent Jaeger's species. The matter is complicated by Théel's description and figures of a species, *spinifera,* based on a single specimen taken by the "Challenger" at her station 208, in the Philippine Islands, in 18 fms. The striking feature of this species is the big tables in the papillae, which terminate in a long-drawn-out simple point. On examining the holothurians from Broome and Augustus Island which I called *ocellata* (1938, p. 527), Deichmann found some of

these characteristic big tables and concluded that these specimens are *spinifera.* After a very careful comparison of the external characters and calcareous particles, I think Deichmann is correct. The tables that Théel figures are not the tables of the *ocellata* which the "Gier" took north of Java. It is therefore doubtful whether *ocellata* really occurs in Australia, but it is included here on the strength of the "Challenger" specimen from Torres Strait (station 188, 28 fms.) and the Great Barrier Reef specimen (off Howick Island, 10 fms.). Both these specimens are in the British Museum and should be re-examined, with particular reference to the tables. There is no published figure of the typical tables of *ocellata,* but they are unmistakable—assuming, of course, that the "Gier" specimens are *ocellata.*

To sum up, then, we have the following situation: The "Gier" took, north of Java, certain holothurians which Sluiter called *squamifera* Semper. One of these in the M.C.Z. collection has numerous capitate tables with thorny tops. (There is no published figure of just such a table.) Deichmann considers this to be *ocellata* Jaeger as figured by Théel, though he neither figures nor mentions the characteristic tables. Specimens from northwestern Australia reported by me (1938) as *ocellata* are undoubtedly *spinifera* Théel. Further study of the "Gier" specimens in Amsterdam and of "Challenger" and Barrier Reef material in the British Museum is absolutely necessary.

Holothuria spinifera

Théel, 1886. "Challenger" Hol., p. 175; pl. 8, fig. 1.
Holothuria ocellata H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 527 (NON Jaeger, 1833, p. 19, or Théel, 1886, p. 178).

The only representatives of this species hitherto known were the unique holotype from the Philippines, a rather large holothurian 240 mm. long, and a specimen, not half so large, recorded by Ludwig (1887) from Ceylon. The specimens from northwestern Australia, referred to above (H. L. Clark, 1938), are also only about half as large as the holotype. They show considerable diversity of coloration, the one from Augustus Island being conspicuously lighter than those from Broome. The actual distribution of *spinifera* cannot be determined until the line between it and *ocellata* is clearly recognized.

Holothuria scabra

Jaeger, 1833. De Hol., p. 23.
Semper, 1868. Holothurien, p. 79; pl. 19.
Mitsukuri, 1912. Actin. Hol., p. 135; fig. 24.

This big holothurian is a typical Indo-Pacific species, ranging from Port Natal to the Red Sea on the East African coast and thence eastward to the Caroline and Fiji islands. It does not seem to have reached Hawaii or Tahiti, but it does occur at the Ryukyu Islands in the north, and on the south it reaches Lord Howe Island. It seems to be not uncommon throughout the Barrier Reef region, but we did not find it at Mer, and Kent (1893) does not mention it. Yet it is present in Torres Strait, as we found it on the sand flat southwest of Friday Island. The Barrier Reef Expedition found it common at the Low Isles. It has not yet been reported from west of Darwin. It is extensively used for bêche-de-mer and is marketed at

Thursday Island as either "sand fish" or "curry fish." It grows to a large size (400 mm. long by about one-fourth as much in diameter), but shrinks about one-third in alcohol. The color seems to be unusually varied; the upper surface ranges from light gray or dull cream color to olive brown, or on the other hand to almost black; the lower surface is lighter, often white. The papillae and pedicels commonly have dark tips, but the tentacles are reddish yellow, yellowish, or white. The back may be finely speckled with blackish or it may have a few large blotches of some shade darker than the ground color.

Holothuria martensii

Semper, 1868. Holothurien, p. 86; pl. 30, fig. 16.
Théel, 1886. "Challenger" Hol., p. 177; pl. 7, fig. 12; pl. 16, fig. 2.
H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 233.
Holothuria subverta H. L. Clark, 1921. Ech. Torres Strait, p. 182; pl. 38, figs. 25–32.

This is an obscure and rarely collected little holothurian, 150 mm. or less in length, the width one-fourth to more than one-third as much, and the height usually much less than the width. It lives on the lower side of rock or coral fragments, more or less buried in mud. The dull color corresponds to the habitat. The type was from Amboina, and 2 less typical specimens were from Mariveles, Philippine Islands. The "Challenger" took the largest known specimen at her station 188, near the western end of Torres Strait in 28 fms., and a smaller individual in the Philippines. Pearson (1910) records 2 small specimens from the coral reef south of Pekawi, Kerimba Archipelago, Portuguese East Africa. We took a single specimen at Mer on the under side of a rock on the reef flat. It was dull gray, brownish dorsally. The papillae show no little diversity of form, and many of those on the ventral surface are much like pedicels. The resemblance between the dorsal and ventral sides of the animal is striking. Théel's figure represents the largest known specimen, and the papillae appear to be much less numerous than in the specimen we took at Mer, which was only two-thirds as large. The Barrier Reef Expedition took 2 half-grown specimens near Lizard Island, in 8–13½ fms., in 1 of which the ventral papillae are very white.

Holothuria albiventer

Semper, 1868. Holothurien, p. 83; pl. 30, fig. 14.
Erwe, 1919. Mitt. Zool. Mus. Berlin, vol. 9, p. 185; fig. 4.

Although this species has been met with frequently, few specimens are known. They range from 40 to 130 mm. in length, with the diameter from one-fourth to one-half as much according to the degree of contraction. The color in life is not known, but the best-preserved specimens are, according to Erwe, brown above with a few large dark brown spots, and lighter beneath with each papilla surrounded by a white patch. All the papillae are white. As yet, *albiventer* has been found only twice in Australia. The Barrier Reef Expedition took 3 specimens in Penguin Channel and off Direction Island in 10–19 fms. The Perth Museum has a single specimen taken at Carnarvon, Western Australia. It must be rare or local, as we did not find it at Mer, Darwin, or Broome. The known range is from the Kerimba Archipelago to the Red Sea and eastward to the Philippine Islands and Queensland.

As yet it is not known from farther east save for Théel's specimen in the Stockholm Museum, labeled as from "the Pacific Ocean."

Holothuria notabilis

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 102; pl. 7, fig. 43.

The unique holotype of this species came from Bowen, Queensland, and no other specimens have been referred to it since, except the 2 taken by the Great Barrier Reef Expedition in 1929 (see H. L. Clark, 1932). Lampert (1885) described a *Holothuria klunzingeri* from Kosseir, and Sluiter (1894) referred a specimen from Amboina and one from Macassar to Lampert's species. Panning (1935) treats Lampert's species as a synonym of Ludwig's, and this reference seems almost surely correct. The Barrier Reef specimens are only about half (or less) as big as Ludwig's, which was 150 mm. by 30, but they have a somewhat similar brownish coloring with a double series of darker blotches on the back. The calcareous particles of *notabilis* are distinctive, but Ludwig's figures are inadequate.

Holothuria fusco-olivacea

Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 672; pl. 69, figs. 3, 3*a–f;* pl. 70, fig. 3.

This rare species is included here on the strength of a single specimen, 60 mm. long, from the Low Isles (see H. L. Clark, 1932, p. 232). It is otherwise known only from the unique holotype, taken at the Hawaiian Islands, unless it proves to be identical with *H. olivacea* Ludwig.

Holothuria conica

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 531; fig. 55.

This species is based on 2 specimens from Quail Island, west of Darwin, Northern Territory, taken in 1929, the larger of which was 150 mm. long. A third specimen is in the South Australian Museum; although labeled as from the Semaphore, Lefevre's Peninsula, South Australia, it is more likely to have come from the coast of the Northern Territory. The possibility that *conica* is identical with *bowensis* Ludwig has been suggested, but the difference in the tables seems to me too great to admit of their union.

Holothuria rigida

Stichopus rigidus Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 317; pl. 18, figs. 30, 31.
Holothuria rigida Semper, 1868. Holothurien, p. 79.
Cystipus pleuripus Haacke, 1880. *In* Möbius: Beitr. zur Meeresfauna Mauritius, p. 47.
Holothuria pleuripus Ludwig, 1883. Ber. Oberhess. Gesellsch. Nat.- u. Heilk., vol. 22, p. 174.
H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 235.

This small, sedentary holothurian ranges throughout the Indo-Pacific region from Mauritius to Hawaii and Tahiti, but it has not often been taken and is still imperfectly known. Selenka did not distinguish it from the following species, with

which it is still often confused. In H. L. Clark, 1921 (p. 178) I fail to distinguish it clearly from West Indian forms, as well as from *inhabilis*. Thanks to Deichmann, distinguishing lines may be found between these closely related forms, but further investigation on living material is necessary to determine their validity for separating species. There are specimens of *rigida* in the Museum of Comparative Zoölogy (as determined by Deichmann and confirmed by me) from the Society Islands, Queensland, and the Philippines. The Society Islands specimen is the holotype. The Queensland specimens are from Turtle Bay, Green Island, and Mer; the 2 latter were hitherto regarded by me as *hypamma* (= *inhabilis*). The Philippines specimen, from Port Galera, Mindoro, has also been catalogued as *hypamma*. The Green Island specimen has the upper side brownish, the lower more nearly white. The other specimens all are more or less completely bleached. The longest, the holotype, is about 75 mm. long, but narrow (10–12 mm.) and flat. The specimen from Mer is in better condition but is equally bleached.

Holothuria inhabilis

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 333; pl. 19, figs. 73, 74.
Holothuria hypamma H. L. Clark, 1921. Ech. Torres Strait, p. 177; pl. 38, figs. 20–24.

The holothurians of this type have been a source of confusion and difficulty for over a hundred years. It was noted long ago that more than 1 species was included under the name *Stichopus rigidus* Selenka (which all are agreed is not a *Stichopus*), and possibly one of these was the form called *fuscopunctata* by Jaeger. But Jaeger's name is preoccupied by *Holothuria fuscopunctata* Quoy and Gaimard, and their name is a synonym of *Holothuria monocaria* Lesson. The question as to the correct name for Jaeger's species seems to be debatable. If Semper's figures are to be relied on, the name *rigida* Selenka would seem to be available. Whether *rigida* and *inhabilis* are specifically distinguishable may be open to question, but in my opinion they are distinct and can be told apart by the tables, though each species may have atrophied or hypertrophied tables resembling those normal to the other.

Deichmann's studies on the Museum of Comparative Zoölogy holothurians show that the form I described from the Murray Islands under the name *hypamma* is the same as Selenka's species *inhabilis* from the Hawaiian Islands. The distribution of *inhabilis* is only imperfectly known. The type localities are given by Selenka as Hawaii and the Society Islands. We found it at Mer at the northern end of the Barrier Reef, but it has not yet been found elsewhere in Australia, including Lord Howe Island. That it also occurs on the western coast of tropical America is indicated by specimens in the M.C.Z. In life it may be 250 mm. long or even more, but most preserved specimens are much smaller than that. The body is more or less depressed and tapers somewhat toward each end; the width at the middle may be one-fourth the length. In life the ground color of small specimens is white, but this becomes grayish or pale brown in preserved material, particularly in large specimens. There are often 2 series of dark blotches on the back, with or without numerous blackish spots. The surface of the body is often covered, in the smaller specimens at least, with sand grains held by a cement-like mucus. The animals are apparently very sedentary and commonly solitary, often living buried in the sand under stones or attached to the lower surface of rock fragments partly buried in the sand.

Holothuria bowensis

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 111; fig. 37.

This species is based on a single specimen, 45 mm. long by 15 in diameter; the color is gray, indistinctly marked on the back with blackish. It was taken at Bowen, Queensland. No second specimen has yet been found, and the suggestion has been made that the type of *bowensis* is simply a young *martensii*. This is not incredible, but for the present it is best to let *bowensis* stay in the list of Australian holothurians.

Holothuria impatiens

Fistularia impatiens Forskål, 1775. Descr. anim., p. 121.
Holothuria impatiens Gmelin, 1788. Linné: Syst. Nat., ed. 13, vol. 1, pt. 6, p. 3142.
H. L. Clark, 1921. Ech. Torres Strait, p. 178; pl. 19, figs. 3, 5 (colored).
——— 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 232.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 521.

This big, easily recognized holothurian has a nearly tropicopolitan distribution, though there seem to be no records as yet from the western coast of Africa. It ranges from the Mediterranean and Mozambique, across the Indian Ocean and the Pacific to Hawaii, the Galápagos, and the Panamic region, and also occurs throughout the West Indian area from Bermuda to Trinidad. It has not yet been found in New Zealand, nor does it occur at Lord Howe. But it is widely distributed on the tropical coasts of Australia from Queensland (at least as far south as Great Barrier Island) to Shark Bay on the western coast. It is usually 150–250 mm. long and 20–25 mm. in diameter, but large specimens may be 400 mm. long and 45 mm. in diameter (see Semper, 1868, pl. 22). The diversity of color is remarkable, and the following color forms have been named:

More or less unicolor, though sometimes diversified by various shades:
Purplish gray ..... var. *concolor*
Yellow-brown or brownish yellow ..... var. *lutea*
More or less variegated, often transversely banded; ground color gray or brown (sometimes light), with black, white, and dull purple shades and markings; papillae often with light tips ..... *impatiens s. s.*
More or less bicolored, papillae contrasting with ground color:
Papillae abruptly yellow against dark purple background ..... var. *bicolor*
Papillae abruptly dark brown against greenish-yellow background ..... var. *pulchra*

Among or under rocks near low-water mark on sandy shores is the favorite habitat of *impatiens*. It is somewhat gregarious in some areas. When the animal is disturbed, the copious Cuvier's organs are commonly discharged, their pure white color contrasting markedly with the animal and its surroundings.

Holothuria altimensis

H. L. Clark, 1921. Ech. Torres Strait, p. 172; pl. 37, figs. 20–29.

This species is known only from a single specimen, 20 mm. long, brown, with pedicels and branches of tentacles deep yellow. It was found on the under side of a rock fragment at Mer, Murray Islands, in 1913. The close resemblance to *Holothuria difficilis* was noted, but there are no Cuvier's organs in *altimensis*.

Holothuria rugosa

Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 110; pl. 7, figs. 33*a–c*.

A single specimen, found buried in sand under a rock fragment at Mer, Murray Islands, in 1913, is the basis for including this rare species in the Australian fauna. It is 130 mm. long and about 25 mm. in diameter. The color is yellowish white with the tentacles somewhat darker. The species is little known, but has been taken occasionally in the East Indian region and the western Pacific from the Andaman Islands to Samoa. Deichmann thinks it is better placed in *Labidodemas,* but until that genus is more sharply defined, it seems just as well to leave *rugosa* in *Holothuria.*

Holothuria fuscocinerea

Jaeger, 1833. De Hol., p. 22.
Semper, 1868. Holothurien, p. 88; pl. 27 (colored); pl. 30, figs. 22*a, b.*
H. L. Clark, 1921. Ech. Torres Strait, p. 177.
Holothuria curiosa Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, p. 110; pl. 7, fig. 29.
H. L. Clark, 1932. Sci. rept. Great Barrier Reef Exped., vol. 4, p. 231.

Panning (1935, p. 4) adopts Ludwig's name (*curiosa*) for this species on the ground that Jaeger's name is "burdened with great uncertainty," but Semper (1868) has definitely fixed the name to the form, which he figures beautifully and describes adequately under Jaeger's name. Ludwig (1874) redescribed it under the superfluous name *curiosa.* Panning has also confused *pervicax* with this species, but the two are not difficult to distinguish. The little platelike buttons with only 2 holes are very distinctive.

The distribution of *fuscocinerea* is not clearly known. Erwe's record from Shark Bay, Western Australia, is based on a specimen of *pervicax.* Kent records it from the Barrier Reef, and we found it at Mer and Thursday Island. The type of *curiosa* was taken at Bowen, Queensland, and the Barrier Reef Expedition found a similar specimen at Low Isles. But neither in 1929 nor in 1932 were any holothurians taken by us which can be referred to this species. Outside of Australia, there are records from Ceylon, the Philippines, Celebes, Fiji, and Samoa. It is also reported from Japan, but Mitsukuri (1912) does not include it in his monograph. It is rather large, reaching a length of over 200 mm. The coloration as shown by Semper's figure is notably handsome in life, but preserved specimens are not striking. In some cases the bases of the papillae are surrounded by dark rings, but these are not evident in Semper's figure.

Holothuria macroperona

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 535.

This little holothurian, less than 20 mm. long, lives on the under side of rock fragments on sandy bottom at Rottnest Island, Western Australia. It has not yet been found elsewhere. The color in life is pale gray or sand color, in harmony with the environment. Preserved specimens are white, gray, or brown. Deichmann inclines to the view that these little holothurians are the young of *hartmeyeri.*

Holothuria difficilis

Semper, 1868. Holothurien, p. 92; pl. 30, fig. 21.
(*Actinopyga parvula* H. L. Clark, 1921. Ech. Torres Strait, p. 190; probably also of Fisher, 1907, p. 645, *et al.*)

The confusion between *Holothuria captiva* Ludwig, *H. difficilis* Semper, and *Mülleria parvula* has been so complete that radical treatment is necessary. Deichmann (1930, pp. 70–71), taking *parvula* out of *Mülleria* (= *Actinopyga*), treats it as a *Holothuria,* in spite of calcified anal papillae which occur in many adult specimens, if not all. Those without such "anal teeth" are of course *H. captiva* Ludwig, and that name is thus a synonym of *parvula.*

The same course must be pursued with Indo-Pacific specimens which have been called *parvula.* They must be treated as *Holothuria,* whereupon it is obvious that they are *H. difficilis* Semper. As Deichmann has said (1930, p. 72), it seems better for the present to treat *difficilis* and *parvula* as distinct species, but the differences are rather intangible. The nature of the so-called anal teeth in the 2 species and their relation to the anal teeth of *Actinopyga* need careful study. Are they homologous? Are they perchance a senescent growth? Until such questions can be answered, it is best to keep the West Indian and Indo-Pacific forms separate and leave them in the heterogeneous group *Holothuria.*

At Lord Howe Island, *difficilis* is one of the commonest holothurians. It also occurs at the Capricorn group and probably elsewhere along the Queensland coast. At Mer it is not rare, being found on both sides of the island. Its occurrence west of Torres Strait needs more evidence. We did not find it anywhere, but Erwe (1913) records 3 specimens from west Australia as "*difficilis*" and one from southwest Australia as "*Mülleria parvula.*" Outside Australia, this little holothurian has a very great range, from Mauritius to Easter Island, from southern Japan to Lord Howe. It is a small, bright-brown animal, usually 60–80 mm. long (rarely exceeding 100), living on the under side of rock fragments on reef flats. When disturbed it ejects copious white Cuvier's organs.

Holothuria monocaria

Holothuria (*Psolus,* Oken) *monocaria* Lesson, 1830. Cent. zool., p. 225; pl. 78.
Théel, 1886. "Challenger" Hol., p. 172; pl. 8, fig. 10.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 256; pl. 16, fig. 7 (colored).
Holothuria macleari Bell, 1884. "Alert" rept., p. 152; pl. 9, fig. G.

Pearson (1913) has shown what others have suspected, that Bell's species from northeastern Australia is identical with Lesson's, described and figured (after a fashion) half a century earlier. Though there is no little diversity in shades and in the conspicuousness of the white or yellow areas around the papillae, the coloration is on the whole fairly characteristic and reasonably constant. The species is common and widespread from Zanzibar and Mauritius to Hawaii and the Society Islands, north to southern Japan, and south to Lord Howe. From Lord Howe its Australian range extends through Torres Strait to Cape Leveque. We did not find it at Darwin or at Broome or anywhere west of there, but at Allaru Island, west of Port Essington, on the Coburg Peninsula, it is rather common, and in many large specimens the tips and sometimes much more of the papillae were bright grass

green. So striking is this coloring in life, it seems to justify the varietal name *viridis* (see H. L. Clark, 1938, p. 527), but unfortunately the green is fugacious and disappears quickly in alcohol. The absence of *monocaria* from Australia west of Cape Leveque is difficult to explain in view of its very extensive range west, northwest, and north of Australia. Under favorable conditions it grows to a large size, exceeding 400 mm., but as a rule it is less than half that length.

Holothuria remollescens

Lampert, 1885. Seewalzen, p. 242; figs. 8, 9, 22.

This rare holothurian was described from a single very small specimen (23 mm. long) taken at Kosseir (Red Sea). The "Investigator" collected a specimen 50 mm. long at Grand Coco Island, on the eastern side of the Bay of Bengal. The Carnegie Expedition of 1913 took a specimen, 135 mm. long, at Mer, Murray Islands. It was found on the under side of a rock fragment and was dull purplish gray. The previous specimens were brown with darker brown blotches on the back. Obviously more material is necessary.

Holothuria pardalis

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 336; pl. 19, fig. 85.

This common and widespread species ranges from Mozambique and the Red Sea to the Galápagos Islands and Cocos Islands in the extreme eastern Pacific; its northern limit would seem to be in southern Japan, and Lord Howe Island is apparently its farthest south. In Australia it occurs along the coast of Queensland and westward through Torres Strait to the Coburg Peninsula, Cape Leveque, and the Broome region. But it has not been found at Port Hedland or the coast west and south of there. It is a small holothurian, seldom exceeding 100 mm., living in the sand under rock fragments. The color and general appearance show considerable diversity, especially in preserved material. As a consequence, it has received at least half a dozen specific names besides *pardalis* (see Panning, 1935, p. 3), of which *insignis* and *lineata* (both of Ludwig, 1874) are best known.

Holothuria cumulus

H. L. Clark, 1921. Ech. Torres Strait, p. 176; pl. 38, figs. 14–19*a*.

Nothing is known concerning this holothurian beyond what is given in the original account. The unique holotype was about 50 mm. long and whitish in color with yellow pedicels. It was taken from the under surface of a rock fragment at Mer, Murray Islands.

Holothuria hartmeyeri

Erwe, 1913. Fauna Südwest-Australiens, vol. 4, p. 383; pl. 7, figs. 19*a–d*.

Of more than usual interest because it is endemic, this little-known holothurian occurs on the southern coast of Australia from Brighton Beach, South Australia, westward to the corner of the continent and thence northward to Geraldton, Western

Australia. It is 100–150 mm. in length in life, and owing to the flattened ventral surface and the presence of far more pedicels there than dorsally, it is strikingly *Stichopus*-like. There is no little diversity of color, the chief shades being light gray and brown, but it is rarely uniform. The lighter shade is commonly blotched or marked or vermiculated with the darker, sometimes very handsomely.

Holothuria leucospilota

Stichopus (*Gymnochirota*) *leucospilota* Brandt, 1835. Prodr. descr. Anim., p. 51.
Holothuria vagabunda Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 334; pl. 19, figs. 75, 76.
Semper, 1868. Holothurien, p. 81; pl. 21 (colored).
Holothuria leucospilota Ludwig, 1881. Ztschr. f. wissensch. Zool., vol. 35, p. 595.
H. L. Clark, 1921. Ech. Torres Strait, p. 179.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 522.

This common Indo-Pacific holothurian, ranging from Natal and the Red Sea to the Hawaiian and Society islands, occurs all along the tropical Australian coast from Lord Howe Island and southern Queensland through Torres Strait to the Coburg Peninsula, Darwin, and Broome, and southward at least to Shark Bay. It is a big, dark brown holothurian, 400–500 mm. long when full grown and well extended. It lies out on sandy or muddy bottoms as does *atra,* and sometimes the two species occur together. But *leucospilota* is brown, not black, the body wall is less firm than in *atra,* and the surface is seldom covered with sand as it often is in *atra.* Finally, the Cuvier's organs in *leucospilota* are abundant and conspicuous, but are lacking in *atra.* Perhaps this is the reason that *leucospilota* is apparently not used for bêche-de-mer.

Holothuria homoea

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 533; fig. 56.

The solitary little holothurian which serves as the holotype of this species was collected at Lord Howe Island, and as yet no second specimen has been found. It is 46 mm. long and is of a peculiar light purplish-gray color. It was 50 mm. long in life and uniformly red-brown in color. Deichmann thinks this is a young *leucospilota.*

Holothuria arenicola

Holothuria maculata Brandt, 1835. Prodr. descr. anim., p. 46 (NON Chamisso and Eysenhardt, 1821, p. 352).
Holothuria arenicola Semper, 1868. Holothurien, p. 81; pl. 20 (colored); pl. 30, figs. *a, b.*

Apparently this is a tropicopolitan species. At least, specimens referred to it are known from many localities in the West Indian region, from the Red Sea, Zanzibar, and Mauritius, from the East Indies, Philippines, and southern Japan, from Fiji, Hawaii, and Tahiti, from the Galápagos and Cocos Island, and from the eastern coast of Australia between Lord Howe Island and the Murray Islands. It has not, however, reached the western coast of America, the northern or western coasts of Australia, or New Zealand. As yet no characters have been noted which will distinguish the West Indian specimens from those of the Indo-Pacific region.

This is a large species, up to 300 mm. in length, but as it lives buried in the sand under rock fragments and its color harmonizes well with its surroundings, it is easily overlooked, especially when small. Moreover, the tentacles are small, so that the oral end is hard to distinguish even when only partly contracted, the animal tapering toward each end as is well shown in Semper's figure. The habits are sluggish, and there are no Cuvier's organs. The color is grayish white, often more or less markedly tinged with yellow or rust color and almost always with spots or blotches of dull purple, blackish brown, or very dark gray. Usually there are 2 dorsal series of these blotches. Frequently there are numerous small dusky spots scattered all over the body, and when these are well developed the blotches may be wanting.

Holothuria verrucosa

Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 338.
Holothuria immobilis Semper, 1868. Holothurien, p. 90; pl. 29; pl. 30, figs. 27*a, b.*

Few specimens of this fine species have as yet been taken, but it is reported from Mauritius, the Philippines, Samoa, and Hawaii. We found a single adult specimen on the southeastern reef flat at Mer, Murray Islands, in 1913, but it was only about 200 mm. long, whereas Semper's figured specimen exceeds 300. The color was also quite different; the alcoholic specimen is light grayish buff, with a series of dark blotches along each side. The number of tentacles and the calcareous particles, however, seem to justify considering it *verrucosa.* Deichmann believes Semper's species is identical with Selenka's, described a year earlier, and I have no reason to question her verdict.

ACTINOPYGA

Bronn, 1860. Klass. Ord. Thierreichs, vol. 2, p. 403; pl. 45, fig. 10.

Genotype: *Mülleria lecanora* Jaeger, 1833, p. 18.

As it has been repeatedly explained by Bell, Fisher, and others why Bronn's generic name must replace Jaeger's, owing to multiple preoccupation of *Mülleria,* the matter needs no further discussion here. The genus is a relatively small one with about a dozen species, of which only 1 is strictly West Indian, but 1 other is found at Madeira. The remainder are more or less widely distributed in the Indo-Pacific region. Of these, 6 are known from Australia, and 4 of these occur at the Murray Islands; only 1 was taken at Broome and none at Darwin. In the Torres Strait region, all the species are used for bêche-de-mer and 3 are reckoned as "good fish." The Australian species may be distinguished as follows:

Key to the Species of Actinopyga

A. Tentacles 25 or more; calcareous particles rods, rosettes, smooth oval grains ..... *mauritiana*
AA. Tentacles 20 or fewer:
  B. Well developed tables present in skin, but scattered and accompanied by large fenestrated ellipses ..... *nobilis*
  BB. No well developed tables in body wall:
    C. Small (less than 50 mm.), with soft body wall containing scattered imperfect, diskless tables and no other deposits ..... *lubrica*

CC. Large, commonly up to 200 mm. or more; deposits rods (often branched) and rosettes:
D. Area around anus conspicuously light-colored; no large rods among deposits ..... *lecanora*
DD. Area around anus not noticeably different from rest of dorsal side:
Large rods, often branched at ends, sometimes with lateral branches, occur abundantly among countless rosettes ..... *echinites*
No large rods; rosettes minute, often incomplete, not usually crowded ..... *miliaris*

Actinopyga mauritiana

Holothuria mauritiana Quoy and Gaimard, 1833. Voy. "Astrolabe," vol. 4, p. 138.
Actinopyga mauritiana Bell, 1887. Sci. Trans. Roy. Dublin Soc., ser. 2, vol. 3, p. 653; pl. 39, fig. 1.
Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 648; pl. 67, figs. 1–1*d*.

Fisher's account of this holothurian is a model of what such accounts should be. In Australia it is confined to the northeastern corner of the continent, the northern end of the Barrier Reef. It is found at Mer, but is not so common as *lecanora*. It is 150 mm. or more in length when preserved, and in life no doubt may be 200 mm. or more. The geographical range includes the entire Indo-Pacific area from Mozambique, Zanzibar, and the Red Sea to Hawaii, Tahiti, and the Paumotus, northward to southern Japan and southward to Fiji. In Torres Strait it is (or was) much sought as bêche-de-mer and is usually marketed as "redfish."

Actinopyga nobilis

Mülleria nobilis Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 313; pl. 17, figs. 13–15.
Actinopyga nobilis Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 647.

Under the doubly erroneous name *Mülleria maculata,* Erwe (1913) records this species from Shark Bay and Houtman's Abrolhos. As he gives excellent figures (pl. 6, figs. 12*a–d*), his identification cannot be questioned, but we did not find *nobilis* in the Broome region in either 1929 or 1932. Neither did it occur at Darwin nor on the Coburg Peninsula. It was rare at the Murray Islands, but as it was persistently sought by the bêche-de-mer fishermen (to whom it is "teatfish" or "mammy fish"), this is not strange. It grows to a large size (200–300 mm.), perhaps the largest in the genus. The color is black or black and white. Mitsukuri (1912) has given a very full account, with valuable figures, of this holothurian as found in southern Japan. For a discussion of its correct name see H. L. Clark, 1921, page 189. It ranges from Natal to the Red Sea and eastward to Hawaii and Fiji.

Actinopyga lubrica

Mülleria lubrica Sluiter, 1894. Semon's Hol., *in* Jena Denkschr., vol. 8, p. 104.
Actinopyga lubrica H. L. Clark, 1921. Ech. Torres Strait, p. 188.

