# The cidarid Echinoids (Echinodermata) of New South Wales

F. W. E. ROWE and A. K. HOGGETT

ROWE, F. W. E., & HOGGETT, A. K. The cidarid echinoids (Echinodermata) of New South Wales. *Proc. Linn. Soc. N.S.W.* 108 (4), (1985) 1986: 225-261.

Fifteen species of cidarid echinoids are now recorded from New South Wales waters (including Lord Howe Island), from the shore to 1,500m depth. A newly-described species of *Prionocidaris* is common in N.S.W. waters, and also occurs in Queensland, Lord Howe Island, ?Norfolk Island, the Kermadec Islands and New Caledonia. Four other species were not previously known to occur in Australian waters, and new records for N.S.W. are represented for another three species.

*F. W. E. Rowe and A. K. Hoggett, Australian Museum, Sydney, Australia, 2000* (A. K. Hoggett, new address, *Northern Territory Museum of Arts and Sciences, Darwin, Australia, 5794*); *manuscript received 3 June 1985, accepted for publication 23 October 1985.*

## INTRODUCTION

The cidarid echinoids are a conspicuous feature of the invertebrate fauna of southern Australia, in both shallow and moderately deep water. The Cidaridae were the subject of a monograph by Mortensen (1928b), and the Australian cidarids have been reported by H. L. Clark (1946).

The echinoderm fauna of the New South Wales coast is currently being surveyed with the intention of describing its origins and zoogeographical relationships. Comprehensive collections of echinoderms have been made along the New South Wales coast and from Lord Howe Island, from the shoreline to 35m depth. In addition, large collections of echinoderms have been made by the New South Wales State Fisheries research vessel 'Kapala' from off the N.S.W. coast to depths of 1,200m. All this material is deposited in the Australian Museum.

Examination of these collections has revealed the existence of fifteen species of cidarids in New South Wales waters (including Lord Howe Island), compared with seven reported by H. L. Clark in 1946. A new species of *Prionocidaris* is described, four species of cidarid are newly recorded from Australian waters, and three other species have their ranges extended into N.S.W. waters.

The following abbreviations are used: AM = Australian Museum, Sydney; WAM = Western Australian Museum, Perth; NMNZ = National Museum of New Zealand, Wellington; NZOI = New Zealand Oceanographic Institute, Wellington; Qld. = Queensland; N.S.W. = New South Wales; Vic. = Victoria; Tas. = Tasmania; S.A. = South Australia; W.A. = Western Australia; N.T. = Northern Territory; N.Z. = New Zealand. Registration numbers are given only for those specimens examined which are type material, or which belong to an institution other than the Australian Museum.

## SYSTEMATIC ACCOUNT

### Family CIDARIDAE Gray

### Subfamily HISTOCIDARINAE Mortensen

### Genus ***Histocidaris*** Mortensen

*Histocidaris* is a well-defined genus, having well-developed tridentate pedicellariae but no globiferous pedicellariae. Crenulate tubercles and rather sparse tuberculation of the apical system are also conspicuous features of the genus (Mortensen, 1928b).

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Three species of *Histocidaris* (*elegans* Agassiz, 1879, *australiae* Mortensen, 1928a and *crassispina* Mortensen, 1928a) have been recorded from N.S.W. waters. The species are separated mainly on the nature of the primary spines (Mortensen, 1928a,b). The collection of *Histocidaris* from N.S.W. waters in the Australian Museum includes only two recognizable forms; *crassispina*, which is known from a single specimen, is not represented.

Mortensen (1928b) includes 14 nominal species in the genus, of which 8 are each known from a single specimen. Examination of his descriptions shows each species to have one of two basic forms of tridentate pedicellariae: either with broad, spoon-shaped valves, or with narrow, elongate valves. Within these two groups, the species have been separated mainly by the form of the primary spines. It seems likely that insufficient variation in the character of the primary spines at least has been allowed by Mortensen, and a thorough revision of the genus would probably result in considerably fewer species being recognized.

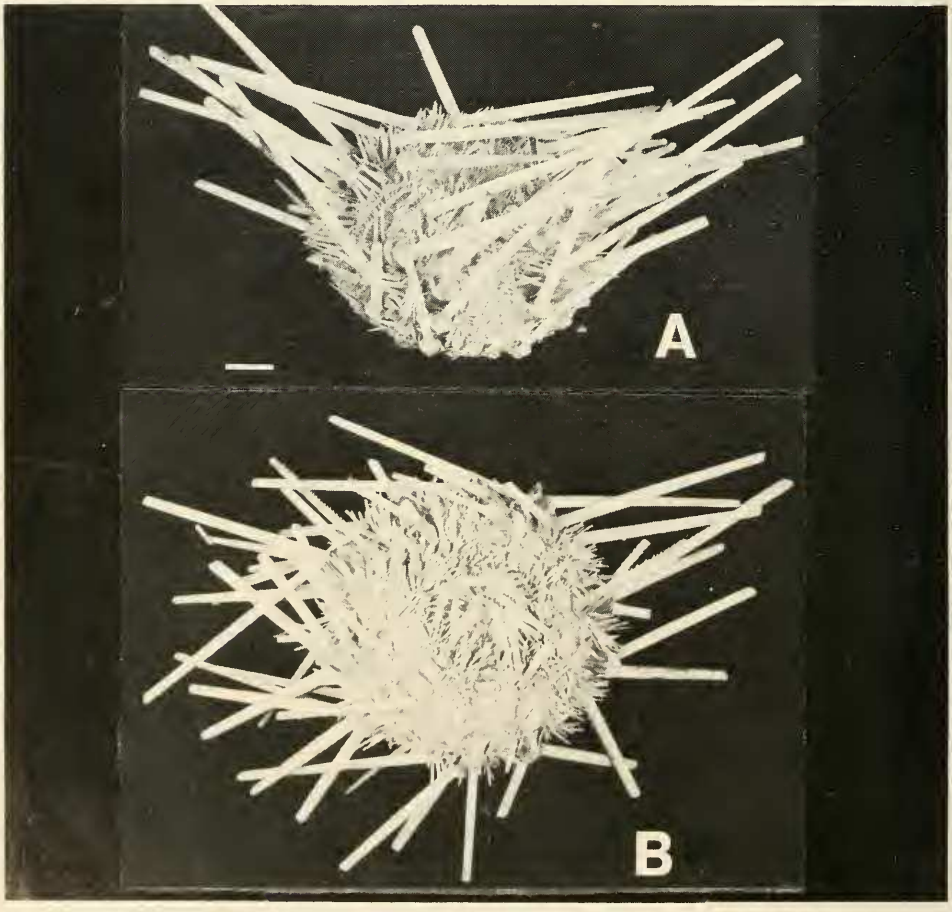


*Fig. 1.* A,B. *Histocidaris elegans*, J15802, off Broken Bay, N.S.W., 720m. Scale = 10mm.

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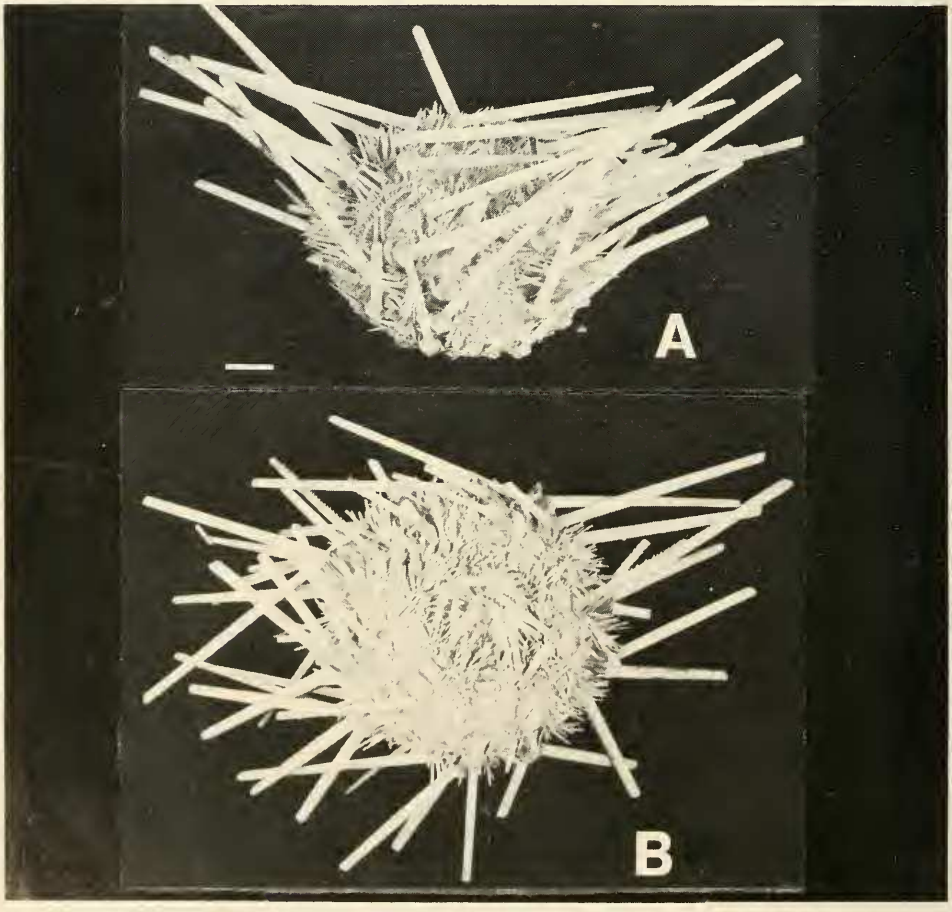


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*Histocidaris elegans* (Agassiz)
Fig. 1**A-B**

*Porocidaris elegans* Agassiz, 1879:198.
*Histocidaris elegans:* Mortensen, 1928b: 72 (synonymy), pl. 1, figs 1-5, pl. 2, figs 1-3, pl. 68, fig. 6, pl. 75, fig. 16, pl. 76, figs 9-13; H. L. Clark, 1946:294; Dartnall, 1980:43; McNamara, 1984:88.
**Diagnosis:** Primary spines have longitudinal rows of very fine serrations covering the shaft; spines are slender, cylindrical for most of their length, but some spines taper and others become flattened near the tip, with serrations becoming more marked; diameter at distal end of the collar of primary spines above the ambitus is 1.4-2.9mm (specimens 21-65mm horizontal diameter); oral primary spines are flattened, not appreciably widened beyond the collar except for the strongly serrate margins.
**Material:** 202 specimens housed in the Australian Museum from off Sugarloaf Pt., N.S.W. to off Flinders Is., Bass St., and from off Broome, W.A. 150-1,475m (188 specimens from N.S.W. waters, 8 from eastern Victorian waters (Gabo Is.), 2 from Bass Strait, and 4 from W.A. waters); 2 specimens, NMNZ Ech 92, 248, 300 miles E. of Cape Farewell, N.Z., 1,980m, 'Challenger'.
**Distribution:** Japan; Philippines; Indonesia; northwest Australia; eastern coast of Australia as far south as Bass Strait; New Zealand. 150-1,980m.
**Remarks:** The species appears to be quite common in moderately deep water off the southeast Australian coast. *H. elegans* will almost certainly be represented in collections made from suitable areas off the Queensland coast. The species is recorded from northwestern Australia for the second time (McNamara, 1984).

*Histocidaris australiae* Mortensen
Fig. 2**A-E**

*Histocidaris australiae* Mortensen, 1928a:66; 1928b:91, pl. 10, figs 1-2, pl. 11, figs 1-5, pl. 68, figs 1-3; H. L. Clark, 1946:295.
**Diagnosis:** Ornamentation of the primary spines changes with growth of the individual; initially, the shafts bear conspicuous scattered thorns, becoming serrated longitudinal ridges distally; larger specimens lose all trace of the thorns and have a smooth shaft, which may have very slight longitudinal ridges; spines gradually taper; diameter at distal end of collar of primary spines above the ambitus 2.5-5.0mm (specimens 38-95mm horizontal diameter; oral primary spines flattened and widened, with a marked broadening of the spine beyond the collar; large specimens have rudimentary primary tubercles on the uppermost coronal plate in each series.
**Material:** 8 specimens in the Australian Museum collection from the range indicated below.
**Distribution:** Off Crowdy Head, N.S.W. to off Flinders Is., Bass St. 180-540m.
**Remarks:** Some characteristics of the specimens are listed in Table 1. Two specimens (E5910) are not included as they are in very poor condition.

The eight specimens examined are considered to be conspecific despite the differences apparent in the ornamentation of their primary spines. The few remaining spines (all broken) on the three largest specimens are very smooth and shining, with the exception of one spine on specimen number J15812, which has a few rounded bumps occurring in longitudinal series. It seems likely that coarse thorns on the primary spines become less pronounced with growth of an individual, resulting in smooth spines on large specimens.

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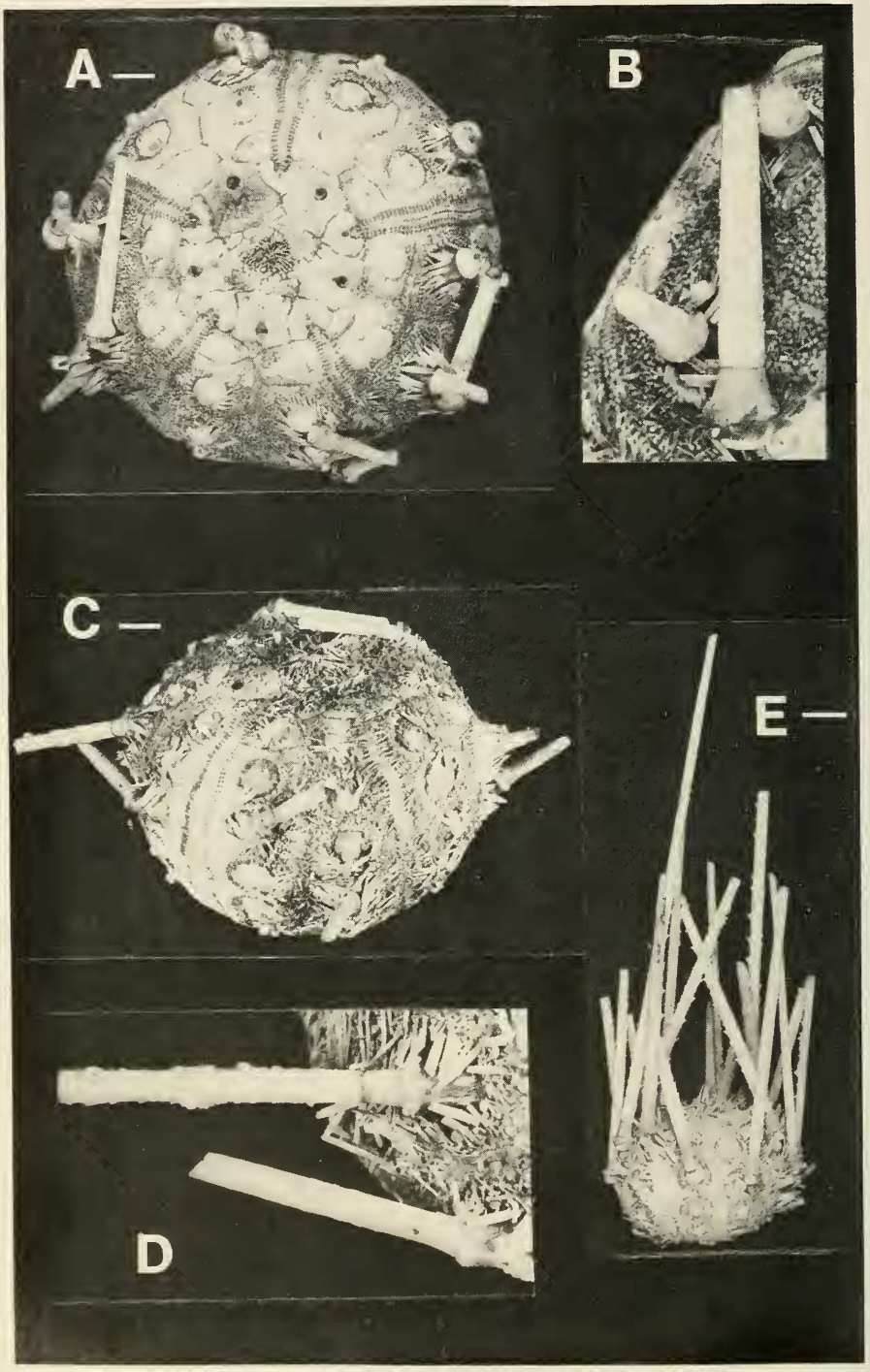


*Fig. 2. Histocidaris australiae.* **A**. J15812, off Shoalhaven Head, N.S.W., 306-360m. Scale = 10mm. **B**. Primary spine of J15182. **C**. J15798, off Gabo Is., Vic., 540m. Scale = 10mm. **D**. Primary spine of J15798. **E**. E4736, off Flinders Is., Bass Strait, 180-540m, 'Endeavour'. Scale = 10mm.

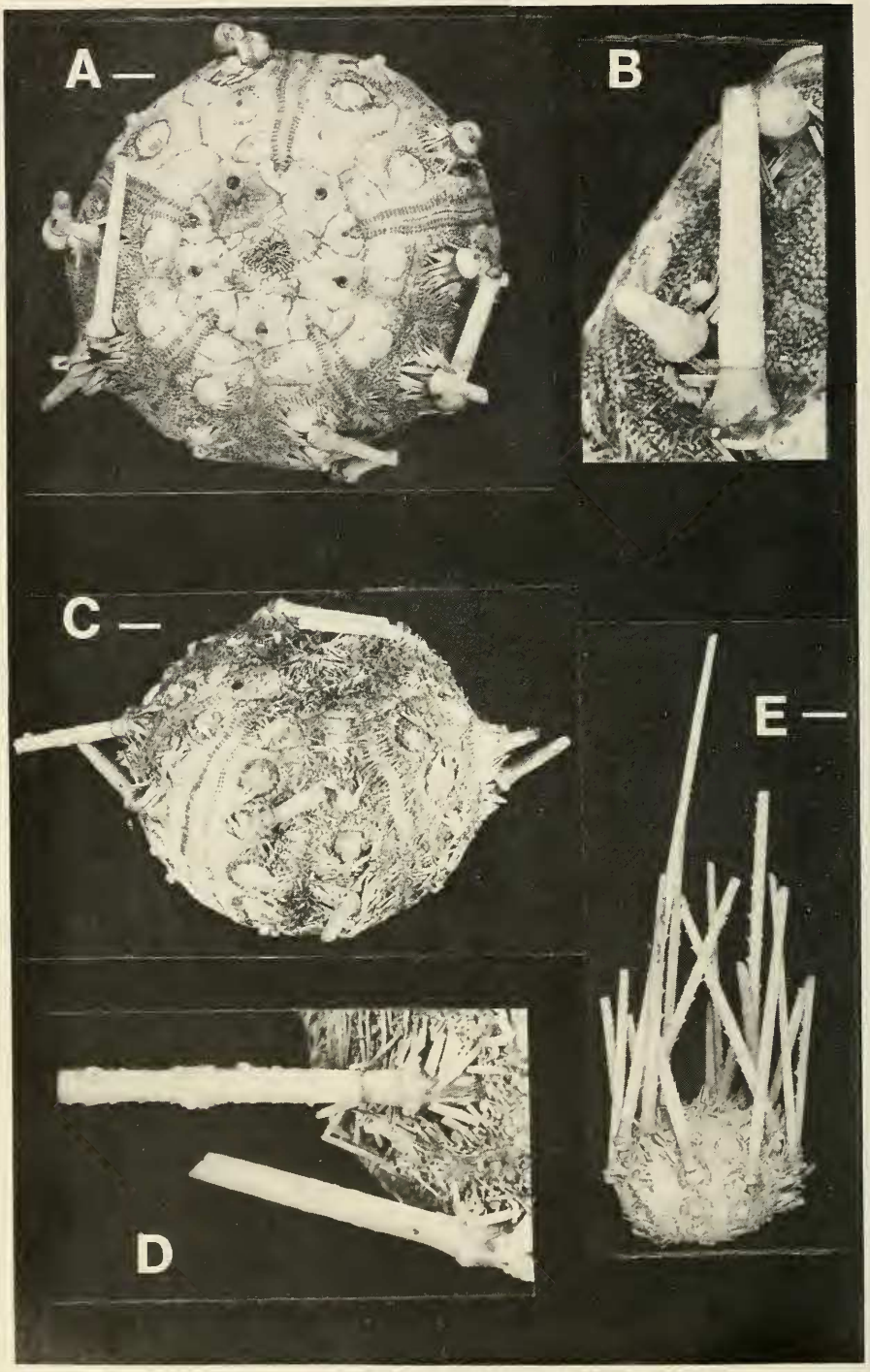


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TABLE 1

*Measurements of individuals of* Histocidaris australiae

1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = no. ambulacrals/interambulacral, 9 = longest spine (mm), 10 = spine diameter at distal end of collar (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| E4376 | 38 | 29 | 18 | 17 | 18 | 4 | 7 | 10 | 120 | 3.0 |
| J18954 | 70 | 54 | 31 | 22 | 33 | 7 | 9-10 | 13-14 | — | 3.1 |
| J15798 | 74 | 55 | 37 | 26 | 35 | 7.5 | 9 | 11-12 | — | 3.2 |
| J15811-1 | 81 | 75 | 33 | 26 | 41 | 7.1 | 10-11 | 12-14 | — | 4.7 |
| J15811-2 | 92 | 83 | 36 | 28 | 46 | 7.4 | 10-11 | 13-15 | — | 4.9 |
| J15812 | 94 | 85 | 40 | 29 | 47 | 7.2 | 10-11 | 12-14 | — | 5.0 |

The only known specimen of a *Histocidaris* species with perfectly smooth spines was described by Mortensen (1927) as *H. magnifica*. The smooth-spined specimens from N.S.W. waters differ from the holotype of *magnifica* in that the peristome is relatively smaller (about 20% of h.d. compared with 26%), and the ambulacra are relatively much narrower (about 16% of interambulacral width compared with 28.6%). Also, the spine diameter of *magnifica* appears smaller from Mortensen's photograph (1927: pls 48,49) than that of the N.S.W. specimens.

The spines of *australiae* are described as being not much longer than the horizontal diameter of the test (Mortensen, 1928b). The longest spines of specimen number E4376 are at least 3 times its horizontal diameter. Mortensen (1928b: pl. 10, figs 1,2) figures the only specimen of *australiae* for which he provides spine-length data. All the spines of this specimen appear to be broken. As the specimens at hand agree in most other respects with Mortensen's (1928a,b) descriptions, the diagnosis of *australiae* is broadened to include specimens with longer spines.

One of the specimens, E4376, is considerably smaller than any previously recorded. The oral primary spines of this specimen are more slender than those of larger specimens, but are more robust than those of similarly-sized specimens of *elegans*. The existence of this small specimen indicates that *australiae* is not an 'old and probably senescent *elegans*' as H. L. Clark (1946) conjectured. *H. australiae* is certainly rarer than *elegans*, and appears to be more restricted in its distribution. Only thirteen specimens of *australiae* are now recorded, compared with hundreds of specimens of *elegans*.

*Histocidaris crassispina* Mortensen

*Histocidaris crassispina* Mortensen, 1928a:66; 1928b:77, pl. 10, figs 4-5, pl. 68, fig. 5, pl. 75, figs 1-2, pl. 77, fig. 23; H. L. Clark, 1946:294.

**Diagnosis:** Primary spines are thick and fusiform, with uniform, fine serrations (after Mortensen, 1928b).

**Remarks:** We have not examined any material of this species, which is known only from the holotype. This specimen was collected from south of Sydney, N.S.W., in 720m, by the 'Challenger' (stn 164b). This is the same station from which the type specimens of *H. elegans* were collected. Despite the large amount of *Histocidaris* material recently obtained from off the N.S.W. coast, no specimens conform to the description of *crassispina*. The species is either very rare or is based on an aberrant specimen of *H. elegans*. H. L. Clark (1946) doubted the validity of this species.

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## Subfamily GONIOCIDARINAE Mortensen

## Genus *Goniocidaris* Agassiz and Desor

*Goniocidaris* forms the basis of the subfamily Goniocidarinae, which is distinguished from other cidarids primarily by the presence of grooves or pits in the horizontal sutures between coronal plates, and by the nature of the pedicellariae. Tridentate pedicellariae are either lacking or are of an unusual, coarse, form developed from small globiferous pedicellariae. Large globiferous pedicellariae are without an end tooth, and small globiferous pedicellariae usually have a conspicuous end tooth (Mortensen, 1928b).

Mortensen's terminology for the two different forms of globiferous pedicellariae as 'large' and 'small' is unfortunate, as pedicellariae of the form described as 'small' can range widely in size. A considerable number of *Goniocidaris* species do not possess 'large', toothless pedicellariae, but possess a range of sizes of 'small', toothed pedicellariae. Mortensen's (1928b) key to the genus groups of the Stereocidarinae is thus quite unsatisfactory. Each of the 'groups' included in the subfamily Stereocidarinae by Mortensen (1928b) have subsequently been elevated to subfamily status by Fell (1966).

Within the Goniocidarinae, *Goniocidaris* is distinguished from the other three genera by the nature of the primary spines, which are said to have either a terminal or a basal disc, or both, on the apical spines (Mortensen, 1928b). However, this feature is absent from a number of *Goniocidaris* species, so this character is not particularly useful in diagnosing the genus. *Goniocidaris* includes a large number of morphologically-diverse species which have been grouped into five poorly-delineated subgenera (Mortensen, 1928b). It appears that the Goniocidarinae is in need of thorough revision.

In practice, *Goniocidaris* is distinguished from other genera by the presence of pits in the sutures of the ambulacra and interambulacra, and by the presence of globiferous pedicellariae with an end tooth, although globiferous pedicellariae without an end tooth may also occur (Mortensen, 1928b).

### *Goniocidaris tubaria* (Lamarck)

Figs 3**A-D**, 5 **A-B**

*Cidarites tubaria* Lamarck, 1816:382.

*Goniocidaris tubaria:* Mortensen, 1928b:156 (synonymy), pl. 12, figs 1-7, pl. 13, figs 10-11, pl. 69, fig. 4, pl. 78, figs 1-6; H. L. Clark, 1946:291 (part).

*Goniocidaris geranoides tubaria:* Stach, 1938:333 (part), pl. 18, fig. 10e [?non figs 10a-d].

