

THE NEW ZEALAND CUCUMARIIDAE (ECHINODERMATA, HOLOTHUROIDEA)

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Abstract

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Three new cucumariid holothurians, *Pseudocnus sentus*, *Squamocnus niveus* and *Squamocnus luteus*, are described from Stewart Island and Fiordland. Five New Zealand and Australian cucumariid species, previously referred to the European genus *Ocnus* Forbes and Goodsir, are assigned to other genera. *Squamocnus brevidentis* (Hutton) is a new combination. *Australocnus* and *Psolidocnus* are new genera, and *Australocnus calcareus* (Dendy), *Australocnus occiduus* (O'Loughlin and O'Hara), *Psolidocnus amokurae* (Mortensen), *Psolidocnus farquhari* (Mortensen) and *Psolidocnus sacculus* (Pawson) are new combinations. *Ocnus brevidentis* var. *carnleyensis* (Dendy) is not recognised. The status of a syntype of *Squamocnus brevidentis* (Hutton) is discussed. A neotype is established for *Australocnus calcareus* (Dendy). *Trachythyone bollonsi* (Mortensen) is synonymised with *Psolidiella nigra* Mortensen. The southern Australian *Plesiocolochirus ignavus* (Ludwig) is reported from New Zealand. *S. brevidentis* and *S. niveus* sp. nov. are brood-protecting. A key is provided for the New Zealand species of Cucumariidae.

Introduction

Recent field observations and collections by one of us (Alcock) at Stewart Island and Fiordland in southern New Zealand have yielded new species of *Pseudocnus* Panning, 1949 and *Squamocnus* O'Loughlin and O'Hara, 1992, and provided the basis for this review.

The New Zealand cucumariid holothurians are known mainly from the works of Hutton (1872, 1878), Dendy (1897, 1909), Ludwig (1898), Dendy and Hindle (1907), Mortensen (1925), Panning (1949, 1961, 1971), Dawbin (1950) and Pawson (1963, 1968, 1970, 1983). A problem developed historically with the identity of *Ocnus brevidentis* (Hutton, 1872). The combined evidence of the original description, and a subsequent description by Dendy (1897) of the probable type specimen in a very poor state of preservation, points to the same species as Dendy (1909) was to later describe as a variety (*brevidentis* var. *carnleyensis*). When the variety was described Dendy (see Dendy and Hindle, 1907) wrongly assumed that another common and related but undescribed species was *brevidentis*. Mortensen (1925) followed the same thinking. This common undescribed species is one of two new *Squamocnus* species described here. A syntype, of uncertain status, from Stewart Island labelled *Thyone brevidentis* Hutton, held in The

Natural History Museum in London, is the strawberry-red cucumariid described by Dendy (1909) as *brevidentis* var. *carnleyensis* but confirmed here to be Hutton's *brevidentis*.

Five cucumariid species and one variety from New Zealand and Australia have at times been referred to the initially European genus *Ocnus* Forbes and Goodsir in Forbes, 1841 – *O. brevidentis* (Hutton, 1872), *O. calcareus* (Dendy, 1897), *O. brevidentis* var. *carnleyensis* (Dendy, 1909), *O. farquhari* (Mortensen, 1925), *O. sacculus* Pawson, 1983 and *O. occiduus* O'Loughlin and O'Hara, 1992. A review of the assignment of these species to *Ocnus* faces a further historical problem as to which is the type species of *Ocnus*. Panning (1949) revived the genus *Ocnus*, designating *O. brunneus* (Forbes ms. in Thompson, 1840) as the type species. Mortensen (1927) had synonymised *O. brunneus* with *O. lacteus* (Forbes and Goodsir, 1839). Panning (1971) accepted the synonymy by Cherbonnier (1951) of *O. brunneus* with *O. planci* (Brandt, 1835), and considered *O. planci* to be the type species. Rowe (1970, 1995 in Rowe and Gates) followed Mortensen's synonymy, nominating *O. lacteus* as the type species. McKenzie (1984) detailed the history of the genus *Ocnus*; recognised *O. brunneus* as distinct from *O. lacteus*; described a neotype for *O. brunneus*; and discussed the possible synonymy of *O. brunneus* with *O. planci*.

