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

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"

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. 18, 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. 74g) 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 (NOT 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.

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.
Orthlophus 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. 5–5c.

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., westsouthwest 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 inadequate 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 *arnigera* 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.

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 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 *Monostychic 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 supramarginal; 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*c*, 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*c*, 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 ..... *scuber*
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 8×7.25×1.5 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 ..... *Pleiolampas*
      Petals and phyllodes more or less well defined ..... *Echinolampas*

*CASSIDULUS

Lamarck, 1801. Syst. anim. sans vert., p. 349.

Genotype: *Cassidulus caribocarum* 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 × 15.5 × 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, 2a; 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, 1914a. 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, $53 \times 46 \times 35$ 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), *7a*, *7b*.
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 130×108×74 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.