*Adelecidaris tubaria:* Cotton and Godfrey, 1942:217.

**Diagnosis:** Basal discs are absent from primary spines; globiferous pedicellariae are of two forms, the larger of which does not have an end tooth and is conspicuous due to its globular shape (Mortensen, 1928b); genital plates (other than madreporite) have tubercles in two patches, one surrounding the genital pore and another on the inner edge, thus leaving bare lateral areas; miliary spines are more or less pointed; interpore areas of ambulacra have a wide, continuous bare area.

**Material:** 478 specimens housed in the Australian Museum from the areas indicated below (428 specimens from N.S.W. waters, 19 from Victorian waters, 8 from Tasmania and Bass Strait, 18 from S.A. waters, and 5 from W.A. waters).

**Distribution:** Ballina, N.S.W., south to Oyster Bay, Tasmania, across Victoria and South Australia to Perth, W.A., shore — 630m.

**Remarks:** *Goniocidaris impressa* Koehler, 1926, was regarded by Mortensen (1928b) and H. L. Clark (1946) to be merely a variety of *G. tubaria*. However, examination of the large collection of *Goniocidaris* material in the Australian Museum (including the type material of *impressa*) indicates that they can be readily distinguished, and *G. impressa* should be recognized as a distinct species. Cotton and Godfrey (1942) arrived at the

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## Genus *Goniocidaris* Agassiz and Desor

*Goniocidaris* forms the basis of the subfamily Goniocidarinae, which is distinguished from other cidarids primarily by the presence of grooves or pits in the horizontal sutures between coronal plates, and by the nature of the pedicellariae. Tridentate pedicellariae are either lacking or are of an unusual, coarse, form developed from small globiferous pedicellariae. Large globiferous pedicellariae are without an end tooth, and small globiferous pedicellariae usually have a conspicuous end tooth (Mortensen, 1928b).

Mortensen's terminology for the two different forms of globiferous pedicellariae as 'large' and 'small' is unfortunate, as pedicellariae of the form described as 'small' can range widely in size. A considerable number of *Goniocidaris* species do not possess 'large', toothless pedicellariae, but possess a range of sizes of 'small', toothed pedicellariae. Mortensen's (1928b) key to the genus groups of the Stereocidarinae is thus quite unsatisfactory. Each of the 'groups' included in the subfamily Stereocidarinae by Mortensen (1928b) have subsequently been elevated to subfamily status by Fell (1966).

Within the Goniocidarinae, *Goniocidaris* is distinguished from the other three genera by the nature of the primary spines, which are said to have either a terminal or a basal disc, or both, on the apical spines (Mortensen, 1928b). However, this feature is absent from a number of *Goniocidaris* species, so this character is not particularly useful in diagnosing the genus. *Goniocidaris* includes a large number of morphologically-diverse species which have been grouped into five poorly-delineated subgenera (Mortensen, 1928b). It appears that the Goniocidarinae is in need of thorough revision.

In practice, *Goniocidaris* is distinguished from other genera by the presence of pits in the sutures of the ambulacra and interambulacra, and by the presence of globiferous pedicellariae with an end tooth, although globiferous pedicellariae without an end tooth may also occur (Mortensen, 1928b).

### *Goniocidaris tubaria* (Lamarck)

Figs 3**A-D**, 5 **A-B**

*Cidarites tubaria* Lamarck, 1816:382.

*Goniocidaris tubaria:* Mortensen, 1928b:156 (synonymy), pl. 12, figs 1-7, pl. 13, figs 10-11, pl. 69, fig. 4, pl. 78, figs 1-6; H. L. Clark, 1946:291 (part).

*Goniocidaris geranoides tubaria:* Stach, 1938:333 (part), pl. 18, fig. 10e [?non figs 10a-d].

*Adelecidaris tubaria:* Cotton and Godfrey, 1942:217.

**Diagnosis:** Basal discs are absent from primary spines; globiferous pedicellariae are of two forms, the larger of which does not have an end tooth and is conspicuous due to its globular shape (Mortensen, 1928b); genital plates (other than madreporite) have tubercles in two patches, one surrounding the genital pore and another on the inner edge, thus leaving bare lateral areas; miliary spines are more or less pointed; interpore areas of ambulacra have a wide, continuous bare area.

**Material:** 478 specimens housed in the Australian Museum from the areas indicated below (428 specimens from N.S.W. waters, 19 from Victorian waters, 8 from Tasmania and Bass Strait, 18 from S.A. waters, and 5 from W.A. waters).

**Distribution:** Ballina, N.S.W., south to Oyster Bay, Tasmania, across Victoria and South Australia to Perth, W.A., shore — 630m.

**Remarks:** *Goniocidaris impressa* Koehler, 1926, was regarded by Mortensen (1928b) and H. L. Clark (1946) to be merely a variety of *G. tubaria*. However, examination of the large collection of *Goniocidaris* material in the Australian Museum (including the type material of *impressa*) indicates that they can be readily distinguished, and *G. impressa* should be recognized as a distinct species. Cotton and Godfrey (1942) arrived at the

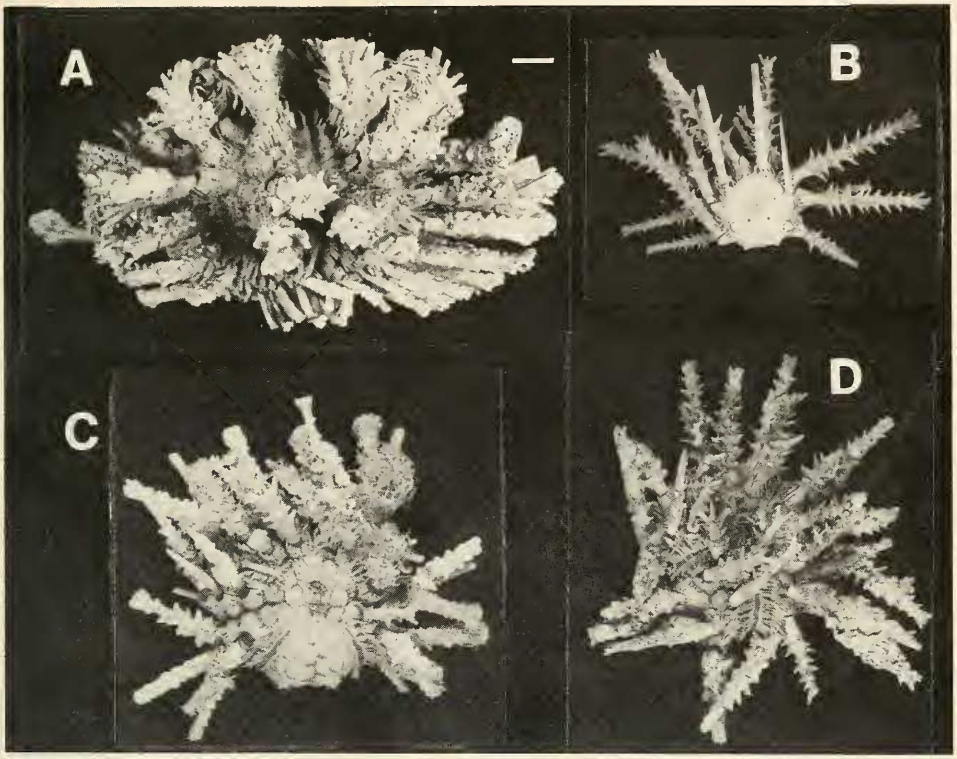


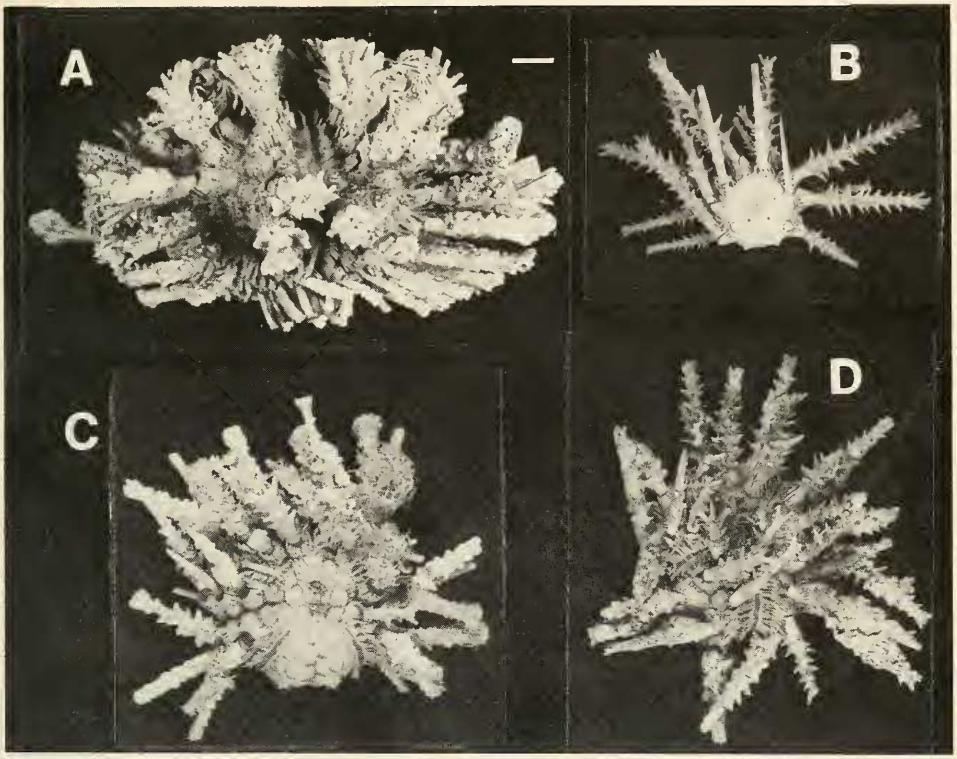

*Fig. 3. Goniocidaris tubaria.* **A**. J234, Port Phillip, Vic. **B**. J6046, off Broughton Is., N.S.W., 81-90m. **C**. J12106, Sorrento Reef, Perth, W.A. **D**. J3480, Norah Head, N.S.W., 47-68m. Scale = 10mm.

same conclusion after examining South Australian and Tasmanian specimens. *G. impressa* is illustrated in Figs 4 **A-C**, 5 **C-D**, for comparison with *G. tubaria.*

*G. impressa* differs from *tubaria* in the following features: genital plates are evenly covered with tubercles; miliary spines are more or less club-shaped; the interpore zones of the ambulacra have small tubercles extending into the bare median areas, often to the extent that the bare area becomes a discontinuous series of patches.

The primary feature used by Mortensen (1928b) and H. L. Clark (1946) to distinguish the 'varieties' was the last-mentioned one above. This character is slightly variable in *impressa*, leading to the impression that forms intermediate between *tubaria* and *impressa* exist. However, tuberculation of the genital plates provides a very consistent difference between the species. This feature was noted by Mortensen (1928b:163, fig. 51), but he apparently placed little emphasis on it. Mortensen's (1928b) fig. 51.2 shows the apical system of a male specimen of *G. tubaria* with only slightly bare patches on the genital plates. This figure represents the most extreme case of tuberculation in this position on any specimen of *tubaria* we have examined. Mortensen (1928b) describes *tubaria* as having club-shaped miliary spines. This must be due to his having confused the species, as the miliary spines of *tubaria* are pointed, or at the most, flattened and slightly spatulate. The miliary spines of *impressa*, however, are distinctly club-shaped.

When the species are separated on the basis of tuberculation on the apical system and miliary spine shape, much of the apparent gradation of characters between the

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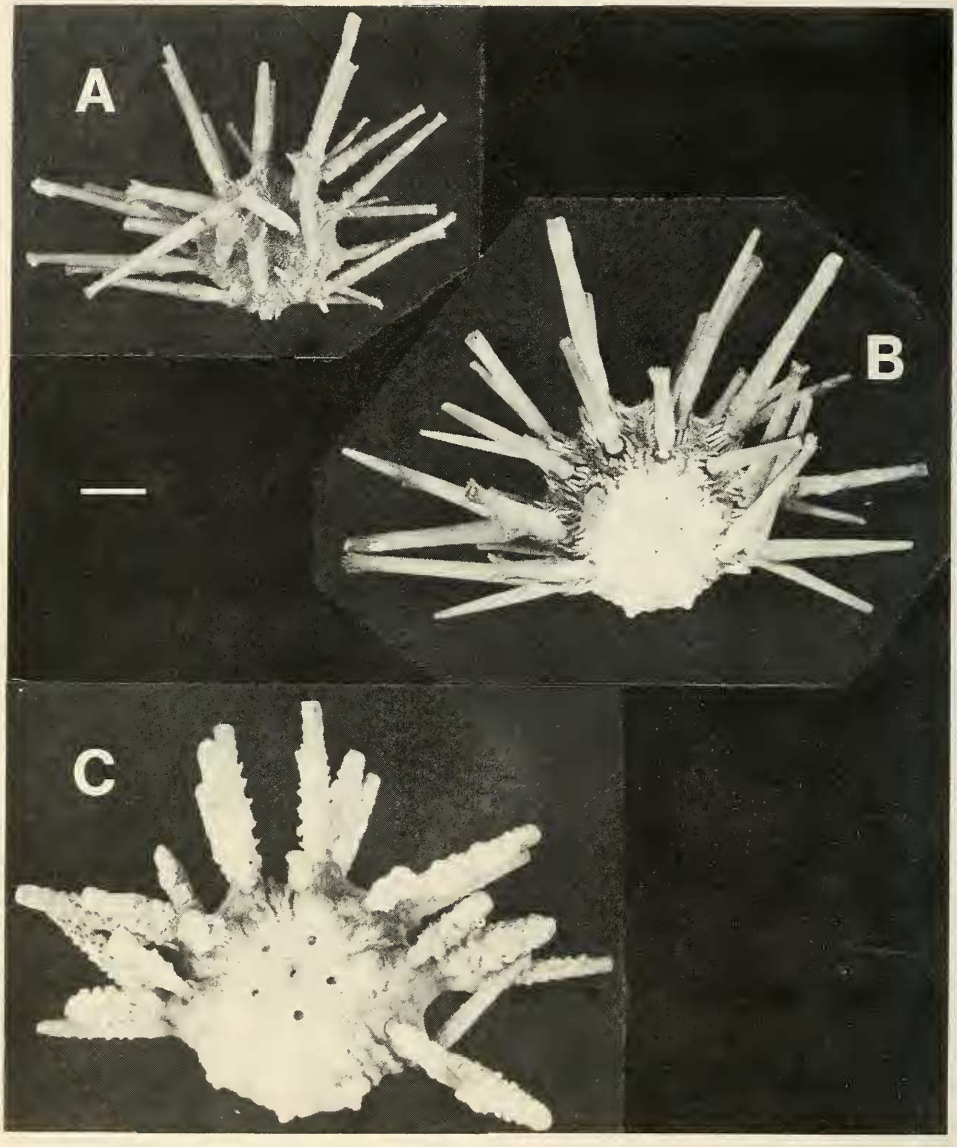
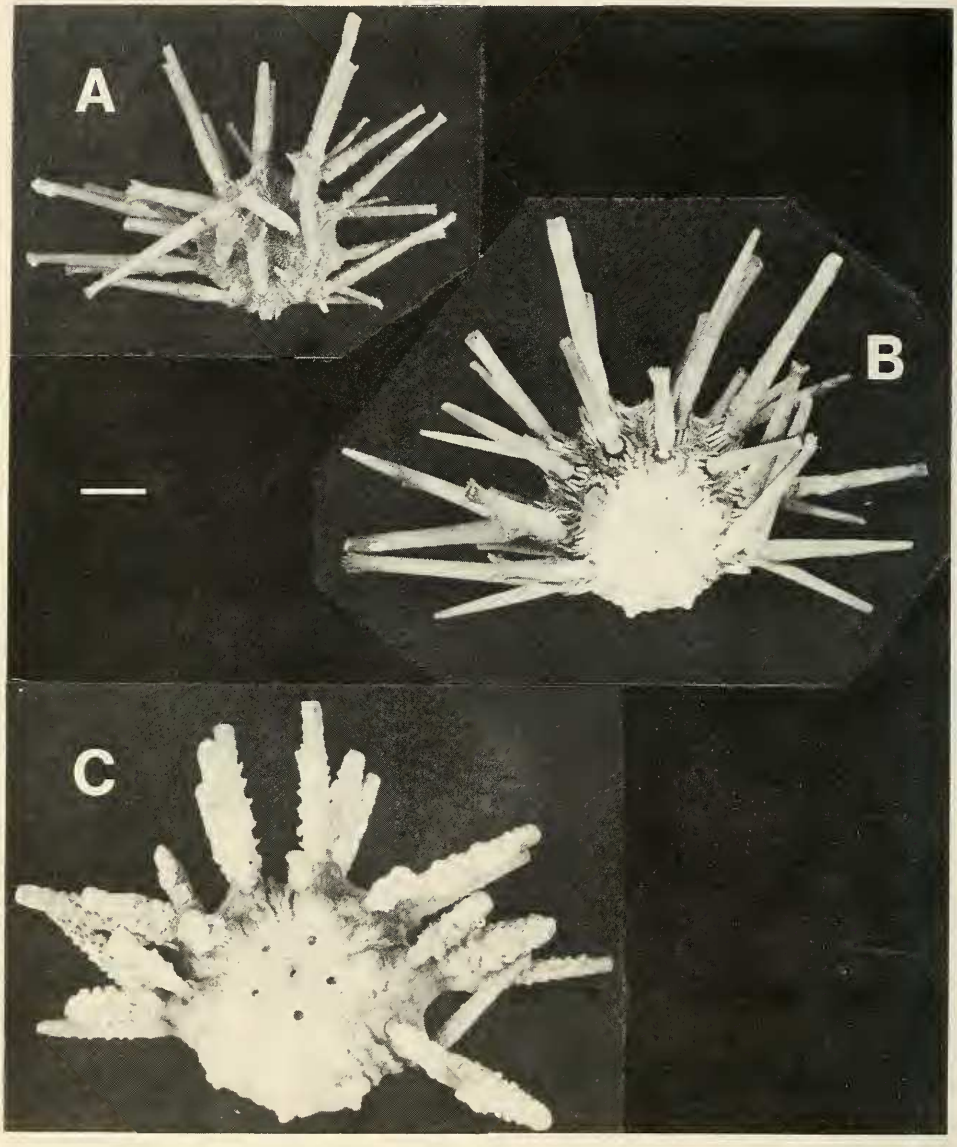



*Fig. 4. Goniocidaris impressa.* **A.** J4908 (part), paratype, Maria Is., Tas., 117m. **B.** J5438, D'Entrecasteaux Channel, Tas., 9m. **C.** J11396, Flinders Is., Bass Strait. Scale = 10mm.

species is lost. A continuous bare area in the interpore zone of the ambulacrum is a constant feature of *G. tubaria*; large bare areas are also usually present in the interambulacra, but the extent of these is slightly variable. All specimens of *G. tubaria* have thorny primary spines, though there is some variation in their relative length and thickness. In comparison, *G. impressa* has a softer appearance, due to the less thorny primary spines, the club-shaped miliary spines and the greater tuberculation of the apical system, ambulacra and interambulacra. The denuded tests also differ in colour. The ambulacra and median interambulacral regions of *impressa* are, at most, slightly darker

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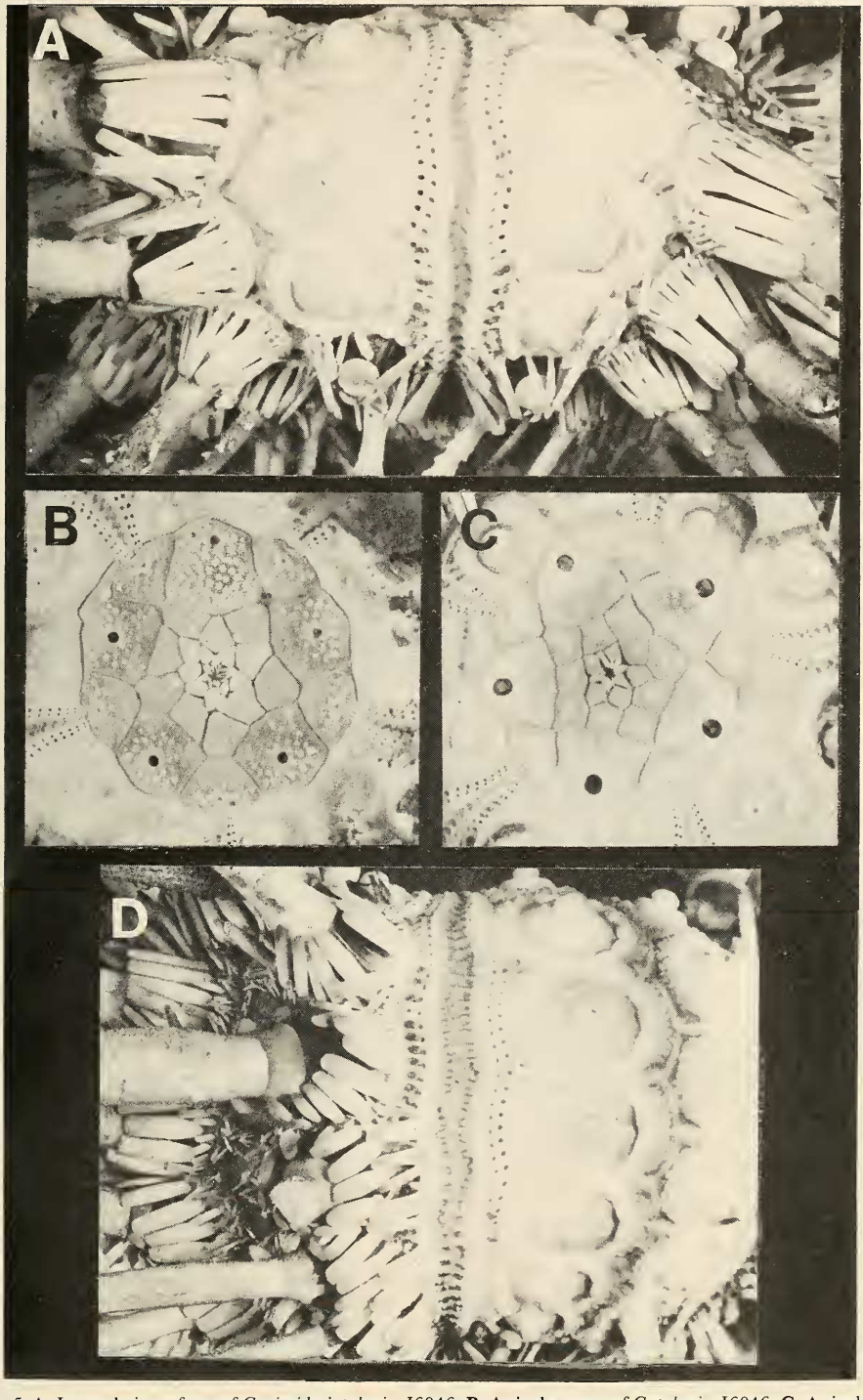
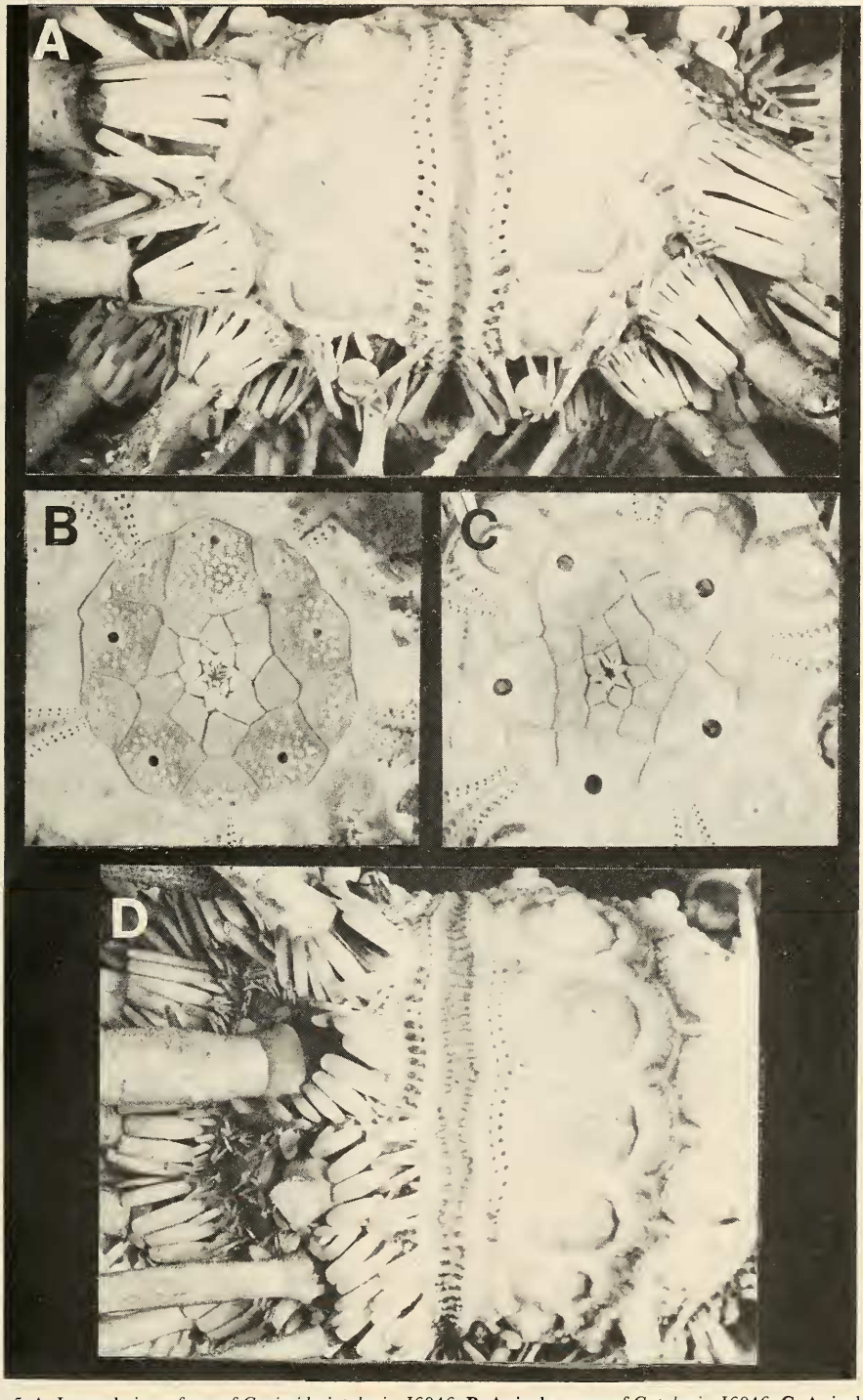



*Fig. 5.* **A**. Lateral view of test of *Goniocidaris tubaria*, J6046. **B**. Apical system of *G. tubaria*, J6046. **C**. Apical system of *G. impressa*, J5348. **D**, Lateral view of test of *G. impressa*, J5348.