McKenzie (1991) subsequently considered growing evidence that *O. planci* and *O. brunneus* were conspecific, and that characters used to separate *O. brunneus* from *O. lacteus* were not reliable. *O. planci*, *O. lacteus* and *O. brunneus* have all been designated type species for *Ocnus* which is considered here to be a European genus with diagnostic characters inapplicable to the New Zealand and Australian species.

Panning (1971) restricted *Ocnus* to five species, included *O. calcareus*, excluded *O. brevidentis* and *O. farquhari*, reassigned *brevidentis* to *Pentacta* Goldfuss, 1820, but did not reassign *O. farquhari*. O'Loughlin and O'Hara (1992) and Rowe (in Rowe and Gates, 1995) continued to assign *brevidentis* to *Ocnus*. Rowe (in Rowe and Gates, 1995) reassigned *occiduus* to *Plesiocolochirus* Cherbonnier, 1946. Panning (1971: 36), Pawson (1983: 227), O'Loughlin and O'Hara (1992: 237, 247) and Rowe (in Rowe and Gates, 1995: 279) questioned whether *Ocnus* was the appropriate genus for New Zealand and Australian species. The five species listed above fall into three groups. *Ocnus brevidentis* (Hutton) is reassigned to *Squamocnus* O'Loughlin and O'Hara, where two of the new species are assigned. *O. calcareus* (Dendy) and *O. occiduus* O'Loughlin and O'Hara are assigned to a new genus. *O. farquhari* (Mortensen) and *O. sacculus* Pawson are assigned to a second new genus, as is *Trachythyone amokurae* (Mortensen, 1925). *Trachythyone bollonsi* (Mortensen, 1925) is synonymised here with *Psolidiella nigra* Mortensen, 1925.

Plesiocolochirus ignavus (Ludwig, 1874), known from across southern Australia, is reported for New Zealand from NIWA specimens which had been identified as *Ocnus brevidentis* and from an unidentified MNZ specimen from Fiordland.

O'Loughlin (1994) listed 30 brood-protecting cucumariid species, including the three New Zealand species *Trachythyone amokurae* (Mortensen), *Psolidiella nigra* Mortensen and *Ocnus sacculus* Pawson. Two additional cases of brood-protection by the New Zealand cucumariid species *Squamocnus brevidentis* (Hutton) and *Squamocnus niveus* sp. nov. are reported here.

Abbreviations for institutions are as follows: AM, Australian Museum, Sydney, Australia; MNZ, Museum of New Zealand, Te Papa Tongarewa, Wellington, New Zealand; NMV, Museum Victoria, Melbourne, Australia; MPE, Dr Th. Mortensen's Pacific Expedition 1914-1916; BMNH, The Natural History Museum, London; NIWA, New Zealand Institute of Water and Atmospheric Research, Wellington,

New Zealand; USNM, US Museum of Natural History, Smithsonian Institution, Washington, USA; ZMUC, Zoological Museum, University of Copenhagen, Denmark.

The following terms are defined:

Bent and curved. Elongate tentacle and tube foot plates may be straight or bent (angular) in one plane (surface) which itself may be flat or curved or concave (Fig. 3l illustrating straight and curved, and Fig. 4i illustrating bent and curved).

Buttons. Thickened plates which are perforated, regular to irregular in outline, small (typically 0.08 mm long), discretely knobbed (Figs 3i, 5c) or lumpy (Figs 6f, 6i) or smooth, typically four perforations.