Based on 2 small specimens, 46 mm. long by 20 mm. wide, this species is open to grave suspicions. The material was collected by Semon at Thursday Island and no similar specimens have since been taken. The description suggests the possibility

that 2 specimens of *Holothuria difficilis* were preserved in formalin, which softened and swelled the body wall and partially decalcified it. No figures of the peculiar calcareous particles have been published.

Actinopyga lecanora

Mülleria lecanora Jaeger, 1833. De Hol., p. 18; pl. 2, figs. 2, 2*b*.
Semper, 1868. Holothurien, p. 75; pl. 30, fig. 7.
Actinopyga lecanora Bronn, 1860. Klass. Ord. Thierreichs, vol. 2, explanation of pl. 45, fig. 10.

This was the only species of *Actinopyga* met with by us in Australia in 1929 and 1932. In the former year we found 2 adult specimens among the corals at Cape Leveque, and in the latter year we took 2 smaller specimens at Broome. It is a large species, exceeding 300 mm. in length when fully grown. The coloration is very distinctive: upper surface dark, ranging from brown to deep brownish black; lower surface and a conspicuous area around the anus much lighter, ashy or olive gray. The shades of color show no little range in life as well as in preserved material, and the extent of the light areas also shows individual diversity. The type locality for *lecanora* is Celebes, but the species ranges from Mauritius to Tongatabu, and north to the Ryukyu Islands. In Australia it has been taken often in Torres Strait and on the northern part of the Barrier Reef, where it is in demand for bêche-de-mer, being sold under the name "stone fish." Apparently it may be expected in any suitable area of tropical Australia, at least as far west as long. 120° E.

Actinopyga echinites

Mülleria echinites Jaeger, 1833. De Hol., p. 17.
Semper, 1868. Holothurien, p. 76; pl. 30, fig. 8.
Actinopyga echinites Kent, 1893. Great Barrier Reef, p. 236.

Commercially important in the Torres Strait region under the name "redfish" (also applied to *A. mauritiana*), this holothurian grows to a length of 300–350 mm. according to Kent, who also figures the color in life as dark reddish brown above and light red on the ventral surface. The colors become darker on preservation. It ranges from Zanzibar to Fiji, north to the Ryukyu Islands, and south to Shark Bay, Western Australia, and Port Denison, Queensland. It was not met with on any of my three Australian visits, but Erwe (1913) records it from Shark Bay, and Kent (1893) reports a single large specimen from Port Denison. He says it inhabits deeper water than *mauritiana*.

Actinopyga miliaris

Holothuria miliaris Quoy and Gaimard, 1833. Voy. "Astrolabe," vol. 4, p. 137.
Actinopyga miliaris Bell, 1887. Sci. Trans. Roy. Dublin Soc., ser. 2, vol. 3, p. 653; pl. 40, fig. 1.

Ranging from Mozambique and the Red Sea to the Ryukyu, Caroline, and Tonga islands, this is one of the "good fish" of the bêche-de-mer fishermen, who call it "blackfish." The color in life is a deep brown which looks almost black when the animal is strongly contracted, and becomes black when the transformation into

bêche-de-mer is completed. In Australia, *miliaris* is known from "Western Australia," Torres Strait, and the northern end of the Barrier Reef. The Barrier Reef Expedition took it twice north of the Low Isles, near North Direction Island and Eagle Island, in 10–19 fms.

Order MOLPADONIA

This is the smallest of the 4 orders of holothurians met with on the Australian coast, where it is represented by only 7 species. All are lovers of mud or soft sand and live buried beneath the surface. When undisturbed they are supposed to lie with the oral end of the animal flush with the surface of the bottom where they dwell, the greater part of the body buried several centimeters deep in the sand or mud, and the posterior end, which is often constricted into a more or less elongated caudal region, curving upward so that the anal opening is also at the surface of the sand but more or less distant from the mouth. Buried thus, they move about but little if at all, and they would rarely be seen by man were it not for heavy storms which create such surf and undertow that the holothurians are washed out and up onto the beach, sometimes in very large numbers. The surface of the body is smooth and often slimy, making the contracted animal more or less repulsive. Only 1 family is recognized.

Family MOLPADIIDAE

This small family of 8 or 10 genera is not very well represented in Australia, only 3 of the genera having been taken there as yet. These may be distinguished thus:

Key to the Genera of Molpadiidae

Tentacles with 3–7 short, blunt digits ..... *Molpadia*
Tentacles with 2 pairs of rather long, pointed digits ..... *Paracaudina*
Tentacles without digits or with a minute one on each side of tip ..... *Acaudina*

MOLPADIA

Risso, 1826. Hist. nat. Europe, vol. 5, p. 292.

Genotype: *Molpadia musculus* Risso, 1826, vol. 5, p. 293.

It is futile to attribute this generic name to Cuvier, as is universally done, since he designates no identifiable type. It is only because Risso himself refers to Cuvier's use of the name that subsequent writers have taken Cuvier as the founder of *Molpadia* and dated it from 1817. If we regard Cuvier as the author of *Molpadia,* we must acknowledge either that it has no type, or else that it is monotypic and the type is unrecognizable. By considering Risso the founder of the genus, though not the author of the name, we avoid all difficulties, since *Molpadia musculus* is a widely distributed and well known holothurian.

This is a relatively large genus with some 30 or more species, but in Australian seas it is represented by only 3, all of which have been discovered in the past thirty-five years. Two were taken by the "Thetis" at her station 46, off Jibbon, New South Wales, and neither has been reported since. The third is known only from a single spot near the jetty at Darwin, Northern Territory.

KEY TO THE SPECIES OF MOLPADIA

A. Tables with irregular disks, 100–200 microns or more in diameter; dark red phosphatic bodies present:
  Disks of tables in tail not narrowed and drawn out into projection at each end, but irregularly oval with 20–40 small holes ..... *dissimilis*
  Disks of tables in tail narrowed and drawn out into projection at each end, with few (5–10) holes ..... *productamensis*
AA. Tables with rather regular disk with 3 large holes, usually 3 smaller ones alternating with them; no dark red phosphatic bodies ..... *altimensis*

Molpadia dissimilis

H. L. Clark, 1909. "Thetis" rept., p. 561; pl. 58, figs. 12–21.

Three specimens of this species, 45–70 mm. in length, with the diameter a third as much or more, were taken by the "Thetis" off Jibbon, New South Wales, in 50–66 fms. The bottom was recorded as "mud and abattoir refuse"; probably the latter supplied nourishment for countless mud-loving animals. The holothurians have a grayish color which is largely obliterated in the adults by the dark red phosphatic deposits, except the oral disk and caudal appendage. The smallest specimen has the ground color yellowish gray with the tentacles yellowish. The phosphatic deposits are yellowish red, an indication of youth. In spite of superficial resemblances to the following species and to *intermedia,* the common Pacific *Molpadia,* the specific characters of *dissimilis* seem to be distinctive. But Deichmann considers it identical with *scabrum* Sluiter. Lack of material for comparison prevents a decision.

Molpadia productamensis

H. L. Clark, 1909. "Thetis" rept., p. 562; pl. 58, figs. 22–30.

The only known specimens of this *Molpadia* were taken with the preceding species off Jibbon, New South Wales, in 50–66 fms. on a muddy bottom enriched by abattoir refuse. It is somewhat larger than its congener, the type being 68 by 35 mm. The coloration is essentially the same, deep purplish red with oral disk and caudal appendage light gray. The differences in the calcareous deposits and in the calcareous ring preclude any possibility that the specimens all belong to one species. Deichmann thinks that *productamensis* may be identical with *Trochostoma andamanense* Walsh. Lack of material for comparison again prevents a decision.

Molpadia altimensis

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 538; figs. 58*a–c*.

This species also is known from just 3 specimens, all taken at a single place, in this case near the jetty at Darwin, Northern Territory. The general appearance is very different from that of the New South Wales material, as the thin and delicate body wall is pale gray, with a more or less rusty tinge and a complete absence of dark red phosphatic deposits. But these tropical Molpadias are very small, less than 25 mm. in length, and the body wall is very rough from the high spires of the tables. The 3 known specimens were dredged in only 7 fms. of water on a bottom of soft, black mud. This is a very shallow habitat for *Molpadia,* and the small

size of the specimens suggests that the adults may live in deeper water. The possibility that the specimens from Darwin are the young of *M. scabrum* (Sluiter) or some other Indian Ocean species cannot be denied, but further material must be obtained before we can know.

PARACAUDINA

Heding, 1932. Vidensk. Medd., vol. 92, p. 455.

Genotype: *Molpadia chilensis* Müller, 1850, p. 139.

A detailed discussion of this genus and its allies was published by me in 1935, which showed that 3 species were recognizable and that 1 of these has an extraordinarily wide range and sufficient diversity to justify recognizing 3 varieties. The 3 species all occur in Australia, some member of the genus being presumably present on any part of the coast where conditions permit. They may be distinguished thus:

Key to the Species of Paracaudina

A. Crossed-cups well developed and in large numbers; perforated plates may also be present ..... *chilensis* var. *ransonnetii*

AA. Crossed-cups reduced to irregular perforated plates, usually with knobs or projections, sometimes showing traces of crossed-cup origin:
- Plates of irregular form, usually with about 8 perforations of unequal size and irregular disposition ..... *australis*
- Plates oval or squarish, commonly with 4 large, symmetrically placed perforations, sometimes with 1 or more small ones in addition ..... *tetrapora*

Paracaudina chilensis var. ransonnetii

Caudina ransonnetii von Marenzeller, 1881. Verhandl. K. K. zool.-bot. Gesellsch. Wien, vol. 31, p. 126.
Caudina chilensis (J. Müller) Hozawa, 1928. Sci. rept. Tôhoku Univ., ser. 4, vol. 3, p. 361; pls. 14–17.
Pseudocaudina ransonetti Heding, 1931*a*. Vidensk. Medd., vol. 92, p. 283.
Paracaudina ransonetti Heding, 1932. Vidensk. Medd., vol. 92, p. 455.
Paracaudina chilensis var. *ransonnetii* H. L. Clark, 1935. Ann. Mag. Nat. Hist., ser. 10, vol. 15, p. 281.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 540.

This interesting holothurian is common in the sandy mud of Roebuck Bay, northwestern Australia, and probably occurs at many other suitable localities in the Australian tropics. It is also known from the East Indies, China, Japan, the Aleutian Islands, and California. As to where it merges with typical *chilensis,* we have no present knowledge. Deichmann (1938) has recorded *chilensis* from California, Mexico, and Guatemala. Full-grown *ransonnetii* exceed 200 mm. in length; about one-third to one-half of the length may be in the caudal part. The color in life is white, with a slight purplish cast especially near the anterior end; the caudal part is cream color; the tentacles are reddish at the base and on the outer side, apparently from the blood they contain. Preserved specimens are light gray. Those collected at Broome were very inert and apparently lived 5–10 inches below the surface of the mud.

Paracaudina australis

Molpadia australis Semper, 1868. Holothurien, p. 233; pl. 39, fig. 14.
Pseudocaudina australis Heding, 1931*a*. Vidensk. Medd., vol. 92, p. 283.
Paracaudina australis Heding, 1932. Vidensk. Medd., vol. 92, p. 455.

This *Paracaudina* is reported from the eastern and southern coasts of Australia. Semper's type was from Rockhampton, Queensland, and Joshua and Creed (1915) examined more than 40 specimens from "various localities off the South Australian coast." Semper's type was only 100 mm. long and yellowish brown in color, but Joshua and Creed report great diversity in size (70–125 mm.), form, and color. Their largest specimen either was abnormal or had lost its caudal appendage. The color is recorded as "yellow with patches of rusty-pink." The small specimens were white.

Paracaudina tetrapora

Caudina tetrapora H. L. Clark, 1914. Rec. W. Australian Mus., vol. 1, p. 170; fig. 1.
Paracaudina tetrapora H. L. Clark, 1935. Ann. Mag. Nat. Hist., ser. 10, vol. 15, p. 284.

The occurrence of a *Paracaudina* in Western Australia had not been suspected until specimens in the Western Australian Museum, from Cottesloe Beach and the Abrolhos Islands, were examined in 1913. Since then it has become known that specimens are often washed up on Cottesloe Beach after a storm. They grow to be nearly 200 mm. in length and 30 mm. in diameter. The absence of a caudal part in some individuals is probably accidental. All the preserved specimens are more or less white. In the South Australian Museum at Adelaide, 2 specimens of *Paracaudina* were found which were taken near the Semaphore, on Lefevre's Peninsula, South Australia. It was supposed these were *australis,* but examination of the calcareous particles showed them to be *tetrapora.* It is probable, therefore, that this big *Paracaudina* ranges from the Gulf of St. Vincent westward and northward to the Abrolhos Islands, and that *australis* ranges from Discovery Bay eastward and northward to Rockhampton, Queensland. But there are vast areas of these coasts where no Paracaudinas are as yet known.

ACAUDINA

H. L. Clark, 1908. Apod. hol., p. 178.

Genotype: *Molpadia demissa* Sluiter, 1901, p. 110 = *Haplodactyla molpadioides* Semper, 1868, p. 41. See Deichmann, 1940, p. 212.

Recent studies have shown that *Aphelodactyla* and *Acaudina* are synonyms, and the shorter name has priority. Nearly a dozen specific names have been applied to various individuals in this East Indian genus, but it is now generally agreed that the type is the only valid species, save for the 2 following, recently described from northwestern Australia. These differ from the genotype in having characteristic calcareous plates. They differ from each other in the form of these deposits.

Calcareous deposits scattered perforated plates, larger ones with big perforations having serrate margins ..... *delicata*
Calcareous deposits small oval plates with 3 or 4 perforations, a few doughnut-shaped bodies, and short, irregularly branched particles with wide, blunt branches ..... *leucoprocta*

Acaudina delicata

Aphelodactyla delicata H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 542; figs. 59*a, b*.

This apparently well marked species was found in muddy sand, in 5–8 fms. of water, southwest of Broome in 1929 and again in 1932. Its small size, 52 mm. or less in length, suggests that the known specimens are not adult. But the calcareous spicules are so characteristic it is hard to doubt the validity of the species. The color was pale gray with the tentacles yellowish or brownish.

Acaudina leucoprocta

Aphelodactyla leucoprocta H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 543; figs. 60*a–c*.

The curious color character of this relatively big molpadiid is notably distinctive, for no other Australian holothurian has the cloacal lining and the adjoining body surface white in contrast with the general dark purple or purplish-brown color. The otherwise very different and much larger *Actinopyga lecanora* has the area around the anus light gray, sometimes almost white, in contrast with a dark general color, but the contrast is not so marked as in the *Acaudina*. Only 3 specimens of this molpadiid were taken, all from the Broome region but at three widely separated points. Two occurred near low-water mark, more or less buried in sand or sandy mud. The third was dredged in sandy mud in 7–8 fms. of water. The specimens ranged from 100 to 140 mm. in length, with the greatest diameter about one-third as much. The body wall is notably slimy and the animal is unusually inert.

Order APODA

The holothurians of this group have, as a rule, more or less elongated bodies; as a consequence, the large species have a superficial resemblance to snakes, and the smaller ones are quite like worms. They are widely distributed in all seas, but are most common in the East Indies. They occur on all sides of the Australian continent, but are most abundant at the northeastern corner, where about half the species are found. The temperate coasts of New South Wales, Victoria, and South Australia are the home of only 4 or 5 species. Two quite distinct families are recognizable, and are easily told apart by the differences in the tentacles and in the calcareous deposits:

Calcareous particles perforated plates, accompanied by anchors; tentacles usually more or less definitely pinnate, never peltato-digitate ..... Synaptidae
Calcareous particles wheels with or without sigmoid bodies, or sigmoid bodies alone; tentacles peltato-digitate ..... Chiridotidae

Family SYNAPTIDAE

Most of the Apoda occurring in Australia belong in this family, 7 genera being represented. They show great diversity in size and color, but otherwise they are distinguished chiefly by the character of the calcareous particles in the body wall.

They are commonly found either free-living among sponges or corals, or under rock fragments, where they are usually somewhat buried in the sand or mud. The Australian genera may be distinguished as follows, chiefly by the character of the anchors and anchor plates:

Key to the Genera of Synaptidae

A. Arms of anchors smooth; vertex usually with minute knoblike projections:
  B. Cartilaginous ring, posterior to calcareous ring, usually wanting; stock of anchor irregularly branched:
    Calcareous ring without noticeable anterior projections; anchor plates not abruptly contracted at posterior end, but with large, smooth hole on each side ..... *Euapta*
    Calcareous ring with conspicuous anterior projections; anchor plates abruptly contracted posteriorly and thus lacking large, smooth hole on each side ..... *Opheodesoma*
  BB. Cartilaginous ring commonly present; stock of anchor not branched:
    C. Tentacles numerous, normally 25, but ranging from 16 to 27, apparently according to age but not to size ..... *Polyplectana*
    CC. Tentacles normally 15 or fewer:
      Very large, 500–2000 mm. in length; anchor plates subrectangular or irregular, with numerous smooth holes ..... *Synapta*
      Size diverse, 40–500 mm.; anchor plates rounded in front, narrow behind, with few holes, the largest dentate and regularly arranged ..... *Chondrocloea*
AA. Arms of anchors usually serrate, but sometimes smooth; vertex without knobs:
  Tentacles pinnate, with 5–21 digits (usually more than 7) ..... *Leptosynapta*
  Tentacles digitate, with 3–5 digits ..... *Protankyra*

EUAPTA

Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 112.

Genotype: *Synapta godeffroyi* Semper, 1868, p. 231.

This genus of large tropical synaptids contains, according to Heding (1928), 5 species rather than the 2, one West Indian and the other Indo-Pacific, which have long been recognized. Only 1 species has as yet been taken in Australia.

Euapta godeffroyi

Synapta godeffroyi Semper, 1868. Holothurien, p. 231; pl. 39, fig. 13.
Euapta godeffroyi Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 113.
H. L. Clark, 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 462; pl. 1, figs. 1–4.

Semon took 3 specimens of this holothurian at or near Thursday Island, and we took a single small specimen at Mer. The species ranges from Mauritius to Hawaii, but is apparently not found in Australian waters except in the Torres Strait region. Fully grown specimens are up to 400 mm. in length, with a diameter in life (when

normally extended) of about one-twentieth as much. The coloration is yellow-gray or creamy white, with radii indicated by greenish-brown or pale brown stripes and the dorsal interradii marked with large dusky, greenish-brown blotches. Nothing is known of the habits, but Fisher (1907) gives a very full account of this synaptid and its occurrence in Hawaii.

OPHEODESOMA

Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 723.

Genotype: *Opheodesoma spectabilis* Fisher, 1907, p. 723.

This is a group of 4 or more species widely distributed in the Indo-Pacific region. According to Heding (1928, 1931), there are 11 species, but he makes so little allowance for individual diversity, youthful and senescent features, and abnormalities, we are justified in being skeptical as to the validity of his species. Apparently 2 or possibly 3 species are found on the Queensland coast, one of which is, so far as we now know, endemic. No member of the genus has been found as yet west of Torres Strait. The 3 Australian forms are supposed to be distinguished by the presence or absence of a membrane uniting the bases of the digits of the tentacles, a character in whose consistency I have no faith; and by the size of the anchors and plates, a character subject to the "personal equation" of the observer as well as to age differences in the individuals observed. It is important to remember that age differences and size differences are not the same thing. Differences in the calcareous ring are unreliable, as that organ varies more or less with age, size, and environment. Large series of specimens have not been available for studying any of the Australian Opheodesomas, which are supposed to differ from each other thus:

Key to the Species of Opheodesoma

A. Base of digits united by membrane:
  Anchors rather small and narrow, 275 microns or less in length; width across arms about half as much ..... *glabra*
  Anchors 290–370 microns in length; width across arms about two-thirds as much ..... *australiensis*
AA. Base of digits not united by membrane; anchors 275–357 microns in length; width across arms about three-fourths as much ..... *grisea*

Opheodesoma glabra

Synapta glabra Semper, 1868. Holothurien, p. 12; pl. 2 (colored); pl. 4, fig. 8.
Opheodesoma glabra Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 723.
H. L. Clark, 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 465; pl. 2, figs. 4–6.

The inclusion of this species in the Australian fauna is based wholly upon 2 specimens taken by Semon in the Thursday Island region, but Sluiter (1894) says nothing definite about their size or color. The species has been reported from the Philippines, the Dutch East Indies, and Fiji, and is said to reach a length of 900 mm. The color is recorded as uniformly brown, as shown by Semper, or dark gray, sometimes with white spots due to large heaps of miliary granules. Nothing is as yet recorded as to habitat or habits.

Opheodesoma australiensis

Heding, 1931. Zool. Jahrb., Abt. syst., vol. 61, p. 640; figs. 1, *1–11;* fig. 2, *4.*
Opheodesoma ramispicula Heding, 1931. Zool. Jahrb., Abt. syst., vol. 61, p. 643; figs. 1, *12–17;* figs. 2, *1, 5.*

This species is based on 5 specimens from Bowen, Queensland, of which the largest, 340 mm. in length, was considered by Heding a different species from the others. But the peculiarities of this specimen are so trivial, I cannot believe it is anything other than an individual variant, perhaps senescent, and I feel rather sure that all 5 are either *glabra* or *grisea*—if indeed those 2 species prove to be really distinct.

Opheodesoma grisea

Synapta grisea Semper, 1868. Holothurien, p. 11; pl. 4, figs. 6, 7.
Opheodesoma grisea Fisher, 1907. Proc. U. S. Nat. Mus., vol. 32, p. 723.
H. L. Clark, 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 466; pl. 2, figs. 1–3.

We took 5 specimens of this synaptid at Mer, and Semon took 2 at Thursday Island. Two specimens, 1 in the Museum of Comparative Zoölogy from Zanzibar, and 1 taken by the Great Barrier Reef Expedition near North Direction Island in 19 fms., lack their head ends, and their identification is open to question on that account, but the anchors and plates justify calling them *grisea.* In size, this species is not inferior to *glabra;* in color it is much more diversified, ranging from pure white (var. *alba* Sluiter) to mottled dusky greenish or bluish gray, with narrow dusky lines and irregular spots. Synaptids referred to *grisea* have been taken on the East African coast at Lumbo and Zanzibar; at Ceylon; in the Philippines; and in the Dutch East Indies. Heding (1928) reports it from Pearl Harbor, Hawaii, the type locality for *O. spectabilis* Fisher. On the other hand, he found no specimens of *spectabilis* in Mortensen's Pearl Harbor collection, whereas Fisher in 1902 and I in 1913 found it very common there, and it was the only synaptid we did find. Obviously Heding's identifications need confirmation. There are Australian records of *grisea* from Fitzroy Island and Bowen, Queensland. As to habits or habitat, however, nothing is recorded.

POLYPLECTANA

H. L. Clark, 1908. Apod. hol., pp. 16, 22, 76.

Genotype: *Synapta kefersteinii* Selenka, 1867, p. 360.

This has been a monotypic Indo-Pacific genus, well characterized by the large number of tentacles, but in 1928 and 1931 Heding added 9 new species, of which none are reported from Australia. The validity of these species therefore does not concern us here.

Polyplectana kefersteinii

Synapta kefersteinii Selenka, 1867. Ztschr. f. wissensch. Zool., vol. 17, p. 360.
Polyplectana kefersteinii H. L. Clark, 1908. Apod. hol., pp. 16, 77.
——— 1921. Ech. Torres Strait, p. 159.
——— 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 468; pl. 1, figs. 8–12.

The type locality for this species is the Hawaiian Islands, whence it ranges southward to Tahiti and westward to Kosseir on the Red Sea. It does not appear to have been found at Zanzibar or Mauritius, nor as yet at Ceylon. In Australia, it is known only from the Murray Islands and apparently from the Low Isles. The latter record is, however, open to some question, as the specimen was fragmentary and headless and the identification rests wholly on the calcareous particles. Large specimens are up to 450 mm. in length, and the color is some shade of brown, often lighter on the lower side. Spots and blotches of a light gray or whitish color may occur as a result of aggregations of miliary spicules.

SYNAPTA

Eschscholtz, 1829. Zool. Atlas, vol. 2, p. 12.

Genotype: *Synapta mammillosa* Eschscholtz, 1829, p. 12 = *Holothuria maculata* Chamisso and Eysenhardt, 1821, p. 352.

This genus has long been considered monotypic, but Heding (1928) is quite sure that Lesson's (1830) species *oceanica* from Tahiti is distinct from Chamisso and Eysenhardt's *maculata* from the Marshall Islands. The single specimen which I collected at Papeete in 1913 seems to justify his position, but much more material is needed from other islands to settle the matter. All Australian material seems to represent a single species.

Synapta maculata

Holothuria maculata Chamisso and Eysenhardt, 1821. Nova acta Deutsch. Akad., vol. 10, p. 352.
Synapta maculata Jaeger, 1833. De Hol., p. 15.
H. L. Clark, 1908. Apod. hol., p. 78; pl. 1 (colored).
——— 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 471; pl. 3, figs. 1, 2; pl. 4, fig. 1.

Though the western limits of the range of this species, Zanzibar to Kosseir, are well known, there is still doubt as to the eastern limits. If the Tahitian Synaptas represent a different species, as is at least possible, the region where its western range limit meets the eastern limit of *maculata* is completely unknown. Apparently neither form has reached the Hawaiian Islands. The genus enters the Australian fauna only in the region of the northern end of the Barrier Reef. Semon did not find it at Thursday Island, but *maculata* is not uncommon at the Murray Islands, the Museum of Comparative Zoölogy has a specimen from Hope Island, and the Barrier Reef Expedition took at least 2 at the Low Isles. So long and snakelike are these biggest of synaptids and longest of holothurians, accurate statements as to length are not available. There is no doubt that normal adults may exceed a meter even when only naturally extended. That such a specimen could be stretched to 2 meters is not at all unlikely. The color is some shade of brown, often yellow-brown, but the degree of contraction or extension makes much difference. Striped forms are reported, but these may be the other possible species. More careful observations in life are needed. Like all synaptids, *maculata* is very sluggish in all its movements, save for the ceaseless bending and twisting of the tentacles. It frequently occurs unsheltered on "grassy" bottoms, but it is more commonly found, often several individuals together, under rock fragments on the reef flat or near low-water mark.

CHONDROCLOEA

Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 113.

Genotype: *Synapta nigra* Semper, 1868, p. 12.

The question of the type of this genus is complicated by the fact that Östergren included a single West Indian synaptid with the dozen East Indian species which he grouped in his proposed *Chondrocloea.* But this West Indian form had already been made the type of a genus *Synaptula,* and it is now generally agreed that this genus is valid and monotypic. Östergren's proposed name must then be used for the East Indian group of species. In 1908 (p. 80, last line) I suggested that *nigra* "best represented" this group, thus virtually making it the type of *Chondrocloea.* Yet in 1928, Heding (p. 155) says: "The genotype of Chondrocloea is *Synapta indivisa* Semper." In 1938 (p. 546) I thoughtlessly accepted his statement, forgetting my own designation of *nigra.* Heding gives no reason for his choice of *indivisa,* but presumably it is because Östergren (1898, p. 114) in listing his species of *Chondrocloea* arranged them alphabetically and thus put *indivisa* first. There is no indication that *indivisa* was to be considered typical or a type in any sense. Neither *nigra* nor *indivisa* is a satisfactory genotype, as neither is adequately known. But for the present Östergren's name may continue in use for the group which he had in mind. There is little doubt that *recta* is the commonest and best-known species, but of course we cannot now adopt it for genotype.

When we come to consider the component species of *Chondrocloea,* it is evident that complete revision of the group is demanded. This is not the place for such a revision, but the situation must be stated. In 1908, I recognized 8 species of *Synaptula,* but of course 1 of these was the unique genotype, *hydriformis.* The remaining 7 species made up *Chondrocloea.* In 1928, Heding rejected *nigra* as a member of *Chondrocloea,* but added 17 new species and restored 4 old names which I had rejected as synonyms of earlier names. He thus included 28 species in *Synaptula,* not separating the single West Indian form from its multitude of East Indian congeners. In making up his key (1928) he has relied so largely on color that anyone who has handled large quantities of such a diversified species as *recta* (see H. L. Clark, 1938, p. 545) is in despair. It is further noteworthy that most of Heding's 27 East Indian Chondrocloeas are from three localities, 8 species being recorded from Banda, 8 from Toeal and Vatek opposite Toeal, and 3 from Jolo. In 1931, Heding added 2 more species to his genus *Synaptula,* and established a new genus, *Pendekaplectana,* for a single *Synaptula*-like specimen from Ponape. I doubt the validity of both the species and the genus, since it is evident that Heding and I have different concepts of what constitutes a species or a genus.

None of Heding's material is recorded from Australia save the 2 "new species" described in 1931. One of these is based on 2 specimens from Bowen, the other on 8 specimens from Shark Bay. The latter were reported by Erwe (1913) as *Chondrocloea recta,* but Heding has overlooked Erwe's admirable paper. His supposed species from Bowen is also probably *recta,* which is common and widespread in tropical Australia. The other Australian Chondrocloeas are very unsatisfactorily known from inadequate material. They, together with the East Indian forms, require a complete revision.

KEY TO THE SPECIES OF CHONDROCLOEA

A. Tentacles 15:
  Color dark brown or purplish brown; anchors rather stout, with short, divergent flukes; miliary granules, minute irregularly branched plates ..... *nigra*
  Colors greenish brown (olive green in alcohol) and dirty cream color (light buff in alcohol); anchors slender, with longer, less divergent flukes; miliary granules, typical rosettes ..... *macra*
AA. Tentacles 13:
  Gonads unbranched; polian vessels few; tentacles very long and slender, with about 10 pairs of digits ..... *indivisa*
  Not as above ..... *recta*

Chondrocloea nigra

Synapta nigra Semper, 1868. Holothurien, p. 12; pl. 4, figs. 9*a–c*.
Chondrocloea nigra Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 114.
Synaptula nigra H. L. Clark, 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 474; pl. 3, figs. 3, 4; pl. 4, fig. 2.