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than the rest of the cream-coloured test, and there is often a distinct greenish cast over the apical system. There is no green colour present on the apical system of *tubaria*, and the bare areas of the ambulacra are usually conspicuously purple.

*G. tubaria* and *G. impressa* are closely related to the New Zealand species *G. magi* Pawson, 1964, and *G. corona* Baker, 1968. These are the only four *Goniocidaris* species which do not possess either terminal or basal discs on the primary spines, and constitute the nominate subgenus of *Goniocidaris* (Mortensen, 1928b). *G. magi* and *G. corona* lack the large, globular globiferous pedicellariae (Baker, 1968) which are conspicuous on the two Australian species. Both New Zealand species are small in size, the largest specimen (a paratype of *magi*) having a reported horizontal diameter of 19mm (Pawson, 1964).

We have examined this paratype of *magi* (NZOI P11), and find its horizontal diameter to measure only 18mm. The tuberculation of the apical system is similar to that of *G. tubaria*. We concur with Pawson (1964) that the two species are distinct; the primary spines of *magi* lack conspicuous thorns, and the ambulacra and interambulacra of *magi* have fewer secondary tubercles than those of *tubaria*. In addition, the marginal ambulacral spines are virtually indistinguishable from the scrobicular spines in *magi*, whereas in both *tubaria* and *impressa*, the marginal spines are distinctly shorter and narrower than the scrobicular spines.

Comparison of a specimen of *corona* (AM J9291) from Bay of Islands, New Zealand, with Australian *Goniocidaris* specimens shows that this species is also distinctive. Like *magi*, its marginal ambulacral spines are of approximately the same size as its scrobicular spines. Baker (1968) describes the miliary spines of *corona* as club-shaped, but the specimen we have examined has club-shaped spines only on the peristome. Those of the apical system are quite cylindrical, and those on the ambulacra and interambulacra are flattened. Baker's (1968: fig. 1J) figure of the apical system of *corona* shows the even distribution of tubercules to be similar to that of *impressa*, though the density is less. The position of the genital pores differs, however, with those of *corona* being right at the outer edge of the plate, while those of *impressa* being situated away from the edge, about half way to the centre of the plate.

Specimens of *G. tubaria* from localities west of Bass Strait differ slightly in appearance from those occurring on the east coast of Australia. Preserved east coast specimens (including those from Victoria and Bass Strait) have pink/red scrobicular spines, usually with greenish tips. Most specimens from South Australia and Western Australia which we have examined have much paler scrobicular spines, either white or cream, with no change in colour near the tip. Cotton and Godfrey (1942) describe the colour of the secondary spines of live South Australian specimens as being cream to yellow. One specimen from Western Australia (AM J12246), however, has exactly the same colour pattern as its east Australian counterparts. The primary spines of the western specimens are generally shorter and thicker than those of most of the eastern specimens. Also, the thorns on the primary spines of the western specimens are either poorly developed or are not as sharp as those on the eastern specimens. It is possible, with more material from west of Bass Strait, that the western form may be found to comprise a valid species distinct from *tubaria*.

*G. tubaria* is apparently quite rare in Tasmania, as only two specimens are known from there. The distribution of *G. impressa*, determined from the 132 specimens (including the type series) in the Australian Museum, is from Cape Jarvis, S.A., to Wilson's Promontory, Vic., through Bass Strait and circumscribing Tasmania, 9-160m. A single specimen of *impressa* is labelled as being from 'Off Sydney, "Challenger" '; this record is regarded as dubious. Similarly, Cotton and Godfrey's (1942) record of a specimen of *impressa* from Port Curtis, Qld, is probably erroneous. *G. impressa* and *G. tubaria* thus

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co-occur along the Victorian and South Australian coast, in Bass Strait and rarely in Tasmania.

*Goniocidaris sibogae* Mortensen

Fig. 6 **A-D**

*Goniocidaris clypeata:* H. L. Clark, 1916:102 [non *Goniocidaris clypeata* Döderlein, 1885].
*Goniocidaris alba* Mortensen, 1928a:67.
*Goniocidaris sibogae* Mortensen, 1928a:68.
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*Goniocidaris (Aspidocidaris) alba:* Mortensen, 1928b:193, pl. 15, fig. 14, pl. 69, fig. 7, pl. 79, fig. 6.
*Goniocidaris (Aspidocidaris) sibogae:* Mortensen, 1928b:198, pl. 16, figs 6-9, pl. 69, fig. 11, pl. 78, figs 14-16.
*Goniocidaris (Aspidocidaris) australiae:* Mortensen, 1928b:201, pl. 16, figs 1-5, pl. 69, fig. 12, pl. 78, figs 21-25.

**Diagnosis:** Basal discs are present on the primary spines and the adapical ones have a conspicuous terminal disc; globiferous pedicellariae are of a single, slender form, in which an end tooth is present; primary spines are finely thorned; secondary spines are flattened with a straight-cut tip; a distinct greenish colour is often present on the apical area of the denuded test.

**Material:** 44 specimens in the Australian Museum collection from Norah Head, N.S.W. to the eastern and southern coasts of Tasmania. (30 specimens from N.S.W. waters, 8 from Victorian waters, 2 from Bass Strait and 4 from Tasmanian waters. The specimens from Victoria, Bass Strait and all but one from Tasmania were collected by the 'Endeavour' in 1914.)

**Distribution:** Japan; Indonesia; east Australian coast as far south as Tasmania, 120-490m.

**Remarks:** The southeast Australian specimens at hand clearly fall into the group of *Goniocidaris* species united in the subgenus *Aspidocidaris* Mortensen, which is characterized by the presence of basal and terminal discs, a coat of anastomosing hairs on the primary spines, and by the secondary spines which are flattened with a straight-cut tip. Seven species have been referred to this subgenus: *clypeata* Döderlein, 1885, *fimbriata* De Meijere, 1904b, *alba* Mortensen, 1928a, *crassa* Mortensen, 1928a, *sibogae* Mortensen, 1928a, *australiae* Mortensen, 1928a and *parasol* Fell, 1958. In light of the variation observed in the 40 Australian specimens, it seems likely that some of these species have been based on characters which are subject to individual variation.

The species occurring in southeastern Australia was first identified as the Japanese species, *G. clypeata*, by H. L. Clark (1916). However, Mortensen (1928a,b) did not consider the Australian specimens to be conspecific with *clypeata* due to differences in the disc and hair coat of the primary spines, the relative size of the peristome, and colour of the naked test. Mortensen (1928a) described a new species, *australiae*, for the Australian specimens.

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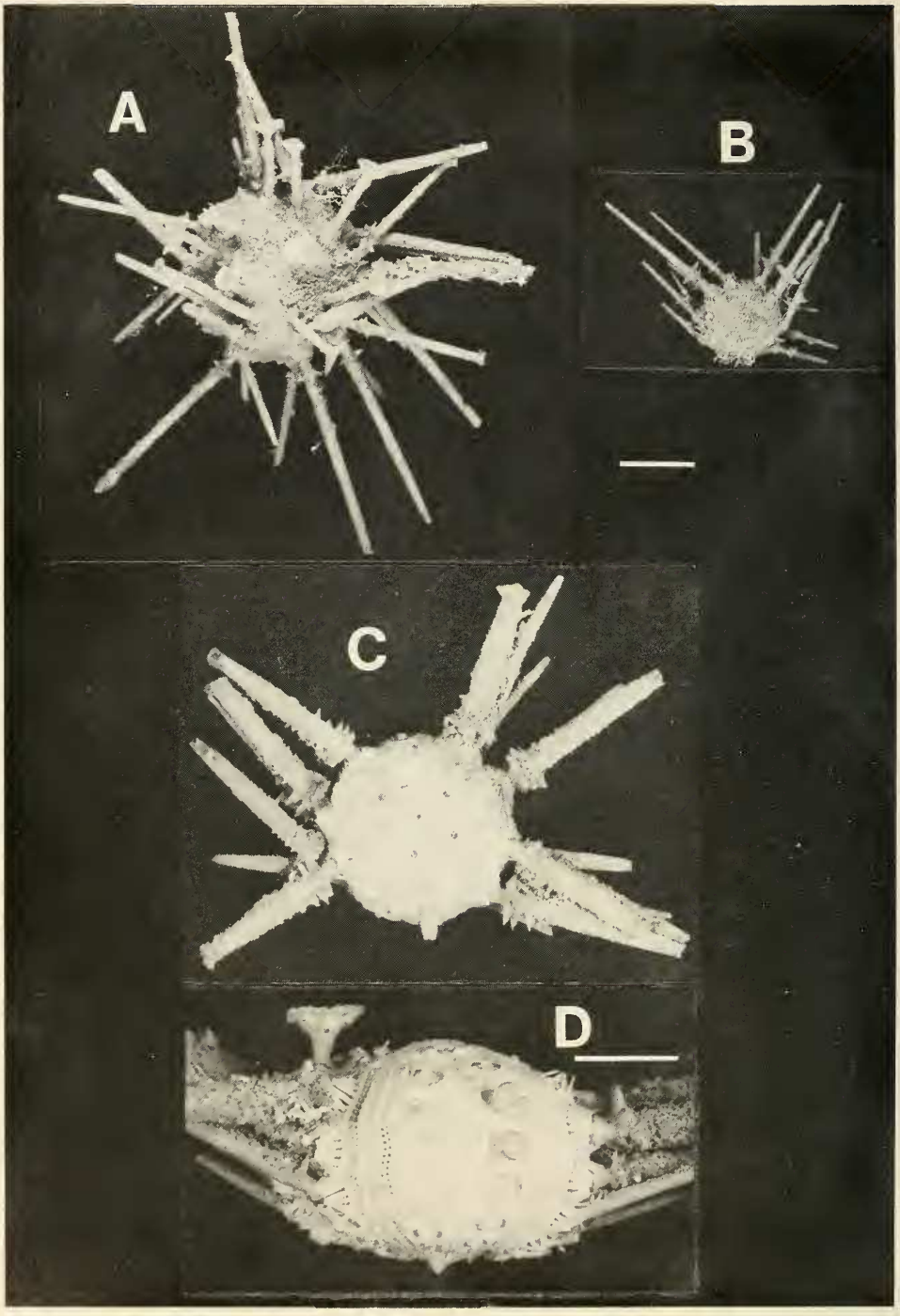


*Fig. 6. Goniocidaris sibogae.* **A**. E5919 (part), S. of Cape Everard, Vic., 360-486m, 'Endeavour'. **B**. E5114, E. of Maria Is., Tas., 230m. **C,D**. J15844, off Kiama, N.S.W., 405m. Scale = 10mm.

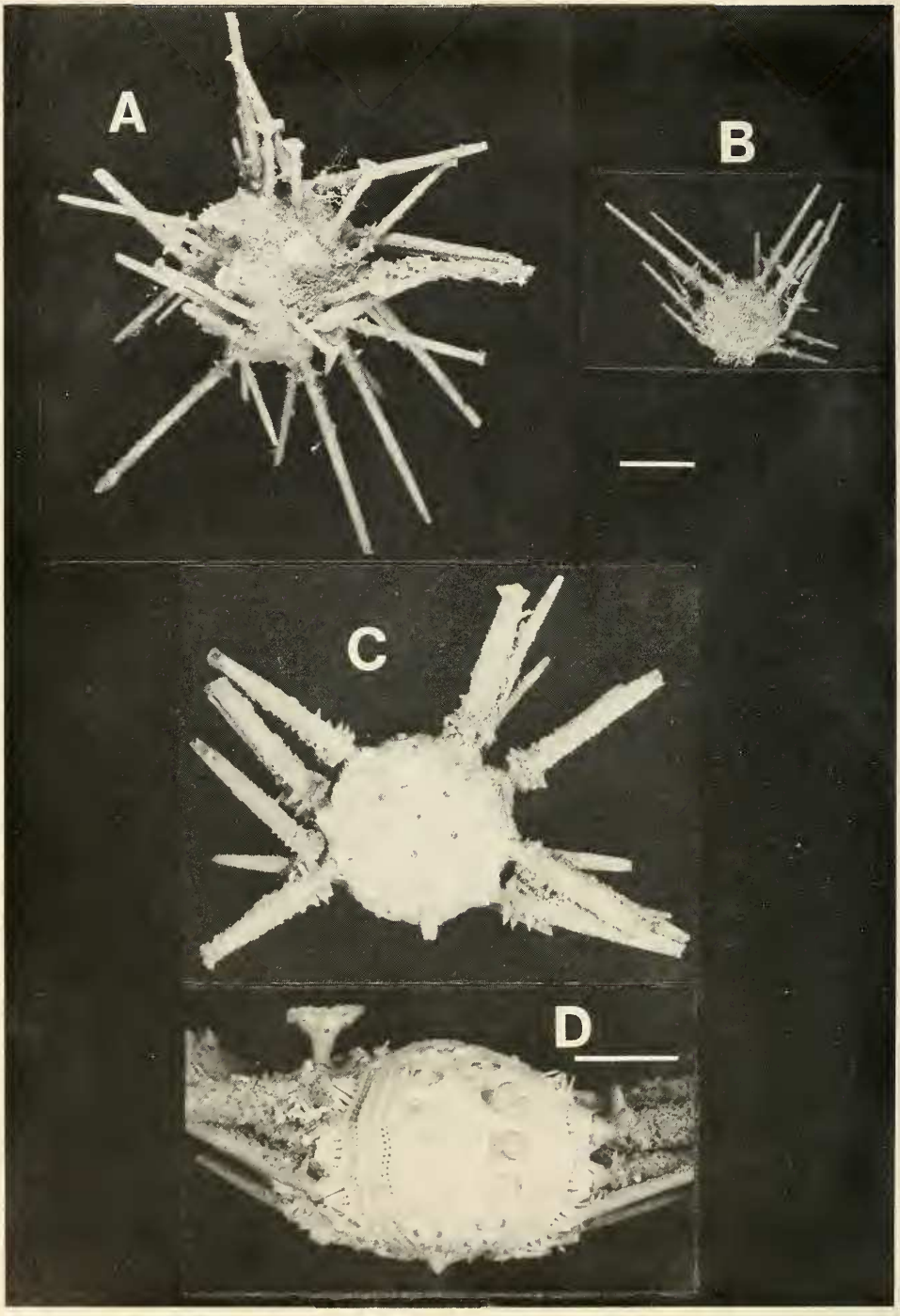


*Fig. 6. Goniocidaris sibogae.* **A**. E5919 (part), S. of Cape Everard, Vic., 360-486m, 'Endeavour'. **B**. E5114, E. of Maria Is., Tas., 230m. **C,D**. J15844, off Kiama, N.S.W., 405m. Scale = 10mm.

material, but 13 of the specimens examined by us were collected by the 'Endeavour' from near the type locality. None of the specimens we have examined has globiferous pedicellariae of the form indicated by Mortensen (1928b: pl. 78, figs 21-23). This form of pedicellaria is thus either extremely rare, or it is in fact absent from the Australian specimens, Mortensen's assertion to the contrary being a mistake. Assuming that *clypeata* does have pedicellariae of two distinct forms, the absence of this feature in all other species of the subgenus indicates the distinctness of *clypeata*.

De Meijere (1904b) described *fimbriata* from two specimens of 10 and 11mm horizontal diameter respectively. Neither of the type specimens has terminal discs. Later, Mortensen (1928b) referred two other specimens of 13 and 15mm diameter to the species. These specimens have very well-developed, shield-shaped terminal discs. Mortensen (1928b) considered De Meijere's specimens to be juveniles which had not yet developed terminal discs. The extreme development of the discs shown in Mortensen's specimens (1928b: pl. 15, figs 8, 11) appears unlikely to have occurred with just 2-5mm of growth in horizontal diameter. On the evidence provided by Mortensen (1928b), we consider it unlikely that the larger specimens are conspecific with the types of *fimbriata*.

In common with the types of *fimbriata*, there are no terminal discs on the apical spines of the four known specimens of *G. crassa*. These specimens are considerably larger (19-24mm in horizontal diameter) than the types of *fimbriata*, but Mortensen (1928b) considers them to be juveniles of a species which will eventually develop terminal discs. If Mortensen's identification of the two larger specimens referred to *fimbriata* is incorrect, there is no reason to recognize *crassa* as a species distinct from *fimbriata*. Accordingly, we regard *crassa* as a junior synonym of *fimbriata*. If *fimbriata* does not develop terminal discs, its position in *Aspidocidaris* is questionable.

Of the remaining species in the subgenus, *parasol* is quite distinct from *alba, sibogae* and *australiae*. The ambulacra of *parasol* have a broad, bare, sunken median area which is almost straight. This feature is conspicuous and apparently constant. In contrast, the median areas of the ambulacra of the other three nominal species are more heavily tuberculated, the narrow bare areas being clearly zig-zag in arrangement.

The 40 Australian specimens which we have examined are regarded as being conspecific, but different individuals fit variously into the descriptions of *alba, sibogae* and *australiae*. The specimens range in horizontal diameter from 7mm to 26mm. The smallest specimens (7 and 8mm) do not have terminal discs on their primary spines. Although many of the spines are broken, it appears that terminal discs occur on all specimens larger than these. As the horizontal diameter increases, the relative length of the apical spines bearing the discs decreases, and the size of the discs increases. A similar change occurs with growth in *G. parasol* (we have compared juvenile specimens, identified by Fell, with Fell's description of adult specimens of *parasol*). Other changes which occur with growth are loss of green coloration on the apical area of the naked test, and increased tuberculation of the median areas of the ambulacra and interambulacra. Specimens thus range from small, with a green apical area, wide bare areas in the interambulacra, and with long, slender apical primary spines bearing small discs, to large, with a white apical area, narrow bare areas in the interambulacra, and with short, squat apical primary spines bearing large discs. There is also considerable individual variation in the thickness of the primary spines, and some variation in the thorniness of the shaft.

The three nominal species, *alba, sibogae* and *australiae*, whose descriptions were published simultaneously by Mortensen (1928a), were separated on the basis of the extent of the naked vertical midline of the interambulacra, the shape and thickness of the primary spines, and the presence or absence of green coloration on the naked test. Given the variation indicated above, the three nominal species are regarded as synonymous.

material, but 13 of the specimens examined by us were collected by the 'Endeavour' from near the type locality. None of the specimens we have examined has globiferous pedicellariae of the form indicated by Mortensen (1928b: pl. 78, figs 21-23). This form of pedicellaria is thus either extremely rare, or it is in fact absent from the Australian specimens, Mortensen's assertion to the contrary being a mistake. Assuming that *clypeata* does have pedicellariae of two distinct forms, the absence of this feature in all other species of the subgenus indicates the distinctness of *clypeata*.

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In common with the types of *fimbriata*, there are no terminal discs on the apical spines of the four known specimens of *G. crassa*. These specimens are considerably larger (19-24mm in horizontal diameter) than the types of *fimbriata*, but Mortensen (1928b) considers them to be juveniles of a species which will eventually develop terminal discs. If Mortensen's identification of the two larger specimens referred to *fimbriata* is incorrect, there is no reason to recognize *crassa* as a species distinct from *fimbriata*. Accordingly, we regard *crassa* as a junior synonym of *fimbriata*. If *fimbriata* does not develop terminal discs, its position in *Aspidocidaris* is questionable.

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The 40 Australian specimens which we have examined are regarded as being conspecific, but different individuals fit variously into the descriptions of *alba, sibogae* and *australiae*. The specimens range in horizontal diameter from 7mm to 26mm. The smallest specimens (7 and 8mm) do not have terminal discs on their primary spines. Although many of the spines are broken, it appears that terminal discs occur on all specimens larger than these. As the horizontal diameter increases, the relative length of the apical spines bearing the discs decreases, and the size of the discs increases. A similar change occurs with growth in *G. parasol* (we have compared juvenile specimens, identified by Fell, with Fell's description of adult specimens of *parasol*). Other changes which occur with growth are loss of green coloration on the apical area of the naked test, and increased tuberculation of the median areas of the ambulacra and interambulacra. Specimens thus range from small, with a green apical area, wide bare areas in the interambulacra, and with long, slender apical primary spines bearing small discs, to large, with a white apical area, narrow bare areas in the interambulacra, and with short, squat apical primary spines bearing large discs. There is also considerable individual variation in the thickness of the primary spines, and some variation in the thorniness of the shaft.

The three nominal species, *alba, sibogae* and *australiae*, whose descriptions were published simultaneously by Mortensen (1928a), were separated on the basis of the extent of the naked vertical midline of the interambulacra, the shape and thickness of the primary spines, and the presence or absence of green coloration on the naked test. Given the variation indicated above, the three nominal species are regarded as synonymous.

*G. sibogae* is selected as the name of the taxon under the first revisor principle of the International Code of Zoological Nomenclature (Article 24A), as this name does not describe a colour or locality which is no longer applicable to the species.

The species is thus known from little material in distant localities: *sibogae* was originally known only from 3 specimens from Indonesia, *alba* was described on a single specimen from Japan, and *australiae* was thought to be an endemic southeast Australian species. The two specimens (from Indonesia) with terminal discs, referred by Mortensen (1928b) to *fimbriata*, are also likely to represent *sibogae*.

*G. sibogae* is readily distinguished from *G. tubaria* and *G. impressa*, with which it occurs in southeast Australian waters, by its lack of globular globiferous pedicellariae without an end tooth, and by the presence of terminal and basal discs on the apical primary spines.

## Subfamily STEREOCIDARINAE Lambert

## Genus ***Stereocidaris*** Pomel

The genus is characterized by the presence of grooves in the upper interambulacral sutures, rudimentary upper primary tubercles, globiferous pedicellariae without an end tooth, and pores which are not very close together and are not confluent (Mortensen, 1928b). Mortensen (1928b) recognizes 16 species and 7 varieties of *Stereocidaris*, 14 of which taxa were originally described by him. Many of these taxa are based on very few specimens, and little variation within a species or variety appears to have been allowed. It seems likely that re-examination of Mortensen's material would reveal considerably fewer species and varieties of *Stereocidaris*.

Although *Stereocidaris* was first recorded from northwestern Australian waters by McNamara (1984), he did not identify the species. The species identified here, therefore, are newly recorded from Australian waters.

### *Stereocidaris sceptriferoides* (Döderlein)

Fig. 7**A**

*Cidaris (Stereocidaris) sceptriferoides* Döderlein, 1887:5, pl. II, figs 12-17, pl. III, figs 3a-e.
*Stereocidaris sceptriferoides:* Mortensen, 1928b:274 (synonymy), pl. 29, figs 5-7, pl. 67, figs 1-3, pl. 70, fig. 12, pl. 81, figs 1-4; Pawson, 1965:199, pl. 1.

**Diagnosis:** Small globiferous pedicellariae have slender, elongate valves, resembling tridentate pedicellariae; primary spines occur above the ambitus, are more or less circular in cross-section, and either gently taper or flare at the tip; primary spines bear numerous low, serrated, longitudinal ridges, and the neck is conspicuous and shining; marginal ambulacral spines are flattened; miliary spines are slender, more or less cylindrical and abruptly differentiated from the longer, flat, scrobicular spines; genital plates are convex, longer than wide, and pointed on the outer edge forming a pentagonal plate.

**Material:** 1 specimen, off Clarence R., N.S.W., 450m, 'Kapala'.

**Distribution:** Japan; eastern Australia (Ballina, N.S.W.); north of New Zealand. The variety *lanceolata* Mortensen, 1928a, is recorded from the Sagami Sea, and the variety *lamellata* Mortensen, 1927, is recorded from the Kei Islands, 360-841m.

**Remarks:** Some characteristics of the specimen are listed below.

| | |
|---|---|
| Horizontal diameter (mm) | 43 |
| Vertical diameter (mm) | 26 |
| Apical system diameter (mm) | 20 |
| Peristome diameter (mm) | 15 |
| No. interambulacrals | 6 |
| Width interambulacrum (mm) | 20 |

*G. sibogae* is selected as the name of the taxon under the first revisor principle of the International Code of Zoological Nomenclature (Article 24A), as this name does not describe a colour or locality which is no longer applicable to the species.

The species is thus known from little material in distant localities: *sibogae* was originally known only from 3 specimens from Indonesia, *alba* was described on a single specimen from Japan, and *australiae* was thought to be an endemic southeast Australian species. The two specimens (from Indonesia) with terminal discs, referred by Mortensen (1928b) to *fimbriata*, are also likely to represent *sibogae*.

*G. sibogae* is readily distinguished from *G. tubaria* and *G. impressa*, with which it occurs in southeast Australian waters, by its lack of globular globiferous pedicellariae without an end tooth, and by the presence of terminal and basal discs on the apical primary spines.

## Subfamily STEREOCIDARINAE Lambert

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### *Stereocidaris sceptriferoides* (Döderlein)

Fig. 7**A**

*Cidaris (Stereocidaris) sceptriferoides* Döderlein, 1887:5, pl. II, figs 12-17, pl. III, figs 3a-e.
*Stereocidaris sceptriferoides:* Mortensen, 1928b:274 (synonymy), pl. 29, figs 5-7, pl. 67, figs 1-3, pl. 70, fig. 12, pl. 81, figs 1-4; Pawson, 1965:199, pl. 1.

**Diagnosis:** Small globiferous pedicellariae have slender, elongate valves, resembling tridentate pedicellariae; primary spines occur above the ambitus, are more or less circular in cross-section, and either gently taper or flare at the tip; primary spines bear numerous low, serrated, longitudinal ridges, and the neck is conspicuous and shining; marginal ambulacral spines are flattened; miliary spines are slender, more or less cylindrical and abruptly differentiated from the longer, flat, scrobicular spines; genital plates are convex, longer than wide, and pointed on the outer edge forming a pentagonal plate.