Cups. Thin plates which are perforated, concave, shallow (species in this paper) or deep, oval to rectangular, small (typically 0.04 mm long), cruciform (Figs 2g, 3f, 4d) or tripartite (Figs 5i, 5j) centrepiece, typically four large with frequently four small corner perforations, spinelets on rim and sometimes on centrepiece, sometimes with bridging connections across rim.

Denticulate. With pointed to bluntly spinous teeth-like spinelets on ossicles (Figs 1h, 1k).

Digitate. With finger-like spinelets on ossicles (Figs 1f, 4d).

Multilayered ossicles. Ossicles which are nodular, irregularly oval in outline, large (more than 0.2 mm long), comprising a perforated knobbed base plate with additional layers built on both sides creating low domes bilaterally (Figs 2k, 3j).

Sole. Flattened, delimited, modified ventral body wall, bounded peripherally by tube feet which do not extend in series to the introvert and anus, and the place of attachment to the substrate.

Ventrum. Modified ventral body wall, bounded laterally by the lateroventral series of tube feet, not bounded peripherally by tube feet, and the place of attachment to the substrate (Figs 3b, 6b).

Order *Dendrochirotida* Grube, 1840 *Cucumariidae* Ludwig, 1894

Remarks. Thirteen species of *Cucumariidae* are now known for New Zealand. The two species not discussed, *Amphicyclus thomsoni* (Hutton, 1878) and *Neocucumella bicolumnata* (Dendy and Hindle, 1907), were discussed and illustrated by Pawson (1963, 1970). Ten are endemic species, while *P. ignavus* is a common southern Australian species, *A. calcareus* is reported for Macquarie and Juan Fernandez Islands, and *P. nigra* occurs in south-eastern Australia (O'Loughlin, 2000). A South Australian specimen, initially referred to *N. bicolumnata*, was

subsequently assigned to *Neocucumella fracta* O'Loughlin and O'Hara, 1992. The continuing absence of *Pseudopsolus macquariensis* (Dendy) during recent intensive collecting at Stewart Island reinforces the probability that it is a Macquarie Island species, and it is not included in the key (Mortensen, 1925).

The following cucumariids are distinguished from other New Zealand holothurian species by having multiple-branching (dendritic) tentacles; by having a cylindrical and not U-shaped body form; by having a calcareous ring of ten pieces which lack posterior prolongations; and by lacking a total or dorsal cover of imbricating scales.

Key to New Zealand Cucumariidae

1. Cups and/or rudimentary cup ossicles and/or concave crosses present in body wall; tables and terminally spinous buttons absent.....2
- Cups and/or rudimentary cup ossicles and/or concave crosses absent from body wall; tables or terminally spinous buttons present.....10
2. Multilayered (nodular) ossicles present in body wall.....3
- Multilayered (nodular) ossicles absent from body wall.....9
3. Body with angular dorsolateral edges; tube feet on radii only; dorsal tube feet surmount raised calcareous wreaths; some cups with bridges across rim; live colour mottled red, mauve, brown, orange, cream and white
..... *Plesiocolochirus ignavus* (Ludwig)
- Body rounded dorsolaterally; dorsal tube feet densely or sparsely scattered or absent; dorsal tube feet not surmounting raised calcareous wreaths; cups all lack bridges across rim; live colour not mottled.....4
4. Ventral tube feet radial series continuous to introvert; dorsal tube feet abundant and predominantly scattered; multilayered ossicles not macroscopically evident as scales; body wall cups with predominantly more than 4 holes; buttons with discrete rounded knobs.....5
- Ventral tube feet radial series not continuous to introvert; dorsal tube feet sparse and scattered or absent; multilayered ossicles macroscopically evident as scales; body wall cups with predominantly 4 holes; buttons with swellings more than discrete knobs.....7
5. Tube feet present on the ventral interradii; shallow concave perforated knobbed plates about 0.1 mm long present in body wall; live colour pale-spotted strawberry-red dorsally; lacking dark brown to black coloration anteriorly and posteriorly.....*Squamocnus brevidentis* (Hutton)
- Tube feet absent on ventral interradii; lacking concave perforated knobbed plates; live colour white or brown or grey or yellow; dark brown to black coloration present anteriorly and posteriorly.....6
6. Cups in body wall with predominantly finely knobbed rarely semidigitate spinelets; largest elongate tentacle plates often straight and curved; live colour predominantly white.....*Squamocnus niveus* sp. nov.
- Cups in body wall frequently with semidigitate to digitate spinelets; largest elongate tentacle plates bent and curved, not straight; live colour yellow
..... *Squamocnus luteus* sp. nov.
7. Tube feet scattered and sparse dorsally; abundant concave multiradiate ossicles epidermally.....*Psolidocnus amokurae* (Mortensen)
- Tube feet absent dorsally; multiradiate ossicles absent.....8
8. Ventral tube feet in double radial series; dorsal body wall scales frequently towered, creating a knobbed surface.....*Psolidocnus farquhari* (Mortensen)
- Ventral tube feet in single radial series; dorsal body wall scales not towered, creating a smooth plated surface.....*Psolidocnus sacculus* (Pawson)
9. Distinct sole; tube feet numerous and scattered dorsally, laterally, around oral and anal cones; ventral body wall ossicles concave crosses and rudimentary cups, perforated plates small, buttons not discretely knobbed; dorsal colour blackish.....*Psolidiella nigra* Mortensen