This synaptid is still very imperfectly known. Its right to a place here rests on the single indefinite record of Lampert (1885) and the half-dozen specimens which we collected at Mer in 1913. Östergren's inclusion of *nigra* in *Chondrocloea* seems to me much more natural than Heding's (1928) suggestion that it be placed in *Polyplectana* or made the type of a new genus. The species is of moderate size, up to 350 mm. long in life, shrinking one-fourth or more in alcohol. The dark coloration is apparently constant, but skepticism on this point is justifiable. The geographical range is unknown, Bohol in the Philippines and Mer, Murray Islands, Australia being the two localities so far defensible. Lampert's (1885) record from the Red Sea needs verification.

Chondrocloea macra

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 547.

The validity of this species, based on a single specimen collected near Allaru Island, Coburg Peninsula, northern Australia, on eelgrass bottom, in shallow water, is obviously open to question. The length in life was about 425 mm. with a diameter of 10. The shrinkage in alcohol was less than 10 per cent. The calcareous particles are essentially like those of *recta*. What may well be a second individual of this species is in the Museum of Comparative Zoölogy collection. It comes from Ponape, Caroline Islands, and is now 425 mm. long. Color, faded yellowish brown.

Chondrocloea indivisa

Synapta indivisa Semper, 1868. Holothurien, p. 13; pl. 4, fig. 1.
Chondrocloea indivisa Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 114.

The validity of this species is indeed dubious. It was described from a single specimen collected at Zamboanga, Philippine Islands, which was only 42 mm. long, the tentacles being 12 mm. of that. The only other reported specimen was collected by Semon in the Thursday Island region and hence entitles the species to a place in the Australian fauna; but Sluiter (1894) gives no data as to Semon's specimen. Heding (1928) includes it in his key to the species of *Synaptula,* considering the

unbranched gonads and excessively long tentacles valid distinguishing characters, but Mortensen collected no specimens. It will probably be discovered that the unique type of *indivisa* was a young individual of some other species of *Chondrocloea.*

Chondrocloea recta

Synapta recta Semper, 1868. Holothurien, p. 14; pl. 4, figs. 2, 3.
Chondrocloea recta Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 114.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 545; pl. 15, figs. 5, 6 (colored).
Synaptula recta H. L. Clark, 1921. Ech. Torres Strait, p. 160.
——— 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 475; pl. 1, fig. 13; pl. 3, fig. 9; pl. 4, fig. 3.

This is another of Semper's Philippine Islands species which has been found in Australia, but in this case it proves to be a common and characteristic species ranging from the Low Isles of Queensland to Shark Bay, Western Australia. It is extraordinarily variable in color and ranges in length up to nearly 400 mm. It occurs among corals and sponges and, at Broome at least, is very gregarious. A careful study of the coloration based on the hundreds of specimens obtainable at Broome would be very rewarding. Further investigation into the number of tentacles and its relation to age would also prove well worth while.

LEPTOSYNAPTA

Verrill, 1867. Trans. Connecticut Acad., vol. 1, p. 325, footnote.

Genotype: *Holothuria inhaerens* O. F. Müller, 1776, p. 232.

This is a genus of world-wide distribution though chiefly in temperate seas. As in the case of *Chondrocloea,* I find myself completely at variance with Heding with reference to the number of species to be recognized. He includes 25 species even after eliminating half a dozen others. At least one-third of these nominal species seem to me invalid, but the only forms that need concern us here are those from Australia, which according to Heding require 7 names. He had examples of 5 of these "species," but also recognized 2 named by me of which he had no material. As I have pointed out previously (1938, p. 549), I am unable to recognize as valid any one of the 4 "new" species to which he gives names. He appears to make no allowance for growth stages and individual diversity. In my judgment, *Leptosynapta* is represented in Australia by not more than 4 species. These may be distinguished by the following key, but it ought to be emphasized that 2 of them are known from only a single specimen each, and a third is probably only a localized extreme of the widespread fourth.

Key to the Species of Leptosynapta

A. Anchor plates more or less oval but not kite-shaped; color white, yellowish, or reddish, often translucent in life:
  B. Anchors 200 microns or more in length; plates 160 microns or more:
    Miliary granules thick C- or O-shaped bodies or slender rods ..... *dolabrifera*
    Miliary granules spherical, ovoid, ellipsoid, or reniform bodies ..... *dyscrita*
  BB. Anchors 160 microns or less in length; plates 110 microns or less ..... *parvipatina*
AA. Anchor plates rounded kite-shape; color more or less blackish or gray with cream-white tentacles ..... *ictinodes*

Leptosynapta dolabrifera

Synapta dolabrifera Stimpson, 1855. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, p. 386.
Leptosynapta dolabrifera H. L. Clark, 1908. Apod. hol., p. 89.
——— 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 480; pl. 7, figs. 1–6.
——— 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 548.
Heding, 1928. Vidensk. Medd., vol. 85, p. 221; figs. 34, *1–4;* figs. 35, *1–5.*
Leptosynapta variopatina Heding, 1928. Vidensk. Medd., vol. 85, p. 226; figs. 36, *1, 2, 5–9;* figs. 37, *1–3.*
Leptosynapta jacksonia Heding, 1928. Vidensk. Medd., vol. 85, p. 228; figs. 36, *3, 4, 10–13;* figs. 37, *4–7.*

This is the common synaptid of the temperate coasts of Australia, from Lord Howe Island and Port Jackson to Fremantle, but it apparently extends its range northward on the western coast well into the tropics. A full account, with a discussion of Heding's proposed species, is given in H. L. Clark, 1938.

Leptosynapta dyscrita

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 551; figs. 61*a–c.*

The validity of this species is open to question, but as it appears to be locally isolated at Broome, it seems best to designate it by a name, which may serve for reference purposes. The dozen specimens were less than 60 mm. in length and translucent white in color. The resemblance to *dolabrifera* is so complete, it will not be surprising if further collecting on the northwest coast shows that *dyscrita* has no validity, the supposed peculiarity of the miliary particles being inconstant and unreliable.

Leptosynapta parvipatina

H. L. Clark, 1921. Ech. Torres Strait, p. 161; pl. 36, figs. 12*a–c.*

The small size of the calcareous particles seems to warrant the belief that the unique and imperfect holotype represents a species distinct from *dolabrifera.* While living it was translucent white with numerous minute pinkish spots. Preservation in alcohol has intensified the reddish shade. In life, the length was undoubtedly over 100 mm., but as the anterior end is missing, we can only guess as to this. The specimen was found in the sand under a rock fragment on the reef flat southwest of Friday Island, Torres Strait.

Leptosynapta ictinodes

H. L. Clark, 1924. Bull. Mus. Comp. Zoöl., vol. 65, p. 481; pl. 7, figs. 7–11.

This species also rests on a single specimen, in this case from the opposite side of the continent. It is, however, complete though very small, only 45 mm. long. The color as preserved is pale gray, but the body is covered with verrucae full of a dark purplish-brown pigment; where they are crowded together, as they are anteriorly, they cause the body wall to look almost black, with the cream-colored tentacles contrasting sharply. The specimen was collected at Western Port, Victoria,

and is, so far as is known, unique, but Joshua (1914) speaks of a synaptid, considered *dolabrifera* by him, collected at Wilson's Promontory, that was "deep purple-black." There can be little doubt that it was the present species.

PROTANKYRA

Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 116.

Genotype: *Synapta abyssicola* Théel, 1886, p. 14.

This is a large genus of more than 30 nominal species. Heding (1928) lists 31 (he says 32) species and names 2 others as probably valid. But he discusses none from Australia, so his treatment of the genus requires no further comment here. The Australian species are all from shallow water on the tropical coasts of the continent, and 2 are still known from quite inadequate material.

Key to the Species of Protankyra

A. Accessory calcareous particles (in addition to anchors and plates) short, straight rods more or less forked at each end ..... *similis*
AA. Accessory calcareous particles not short, straight, forked rods:
B. Accessory calcareous particles granules and small perforated plates .... *bisperforata*
BB. No small perforated plates:
Anchor arms long (more than 0.40 length) and wide-spreading (more than 0.70 length); width of stock about 0.33 anchor length ..... *insolens*
Anchor arms short (less than 0.35 length) and not wide-spreading (less than 0.60 length); width of stock more than 0.40 anchor length ..... *verrilli*

Protankyra similis

Synapta similis Semper, 1868. Holothurien, p. 10; pl. 3, fig. 2; pl. 4, figs. 14*a–d*.
Protankyra similis Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 117.

This species is still very inadequately known. It is included in the Australian fauna on the strength of Sluiter's (1894) record of a headless fragment, taken by Semon near Thursday Island. The record needs confirmation, especially as Sluiter makes no direct reference to the form of the calcareous particles.

Protankyra bisperforata

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 553; figs. 62*a–f*.

This well marked species is known as yet only from the vicinity of Broome, Western Australia. The holotype is 130 mm. long and 5–6 mm. in diameter, somewhat larger in life. All the other specimens taken are smaller. The color in life is translucent flesh pink. On being placed in alcohol, it becomes quite red, but this color subsequently fades. In life, these synaptids occur in firm, sandy mud near low-water mark.

Protankyra insolens

Synapta insolens Théel, 1886. "Challenger" Hol., p. 13; pl. 1, figs. 3*a–c*.
Protankyra insolens Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 117.

This synaptid is still known only from the unique holotype, taken by the "Challenger" at her station 188 at the western end of Torres Strait, in 28 fms. It was 110 mm. long and yellowish white in color (when preserved).

Protankyra verrilli

Synapta verrilli Théel, 1886. "Challenger" Hol., p. 12; pl. 1, figs. 1*a–d*.
Protankyra verrilli Östergren, 1898. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, p. 117.
H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 552; pl. 15, fig. 4 (colored).

This species was also one of the "Challenger" 's Torres Strait prizes, but was taken at station 186 in only 8 fms. Two small specimens were obtained, the larger only 23 mm. long. At Broome, however, we found this to be a common holothurian, and took it as far to the southwest as the northern end of Eighty-Mile Beach. The little one secured at that point was less than 25 mm. long, colorless and nearly transparent. Adults are 100–150 mm. long, 8–10 mm. in diameter, and milk white in color, with scattered spots of crimson. They are fairly common in the firm, sandy mud of Roebuck Bay. We should have found *verrilli* at the Coburg Peninsula and at Darwin, but failed to do so.

Family CHIRIDOTIDAE

This little family of small holothurians is represented in Australia by only 5 genera and 10 species. Though the type genus is world-wide in distribution, the others are for the most part found in the southern hemisphere or in Japan. One or 2 of the species reach a considerable size, but as a rule, individuals are less than 100 mm. long. The Australian genera may be easily distinguished as follows:

Key to the Genera of Chiridotidae

A. No sigmoid bodies; wheels in little heaps:
  Tentacles 12 (10–14) ..... *Chiridota*
  Tentacles 18 (16–20) ..... *Polycheira*
AA. Sigmoid bodies present:
  B. Wheels present:
    Wheels gathered into sharply defined papillae ..... *Taeniogyrus* ✓
    Wheels scattered in skin, often crowded into ill defined heaps, sometimes so few and scattered as to be easily overlooked ..... *Trochodota*
  BB. Wheels wanting ..... *Scoliorhapis*

CHIRIDOTA

Eschscholtz, 1829. Zool. Atlas, vol. 2, p. 12.

Genotype: *Chiridota discolor* Eschscholtz, 1829, p. 12.

A genus of world-wide distribution, *Chiridota* is poorly represented in Australia, for although more than 20 species are known, only 4 are reported from that con-

tinent and 2 of these are each known only from a unique holotype which is itself only a fragment. The 4 are easily distinguished by the following characters:

Key to the Species of Chiridota

A. Recent species; calcareous wheels less than 150 microns in diameter:
  B. Small, 125 mm. or less in length; calcareous particles in body wall (in addition to wheels) small (30–40 microns) bent, or more or less straight, rods with rough or irregular tips ..... *rigida*
  BB. Large, exceeding 150 mm. in length and 8 mm. in diameter when adult:
    Calcareous particles (besides wheels) big, slightly curved rods, 100 microns long and 20–25 microns wide, with rough ends ..... *gigas*
    Calcareous particles very small bracket-shaped bodies, 30–40 microns long and 5 or 6 microns wide, with smooth, enlarged ends, sometimes notched as if to fork ..... *magna*
AA. Extinct species; wheels more than 250 microns in diameter ..... *ingens*

Chiridota rigida

Semper, 1868. Holothurien, p. 18; pl. 3, fig. 3; pl. 5, figs. 3, 13.

At Lord Howe Island this little holothurian is quite common, but it is not otherwise reported from Australia, save for the single small individual that we took at Mer in 1913. Even the largest specimen taken at Lord Howe did not exceed 50 mm. when living. The color is more or less bright reddish, with the tentacles and wheel papillae white. The animals live in the sand under rock fragments near low-water mark. The species ranges throughout the East Indian region, but the eastern and western limits of its distribution are yet to be established.

Horn to.

Chiridota gigas

Dendy and Hindle, 1907. Jour. Linn. Soc. (Zool.), vol. 30, p. 110; pl. 12, figs. 9–11*h*.

Originally described from a single specimen 113 mm. long in alcohol, from the Chatham Islands, New Zealand, this big *Chiridota* was next reported from the coast of Victoria. Joshua (1914) has given a brief but good account of its Australian occurrence, particularly at Torquay, Wilson's Promontory. He says that when extended it may be 450–500 mm. long. It is bright scarlet, with prominent white papillae. Smaller specimens, now in the Museum of Comparative Zoölogy, were taken at Wynyard on the northeastern coast of Tasmania in 1927, but these are dull purplish brown and show no trace now of scarlet coloring.

Chiridota magna

H. L. Clark, 1938. Mem. Mus. Comp. Zoöl., vol. 55, p. 556; fig. 63.

This species rests on a single fragment of a specimen in the Australian Museum, which was taken in Port Jackson, off Sow and Pigs reef, in 6 fms. The fragment is 47 mm. long and 13 mm. in diameter near the larger end. The color is yellowish white to pale brown, with the longitudinal muscles brown.

*Chiridota ingens

Chiridota sp.? Hall, 1902. Proc. Roy. Soc. Victoria, n. s., vol. 15, p. 82; pl. 11, fig. 8.
Chiridota ingens Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 8.

This is the first and only fossil holothurian remnant as yet reported from Australia. The exceptionally large size of this single wheel (Hall says 0.27 mm., Joshua says 200 microns) seems to justify Joshua in giving it a specific name, but he could give no further information concerning the animal. It is supposed to date back to Tertiary times, but even that is not certain. The wheel was found in the Bird Rock zone at Spring Creek, Victoria, and Hall states that the material is "Eocene?"

POLYCHEIRA

H. L. Clark, 1908. Apod. hol., pp. 17, 22, 120.

Genotype: *Chiridota rufescens* Brandt, 1835, p. 59.

Originally monotypic, this genus is considered by Östergren to contain at least 3 and possibly 4 species. Only the following is found in Australia.

Polycheira rufescens

Chiridota rufescens Brandt, 1835. Prodr. descr. anim., p. 59.
Polycheira rufescens H. L. Clark, 1908. Apod. hol., p. 120; pl. 7, figs. 14–18.

This East Indian species ranges from Ceylon to Fiji, north to Japan, and south to Queensland. The first Australian record was Semper's from Cape York (1868, p. 231, as *Chiridota variabilis*), and no other was established until Heding's (1931) report of one from Bowen, Queensland. Later the Great Barrier Reef Expedition found *Polycheira* common at the Low Isles. The usual size of preserved specimens is less than 100 mm. by 10–15, but a field note with some specimens in the Museum of Comparative Zoölogy from Fiji says the largest was "10 inches" (=250 mm.) in length when fully extended, living. The color shows no little diversity in life, ranging from pale brown or purplish to red-brown, deep brown, brownish purple, or almost black. Apparently adults are very dark, especially at the anterior end. The field notes with the Fijian specimens just referred to say the color becomes "brilliant red" when the animal is killed with acid, but can be restored by ammonia. Heding (1928, p. 322) gives an interesting note on the habits of this "nearly black synaptid" at Koh Lom in the Gulf of Siam.

TAENIOGYRUS

Semper, 1868. Holothurien, p. 23.

Genotype: *Chiridota australiana* Stimpson, 1855, p. 386.

Originally monotypic, this little genus now contains half a dozen nominal species, but the validity of 1 or 2 admits of question. All occur in the southern oceans between Kerguelen and the Strait of Magellan, or northward in Australia, Japan, and Hawaii. Only 3 occur in Australia, and these on opposite sides of the continent. They differ thus:

KEY TO THE SPECIES OF TAENIOGYRUS

A. Sigmoid bodies in groups, at least dorsally ..... *australianus*
AA. Sigmoid bodies not in groups, but scattered:
Sigmoid bodies of 1 kind; tentacle rods slender, more or less forked at tip ..... *cidaridis*
Sigmoid bodies of 2 kinds, large and small; tentacle rods rather stout, with knobs and projections along sides ..... *heterosigmus*

Taeniogyrus australianus

Chiridota australiana Stimpson, 1856. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, p. 386.
Taeniogyrus australianus Semper, 1868. Holothurien, p. 23.
Heding, 1928. Vidensk. Medd., vol. 85, p. 315; figs. 67, *9–16*.

So far as is at present known, this little holothurian is found only in Port Jackson, New South Wales, where it occurs, as Whitelegge (1889) says, with *Leptosynapta dolabrifera* "under stones in muddy places." It may reach a length of 50 mm., but most specimens are not so large. The color is yellowish, more or less translucent.

Taeniogyrus cidaridis

Ohshima, 1914. Synaptidae of Japan, p. 477 (*nomen nudum*).
——— 1915. Proc. U. S. Nat. Mus., vol. 48, p. 286.
Heding, 1928. Vidensk. Medd., vol. 85, p. 316; figs. 68, *1–9*.

The inclusion of this species in the Australian fauna is due to the taking of a single small specimen at Rottnest Island, Western Australia, in January 1931, by G. Bourne. It is only about 22 mm. long. The sigmoid bodies resemble those of *cidaridis* more nearly than they do those of the somewhat geographically nearer species *keiensis,* but it is quite possible that the two supposed species are not valid.

Taeniogyrus heterosigmus

Heding, 1931. Zool. Jahrb., Abt. syst., vol. 61, p. 691; figs. 16, *1–15*.

The unique holotype of this species is in the Hamburg Museum. It is only a fragment, 3 mm. long, and was originally identified by Erwe (1913) as *Chiridota contorta.* In spite of its being so labeled, Heding makes no reference to Erwe or his report on Michaelsen's collection. The fragment was collected in Koombana Bay, southwestern Australia. It will be surprising if good series of *Taeniogyrus* from Western Australia justify the maintenance of 2 species.

TROCHODOTA

Ludwig, 1892. Bronn's Klass. Ord. Thierreichs, vol. 2, pt. 3, bk. 1, p. 359.

Genotype: *Holothuria purpurea* Lesson, 1830, p. 155.

This genus of small chiridotids seems to contain 9 or 10 species, of which 1 occurs in the Mediterranean Sea, 3 in Japan, and the remainder in the southern hemisphere, 3 in Australia. Few of the species are known from adequate material and several are imperfectly described. The Australian species may be distinguished thus:

KEY TO THE SPECIES OF TROCHODOTA

A. Wheels with inner margin of rim uniformly serrated; tentacles with 4 digits ..... *roebucki*
AA. Wheels with inner margin of rim not uniformly serrated, but teeth present in well separated groups; tentacles with 8–10 digits:
Sigmoid bodies 120–130 microns in length, not in heaps or groups, but well scattered in body wall ..... *allani*
Sigmoid bodies only 66–77 microns in length, chiefly in little heaps or groups ..... *maculata*

Trochodota roebucki

Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 9; pl. 1, figs. 4*a–c*.

This little holothurian attains a length of 75 mm. and a diameter of 6. The color is red. The dorsal tentacles are distinctly longer than the ventral. At Torquay, Victoria, a number of specimens were taken by Roebuck, and Joshua collected others at the same place. In 1929, we collected several Trochodotas at Geraldton, Western Australia, and more were found at Rottnest Island. They are apparently identical with the Victorian form. Probably the species occurs wherever conditions are favorable along the whole temperate coast of southern Australia.

Trochodota allani

Taeniogyrus allani Joshua, 1912. Proc. Roy. Soc. Victoria, n. s., vol. 25, pt. 1, p. 79; pls. 3, 4.
Trochodota allani Joshua, 1914. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, p. 8.

This little holothurian, up to 80 mm. long and carmine in color in life, has been adequately described and discussed by Joshua, who says it is "extraordinarily abundant on the sludge banks which form the greater part of the bottom of Port Phillip Bay." He adds: "I have seen the dredge presenting the appearance of having been dragged through a mass of blood slime from the thousands of this species adhering to it. Accompanying it, usually are about one per cent of *Leptosynapta dolabrifera.*" Later Joshua and Creed (1915) report a specimen from Kangaroo Island, South Australia. A single specimen was taken by me in the estuary of the Derwent, Tasmania, in November 1929, but it lacked the carmine color; probably from immaturity, as it was less than 30 mm. long.

Trochodota maculata

H. L. Clark, 1921. Ech. Torres Strait, p. 163; pl. 36, figs. 14–21.

A single *Trochodota,* only 26 mm. long, is the basis of this species. It was taken from under a rock fragment on the southeastern reef flat at Mer, Murray Islands, and further search proved futile. The color in life was pale pink with numerous minute spots of a darker shade. In its preserved condition the holotype is bright brown, covered with minute papillae tipped with bright brown-red.

SCOLIORHAPIS, nom. nov.

Scoliodota Heding, 1928. Vidensk. Medd., vol. 85, p. 319 (NON H. L. Clark, 1908, p. 125).

Heding's attempt to resuscitate *Scoliodota* is futile. The genus was established with only a single species, hence that species must be the type. Furthermore, this species was definitely named as "*Chirodota japonica* v. Marenzeller" from Enosima, Japan. Ohshima (1913) has shown that von Marenzeller's specimens, and hence the species based upon them, were Trochodotas, hence *Scoliodota* is a dead synonym of *Trochodota.* Now Heding's specimens are not Trochodotas, but represent a new genus. To his species he gives the name *théelii,* but he leaves it generically nameless, as he cannot revive *Scoliodota.* The fact that I had also referred to *Scoliodota* chiridotids from Port Jackson does not alter the fact that that generic name was stillborn by reason of my definite selection of Japanese material for type. Hence it is necessary to make a new generic name for the Australian species, and I propose the somewhat similar *Scoliorhapis* (σκολιός = crooked + ῥαπίς = rod, in reference to the sigmoid bodies).

Genotype: *Scoliodota théelii* Heding, 1928, p. 319.

Scoliorhapis théelii

Scoliodota théelii Heding, 1928. Vidensk. Medd., vol. 85, p. 319; figs. 69, *1–16.*

This interesting chiridotid was first collected in Port Jackson by the "Challenger," but Théel (1886, p. 17) decided that the imperfect specimens were best referred to von Marenzeller's Japanese species, *Chiridota japonica.* Years later Ohshima (1913) pointed out that the Japanese form was undoubtedly a *Trochodota.* In October 1914, Mortensen collected specimens in Port Jackson that seem to be identical with the "Challenger" material, and Heding (1928) has given an excellent account of these with good figures. He shows that the Port Jackson chiridotid is not a *Trochodota* and so revives the invalid name *Scoliodota* for them. He thus uses a generic name proposed in 1908, but designates as type a species unknown, or at least undescribed, until 1928.

As yet this chiridotid is reported only from Port Jackson, New South Wales. Complete specimens are still unknown, but certainly exceed 175 mm. There are 10 tentacles with 7 or 8 pairs of digits. The color of the preserved animals is gray, light posteriorly, but anteriorly numerous dark brown or purple papillae give a dark brownish or purplish appearance.

PART II

THE RELATIONSHIPS OF THE AUSTRALIAN ECHINODERM FAUNA

THE RELATIONSHIPS OF THE AUSTRALIAN ECHINODERM FAUNA

Though it is not to be supposed that our knowledge of the echinoderms of Australia is nearly complete, there is justification for assuming that our further knowledge of the group will not greatly alter conclusions which may now be drawn regarding the origin and relationships of that fauna. Though there are still long stretches of coast, notably between Torres Strait and Darwin, between Darwin and Cape Leveque, around the northwestern corner of the continent, and in the Great Australian Bight, which will prove happy hunting grounds for the marine zoologist, there is no reason to believe that the novelties to be found will be extraordinary.

The Recent Echinoderms of Australia

Disregarding, for the present, the extinct echinoderms, the first step is obviously to study the composition of the Australian fauna with reference to the four sides of the continent, for the most superficial observation shows striking differences between the echinoderms of the eastern and western coasts and between the northern and southern. It is true that A. H. Clark in his important discussion of the Australian crinoid fauna (1911) considered the fauna of the tropical and subtropical coasts of the continent from Shark Bay on the western coast to Sydney on the east to be a "North Australian Subregion" of the "General Indo-Pacific-Japanese Region," and believed that the remaining coast of the continent "must be subordinated as a daughter division." No doubt this conservative view concerning the Australian marine fauna is largely due to the small number of species involved in Clark's discussion—only 46. Some fifteen years later, Charles Hedley, the well known conchologist of Sydney, published his conclusions based on his knowledge of Australia's marine Mollusca, numbering thousands of species (see "The Australian encyclopedia," vol. 2, 1926, article on Zoogeography). Hedley recognized four "provinces" on the continental coast: the Dampierian on the north, extending from the Abrolhos Islands and Geraldton on the west to Cape York at the northeastern corner of the continent; the Solanderian, extending southward from Cape York to Wide Bay, Queensland, at about 26° S.; the Peronian, from Wide Bay to eastern Victoria in Bass Strait; and the Adelaidean, from Bass Strait westward and northward to Geraldton. Tasmania, except the Bass Strait coast, is designated as Mangean. Objection has been made to his term Adelaidean because that adjective was previously used in a different sense, so

Flindersian has been substituted by Cotton and others for the fauna of the southern continental coasts.

The study of the echinoderm fauna as a whole seems to confirm this suggested grouping and warrants belief that although the proposed areas are not sharply defined but tend to merge where they meet, they are rather well marked by characteristic groups of species. Whether they should be designated as regions or subregions or provinces matters little save for consistency in comparing them with corresponding areas in other parts of the world. If the Australian fauna warrants treating the area as a distinct region, each of Hedley's provinces would be a "subregion," but since some zoogeographers consider Australia a subregion of a larger area including much of the western Pacific, Hedley's choice of the term "province" is to be preferred. For a clear understanding of the echinoderm fauna of the continent it is necessary to consider each of these zoological provinces by itself. It should again be emphasized that species occurring only at great depths (over 500 fathoms or 900 meters) are not considered.

The Dampierian Province

As the fauna of the Dampierian province includes more species than any of the others (290) and is the only one in direct contact with an outside zoological area, it will be desirable to examine it first. The other three provinces are separated by very deep water from any other zoological area. The western limit of the Dampierian province is for the present somewhat arbitrarily set at Geraldton and the neighboring group of islands known as Houtman's Abrolhos, but several characteristic genera and species extend as far south as Rottnest Island and the vicinity of Fremantle. The fauna of Shark Bay, however, is very imperfectly known, and the vicinity of Northwest Cape has not been explored at all for echinoderms. Moreover, the very extensive coastal area west of Darwin as far as Cape Leveque has seen little collecting, and that eastward from Darwin to Cape York is also well-nigh a *terra incognita.* Nevertheless our present knowledge warrants treating this extensive coast line between Cape York and Geraldton as a unit, concerning which the following facts are pertinent: Of the 290 species, only 69 have been taken in the Darwin region, including the Coburg Peninsula; 45 of these occur also in the northern Queensland fauna, but only 3 are found on the coast of New South Wales. These are the ubiquitous *Amphipholis squamata* and *Ophiactis savignyi* and the circumcontinental *Amphiura constricta.* On the other hand, of the 69 species at Darwin, 50 have been taken farther west but only 9 extend their range to the western coast below Geraldton. Of these, 3 are the widespread brittle stars just mentioned as occurring in New South Wales, 2 others are common East Indian ophiurans, 2 more are Australian brittle stars of

wide but as yet ill defined range, and 2 are flat laganids of the genus *Peronella,* which have been found in the East Indies as far north as the Philippines and southern Japan. It is evident, therefore, that although the Dampierian province is worthy of recognition, it merges markedly with the Solanderian on the eastern coast and the Flindersian on the west without very sharp lines of separation. It is characterized well by the following species, which have not been taken east of Cape York or south of Houtman's Abrolhos:

Comanthina belli
Petasometra, 2 species
Stellaster princeps
Gymnanthenea globigera
Asterina coronata fascicularis
Amphioplus depressus
Amphioplus didymus
Ophiactis fuscolineata
Ophiactis modesta
Macrophiothrix scotia
Macrophiothrix belli
Placophiothrix melanosticta
Placophiothrix plana
Lissophiothrix delicata
Ophiotrichoides smaragdina
Ophiurodon cinctum
Phyllacanthus longispinus
Protankyra verrilli

This small group is supplemented by the following species which are essentially of the Dampierian province, but whose range has not yet extended, so far as we know, east of Cape Londonderry. It is of course possible, one might almost say probable, that careful collecting between Darwin and the Port George Mission would reveal many of these western species, of which the following are representative:

Zygometra comata
Monilimetra, 4 species
Astropecten monacanthus
Goniodiscaster australiae
Goniodiscaster acanthodes
Pseudoreaster obtusangulus
Anthenea conjungens
Protoreaster nodulosus
Asterina lutea
Echinaster varicolor
Amphiura phrixa
Placophiothrix lineocaerulea
Ophiocnemis marmorata
Ophionereis stigma
Ophiarachnella rugosa
Cryptopelta callista
Dictenophiura stellata
Arachnoides tenuis
Peronella tuberculata
Echinodiscus auritus

The Dampierian province is thus seen to have a very characteristic fauna of more than 40 species of echinoderms which are not known from the more southern coasts. Their relation to the East Indian fauna will be considered farther on, but it may be mentioned at this point that of the 290 species here regarded as Dampierian, 147, almost exactly half, are endemic in Australia.