**Material:** 1 specimen, off Clarence R., N.S.W., 450m, 'Kapala'.

**Distribution:** Japan; eastern Australia (Ballina, N.S.W.); north of New Zealand. The variety *lanceolata* Mortensen, 1928a, is recorded from the Sagami Sea, and the variety *lamellata* Mortensen, 1927, is recorded from the Kei Islands, 360-841m.

**Remarks:** Some characteristics of the specimen are listed below.

| | |
|---|---|
| Horizontal diameter (mm) | 43 |
| Vertical diameter (mm) | 26 |
| Apical system diameter (mm) | 20 |
| Peristome diameter (mm) | 15 |
| No. interambulacrals | 6 |
| Width interambulacrum (mm) | 20 |

| | |
|---|---|
| Width ambulacrum (mm) | 5 |
| Longest spine (mm) | 50 |

The ambulacra differ from Mortensen's (1928b) description only in that the midline is not sunken, the whole interporiferous zone being slightly convex. Similarly, Pawson (1965) described three specimens of *sceptriferoides* from northeast of New Zealand as being without a sunken midline. The interambulacra are as described by Mortensen (1928b).

The apical system is slightly raised, the genital plates in particular being convex. All the apical plates are densely tuberculate, as depicted by Pawson (1965: fig. 2), and the genital plates do not exhibit the bare areas described by Mortensen (1928b). Some periproctal plates, one genital plate and one ocular have apparently suffered damage. Oculars I, II and III are broadly exsert, and ocular IV is broadly insert. The genital pores are approximately 1mm in diameter, and are situated near the outer edge of the plates. The specimen is thus probably a male (Pawson, 1965).

The primary spines differ from Mortensen's (1928b) description only in that they do not flare conspicuously near the tip. Some of the spines appear to be intact, and these taper gently throughout their length. They are more or less cylindrical, with slight evidence of carination on some spines. The conspicuous, shining neck is pale pink in colour.

The scrobicular and miliary spines are of the shape and size described by Mortensen (1928b) for the 'typical' variety of *sceptriferoides*, but there is a moderately abrupt transition between the two. The miliary spines appear to be appressed, but this is probably a result of preservation.

No tridentate pedicellariae were found. Two forms of globiferous pedicellariae are present, one having very long, slender valves (Mortensen, 1928b). Both forms have a small subterminal opening. Spicules of the tube feet are fenestrated plates.

Two varieties of *sceptriferoides* have been described: *lanceolata* Mortensen, 1928a, differs from the nominal variety in the character and distribution of secondary spines, and *lamellata*.Mortensen, 1927, is characterized by the presence of conspicuous lamellae on the primary spines. The specimen at hand represents the 'typical' variety described by Mortensen (1928b).

A group of *Stereocidaris* species have small globiferous pedicellariae with very elongate valves, resembling tridentate pedicellariae. Tridentate pedicellariae are rare or absent from these species, which include *sceptriferoides, alcocki, capensis*, and apparently *indica*. Mortensen's (1928b) figures of the pedicellariae of *indica* show them to be elongate, but the position of *indica* in Mortensen's key indicates the opposite to be the case.

*S. sceptriferoides* appears to be closely related, if not identical, to *S. alcocki* var. *teretispina* (Döderlein, 1906), which is known from a single specimen. The diameter of the peristome relative to the horizontal diameter ($<25\%$ or $>30\%$) is the key character used by Mortensen (1928b) to distinguish between these nominal taxa. This ratio is about 35% in the specimen at hand, clearly indicating *sceptriferoides*. However, the measurements given by Pawson (1965) for three specimens referred by him to *sceptriferoides* indicate this ratio ranges from 24% to 31%, which straddles the supposed gap between the taxa.

McKnight (1975) recorded a specimen of *S. sceptriferoides* from the northern Tasman Sea. We have examined this specimen, and although no pedicellariae remain, it appears to represent a small specimen of *Stylocidaris reini* (see p.245).

| | |
|---|---|
| Width ambulacrum (mm) | 5 |
| Longest spine (mm) | 50 |

The ambulacra differ from Mortensen's (1928b) description only in that the midline is not sunken, the whole interporiferous zone being slightly convex. Similarly, Pawson (1965) described three specimens of *sceptriferoides* from northeast of New Zealand as being without a sunken midline. The interambulacra are as described by Mortensen (1928b).

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The primary spines differ from Mortensen's (1928b) description only in that they do not flare conspicuously near the tip. Some of the spines appear to be intact, and these taper gently throughout their length. They are more or less cylindrical, with slight evidence of carination on some spines. The conspicuous, shining neck is pale pink in colour.

The scrobicular and miliary spines are of the shape and size described by Mortensen (1928b) for the 'typical' variety of *sceptriferoides*, but there is a moderately abrupt transition between the two. The miliary spines appear to be appressed, but this is probably a result of preservation.

No tridentate pedicellariae were found. Two forms of globiferous pedicellariae are present, one having very long, slender valves (Mortensen, 1928b). Both forms have a small subterminal opening. Spicules of the tube feet are fenestrated plates.

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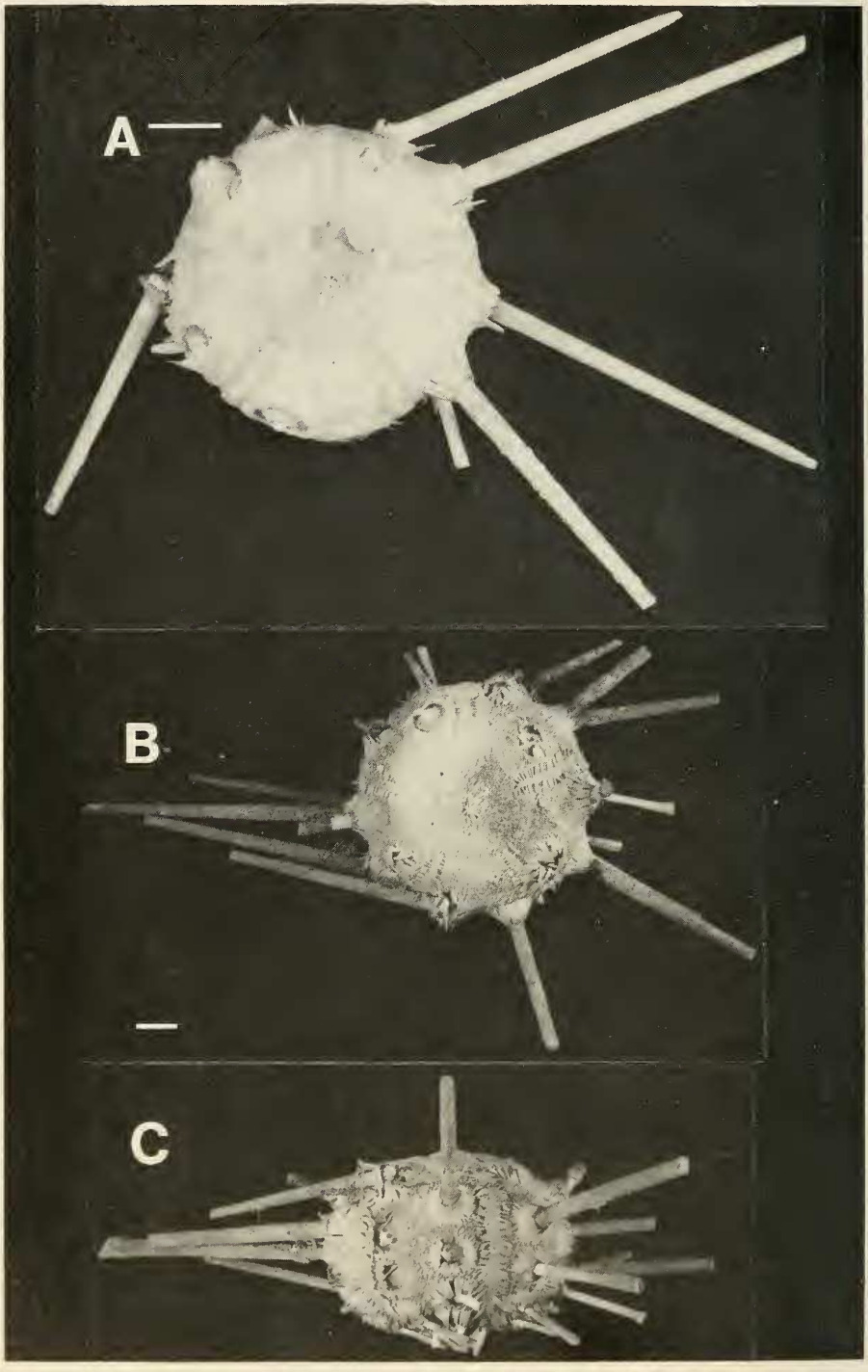


*Fig. 7.* **A.** *Stereocidaris sceptriferoides*, J15790, off Clarence R., N.S.W., 450m. **B,C.** *S. microtuberculatum*, J15791, off Shoalhaven Bight, N.S.W., 702-792m. Scale = 10mm.

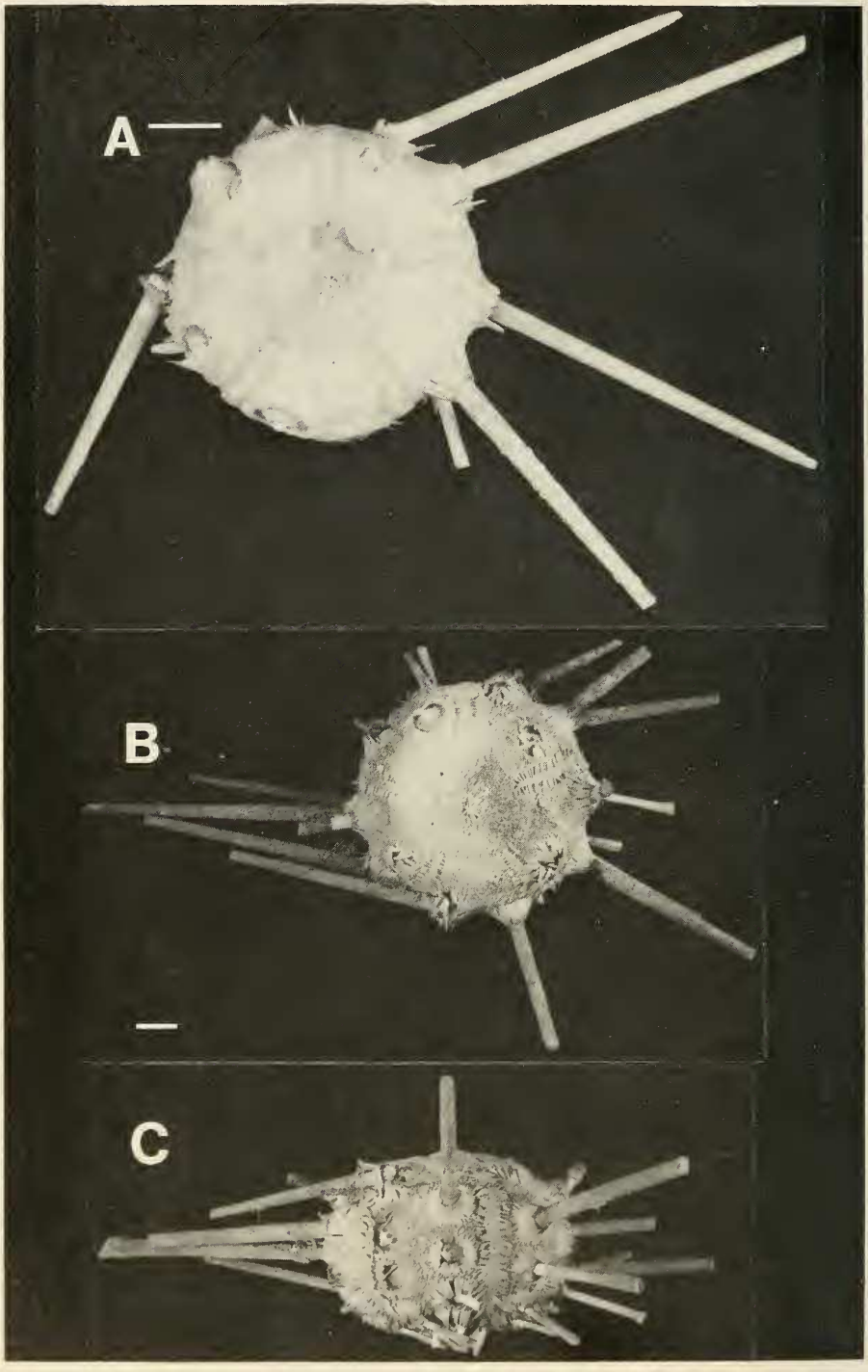


*Fig. 7.* **A.** *Stereocidaris sceptriferoides*, J15790, off Clarence R., N.S.W., 450m. **B,C.** *S. microtuberculatum*, J15791, off Shoalhaven Bight, N.S.W., 702-792m. Scale = 10mm.

*S. sceptriferoides* differs from the only other known species of *Stereocidaris* in Australian waters, *S. microtuberculata*, most markedly by the nature of the pedicellariae and of the miliary spines.

*Stereocidaris microtuberculata* (Yoshiwara)

Fig. 7**B-C**

*Cidaris (Stereocidaris) microtuberculatus* Yoshiwara, 1898:57.

*Stereocidaris microtuberculata:* Mortensen, 1928b:257 (synonymy).

?*Stereocidaris* sp.: McKnight, 1975:71.

**Diagnosis:** Globiferous pedicellariae are not elongated, not resembling tridentate pedicellariae; primary spines bear numerous longitudinal rows of low, rounded projections; miliary spines are flattened, pointed, scale-like and appressed to the test, more or less abruptly differentiated from the longer, flat, scrobicular spines; genital plates are more or less rectangular, broader than long.

**Material:** 8 specimens in the Australian Museum collection from off Brisbane, Qld to off Batemans Bay, N.S.W. (7 specimens from N.S.W. waters and 1 specimen from Qld waters).

**Distribution:** Japan; east Australian coast, 140-700m; ?New Zealand.

**Remarks:** Some characteristics of the specimens are listed in Table 2.

The specimens differ from the description of *microtuberculata* given by Mortensen (1928b) in that the ambulacra are slightly wider relative to the interambulacra (18-23% rather than 18-20%), and the few large primary spines remaining intact are not conspicuously widened or flaring. However, in the original description of the species, Yoshiwara (1898) indicates the ambulacra are 18.5-25% the width of the interambulacra, and he does not mention this feature of the primary spines. Mortensen (1928b) indicates that the oral primaries in particular are 'trumpet-shaped'. The oral primaries of the Australian specimens widen only slightly, if at all, and the adoral sides of the spines are flattened. This is apparently contrary to Yoshiwara's (1898) comment: 'Spines near peristome not flattened . . .'.

TABLE 2

*Measurements of individuals of* Stereocidaris microtuberculata

1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = longest spine (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| J15792 | 50 | 36 | 23 | 18 | 23 | 5 | 6 | 55 |
| J15848 | 55 | 40 | 28 | 17 | 28 | 6 | 6-7 | – |
| J15791 | 57 | 42 | 26 | 19 | 28 | 6 | 7 | 70 |
| J15789 | 59 | 42 | 26 | 24 | 28 | 6 | 7 | 60 |
| J15788 | 61 | 38 | 31 | 23 | 30 | 6 | 6 | 50 |
| J15851 | 78 | 58 | 34 | 24 | 37 | 8 | 7 | – |
| J15849 | 82 | 54 | 36 | 25 | 40 | 9 | 7 | – |
| J15850 | 85 | 68 | 35 | 25 | 39 | 8 | 7-8 | – |

The genital plates of all the specimens examined are considerably broader than long, in agreement with Yoshiwara's (1898) description. The plates have relatively straight sides, and are approximately rectangular in shape, rather than hexagonal or heptagonal as described by Mortensen (1928b). Other *Stereocidaris* species with broad genital plates are *grandis* Döderlein, *tubaria* var. *impressa* Mortensen, *hawaiiensis*

*S. sceptriferoides* differs from the only other known species of *Stereocidaris* in Australian waters, *S. microtuberculata*, most markedly by the nature of the pedicellariae and of the miliary spines.

*Stereocidaris microtuberculata* (Yoshiwara)

Fig. 7**B-C**

*Cidaris (Stereocidaris) microtuberculatus* Yoshiwara, 1898:57.

*Stereocidaris microtuberculata:* Mortensen, 1928b:257 (synonymy).

?*Stereocidaris* sp.: McKnight, 1975:71.

**Diagnosis:** Globiferous pedicellariae are not elongated, not resembling tridentate pedicellariae; primary spines bear numerous longitudinal rows of low, rounded projections; miliary spines are flattened, pointed, scale-like and appressed to the test, more or less abruptly differentiated from the longer, flat, scrobicular spines; genital plates are more or less rectangular, broader than long.

**Material:** 8 specimens in the Australian Museum collection from off Brisbane, Qld to off Batemans Bay, N.S.W. (7 specimens from N.S.W. waters and 1 specimen from Qld waters).

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**Remarks:** Some characteristics of the specimens are listed in Table 2.

The specimens differ from the description of *microtuberculata* given by Mortensen (1928b) in that the ambulacra are slightly wider relative to the interambulacra (18-23% rather than 18-20%), and the few large primary spines remaining intact are not conspicuously widened or flaring. However, in the original description of the species, Yoshiwara (1898) indicates the ambulacra are 18.5-25% the width of the interambulacra, and he does not mention this feature of the primary spines. Mortensen (1928b) indicates that the oral primaries in particular are 'trumpet-shaped'. The oral primaries of the Australian specimens widen only slightly, if at all, and the adoral sides of the spines are flattened. This is apparently contrary to Yoshiwara's (1898) comment: 'Spines near peristome not flattened . . .'.

TABLE 2

*Measurements of individuals of* Stereocidaris microtuberculata

1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = longest spine (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| J15792 | 50 | 36 | 23 | 18 | 23 | 5 | 6 | 55 |
| J15848 | 55 | 40 | 28 | 17 | 28 | 6 | 6-7 | – |
| J15791 | 57 | 42 | 26 | 19 | 28 | 6 | 7 | 70 |
| J15789 | 59 | 42 | 26 | 24 | 28 | 6 | 7 | 60 |
| J15788 | 61 | 38 | 31 | 23 | 30 | 6 | 6 | 50 |
| J15851 | 78 | 58 | 34 | 24 | 37 | 8 | 7 | – |
| J15849 | 82 | 54 | 36 | 25 | 40 | 9 | 7 | – |
| J15850 | 85 | 68 | 35 | 25 | 39 | 8 | 7-8 | – |

The genital plates of all the specimens examined are considerably broader than long, in agreement with Yoshiwara's (1898) description. The plates have relatively straight sides, and are approximately rectangular in shape, rather than hexagonal or heptagonal as described by Mortensen (1928b). Other *Stereocidaris* species with broad genital plates are *grandis* Döderlein, *tubaria* var. *impressa* Mortensen, *hawaiiensis*

Mortensen, *granularis* Mortensen, *indica* Döderlein and *excavata* Mortensen. The specimens at hand do not have the concave genital plates characteristic of *excavata*. Of the remaining species, *microtuberculata* has the broadest and most rectangular genital plates.

McKnight (1975) recorded '4 fragments' from the northern Tasman Sea (32°01'S 168°03'E, 500m) as *Stereocidaris* sp. It is possible that these fragments represent *S. microtuberculata*, but judging from McKnight's description, the material is inadequate for positive identification.

The present material extends the range of *S. microtuberculata* from Japan to N.S.W.

## Subfamily CIDARINAE Gray

## Genus ***Stylocidaris*** Mortensen

*Stylocidaris* is characterized by the nature of the pedicellariae and the primary spines, the presence of non-conjugate pores, and that the pores occur in a single series on the peristome (Mortensen, 1928b).

*S. conferta* was the only species of the genus previously known to occur in N.S.W. waters. Two other species are here recorded from N.S.W. waters for the first time.

### *Stylocidaris conferta* (H. L. Clark)

Figs 8**A**, 9**A**

*Cidaris conferta* H. L. Clark, 1916:100, pl. 38, figs 1-4.
*Stylocidaris conferta:* Mortensen, 1928b:351, pl. 37, figs 3-7, pl. 72, fig. 14, pl. 85, figs 30-32; H. L. Clark, 1946:289; Dartnall, 1980:43.

**Diagnosis:** Primary spines are cylindrical for most of their length, then abruptly taper close to the tip; spines are ornamented with evenly-sized, closely-spaced, low, rounded knobs, arranged without regular pattern; spines are pale in colour, white to yellow, and may have 1 or 2 pink transverse bands; a conspicuous dark brown spot is usually present on each genital plate, and dark spots are usually present at the corners of each interambulacral plate, particularly on the median side; secondary spines are faintly marked with a dull-coloured, median longitudinal stripe.

**Material:** Holotype, AM E4685, eastern slope, Bass Strait, 144-360m; 2 paratypes, E4740-1, south of Gabo Is., Victoria, about 360m; 96 other specimens in the Australian Museum collection, from the geographical and bathymetrical range indicated below (1 specimen from Qld waters, 81 specimens from N.S.W. waters, 7 from Victorian waters, 7 specimens from Tasmanian waters).

**Distribution:** Off Gold Coast, Qld (28°06'S 153°58'E) to off Wineglass Bay, Tasmania, 140-550m.

**Remarks:** The species was adequately described by H. L. Clark (1916) and by Mortensen (1928b). *S. conferta* has not previously been recorded from north of Port Jackson or south of Bass Strait. The present records thus extend the known geographical range of the species.

### *Stylocidaris reini* (Döderlein)

Figs 8**B**, 9**B**

*Cidaris (Dorocidaris) reini* Döderlein, 1887:7, pl. 4, figs 1-7, pl. 8, figs 4a-d.
*Stylocidaris reini:* Mortensen, 1928b:342, pl. 35, figs 1-9, pl. 72, figs 17-19, pl. 84, figs 1-11.
*Stereocidaris sceptriferoides:* McKnight, 1975:71 [non *S. sceptriferoides* (Döderlein, 1887)].

**Diagnosis:** Primary spines are round in cross-section, tapering evenly throughout their length; small, sharp serrations are arranged in longitudinal ridges along the spines; small hairs cover the spines between the ridges; spines are pale in colour with numerous

Mortensen, *granularis* Mortensen, *indica* Döderlein and *excavata* Mortensen. The specimens at hand do not have the concave genital plates characteristic of *excavata*. Of the remaining species, *microtuberculata* has the broadest and most rectangular genital plates.

McKnight (1975) recorded '4 fragments' from the northern Tasman Sea (32°01'S 168°03'E, 500m) as *Stereocidaris* sp. It is possible that these fragments represent *S. microtuberculata*, but judging from McKnight's description, the material is inadequate for positive identification.

The present material extends the range of *S. microtuberculata* from Japan to N.S.W.

## Subfamily CIDARINAE Gray

## Genus ***Stylocidaris*** Mortensen

*Stylocidaris* is characterized by the nature of the pedicellariae and the primary spines, the presence of non-conjugate pores, and that the pores occur in a single series on the peristome (Mortensen, 1928b).

*S. conferta* was the only species of the genus previously known to occur in N.S.W. waters. Two other species are here recorded from N.S.W. waters for the first time.

### *Stylocidaris conferta* (H. L. Clark)

Figs 8**A**, 9**A**

*Cidaris conferta* H. L. Clark, 1916:100, pl. 38, figs 1-4.
*Stylocidaris conferta:* Mortensen, 1928b:351, pl. 37, figs 3-7, pl. 72, fig. 14, pl. 85, figs 30-32; H. L. Clark, 1946:289; Dartnall, 1980:43.

**Diagnosis:** Primary spines are cylindrical for most of their length, then abruptly taper close to the tip; spines are ornamented with evenly-sized, closely-spaced, low, rounded knobs, arranged without regular pattern; spines are pale in colour, white to yellow, and may have 1 or 2 pink transverse bands; a conspicuous dark brown spot is usually present on each genital plate, and dark spots are usually present at the corners of each interambulacral plate, particularly on the median side; secondary spines are faintly marked with a dull-coloured, median longitudinal stripe.

**Material:** Holotype, AM E4685, eastern slope, Bass Strait, 144-360m; 2 paratypes, E4740-1, south of Gabo Is., Victoria, about 360m; 96 other specimens in the Australian Museum collection, from the geographical and bathymetrical range indicated below (1 specimen from Qld waters, 81 specimens from N.S.W. waters, 7 from Victorian waters, 7 specimens from Tasmanian waters).

**Distribution:** Off Gold Coast, Qld (28°06'S 153°58'E) to off Wineglass Bay, Tasmania, 140-550m.

**Remarks:** The species was adequately described by H. L. Clark (1916) and by Mortensen (1928b). *S. conferta* has not previously been recorded from north of Port Jackson or south of Bass Strait. The present records thus extend the known geographical range of the species.

### *Stylocidaris reini* (Döderlein)

Figs 8**B**, 9**B**

*Cidaris (Dorocidaris) reini* Döderlein, 1887:7, pl. 4, figs 1-7, pl. 8, figs 4a-d.
*Stylocidaris reini:* Mortensen, 1928b:342, pl. 35, figs 1-9, pl. 72, figs 17-19, pl. 84, figs 1-11.
*Stereocidaris sceptriferoides:* McKnight, 1975:71 [non *S. sceptriferoides* (Döderlein, 1887)].