- Lacking a distinct sole; ventral tube feet in radial series; dorsal tube feet predominantly in radial series; body wall ossicles predominantly knobbed buttons with commonly 4 holes and 12 peripheral discrete knobs, cups, rare large single-layered perforated plates; live colour white with dorsal tube feet ends red..... *Australocnus calcareus* (Dendy)
10. Table ossicles present in body wall, at least anteriorly and posteriorly; 20 or 25 tentacles..... 11
- Table ossicles not present in body wall; 10 tentacles..... 12
11. Table ossicles abundant, regular, 8 perforations; 20 tentacles; tube feet in double radial rows; tube feet discs and tentacles not white.....
..... *Neocucumella bicornata* (Dendy and Hindle)
- Table ossicles present only anteriorly and posteriorly, irregular, predominantly more than 8 perforations; 25 tentacles; tube feet in more than 2 rows radially; tube feet discs and tentacles white... *Amphicyclus thomsoni* (Hutton)
12. 10 equal tentacles; body wall ossicles knobbed buttons spinous at one end; multilayered ossicles absent..... *Pseudocnus leoninoides* (Mortensen)
- 8 large and 2 small ventral tentacles; knobbed buttons and multilayered ossicles present, some with spinous ends..... *Pseudocnus sentus* sp. nov.

Pseudocnus Panning

Pseudocnus Panning, 1949: 422.—Panning, 1962: 58.—Lambert, 1998: 474.

Diagnosis (emended). Cucumariidae with body wall ossicles pear-shaped to irregular, single-layered, knobbed, perforated plates with one end denticulate (*laevigatus*-group); sometimes with knobbed buttons also present, and sometimes the denticulate plates intergrading with or replaced by multilayered ossicles some of which are denticulate (*dubiosus*-group); sometimes buttons only (*curatus*-group); cups and tables absent.

Remarks. The new species described here has knobbed buttons, and multilayered ossicles some of which have a denticulate end. The latter intergrade with single-layered terminally digitate ossicles which are typical of *Pseudocnus*. The combination of ossicle types in the new species places it in the *dubiosus*-group of *Pseudocnus* categorised by Panning (1962: 58–59). Descriptions and illustrations of some members of the *dubiosus*-group by Panning (1962: 66–69) indicate the presence of multilayered ossicles. Rather than establish a new monotypic genus, the relationship with *Pseudocnus* is recognised and the diagnosis emended to explicitly include multilayered terminally denticulate ossicles. Based on morphology and mitochondrial DNA studies Lambert (1998) emended the diagnosis of *Pseudocnus* to include species with thick lobed non-denticulate buttons only, and proposed a *curatus*-group in addition to the *dubiosus*- and *laevigatus*-groups of Panning (1962: 58, 70). *Pseudocnus* now embraces species with widely different ossicle types.