The Solanderian Province

The Solanderian province is essentially the Great Barrier Reef area, extending from the Murray Islands in the north to Lady Elliot Island in the south,

but it includes as well, very naturally, the coastal fauna of Queensland from Cape York southward. Just how far south we should place the southern limit is debatable, but as Hedley selects Wide Bay, it is proper to accept his judgment and adopt that locality. It should, however, be mentioned that a few Solanderian species extend their range to the vicinity of Port Jackson and to Lord Howe Island. The majority of the 208 species here regarded as Solanderian are found in the East Indies, only 87 being endemic in Australia. Characteristic echinoderms of this province are the following, chosen because they do not extend their range on the Australian coast west of Cape York or south of Wide Bay:

Goniodiscaster integer
Ogmaster capella
Asterope carinifera
Nardoa pauciforis
Linckia laevigata
Ophidiaster granifer
Ophiotrichoides nereidina
Ophiocoma schoenleinii
Ophiarthrum pictum
Ophiarachna incrassata
Astropyga radiata
Stomopneustes variolaris
Temnopleurus toreumaticus
Salmacis belli
Salmacis dussumieri
Lytechinus verruculatus
Pentacta cucumis
Phyllophorus trapezus
Stichopus chloronotus
Holothuria argus
Holothuria edulis
Holothuria arenicola
Opheodesoma grisea
Synapta maculata
Polycheira rufescens

The Peronian Province

The Peronian province is the area between Wide Bay, Queensland, and Hobart, Tasmania, with a bit of the eastern end of the Victorian coast. There is nothing about the echinoderms of Tasmania that warrants the recognition of a Mangean province, distinct from the Peronian and Flindersian, except for a very few species which also occur in New Zealand. If the origin of Bass Strait is quite recent, as is generally accepted, the Tasmanian fauna is just what might be expected at the southeast corner of the continent well below tropical influences. Whether Lord Howe Island should be included in the Solanderian or Peronian province is perhaps more debatable, but on the whole the evidence seems to favor its inclusion in the Solanderian province, as nearly half its echinoderms occur on the Barrier Reef and 10 more are endemic. Only about a dozen are really Peronian, and half a dozen are wide-ranging species not peculiar to any province. All together only 107 species of echinoderms are characteristic of the Peronian province, but of these 82 per cent are endemic in Australia. The others are found also in New Zealand or the East Indies, but are in general species of whose distribution we still lack

adequate knowledge. The following species are typical of the Peronian province and give a characteristic facies to the fauna of Port Jackson:

Austrometra thetidis
Ptilometra australis
Anthenea acuta
Asterina inopinata
Patiriella calcar
Paranepanthia praetermissa
Uniophora granifera
Ophiacantha heterotyla
Amphiura multiremula
Amphiura dolia
Ophiocentrus pilosus
Macrophiothrix lampra
Ophiomisidium flabellum
Haplophiura gymnopora
Dictenophiura ctenophora
Phyllacanthus parvispinus
Centrostephanus rodgersii
Holopneustes pycnotilus
Urodemas perspicillum
Taeniogyrus australianus
Scoliorhapis théelii

The Flindersian Province

Extending as it does from Hobart, Tasmania, and the eastern end of Bass Strait to Geraldton, Western Australia, and Houtman's Abrolhos, the Flindersian province is of about the same extent as the Dampierian but does not include nearly so rugged or varied a coast line. As in the case of the northern province, there is an extensive area between the eastern and western ends concerning the fauna of which we are still comparatively ignorant. Little indeed is known of the echinoderms of the coast between Port Lincoln, South Australia, and Albany, Western Australia, and although much of it is apparently a sandy waste, there is a considerable area east of Albany that should harbor a fairly rich marine fauna. The echinoderm fauna of the Flindersian province is much smaller than that of the Dampierian, but very much more distinctive. The number of species now known from this southern province is only 166, but of these nearly 89 per cent are endemic in Australia. Most of these have not yet been taken on all the coasts of the Flindersian province, but they may fairly be looked for anywhere along the coast between Port Phillip and Fremantle.

In December 1942, an important paper on the "Echinodermata of the Flindersian Region, Southern Australia," by Bernard C. Cotton and Frank K. Godfrey, appeared (see bibliography). This list includes 164 species, and the present report includes 166. There is a striking discrepancy, however, as regards the echini, and an equally striking but reversed difference in the tabulation of the holothurians. Cotton and Godfrey include 43 echini, whereas the present report counts only 33 species as Flindersian. This apparent discrepancy is due to these authors' recognition and tabulation of several varieties which do not seem to me valid, and to the fact that I treat as Peronian, Dampierian, or Solanderian a number of species which they have included as

Flindersian. There are, however, 4 species which seem to me unquestionably Flindersian that are omitted by them. As these differences are purely a matter of opinion, they do not in the least lessen the value of their report. As regards the holothurians, the list of 17 species given by Cotton and Godfrey is obviously a compilation, apparently based chiefly on Joshua's work, but it overlooks several of the species which he listed in 1914 and others reported in recent years by other writers. It is not strange, therefore, that the list is incomplete.

The 166 species of echinoderms which characterize the Flindersian province may be grouped in three divisions. First are those which are strictly Flindersian, being found on the coasts of Victoria, South Australia, and Western Australia, but not having been taken as yet east of Bass Strait or north of Geraldton. The following species are typical of this group:

Comatulella brachiolata
Ptilometra macronema
Anthaster valvulatus
Austrofromia polypora
Paranepanthia grandis
Echinaster arcystatus
Phyllacanthus irregularis
Temnopleurus michaelseni
Microcyphus, 3 species
Amblypneustes, 3 species
Holopneustes, 2 species
Protenaster australis
Lipotrapeza vestiens
Holothuria hartmeyeri
Paracaudina tetrapora
Trochodota roebucki

Some 60 species have been found as yet only at the eastern end of the province, on the South Australian coasts, while more than 50 others are known as yet only at the western end and have not been found east of Albany. There are, however, a dozen or more Flindersian species which extend their range eastward into the Peronian province, most of them occurring also in Western Australia. These may well be listed here:

Cenolia trichoptera
Luidia australiae
Astropecten vappa (extends into the Solanderian province)
Pentagonaster dübeni
Tosia australis
Patiriella gunnii
Placophiothrix spongicola
Ophionereis schayeri
Ophiocoma canaliculata
Ophiocoma pulchra
Ophiarachnella ramsayi
Goniocidaris tubaria
Heliocidaris erythrogramma

There are 7 species found still farther to the east in New Zealand waters. Probably these are best considered New Zealand species which have extended their range westward. They are:

Allostichaster polyplax
Ophiactis resiliens
Lipotrapeza dearmatus
Mensamaria bicolumnata
Mensamaria thomsoni
Stichopus mollis
Chiridota gigas

Finally, there are a dozen species with a still wider range, and most of these are no more Flindersian than Peronian or Dampierian. These are:

Psilaster acuminatus, a deep-water species, taken off New Zealand, southern Australia, and South Africa.

Henricia hyadesi, a South American species; the Henricias from the Great Australian Bight, now listed as *hyadesi,* are almost certainly not that species, but material and data are too scanty to make proper treatment possible.

Coscinasterias calamaria ranges from Natal and Mauritius on the west to Lord Howe Island and New Zealand on the east.

Ophiomyxa australis is also known from Mauritius and Lord Howe Island. It extends its range northward into the East Indies, but is replaced in New Zealand by an endemic species.

Amphiura constricta occurs on all the coasts of Australia and at Lord Howe Island.

Ophiozonella elevata, Ophiomusium simplex, and *Taeniogyrus cidaridis* are Japanese species reported from Australia, but adequate material for validating these identifications is lacking.

Fibularia craniolaris and *Holothuria cinerascens* are East Indian species of ill defined range and equally ill defined specificity.

Echinocardium cordatum is nearly cosmopolitan in its distribution, occurring in the northern hemisphere as well as in South Africa, Australia, and New Zealand.

Leptosynapta dolabrifera is found not only in the Flindersian province, but in the Peronian and the western part of the Dampierian also. It occurs at Lord Howe Island, but not in New Zealand.

The above analysis of the existing Australian echinoderm fauna brings out the interesting fact that the farther one goes from the Torres Strait region, either south and then west or west and then south, the more endemic and characteristic the fauna becomes, until at the southwestern corner of the continent, between Fremantle and Albany, we have a group of echinoderms of which practically none of the species and very few of the genera occur in the East Indian region. The origin of this fauna is possibly bound up with the geological history of Australia and its past relationships with other land areas, but it is justifiable to point out that this further study of Australian echinoderms confirms the conclusions reached (H. L. Clark, 1921, p. 212) from a critical study of the echinoderms of Torres Strait. It can scarcely be questioned that the Solanderian fauna of Queensland is quite closely related to that of the area northeast of it and is distinctly less endemic (only 42 per cent) than that of any of the other Australian provinces. Further discussion of this interesting matter may, however, be better postponed until the extinct fauna of the Australian continent is considered and the existing faunas of the land masses lying west, north, and east of the continent are critically compared with that of Australia.

The Extinct Echinoderms of Australia

The inclusion of the extinct echinoderms in this report is not for the purpose of discussing the geological relations of various areas and strata, but solely for the purpose of ascertaining whether they throw any light on the origin or movements of the present-day fauna. The fact that so large a number are from very old rocks and that very few are closely allied to species now living is disconcerting. It makes any use of the data concerning them in discussing the Recent forms hazardous if not futile, and seriously invalidates any conclusions one might hope to draw. Nevertheless it is desirable to formulate such conclusions as we can concerning them, and this can best be done by considering each class by itself.

Crinoidea

Few of the fossil crinoids found in Australia have as yet been collected in sufficient quantity (not to mention quality of preservation) to enable us really to know them adequately from the zoologist's point of view.

In the Silurian rocks of New South Wales and Victoria 4 species are known to occur, but none of them are nearly related to any Recent forms. Some 10 or a dozen more are recorded from Carboniferous or Permocarboniferous rocks, from Queensland to Tasmania but chiefly in New South Wales. Their relationship to any of the Recent species is remote and uncertain. From the Cretaceous rocks of Western Australia have come fragments of individuals of 2 genera (*Marsupites* and *Uintacrinus*) which are widely distributed in the northern hemisphere. They have no near relatives among living crinoids. In the Cretaceous rocks of Queensland, New South Wales, and South Australia, abundant remains occur of a large stalked crinoid which for the present is referred to *Isocrinus*. It is obviously related to the Recent species of *Metacrinus* still living in moderately deep water off the northwestern and southeastern coasts of Australia, but until it is more fully described and figured, it can hardly be considered as in any sense ancestral to them. Obviously, then, our fragmentary knowledge of the extinct crinoids of Australia throws practically no light on the past history of the continent or on the origin and relationships of the present crinoid fauna.

Asteroidea

From the zoologist's point of view the extinct sea stars of Australia are as exasperatingly imperfect and unsatisfactory as the crinoids. Though 17 species have been described and figured to such an extent that it is possible to include them in this report, in some sort of natural relation to the living species, they really throw no light on either the geological or the morphological history

of Australia's sea-star fauna of today. Nearly all are from the Silurian rocks of Victoria, only 3 having been found in the Permocarboniferous rocks of New South Wales. About two-thirds of the species are regarded as Phanerozonia, the remainder being placed in the Spinulosa, but very little of the material is adequate for the basing of positive conclusions. On the whole, the Australian fossil sea stars are of no use to the zoologist who is striving to throw light on either the phylogeny or the geographical distribution of the Asterozoa. As horizon indicators for the geologist they may perhaps be of more service.

Ophiuroidea

The extinct ophiurans of Australia are of little more use to us than the sea stars in an effort to find connecting links between the extinct fauna and that of the present day. Fourteen fossil species are described with reasonable care, and one of these can even be referred to a Recent family. But they are in no sense really connecting links between the far distant paleozoic and the present. The one species referable to a Recent family is from the Mesozoic rocks of Queensland and is referred to the heterogeneous group *Ophiacantha,* but the material is too inadequate to warrant attempting to find in it a connecting link. The remaining fossils are referred to 10 genera in half a dozen or more families (all extinct), but the material is too scanty to justify any positive conclusions as to their relation either to Asterozoa or to one another.

Echinoidea

The number of fossil echini now known from Australia (56) considerably exceeds the number of extinct species of the other four classes combined. Moreover, they are for the most part from far more recent strata, and their relationship to existing species is much more obvious. Only 3 occur in rocks older than the Tertiary, 1 having lived in the Paleozoic and 2 in the Mesozoic. The Paleozoic species (*Archaeocidaris selwyni*) is very old phylogenetically as well as geologically. Extinct since Carboniferous days, it is apparently in no sense ancestral to any part of the present-day Australian fauna. The 2 Mesozoic species have been found on opposite sides of the continent—one, a cidaroid (*Cidaris comptoni*), in Western Australia; the other, a spatangoid (*Micraster sweeti*), in Queensland. The former is very possibly in some sense ancestral to *Stylocidaris* (see p. 281). The latter is too incompletely known to warrant any assertions as to its descendants, but it might possibly have been in the line from which *Brissus* or *Brissopsis* has come.

The 53 Tertiary species are all from the southeastern coastal region of the continent, and it is quite conceivable that some of them are ancestral to some

of the species now living on those coasts. That *Eupatagus valenciennesi* and *Protenaster australis,* for instance, are derived from some of the related Tertiary spatangoids is quite possible, but in the light of our actual knowledge the steps are not yet visible. When the amount and condition of the material enables us to work out the development of such forms, the relation of the Recent to the Tertiary species may be ascertained with a greater or lesser degree of probability. Meanwhile it must be admitted that our knowledge of the extinct forms and of the developmental growth changes of the Recent species is inadequate.

Holothurioidea

No fossils that could reasonably be regarded as the remains of holothurians have yet been found in the rock record of Australia save for the wheel-like spicule found by T. S. Hall in the Bird Rock zone, Spring Creek, Victoria. This spicule is about double the size of the "wheels" occurring in the body wall of the chiridotids now living on the coast of Victoria. But of course we cannot be sure that the species characterized by such spicules is actually extinct, for it may still be living under conditions which make it inaccessible to a collector. Clearly paleontology throws no light on the history of Australian holothurians.

The Echinoderms of Lands Surrounding Australia [1]

Kerguelen

The nearest land to Australia on the southwest is the desolate island of Kerguelen. Although large, well covered with vegetation, and with many more or less good harbors, it is uninhabited by man. It has been visited and to a great extent explored and mapped by scientific expeditions, and its fauna is fairly well known. The "Challenger" spent about three weeks there and took many echinoderms. Subsequent visitors have taken additional forms, and 70 species are now listed from Kerguelen. No other land mass of importance lies so far south between the Greenwich meridian and 80° E., but Stewart Island, New Zealand, is only about 2° nearer the equator. Directly south of Australia lies only the Antarctic Ocean, the echinoderm fauna of which is now fairly well known. It is, however, entirely lacking in forms characteristic of Australia; for example, of the more than 50 genera of sea stars listed by Fisher (1940) as Antarctic, only 4 occur in Australia, and those are all found in the northern hemisphere also. Obviously the Antarctic echinoderms have played little or no part in the development of the Australian fauna.

This is equally true of the echinoderms of Kerguelen. Only 1 of them has

[1] Species occurring only at great depths (500 fathoms or 900 meters or more) are not considered.

ever been reported from Australia, and that is almost certainly wrongly identified. Joshua and Creed (1915) record a single specimen of a *Cucumaria* from Encounter Bay, South Australia, as *C. squamata* Ludwig, itself known from only a single small specimen collected at Betsy Cove, Kerguelen. Without more material or at least without actual comparison of specimens, we cannot admit this Kerguelen holothurian to the Australian fauna (see p. 389). *Promachocrinus,* the characteristic crinoid of Kerguelen, is not known from Australia. Six genera of sea stars occur in Australia and also in Kerguelen, but 5 of these are well-nigh cosmopolitan, and the Australian member of the sixth (*Smilasterias*) is of very dubious status. The situation is virtually the same as regards the ophiurans, and none of the Kerguelen genera of echini occur in Australia. It is proper, therefore, to say that there is nothing in common between the echinoderms of Australia and those of Kerguelen.

Mauritius

Far to the north of Kerguelen and somewhat to the west lies the island of Mauritius. With its neighbors, Rodriguez and Réunion, it makes up the next nearest land mass to Australia, on the west, south of 10° S. The echinoderm fauna of Mauritius is remarkably well known, thanks principally to the industry of M. V. Robillard as a collector and of P. de Loriol as the zoologist who not only provided the stimulus for the work, but carefully described the material collected. There have been also a few other collectors and students to whom marine zoologists are indebted for our present knowledge of the echinoderm fauna of the island. This fauna consists of rather more than 150 species; some of these are perhaps invalid, but no doubt others are as yet unrecognized. Comparison of this fauna with that of Australia reveals the following noteworthy facts. From Mauritius, 7 species of crinoid are known, each representing a different genus. All these genera occur in Australian seas, but in every case the Mauritian species is different from the Australian. Moreover, each of the Mauritian crinoids belongs to a genus which is fundamentally East Indian, ranging from the Red Sea along the southern coast of Asia to southern Japan on the north and to the Tonga Islands on the southeast. Most of the Mauritian species occur in Madagascar and several are found on the African coast either southwestward toward Natal or northwestward to the Red Sea.

The Asteroidea are better represented in Mauritius, at least 35 species, in 23 genera, being reported from the island. Of these a dozen occur also in Australia, and their occurrence in Mauritius is therefore of importance. But 9 of the 12 are widespread in the Indo-Pacific region and may properly be considered East Indian species. Of the other 3, *Linckia guildingii* is practically tropico-

politan, and its occurrence in Mauritius is not surprising. More puzzling is the case of *Leiaster leachii,* which occurs at Lord Howe Island as well as at Mauritius. It is highly probable that this species occurs throughout the East Indian region, but it is very secretive in its habits and few specimens have been collected. Lastly we have the remarkable case of *Coscinasterias calamaria,* which occurs on the South African coast, at Mauritius, all along the southern coast of Australia, at Lord Howe Island, and in New Zealand. Whether this range through 150 degrees of longitude involves 1, 2, or more species cannot be determined without far more comparable specimens than are yet available, but it matters little so far as the remarkable distribution is concerned, for it can scarcely be doubted that this is all a single stock with a common origin. A simple, but quite unprovable, explanation is that these sea stars have traveled on foul ship bottoms in the cool waters of the south temperate seas from New Zealand to Australia, Lord Howe Island, and Tasmania, and thence to South Africa. From here the introduction to Mauritius is equally imaginable. The warmer seas of the equatorial regions have prevented any extension of range to the north of latitude 20° S. If this be nonsense, make the most of it!

The ophiurans of Mauritius are not so numerous as might be expected, but this is probably due to M. Robillard's not having hunted for and collected the small, easily overlooked forms such as *Amphiura* and its allies. Only 38 species are as yet listed from Mauritius, whereas 51 are known from the little island of Mer at the northern end of the Great Barrier Reef. Mortensen (1924) lists only 41 species from New Zealand, so Mauritius is not far behind that much larger area. It is a very striking fact that not a single species of ophiuran is common to New Zealand and Mauritius. Of the 38 ophiurans found at Mauritius, 17 occur in Australia, but one of these is the tropicopolitan *Ophiactis savignyi,* and its occurrence has no significance. Of the others, all occur in the East Indian region save one, the rare and little-known *Cryptopelta granulifera,* once taken at the Low Isles, Queensland, and once at Mauritius, with a close congener in the Philippines. Of only one other is any discussion necessary. That one is *Ophiomyxa australis.* It occurs at Lord Howe Island and throughout the Flindersian region of Australia, like *Coscinasterias calamaria,* but unlike that sea star, it is found along the eastern coast of Australia, in the East Indies, and even as far north as southern Japan. Hence its occurrence at Mauritius, though unexpected, does not require any extraordinary explanation. The occurrence in Lord Howe Island, Tasmania, and the coastal waters of the southern side of Australia would seem to be the perplexing feature of its distribution. Apparently it does not occur on the western coast of the continent. None of the other ophiurans of Mauritius occur in the Flindersian province of Australia, at least at its western end.

More species of echini than of ophiurans are known from Mauritius; in Australia there are only 134 Recent echini to 223 ophiurans; in Mauritius there are 39 echini to 38 ophiurans. The explanation, however, is probably to be found in the fact that M. Robillard, being a paid but untrained collector, naturally found the echini a more noticeable, interesting, and easily preserved group. It seems likely that his collection of echini is more completely representative of the Mauritian fauna than is the collection of ophiurans. Of the 39 species of sea urchins now known from the island, 23 are found also in Australia, but 14 are characteristic of the Solanderian province, 8 of the Dampierian, and 1 (*Echinoneus cyclostomus*) is tropicopolitan. All 23 are found more or less commonly in the East Indian region. It is a striking fact that none of the echini of Mauritius occur in the Flindersian province of Australia, with the possible exception of stragglers from the Dampierian province which occur at Houtman's Abrolhos and even at Rottnest. But a very characteristic Flindersian genus, *Microcyphus,* is represented at Mauritius by a species (*maculatus*) which is not found in Australia. It is, however, found at the Andaman Islands and in southern Japan and is reported from Samoa. Hence the occurrence in Mauritius is a tie with the East Indian region rather than with Australia.

The holothurians of Mauritius are apparently pretty completely known, as 34 species are already recorded. Of these 22 occur in Australia, 14 being Dampierian species and 8 Solanderian. All are widespread Indo-Pacific species, and their occurrence in Mauritius is quite natural. There is no indication whatever that the Mauritius holothurians are allied to those of Australia, and particularly Western Australia, any more than to those of the East Indies.

It is evident from this survey of the echinoderms of Mauritius that the littoral fauna of that island is of East Indian origin. The peculiar distribution of *Coscinasterias calamaria* and *Ophiomyxa australis* must be explained in some other way than by an assumption of former land connection between Mauritius and Australia.

Southeastern Africa: Mozambique to Cape Town

During the past twenty years the marine fauna of the South African coast, especially east from Cape Town, has received much attention, and the echinoderms may be considered fairly well known. No fewer than 235 species are recorded with more or less detail, and it is therefore possible to compare this fauna profitably with that of Australia, particularly with the Flindersian element of the southwestern part of the continent.

The crinoid fauna of South Africa is relatively depauperate, containing only half a dozen species each representing a different genus. Two of these genera, *Cenolia* and *Tropiometra,* occur in Australia, but the other 4 are East Indian

groups having widely different ranges, yet not entering the Australian fauna. *Tropiometra* is represented in the Australian tropics (Dampierian province) by a large species nearly related to one from Japan, whereas the South African species is a small form with an extraordinary range, from the western part of the East Indian region, around South Africa, northwestward to the southern West Indies. The South African *Cenolia,* on the other hand, finds its nearest relatives in the Flindersian province of Australia and in New Zealand, a striking reminder of *Coscinasterias calamaria.* The habits of these little comatulids are such as to make their distribution on foul ship bottoms very easy, and it is reasonable to suppose that *Cenolia,* like *Coscinasterias,* has reached South Africa in this way. It should be noted, of course, that the African *Cenolia* is a different species from the Australian, and that the latter is not known from west of King George Sound.

The sea stars of South Africa are a large and interesting group of 75 Recent species and 1 fossil form. The latter is called "*Archaster pattersoni,*" but it is certainly not congeneric with the Recent species now included in *Archaster,* and even more certainly it is not nearly allied to any of the extinct Australian sea stars. It has no significance, then, in the matter of the relation between the South African and Australian faunas. The 75 Recent species represent 45 genera, of which 20 are found in Australian waters, but of the 75 species only 6 are common to the two areas. Of these, 3 are wide-ranging Indo-Pacific species whose occurrence in South Africa is merely the extreme southwesterly extension of their range. Of the other 3, one is *Coscinasterias calamaria,* whose occurrence is, as already suggested, probably due to transference from Australia on foul ship bottoms. Another is *Disasterina leptalacantha,* which is too rare and little known to carry much weight, but whose distribution is quite likely East Indian like that of *Patiriella exigua,* a near relative. The third is *Psilaster acuminatus,* first taken off New Zealand and New South Wales, subsequently found in Bass Strait and the Great Australian Bight, and lastly recorded several times off South Africa. That its occurrence there could be by transference on ship bottoms is so highly improbable that we must account for it in some other way. The genus is virtually world-wide in distribution, with representatives in all seas, including both Arctic and Antarctic oceans. It also occurs at all depths from very shallow water (in the Antarctic Ocean) to over 1800 fms. Since great depths are apparently not barriers to the spread of *Psilaster,* the distribution of *P. acuminatus* in South Africa, southern Australia, and New Zealand is possibly not beyond comprehension, but it is certainly of unusual interest.

Of the other 14 genera of sea stars common to Australia and South Africa, 4 are widely distributed Indo-Pacific groups, and 5 others are even more widely distributed, being tropicopolitan or having representatives in temperate seas of the northern hemisphere. Of the others, the South African species have notable

peculiarities that justify skepticism as to their generic position. Thus, the South African *Tosia* is very different from any of the Australian species and can hardly be congeneric. The *Anthenoides* is almost certainly not congeneric with the much smaller Australian sea star doubtfully referred to this West Indian genus. The *Austrofromia* is quite different from the Australian species; specimens of the two are rare and have never been compared. The *Hacelia* is very near the West Indian genotype and not very similar to the Australian species. As for *Parasterina,* comparison of Mortensen's figure of his South African species (1933, pl. 12, figs. 9, 10) and my figure of the Western Australian species (1938, pl. 21, fig. 5) certainly justifies great doubt whether the two are really congeneric. Satisfactory material is still too scanty to permit the necessary direct comparison, but the supposed resemblances do not outweigh the obvious differences. Clearly, then, none of the cases of genera recorded from both Australian and South African seas give any justification for a belief in their common origin save by the gradual diversification of widely distributed ancestral stocks.

The brittle stars of South Africa are little more numerous than the sea stars, only 79 species being known. These represent 40 genera, of which 23 occur in Australian seas, but 16 of these are more or less tropicopolitan and 4 others are East Indian. The remaining 3 have been found as yet only on Australian or South African coasts, but in no case is the South African species identical with the Australian. Indeed, of the 79 South African brittle stars only 7 are recorded from Australia, and all these are widely distributed tropicopolitan or East Indian species. *Astroconus* has a representative in South Africa, but it is so different from the Australian species of that genus that Mortensen, the describer, hesitated about calling it congeneric with them. The Australian *Cryptopelta* is conspicuously different from the African species, and occurs only in the Dampierian province. The same is true of the Australian *Dictenophiura.* The South African *Ophiomyxa* is supposed to be identical with that of southern South America, and is not closely allied to the Australian species. It must therefore be admitted that the ophiurans of southwestern Australia have very little in common with those of South Africa.

The South African echinoid fauna as now known contains 45 Recent and only 1 fossil species. The single extinct form is *Cidaris pustulifera,* which is probably related to one of the Recent cidarids now living on the South African coast, but more material is necessary to establish its real position. The 45 species of echini now living on the coast represent 37 genera, no genus having more than 2 species. Of these genera, 24 occur in Australia, but of the 45 species, only 16 are known from that continent. Of the 16 species, 14 are well known East Indian forms whose occurrence in the South African region is only the extreme southwestern extension of their tropical range. One is the

almost cosmopolitan *Echinocardium cordatum*. The sixteenth is the remarkable *Dermechinus horridus,* first found by the "Challenger" in 175 fms. off the southern end of South America, but later discovered in somewhat greater depths off the southeastern coast of South Africa and in similar depths off the southeastern corner of Australia. Whether we consider that the collected material represents a single species, or 3 closely related but probably distinguishable forms, does not alter the remarkable nature of the distribution of this urchin. It may, however, be pointed out that the genus *Echinus,* even if rather strictly defined, is well-nigh world-wide in its range and may have spread southward along several widely separated lines. On the other hand, the occurrence of *horridus* as at present known could be used as an argument in support of the former approximation of the three southern continents. What is more probable (in keeping with the distribution of several New Zealand echinoderms), it may indicate the former existence of an Antarctic land mass, or at least a shallow-water area, connecting South America, New Zealand, Tasmania, and South Africa. The apparent absence of *horridus,* however, from both New Zealand and Kerguelen throws doubt on this. It is curious that there is no other echinoderm known with a distribution like that of *horridus.*

The holothurian fauna of South Africa seems to be rather depauperate, as only 28 species are known and these represent but 10 genera, all but 1 of which are more or less cosmopolitan or at least tropicopolitan. The monotypic *Discucumaria* is widespread in the East Indian region. None of the genera are in any way distinctive of South Africa. Of the 28 species, 12 occur on the Australian coast, but all are more or less common, widely distributed East Indian forms and give no indication of any connection between South Africa and Australia other than by way of the East Indies.

This comparison, then, of the Australian and South African echinoderm faunas brings out very clearly the lack of any evidence in that conspicuous group of littoral marine animals to justify belief in any former closer relation between the two continents. The four suggestive cases (the comatulid *Cenolia,* the sea stars *Coscinasterias* and *Psilaster,* and the sea urchin *Dermechinus horridus*) all involve either New Zealand or South America as much as they do South Africa, and might be construed as evidence for a Gondwana-land connection such as is demanded according to the Wegener hypothesis.

East Africa: the Zanzibar Region, from 14° 30′ S. to 10° N., with Madagascar and the Seychelles

There is reason to believe that our knowledge of the Recent echinoderms of the East African area is still very incomplete, but thanks to the activities of French geologists and paleontologists our knowledge of the *fossil* echini is

very considerable. Few or no fossils of the other classes of echinoderms have been described, and the Recent species are neither numerous nor remarkable.

Of crinoids, only 16 species are listed, representing 13 genera. The genus *Heterometra,* of which 2 species occur in Australia, is represented by 4 species, but none of them are known from the island continent. Of the other dozen genera, 10 are found in Australia, but only 3 of the African species occur there, and these are well known, widespread East Indian forms. All the African genera are extensively distributed in the Indo-Pacific region or at least in its western half. There is therefore no indication of any close relation with Australia.

The 36 species of sea star now known from the Zanzibar region represent 24 genera, all but 5 of which are more or less common in tropical Australia. A dozen of the species are also found in the Dampierian or the Solanderian province of that continent, but these are all widely distributed East Indian forms whose range has stretched southward along the eastern coasts of both Africa and Australia. There is nothing, apparently, in the sea-star fauna of East Africa that is suggestive of Australia except through an East Indian connection.