**Diagnosis:** Primary spines are round in cross-section, tapering evenly throughout their length; small, sharp serrations are arranged in longitudinal ridges along the spines; small hairs cover the spines between the ridges; spines are pale in colour with numerous

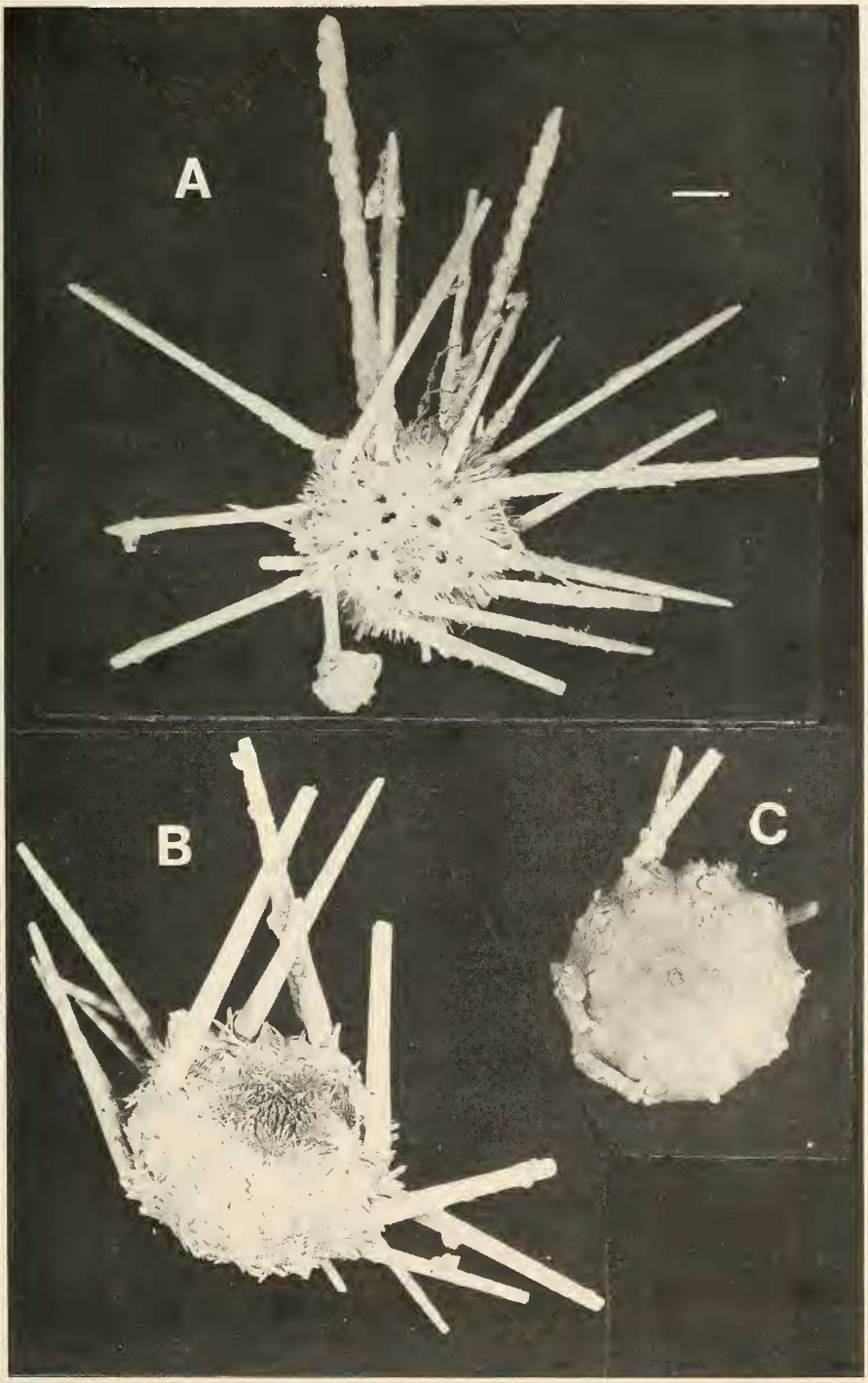


*Fig. 8.* **A.** *Stylocidaris conferta*, J15822, off Sydney, N.S.W., 266m. **B.** *S. reini*, J15816, off Newcastle, N.S.W., 270m. **C.** *S. brevicollis*, J15750, off Ball's Pyramid, Lord Howe Is., 90-180m. Scale = 10mm.

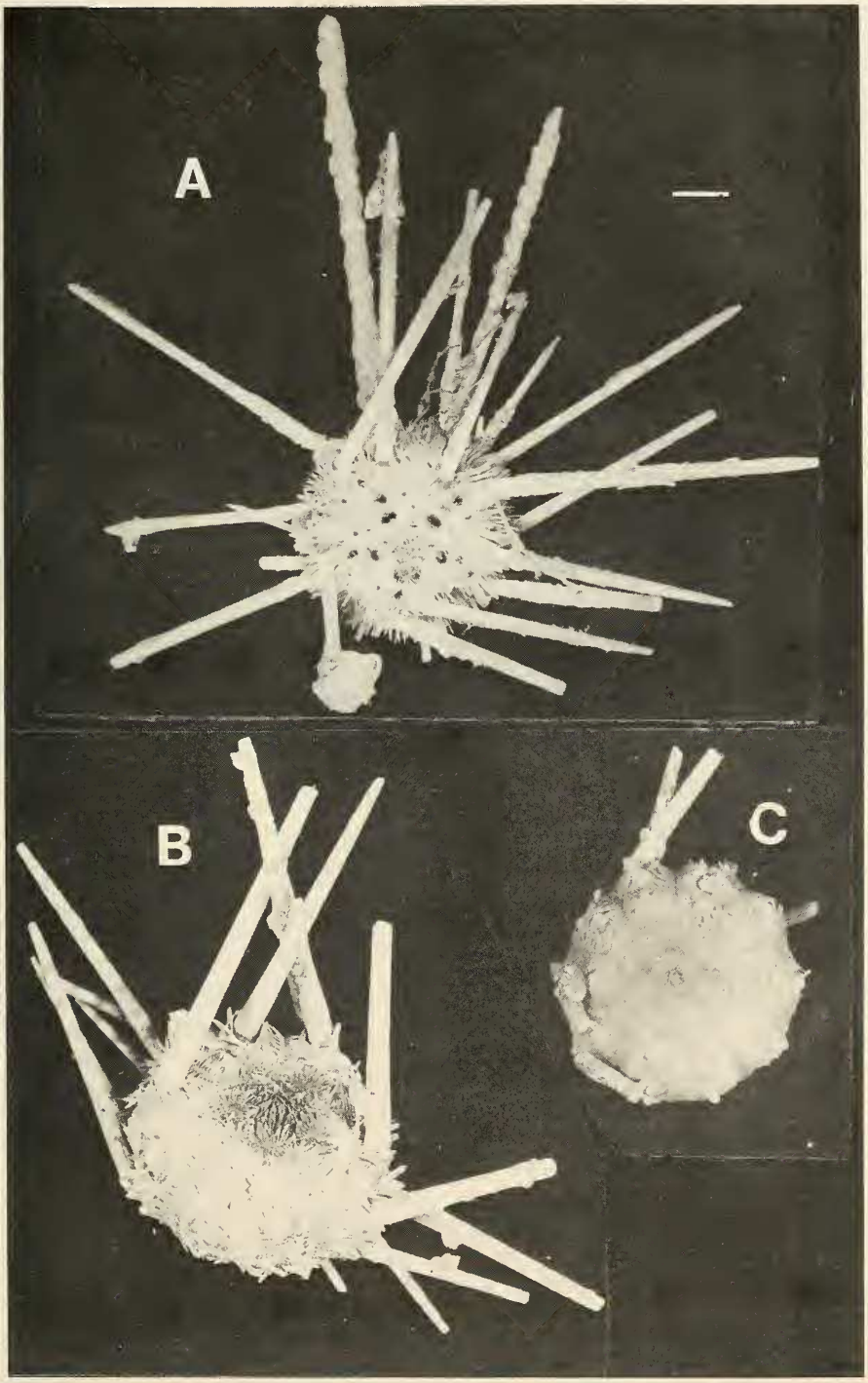


*Fig. 8.* **A.** *Stylocidaris conferta*, J15822, off Sydney, N.S.W., 266m. **B.** *S. reini*, J15816, off Newcastle, N.S.W., 270m. **C.** *S. brevicollis*, J15750, off Ball's Pyramid, Lord Howe Is., 90-180m. Scale = 10mm.

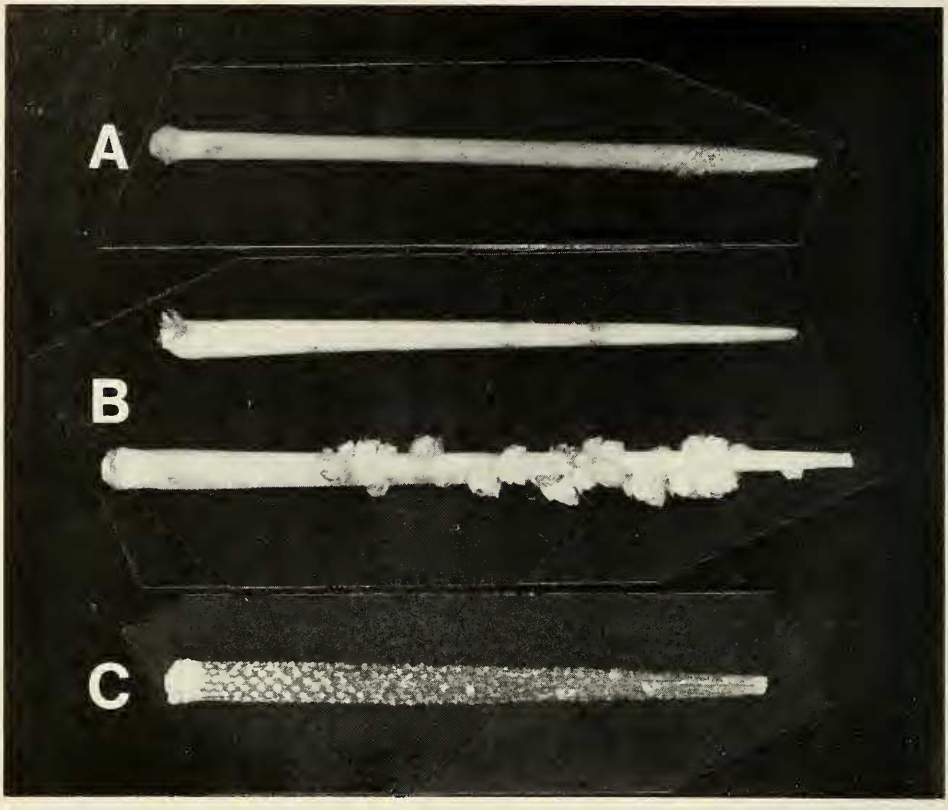


*Fig 9.* **A.** Primary spine of *Stylocidaris conferta*, J15822. **B.** Primary spine of *S. reini*, J15816. **C.** Primary spine of *S. brevicollis*, J15750.

pink transverse bands; whole of the apical area is usually conspicuously darker in colour than the rest of the animal; secondary spines have a conspicuous, dull-coloured, median longitudinal stripe.

**Material:** 32 specimens in the Australian Museum collection: (1 specimen from the Philippines, 1 from Indonesian waters, 14 from Qld waters, and 16 specimens from N.S.W. waters); 1 specimen, NZOI stn Z2098, east of Norfolk Island (28°39.5'S 173°01'E), 841m.

**Distribution:** Japan; Philippines; Indonesia; New Guinea; east coast of Australia, as far south as Montague Is., N.S.W.; northern Tasman Sea, east of Norfolk Island, 100-841m.

**Remarks:** Mortensen (1928a) described two varieties of *reini*. The variety *cladothrix* is distinguished from 'typical' *reini* by the hairs of the primary spines being 'bush-shaped' rather than simple. One of the specimens examined (AM J5158, Philippines) was identified as *cladothrix* by Mortensen. There are no hairs remaining on the spines of this specimen, but the serrations on the primary spines are very large compared with those on the N.S.W. specimens. The specimen from Kei Ids, (AM J5157) and the specimen from Bowen, Qld (AM J205) also have more prominent serrations, especially basally, than the N.S.W. specimens. The variety *rubra* differs from 'typical' *reini* mainly in the coloration of the primary spines, although other slight differences also occur. However, Mortensen (1928a,b) noted that these characters are not reliable as distinguishing features.

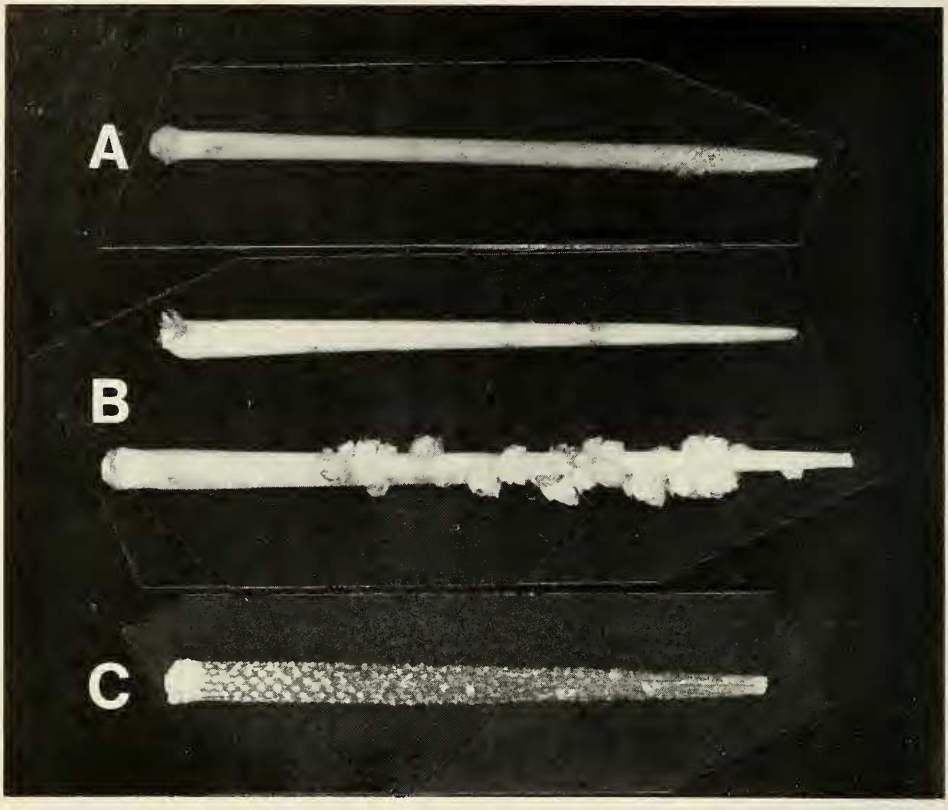


*Fig 9.* **A.** Primary spine of *Stylocidaris conferta*, J15822. **B.** Primary spine of *S. reini*, J15816. **C.** Primary spine of *S. brevicollis*, J15750.

pink transverse bands; whole of the apical area is usually conspicuously darker in colour than the rest of the animal; secondary spines have a conspicuous, dull-coloured, median longitudinal stripe.

**Material:** 32 specimens in the Australian Museum collection: (1 specimen from the Philippines, 1 from Indonesian waters, 14 from Qld waters, and 16 specimens from N.S.W. waters); 1 specimen, NZOI stn Z2098, east of Norfolk Island (28°39.5'S 173°01'E), 841m.

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The N.S.W. specimens range in horizontal diameter from 8-56mm. They do not have 'bush-shaped' spine hairs which are characteristic of *cladothrix*, but the primary spines of most of the specimens are conspicuously banded with red as in *rubra*. Similarly, the interporiferous zone is rather bare in many of the N.S.W. specimens, but this feature is shared with the specimen from Kei Ids, (J5157), which was identified as *reini* by Mortensen.

McKnight (1975) recorded a specimen from the northern Tasman Sea (NZOI stn Z2098) as *Stereocidaris sceptriferoides*. We have examined this specimen, which is in poor condition. The test, 18mm in horizontal diameter, has lost many secondary spines, no pedicellariae were found, and only the bases of a few primary spines remain. Colour of the test and remaining spines, as well as test morphology, indicate that this specimen represents *Stylocidaris reini* rather than *Stereocidaris sceptriferoides*. The only difference observed between the NZOI specimen and those of similar size from N.S.W., is that the thorns of the primary spines of the former are more or less coalesced into longitudinal ridges.

*S. reini* was previously known to occur from Japan to New Guinea, and a single specimen was known from Bowen, Qld (Mortensen, 1928b). The occurrence of *S. reini* in the Tasman Sea thus represents a southern and eastern extension of range for the species.

*Stylocidaris brevicollis* (De Meijere)

Figs 8C, 9C

*Cidaris (Cidaris) baculosa* var. *brevicollis* De Meijere, 1904b:11, pl. 2, figs 8, 13 [non 7], pl. 11, fig. 110.

*Stylocidaris brevicollis:* Mortensen, 1928b: 379 (synonymy), pl. 38, figs 4-6, pl. 72, figs 1-2, pl. 85, figs 3, 16-20.

**Diagnosis:** Primary spines are round in cross-section, tapering evenly throughout their length; small, sharp, white thorns are arranged in longitudinal series along the red shaft; very short hairs occur on the surface of the shaft between the rows of thorns; the collar is very short (<1mm); scrobicular spines have a broad, red, longitudinal midline; miliary spines are scale-like, and red in colour; the naked test is red on the ambulacra, apical system, peristome and median area of the interambulacra.

**Material:** 3 specimens (1 in fragments) from off Ball's Pyramid, near Lord Howe Island, 90-180m.

**Distribution:** Indonesia; Lord Howe Island area, 69-180m.

**Remarks:** The two intact specimens measure 13mm and 39mm in horizontal diameter respectively, which corresponds almost exactly to that of the two type specimens (13mm and 40mm; Mortensen, 1928b). Other measurements of the Lord Howe specimens differ little from those of the type specimens. The only differences are that the larger specimen has only 7 interambulacral plates in a series (compared with 8 in the larger type specimen) and the vertical diameter is slightly less (23mm compared with 26mm in the largest type specimen). The specimens at hand agree with Mortensen's description in all respects, except that no large globiferous pedicellariae were found. The small globiferous pedicellariae have quite a small end tooth on each valve.

*S. brevicollis* has only rarely been collected, the three specimens reported here increasing the known number to eight. The species was previously known only from Indonesian seas, and its occurrence near Lord Howe Island represents a considerable extension of range.

The N.S.W. specimens range in horizontal diameter from 8-56mm. They do not have 'bush-shaped' spine hairs which are characteristic of *cladothrix*, but the primary spines of most of the specimens are conspicuously banded with red as in *rubra*. Similarly, the interporiferous zone is rather bare in many of the N.S.W. specimens, but this feature is shared with the specimen from Kei Ids, (J5157), which was identified as *reini* by Mortensen.

McKnight (1975) recorded a specimen from the northern Tasman Sea (NZOI stn Z2098) as *Stereocidaris sceptriferoides*. We have examined this specimen, which is in poor condition. The test, 18mm in horizontal diameter, has lost many secondary spines, no pedicellariae were found, and only the bases of a few primary spines remain. Colour of the test and remaining spines, as well as test morphology, indicate that this specimen represents *Stylocidaris reini* rather than *Stereocidaris sceptriferoides*. The only difference observed between the NZOI specimen and those of similar size from N.S.W., is that the thorns of the primary spines of the former are more or less coalesced into longitudinal ridges.

*S. reini* was previously known to occur from Japan to New Guinea, and a single specimen was known from Bowen, Qld (Mortensen, 1928b). The occurrence of *S. reini* in the Tasman Sea thus represents a southern and eastern extension of range for the species.

*Stylocidaris brevicollis* (De Meijere)

Figs 8C, 9C

*Cidaris (Cidaris) baculosa* var. *brevicollis* De Meijere, 1904b:11, pl. 2, figs 8, 13 [non 7], pl. 11, fig. 110.

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*S. brevicollis* has only rarely been collected, the three specimens reported here increasing the known number to eight. The species was previously known only from Indonesian seas, and its occurrence near Lord Howe Island represents a considerable extension of range.

Genus ***Eucidaris*** Pomel

*Eucidaris* is characterized by the nature of the pedicellariae and of the primary spines, which terminate in a small crown with a central prominence, and by having non-conjugate pores.

*Eucidaris metularia* (Lamarck)

*Cidarites metularia* Lamarck, 1816:56.

*Eucidaris metularia:* Mortensen, 1928b:386 (synonymy), pl. 41, figs 1-8, pl. 73, fig. 6, pl. 86, figs 11-14; H. L. Clark, 1946:288; Clark and Rowe, 1971:140, 150.

**Diagnosis:** Primary spines are thick and robust, usually shorter than the horizontal test diameter; shafts are set with low, rounded projections arranged in longitudinal series; apical system is very sparsely tuberculated, except for a single series of large tubercles around the outer edge.

**Material:** 1 specimen from Sugarloaf Island, Lord Howe Island, 15m; 28 other specimens in the Australian Museum collection (11 from Queensland waters, 1 from northwestern Australia, 16 from other Indo-west Pacific localities).

**Distribution:** Widespread throughout the Indo-Pacific, including Lord Howe Island. Littoral — 570m.

**Remarks:** The published record of *E. metularia* in Australian waters has rested on specimens from northwestern Australia in the British Museum reported by H. L. Clark (1925), and other specimens from the same area by Marsh and Marshall (1983). The collection of this species in the Australian Museum extends its known distribution in Australia to the entire length of the Great Barrier Reef to Lady Elliot Island, and to Lord Howe Island. Lord Howe Island represents the southern limit of distribution of *E. metularia*.

Subfamily RHABDOCIDARINAE Lambert

Genus ***Acanthocidaris*** Mortensen

*Acanthocidaris* is characterized by its long, flattened primary spines which have a long collar, and by having crenulate tubercles. The genus is here recorded from Australian waters for the first time.

Fell (1966) omitted this genus from his classification of the cidaroids. Following Mortensen's (1928b) conviction that *Acanthocidaris* is especially closely related to *Prionocidaris*, the genus is included here in the Rhabdocidarinae.

*Acanthocidaris curvatispinis* (Bell)

Fig. 10**A-D**

*Cidaris curvatispinis* Bell, 1892:303, pl. 38.

*Porocidaris maculicollis* De Meijere, 1904a:1.

*Cidaris (Cidaris) maculicollis:* De Meijere, 1904b:15, pl. 3, figs 18-19, pl. 11, figs 111-116.

*Acanthocidaris hastigera* Agassiz and Clark, 1907:39, pl. 11, figs 1-5, pl. 12, figs 1-17, pl. 12b, figs 18, 19, pls 37-42; Mortensen, 1928b:325 (synonymy), pl. 83, fig. 11.

*Acanthocidaris maculicollis:* Koehler, 1927:23, pl. 5, figs 2-3, pl. 23, fig. 4; Mortensen, 1928b:329 (synonymy), pl. 43, figs 1-2, pl. 44, fig. 1, pl. 54, figs 5-6, pl. 83, figs 12-15; 1932:157, pl. 5, fig. 6, pl. 11, fig. 5.

*Acanthocidaris curvatispinis:* Mortensen, 1928b:323 (synonymy), pl. 83, figs 16-18; Mortensen, 1932:156, pl. 5, figs 1-5, pl. 11, fig. 4, pl. 12, fig. 8; Mortensen, 1939:17, pl. 5, fig. 3.

**Diagnosis:** Primary spines are dorso-ventrally compressed and the collars are relatively long and conspicuous; colour pattern of primary spines is variable, but small dark spots are usually present in longitudinal series on the collars; spines below the upper 1 or 2

Genus ***Eucidaris*** Pomel

*Eucidaris* is characterized by the nature of the pedicellariae and of the primary spines, which terminate in a small crown with a central prominence, and by having non-conjugate pores.

*Eucidaris metularia* (Lamarck)

*Cidarites metularia* Lamarck, 1816:56.

*Eucidaris metularia:* Mortensen, 1928b:386 (synonymy), pl. 41, figs 1-8, pl. 73, fig. 6, pl. 86, figs 11-14; H. L. Clark, 1946:288; Clark and Rowe, 1971:140, 150.

**Diagnosis:** Primary spines are thick and robust, usually shorter than the horizontal test diameter; shafts are set with low, rounded projections arranged in longitudinal series; apical system is very sparsely tuberculated, except for a single series of large tubercles around the outer edge.

**Material:** 1 specimen from Sugarloaf Island, Lord Howe Island, 15m; 28 other specimens in the Australian Museum collection (11 from Queensland waters, 1 from northwestern Australia, 16 from other Indo-west Pacific localities).

**Distribution:** Widespread throughout the Indo-Pacific, including Lord Howe Island. Littoral — 570m.

**Remarks:** The published record of *E. metularia* in Australian waters has rested on specimens from northwestern Australia in the British Museum reported by H. L. Clark (1925), and other specimens from the same area by Marsh and Marshall (1983). The collection of this species in the Australian Museum extends its known distribution in Australia to the entire length of the Great Barrier Reef to Lady Elliot Island, and to Lord Howe Island. Lord Howe Island represents the southern limit of distribution of *E. metularia*.

Subfamily RHABDOCIDARINAE Lambert

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*Acanthocidaris curvatispinis* (Bell)

Fig. 10**A-D**

*Cidaris curvatispinis* Bell, 1892:303, pl. 38.

*Porocidaris maculicollis* De Meijere, 1904a:1.

*Cidaris (Cidaris) maculicollis:* De Meijere, 1904b:15, pl. 3, figs 18-19, pl. 11, figs 111-116.

*Acanthocidaris hastigera* Agassiz and Clark, 1907:39, pl. 11, figs 1-5, pl. 12, figs 1-17, pl. 12b, figs 18, 19, pls 37-42; Mortensen, 1928b:325 (synonymy), pl. 83, fig. 11.

*Acanthocidaris maculicollis:* Koehler, 1927:23, pl. 5, figs 2-3, pl. 23, fig. 4; Mortensen, 1928b:329 (synonymy), pl. 43, figs 1-2, pl. 44, fig. 1, pl. 54, figs 5-6, pl. 83, figs 12-15; 1932:157, pl. 5, fig. 6, pl. 11, fig. 5.

*Acanthocidaris curvatispinis:* Mortensen, 1928b:323 (synonymy), pl. 83, figs 16-18; Mortensen, 1932:156, pl. 5, figs 1-5, pl. 11, fig. 4, pl. 12, fig. 8; Mortensen, 1939:17, pl. 5, fig. 3.

**Diagnosis:** Primary spines are dorso-ventrally compressed and the collars are relatively long and conspicuous; colour pattern of primary spines is variable, but small dark spots are usually present in longitudinal series on the collars; spines below the upper 1 or 2

have numerous, low and narrow dark-coloured longitudinal ridges on upper and lower surface of shaft.

**Material:** 10 specimens in the Australian Museum collection: (9 specimens from between Ballina and the Solitary Islands, N.S.W. 108-126m; 1 specimen from Jurien Bay, W.A. 108m).

**Distribution:** Mauritius; Indonesia; northern N.S.W.; Hawaii; ?southern Africa; ?southwestern Australia; ?Japan. 40-355m.