Pseudocnus sentus sp. nov.

Figure 1a–j

Material examined. Holotype (MNZ EC7483). New Zealand, Stewart Island, Paterson Inlet, S side of Faith Hope and Charity Group, granite or diorite rock substrate covered in pink coralline alga, 0–4 m, N. Alcock, 30 Mar 1998.

Paratypes. Type locality and date, NMV F82784 (1); 26 Sep 1998, MNZ EC7484 (5), NMV F82781 (6), NIWA (5).

Comparative material. Syntypes of *Pseudocnus leoninoides* (Mortensen, 1925) [ZMUC (207), MNZ EC531 (16)], Auckland Islands, Masked Island, Carnley Harbour, on rock wall with *Melobesia*, MPE, 30 Nov 1914 (Figure 1 k–l).

Diagnosis. Cucumariidae with 10 dendritic tentacles, ventral 2 smaller; tube feet in zig-zag to double radial rows ventrally, less regular double to zig-zag rows dorsolaterally, rare interradially; body wall ossicles irregular knobbed buttons, single to multilayered (up to 0.6 mm long) knobbed ossicles sometimes terminally denticulate or digitate and sometimes narrowed at the denticulate end, rosettes in tentacles and introvert.

Description. Body up to 27 mm long, 8 mm diameter (preserved, tentacles fully withdrawn), rounded to quadrangular to pentagonal in transverse section, elongate, anal cone upturned, mouth slightly upturned, lacking distinct ventrum, oral valves well developed; body wall thin, firm, flexible, calcareous, surface rough; 10 dendritic tentacles, ventral 2 smaller; calcareous ring with narrow parallel anterior projections, deep posterior indentations (interradial) and notches (radial), lacking posterior prolongations; 1–2

polian vesicles left lateral; small free madreporite close to ring dorsally; microscopic anal scales.

Tube feet extending from introvert to anus, close zig-zag to double radial rows ventrally, less regular double to zig-zag rows dorsolaterally, rare interradially, single very extensible tube feet at introvert, tube feet not on introvert, 5 present anally.

Body wall with multilayered ossicles, sometimes imbricating anteriorly and posteriorly, some denticulate at one end, up to 0.6 mm long; intergrading with irregular finely to thickly knobbed buttons, some digitate at one end or side, typically 0.1 mm long; tube feet with endplates, thin perforated denticulate irregularly oval curved support plates 0.1 mm long, elongate bent centrally widened perforated knobbed support plates 0.24 mm long; introvert with numerous thin finely knobbed (sometimes with connecting bridges) perforated non-denticulate plates typically 0.08 mm long with 4 central holes, intergrading with open to densely branched and knobbed rosettes typically 0.05 mm long, fewer smooth or knobbed thick perforated non-denticulate oval to triangular plates typically 0.17 mm long; tentacles with thin perforated denticulate irregularly oval convex plates 0.08 mm long, irregular elongate ossicles 0.16 mm long with large central perforations, rosettes 0.04 mm long. Ossicle form consistent through small to large specimens.

Colour (live). Body white, to white with brown spots, to pale brown (grey preserved) with brown spotting, to dark grey with black spotting; tentacles yellow, with or without dark brown markings; intestine (preserved) cream, to cream with brown spotting.

Reproduction. Gonad tubules long, unbranched; prominent without discernible eggs in September.

Etymology. From the Latin *sentus* (rough), referring to the surface of the body.

Distribution. New Zealand, Stewart Island, Paterson Inlet, rocky shallows, 0–4 m.