The ophiuran fauna of the Zanzibar and Madagascar area includes some 57 species of 36 genera. Twenty-two of the genera occur in Australia and 17 of the species. But all these genera and species occur in the East Indies and are characteristic of that fauna. Hence there is no evidence that the ophiurans of the East African coast have any relation to those of Australia except by way of the East Indies.

The echini of the East African region must be treated under two heads, the living Recent fauna and the extinct fossil forms. The activity of French paleontologists in Madagascar has thrown a flood of light on the fossil echini, revealing an extraordinarily rich fauna, and a comparison of this with the much smaller extinct group in Australia will naturally be interesting. But first, consideration may better be given to the Recent fauna, which includes 46 species of 38 genera. It is surprising to find that it is notably different from that of Mauritius, only a short distance farther east. Of the 32 genera found at Mauritius, 11 have not been found in the Zanzibar-Madagascar area, and of the 38 genera in the latter region, 21 have not been found at Mauritius. No doubt this striking difference is in part due to incomplete collecting, but it is possible that local conditions markedly alter the character of the fauna. Comparison of the Zanzibar-Madagascar fauna with that of the Australian region shows that 29 of the 46 species are found on the coasts of that continent; 17 are Solanderian, 9 Dampierian, and 1 Flindersian; the *Echinoneus* is tropicopolitan and the *Echinocardium* is even more widespread. The remaining 17 are all either East

Indian species or endemic species of East Indian genera. There is no evidence of a distinctive Australian element.

Comparison of the fossil echini of the Zanzibar-Madagascar region with that of the similar fauna in Australia is somewhat difficult, as the Madagascan group is so much larger. It includes more than 175 species of at least 120 genera, whereas in Australia only 56 species of 40 genera are as yet known. Only 12 of the 40 are found in the Madagascan fauna, and these nearly all belong to large, ill defined groups such as *Cidaris* and its allies, *Salenidia, Clypeaster, Nucleolites, Echinolampas, Linthia,* and *Schizaster.* Naturally none of the species of the two regions can be considered identical. On the whole, the impression given by comparison of the two faunas is one of surprising dissimilarity. There is not the least indication that they were ever in any way associated or even remotely connected.

The East African holothurians are a small group of 32 species of 14 genera. Of the genera, all but 1 (*Patinapta*) occur in Australia. Of the 32 species, 24 occur in Australia. This would seem like a remarkable similarity in the makeup of the faunas were it not that the same genera and most of the species also occur throughout the East Indian region, so that the natural explanation of the similarity between the East African and the Australian faunas is that each is a southern or southwestern extension of the East Indian fauna. All the Australian species concerned are found in the Dampierian region or on the eastern coast, evidently incomers from the East Indies. The holothurians of the western coast are not so much like those of East Africa as are those of the northern and northeastern coasts.

Arabian Area, including Red Sea, Gulf of Aden, and Persian Gulf

The northwestern part of the East Indian area has a relatively small echinoderm fauna, especially as contrasted with that of the central and eastern parts. It includes about 170 Recent species, not many more than are found at the small island of Mauritius and much fewer than are found on the coast of southeastern Africa. As in the case of the Zanzibar-Madagascar area, the fossil echini are very numerous, at least 110 species in 80 genera having been recorded from Egypt, Persia, and Baluchistan.

The crinoid fauna of the Arabian area includes 17 species of 12 genera. All the genera, save 2, occur in the Australian seas, but only 3 of the species, all well known East Indian forms, are known from the island continent. All the genera, save the recently described, endemic, monotypic *Repometra,* are well known East Indian groups, but a dozen of the species are apparently endemic in the Arabian region, indicating a long period of relative isolation.

The sea-star fauna of the region includes 36 species of 20 genera. All but

5 of the genera occur in Australia, but only 7 of the species. The missing genera, like the 15 that are present, are widespread East Indian groups, or more or less endemic in the western Indian Ocean. Of the 7 Australian species, 3 occur in the Dampierian province and 4 in the Solanderian. All are widespread in the East Indian region. There is then no indication of any connection between the Arabian and Australian areas except by way of the East Indies.

The ophiurans of the Arabian region are neither numerous nor notable. Forty-two species of 21 genera are recorded; all but 4 of the genera but only 7 of the species are also Australian. Just as in the case of the sea stars, the fauna is essentially East Indian though 1 of the 4 non-Australian genera is endemic in the Arabian area. All the 7 Australian species (2 Dampierian and 5 Solanderian) are East Indian, yet of the 35 non-Australian species only 10 are East Indian, some 25 being more or less endemic in the Arabian area. All this accords well with the situation among the crinoids.

The Recent sea-urchin fauna of the Arabian area is not rich, but the fossil forms are numerous and varied. Thirty-six Recent species, grouped in 28 genera, are now found in the region. Of the 28 genera, all are East Indian and all but *Acanthocidaris* and *Toxopneustes* are Australian. Of the 36 species, however, 8 are not East Indian, 15 not Australian. One very interesting case is that of the species *Nudechinus scotiopremnus,* which is found in the Red Sea and also on the northwestern coast of Australia, but which has not yet been found in the East Indies. The genus is, however, known from the Amirante Islands in the western Indian Ocean, from northeastern Australia, and from the Sulu Archipelago, Philippine Islands, so it is quite possible that *scotiopremnus* will ultimately be found in the East Indies.[1] The other 7 species which have not yet been taken in the East Indies are more or less endemic in the Arabian area or at least in the western Indian Ocean. They are in no sense connecting links with Australia.

The fossil echini of the Arabian area are in general surprisingly different from those of Madagascar. Of the 80 genera, 46 have not yet been found south of the equator in Africa. But they are much more unlike those of Australia, with which they have nothing in common save for 8 or 10 large, ill defined genera of cidaroids and spatangoids widely distributed in the Mesozoic. One looks in vain for any evidence that the Mesozoic Australian echinoid fauna had any geographical association with that of the Arabian area.

The holothurians of the northwestern corner of the Indian Ocean and its associated gulfs comprise some 38 species in a dozen genera, all of which (except 1 or 2 concerning whose validity there may be question) occur in

[1] The similar case of *Nudechinus gravieri* is vitiated by the inadequacy of the material and the very great doubt whether the Australian specimens really are *gravieri.*

Australia and throughout the East Indies. Of the 38 species, however, about 16 appear to be endemic; the remainder are East Indian and apparently most of them extend their range into the Dampierian or the Solanderian province of Australia. The high percentage of endemic species confirms what was suggested by the crinoids and ophiurans, that the Arabian region has been more or less isolated for a long period.

Ceylon

The echinoderm fauna of Ceylon being fairly well known and the island being somewhat nearer to northwestern Australia than is Mauritius, it is interesting to note the characteristic features of the fauna. The statements made in 1915, however (H. L. Clark, 1915, p. 92), regarding the incompleteness of our knowledge are still true, and the deductions made here will very likely be considerably modified at some future day. Some 193 species of echinoderms are now included in the Ceylon list, nearly one-third more than have yet been reported from Mauritius.

At least 25 species of crinoids are recorded from Ceylon, whereas only 7 have been taken at Mauritius. The latter represent 7 genera, all but 1 of which occur in Ceylon, but of the 7 Mauritian species only *Comanthus parvicirra* and *Oligometra serripinna* are in the Ceylon list. Both of these are widespread East Indian species, and the *Comanthus* is notoriously variable. When we compare the Ceylon list with the Australian, we are struck with the similarities, for all the Ceylon genera, except *Mastigometra,* occur in Australia, and even when the species are different, as is true in several genera, the similarities are more striking than the differences. There can scarcely be any question that the two faunas have had a common origin.

Turning now to the sea stars, we find 35 species in Mauritius as against 41 in Ceylon. Twenty genera occur in Ceylon and 23 in Mauritius; 16 are common to the two. Comparing species, we find but 15 in common, indicating that the two faunas have long been completely isolated from each other. Comparison of the sea stars of Mauritius with those of Australia revealed a dozen species in common. In the case of Ceylon, we find 18. In other words, 33 per cent of Mauritian sea stars are Australian, and 44 per cent of those in Ceylon.

In the case of the brittle stars, there are 38 species in Mauritius and 37 in Ceylon. Of the 22 genera occurring in Ceylon, 9 have not been found in Mauritius; of the 21 found in Mauritius, 8 have yet to be taken in Ceylon. As for the species, we find only 15 of the Ceylon species at Mauritius, and of course 14 of the Mauritius species at Ceylon. These differences in the faunas of the two islands are interesting but are no doubt due in part to incomplete collecting. Comparison of the ophiurans of Mauritius with those of Australia

revealed 17 species in common. In the case of Ceylon we find 21. That is, 45 per cent of Mauritian ophiurans are Australian and 56 per cent of Ceylonese species.

In the case of the echini, there are 39 species in Mauritius and 38 in Ceylon. Of the 28 genera occurring in Ceylon, 23 are found in Mauritius; of the 32 found in Mauritius, 9 have yet to be taken in Ceylon. As for the species, we find 25 of the Ceylon species at Mauritius, and of course 13 of the Mauritius species at Ceylon. Though these differences may be due in part to incomplete collecting, this is less likely to be the case than with the brittle stars, as echini are less easily overlooked. Of the echini now known from Mauritius, 23 occur also in Australia; of the Ceylonese echini, 25. That is, 59 per cent of Mauritian sea urchins are Australian, and 66 per cent of those found at Ceylon.

Turning now to the holothurians, we find no fewer than 51 species recorded from Ceylon as contrasted with only 28 from Mauritius. This is obviously due in part to the fact that Robillard and de Loriol made no effort to include the holothurians in their collecting and study of Mauritian echinoderms. Of the 15 genera listed from Ceylon, only 8 have been reported from Mauritius; 2 genera, *Psolus* and *Discucumaria,* reported from Mauritius, are not yet recorded from Ceylon. So far as species are concerned, only 10 of the species listed from Ceylon are reported as yet from Mauritius, but comparison with Australia shows 26 species in common. Of Mauritian holothurians only 12 are Australian. That is to say, 43 per cent of the Mauritian holothurians and practically 50 per cent of those in Ceylon also occur in Australia.

It seems evident, then, that the Ceylon echinoderm fauna is not less than 10 per cent more Australian than is that of Mauritius, a fact no doubt to be explained in part by the location of Ceylon so much nearer to the island continent (about a thousand miles). But the more probable reason is that Ceylon is so much nearer than Mauritius to the East Indian islands, the hotbed of echinoderms, if not of all marine life.

The East Indian Area

The boundaries of this great and interesting tropical region are necessarily artificial. For practical purposes in the present connection, it includes the sea and its islands between 90° and 155° E., with arbitrary and irregular southern and northern limits. Obviously the southern limit must coincide with the northern limit arbitrarily fixed herein for the Australian region (9° 30′ S.) as far as 145° E., where it drops to 12° S. for the next 10°. The eastern boundary then follows longitude 155° between the Bismarck Archipelago and the Solomon Islands to 5° N., where it turns west to 130° E., then north to 20° N., on which parallel it runs westward to 90° E., then straight

south to 9° 30′ N. The western boundary thus excludes most of the Bay of Bengal but includes the Andaman Islands. The northern boundary includes the Philippines and the coasts of Indo-China and the Malay Peninsula. Though these boundaries are admittedly arbitrary and artificial, the area contained is a natural marine province. Obviously its boundaries have nothing to do with the lines which delimit the areas occupied by the land vertebrates of the region. The echinoderm fauna of this interesting area is extremely rich, and thanks to the "Siboga" and "Albatross" collections and those made by Sluiter, Mortensen, and other zoologists, it is remarkably well known. More than 1300 Recent species, in about 400 genera, are already recorded from the East Indies—more than one-fourth of all the echinoderms at present known. There are in addition scores of fossil species, nearly all echini, recorded in about 60 genera, of which three-fourths are long since extinct. Comparison of this rich fauna with that of the Australian region is most interesting and informative.

The crinoids of the East Indies are surprisingly numerous, more species being known than in any of the other classes, except the ophiurans. There are a number of fossil forms, imperfectly known, but as these have no near relation to either the Recent species or the extinct Australian crinoids, it is not necessary or desirable to include them in this discussion. The Recent crinoids number 245 species of 75 genera. Of these genera, 35 occur in Australia, and the remaining 7 Australian genera are endemic, all but 1 being confined to the Peronian or the Flindersian province. Of the 83 species of Recent Australian crinoids, 33 are endemic. The remaining 50 all occur in the East Indies and are obviously members of that fauna. The single tropical endemic Australian genus is the curious *Monilimetra* of the Broome region, with 4 species apparently differentiated in that area. Its nearest relatives, so far as we may guess at them, occur in the northern East Indies. Clearly the relationship between the East Indian crinoids and those of Australia is very close. The facts justify the conclusion that the Australian crinoid fauna is the southern extension of that of the East Indies.

The East Indian Asteroidea are numerous and diversified to a marked degree, 231 species grouped in 83 genera—not quite 3 species to a genus. The Australian Asteroidea form a group more nearly comparable with them in size and diversity than was the case with the crinoids. In Australia, there are 189 species of sea stars in 73 genera, about 2.5 species to a genus. Apparently this indicates more active speciation in the more southern group, associated with its greater isolation. Of the 73 Australian genera, 30 are lacking from the East Indian list, and of these 18 are endemic; 9 of the latter are in the Flindersian region and 2 are Peronian. Three genera are so widely dispersed that they are found in the northern and western hemispheres as well as in

the southern and eastern. The remaining 9 genera which are not endemic occur in New Caledonia, New Zealand, Kerguelen, Mauritius, and South Africa. In several of these cases, however, material is scanty and our knowledge of the genus is very incomplete. Of the 189 Recent species of Asteroidea occurring in Australia, 139 are endemic. The remaining 50 are all East Indian species, except half a dozen of whose distribution we know very little or which occur in New Zealand as well as in southern Australia. There can be little doubt, therefore, that the Australian asteroid fauna is an extension southward of that of the East Indies, which has become diversified and distinctive as a result of its isolation in a cooler or otherwise different environment.

The brittle stars of the East Indies are a very large group, containing nearly as many species as the crinoids and sea stars together. There are 458 species of 110 genera, and the comparison with the large Australian group is interesting and instructive, though the latter contains only about half as many species. There are 70 genera of Australian ophiurans; of these, 54 may fairly be called East Indian, and 13 are endemic. The remaining 3 are *Asteroporpa,* which occurs in the West Indies, in Japan, and in New Zealand; *Ophiocomina,* which is known as yet only from South Australia and from European seas and the northwestern Atlantic (a perfectly inexplicable distribution); and *Ophioprium,* a West Indian genus. A comparison of the Australian and East Indian species shows that of the 223 Australian forms 133 are endemic, and 85 are East Indian. The remaining 5 are 2 New Zealand species of *Ophiactis,* an *Ophiocoma,* an *Ophiomastix* (known as yet only from the far distant Paumotu Islands), and *Cryptopelta granulifera* from Mauritius. These last 3 will almost surely prove to be East Indian forms. Obviously the relationship of the Australian ophiurans to the East Indian fauna is so close that there can be no doubt of their common origin or of the southern group's being derived from the larger tropical one.

The East Indian echini are a large and diversified group of 166 Recent species, representing 85 genera. There is also a large group of extinct species of 46 additional genera. Fossil species of 13 of the Recent genera have also been found. Not all these fossil forms are from the East Indian area as defined for the Recent species; many are from mainland areas outside the limits given above. A comparison of these extinct forms, however, brings out the interesting fact that 26 of the genera occur in Australia, 17 as extinct, 9 as still living genera. It is probable that when the extinct faunas of Australia and of the East Indies are more fully known and proper consideration can be given to the geological horizons, and their correlation in the two regions, the resemblance between the two faunas will be striking. Meantime a comparison of the Recent genera and species shows that 9 of the East Indian genera and 56 of the species

occur in Australia, and that 9 genera and 69 species are endemic there. The 10 remaining species occur in South Africa, New Zealand, the Pacific Islands, or Japan. In most of these cases it is probable the species occurs also in the western part of the East Indian area but has not yet been collected there. The extraordinary case of *Dermechinus horridus* has been discussed in connection with South Africa (see p. 480). On the whole, the relation between the Australian echini and those of the East Indies is about as close as in the case of the sea stars.

Coming now to the holothurians, we find a rich East Indian fauna of over 200 species, in some 40 or more genera. No fossil holothurian remains have yet been reported. When we compare the East Indian and Australian faunas, we realize that the latter has been more critically studied and hence the number of genera in proportion to the number of species is considerably greater in the Australian area—about 4 species to a genus, whereas in the East Indies there are 5 species to a genus. Moreover, thanks to the work of the "Siboga," 7 genera of deep-water holothurians are known from the East Indies which have not yet been collected in Australia, owing to the very small amount of dredging that has been done on the continental slope. Making due allowance for these facts, we find that the genera of East Indian and Australian holothurians are otherwise almost identical. The two small apodous genera *Anapta* and *Labidoplax* have not yet been found in Australia. Looked at in reverse, it may be said that all Australian genera occur in the East Indies except the small apodous genus *Trochodota* and perhaps some of the recent segregates from the genera *Cucumaria, Thyone,* and *Phyllophorus.* Examination of the lists of species found in the two areas reveals the following facts: Eighty-two of the holothurians found in Australia are endemic. Of the remaining 76, 67 are East Indian, the other 9 being New Zealand or Pacific species. Of these 9, several are of dubious validity and uncertain relationships. There can be no doubt, then, that the Australian holothurians are, like the other echinoderms, almost certainly of East Indian origin.

The Southwestern Pacific

Our knowledge of the echinoderm fauna of the southwestern Pacific is fragmentary and incomplete. No thoroughgoing, adequate collecting or studying of the marine fauna of even the well known island groups has ever been carried on. There is, however, some material in various museums which has enabled us to gain a little knowledge of the echinoderms of this interesting and important region. Most of this material has come from Fiji, Samoa, or Tonga. About 150 species have been listed at various times in scattered

publications from this southwestern Pacific area, and it is of interest to study this list in comparison with the East Indian and Australian faunas.

Only about a dozen crinoids are reported from the southwestern Pacific area. As carefully reidentified and correctly named by A. H. Clark (1936), there are apparently 13 comatulids in the list, with several additional species found in depths below 500 fms. All the genera and 10 of the species occur in Australia, but all the genera and *all the species,* barring possible varietal differences, are East Indian. Apparently the crinoids of the southwestern Pacific are a development parallel to the Australian group from a common East Indian center.

Only 23 species of sea stars have been reported from Fiji, Tonga, and Samoa, but they represent 17 genera. Only 12 of the genera and 12 of the species occur in Australia, but 16 of the genera and 18 of the species are East Indian. The other species are little-known sea stars whose status and distribution are yet to be made clear. There seems to be little doubt that the sea stars of the southwestern Pacific have diverged from the East Indian group rather less than the Australian asteroids, but this divergence has led to obvious differences between the faunas of the two regions.

Of brittle stars only 40-odd species of 27 genera are recorded from Fiji, Tonga, and Samoa, and these are probably not more than half the forms occurring in that area. Comparison with Australia shows only 6 genera and a dozen species not known in that region. This indicates a much closer resemblance between the brittle stars of the southwestern Pacific and those of Australia than we find in the sea-star population. But this difference is probably due at least in part to a very incomplete knowledge of the brittle stars of the southwestern Pacific; for 4 of the genera and 10 species are not East Indian, so far as we yet know, and this is an abnormal proportion as compared with the other classes.

Only 32 species of echini are listed from the southwestern Pacific, but this is a much larger proportion of the actual echinoid population than we have found among the sea stars or ophiurans. The 32 species represent 22 genera, one of which is the remarkable endemic *Zenocentrotus* of Tonga, which includes 2 species. Aside from this case, 1 genus and 6 species do not occur in Australia, but every genus and all but 2 species are East Indian. As *Zenocentrotus* is apparently a local specialization of *Echinometra,* it is obvious that the East Indian fauna is the source of the echinoid fauna of the southwestern Pacific.

The holothurian fauna of the Fiji-Tonga area is almost completely East Indian, for of the 34 species so far listed, all but 1 occur in the East Indies. That one is the deep-water synaptid *Protankyra challengeri,* which was taken in comparatively shallow water at Fiji but in the East Indies has been collected only at great depths. The absence of 4 species of *Holothuria,* as well as of

Protankyra, from the Australian fauna distinguishes it from the southwestern Pacific group, in addition to the fact that it includes more than a hundred species not known in that area.

The result of this survey of the echinoderm fauna of the southwestern Pacific, so far as it is at present known, leaves little doubt that it has been derived from the East Indies and that any resemblance it may have to the Australian fauna is quite secondary.

The New Zealand Area

Thanks to Mortensen (1921, 1924, 1925), our knowledge of the echinoderm fauna of New Zealand is definite and reliable and probably reasonably complete, except for the Kermadec Islands and the northwestern part of the North Island. A comparison of it with that of Australia is of particular interest.

Only 3 species of crinoids have been found in New Zealand, and these are all endemic forms occurring on the west coast of the south island and off North Cape and the Three Kings Islands. They are closely related to species of the southern coast of Australia and somewhat less closely to a South African species and to one from Hawaii.

Of sea stars, some 30 species (and 1 variety) are recognized by Mortensen, of which all but 4 are endemic. They represent 22 genera, of which 6 have a world-wide distribution and 6 are Australian. The remainder are of southern relationships or are endemic. Ten of the genera are East Indian or at least are represented in that fauna, and a dozen are Australian in the same way. There can be no doubt of the striking fact that the New Zealand sea stars have but little in common with those of Australia and even less with those of the East Indies.

More than 40 species of ophiurans occur in New Zealand, and of these, all but 4 or 5 are apparently endemic. Of the 22 genera, only 1 is strictly endemic; 1 occurs also on the coast of California, 1 occurs in Australia and the West Indies, 14 others occur in Australia, and 18 occur in the East Indies. The ophiuran fauna is thus somewhat more closely allied to the East Indian than to the Australian. There are apparently only 1 or 2 ophiurans that suggest a southern relationship.

The sea-urchin fauna of New Zealand is small, only 20 species being represented, but these are distributed in 17 genera. One is based on so young a specimen it may well be ignored in the present connection, and another, *Holopneustes,* is too doubtfully a New Zealand urchin to be useful in this connection. The remarkable habit of *Holopneustes* of living wrapped in the fronds of *Ecklonia* and *Cystophora* (and possibly other algae) would naturally lead to its wide distribution wherever uprooted algae were driven by winds

and currents. As only 2 specimens of *Holopneustes* are known from New Zealand, and both are dead, bare tests washed up on the beach, it seems to me beyond doubt that this sea urchin does not live in New Zealand waters and cannot properly be regarded as a member of that fauna. There are then only 18 species of 15 genera to be considered here. Of these, 14 of the species are endemic and the other 4 occur in Australia, 2 of them also in the East Indies or Japan, and 1 in the Kermadec Islands. Of the genera, 2 are endemic: *Ogmocidaris,* closely related to the southern *Austrocidaris,* and *Evechinus,* possibly related to the East Indian *Echinus armatus.* Four are more or less world-wide in distribution. Of the remaining 9, 8 occur in Australia (4 of these in the East Indies also), and 1 is evidently a southern form. The relationships of such a fauna are difficult to determine. How to account for such genera as *Brissopsis, Spatangus,* and *Echinocardium* is beyond me.

The holothurian fauna of New Zealand has been fairly well studied, and Mortensen's list of 28 species and 2 varieties is probably nearly complete. A striking feature is the almost complete absence of species of *Holothuria* and the very large number of Cucumarias. Fourteen genera are represented, of which 11 occur in Australia. The other 3 are endemic, and 2 of them show a distinctly southern relationship. One genus, *Trochodota,* occurs in Australia but not in the East Indies. The other genera are, however, East Indian. Of the species, 6 occur in the Flindersian province of southern Australia. The rest are apparently endemic, but 9 are obviously subantarctic in their relationship.

This hasty summary of the echinoderm fauna of New Zealand reveals strikingly how different it is from that of Australia, and even more from that of the East Indies. Mortensen has very fully discussed (1925) this remarkable fauna and made the surprising suggestion that the similarities between the echinoderms of New Zealand and those of Australia indicate a "former closer connection" between the two areas and are "easily explained through the Continental drift theory of Wegener according to which New Zealand was originally directly connected with Australia, forming the eastern border of the great Australian continental block from which it was then separated through Australia drifting away from it." The resemblances between the two faunas are too few and trivial and the differences too numerous and striking to warrant any such conclusion. The absence from New Zealand of numerous characteristic Australian genera such as *Comatula, Comanthus, Ptilometra, Compsometra, Tosia, Stellaster, Anthenea, Petricia, Uniophora, Astroconus, Ophiocrossota, Phyllacanthus, Salmacis, Temnopleurus, Microcyphus, Amblypneustes, Breynia, Urodemas, Actinopyga,* and *Taeniogyrus,* not to mention numerous East Indian genera common in Australia, precludes any idea that

New Zealand has derived any considerable part of its echinoderms from the island continent. On the other hand, the notable proportion of its echinoderms derived from a southern source suggests a subantarctic or south temperate area with which New Zealand and possibly Tasmania and southeastern Australia were associated. Since the origin of the New Zealand fauna is no concern of the present work, all that needs to be emphasized here is that its echinoderms have very little significance as regards the composition and origin of the Australian fauna. The suggestion that Lord Howe Island is to be associated with New Zealand rather than Australia is strongly contradicted by its echinoderm fauna. Of its 39 genera and 59 species, 1 genus and 10 species are endemic, 21 genera but only 4 species occur in New Zealand, and 36 genera and 46 species occur on the Australian coast. All the 4 species and 20 of the 21 genera occurring in New Zealand also occur in Australia.

The Apparent Origin of Australia's Echinoderm Fauna

Having now surveyed the echinoderm fauna of each of the adjoining areas, we are in a position to consider fairly the origin of Australia's and the probable routes it has followed in finding its present homes. The most conspicuous fact that stands out as we look over the preceding data is the predominance of tropical forms and influence. The Dampierian and Solanderian provinces include more than 500 of the 787 species recorded from the continent, almost two-thirds indeed, and many of the Flindersian and Peronian species belong to genera which are for the most part tropical. It has already been mentioned (p. 471) that the greatest preponderance of tropical forms is to be noted in the Torres Strait region, where the Dampierian and Solanderian provinces meet. In that region more than half the echinoderms are definitely tropical forms, but as we pass westward toward Cape Londonderry and still farther to Northwest Cape, the percentage of endemic species increases, and the same change occurs as we pass southward toward Cape Howe and Bass Strait. In the Peronian province 82 per cent of the echinoderms are endemic, and in the Flindersian province practically nine-tenths. It can scarcely be questioned, then, that the echinoderm fauna of Australia has come from the north and apparently from the East Indian region, particularly from its southeastern part, where New Guinea overlaps Queensland, and from its extreme southern point at Timor and across the Sahul Banks. As was shown in my Torres Strait report (1921), the Queensland fauna is clearly derived from the depression of land areas east of New Guinea which led to the connection of the Coral Sea with the western Pacific and the East Indian region. The Dampierian fauna, on the other hand, came from farther west and was probably already well extended down the western coast of the continent when the formation of Torres Strait

made a mingling of the two faunas possible. Apparently, however, there has never been a very extensive mingling, and the Solanderian fauna is still quite distinguishable from the Dampierian and is less differentiated from the original stock. This explains also why the echinoderm fauna of the southwestern corner of the continent shows the highest percentage of endemic forms. It is the youngest and hence the most specialized echinoderm stock to be found in Australia. This Flindersian fauna is naturally continuous to the north with the Dampierian, and on the southern coast it has extended to the east until it has met and mingled with the Peronian, which is the most specialized part of the echinoderm stream that flowed down the Queensland coast.

Comparison of the Australian fauna with that of southern and eastern Africa, Madagascar, and Mauritius gives practically no evidence of any common origin or close relationship, save for the few species already discussed and concerning which further discussion will be found on page 494. Comparisons between the echinoderm faunas of the Arabian and Ceylon areas and the Australian emphasize the connections through the East Indian fauna, and comparison of the latter with the Australian shows a very striking relationship. This similarity between the Australian and neighboring faunas reaches its climax in the East Indies and leaves little room for doubt as to the origin of the Australian fauna. Comparison with the still imperfectly known fauna of the southwestern Pacific indicates a less close relationship than the East Indian fauna itself shows, but this is possibly due in part to our greater ignorance of the island faunas.

Coming now to New Zealand, we are struck by the conspicuous differences between its fauna and that of Australia, but equally striking are the similarities shown, though they are much fewer. The fact that over 80 per cent of the New Zealand species are endemic indicates a long-isolated fauna. Only about 20 of the species are known to occur in Australia, and many of these are found in the East Indies or even more widely distributed (*Echinocardium cordatum, Laganum depressum, Placophiothrix aristulata,* etc.), but a few are local (*Araeosoma thetidis, Heliocidaris tuberculata,* etc.). Among these species common to New Zealand and Australia, a number call for special comment, as indicators of a possible relationship between the two faunas which deserves careful consideration.

Among crinoids, we find the genus *Cenolia* with small closely allied species in New Zealand, Tasmania, Lord Howe Island, the southern coasts of Australia, and South Africa. Among sea stars, *Coscinasterias calamaria* has the same distribution, with Mauritius as an additional locality. The much smaller *Allostichaster polyplax* occurs in New Zealand, Tasmania, and southern Australia, with an allied species in southern South America, but the

genus is not known in South Africa. The sea star *Psilaster acuminatus* occurs in moderately deep water off New Zealand, Australia, and South Africa, but the genus is widely distributed in deep water and hence is of doubtful value in determining former land connections. *Nectria,* characteristic of the Flindersian coasts of Australia, has an endemic species in New Zealand but is not known elsewhere. Of brittle stars, *Ophiomyxa australis* is characteristic of the Flindersian region of Australia, but it (or very closely allied species) has a wide range in the East Indian region, in Mauritius, South Africa, New Zealand, Fiji, Japan, and southern South America. The genus is an old one with 17 species or more, ranging throughout the tropics, down to depths of over 300 fms. Specific lines are not well drawn or easy to make out, but there can be little question that the southern forms are very closely allied. The Australian *Ophiactis resiliens* is a Flindersian species which also occurs in New Zealand and at Lord Howe Island. Allied species occur in many parts of the world. Their secretive habits would facilitate transportation by artificial means, such as floating seaweed or foul ship bottoms.