**Remarks:** The three nominal species which have been referred to *Acanthocidaris* apparently differ from each other only in colour pattern. The colour of the spines given in the original description of each of the species is indicated in Table 3. The descriptions of *curvatispinis* and *hastigera* do not indicate the presence of spots on the collars of these species, but the plates provided with each of the original descriptions shows that the collars are indeed spotted. Despite the apparent colour differences, and because no significant morphological differences are known to exist between the nominal species, we consider them to be synonymous, and the name *curvatispinis* has priority. Mortensen (1928b) indicated that the distinction between *curvatispinis* and *hastigera* could probably not be maintained.

The *Acanthocidaris* specimens from N.S.W. waters present yet another apparently constant colour form. The shafts of the primary spines of all the N.S.W. specimens examined are red/brown on the upper surface and markedly paler on the lower surface. There are numerous low, narrow, dark brown longitudinal ridges on both sides. Some of the spines also have indistinct, darker spots occurring at intervals along the shaft. The uppermost 1-2 spines are not distinctively marked; they are without collars, and longitudinal ridges are absent.

TABLE 3

*Original descriptions of the colour patterns of the nominal species of* Acanthocidaris

| | Primary spines | | Secondary spines |
|---|---|---|---|
| | collar | shaft | |
| *curvatispinis* Bell, 1882 | creamy yellow | reddish brown, occ. banded brown and pale yellow at tip | creamy or yellowish |
| *hastigera* Agassiz & Clark, 1907 | yellowish or porcelain | brown with a pinkish tinge | uniformly chocolate brown |
| *maculicollis* De Meijere, 1904 | pale greenish white with many red spots | ground colour not stated; 3-4 indistinct red bands | with a longitudinal median dark line |

Collar ornamentation varies slightly between individuals and according to position of the spine on the test. Small specimens, and spines situated low on the test of larger specimens, have collars with pale yellow ground colour and numerous red/brown spots arranged in 5-7 longitudinal rows on the upper surface, corresponding to the longitudinal ridges of the shaft. Towards the base of the collar, the red/brown colour becomes

have numerous, low and narrow dark-coloured longitudinal ridges on upper and lower surface of shaft.

**Material:** 10 specimens in the Australian Museum collection: (9 specimens from between Ballina and the Solitary Islands, N.S.W. 108-126m; 1 specimen from Jurien Bay, W.A. 108m).

**Distribution:** Mauritius; Indonesia; northern N.S.W.; Hawaii; ?southern Africa; ?southwestern Australia; ?Japan. 40-355m.

**Remarks:** The three nominal species which have been referred to *Acanthocidaris* apparently differ from each other only in colour pattern. The colour of the spines given in the original description of each of the species is indicated in Table 3. The descriptions of *curvatispinis* and *hastigera* do not indicate the presence of spots on the collars of these species, but the plates provided with each of the original descriptions shows that the collars are indeed spotted. Despite the apparent colour differences, and because no significant morphological differences are known to exist between the nominal species, we consider them to be synonymous, and the name *curvatispinis* has priority. Mortensen (1928b) indicated that the distinction between *curvatispinis* and *hastigera* could probably not be maintained.

The *Acanthocidaris* specimens from N.S.W. waters present yet another apparently constant colour form. The shafts of the primary spines of all the N.S.W. specimens examined are red/brown on the upper surface and markedly paler on the lower surface. There are numerous low, narrow, dark brown longitudinal ridges on both sides. Some of the spines also have indistinct, darker spots occurring at intervals along the shaft. The uppermost 1-2 spines are not distinctively marked; they are without collars, and longitudinal ridges are absent.

TABLE 3

*Original descriptions of the colour patterns of the nominal species of* Acanthocidaris

| | Primary spines | | Secondary spines |
|---|---|---|---|
| | collar | shaft | |
| *curvatispinis* Bell, 1882 | creamy yellow | reddish brown, occ. banded brown and pale yellow at tip | creamy or yellowish |
| *hastigera* Agassiz & Clark, 1907 | yellowish or porcelain | brown with a pinkish tinge | uniformly chocolate brown |
| *maculicollis* De Meijere, 1904 | pale greenish white with many red spots | ground colour not stated; 3-4 indistinct red bands | with a longitudinal median dark line |

Collar ornamentation varies slightly between individuals and according to position of the spine on the test. Small specimens, and spines situated low on the test of larger specimens, have collars with pale yellow ground colour and numerous red/brown spots arranged in 5-7 longitudinal rows on the upper surface, corresponding to the longitudinal ridges of the shaft. Towards the base of the collar, the red/brown colour becomes

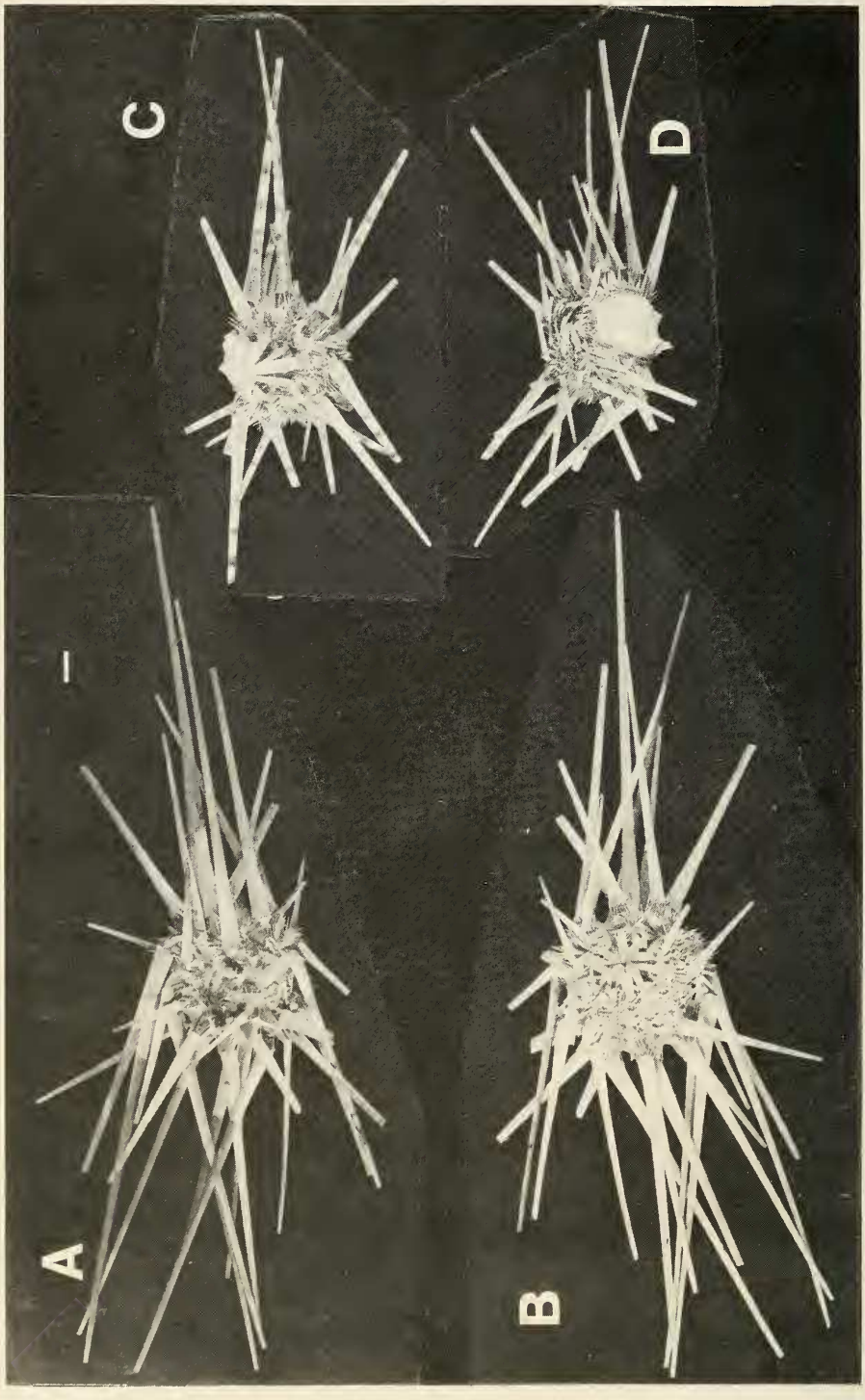


*Fig. 10. Acanthocidaris curvatispinis.* **A,B.** J16176(3), off North Solitary Is., N.S.W., 120-126m. **C,D.** J17938, Jurien Bay, W.A., 108m. Scale = 10mm.

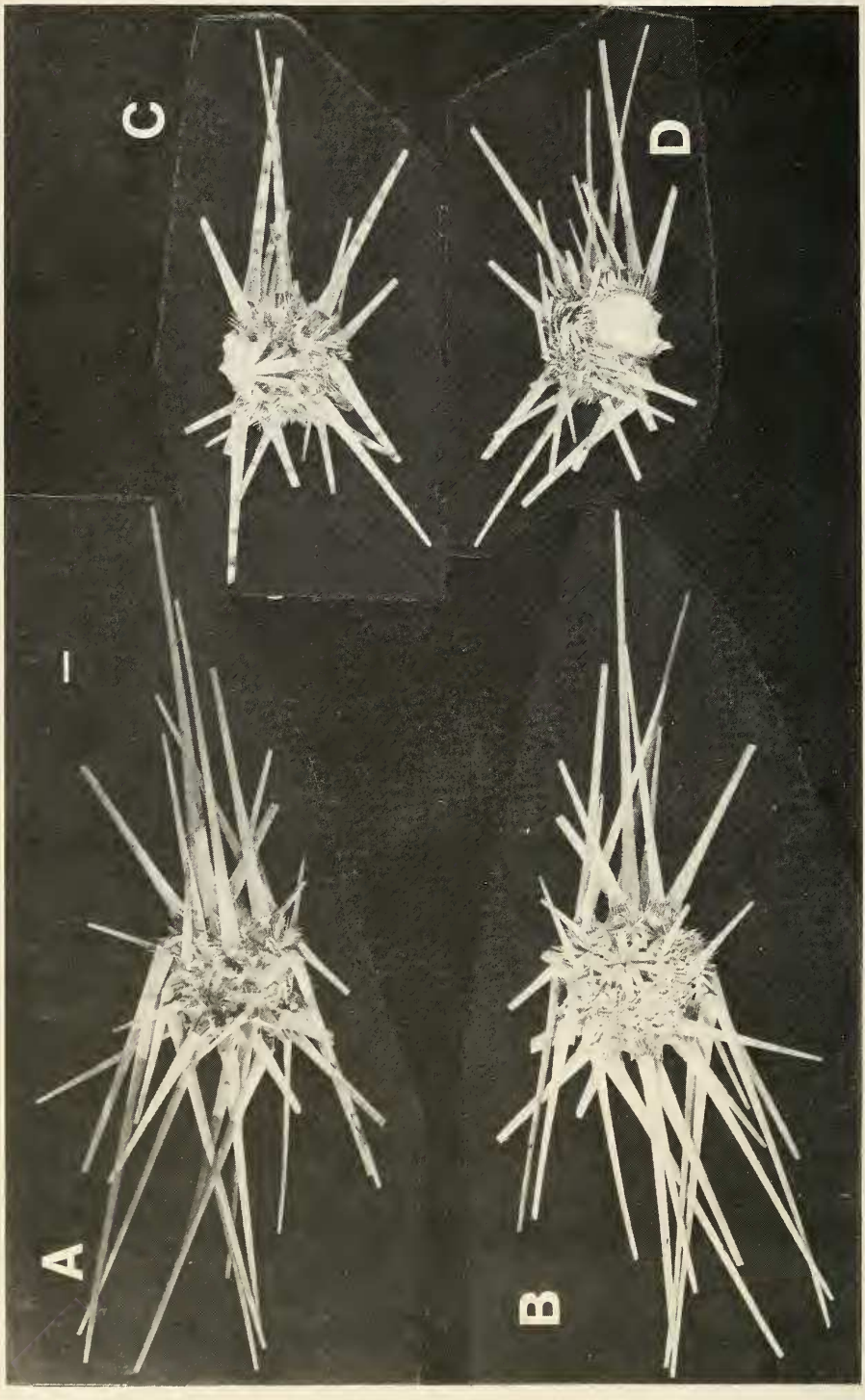


*Fig. 10. Acanthocidaris curvatispinis.* **A,B.** J16176(3), off North Solitary Is., N.S.W., 120-126m. **C,D.** J17938, Jurien Bay, W.A., 108m. Scale = 10mm.

more diffuse, and the colour pattern appears to be reversed: pale spots on a red/brown background. It is only on spines very low on the test that the pale areas between the red spots in each longitudinal series are situated on small tubercles. Larger specimens, and spines situated high on the test have collars with less marked ornamentation. Their upper surfaces are more or less uniform pink/brown with slightly paler longitudinal lines corresponding to the dark longitudinal lines on the shaft. The lower collar surface is generally paler, and is usually yellow laterally and pink/brown centrally, or longitudinal lines of red/brown spots may occur as on the upper surface.

The scrobicular spines are red/brown on the upper and lower sides of the areoles, and olive green with a darker green centre line on the lateral sides of the areoles. The marginal spines of the ambulacra are red/brown. 'Large' globiferous pedicellariae are as described for *curvatispinis* and *hastigera* (Mortensen, 1928b), having a long, poorly-defined terminal opening without an end tooth. An inconspicuous limb of projecting rods is present on the stalk. The 'small' globiferous pedicellariae have a distinct end tooth, and tridentate pedicellariae are present. Some measurements of the N.S.W. specimens are given in Table 4.

TABLE 4

*Measurements of individuals of* Acanthocidaris curvatispinis

1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = no. ambulacrals/interambulacral, 9 = pore zone width (mm), 10 = interpore zone width (mm), 11 = no. of exsert oculars, 12 = longest spine (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J17938 | 38 | 27 | 15 | 13 | 17 | 4.7 | 8 | — | 1.3 | 2.0 | 0 | 87 |
| J16175-1 | 38 | 26 | 18 | 14 | 18 | 4.1 | 8 | — | 1.2 | 1.9 | ⩽2 | 121 |
| J15770 | 40 | 28 | 16 | 15 | 19 | 4.3 | 8 | 11 | 1.4 | 1.9 | ⩽2 | 97 |
| J16175-2 | 41 | 29 | 18 | 16 | 21 | 5.0 | 9 | — | 1.2 | 2.2 | 1 | 127 |
| J16176-3 | 42 | 29 | 16 | 14 | 21 | 4.4 | 8 | 11 | 1.5 | 2.2 | 0 | 124 |
| J16176-4 | 42 | 29 | 18 | 14 | 21 | 5.2 | 9 | — | 1.6 | 2.2 | 0 | 119 |
| J16176-2 | 44 | 29 | 18 | 18 | 21 | 5.0 | 8 | 12 | 1.6 | 2.5 | 0 | 130 |
| J16176-1 | 46 | 34 | 19 | — | 23 | 5.0 | 9 | — | 1.7 | 2.0 | — | 135 |
| J15571-1 | 61 | 47 | 24 | 18 | 28 | 7.0 | 10 | 13 | 2.0 | 2.7 | 0 | — |
| J15571-2 | 61 | 49 | 25 | 18 | 31 | 7.0 | 10 | — | 1.8 | 2.7 | 0 | 121 |

The N.S.W. specimens run down to *maculicollis* in Mortensen's (1928b) key, due to the presence of red spots on the collar of the primary spines. However, we have found that this character is not diagnostic of *maculicollis* as it is shared by the other two nominal species. The N.S.W. specimens resemble photographs of: the types *maculicollis* (De Meijere, 1904b: pl. 3, figs 18-19); specimens of *maculicollis* from the Indian Ocean (Koehler, 1927: pl. 5, figs 2-3); the types of *hastigera* (Agassiz and Clark, 1907: pls 37-42); and specimens of *curvatispinis* from Mauritius, the type locality of the species (Mortensen, 1932: pl. 5, figs 1-5).

The specimens identified as *maculicollis* by Mortensen (1928b: pl. 43, pl. 44, fig. 1; 1932: pl. 5, fig. 6) do appear to have a different colour pattern from the specimens indicated above. The dark spots on the collar are of a greater intensity, and appear to be more widely distributed over the collar. The bands of darker colour on the shafts of the primary spines are also much more conspicuous, especially in the specimen depicted in Mortensen's pl. 43.

more diffuse, and the colour pattern appears to be reversed: pale spots on a red/brown background. It is only on spines very low on the test that the pale areas between the red spots in each longitudinal series are situated on small tubercles. Larger specimens, and spines situated high on the test have collars with less marked ornamentation. Their upper surfaces are more or less uniform pink/brown with slightly paler longitudinal lines corresponding to the dark longitudinal lines on the shaft. The lower collar surface is generally paler, and is usually yellow laterally and pink/brown centrally, or longitudinal lines of red/brown spots may occur as on the upper surface.

The scrobicular spines are red/brown on the upper and lower sides of the areoles, and olive green with a darker green centre line on the lateral sides of the areoles. The marginal spines of the ambulacra are red/brown. 'Large' globiferous pedicellariae are as described for *curvatispinis* and *hastigera* (Mortensen, 1928b), having a long, poorly-defined terminal opening without an end tooth. An inconspicuous limb of projecting rods is present on the stalk. The 'small' globiferous pedicellariae have a distinct end tooth, and tridentate pedicellariae are present. Some measurements of the N.S.W. specimens are given in Table 4.

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J17938 | 38 | 27 | 15 | 13 | 17 | 4.7 | 8 | — | 1.3 | 2.0 | 0 | 87 |
| J16175-1 | 38 | 26 | 18 | 14 | 18 | 4.1 | 8 | — | 1.2 | 1.9 | ⩽2 | 121 |
| J15770 | 40 | 28 | 16 | 15 | 19 | 4.3 | 8 | 11 | 1.4 | 1.9 | ⩽2 | 97 |
| J16175-2 | 41 | 29 | 18 | 16 | 21 | 5.0 | 9 | — | 1.2 | 2.2 | 1 | 127 |
| J16176-3 | 42 | 29 | 16 | 14 | 21 | 4.4 | 8 | 11 | 1.5 | 2.2 | 0 | 124 |
| J16176-4 | 42 | 29 | 18 | 14 | 21 | 5.2 | 9 | — | 1.6 | 2.2 | 0 | 119 |
| J16176-2 | 44 | 29 | 18 | 18 | 21 | 5.0 | 8 | 12 | 1.6 | 2.5 | 0 | 130 |
| J16176-1 | 46 | 34 | 19 | — | 23 | 5.0 | 9 | — | 1.7 | 2.0 | — | 135 |
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A specimen from Jurien Bay, W.A. (AM J17938, donated by the Western Australian Museum) greatly resembles Mortensen's *'maculicollis'*. The primary spines of this specimen are white/yellow with red/brown spots occurring at intervals on both sides of the shaft, and darker, narrow longitudinal ridges are present. The collars are olive green on both sides, the upper surface with longitudinal series of small red/brown spots occurring on ridges corresponding to those on the shaft. Near the distal edge of the collar on the upper side, the small red/brown spots are arranged to form a larger spot similar to those occurring on the shaft. The under surface of the collar has one or two diffuse, red/brown spots situated centrally. The scrobicular spines are of similar colour pattern to the N.S.W. specimens, and the marginal spines of the ambulacra are olive green. The pedicellariae do not differ from those of the N.S.W. specimens, except that the 'large' globiferous form was not found.

The only morphological differences found between this specimen and the N.S.W. specimens is the slightly shorter length of primary spines and the relatively wider ambulacra in the former. The primary spines of Mortensen's *'maculicollis'* specimens also appear to be slightly shorter than those of other *Acanthocidaris* specimens. If the specimen from W.A. and the *'maculicollis'* specimens reported by Mortensen (1928b: Bay of Ambon, Bonin Islands, Sagami Bay; 1932: southern Africa) are not conspecific with *maculicollis* De Meijere (a synonym of *curvatispinis* Bell), they must represent an unnamed species.

The synonymy of *hastigera* and *maculicollis* with *curvatispinis* results in a species with a very wide geographical distribution. The occurrence of specimens of *A. curvatispinis* in N.S.W. waters represents a considerable extension of range for the species.

## Genus ***Prionocidaris*** Agassiz

*Prionocidaris* is distinguished by the nature of the primary spines and by its distinctly conjugate pores.

The large collection of *Prionocidaris* material from N.S.W. waters in the Australian Museum collection contains two distinct colour forms. Both Mortensen (1928b) and H. L. Clark (1946) indicated the colour of *P. australis* to be variable, and both colour forms had been identified as this species. However, there are consistent morphological differences between them, and one is described as a new species.

### *Prionocidaris australis* (Ramsay)

Figs 11, 13**A**

*Phyllacanthus australis* Ramsay, 1885:3, 46, pl. 1, 1a, 1b.
*Cidaris (Cidaris) glandulosa* De Meijere, 1904b:13, pl. 1, figs 5-6.
*Prionocidaris australis:* Mortensen, 1928b (part):456 (synonymy), pl. 52, pl. 53, fig. 12, ?pl. 73, fig. 17, ?pl. 86, figs 17-19, ?pl. 87, figs 6-8; H. L. Clark, 1946 (part):285.
*Prionocidaris glandulosa:* Mortensen, 1928b:461 (synonymy), pl. 54, figs 7-8, pl. 73, fig. 11, pl. 87, fig. 9.

**Diagnosis:** Collars of the primary spines have white spots on a green to purple background; scrobicular spines have a broad green midline, often becoming brown/purple near the tip; on the denuded test, the ambulacra (particularly the interpore zone) and the median interambulacral sutures are coloured brown/purple, and the apical system is brown/purple with some green; areoles of coronal plates above ambitus more or less circular (height 84-96% of width); coronal plates above ambitus bear a complete ring of scrobicular tubercles.

**Material:** Holotype of *P. australis*, AM J193, South Reef, Port Jackson, N.S.W., 10m; 54 other specimens in the Australian Museum collection (45 from N.S.W. waters and 9 from Qld waters).

A specimen from Jurien Bay, W.A. (AM J17938, donated by the Western Australian Museum) greatly resembles Mortensen's *'maculicollis'*. The primary spines of this specimen are white/yellow with red/brown spots occurring at intervals on both sides of the shaft, and darker, narrow longitudinal ridges are present. The collars are olive green on both sides, the upper surface with longitudinal series of small red/brown spots occurring on ridges corresponding to those on the shaft. Near the distal edge of the collar on the upper side, the small red/brown spots are arranged to form a larger spot similar to those occurring on the shaft. The under surface of the collar has one or two diffuse, red/brown spots situated centrally. The scrobicular spines are of similar colour pattern to the N.S.W. specimens, and the marginal spines of the ambulacra are olive green. The pedicellariae do not differ from those of the N.S.W. specimens, except that the 'large' globiferous form was not found.

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### *Prionocidaris australis* (Ramsay)

Figs 11, 13**A**

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*Cidaris (Cidaris) glandulosa* De Meijere, 1904b:13, pl. 1, figs 5-6.
*Prionocidaris australis:* Mortensen, 1928b (part):456 (synonymy), pl. 52, pl. 53, fig. 12, ?pl. 73, fig. 17, ?pl. 86, figs 17-19, ?pl. 87, figs 6-8; H. L. Clark, 1946 (part):285.
*Prionocidaris glandulosa:* Mortensen, 1928b:461 (synonymy), pl. 54, figs 7-8, pl. 73, fig. 11, pl. 87, fig. 9.

**Diagnosis:** Collars of the primary spines have white spots on a green to purple background; scrobicular spines have a broad green midline, often becoming brown/purple near the tip; on the denuded test, the ambulacra (particularly the interpore zone) and the median interambulacral sutures are coloured brown/purple, and the apical system is brown/purple with some green; areoles of coronal plates above ambitus more or less circular (height 84-96% of width); coronal plates above ambitus bear a complete ring of scrobicular tubercles.

**Material:** Holotype of *P. australis*, AM J193, South Reef, Port Jackson, N.S.W., 10m; 54 other specimens in the Australian Museum collection (45 from N.S.W. waters and 9 from Qld waters).

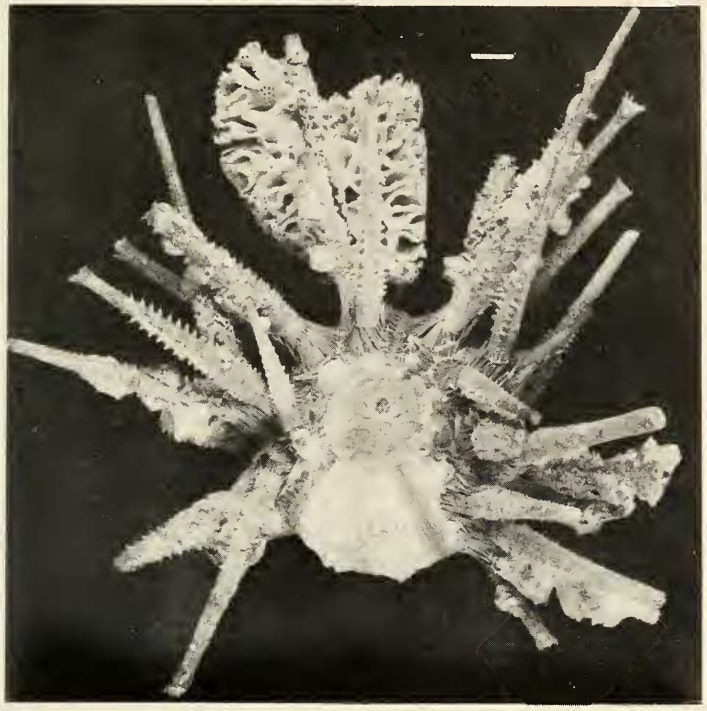

*Fig. 11. Prionocidaris australis*, holotype, J193, Port Jackson, N.S.W., 10m. Scale = 10mm.

**Distribution:** Philippines; Indonesia; Macclesfield Bank; east Australian coast (Fraser Is., Qld to Sydney, N.S.W.). 10-145m.

**Remarks:** Ramsay's original description (1885) of the species referred to two specimens, one of which is figured and referred to in the caption as 'the type'. This is accepted as designation of the holotype, and the specimen is present in the AM collection (J193). The holotype has never been adequately described, so some measurements are included in Table 5. The colour pattern of the holotype is as follows: collars of the primary spines change from purple basally to green distally, with white spots sometimes coalescing into lines; some primary spine tips exhibit pale/dark banding; scrobicular spines are cream-coloured on the edges, with a wide green midline becoming brown/purple near the spine tip; miliary spines are green, inconspicuous; ambulacral spines are brown; denuded test is generally cream-coloured, with the ambulacra conspicuously coloured brown/purple, and patches of this colour also occur on and near the median interambulacral sutures; the denuded apical system is dark, with greenish patches on the genital and ocular plates.