Remarks. This new species is distinguished from other species of *Pseudocnus* by having single and multilayered, knobbed, sometimes terminally denticulate or digitate body wall ossicles. *Pseudocnus leoninoides* (Mortensen, 1925) was reported by Dendy (1909) for the Auckland Islands (as *Cucumaria leonina* Semper var.), by Mortensen (1925) from Auckland and Campbell Islands, and by Pawson (1965) from The Snares islands (just south of Stewart Island). A specimen

from the Macquarie Seamount (NIWA stn D18), identified as *P. leoninoides*, was redetermined by the authors as *Pseudocnus laevigatus* (Verrill, 1876). Pawson noted (1965: 258) that *leoninoides* could be expected for New Zealand, and while *Pseudocnus* is reported here for Stewart Island it is not *P. leoninoides*.

Numerous syntypes of *Pseudocnus leoninoides* were examined (Figures 1 k–l). With single-layered, typically 0.14 mm long, knobbed, terminally denticulate body wall ossicles only, it belongs to the *laevigatus*-group of *Pseudocnus* species. In addition to lacking knobbed non-denticulate buttons and multilayered sometimes denticulate ossicles and tentacle rosettes, *P. leoninoides* has 10 equal tentacles, has radial tube feet on the introvert, has a very thin indistinctly present calcareous ring, and has a thin relatively soft body wall. In all of these features *P. leoninoides* differs from *P. sentus*.

In body form, tentacle number and form, tube feet distribution, and ossicle combination of multilayered ossicles and knobbed buttons with an absence of cups, *Pseudocnus sentus* is similar to *Cucuvitrum rowei* O'Loughlin and O'Hara, 1992. But the monotypic genus *Cucuvitrum* lacks the distinctive pointed and digitate ossicle spinelets of *P. sentus*.

Squamocnus O'Loughlin and O'Hara

Squamocnus O'Loughlin and O'Hara, 1992: 236–237.

Diagnosis (emended). Cucumariidae with calcareous body wall; body rounded to slightly angular dorsolaterally; lacking body wall growths on radii; distinct ventrum with tube feet series extending to introvert and frequently to anus, not sole; 10 dendritic tentacles, ventral 2 smaller; tube feet scattered dorsally and laterally sometimes in irregular dorsolateral series, on ventral radii sometimes extending onto ventral interradii, absent on introvert. Body wall ossicles shallow cruciform spinous cups (up to 0.05 mm long), larger cups sometimes intergrading with shallow concave finely knobbed plates (up to 0.13 mm long), regular to irregular buttons with discrete knobs, numerous large multilayered ossicles; lacking connecting bridges across cups and buttons; sometimes with tentacle rosettes.

Type species. *Squamocnus aureoruber* O'Loughlin and O'Hara, 1992.

Species. *S. aureoruber* O'Loughlin and O'Hara, 1992, *S. brevidentis* (Hutton, 1872), *S. niveus* sp. nov., *S. luteus* sp. nov..

Distribution. Coastal New Zealand, New Zealand subantarctic islands, and south-eastern Australia; 0–130 m.

Remarks. The genus *Squamocnus* comprises four closely related species characterised by a rounded dorsal body, scattered dorsal and lateral tube feet, ventral tube feet series extending to introvert, and a body wall ossicle combination of large multilayered ossicles, buttons with discrete knobs, and cruciform spinous cups without bridges. The presence of multilayered ossicles, cups that are predominantly cruciform as distinct from triradiate, and scattered dorsal and lateral tube feet distinguish *Squamocnus* from *Ocnus* Forbes and Goodsir.

Squamocnus brevidentis (Hutton) comb. nov.

Figure 2a–l

Colochirus brevidentis.—Dendy, 1897: 40–41, pl. 5 figs 54–61.—Farquhar, 1898: 325.