Among echini, we have two interesting cases showing possibilities as land-connection indicators, one of which, that of *Dermechinus horridus,* has already been discussed (see p. 480). It is difficult to account for its occurrence in South African, South American, and southeastern Australian seas except by some sort of land connection. Its absence from New Zealand is interesting but proves nothing. The genus *Pseudechinus* has developed 4 species in New Zealand and 2 in southern Australia, a fact which is at least suggestive of former shallow-water connection. Among the holothurians we find 4 cases of New Zealand species occurring on the southern coasts of Australia: *Stichopus mollis, Mensamaria thomsoni, Lipotrapeza dearmatus,* and *Chiridota gigas.* With the possible exception of *Stichopus mollis,* none of these species is sufficiently well known to make a firm basis for any argument about distribution.

As we review this summary of similarities between the echinoderms of New Zealand and those of Australia and South Africa, we are forced to the conclusion that in most cases they can be accounted for by transportation on ship bottoms or floating masses of seaweed or other flotsam. Such forms as *Psilaster* and *Dermechinus* can hardly have reached their present locations in this way, and the assumption that a shore-line connection once existed between the southern land masses is an easy explanation. But if such a connection ever really existed, it is hard to see why there is not more evidence of it. Much greater similarities ought to exist between the faunas of South America, South Africa, Australia, and New Zealand than we have found. Only a desperate desire to validate the Wegener hypothesis can find in the echinoderm fauna of Australia any evidence that it is at all closely allied to that of South Africa

or even of New Zealand. The evidence is overwhelming that the Australian echinoderms have come southward from the East Indian area,[1] either around the eastern end of New Guinea or across the Timor Sea. Any similarities to the South African fauna are due to the fact that the latter fauna has come in large part from the northeast and hence traces back to the same East Indian source as Australia's. So, too, the similarities between the New Zealand and Australian faunas are due to a common source in the East Indian fauna which passed around the southeastern end of New Guinea into the Coral Sea, one line following the western shore of that sea down the Queensland coast, the other following the eastern shore to New Caledonia (of which we know almost nothing) and New Zealand. That an antarctic land mass, some sort of Gondwana-land, may have existed in the remote past seems possible, but it has played only a trivial part in the formation and development of the Australian echinoderm fauna.

[1] In 1911, Austin H. Clark wrote (1911*c*, p. 132), "The crinoids of Australia have come from the north, from the great East Indian Archipelago"—a statement amply confirmed by the present study.

BIBLIOGRAPHY

BIBLIOGRAPHY

No attempt has been made to include in this bibliography all works in which Australian echinoderms are mentioned. Only authors and their works to which reference is made in the present volume are included herein.

Agassiz, Alexander

1863 List of the echinoderms sent to different institutions, etc. Bull. Mus. Comp. Zoöl., vol. 1, no. 2, pp. 17–28.

1863*a* Echinoids of the North Pacific Exploring Expedition, etc. Proc. Acad. Nat. Sci. Philadelphia, pp. 352–360.

1869 Preliminary report on the echini and starfishes, dredged by Pourtales, etc. Bull. Mus. Comp. Zoöl., vol. 2, no. 9, pp. 253–308.

1872 Preliminary notice of a few species of echini. Bull. Mus. Comp. Zoöl., vol. 3, no. 4, pp. 55–58.

1872*a* Revision of the echini. Pts. 1, 2, pp. i–xii, 1–378; 49 pls.

1873 Revision of the echini. Pt. 3, pp. 379–630; 45 pls.

1877 North American starfishes. Mem. Mus. Comp. Zoöl., vol. 5, no. 1. v+137 pp., 20 pls.

1878 Report on the echini (of the "Blake" collection in the Gulf of Mexico). Bull. Mus. Comp. Zoöl., vol. 5, no. 9, pp. 185–194; pls. 1–5.

1879 Preliminary report on the "Challenger" echini. Proc. Amer. Acad. Arts and Sci., vol. 14, pp. 190–212.

1880 Preliminary report on the echini (of the "Blake" collection in the Caribbean Sea and western Atlantic). Bull. Mus. Comp. Zoöl., vol. 8, no. 2, pp. 69–84.

1881 Report on the Echinoidea. "Challenger" sci. results: Zoology, vol. 3, no. 9, pp. i–vii, 1–321; pls. 1–45 (but there are 65 pls. in all).

Agassiz, A., and H. L. Clark

1907 Preliminary report on the echini, etc. Bull. Mus. Comp. Zoöl., vol. 51, no. 5, pp. 109–139.

1909 Hawaiian and other Pacific echini: The Echinothuridae. Mem. Mus. Comp. Zoöl., vol. 34, no. 3, pp. 139–203; pls. 60–89.

Agassiz, Louis

1835 Notice sur les fossiles du terrain crétacé au Jura neuchâtelois. Mém. Soc. sci. nat. Neuchâtel, vol. 1, pp. 126–145.

1835*a* Prodrome d'une monographie des radiaires ou échinodermes. Mém. Soc. sci. nat. Neuchâtel, vol. 1, pp. 168–199.

1838 Monographies d'échinodermes vivants et fossiles: Echinites. Famille des cidarides. I^e monographie: des Salénies. 32+2 pp., 5 pls.

1839 Description des échinodermes fossiles de la Suisse. Pt. 1: Spatangoides et clypeastroides, pp. 1–101; pls. 1–13 bis.

1840 Catalogus systematicus ectyporum Echinodermatum fossilium, etc. 20 pp.

1841 Monographies d'échinodermes, etc. IIe monographie: des Scutelles. vi+152 pp., 27 pls.

1841*a* Monographies d'échinodermes, etc. Observations sur les progrès récents de l'histoire naturelle des échinodermes. 20 pp.

1841*b* Monographies d'échinodermes, etc. Preface *to* Valentin: Anatomie du genre *Echinus,* pp. i–x.

Agassiz, L., and E. Desor
1846 Catalogue raisonné des échinides. Ann. sci. nat., Zool., ser. 3, vol. 6, pp. 305–374; pls. 15, 16.
1847 Catalogue raisonné des échinides. Ann. sci. nat., Zool., ser. 3, vol. 7, pp. 129–168; vol. 8, pp. 1–35, 355–380.

Alcock, A.
1893 An account of the . . . deep sea Asteroidea. Ann. Mag. Nat. Hist., ser. 6, vol. 11, pp. 73–121; pls. 4–6.

Alexander, W. B.
1914 Western Australian echinoderms. Rec. W. Australian Mus., vol. 1, pt. 3, pp. 105–112, p. 156 footnote.

Angelin, N. P.
1878 Iconographia Crinoideorum Silur., etc. Folio, (2) + iv + 34 pp., 29 pls.

Audouin, J. V.
1826 Explication sommaire des planches dont . . . M. J. C. de Savigny, etc. *In* Description de l'Egypte, vol. 1, pt. 4, pp. 203–212.

Austin, Thomas, Esq., and Thomas Austin, Jr.
1842 Proposed arrangement of the Echinodermata, etc. Ann. Mag. Nat. Hist., vol. 10, pp. 106–113.
1843 Descriptions of several new genera and species of Crinoidea. Ann. Mag. Nat. Hist., vol. 11, pp. 195–207.

Bather, F. A.
1889 Note on *Marsupites testudinarius*. Quart. Jour. Geol. Soc. London, vol. 45, pp. 172–174.
1897 *Hapalocrinus victoriae* n. s., Silurian, Melbourne, and its relation to the Platycrinidae. Geol. Mag., n. s., dec. 4, vol. 4, pp. 337–345; pl. 15.

Bell, F. Jeffrey
1881 The species of the genus *Asterias*. Proc. Zool. Soc. London (1881), pp. 492–515; pls. 47, 48.
1882 Descriptions of new or rare species of Asteroidea, etc. Proc. Zool. Soc. London (1882), pp. 121–124.
1882*a* An attempt to apply a method . . . to . . . Comatulidae, etc. Proc. Zool. Soc. London (1882), pp. 530–536.
1883 Studies in the Holothurioidea. II: Descriptions of new species. Proc. Zool. Soc. London (1883), pp. 58–62; pl. 15.
1884 Echinodermata. Rept. zool. coll. Indo-Pacific Ocean, voyage of H. M. S. "Alert," 1881–82, pp. 117–177; pls. 8–17.
1884*a* On the generic position . . . of *Echinanthus tumidus* Woods. Proc. Zool. Soc. London, pp. 40–45; pls. 2, 3.
1887 The echinoderm fauna of the island of Ceylon. Trans. Roy. Dublin Soc., ser. 2, vol. 3, pp. 643–688; pls. 39, 40.
1887*a* Studies in the Holothurioidea. VI. Proc. Zool. Soc. London, pp. 531–534; pl. 45, fig. 2.
1888 Notes on echinoderms collected at Port Phillip. Ann. Mag. Nat. Hist., ser. 6, vol. 2, pp. 401–407.
1888*a* Descriptions of four new species of ophiurids. Proc. Zool. Soc. London, pp. 281–284; pl. 16.
1893 On a small collection of crinoids from the Sahul Bank, North Australia. Jour. Linn. Soc. (Zool.), vol. 24, pp. 339–341; pls. 23, 24.
1894 On the echinoderms collected during the voyage of H. M. S. "Penguin" and by H. M. S. "Egeria" when surveying Macclesfield Bank. Proc. Zool. Soc. London (1894), pp. 392–413; pls. 23–27.

Bell, F. Jeffrey—*Continued*

1909 Report on the echinoderms (other than holothurians) collected by Mr. J. Stanley Gardiner in the western parts of the Indian Ocean. Trans. Linn. Soc. London, ser. 2, vol. 13, pt. 1, no. 2, pp. 17–22.

Billings, E.

1857 New species of fossils from the Silurian rocks of Canada. Geol. Surv. Canada, Rept. progress for 1855–1856, pp. 256–345.

1858 On the Asteriadae of the Lower Silurian rocks of Canada. Geol. Surv. Canada, Can. org. remains, dec. 3, pp. 75–85; pls. 8–10.

Bittner, A.

1892 Über Echiniden des Tertiärs von Australien. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 101, pt. 1, pp. 331–371 (reprint pp. 1–41); pls. 1–4.

Blainville, H. M. D. de

1820 Fibulaire (Fibularia). Dict. sci. nat., vol. 16, pp. 510–572.

1825 Oursin. Dict. sci. nat., vol. 37, pp. 59–98.

1830 Zoophytes. Dict. sci. nat., vol. 60, pp. 1–546.

1834 Manuel d'actinologie, ou de zoophytologie. 688 pp., 100 pls.

Blandowski, W.

1858 Recent discoveries in natural history on the lower Murray. Trans. Philos. Inst. Victoria, vol. 2, pp. 124–137.

Brandt, J. F.

1835 Prodromus descriptionis animalium ab H. Mertensio . . . observatorum. Fasc. 1, pp. 1–75.

Brock, J.

1888 Die Ophiuriden-fauna des indischen Archipels. Ztschr. f. wissensch. Zool., vol. 47, pp. 465–539.

Brongniart, Alex.

1822 Description géologique des environs de Paris. 428 pp., 11 pls.

Bronn, H. G.

1860 Die Klassen und Ordnungen der Strahlenthiere (Actinozoa). Klass. u. Ord. d. Thier-Reichs, vol. 2, pp. 1–434; pls. 23–48.

Carpenter, P. H.

1881 The Comatulae of the Leyden Museum. Notes Leyden Mus., vol. 3, pp. 173–217.

1882 Description of new or little known Comatulas. Jour. Linn. Soc. (Zool.), vol. 16, pp. 487–526.

1882*a* The stalked crinoids of the Caribbean Sea. Bull. Mus. Comp. Zoöl., vol. 10, pp. 165–181.

1884 Report on the Crinoidea: The stalked crinoids. "Challenger" sci. results: Zoology, vol. 11, no. 2, pp. i–vii, 1–442; pls. 1–62.

1888 Report on the Crinoidea: The Comatulae. "Challenger" sci. results: Zoology, vol. 26, no. 1, pp. i–ix, 1–401; pls. 1–70.

Chamisso, A. de, and C. G. Eysenhardt

1821 De animalibus . . . duce Ottone de Kotzebue . . . observatis. Nova acta Deutsch. Akad., vol. 10, pp. 345–374.

Chapman, Frederick

1903 New or little known Victorian fossils in the National Museum, Melbourne. Pt. 1: Some Palaeozoic species. Proc. Roy. Soc. Victoria, n. s., vol. 15, pp. 104–122; pls. 16–18.

1907 New or little known Victorian fossils in the National Museum, Melbourne. Pt. 8: Some Palaeozoic brittle-stars of the Melbournian series. Proc. Roy. Soc. Victoria, n. s., vol. 19, pp. 21–27; pls. 6–8.

CHAPMAN, FREDERICK—*Continued*

1908 New or little known Victorian fossils in the National Museum, Melbourne. Pt. 9: Some Tertiary species. Proc. Roy. Soc. Victoria, n. s., vol. 20, pp. 208–221.

1913 Descriptions of new and rare fossils obtained by deep boring in the Mallee. Pt. 1. Proc. Roy. Soc. Victoria, n. s., vol. 26, pp. 165–191; pls. 16–19.

1934 A Lower Cretaceous brittle-star from Queensland. Proc. Roy. Soc. Victoria, n. s., vol. 46, pp. 195–199; pl. 7.

1934*a* New species of a crinoid (*Lecanocrinus*), etc. Proc. Roy. Soc. Victoria, n. s., vol. 47, pp. 190–195; pl. 10.

CHAPMAN, FREDERICK, and FRANCIS A. CUDMORE

1928 *In* Chapman: The Sorrento Bore, Mornington Peninsula, with a description of new or little-known fossils. Rec. Geol. Surv. Victoria, vol. 5. 192 pp., 12 pls.

1934 The Cainozoic Cidaridae of Australia. Mem. Nat. Mus. Victoria, no. 8, pp. 126–149; pls. 12–15.

CLARK, AUSTIN HOBART

1907 New genera of Recent free crinoids. Smithsonian Misc. Coll., vol. 50, pt. 3, pp. 343–364.

1907*a* Descriptions of new species of Recent unstalked crinoids, etc. Proc. U. S. Nat. Mus., vol. 33, pp. 127–156.

1908 New genera of unstalked crinoids. Proc. Biol. Soc. Washington, vol. 21, pp. 125–136.

1908*a* The crinoid genus *Comatula* Lamarck, etc. Proc. U. S. Nat. Mus., vol. 33, pp. 683–688.

1908*b* The nomenclature of the Recent crinoids. Proc. U. S. Nat. Mus., vol. 34, pp. 435–542.

1908*c* Preliminary notice of a collection of Recent crinoids from the Philippine Islands. Smithsonian Misc. Coll., vol. 52, pt. 2, pp. 199–234.

1908*d* New genera and species of crinoids. Proc. Biol. Soc. Washington, vol. 21, pp. 219–232.

1908*e* On a collection of feather-stars or comatulids from Japan. Proc. U. S. Nat. Mus., vol. 34, pp. 305–319.

1909 A revision of the crinoid families, Thalassometridae and Himerometridae. Proc. Biol. Soc. Washington, vol. 22, pp. 1–22.

1909*a* Two new Australian crinoids. Proc. Biol. Soc. Washington, vol. 22, pp. 39–42.

1909*b* The type of the genus *Comaster*. Proc. Biol. Soc. Washington, vol. 22, p. 87.

1909*c* New Recent Indian crinoids. Proc. Biol. Soc. Washington, vol. 22, pp. 143–152.

1909*d* On a collection of Recent crinoids from the Philippine Islands. Proc. U. S. Nat. Mus., vol. 36, pp. 391–410.

1909*e* Revision of the crinoid family Comasteridae, etc. Proc. U. S. Nat. Mus., vol. 36, pp. 493–567.

1909*f* Descriptions of seventeen new species of Recent crinoids. Proc. U. S. Nat. Mus., vol. 36, pp. 633–651.

1909*g* The crinoids of the "Gazelle" Expedition. Zool. Anz., vol. 34, pp. 363–370.

1909*h* Five new species of Recent unstalked crinoids. Proc. U. S. Nat. Mus., vol. 37, pp. 29–34.

1909*i* On a collection of crinoids from the Zoological Museum of Copenhagen. Vidensk. Medd., vol. 61, pp. 115–194.

1910 A new Australian crinoid. Proc. U. S. Nat. Mus., vol. 38, pp. 275–276.

1911 The Recent crinoids of Australia. Mem. Australian Mus., vol. 4, pp. 706–804.

1911*a* The Recent crinoids of the Leyden Museum. Notes Leyden Mus., vol. 33, pp. 175–192.

CLARK, AUSTIN HOBART—*Continued*

1911*b* Notes sur les crinoides actuels du Muséum d'histoire naturelle de Paris. Bull. Mus. hist. nat. Paris, no. 4, pp. 243–260.

1911*c* The comparative age of the Recent crinoid faunas. Amer. Jour. Sci., ser. 4, vol. 32, pp. 127–132.

1911*d* On a collection of unstalked crinoids made by the . . . "Albatross" in the vicinity of the Philippine Islands. Proc. U. S. Nat. Mus., vol. 39, pp. 529–563.

1911*e* The Recent crinoids of the coasts of Africa. Proc. U. S. Nat. Mus., vol. 40, pp. 1–51.

1911*f* A new unstalked crinoid from the Philippine Islands. Proc. U. S. Nat. Mus., vol. 41, pp. 171–173.

1911*g* Crinoidea. Die Fauna Südwest-Australiens, vol. 3, pp. 435–467.

1912 The crinoids of the Indian Ocean. Echinoderma of the Indian Museum, pt. 7. 325 pp., 61 figs.

1912*a* The crinoids of the Natural History Museum at Hamburg. Smithsonian Misc. Coll., vol. 60, no. 10, pp. 1–33.

1912*b* Seventeen new East Indian crinoids, etc. Proc. Biol. Soc. Washington, vol. 25, pp. 17–28.

1913 Notes on the Recent crinoids in the British Museum. Smithsonian Misc. Coll., vol. 61, no. 15, pp. 1–89.

1913*a* A revision of the crinoid family, Mariametridae. Proc. Biol. Soc. Washington, vol. 26, pp. 141–144.

1914 Crinoids collected by the "Endeavour," etc. Rec. W. Australian Mus., vol. 1, pt. 3, pp. 113–131.

1916 The first New Zealand crinoid. Proc. Biol. Soc. Washington, vol. 29, p. 48.

1916*a* Seven new genera of echinoderms. Jour. Washington Acad. Sci., vol. 6, pp. 115–122.

1916*b* Six new genera of unstalked crinoids, etc. Jour. Washington Acad. Sci., vol. 6, pp. 605–608.

1917 A revision of the crinoid family Antedonidae, etc. Jour. Washington Acad. Sci., vol. 7, pp. 127–131.

1918 The unstalked crinoids of the "Siboga" Expedition. "Siboga" rept., livr. 83, pp. 1–300; pls. 1–28.

1918*a* A new crinoid from New Zealand and another from Tasmania. Proc. Biol. Soc. Washington, vol. 31, pp. 41–44.

1921 A monograph of the existing crinoids. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 2. 795 pp., 57 pls.

1923 A revision of the Recent . . . Pentacrinidae, etc. Jour. Washington Acad. Sci., vol. 13, pp. 8–12.

1929 On some Recent crinoids in the collection of the British Museum. Jour. Linn. Soc. (Zool.), vol. 36, pp. 635–644; pls. 40–44.

1931 A monograph of the existing crinoids. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 3. 816 pp., 82 pls.

1934 On a collection of crinoids from the Raffles Museum, Singapore. Proc. Biol. Soc. Washington, vol. 47, pp. 9–14.

1936 Crinoidea. Sci. rept. John Murray Exped. 1933–34, vol. 4, no. 4, pp. 87–108; pl. 1.

1939 Echinoderms (other than holothurians) collected on the Presidential cruise of 1938. Smithsonian Misc. Coll., vol. 98, no. 11, pp. 1–18; pls. 1–5.

1941 A monograph of the existing crinoids. Bull. 82 U. S. Nat. Mus., vol. 1, pt. 4*a*. 603 pp., 61 pls.

Clark, E. V.

1900 Geological notes on the cliffs separating Aldinga and Myponga bays. Trans. Roy. Soc. S. Australia, vol. 24, pp. 1–5.

Clark, Hubert Lyman

1904 The echinoderms of the Woods Hole region. Bull. U. S. Fish Comm. (1902), vol. 22, pp. 545–576; pls. 1–14.

1908 The apodous holothurians. Smithsonian Contrib. to Knowledge, vol. 35, no. 1723. 231 pp., 13 pls.

1908*a* Some Japanese and East Indian echinoderms. Bull. Mus. Comp. Zoöl., vol. 51, no. 11, pp. 277–311.

1909 "Thetis" echinoderms. Mem. Australian Mus., vol. 4, pp. 519–564; pls. 47–58.

1909*a* Notes on some Australian and Indo-Pacific echinoderms. Bull. Mus. Comp. Zoöl., vol. 52, no. 7, pp. 107–137; 1 pl.

1911 North Pacific ophiurans. Bull. 75 U. S. Nat. Mus. xvi+302 pp., 144 figs.

1912 Hawaiian and other Pacific echini. Mem. Mus. Comp. Zoöl., vol. 34, no. 4, pp. 205–383; pls. 90–121.

1914 The echinoderms of the Western Australian Museum. Rec. W. Australian Mus., vol. 1, pp. 132–173; pls. 17–26.

1914*a* Hawaiian and other Pacific echini. Mem. Mus. Comp. Zoöl., vol. 46, no. 1, pp. 1–78; pls. 122–143.

1915 Catalogue of Recent ophiurans. Mem. Mus. Comp. Zoöl., vol. 25, pp. 163–227; pls. 1–20.

1915*a* Echinoderms of Ceylon. Spolia zeylanica, vol. 10, p. 83–102.

1915*b* The comatulids of Torres Strait. Carnegie Inst. Wash. Pub. 212, Papers from Dept. Marine Biol., vol. 8, pp. 97–125.

1916 "Endeavour" sea-lilies, starfishes, brittle-stars and sea-urchins. Repts. Dept. Trade and Customs: Fisheries, Sydney, N. S. Wales, vol. 4. 123 pp., 44 pls.

1917 Hawaiian and other Pacific echini. Mem. Mus. Comp. Zoöl., vol. 46, no. 2, pp. 81–283; pls. 144–161.

1917*a* Ophiuroidea: Eastern Tropical Pacific Exped. Bull. Mus. Comp. Zoöl., vol. 61, pp. 429–453; pls. 1–5.

1918 Brittle-stars, new and old. Bull. Mus. Comp. Zoöl., vol. 62, pp. 265–338; pls. 1–8.

1921 The echinoderm fauna of Torres Strait. Carnegie Inst. Wash. Pub. 214, Dept. Marine Biol., vol. 10. viii+224 pp., 38 pls. (19 colored).

1922 The holothurians of the genus *Stichopus*. Bull. Mus. Comp. Zoöl., vol. 65, pp. 39–74; pls. 1, 2.

1923 The echinoderm fauna of South Africa. Ann. S. African Mus., vol. 13, pp. 221–435; pls. 8–23.

1923*a* Some echinoderms from West Australia. Jour. Linn. Soc. (Zool.), vol. 35, pp. 229–251; pl. 13.

1924 The holothurians of the Museum of Comparative Zoölogy: The Synaptinae. Bull. Mus. Comp. Zoöl., vol. 65, pp. 459–501; pls. 1–12.

1924*a* Echinoderms from South Africa. Pt. 1: Sea-urchins. Fish and Marine Biol. Surv. Union of South Africa, rept. 4, special rept. 1, pp. 1–16; pls. 1–4.

1925 A catalogue of the Recent sea-urchins in the British Museum. 278 pp., 12 pls.

1926 Notes on a collection of echinoderms from the Australian Museum. Rec. Australian Mus., vol. 15, pp. 183–192.

1928 The sea-lilies, sea-stars, brittle-stars and sea-urchins of the South Australian Museum. Rec. S. Australian Mus., vol. 3, pp. 361–428; figs. 108–142.

1932 Echinoderma other than Asteroidea. Sci. rept. Great Barrier Reef Exped. 1928–29, vol. 4, no. 7, pp. 197–239; 1 pl.

CLARK, HUBERT LYMAN—*Continued*

1935 The holothurian genus *Caudina*. Ann. Mag. Nat. Hist., ser. 10, vol. 15, pp. 267–284.

1938 Echinoderms from Australia. Mem. Mus. Comp. Zoöl., vol. 55. viii+597 pp., 28 pls. (16 colored).

1939 Ophiuroidea. Sci. rept. John Murray Exped. 1933–34, vol. 6, no. 2, pp. 3–136; 63 text figs.

1939*a* A new *Astroconus* from South Australia. Rec. S. Australian Mus., vol. 6, pp. 207–208; pl. 18.

COLEMAN, H. L.

1911 Supplement to Echinodermata. Mem. Australian Mus., vol. 4, pp. 699–701; 1 pl.

COTTEAU, GUSTAVE

1856 *In* Leymerie and Cotteau: Catalogue des échinides fossiles des Pyrénées. Bull. Soc. géol. France, ser. 2, vol. 13, pp. 319–355.

1889 Echinides nouveaux ou peu connus. Mém. Soc. zool. France, vol. 2, pp. 321–332; pls. 14, 15.

1891 Echinides nouveaux ou peu connus. Mém. Soc. zool. France, vol. 4, pp. 620–633; pls. 18, 19.

COTTON, B. C., and F. K. GODFREY

1942 Echinodermata of the Flindersian region, southern Australia. Rec. S. Australian Mus., vol. 7, no. 2, pp. 193–234; pl. 12.

DEFRANCE, J. L. M.

1827 Scutelle (fossile). Dict. sci. nat., vol. 48, pp. 229–231.

DEICHMANN, ELISABETH

1930 The holothurians of the western part of the Atlantic Ocean. Bull. Mus. Comp. Zoöl., vol. 71, no. 3, pp. 43–266; pls. 1–24.

1938 New records of *Paracaudina chilensis,* etc. Proc. New England Zool. Club, vol. 17, pp. 23–25.

1940 Report on the holothurians collected by the Harvard-Havana Expeditions, etc. Mem. Soc. cubana hist. nat., vol. 14, no. 3, pp. 183–240; pls. 31–41.

1941 The Holothurioidea collected by the "Velero III," etc. Pt. 1: Dendrochirota. Repts. Allan Hancock Pacific Exped., vol. 8, no. 3, pp. 61–194; pls. 10–30.

DELLE CHIAJE, S.

1828 Asteria. Mem. anim. senza vert. Napoli, vol. 3, mem. 3, cap. 7, pp. 74–79.

DENDY, ARTHUR

1897 Observations on the holothurians of New Zealand. Jour. Linn. Soc. (Zool.), vol. 26, pp. 22–52; pls. 3–7.

DENDY, ARTHUR, and E. HINDLE

1907 Some additions to our knowledge of the New Zealand holothurians. Jour. Linn. Soc. (Zool.), vol. 30, pp. 95–125; pls. 11–14.

DESOR, E.

1853 Notice sur les échinides du terrain nummulitique des Alpes, etc. Actes Soc. helvét. sci. nat., vol. 38, pp. 270–279 (reprint pp. 1–12).

1858 Synopsis des échinides fossiles. lxviii+490+4 pp., 44 pls.

DÖDERLEIN, L.

1885 Seeigel von Japan und den Liu-Kiu-Inseln. Arch. f. Naturgesch., vol. 51, no. 1, pp. 73–112.

1887 Die japanischen Seeigel. I: Familien Cidaridae und Saleniidae. 59 pp., 11 pls.

1888 Echinodermen von Ceylon. Zool. Jahrb., Abt. syst., vol. 3, pp. 821–846; pls. 31–33.

1896 Bericht über . . . Semon . . . Ophiuroidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 279–300; pls. 14–17; pl. 18, figs. 29–29*b*.

Döderlein, L.—*Continued*

1896*a* Bericht über . . . Semon . . . Asteroidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 301–322; pl. 18, figs. 30–34*f*; pls. 19–22.

1898 Bericht über . . . Semon . . . Crinoidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 473–480; pl. 36.

1898*a* Bericht über . . . Semon . . . epizoisch lebende Ophiuroidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 481–488; pl. 37.

1900 *In* Chun: Aus den Tiefen des Weltmeeres, p. 360.

1903 Bericht über . . . Semon . . . Echinoidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 683–726; pls. 58–65.

1906 "Valdivia" echini. Wissensch. Ergeb. deutsch. Tiefsee-Exped., vol. 5, pp. 61–290; pls. 9–50.

1911 Über japanische und andere Euryalae. Abhandl. K. bayer. Akad. Wissensch. München, suppt. 2, pt. 5, pp. 1–123; pls. 1–9.

1911*a* Über Echinoidea von den Aru Inseln. Abhandl. Senckenb. naturforsch. Gesellsch., vol. 34, pp. 237–248; pls. 9, 10.

1912 "Valdivia" stalked crinoids. Wissensch. Ergeb. deutsch. Tiefsee-Exped., vol. 17, pp. 1–34; pls. 1–12.

1914 Echinoidea. Die Fauna Südwest-Australiens, vol. 4, pp. 443–492; pl. 9.

1915 Die Arten der Asteroiden-Gattung *Anthenea* Gray. Jahrb. Nassau. Ver. Naturk. Wiesbaden, vol. 68, pp. 21–55; pls. 3–11.

1916 Über die Gattung *Oreaster* und Verwandte. Zool. Jahrb., Abt. syst., vol. 40, pp. 409–440; 18 figs.

1917 Die Gattung *Astropecten* und ihre Stammesgeschichte. "Siboga" rept., livr. 81, pp. i–vi, 1–191; pls. 1–17.

1920 Die Gattung *Luidia* und ihre Stammesgeschichte. "Siboga" rept., livr. 88, pp. 192–293; pls. 18–20.

1924 Die Asteriden der "Siboga"-Expedition. II: Pentagonasteridae. "Siboga" rept., livr. 91, pp. 48–69; pls. 14–19.

1926 Über Asteriden aus dem Museum von Stockholm. K. svenska Vetensk.-Akad. Handl., ser. 3, vol. 2, no. 6, pp. 1–22; pls. 1–4.