The colour pattern described for the holotype is typical of the species as is here limited. The overall impression of the colour of the animal is pale green. Measurements of a size range of specimens of *P. australis* are shown in Table 5.

Records of *P. australis* from Lord Howe Island (H. L. Clark, 1946) are incorrect, as all the *Prionocidaris* material from that locality present in the AM represents *P. callista* n. sp. Similarly, the record of *P. australis* from Norfolk Island (Pawson, 1965) also represents the new species. The differences between *P. australis* and *P. callista* are outlined on p.256.

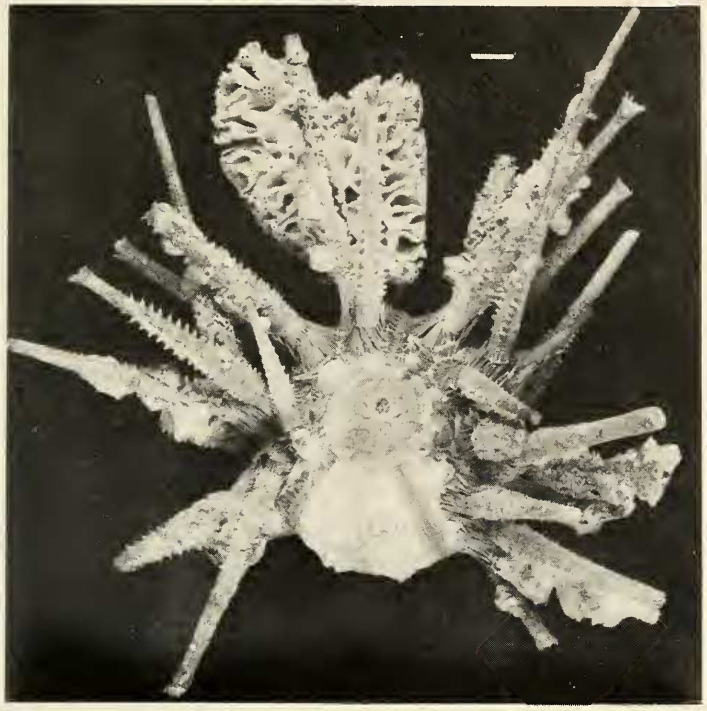

*Fig. 11. Prionocidaris australis*, holotype, J193, Port Jackson, N.S.W., 10m. Scale = 10mm.

**Distribution:** Philippines; Indonesia; Macclesfield Bank; east Australian coast (Fraser Is., Qld to Sydney, N.S.W.). 10-145m.

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TABLE 5

*Measurements of a size range of specimens of* Prionocidaris australis

1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = areole width (mm), 9 = areole height (mm), 10 = height/width areole (%), 11 = maximum spine length (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| J193 (holotype) | 63 | 41 | 27 | 22 | 30.0 | 6.7 | 8-9 | 10.8 | 9.2 | 85 | 81 |
| J16171-1 | 45 | 28 | 19 | 18 | 21.3 | 5.0 | 7 | 8.3 | 7.1 | 86 | 68 |
| J16171-2 | 43 | 25 | 20 | 18 | 20.5 | 4.6 | 7 | 8.3 | 7.2 | 87 | 65 |
| J15846-1 | 36 | 20 | 17 | 16 | 17.0 | 4.1 | 6-7 | 7.0 | 5.9 | 84 | >51 |
| J16171-3 | 28 | 16 | 13 | 13 | 13.5 | 3.4 | 6 | 5.8 | 5.5 | 95 | 60 |
| J18968 | 14 | 6 | 7 | 6 | 6.9 | 1.7 | 5-6 | 2.8 | 2.6 | 93 | 31 |

*P. glandulosa* (De Meijere, 1904b) is known from the Philippines, Indonesia and Macclesfield Bank. Its similarity to *P. australis* (as *P. bispinosa*: Agassiz, 1873, non Lamarck, 1816) has been indicated by De Meijere (1904) and H. L. Clark (1907). In 1925, H. L. Clark implied synonymy of the two nominal species by recording the 10 specimens from Macclesfield Bank as *P. australis*. However, Mortensen (1928b) considered the species to be distinct, owing to the smaller size of *glandulosa*, differences in their colour patterns, and their discontinuous geographical distributions.

The smallest specimen of *australis* in the AM collection (J18968, Table 5) was collected from off Moreton Bay, Qld in 75m. This specimen clearly fits into the growth series of *australis*, but it also has many of the features of *glandulosa*. Indeed, this specimen greatly resembles the photograph of a specimen of *glandulosa* published by Mortensen (1928b: pl. 54, figs 7-8). The specimen shares the following features with *glandulosa*: small size (the largest known specimen of *glandulosa* is 27mm in horizontal diameter), markings are more distinct on the adapical side of the collar, the apical system has a star-like pattern formed from dark-coloured genital and periproctal plates, and white ocular plates, and globiferous pedicellariae, without an end tooth on each valve and with a limb on the stalk, are common. De Meijere named the species *'glandulosa'* due to the abundance of these pedicellariae on the type specimens. Mortensen (1928b) notes, however, that the abundance of these pedicellariae is variable in *glandulosa*. On the basis of the obvious overlap of characters of this small specimen of *australis* with the descriptions of *glandulosa*, we consider *glandulosa* to be a junior synonym of *australis*. Collecting in suitable areas of Queensland should find the species. It is interesting that the species does not appear to reach a large size in tropical waters.

*Prionocidaris callista* n. sp.

Figs 12**A-B**, 13**B**

*Prionocidaris australis:* Mortensen, 1928b (part):456; H. L. Clark, 1946 (part):285; Pawson, 1965:202, pl. 2, figs 1-3; [non *P. australis* (Ramsay, 1885) ].

**Diagnosis:** Collars of the primary spines have white spots on a brown/maroon background; scrobicular spines are red to maroon in colour; the ambulacra and apical system are slightly darker in colour than the rest of the cream-coloured denuded test, and the interambulacra are not pigmented; areoles of coronal plates above the ambitus are considerably wider than high (height 71-79% of width in specimens with horizontal diameter greater than 16mm); scrobicular tubercles of coronal plates above ambitus are reduced in size on the upper and lower sides of the areole.

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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| J193 (holotype) | 63 | 41 | 27 | 22 | 30.0 | 6.7 | 8-9 | 10.8 | 9.2 | 85 | 81 |
| J16171-1 | 45 | 28 | 19 | 18 | 21.3 | 5.0 | 7 | 8.3 | 7.1 | 86 | 68 |
| J16171-2 | 43 | 25 | 20 | 18 | 20.5 | 4.6 | 7 | 8.3 | 7.2 | 87 | 65 |
| J15846-1 | 36 | 20 | 17 | 16 | 17.0 | 4.1 | 6-7 | 7.0 | 5.9 | 84 | >51 |
| J16171-3 | 28 | 16 | 13 | 13 | 13.5 | 3.4 | 6 | 5.8 | 5.5 | 95 | 60 |
| J18968 | 14 | 6 | 7 | 6 | 6.9 | 1.7 | 5-6 | 2.8 | 2.6 | 93 | 31 |

*P. glandulosa* (De Meijere, 1904b) is known from the Philippines, Indonesia and Macclesfield Bank. Its similarity to *P. australis* (as *P. bispinosa*: Agassiz, 1873, non Lamarck, 1816) has been indicated by De Meijere (1904) and H. L. Clark (1907). In 1925, H. L. Clark implied synonymy of the two nominal species by recording the 10 specimens from Macclesfield Bank as *P. australis*. However, Mortensen (1928b) considered the species to be distinct, owing to the smaller size of *glandulosa*, differences in their colour patterns, and their discontinuous geographical distributions.

The smallest specimen of *australis* in the AM collection (J18968, Table 5) was collected from off Moreton Bay, Qld in 75m. This specimen clearly fits into the growth series of *australis*, but it also has many of the features of *glandulosa*. Indeed, this specimen greatly resembles the photograph of a specimen of *glandulosa* published by Mortensen (1928b: pl. 54, figs 7-8). The specimen shares the following features with *glandulosa*: small size (the largest known specimen of *glandulosa* is 27mm in horizontal diameter), markings are more distinct on the adapical side of the collar, the apical system has a star-like pattern formed from dark-coloured genital and periproctal plates, and white ocular plates, and globiferous pedicellariae, without an end tooth on each valve and with a limb on the stalk, are common. De Meijere named the species *'glandulosa'* due to the abundance of these pedicellariae on the type specimens. Mortensen (1928b) notes, however, that the abundance of these pedicellariae is variable in *glandulosa*. On the basis of the obvious overlap of characters of this small specimen of *australis* with the descriptions of *glandulosa*, we consider *glandulosa* to be a junior synonym of *australis*. Collecting in suitable areas of Queensland should find the species. It is interesting that the species does not appear to reach a large size in tropical waters.

*Prionocidaris callista* n. sp.

Figs 12**A-B**, 13**B**

*Prionocidaris australis:* Mortensen, 1928b (part):456; H. L. Clark, 1946 (part):285; Pawson, 1965:202, pl. 2, figs 1-3; [non *P. australis* (Ramsay, 1885) ].

**Diagnosis:** Collars of the primary spines have white spots on a brown/maroon background; scrobicular spines are red to maroon in colour; the ambulacra and apical system are slightly darker in colour than the rest of the cream-coloured denuded test, and the interambulacra are not pigmented; areoles of coronal plates above the ambitus are considerably wider than high (height 71-79% of width in specimens with horizontal diameter greater than 16mm); scrobicular tubercles of coronal plates above ambitus are reduced in size on the upper and lower sides of the areole.

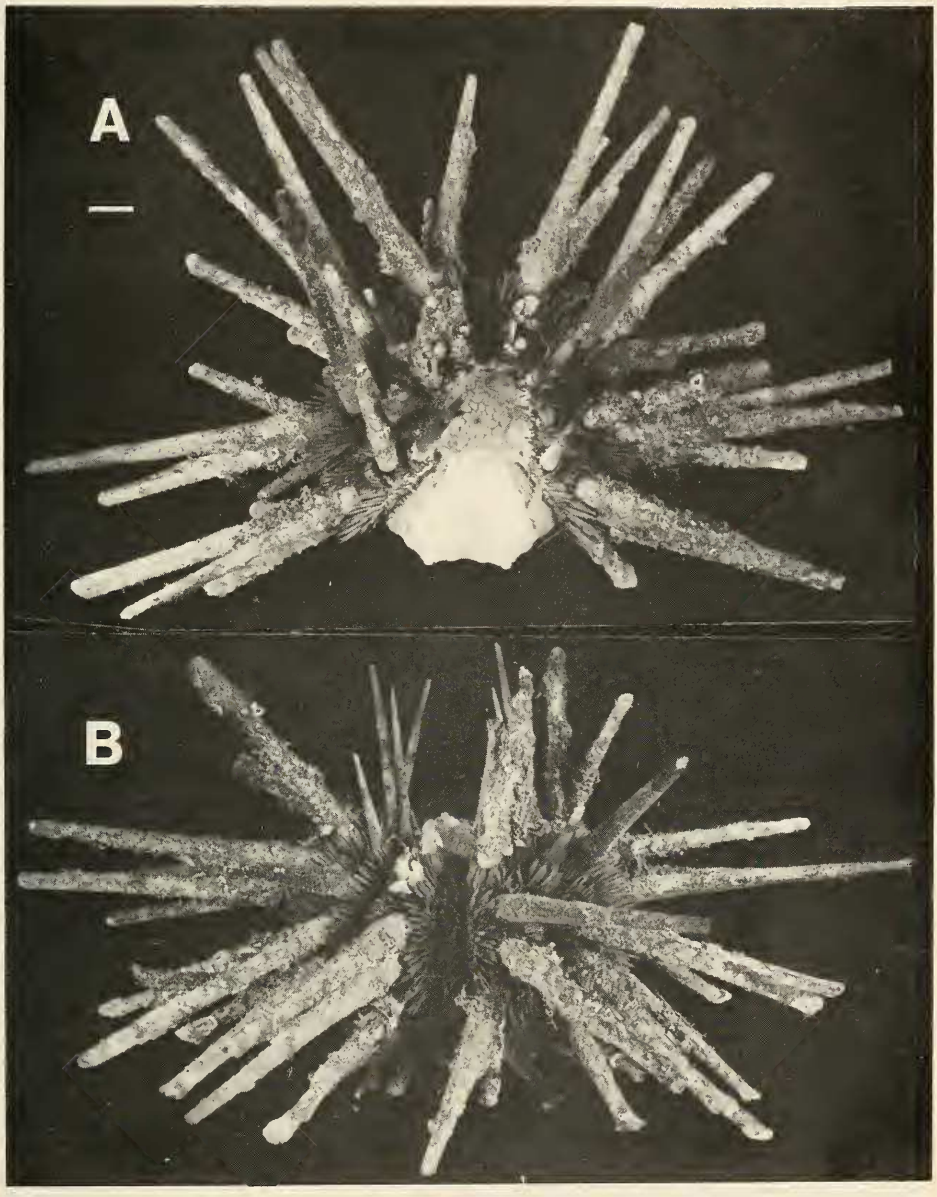
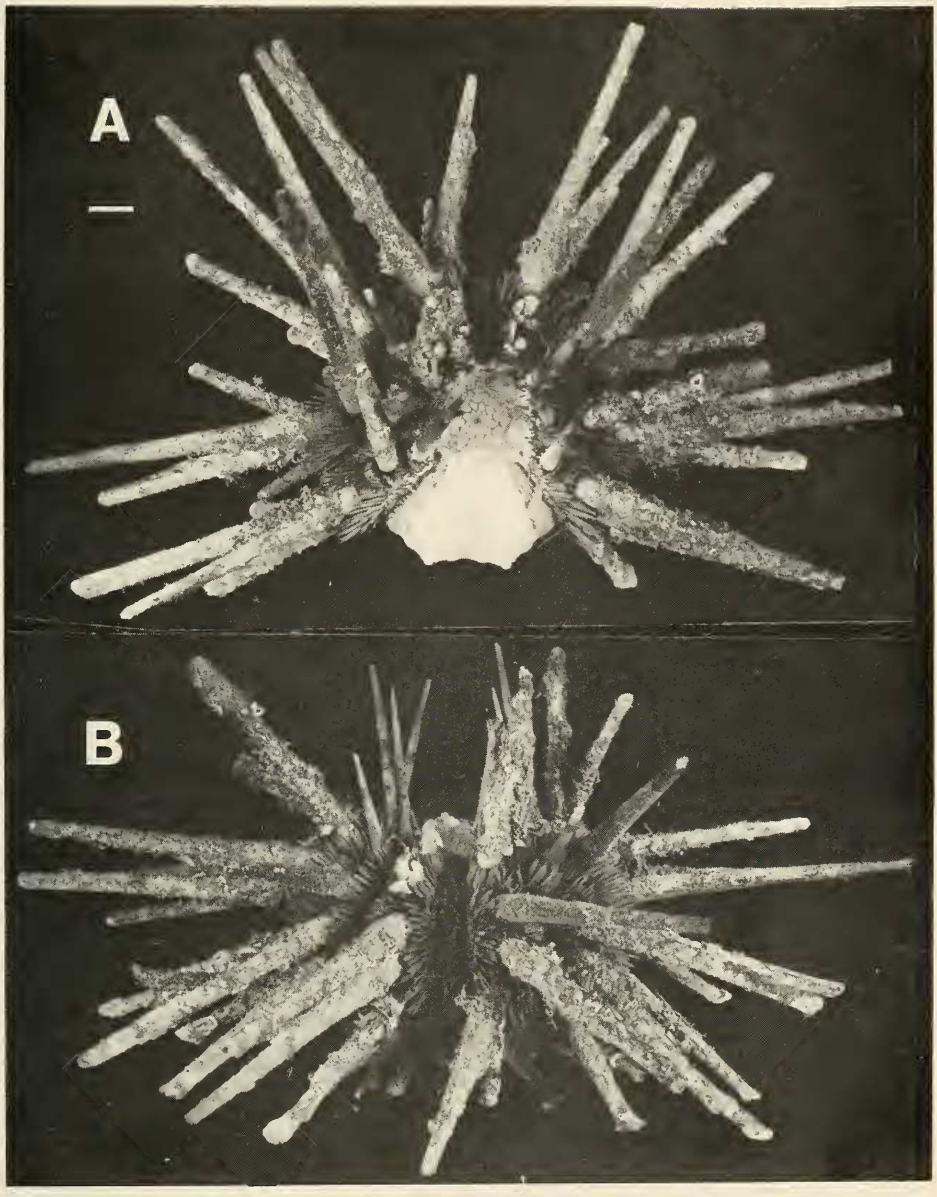



*Fig. 12.* **A,B.** *Prionocidaris callista*, holotype, J15715, Port Jackson, N.S.W., 2-4m. Scale = 10mm.

**Material:** Holotype, AM J15715, Bottle and Glass Rocks, Port Jackson, N.S.W., 2-4m; 5 paratypes, AM J18919-18923, South Solitary Is., N.S.W., 28m; 118 other specimens in the Australian Museum collection (57 specimens from N.S.W. coastal waters, 57 from Lord Howe Island area, 3 from Qld waters, and 2 from New Caledonia); 5 specimens, NMNZ Ech 1988, 4165, Raoul Island, Kermadec Islands, 20-44m.

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**Distribution:** Bushy Is., Qld (20°57'S 150°05'E) to Montague Is., N.S.W.; Lord Howe Island; Norfolk Island; Kermadec Islands; New Caledonia. 2-275m.
**Etymology:** The species is named from the Greek *callista*, for its pleasing appearance.
**Description of holotype:** Dimensions of the holotype are listed in Table 6.

The ambulacra are only very slightly sinuate, the pore zones being sunken relative to the interpore zone and to the interambulacra. The pores are widely separated, conjugate. The interpore zone is about equal to the width of a pore zone at the ambitus. The marginal ambulacral tubercles are smaller than the scrobicular tubercles, in regular series. One to several smaller tubercles occur inside the marginals, usually also in regular longitudinal series. The denuded interpore zone is slightly green in colour.

The interambulacra have 10 coronal plates in each series. The coronal plates and areoles are markedly wider than high, the areoles separated only by a few reduced scrobicular tubercles. Laterally, there are 2-3 uneven rows of larger scrobicular tubercles. Outside these, the plate is covered with numerous, very small tubercles. The median area is about as broad as an areole, and when denuded, has a slightly greenish cast.

TABLE 6

*Measurements of the holotype (J15715) and paratypes (J18919-23) of* Prionocidaris callista
1 = horizontal diameter (mm), 2 = vertical diameter (mm), 3 = apical system diameter (mm), 4 = peristome diameter (mm), 5 = interambulacrum width (mm), 6 = ambulacrum width (mm), 7 = no. interambulacrals, 8 = areole width (mm), 9 = areole height (mm), 10 = height/width areole (%), 11 = maximum spine length (mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| J15715 | 60 | 38 | 26 | 21 | 29.7 | 7.4 | 10 | 9.7 | 7.2 | 74 | 74 |
| J18919 | 43 | 24 | 18 | 17 | 21.6 | 4.9 | 7-8 | 7.9 | 5.6 | 71 | 72 |
| J18920 | 39 | 23 | 16 | 17 | 19.4 | 4.8 | 7-8 | 7.7 | 5.6 | 73 | 63 |
| J18921 | 31 | 16 | 14 | 12 | 14.2 | 3.2 | 7 | 6.2 | 4.8 | 77 | 61 |
| J18922 | 28 | 15 | 13 | 12 | 13.0 | 3.4 | 6-7 | 5.6 | 4.2 | 75 | 55 |
| J18923 | 17 | 8 | 8 | 8 | 7.6 | 2.0 | 6 | 3.4 | 2.7 | 79 | 29 |

The apical system has all the oculars insert, those abutting the slightly enlarged madreporite are less widely insert than the others. The outer edges of the denuded apical system plates are greenish, and the madreporite is brown.

Primary spines at the ambitus are slightly longer than the horizontal test diameter. They are of the form described for *P. australis* by Mortensen (1928b:458). Apart from the newly-formed adapical spines and the oral spines, the primary radioles are more or less completely covered with encrusting organisms. The collars are conspicuous, up to 4mm long, red with white spots which sometimes coalesce into lines.

The scrobicular spines are flattened. The marginal ambulacral spines are flattened basally, becoming round in cross-section near the tip, and tapering. The miliary spines are very short and pointed, not appressed to the test. Spines on the apical system of the holotype have been removed, but the paratype series shows the apical system to be covered with spines of varying lengths, so it does not appear conspicuously bare. All the secondary spines are dark red, with some of the miliary spines being brown/green at the base.

Tridentate and large globiferous pedicellariae were not found on the holotype. The small globiferous pedicellariae have a distinct end tooth, and exhibit no major differences from those described for *P. australis* (Mortensen, 1928b: pl. 87, fig. 6).
**Remarks:** The paratypes represent a wide size range of specimens, and their measurements are listed in Table 6. The width of the median interambulacral area appears to

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| J18920 | 39 | 23 | 16 | 17 | 19.4 | 4.8 | 7-8 | 7.7 | 5.6 | 73 | 63 |
| J18921 | 31 | 16 | 14 | 12 | 14.2 | 3.2 | 7 | 6.2 | 4.8 | 77 | 61 |
| J18922 | 28 | 15 | 13 | 12 | 13.0 | 3.4 | 6-7 | 5.6 | 4.2 | 75 | 55 |
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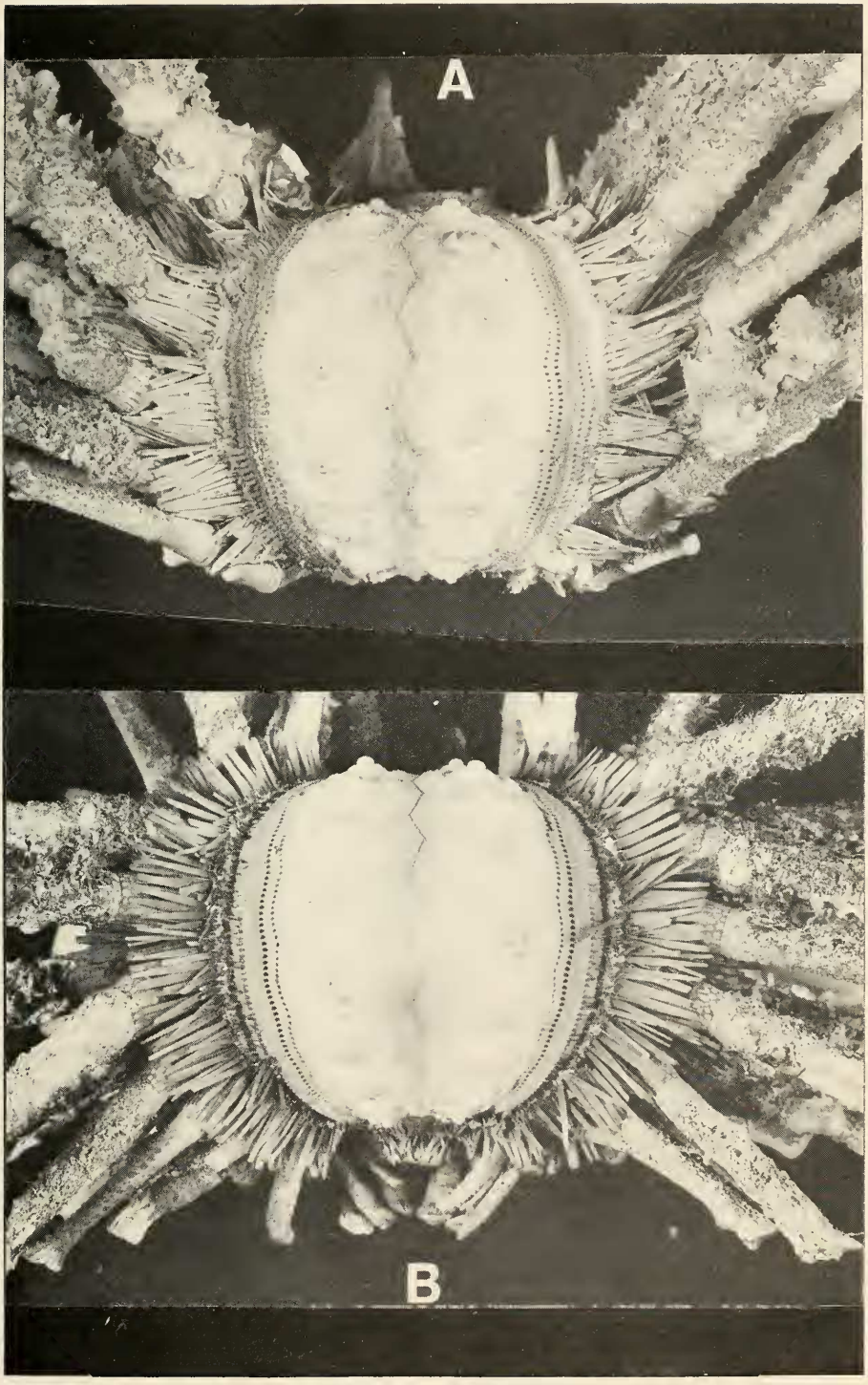
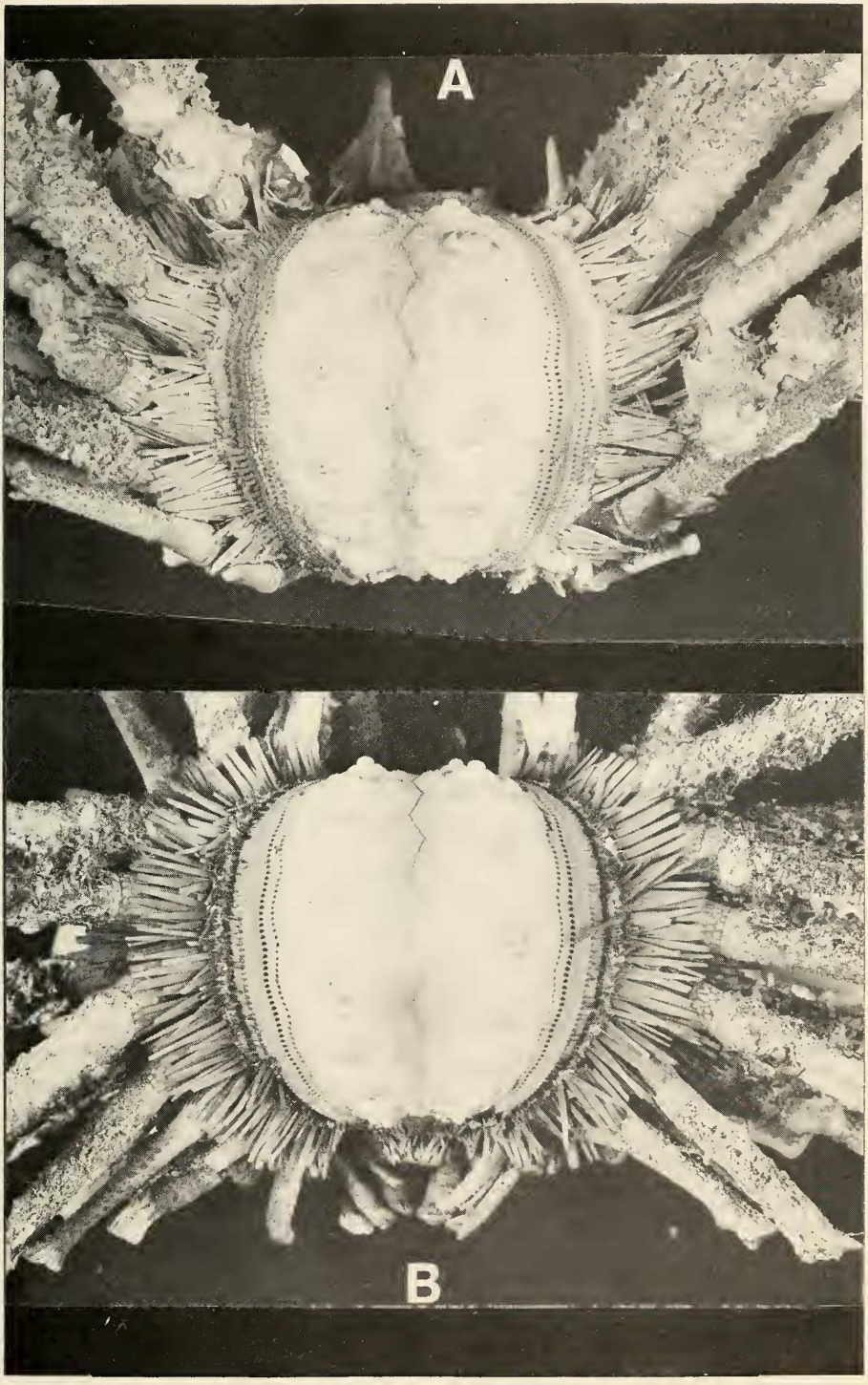



*Fig. 13.* Lateral view of test of **A.** *Prionocidaris australis*, and, **B.** *P. callista.*

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increase with growth; this area may be only half the width of an areole in specimens smaller than the holotype. The paratypes do not otherwise differ significantly from the holotype.