Cucumaria brevidentis.—Perrier, 1905: 110 [uncertain *S. brevidentis*].—Dendy and Hindle, 1907: 99–100 [some, if not all, non *S. brevidentis*].—Dawbin, 1950: 38, fig. 10 [part].

Cucumaria brevidentis (Hutton) var. *carnleyensis* Dendy, 1909: 149–151, pl. 6: 2a–l.—Mortensen, 1925: 332–335, figs 24–25.

Ocnus brevidentis var. *carnleyensis*.—Panning, 1949: 437.

Ocnus brevidentis.—Pawson, 1968: 9, 11, 21–22, 25–27 [part].—1970: 39–40, fig. 8, pl. 2(1) [part].—Fenwick and Horning, 1980: 440, 443 [part].—O'Loughlin and O'Hara, 1992: 237.—Rowe (in Rowe and Gates, 1995): 279.—Alcock, 1999: 9–29.

Material examined. Syntype (labelled “? Co-type”) [BMNH 86.11.18.6.1 (1)]. New Zealand, Stewart Island.

Other material. New Zealand, South Island, Fiordland, Preservation Inlet, exposed rock surfaces, large cluster colonies, 2–15 m, 30 Nov 1996, NMV F81958 (5); 30 Jul 1997, NMV F81957 (17); Kaikoura, 42°42' S, 173°38' E, 100–112 m, 14 Dec 1982, MNZ EC7486 (1); 42°28' S, 173°40' E, 95–98 m, 21 Dec 1982, MNZ EC6908 (1); 42°38' S, 173°40' E, 120–130 m, 11 Dec 1982, MNZ EC6918 (15); Foveaux Strait, 18 m, Feb 1952, MNZ EC6866 (1); Stewart Island, Paterson Inlet, S side of Faith Hope and Charity Group, granite or diorite rocky substrate covered in pink coralline alga, under rocks, small groups, 0–5 m, 20 Aug 1997, NMV F81956 (6); 26 Sep 1998, MNZ EC7485 (3); NIWA (3); Paterson Inlet shore and Ulva Island, MNZ EC533 (6); Bounty Platform, 49°40' S, 178°47' E, 63 m, 9 Nov 1962, NIWA stn A738 (4); Antipodes Islands, 73 m, 7 Nov 1962, NIWA stn A729 (1); SCUBA, 27 Nov. 1978, NMV F82779 (2).

Description of material. Body up to 55 mm long (live, tentacles partly extended); body wall thick,

firm to hard; body domed dorsally, flat ventrally, distinct ventrum thin-walled in relaxed specimens, not sole; mouth anterior, slightly upturned, 5 weakly developed radial oral valves; upturned anal cone, 5 microscopic anal scales; 10 dendritic tentacles, ventral 2 smaller; calcareous ring solid, slender tapering anterior projections and posterior indentations radially and interradially, lacking posterior prolongations; single left lateral polian vesicle.

Tube feet up to 4 rows wide on radii of ventrum, extending onto ventral interradii and ventrolaterally, radial series extending to introvert; double radial rows near introvert on oral valves, absent on introvert, very extensible prominent single radial tube feet at introvert; tube feet dorsally and laterally and around anal cone fewer, evenly scattered, with low tubercle bases.