1927 Indopacifische Euryalae. Abhandl. K. bayer. Akad. Wissensch., math.-naturwiss. Abt., vol. 31, pt. 6, pp. 1–105; pls. 1–10.

1935 Die Asteriden der "Siboga"-Expedition. III: Oreasteridae. "Siboga" rept., livr. 125, pp. 70–110; pls. 20–27.

1936 Die Unterfamilie Oreasterinae. "Siboga" rept., livr. 126, pp. 293–369; pls. 21–32.

Domantay, J. S., and H. A. Roxas

1938 The littoral Asteroidea of Port Galera Bay, etc. Philippine Jour. Sci., vol. 65, pp. 203–237; pls. 1–17.

Duncan, P. Martin

1877 Echinodermata of Australian Cainozoic. Quart. Jour. Geol. Soc. London, vol. 33, pp. 42–73; pls. 3, 4.

1878 On *Lütkenia,* a new genus of Ophiuridae. Ann. Mag. Nat. Hist., ser. 5, vol. 2, pp. 188–193; pl. 9.

1879 On some Ophiuroidea, etc. Jour. Linn. Soc. (Zool.), vol. 14, pp. 445–482; pls. 9–11.

1887 On the ophiurids of the Mergui Archipelago. Jour. Linn. Soc. (Zool.), vol. 21, pp. 85–106.

1887*a* Revision of Echinoidea from Australian Tertiaries. Quart. Jour. Geol. Soc. London, vol. 43, pp. 411–430.

1889 A revision of the genera and great groups of the Echinoidea. Jour. Linn. Soc. (Zool.), vol. 23, pp. 1–311.

Duncan, P. Martin, and W. Percy Sladen
1882 Monograph of the fossil Echinoidea of Western Sind. Palaeontol. indica, ser. 14. 382 pp., 58 pls.

Edwards, Henri Milne
1836 Zoophytes. Pl. 14: Echinodermes. Pédicelles; genre nucléolite. *Nucleolites* Lamarck. Fig. 3, Nucléolite moderne, *Nucleolites recens.*

Eichwald, Eduard
1856 Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands. Alte Periode. Bull. Soc. imp. nat. Moscou, vol. 29, no. 1, sec. 2, pp. 88–127.
1860 Lethaea rossica. Stuttgart (Atlas 1859–60). Vol. 1, xix+1657 pp.; atlas 8 pp., 59 pls.

Ekman, Sven
1918 Holothurioidea of Dr. Mjöberg's Expedition to Australia. K. svenska Vetensk.-Akad. Handl. Stockholm, vol. 58, no. 6. 70 pp., 5 pls.

Ely, Charles A.
1942 Shallow-water Asteroidea and Ophiuroidea of Hawaii. Bernice P. Bishop Mus. Bull. 176. 63 pp., 13 pls.

Engel, Hendrik
1933 Holothuries. Res. sci. voy. Indes Orient. Néerl. Mém. Mus. roy. hist. nat. Belgique, hors sér., vol. 3, fasc. 13, pp. 1–42; pl. 1.

Erwe, Willy
1913 Holothurioidea. Die Fauna Südwest-Australiens, vol. 4, pp. 349–402; pls. 5–8.
1919 Holothurien aus dem Roten Meer. Mitt. Zool. Mus. Berlin, vol. 9, pp. 177–190.

Eschscholtz, F.
1829 Zoologischer Atlas, etc. Vol. 2, pp. 12–13; pl. 10.

Etheridge, Robert, Jr.
1891 On the occurrence of the genus *Palaeaster* in the Upper Silurian rocks of Victoria. Rec. Australian Mus., vol. 1, pp. 199–200; pl. 30, figs. 16, 17.
1892 A monograph of the Carboniferous . . . Invertebrata of New South Wales. Pt. II: Echinodermata, etc. Mem. Geol. Surv. N. S. Wales, Palaeontol., no. 5, pp. i–ix, 65–119; pls. 12–22.
1892*a* *In* Jack and Etheridge: The geology and palaeontology of Queensland and New Guinea. 2 vols., xxii+768 pp., 67 pls.
1899 On the occurrence of a starfish in the Upper Silurian series of Bowning, N. S. Wales. Rec. Australian Mus., vol. 3, pp. 128–129.
1901 Additional notes on the palaeontology of Queensland. Pt. 2. Bull. Geol. Surv. Queensland, vol. 13, pp. 1–38; pls. 1–4.
1904 Notes on Australian Cretaceous fossils. Rec. Australian Mus., vol. 5, pp. 248–252; pls. 27, 28.

Farquhar, H.
1900 On a new species of Ophiuroidea. Trans. New Zealand Inst., vol. 32, pp. 405–406.

Fisher, Walter K.
1906 The starfishes of the Hawaiian Islands. Bull. U. S. Fish Comm. no. 23, pp. 987–1130; pls. 1–49.
1907 The holothurians of the Hawaiian Islands. Proc. U. S. Nat. Mus., vol. 32, pp. 637–744; pls. 66–82.
1908 Necessary changes in the nomenclature of starfishes. Smithsonian Misc. Coll., vol. 52, pp. 87–93.
1908*a* Some necessary changes in the generic names of starfishes. Zool. Anz., vol. 33, pp. 356–359.

FISHER, WALTER K.—*Continued*

1911 Asteroidea of the North Pacific. Bull. 76 U. S. Nat. Mus., pt. 1. vi+419 pp., 122 pls.

1913 New . . . starfishes from the Philippine Islands, etc. Proc. U. S. Nat. Mus., vol. 43, pp. 599–648.

1913*a* New starfishes from the Philippine Islands, etc. Proc. U. S. Nat. Mus., vol. 46, pp. 201–224.

1917 Notes on Asteroidea. Ann. Mag. Nat. Hist., ser. 8, vol. 20, pp. 166–172.

1919 Starfishes of the Philippine seas and adjacent waters. Bull. 100 U. S. Nat. Mus., vol. 3. xi+712 pp., 156 pls.

1923 A preliminary synopsis of the Asteriidae. Ann. Mag. Nat. Hist., ser. 9, vol. 12, pp. 247–258, 596–607.

1926 Notes on the Asteroidea. Ann. Mag. Nat. Hist., ser. 9, vol. 18, pp. 196–200.

1928 Asteroidea of the North Pacific and adjacent waters. Bull. 76 U. S. Nat. Mus., pt. 2. iii+245 pp., 81 pls.

1940 Asteroidea. "Discovery" repts., vol. 20, pp. 69–306; pls. 1–23.

1941 A new genus of sea-stars, etc. Proc. U. S. Nat. Mus., vol. 90, pp. 447–456; pls. 66–70.

FLEMING, JOHN

1828 A history of British animals. xxiii+565 pp.

FORBES, EDWARD

1839 On the Asteriadae of the Irish Sea. Mem. Wernerian Soc. Nat. Hist., vol. 8, pp. 114–128 (reprint pp. 1–16); pls. 3, 4.

1841 A history of British starfishes, etc. xx+270 pp.

1843 On the Radiata of the eastern Mediterranean. Trans. Linn. Soc. London, vol. 19, pp. 143–153; pls. 13, 14.

1848 On the Asteriadae found fossil in British strata. Mem. Geol. Surv. Great Britain, vol. 2, pt. 2, pp. 457–482.

1850 On *Cardiaster,* a new genus of Cretaceous Echinides allied to *Holaster*. Ann. Mag. Nat. Hist., ser. 2, vol. 6, pp. 442–444.

FORSKÅL, PETRUS

1775 Descriptiones animalium, etc. 199 pp., map.

FOURTAU, RENÉ

1904 Contribution à l'étude des échinides vivants dans le Golfe de Suez. Bull. Inst. égypt., ser. 4, vol. 4, pp. 407–446; pls. 1–5.

GERVAIS, PAUL

1841 Astéries. *Asterias*. Dict. sci. nat., suppt. 1, pt. 2, pp. 461–481.

GISLEN, TORSTEN

1922 The crinoids from Dr. S. Bock's expedition to Japan. Nova acta R. soc. sci. Upsala, ser. 4, vol. 5, no. 6, pp. 1–184; pls. 1, 2.

1926 On the generic types of the ophiurid genus *Ophiocentrus,* etc. Göteborgs K. Vetensk. . . . Handl., vol. 30, no. 6, pp. 1–16.

1927 Japanese crinoids. Vidensk. Medd., vol. 83, pp. 1–69; pls. 1, 2.

GLAUERT, LUDWIG

1923 *Cidaris comptoni* sp. nov., a Cretaceous echinid from Gingin. Jour. Roy. Soc. W. Australia, vol. 9, pt. 1, pp. 48–52; pl. 3.

GMELIN, J. F.

1791 Linné: Systema Naturae, ed. 13. Vol. 1, Zoology, pt. 6, pp. 3138–3143, 3160–3201.

GOLDFUSS, G. A.

1820 Handbuch der Zoologie. Pt. 1. 696 pp., 2 pls. Nuremberg.

Goto, Seitaro

1914 A descriptive monograph of Japanese Asteroidea. Pt. 1. Jour. Coll. Sci. Tokyo, vol. 29, pp. 1–808; pls. 1–19.

Gray, John Edward

1825 An attempt to divide the Echinida or sea-eggs into natural families. Ann. Philos., vol. 26, pp. 423–431.

1840 A synopsis of the genera and species of the class Hypostoma. Ann. Mag. Nat. Hist., vol. 6, pp. 175–184, 275–290.

1845 Descriptions of two new invertebrate animals from Australia. Eyre's Jour. . . . Expl. Australia, vol. 1, pp. 435–436; pl. 6.

1847 Descriptions of some new genera and species of Asteriadae. Proc. Zool. Soc. London (1847), pt. 15, pp. 72–83.

1848 List of . . . British animals, etc. Pt. 1: Centroniae or radiated animals. 173 pp.

1851 Description of some new genera and species of Spatangidae in the British Museum. Ann. Mag. Nat. Hist., ser. 2, vol. 7, pp. 130–144.

1851*a* Descriptions of . . . some . . . Scutellidae and Echinolampidae in the . . . British Museum. Proc. Zool. Soc. London (1851), pp. 34–38.

1855 Catalogue of the Recent Echinida . . . in the . . . British Museum. Pt. 1: Echinida irregularia. 69 pp., 6 pls.

1866 Synopsis of the species of starfishes, etc. iv + 17 pp., 16 pls.

Gregory, J. W.

1889 On a new species of the genus *Protaster,* etc. Geol. Mag., n. s., dec. 3, vol. 6, pp. 24–27.

1890 Some additions to the Australian Tertiary Echinodermata. Geol. Mag., n. s., dec. 3, vol. 7, pp. 481–492; pls. 13, 14.

1892 Further additions to Australian fossil Echinoidea. Geol. Mag., n. s., dec. 3, vol. 9, pp. 433–437; pl. 12.

1892*a* *Archaeopneustes abruptus,* a new genus and species, etc. Quart. Jour. Geol. Soc. London, vol. 48, pp. 163–169; pl. 4.

1897 On the classification of the Palaeozoic echinoderms of the group Ophiuroidea. Proc. Zool. Soc. London (1896), pp. 1028–1044.

1899 On *Lindstromaster* and the classification of the palaeasterids. Geol. Mag., n. s., dec. 4, vol. 6, pp. 341–354; pl. 16.

Grinnell, George Bird

1876 On a new crinoid from the Cretaceous formation of the West. Amer. Jour. Sci., ser. 3, vol. 12, pp. 81–84; pl. 4.

Grube, A. E.

1840 Actinien, Echinodermen und Würmer des Adriatischen- und Mittelmeers. 92 pp., 1 pl.

1868 Ueber einige seltenere oder neue Ophiuriden. Jahresber. Schles. Gesellsch. Breslau, vol. 45, pp. 44–45.

Haacke, W.

1880 Holothurien. *In* K. Möbius: Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen, pp. 46–48. Berlin.

Hall, James

1852 The Crinoidea of the Middle Silurian period. Natural history of New York. Palaeontology, vol. 2, pp. 179–248; pls. 41–51.

1868 Contributions to palaeontology. Note on the genus *Palaeaster* and other fossil starfishes. 20th rept. New York State Cabinet, Nat. hist., pp. 282–303; pl. 9.

Hall, T. S.

1902 New or little-known fossils from the Tertiaries of Victoria. Proc. Roy. Soc. Victoria, n. s., vol. 15, pp. 80–85; pl. 11.

HALL, T. S.—*Continued*

1907 Four new echinoids from the Australian Tertiary. Proc. Roy. Soc. Victoria, n. s., vol. 19, pt. 2, pp. 47–53; pls. 13–16.

1908 On the occurrence of a *Marsupium* in an echinoid belonging to the genus *Scutellina*. Proc. Roy. Soc. Victoria, n. s., vol. 20, pt. 2, pp. 140–142.

HAMANN, OTTO

1904 Echinodermen (Stachelhauter). Echinoidea. *In* Bronn: Klassen und Ordnungen des Thier-Reichs, vol. 2, pt. 3, bk. 4, pp. 967–1413; pls. 1–18.

HARTLAUB, CLEMENS

1890 Beitrag zur Kenntniss der Comatulidenfauna des Indischen Archipels. Nachrich. Gesellsch. Göttingen, no. 5, pp. 168–187.

1891 Beitrag zur Kenntniss der Comatulidenfauna des Indischen Archipels. Nova acta Deutsch. Akad., vol. 58, pp. 1–120; pls. 1–5.

HAWKINS, HERBERT L.

1920 On *Apatopygus* gen. nov. and the affinities of some Recent Nucleolitoida and Cassiduloida. Geol. Mag., vol. 57, no. 675, pp. 393–401; pl. 7.

HEDING, S. G.

1928 Synaptidae . . . from Dr. Mortensen's Pacific Expedition. Vidensk. Medd., vol. 85, pp. 105–323; pls. 2, 3.

1931 Über die Synaptiden des Zoologischen Museums zu Hamburg. Zool. Jahrb., Abt. syst., vol. 61, pp. 637–696; pl. 2.

1931*a* On the classification of the molpadids. Vidensk. Medd., vol. 92, pp. 275–284.

1932 *Paracaudina* nom. nov., a correction, etc. Vidensk. Medd., vol. 92, pp. 455–456.

HEDLEY, CHARLES

1926 Zoogeography. Australian encyclopedia, vol. 2, pp. 743–744.

HERKLOTS, J. A.

1869 Echinodermes, peintes d'après Nature, etc. 12 pp., 10 pls.

HÉROUARD, EDGARD

1901 Note préliminaire sur les holothuries . . . Belgica. Arch. zool. exp., Notes, ser. 3, vol. 9, pp. xxxix–xlviii.

HOWCHIN, WALTER

1921 Crinoids from the Cretaceous beds of Australia, etc. Trans. Roy. Soc. S. Australia, vol. 45, pp. 1–4; pl. 1.

HOZAWA, SANJI

1928 On the changes . . . in the calcareous deposits of *Caudina chilensis*. Sci. rept. Tôhoku Univ., ser. 4, vol. 3, pp. 361–378; pls. 14–17.

HUTTON, F. W.

1872 Catalogue of the Echinodermata of New Zealand, etc. vii+19 pp.

1873 Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand. xvi+48 pp.

1879 Notes on some New Zealand Echinodermata, etc. Trans. Proc. New Zealand Inst. (1878), vol. 11, art. 31, pp. 305–308.

JACK, R. L., and ROBERT ETHERIDGE, JR.

1892 The geology and palaeontology of Queensland and New Guinea. 2 vols., xxii+768 pp., 67 pls.

JACKSON, ROBERT TRACY

1912 Phylogeny of the echini. Mem. Boston Soc. Nat. Hist., vol. 7. 491 pp., 76 pls.

JAEGER, G. F.

1833 De Holothuriis. 40 pp., 3 pls.

JAEKEL, OTTO

1895 Beiträge zur Kenntniss der paläozoischen Crinoiden Deutschlands. Palaeontol. Abhandl., vol. 7, no. 1. 116 pp., 10 pls.

John, D. D.
1939 Crinoidea. Rept. British, Australian and New Zealand Antarctic Res. Exped., ser. B, vol. 4, pt. 6, pp. 189–212.

Johnston, Robert M.
1877 Further notes on the Tertiary marine beds of Table Cape. Proc. Roy. Soc. Tasmania (1876), pp. 79–116.
1878 Notes on certain Tertiary and post-Tertiary deposits, etc. Proc. Roy. Soc. Tasmania (1878), pp. 41–50.
1888 Observations with respect to the nature and classification of the Tertiary rocks of Australasia. Proc. Roy. Soc. Tasmania (1887), pp. 135–207.

Joshua, E. C.
1912 On a new holothurian of the genus *Taeniogyrus,* etc. Proc. Roy. Soc. Victoria, n. s., vol. 25, pt. 1, p. 79.
1914 Victorian Holothuroidea, with descriptions of new species. Proc. Roy. Soc. Victoria, n. s., vol. 27, pt. 1, pp. 1–11; pl. 1.

Joshua, E. C., and E. Creed
1915 South Australian Holothuroidea with descriptions of new species. Trans. Roy. Soc. S. Australia, vol. 39, pp. 16–24; pls. 2–4.

Kent, W. Saville
1893 The Great Barrier Reef of Australia. xx+387 pp., 48 pls., 16 chromo pls.

Koehler, René
1895 Catalogue raisonné des échinodermes . . . aux Iles de la Sonde. Mém. Soc. zool., vol. 8, pp. 374–423; pl. 9.
1898 "Investigator" ophiurans: Littoral forms. Bull. sci. France et Belgique, vol. 31, pp. 54–124; pls. 2–5.
1904 Ophiures nouvelles ou peu connues. Mém. Soc. zool. France, vol. 17, pp. 54–119.
1904*a* Ophiures de mer profonde. "Siboga" rept., livr. 15, pp. 1–176; pls. 1–36.
1905 Ophiures littorales. "Siboga" rept., livr. 21, pp. 1–42; pls. 1–18.
1905*a* Echinides, etc. . . . recueillis par M. Gravier, etc. Bull. Mus. hist. nat. Paris, vol. 11, no. 3, pp. 184–186.
1907 Revision de la collection des ophiures du Muséum d'histoire naturelle de Paris. Bull. sci. France et Belgique, vol. 44, pp. 279–351.
1907*a* Ophiuroidea. Die Fauna Südwest-Australiens, vol. 1, pp. 244–254.
1909 The deep-sea Asteroidea. Echinoderma of the Indian Museum, pt. 5. 144 pp., 13 pls.
1909*a* Echinodermes . . . du yacht "Princesse Alice." Rés. . . . sci. . . . prince . . . de Monaco, fasc. 34. 317 pp., 32 pls.
1910 The shallow water Asteroidea. Echinoderma of the Indian Museum, pt. 6. 191 pp., 20 pls.
1910*a* Astéries et ophiures des îles Aru et Kei. Abhandl. Senckenb. naturforsch. Gesellsch., vol. 33, pp. 265–295; pls. 15–17.
1914 A contribution to the study of ophiurans of the U. S. National Museum. Bull. 84 U. S. Nat. Mus. vii+173 pp., 18 pls.
1914*a* Spatangides. Echinodermata of the Indian Museum, pt. 8. 258 pp., 20 pls.
1920 Echinodermata Asteroidea. Rept. Australasian Antarctic Exped., 1911–1914. Sci. rept., ser. C (Zool. and bot.), vol. 8, pt. 1, pp. 1–308; pls. 1–75.
1921 Faune de France: Echinodermes, pp. 1–210; figs. 1–153.
1922 Ophiurans of the Philippine seas and adjacent waters. Bull. 100 U. S. Nat. Mus., vol. 5. x+486 pp., 103 pls.
1926 Echinodermata Echinoidea. Rept. Australasian Antarctic Exped., 1911–14. Sci. rept., ser. C (Zool. and bot.), vol. 8, pt. 3, pp. 1–134; pls. 1–124.

Koehler, René—*Continued*

1927 Revision de quelques ophiures de Ljungman. Ark. Zool., vol. 19*a*, no. 2, pp. 1–29; pls. 1–5.

1930 Ophiures recueillies par le docteur Th. Mortensen dans les mers d'Australie et dans l'Archipel Malais. Vidensk. Medd., vol. 89, pp. 1–295; pls. 1–22.

Koninck, Laurent de

1877 Recherches sur les fossiles Paléozoiques de la Nouvelle-Galles du Sud (Australie). Echinodermes. Mém. Soc. sci. Liége, vol. 6, pt. 3, pp. 158–168; pls. 6, 7.

Lamarck, J. B. P.

1801 Système des animaux sans vertèbres. viii+432 pp.

1816 Histoire naturelle des animaux sans vertèbres. Vol. 2, pp. 522–568; vol. 3, pp. 1–59, 71–74.

Lambert, Jules

1896 Note sur quelques échinides crétacés de Madagascar. Bull. Géol. soc. France, ser. 3, vol. 24, pp. 313–332; pls. 10–13.

Lambert, Jules, and Paul Thiéry

1909 Essai de nomenclature raisonnée des échinides. Fasc. 1, pp. 1–80; pls. 1, 2.

1910 Essai de nomenclature raisonnée des échinides. Fasc. 2, pp. 81–160; pls. 3, 4.

1911 Essai de nomenclature raisonnée des échinides. Fasc. 3, pp. 161–240; pls. 5, 6.

1914 Essai de nomenclature raisonnée des échinides. Fasc. 4, pp. 241–320; pls. 7, 8.

1921 Essai de nomenclature raisonnée des échinides. Fasc. 5, pp. 321–384; pl. 9.

1924 Essai de nomenclature raisonnée des échinides. Fasc. 6, 7, pp. 385–512; pls. 10, 11, 14.

1925 Essai de nomenclature raisonnée des échinides. Fasc. 8, 9, pp. 513–607; pls. 12, 13, 15.

Lampert, Kurt

1885 Die Seewalzen—Holothurioidea. 312 pp., 1 pl.

1889 Die "Gazelle" Holothurien. Zool. Jahrb., Abt. syst., vol. 4, pp. 806–858; pl. 1.

Laube, Gustav C.

1869 Ueber einige fossile Echiniden von den Murray Cliffs in Süd-Australien. Sitzungsber. Kais. Akad. Wissensch. Wien, vol. 59, pp. 183–198; pl. 1.

Leach, W. E.

1815 The zoological miscellany, etc. Vol. 2, pp. 1–162; pls. 61–120.

LeConte, John L.

1851 Zoological notes. Proc. Acad. Nat. Sci. Philadelphia, vol. 5, pp. 316–320.

Leipoldt, Fritz

1895 Asteroidea der "Vettor-Pisani" Exped. 1882–85, etc. Ztschr. f. wissensch. Zool., vol. 59, pp. 545–554; pls. 31, 32.

Leske, N. G.

1778 Additamenta ad Klein, etc. pp. i–xx, 1–236; pls. 37–54.

Lesson, R. P.

1830 Centurie zoologique, etc. 254 pp., 80 pls.

Linck, Johann

1733 De stellis marinis, etc. (22)+107 pp., 42 pls.

Linné, Carl von

1758 Systema Naturae, ed. 10. Vol. 1, pp. 661–666.

1761 Fauna suecica, etc. (47)+578 pp., 2 pls.

1767 Systema Naturae, ed. 12. Vol. 1, pt. 2, pp. 1089–1091, 1098–1105.

1791 *See* Gmelin, J. F.

Livingstone, Arthur A.

1930 On some new and little-known Australian asteroids. Rec. Australian Mus., vol. 18, no. 1, pp. 15–24; pls. 4–8.

LIVINGSTONE, ARTHUR A.—*Continued*

1931 On the restriction of the genus *Ferdina* Gray (Asteroidea). Australian Zoologist, vol. 6, pt. 4, pp. 305–309; pls. 21–24.

1931*a* On a new asteroid from Queensland. Rec. Australian Mus., vol. 18, no. 4, pp. 135–137; pls. 17–19.

1932 Asteroidea. Sci. rept. Great Barrier Reef Exped. 1928–29, vol. 4, no. 8, pp. 241–265; pls. 1–12.

1932*a* Some further notes on species of *Tamaria*. The Australian species of *Tosia*. Rec. Australian Mus., vol. 18, nos. 6, 7, pp. 368–382; pls. 41–44.

1932*b* Notes on some representatives of the asteroid genus *Culcita*. Australian Zoologist, vol. 7, pt. 3, pp. 265–273; pls. 14–17.

1933 Some genera and species of the Asterinidae. A new *Mediaster* from Queensland. Rec. Australian Mus., vol. 19, no. 1, pp. 1–22; pls. 1–6.

1934 Two new asteroids from Australia. Rec. Australian Mus., vol. 19, no. 3, pp. 177–180; pl. 18.

1936 Descriptions of new Asteroidea from the Pacific. Rec. Australian Mus., vol. 19, no. 6, pp. 383–387; pls. 27, 28.

LJUNGMAN, A. V.

1866 Nya Arter af Ophiurider. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 6, pp. 163–166.

1867 Ophiuroidea viventia huc usque cognita enumerat. Öfvers. K. Vetensk.-Akad. Förh., vol. 23, no. 9, pp. 303–336.

1872 Förteckning öfver uti Vestindien af Dr. A. Goës samt . . . Ophiurider. Öfvers. K. Vetensk.-Akad. Förh., vol. 28, no. 5, pp. 615–658.

LORIOL, PERCIVAL DE

1883 Catalogue raisonné des échinodermes, recueillis par M. V. de Robillard à l'île Maurice. I: Echinides. Mém. Soc. phys. hist. nat. Genève, vol. 28, no. 8, pp. 1–64; pls. 1–6 (37 figs. colored).

1885 Catalogue raisonné des échinodermes, recueillis par M. V. de Robillard à l'île Maurice. II: Stellérides. Mém. Soc. phys. hist. nat. Genève, vol. 29, no. 4, pp. 1–84; pls. 7–22 (13 figs. colored).

1891 Notes pour servir à l'étude des échinodermes. Mém. Soc. phys. hist. nat. Genève, suppt. vol. 1890, no. 8, pp. 1–31; pls. 10–12.

1893 Echinodermes de la Baie d'Amboine. Rev. suisse zool., vol. 1, pp. 359–426; pls. 13–15; 1895, vol. 3, pp. 365–366; pls. 10, 11.

LOVÉN, SVEN

1887 On the species of Echinoidea described by Linnaeus, etc. Bih. K. svenska Vetensk.-Akad. Handl., vol. 13, pt. 4, no. 5, pp. 1–185; pls. 1–9.

LUDWIG, HUBERT

1874 Beiträge zur Kenntniss der Holothurien. Arb. Zool.-Zoot. Inst. Würzburg, vol. 2, pp. 77–120; pls. 6, 7.

1881 Revision der Mertens-Brandtschen Holothurien. Ztschr. f. wissensch. Zool., vol. 35, pp. 575–599.

1882 Echinodermen an der Küste von Brasilien gesammelt. Mém. Acad. roy. Belgique, vol. 44, pp. 1–26.

1883 Verzeichniss der Holothurien des Kieler Museums. Ber. Oberhess. Gesellsch. Nat.- u. Heilk., vol. 22, pp. 155–176.

1886 Die von G. Chiercha auf der Fahrt der kgl. ital. Corvette "Vittor-Pisani" gesammelten Holothurien. Zool. Jahrb., Abt. syst., vol. 2, pp. 1–36; pls. 1, 2.

1887 Drei Mittheilungen über alte und neue Holothurien-Arten. Sitzungsber. K. preuss. Akad. Wissensch. Berlin, vol. 54, pp. 1217–1244; pl. 15.

LUDWIG, HUBERT—*Continued*

1888 Die von Dr. J. Brock im Indischen Archipel gesammelten Holothurien. Zool. Jahrb., Abt. syst., vol. 3, pp. 805–820; pl. 30.

1888*a* *Ophiopteron elegans,* eine neue . . . Ophiuridenform. Ztschr. f. wissensch. Zool., vol. 47, pp. 459–464; pl. 35.

1892 Echinodermen. Die Seewalzen. *In* Bronn: Klassen und Ordnungen des Thier-Reichs, vol. 2, pt. 3, bk. 1, pp. i–vii, 1–460; pls. 1–17.

1894 The Holothurioidea (of the "Albatross" 1891 cruise). Mem. Mus. Comp. Zoöl., vol. 17, pp. 1–183; pls. 1–19 (15 figs. colored).

1898 Holothurien. Hamburger Magalhaensische Sammelreise. 98 pp., 3 pls.

LÜTKEN, C. F.

1856 Oversigt over de vestindiske Ophiuren. Vidensk. Medd. (1856), pp. 1–26.

1858 Additamenta ad historiam Ophiuridarum. Pt. 1, pp. 1–74; pls. 1, 2.

1859 Additamenta ad historiam Ophiuridarum. Pt. 2, pp. 75–169; pls. 1–5 (45 figs. colored, in some printings).

1864 Bidrag til Kundskab om Echiniderne. Vidensk. Medd. (1863), pp. 69–207; pls. 1, 2.

1869 Additamenta ad historiam Ophiuridarum. Pt. 3, pp. 22–109.

1871 Fortsatte kritiske . . . om Söstjernerne (Asteriderne). Vidensk. Medd., vol. 23, pp. 227–304.

1872 Ophiuridarum novarum, etc. Overs. K. danske vidensk. Selsk. Forh., pp. 75–158.

LÜTKEN, C. F., and TH. MORTENSEN

1899 The Ophiuridae (of the "Albatross" 1891 cruise). Mem. Mus. Comp. Zoöl., vol. 23, pp. 93–208; pls. 1–23.

LYMAN, THEODORE

1860 Descriptions of new Ophiuridae, etc. Proc. Boston Soc. Nat. Hist., vol. 7, pp. 193–204, 252–262.

1861 Descriptions of new Ophiuridae, etc. Proc. Boston Soc. Nat. Hist., vol. 8, pp. 75–86.

1865 Ophiuridae and Astrophytidae. Illus. cat. Mus. Comp. Zoöl., no. 1. viii+200 pp., 2 pls. (colored).

1869 Preliminary report on the Ophiuridae and Astrophytidae, etc. Bull. Mus. Comp. Zoöl., vol. 1, pp. 309–354.

1871 Supplement to Ophiuridae and Astrophytidae. Illus. cat. Mus. Comp. Zoöl., no. 6. 17 pp.

1874 Ophiuridae and Astrophytidae, old and new. Bull. Mus. Comp. Zoöl., vol. 3, pp. 221–272; pls. 1–7.

1878 "Challenger" Ophiuridae and Astrophytidae. Pt. 1. Bull. Mus. Comp. Zoöl., vol. 5, no. 7, pp. 65–168; pls. 1–10.