The ambulacra of *callista* differ from those of *australis* in having a more densely tuberculated interpore zone. The colours of the denuded ambulacra are also different, that of *australis* being dark purple/brown, while that of *callista* is pale green or fawn.

The interambulacra show the most striking difference between the species. At a particular size, *callista* has one or two more coronal plates than *australis*. The areoles of *callista* are more transversely oval than those of *australis*, and the upper and lower scrobicular tubercles are much reduced in the former species, whereas on *australis*, the scrobicular ring is made up of more or less equally-sized tubercles. The median area of the denuded interambulacra may either have a greenish cast or be unpigmented in *callista*, but there are more or less distinct purplish patches in this position in *australis*. In large specimens, the median area of the interambulacra is about the width of an areole in *callista*, but is only about half this width in *australis*.

Very small specimens of *callista* (less than 17mm in horizontal diameter) may only be distinguishable from *P. australis* by their colour, as the oval shape of the areoles is a feature which becomes more conspicuous with growth.

*P. callista* appears to be closely related to *P. hawaiiensis* (Agassiz and Clark, 1907), which is known only from Hawaii. We have examined a specimen of *hawaiiensis* (AM G6098) of horizontal test diameter 27mm. The areoles of this specimen (height 80-83% of width) are slightly more round in shape than those of *callista*. There are major differences in colour: the naked ambulacra are bright orange in *hawaiiensis* and greenish or brownish in *callista*, and the primary spines are more or less orange in *hawaiiensis* and dark purple in *callista*. The primary spines of *callista* are shorter and broader than those of *hawaiiensis*. The proximal third of the primary spines of *callista* is noticeably bulging, whereas the primary spines of *hawaiiensis* taper continuously in the specimen at hand and Agassiz and Clark's photographs (1907: pl. 24-25).

We have not examined the small specimen from Norfolk Island reported by Pawson (1965) as *P. australis*, but consider this specimen represents *P. callista*.

## Genus ***Phyllacanthus*** Brandt

The genus *Phyllacanthus* is very well-defined. Characters which separate it from other cidarid genera include: the nature of the pedicellariae, pore pairs are conjugate and occur in a double series on the peristome, madreporite is much enlarged, and the scrobicular tubercles are modified (Mortensen, 1928b).

Seven recent species of *Phyllacanthus* are known, of which five occur in Australian waters with little overlap in their distribution. *P. imperialis* (Lamarck, 1816) is widespread in the tropical Indo-Pacific (Clark and Rowe, 1971), and specimens in the Australian Museum have been collected from along the Queensland coast as far south as the Whitsunday Islands. *P. parvispinus* Tenison-Woods, 1880, is endemic to southeastern Australia, and is represented in the Australian Museum collections by specimens from Mooloolaba, Qld, to Gabo Island, Vic., and has been reported from Tasmania (Dartnall, 1980). *P. irregularis* Mortensen, 1928a, is endemic to southwestern Australia, occurring from Perth, W.A. to South Australia. *P. magnificus* H. L. Clark, 1914, was known only from the two type specimens, from between Fremantle and Geraldton, W.A. A juvenile specimen (Western Australian Museum 985-74) and four detached spines (WAM 572-71) appear to belong to this species, and extend the range of *magnifica* north to Shark Bay. *P. longispinus* Mortensen, 1918, is endemic to the west and north coasts of Australia (H. L. Clark, 1946; Clark and Rowe, 1971). Its distribution apparently

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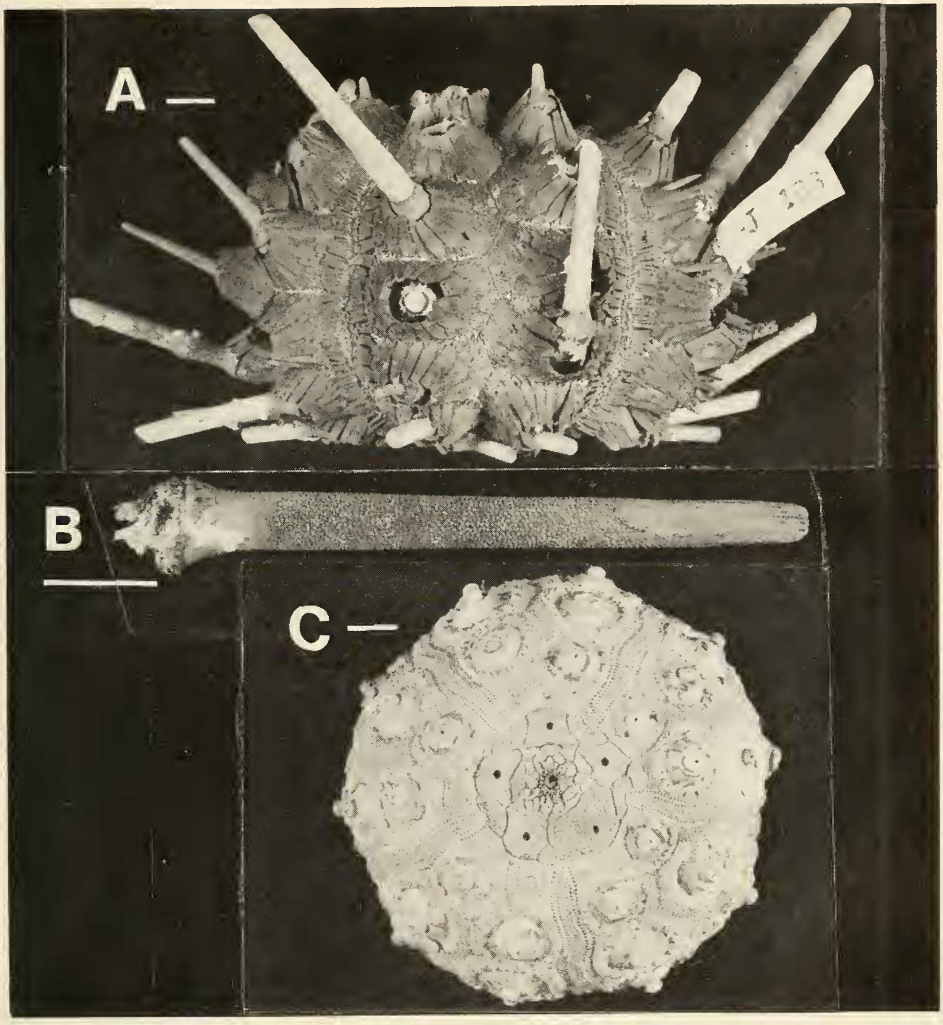



*Fig. 14. Phyllacanthus parvispinus.* **A.** Lectotype, J186, Port Jackson, N.S.W. **B.** Primary spine of J186. **C.** Paralectotype, J187, Port Jackson, N.S.W. Scale = 10mm.

overlaps that of *irregularis* and *magnificus* as a specimen from Rottnest Island, W.A. (WAM 12021), appears to represent *longispinus*, although it has primary spines which are shorter than usual. The five bear considerable superficial resemblance to each other.

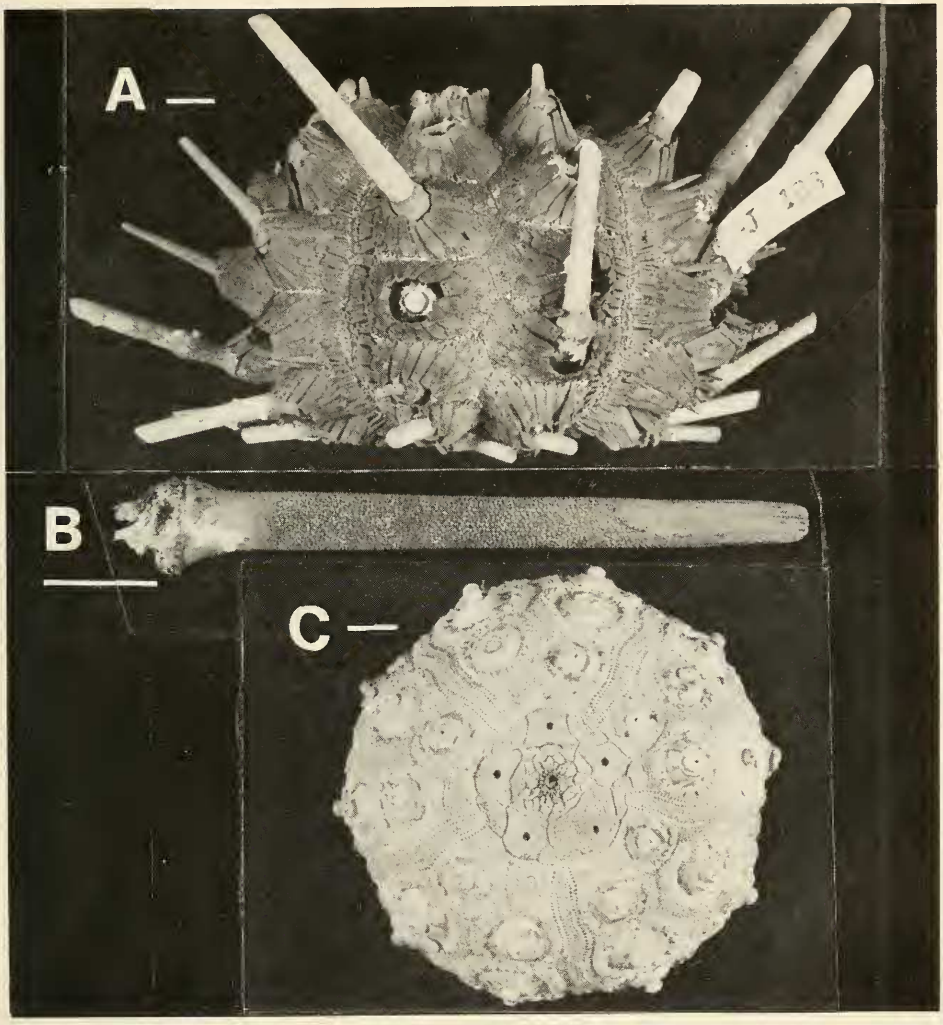
*P. dubius* Brandt, 1835, from the Bonin Islands, appears to be closely related to *longispinus*, from which it differs mainly in having shorter primary spines. The existence of a short-spined specimen of *longispinus* in southwestern Australia may indicate that these nominal species are synonymous. *P. forcipulatus* Mortensen, 1936, from the Indian Ocean, has well-developed, coarse longitudinal ridges on the primary spines, which are unlike those of the other *Phyllacanthus* species.

*Phyllacanthus parvispinus* Tenison-Woods

Figs 14**A-C**, 15

*Phyllacanthus parvispina* Tenison-Woods, 1880:286, pl. 14.

*Phyllacanthus parvispinus:* Mortensen, 1928b:513, pl. 63, figs 1-3, pl. 64, fig. 3, pl. 74, fig. 8, pl. 88, figs 18-24; H. L. Clark, 1946:283; Dartnall, 1980:43.

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**Diagnosis:** Primary spines are long, robust, and taper only slightly, terminating abruptly at a blunt tip; shaft of primary spine appears coarsely reticulate, due to the presence of numerous, low rounded projections without serial arrangement other than near the tip; marginal ambulacral spines very regular in length and arrangement, flattened with rounded tips; miliary spines on apical system are short, flattened and scale-like.

**Material:** Lectotype of *P. parvispinus*, AM J186, Port Jackson, N.S.W.; 1 paralectotype, AM J187, Port Jackson, N.S.W.; 160 other specimens in the Australian Museum collection (6 specimens from Queensland waters, 153 from N.S.W. waters, and 1 from Victorian waters); 3 specimens, NMNZ Ech 607, 274, Meyer Island and Macauley Island, Kermadec Islands.

**Distribution:** Pt. Cartwright, Mooloolaba, Qld, to Gabo Island, Vic., and Tasmania; Kermadec Islands. Shore — 80m.

**Remarks:** Tenison-Woods (1880) indicated that *P. parvispinus* was based on a number of specimens. However, he did not specify a type specimen, beyond providing figures of two specimens (pl. 14 A-B) labelled 'type specimen'. Both these specimens are present in the Australian Museum, and the larger, more intact specimen (J186) is here designated as the lectotype. The other specimen (J187) is thus a paralectotype. A specimen in the National Museum of Victoria, Australia, (H137), which was listed as a syntype of *parvispinus* by Smith (1970), is thus also a paralectotype. Tenison-Woods (1880) gave measurements of a specimen of horizontal diameter 100mm. Neither of the Australian Museum specimens, nor the Victorian Museum specimen (C. Lu, pers. comm.) fit these measurements. The present location of the specimen from which these measurements were taken is not known, but if it still exists, it is also a paralectotype.

The recent species of *Phyllacanthus* were distinguished by Mortensen (1928b) initially on the basis of the number of coronal plates in large specimens (50-70mm horizontal test diameter). This character is clearly of little value when dealing with small specimens. A character noted, but not stressed, by Mortensen (1928b) is the nature of the surface of the primary spines. Each of the species has small rounded knobs, usually described as granules, projecting from the surface of the spine.

*P. imperialis* is distinctly different from *parvispinus, irregularis* and *longispinus* in that these granules are not visible to the naked eye, and are closely arranged in numerous longitudinal rows, giving the shaft a finely striated appearance. In the other three species, the granules are considerably larger (visible to the naked eye), but vary in their arrangement.

The granules of *longispinus* are arranged in longitudinal series over almost the whole length of the shaft, giving the shaft a coarsely-striated appearance.

Tenison-Woods (1880) described the arrangement of granules on the spines of *parvispinus* as being 'very regular lines'. In fact, regular longitudinal series of granules in *parvispinus* occur only near the tip. Both *parvispinus* and *irregularis* have a random arrangement of granules over most of the shaft, with longitudinal series of granules evident only near the tip. The spine shafts of these species have a reticulate appearance. The neck of the spine is also longer in *parvispinus* and *irregularis* than in *imperialis* and *longispinus*.

*P. irregularis* is readily distinguished from *parvispinus* by the characters indicated by Mortensen (1928b), particularly the more pointed spines of the ambulacra and apical system in *irregularis*. However, the occurrence of larger tubercles on the inner edge of the genital plates is not a constant feature of *irregularis*.

Examination of the holotype of *P. magnifica* (WAM 4935) shows the arrangement of the granules on the primary spines to be similar to that of *irregularis* and *parvispinus*, but

**Diagnosis:** Primary spines are long, robust, and taper only slightly, terminating abruptly at a blunt tip; shaft of primary spine appears coarsely reticulate, due to the presence of numerous, low rounded projections without serial arrangement other than near the tip; marginal ambulacral spines very regular in length and arrangement, flattened with rounded tips; miliary spines on apical system are short, flattened and scale-like.

**Material:** Lectotype of *P. parvispinus*, AM J186, Port Jackson, N.S.W.; 1 paralectotype, AM J187, Port Jackson, N.S.W.; 160 other specimens in the Australian Museum collection (6 specimens from Queensland waters, 153 from N.S.W. waters, and 1 from Victorian waters); 3 specimens, NMNZ Ech 607, 274, Meyer Island and Macauley Island, Kermadec Islands.

**Distribution:** Pt. Cartwright, Mooloolaba, Qld, to Gabo Island, Vic., and Tasmania; Kermadec Islands. Shore — 80m.

**Remarks:** Tenison-Woods (1880) indicated that *P. parvispinus* was based on a number of specimens. However, he did not specify a type specimen, beyond providing figures of two specimens (pl. 14 A-B) labelled 'type specimen'. Both these specimens are present in the Australian Museum, and the larger, more intact specimen (J186) is here designated as the lectotype. The other specimen (J187) is thus a paralectotype. A specimen in the National Museum of Victoria, Australia, (H137), which was listed as a syntype of *parvispinus* by Smith (1970), is thus also a paralectotype. Tenison-Woods (1880) gave measurements of a specimen of horizontal diameter 100mm. Neither of the Australian Museum specimens, nor the Victorian Museum specimen (C. Lu, pers. comm.) fit these measurements. The present location of the specimen from which these measurements were taken is not known, but if it still exists, it is also a paralectotype.

The recent species of *Phyllacanthus* were distinguished by Mortensen (1928b) initially on the basis of the number of coronal plates in large specimens (50-70mm horizontal test diameter). This character is clearly of little value when dealing with small specimens. A character noted, but not stressed, by Mortensen (1928b) is the nature of the surface of the primary spines. Each of the species has small rounded knobs, usually described as granules, projecting from the surface of the spine.

*P. imperialis* is distinctly different from *parvispinus, irregularis* and *longispinus* in that these granules are not visible to the naked eye, and are closely arranged in numerous longitudinal rows, giving the shaft a finely striated appearance. In the other three species, the granules are considerably larger (visible to the naked eye), but vary in their arrangement.

The granules of *longispinus* are arranged in longitudinal series over almost the whole length of the shaft, giving the shaft a coarsely-striated appearance.

Tenison-Woods (1880) described the arrangement of granules on the spines of *parvispinus* as being 'very regular lines'. In fact, regular longitudinal series of granules in *parvispinus* occur only near the tip. Both *parvispinus* and *irregularis* have a random arrangement of granules over most of the shaft, with longitudinal series of granules evident only near the tip. The spine shafts of these species have a reticulate appearance. The neck of the spine is also longer in *parvispinus* and *irregularis* than in *imperialis* and *longispinus*.

*P. irregularis* is readily distinguished from *parvispinus* by the characters indicated by Mortensen (1928b), particularly the more pointed spines of the ambulacra and apical system in *irregularis*. However, the occurrence of larger tubercles on the inner edge of the genital plates is not a constant feature of *irregularis*.

Examination of the holotype of *P. magnifica* (WAM 4935) shows the arrangement of the granules on the primary spines to be similar to that of *irregularis* and *parvispinus*, but

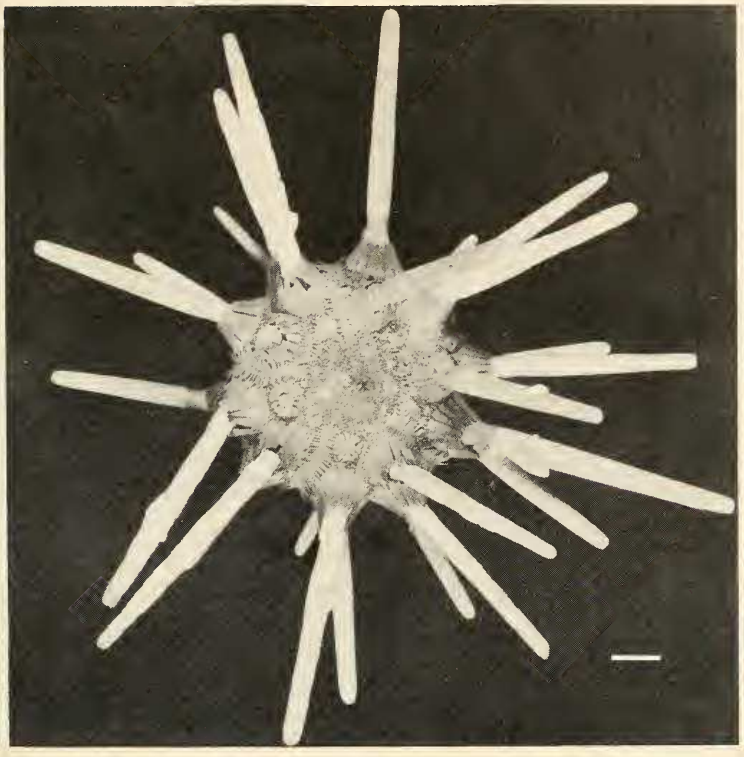


*Fig. 15. Phyllacanthus parvispinus*, J14260, Bateman's Bay, N.S.W. Scale = 10mm.

they are much coarser. In addition, the primary spines are often swollen just distal to the collar in *magnifica*.

*P. parvispinus* is here recorded from the Kermadec Islands for the first time. The three specimens in the NMNZ do not differ significantly from southeast Australian specimens. Two other specimens of *Phyllacanthus* from the Kermadec Islands (NMNZ Ech 273) must be referred to *P. imperialis* because of the ornamentation of the primary spines. This represents a new distribution record for *P. imperialis*.

## Summary of Taxonomic Changes

**New species**

*Prionocidaris callista*

**New synonymies**

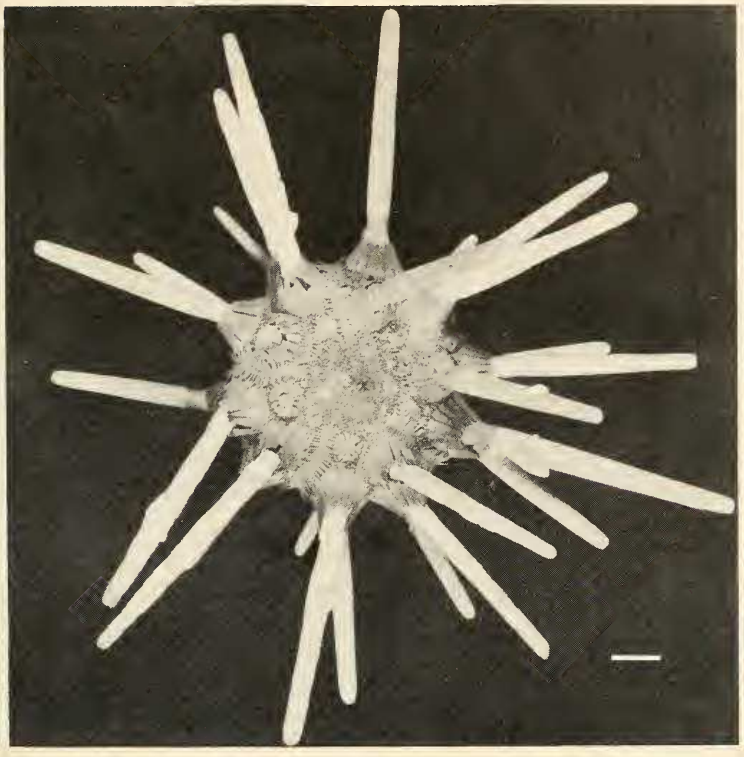
*Goniocidaris alba* Mortensen, 1928a, a junior synonym of *G. sibogae* Mortensen, 1928a

*Goniocidaris australiae* Mortensen, 1928a, a junior synonym of *G. sibogae* Mortensen, 1928a

*Goniocidaris crassa* Mortensen, 1928a, a junior synonym of *G. fimbriata* (De Meijere, 1904b)

*Acanthocidaris maculicollis* (De Meijere, 1904a), a junior synonym of *A. curvatispinis* (Bell, 1892)

*Acanthocidaris hastigera* Agassiz and Clark, 1907, a junior synonym of *A. curvatispinis* (Bell, 1892)



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*Prionocidaris glandulosa* (De Meijere, 1904b), a junior synonym of *P. australis* (Ramsay, 1885)

**Taxa with elevated status**

*Goniocidaris impressa* Koehler, 1926, a valid species distinct from *G. tubaria* (Lamarck, 1816)

**Species newly recorded from N.S.W. waters**

(* indicates also newly recorded from Australia)

*Goniocidaris sibogae*
* *Stereocidaris sceptriferoides*
* *Stereocidaris microtuberculata*
*Stylocidaris reini*
* *Stylocidaris brevicollis*
*Eucidaris metularia*
* *Acanthocidaris curvatispinis*
* *Prionocidaris callista* n. sp.

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