1878*a* Ophiurans and astrophytons. Bull. Mus. Comp. Zoöl., vol. 5, no. 9, pp. 217–238; pls. 1–3.

1879 "Challenger" Ophiuridae and Astrophytidae. Pt. 2. Bull. Mus. Comp. Zoöl., vol. 6, pp. 17–83; pls. 11–19.

1882 Report on the Ophiuroidea. "Challenger" sci. results: Zoology, vol. 5, pp. 1–386; pls. 1–48.

1883 Report on the Ophiuroidea (of the "Blake"). Bull. Mus. Comp. Zoöl., vol. 10, pp. 227–287; pls. 1–8.

MACAN, T. T.

1938 Asteroidea. Sci. rept. John Murray Exped. 1933–34, no. 9, pp. 323–425; pls. 1–6.

MANTELL, G.

1835 A tabular arrangement of the organic remains of the County of Sussex. Trans. Geol. Soc. London, ser. 2, vol. 3, no. 10, pp. 201–216.

MARENZELLER, E. VON

1881 Neue Holothurien von Japan und China. Verhandl. K. K. zool.-bot. Gesellsch. Wien, vol. 31, pp. 121–140; pls. 4, 5.

MARKTANNER-TURNERETSCHER, G.

1887 Beschreibungen neuer Ophiuriden, etc. Ann. K. K. naturhist. Hofmus. Wien, vol. 2, pp. 291–316; pls. 12, 13.

MARTENS, E. VON

1865 Über ostasiatische Echinodermen. Arch. f. Naturgesch., vol. 31, pt. 1, pp. 345–360.

1865*a* Über zwei neue ostasiatische Echiniden. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 140–144.

1866 Über ostasiatische Echinodermen. Arch. f. Naturgesch., vol. 32, pt. 1, pp. 57–88, 133–189.

1867 Über ostasiatische Echinodermen. Arch. f. Naturgesch., vol. 33, pt. 1, pp. 106–119.

MATSUMOTO, HICKOSCHICHERO

1912 The Gorgonocephalidae of Japan. Zool. Mag. Tokyo, vol. 24, pp. 198–207; 2 pls.

1915 A new classification of the Ophiuroidea, etc. Proc. Acad. Nat. Sci. Philadelphia, vol. 67, pp. 43–92.

1917 A monograph of Japanese Ophiuroidea. Jour. Coll. Sci. Tokyo, vol. 38, art. 2, pp. 1–408; pls. 1–7.

MCCOY, FREDERICK

1847 On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist., vol. 20, pp. 226–236; pl. 12.

1849 On some new Palaeozoic Echinodermata. Ann. Mag. Nat. Hist., ser. 2, vol. 3, pp. 244–254.

1851 Echinodermata. Brit. Palaeozoic fossils, pp. 51–60, 76, 116–125.

1874 Asteroidea. Prodromus palaeontol. Victoria, dec. 1, pp. 41–43; pl. 10.

1879 Echini. Prodromus palaeontol. Victoria, dec. 6, pp. 33–42; pls. 59, 60.

1882 Echini. Prodromus palaeontol. Victoria, dec. 7, pp. 15–22; pls. 64–68.

1885 Prodromus of the zoology of Victoria, etc. Vol. 1, dec. 10, pp. 33–35; pl. 100 (colored).

1890 Prodromus of the zoology of Victoria, etc. Vol. 2, dec. 20, pp. 371–375; pl. 200 (colored).

MCNEILL, FRANK A., and A. A. LIVINGSTONE

1926 A supplementary list of the echinoderms collected by . . . W. E. J. Paradice, etc. Rec. Australian Mus., vol. 15, pp. 193–199; pl. 17.

MEEK, F. B.

1872 Descriptions of . . . Silurian fossils, etc. Amer. Jour. Sci., ser. 3, vol. 4, pp. 274–280.

MEEK, F. B., and A. H. WORTHEN

1869 Descriptions of new Carboniferous fossils from the Western states. Proc. Acad. Nat. Sci. Philadelphia, vol. 21, pp. 137–172.

MEIJERE, J. C. H. DE

1903 Vorläufige Beschreibung der neuen . . . Echiniden. Tijdschr. Nederlandsche dierk. Ver., ser. 2, vol. 8, pp. 1–16.

1904 Die Echinoidea der "Siboga" Expedition. "Siboga" rept., livr. 14, pp. 1–252; pls. 1–23.

MEYER, HERMANN VON

1837 *Isocrinus* und *Chelocrinus,* zwei neue Typen . . . der Crinoiden. Abhandl. Mus. senckenb., vol. 2, pp. 249–263; pl. 16.

MICHELIN, H.
1845 Zoophytes, échinodermes et stellérides (de l'île Maurice). Mag. zool., vol. 7, pp. 173–199 (reprint pp. 1–27).
1862 Echinides et stellérides. Annexe A *in* Maillard: Réunion, pp. 1–7.

MILLER, J. S.
1821 A natural history of the Crinoidea, etc. viii+150 pp., 50 pls. (irregularly numbered and more or less colored or tinted).

MILLER, S. A., and W. F. E. GURLEY
1890 (1891) Description of some new genera and species of Echinodermata, etc. 16th rept. Geol. Surv. Indiana, pp. 327–373; pls. 1–10.

MILNE-EDWARDS, HENRI
See EDWARDS, HENRI MILNE.

MITSUKURI, K.
1912 Studies on actinopodous Holothurioidea. Jour. Coll. Sci. Tokyo, vol. 29, art. 2, pp. 1–284; pls. 1–8.

MÖBIUS, K.
1859 Neue Seesterne des Hamburger und Kieler Museums. 14 pp., 4 pls.

MOORE, CHARLES
1870 On Australian Mesozoic geology and palaeontology, etc. Quart. Jour. Geol. Soc. London, vol. 26, pp. 226–263; pls. 10–18.

MORRIS, JOHN
1843 A catalogue of British fossils, etc. xii+222 pp.

MORTENSEN, TH.
1903 Echinoidea. Pt. 1. Danish "Ingolf" Exped. rept. 195 pp., 21 pls., map.
1903*a* *Chaetodiadema granulatum* n. g., n. sp., a new diadematid, etc. Vidensk. Medd., pp. 1–3.
1904 Echinoidea (1). Danish Exped. to Siam 1899–1900, vol. 2. 124 pp., 7 pls., map.
1907 Echinoidea. Pt. 2. Danish "Ingolf" Exped. rept. 200 pp., 19 pls., list of stations.
1909 Die Echinoiden. Rept. Deutsch. Südpolar-Exped. 1901–1903. Vol. 11: Zool., vol. 3. 113 pp., 19 pls.
1915 Preliminary note on the remarkable, shortened development of an Australian sea-urchin, *Toxocidaris erythrogrammus*. Proc. Linn. Soc. N. S. Wales, vol. 40, pp. 203–206.
1918 Echinoidea of Dr. Mjöberg's expedition to Australia. K. svenska Vetensk.-Akad. Handl. Stockholm, vol. 58, no. 9. 22 pp., 5 pls.
1920 Notes on some Scandinavian echinoderms, etc. Vidensk. Medd., vol. 72, pp. 45–79.
1921 Echinoderms of New Zealand, etc. I: Echinoidea. Vidensk. Medd., vol. 73, pp. 139–198; pls. 6–8.
1924 Echinoderms of New Zealand, etc. II: Ophiuroidea. Vidensk. Medd., vol. 77, pp. 91–177; pls. 3, 4.
1925 Echinoderms of New Zealand, etc. III–V: Asteroidea, Holothurioidea and Crinoidea. Vidensk. Medd., vol. 79, pp. 261–420; pls. 12–14.
1928 New Cidaridae. Vidensk. Medd., vol. 85, pp. 65–74.
1928*a* A monograph of the Echinoidea. I: Cidaroidea. 2 pts., 551+24 pp., 88 pls.
1932 New contributions to the knowledge of the cidarids. I: Notes on some Recent cidarids. K. danske Vidensk. Selsk. Skr. København, vol. 4, pp. 145–174; pls. 1–13.
1932*a* On an extraordinary ophiurid, etc. Vidensk. Medd., vol. 93, pp. 1–21; pl. 1.
1933 Echinoderms of South Africa. Vidensk. Medd., vol. 93, pp. 215–400; pls. 8–19.

Mortensen, Th.—*Continued*

1935 A monograph of the Echinoidea. II: Bothriocidaroida, Melonechinoida, Lepidocentroida and Stirodonta. 2 pts., 647+16 pp., 89 pls.

1940 A monograph of the Echinoidea. III: Aulodonta (with additions to vol. II). 2 pts., 370+22 pp., 87 pls.

Müller, Johannes

1841 Ueber die Gattungen und Arten der Comatulen. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 179–189. Duplicated in Arch. f. Naturgesch., vol. 7, pp. 139–148.

1846 Nachtrag zu der Abhandlung über die Comatulen. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 177–179.

1849 Über die Gattung *Comatula* Lam. und ihre Arten. Abhandl. K. preuss. Akad. Wissensch. Berlin (1847), pp. 236–265 (reprint pp. 1–29).

1850 Anatomische Studien über die Echinodermen. Arch. f. Anat. u. Physiol. (1850), pp. 117–160.

Müller, Johannes, and Franz Hermann Troschel

1840 Beobachtungen über die Asteriensammlung des Zoologischen Museums. Ber. Verhandl. K. preuss. Akad. Wissensch. Berlin, Apr. 1840, pp. 100–106. Reprinted, with slight changes and 3 footnotes, under the title Ueber die Gattungen der Asterien. Arch. f. Naturgesch., vol. 6, no. 1, pp. 318–326.

1842 System der Asteriden. xx+135 pp., 12 pls.

1843 Neue Beiträge zur Kenntniss der Asteriden. Arch. f. Naturgesch., vol. 9, no. 1, pp. 113–120.

1844 Beschreibung neuer Asteriden. Arch. f. Naturgesch., vol. 10, no. 1, pp. 178–185.

Müller, Otto Friedrich

1776 Zoologiae danicae prodromus; seu Animalium Daniae et Norvegiae, etc. xxxii+282 pp.

1789 Zoologia danica; seu Animalium Daniae et Norvegiae, etc. Vol. 3, pp. 1–71; pls. 71–120.

Nardo, J. D.

1834 De asteriis. Oken's Isis, vol. 7, pp. 716–717.

Ohshima, Hiroshi

1913 Synaptiden von Misaki. Dobuts. Zasshi (=Zool. Mag.) Tokyo, vol. 25, pp. 253–262; pl. 6.

1914 The Synaptidae of Japan. Annot. zool. jap. Tokyo, vol. 8, pp. 467–482.

1915 Report on the holothurians collected by the . . . "Albatross" in the northwestern Pacific, etc. Proc. U. S. Nat. Mus., vol. 48, pp. 213–291; pls. 8–11.

Oken, Lorenz

1815 Lehrbuch der Naturgeschichte. Pt. 3: Zoologie. xxviii+850+xviii pp.

Östergren, Hjalmar

1898 Das System der Synaptiden. Öfvers. K. Vetensk.-Akad. Förh., vol. 55, pp. 111–120.

1898*a* Zur Anatomie der Dendrochiroten, etc. Zool. Anz., vol. 21, no. 552, pp. 102–110, 133–136.

Pallas, P. S.

1766 Miscellanea zoologica, etc. xii+224 pp., 14 pls.

1774 Spicilegia zoologica. Vol. 1, pt. 10, pp. 1–41; index; pls. 1–4.

Panning, A.

1929–1935 Die Gattung *Holothuria*. Mitt. Zool. Staats-Inst. u. Zool. Mus. Hamburg, vols. 44–46, 5 pts.: pp. 91–138, 24–50, 65–84, 85–107, 1–18.

Parkinson, James

1808 Organic remains of a former world. Vol. 2: The fossil zoophytes. xvi+286 pp., 19 pls.

PEARSON, JOSEPH

1903 Report on the Holothurioidea. Rept. Ceylon Pearl Oyster Fish., suppt. rept. no. V, pp. 182–208.

1910 Littoral marine fauna, Kerimba Archipelago, etc. Holothurioidea. Proc. Zool. Soc. London (1910), pp. 167–182.

1910*a* Marine fauna: Mergui Archipelago, Lower Burma, etc. Holothurioidea. Proc. Zool. Soc. London (1910), pp. 183–194.

1913–1914 Notes on Holothurioidea. Spolia zeylanica, vol. 9, pp. 49–101, 163–190; pls. 5–14, 27–29.

PENNANT, THOMAS

1777 British zoology. 4th ed., vol. 4. 174 pp., 93 pls.

PERRIER, EDMOND

1869 Recherches sur les pédicellaires et les ambulacres des astéries et des oursins. Ann. sci. nat., ser. 5, vol. 12, pp. 197–304; pls. 17, 18.

1875 Revision de la collection de stellérides du Muséum, etc. Arch. zool. exp., vol. 4, pp. 265–450 (pp. 1–185 of reprint).

1876 Revision de la collection de stellérides du Muséum, etc. Arch. zool. exp., vol. 5, pp. 1–104, 209–304 (pp. 185–384 of reprint).

1878 Etudes . . . des astérides. Nouv. arch. Muséum, ser. 2, vol. 1, pp. 1–108.

1881 Description sommaire des espèces nouvelles d'astéries. Bull. Mus. Comp. Zoöl., vol. 9, pp. 1–31.

1885 Première note préliminaire sur les échinodermes . . . du "Travailleur" et du "Talisman." Stellérides. Ann. sci. nat., ser. 6, vol. 19, no. 8, pp. 1–72.

1885*a* Sur les Brisingidae de la mission du "Talisman." Compt. rend., vol. 101, pp. 441–444.

1891 Echinodermes. I: Stellérides. Rept. Mission sci. du Cap Horn, 1882–83. Vol. 6, pt. 3: Zoologie, pp. K1–K198; pls. 1–13.

1894 Echinodermes. Pt. I: Stellérides. Expéd. du "Travailleur" et du "Talisman." iv+431 pp., 26 pls.

PERRIER, RÉMY

1904 Holothuries du Cap Horn. Bull. Mus. hist. nat. Paris, vol. 10, pp. 13–17.

1905 Holothuries antarctiques du Muséum d'histoire naturelle de Paris. Ann. sci. nat., Zool., ser. 9, vol. 1, pp. 1–146; pls. 1–5.

PETERS, WILHELM

1851 Übersicht der von Mossambique eingesammelten Ophiuren, etc. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 463–466.

1852 Übersicht der Seesterne (Asteridae) von Mossambique. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 177–178.

1853 Ueber die an der Küste von Mossambique beobachteten Seeigel, etc. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 187–188.

1855 Ueber die an der Küste von Mossambique beobachteten Seeigel, etc. Abhandl. K. preuss. Akad. Wissensch. Berlin, pp. 101–119; pls. 1, 2.

PFEFFER, GEORG

1887 Zoologische Kleinigkeiten, no. 9. Ueber *Parasalenia gratiosa* (A. Agass.) und *P. pohlii* n. sp. Verhandl. Naturwiss. Ver. Hamburg, vol. 6, pp. 110–113.

PHILIPPI, R. A.

1845 Beschreibung einiger neuer Echinodermen, etc. Arch. f. Naturgesch., vol. 11, pp. 344–359; pl. 11.

POMEL, AUGUSTE

1869 Revue des échinodermes et de leur classification, etc. lxvii pp.

1883 Classification méthodique et genera des échinides vivants et fossiles. 120+10 pp., 1 pl.

PRITCHARD, G. B.
1908 On the occurrence of the genus *Linthia* in Victoria, etc. Proc. Roy. Soc. Victoria, n. s., vol. 21, pt. 1, pp. 392–400; pls. 22, 23.

QUOY, J. R. C., and P. GAIMARD
1833 Voyage de découvertes de l' "Astrolabe," etc. Zoologie. Vol. 4: Zoophytes, pp. 1–390; atlas, pls. 6–8.

RAMSAY, E. P.
1885 Catalogue of the Echinodermata in the Australian Museum. Pt. 1: Echini. vi+54 pp., 3 pls.

RATTE, FELIX
1885 On *Tribrachyocrinus corrugatus,* etc. Proc. Linn. Soc. N. S. Wales, vol. 9, p. 1158; pl. 68.

RETZIUS, ANDERS JAHAN
1783 Genera et species insectorum, etc. K. Vetensk.-Akad. Handl., vol. 4, pp. 230–248.
1805 Dissertatio sistans species cognitas asteriarum, etc., pp. 1–37.

RISSO, A.
1826 Histoire naturelle . . . de l'Europe méridionale, etc. Vol. 5: Description des principaux radiaires, etc. Ordre 1: Les Echinodermes, pp. 267–293; pls. 6, 7 (*partim*).

SALTER, J. W.
1857 On some new Palaeozoic star-fishes. Ann. Mag. Nat. Hist., ser. 2, vol. 20, pp. 321–334; pl. 9.

SARS, MICHAEL
1861 Oversigt af Norges Echinodermer. vi+160 pp., 16 pls.

SAVIGNY, J. C. DE
1809 Explication sommaire des planches. *In* Description de l'Egypte: Histoire naturelle. 339 pp. Echinodermes, pp. 203–212; pls. 1–9.

SAY, THOMAS
1825 On the species of the Linnean genus *Asterias,* etc. Jour. Acad. Nat. Sci. Philadelphia, vol. 5, pp. 141–154.

SCHLOTHEIM, ERNST FREIHERR VON
1820 Die Petrefactenkunde, etc. pp. i–lxii, 1–436; pls. 15–29.

SCHUCHERT, CHARLES
1914 Fossilium catalogus. I: Animalia. Pt. 3: Stelleroidea palaeozoica, pp. 1–53.
1915 Revision of Paleozoic Stelleroidea, etc. Bull. 88 U. S. Nat. Mus. 311 pp., 38 pls.

SELENKA, EMIL
1867 Beiträge zur Anatomie und Systematik der Holothurien. Ztschr. f. wissensch. Zool., vol. 17, pp. 291–374; pls. 17–20.
1868 Nachtrag dazu. Ztschr. f. wissensch. Zool., vol. 18, pp. 109–118; pl. 8.

SEMPER, C.
1868 Reisen im Archipel der Philippinen. Pt. 2: Wissensch. Res. Vol. I: Holothurien. 288 pp., 40 pls. (21 colored).

SISMONDA, EUGENIO
1841 Monografia degli echinidi fossili del Piemonte. Mem. R. accad. sci. Torino, ser. 2, vol. 4, pp. 1–54; pls. 1–3.

SLADEN, W. PERCY
1882 "Challenger" Pterasteridae. Jour. Linn. Soc. (Zool.), vol. 16, pp. 189–246.
1883 "Challenger" Astropectinidae. Jour. Linn. Soc. (Zool.), vol. 17, pp. 214–269.
1885 "Challenger" Exped. narrative, vol. 1, pt. 2. 1110 pp.
1889 Report on the Asteroidea. "Challenger" sci. results: Zoology, vol. 30, pp. i–xlii, 1–893; pls. 1–117.

SLUITER, C. PH.

1894 Bericht über . . . Semon . . . Holothurioidea. Jena Denkschr., vol. 8; Semon's Zool. Forsch. Austral., vol. 5, pp. 101–106.

1901 Die Holothurien der "Siboga"-Expedition. "Siboga" rept., livr. 1, pp. 1–142; pls. 1–10 (3 colored).

1914 Die . . . "Gier" . . . Holothurien. Buitenzorg Contr. Fauna Indes Néerl., vol. 1, pp. 1–28; pl. 1.

SMITH, E. A.

1876 Diagnoses of new species of Mollusca and Echinodermata from the island of Rodrigues. Ann. Mag. Nat. Hist., ser. 4, vol. 17, pp. 404–406.

1876*a* Descriptions of two new species of *Ophiocoma*. Ann. Mag. Nat. Hist., ser. 4, vol. 18, pp. 39–40.

1878 Description of *Acantharachna mirabilis*, a new form of Ophiuridae. Jour. Linn. Soc. (Zool.), vol. 13, pp. 335–337.

1879 Transit of Venus Exped.: Echinoderms. Philos. Trans., vol. 168, pp. 564–568; pl. 1.

SPENCER, W. K.

1916 A monograph of the British Palaeozoic Asterozoa. Palaeontogr. Soc. London, pt. 2, pp. 57–108; pls. 2–5.

1922 A monograph of the British Palaeozoic Asterozoa. Palaeontogr. Soc. London, pt. 5, pp. 197–236; pls. 14–17.

1925 A monograph of the British Palaeozoic Asterozoa. Palaeontogr. Soc. London, pt. 6, pp. 237–324; pls. 18–22.

1927 A monograph of the British Palaeozoic Asterozoa. Palaeontogr. Soc. London, pt. 7, pp. 325–388; pls. 23, 24.

1930 A monograph of the British Palaeozoic Asterozoa. Palaeontogr. Soc. London, pt. 8, pp. 389–436; pls. 25–28.

STACH, L. W.

1938 Echinodermata (of Sir Joseph Banks Islands). Proc. Roy. Soc. Victoria, vol. 50, pp. 329–337; pl. 18.

STIMPSON, WILLIAM

1852 Two new species of *Ophiolepis*. Proc. Boston Soc. Nat. Hist., vol. 4, pp. 224–226.

1855 Descriptions of some new marine invertebrates: Echinodermata. Proc. Acad. Nat. Sci. Philadelphia, vol. 7, pp. 385–387.

1857 Echinodermata. Boston Jour. Nat. Hist., vol. 6, pp. 522–531; pl. 23, figs. 7–11.

STUDER, TH.

1877 Über Echinodermen aus dem Antarctischem Meere. Monatsber. K. preuss. Akad. Wissensch. Berlin, July 1876, pp. 452–465.

1880 Übersicht über die . . . "Gazelle" . . . Echinoiden. Monatsber. K. preuss. Akad. Wissensch. Berlin, pp. 861–885.

1882 Ophiurien. Abhandl. K. preuss. Akad. Wissensch. Berlin, vol. 1, pp. 1–37; 3 pls.

1883 Über die Asteriden . . . "Gazelle" . . . gesammelt. Sitzungsber. Gesellsch. Naturforsch. Freunde, Berlin, pp. 128–132.

1884 Verzeichniss der . . . "Gazelle" . . . Asteriden und Euryaliden. Abhandl. K. preuss. Akad. Wissensch. Berlin, vol. 2, pp. 1–64; pls. 1–5.

STÜRTZ, BERNHARD

1886 Ueber palaeozoische Seesterne. Neues Jahrb. Min., vol. 2, pp. 142–154.

1886*a* Beitrag zur Kenntniss paläozoischer Seesterne. Palaeontographica, vol. 32, pp. 75–98; pls. 8–14.

1893 Ueber versteinerte und lebende Seesterne. Verhandl. Naturhist. Ver. preuss. Rheinland, vol. 50, pp. 1–92; pl. 1.

Stürtz, Bernhard—*Continued*

1900 Ein weiterer Beitrag zur Kenntniss palaeozoischen Asteroiden. Verhandl. Naturhist. Ver. preuss. Rheinland, vol. 56, pp. 176–240; pls. 2–4.

Tate, Ralph

1877 On new species of . . . *Salenia* from the Middle Tertiaries of South Australia. Quart. Jour. Geol. Soc. London, vol. 33, pp. 256–259.

1884 Notes on the physical and geological features of the basin of the lower Murray River. Trans. Proc. Roy. Soc. S. Australia, vol. 7, pp. 24–46; pl. (map).

1885 Notes on fossils. Southern Science Record, n. s., no. 1, pp. 1–4.

1891 A bibliography and revised list of the described echinoids of the Australian Eocene, etc. Trans. Proc. Roy. Soc. S. Australia, vol. 14, pp. 270–282.

1892 Critical remarks on A. Bittner's "Echiniden des Tertiars von Australien." Trans. Proc. Roy. Soc. S. Australia, vol. 15, pp. 190–194.

1893 Unrecorded genera of the older Tertiary fauna of Australia, etc. Jour. Proc. Roy. Soc. N. S. Wales, vol. 27, pp. 167–197; pls. 10–13.

1898 A second supplement to a census of the fauna of the oldest Tertiary of Australia. Jour. Proc. Roy. Soc. N. S. Wales, vol. 31, pp. 381–412.

Tate, Ralph, and J. Dennant

1896 Correlation of the marine Tertiaries of Australia. Trans. Proc. Roy. Soc. S. Australia, vol. 20, pp. 118–148.

Tenison-Woods, J. E.

1878 The echini of Australia. Proc. Linn. Soc. N. S. Wales, vol. 2, pp. 145–176, 342–344.

1879 On some new Australian echini. Proc. Linn. Soc. N. S. Wales, vol. 4, pp. 282–291; pls. 13, 14.

1881 On some of the littoral marine fauna of northeast Australia. Proc. Linn. Soc. N. S. Wales, vol. 5, pp. 106–131.

1881*a* On the habits of some Australian echini. Proc. Linn. Soc. N. S. Wales, vol. 5, pp. 193–204.

1883 On a new species of *Stomopneustes* and a new variety of *Hipponoe variegatus*. Proc. Linn. Soc. N. S. Wales, vol. 7, pp. 93–94; pls. 6, 7.

Théel, Hjalmar

1886 Report on the Holothurioidea. "Challenger" sci. results: Zoology, vol. 14, pt. 39, pp. 1–290; pls. 1–16.

Thomson, C. Wyville

1872 On the Echinidea of the "Porcupine" deep-sea dredging expeditions. Proc. Roy. Soc., vol. 20, pp. 491–497.

1873 The depths of the sea. xx+527 pp., many figs.

Tiedemann, Friedrich

1816 Anatomie der Röhren-Holothurie, etc. viii+98 pp., 10 pls.

Tortonese, Enrico

1935 Descrizione di una nuova stella di mare, etc. Bull. Mus. zool. Univ. Torino, vol. 45, ser. 3, no. 60, pp. 1–6; pl. 1.

Trautschold, Hermann

1879 Die Kalkbrüche von Mjatschkowa. Nouv. mém. Soc. imp. nat. Moscou, vol. 14. 82 pp., 7 pls.

Troschel, Franz Hermann

1846 Neue Holothurien-Gattungen. Arch. f. Naturgesch., vol. 1, pp. 60–66.

1869 Ueber einige neue Seeigel, etc. Sitzungsber. Niederrhein. Gesellsch. Bonn, p. 96.

Valenciennes, Achille

1846 Voyage de "Venus": Zoophytes, pls. 1–15.

VANEY, CLEMENT

1912 Holothurien der Aru-Inseln. Abhandl. Senckenb. naturforsch. Gesellsch., vol. 34, pp. 289–291.

VERRILL, ADDISON E.

1867 Notes on the Radiata in the Museum of Yale College, etc. Trans. Connecticut Acad., vol. 1, pp. 247–351.

1876 Natural history of Kerguelen: Echinoderms. Bull. 3 U. S. Nat. Mus., pp. 68–75.

1899 Revision of certain genera and species of starfishes, etc. Trans. Connecticut Acad., vol. 10, pt. 2, pp. 145–234; pls. 24–30.

1899*a* (Sept.) Report on the Ophiuroidea, etc. Bull. Nat. Hist. Univ. Iowa, vol. 5, no. 1, pp. 1–86; pls. 1–8.

1899*b* (Oct.) North American Ophiuroidea. Trans. Connecticut Acad., vol. 10, pt. 2, pp. 301–386; pls. 42, 43.

1913 Revision of the genera of starfishes of the subfamily Asterininae. Amer. Jour. Sci., ser. 4, vol. 35, pp. 477–485.

1914 Monograph of the shallow-water starfishes of the North Pacific coast, etc. Harriman Alaska Ser., vol. 14. 2 vols., xii+408 pp., 110 pls.

WACHSMUTH, CHARLES, and FRANK SPRINGER

1879 Revision of the Palaeocrinoidea. Pt. 1. Proc. Acad. Nat. Sci. Philadelphia, pp. 226–378 (reprint pp. 1–153); pls. 15–17.

1886 Revision of the Palaeocrinoidea. Pt. 3, sec. 2. Proc. Acad. Nat. Sci. Philadelphia, pp. 64–226.

WESTERGREN, MAGNUS

1911 *Echinoneus* and *Micropetalon*. Mem. Mus. Comp. Zoöl., vol. 39, no. 2, pp. 35–68; pls. 1–31 (pl. 1 colored).

WHITELEGGE, THOMAS

1889 Invertebrate fauna of Port Jackson, etc. Subkingdom Echinodermata. Proc. Roy. Soc. N. S. Wales, vol. 23, pp. 197–206.

WILTON, CHARLES P. N.

1843 On a new species of encrinite (*Encrinus australis*). Tasmanian Jour. Nat. Sci., vol. 2, pp. 118–120.

WITHERS, R. B., and R. A. KEBLE

1934 The Palaeozoic starfish of Victoria. Proc. Roy. Soc. Victoria, n. s., vol. 46, pp. 220–242; pls. 10–12.

1934*a* The Palaeozoic brittle-stars of Victoria. Proc. Roy. Soc. Victoria, n. s., vol. 47, pp. 196–208; pl. 11.

WOODWARD, SAMUEL

1833 An outline of the geology of Norfolk. (4)+54+(6) pp., 6 pls.

WRIGHT, THOMAS

1864–1882 Monograph on the British fossil Echinodermata, etc. xviii+371 pp., 80 pls.

1864*a* On the fossil Echinidae of Malta. Quart. Jour. Geol. Soc. London, vol. 20, pp. 470–491; pls. 21, 22.

WYVILLE-THOMSON. *See* THOMSON, C. WYVILLE.

YOSHIWARA, S.

1898 Preliminary notice of new Japanese echinoids. Annot. zool. japon., vol. 2, no. 2, pp. 57–61.

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