Body wall ossicles cups, small concave finely knobbed perforated plates, buttons and multilayered ossicles; small cups regular cruciform, rarely with triradiate centrepiece, 0.025–0.048 mm long, 4–8 holes, smallest cups with bare cruciform centrepiece and digitate spinelets on rim all pointing up from cup; larger cups intergrade with regular cruciform to irregular very shallow concave plates; concave plates frequently with 8, up to 26, holes large centrally decreasing in size towards periphery, 0.09–0.13 mm long, finely knobbed over whole plate, knobs pointing in all directions; concave plates intergrade with buttons; buttons with discrete knobs predominantly irregular, about 1 in 4 may be regular with 4 holes, typically 4–7 very rarely up to 14 holes, knobs bulbous and sometimes fused and irregular, small buttons frequently with 1 oblong knob centrally less commonly 2 discrete knobs centrally, smallest buttons typically 0.1 mm long; numerous multilayered ossicles up to 0.9 mm long. Introvert with typical cups and knobbed concave plates only; concave plates frequently elongate, up to 0.13 mm long. Tentacle ossicles large elongate narrow curved thickened perforated plates (holes decreasing in size distally) up to 0.6 mm long, irregular perforated denticulate convex plates typically 0.06 mm long, narrow centrally-enlarged perforated bent plates typically 0.15 mm long, lacking rosettes. Tube feet ossicles endplates up to 0.24 mm diameter, irregular denticulate perforated curved plates typically 0.15 mm long, elongate narrow centrally-widened curved bent perforated plates typically 0.15 mm long, cups, buttons. Anal ossicles typical body wall ossicles and large perforated plates; perforated plates thick, irregularly elongate or pear-shaped, single-layered not knobbed at end(s), knobs and

secondary layers extensive, frequently bluntly denticulate at narrow end, up to 0.8 mm long.

Colour (live). Body wall, dorsally and laterally and around oral and anal cones, and tentacles strawberry-red; ventrum cream to pale pink; dorsal and lateral white spotting associated with tubercles and tube feet; small dark brown irregular spots dorsally, laterally, ventrally; lacking dark coloration or markings on tentacles or introvert or anteriorly or anally. Preserved colour (alcohol) fades slowly to pale brown and finally white.

Reproduction. Live male gonad tubules pink, female tubules brownish red; elongate, unbranched; eggs up to 0.75 mm long (March); brood-protects during autumn/winter under body (Alcock, 1999); not fissiparous.

Distribution (confirmed here). New Zealand. South Island, Kaikoura, Fiordland, Foveaux Strait, Stewart, Antipodes, Auckland and Campbell Islands, Bounty Platform; 0–130 m.

Remarks. There is no literature reference to a syn-type, and the one held by BMNH is recorded with a question mark. Locality is given, but no information about collector, date, identifier or donor. The specimen is in good condition and is clearly identifiable as the strawberry-red species and is confirmed here as *S. brevidentis*. Hutton (1872) described a brown body, pink tentacles with yellowish tips, and tube feet all over the body and more spread dorsally than ventrally for the type specimen of *S. brevidentis*. In describing what he judged to be the same specimen Dendy (1897) added that the tube feet were thickly and irregularly scattered over the ventral surface, the dorsal tube feet were abundant and fairly uniformly scattered over the remainder of the body and twice the size of the ventral ones, and the ossicles were large reticulate nodules, irregular buttons, and cups similar to *S. calcareus* but with some more flat and irregular. Dendy (1897: fig. 58) illustrated these last-mentioned distinctive ossicles for the type specimen of *S. brevidentis*, and illustrated (1909: pl. 6, 2h and 2k) similar ossicles for *S. brevidentis* var. *carnleyensis*. Hutton's and Dendy's characters refer to the strawberry species described subsequently by Dendy (1909) as *S. brevidentis* var. *carnleyensis*. Mortensen (1925) followed Dendy (1909). The descriptions of var. *carnleyensis* by Dendy (1909) and Mortensen (1925) are descriptions of Hutton's *S. brevidentis*.

There are white and yellow (white preserved) undescribed species in New Zealand which are similar to the strawberry *S. brevidentis*, and one

or both have been assumed to be *S. brevidentis* by Dendy and Hindle (1907), Dendy (1909), Mortensen (1925) and Panning (1949, 1971). In addition to differing from *S. brevidentis* in live colour, both species (described below) have double ventral radial series of tube feet with bare interradii, and lack the unique shallow concave knobbed plate ossicles illustrated by Dendy (1909: pl. 6, 2h and 2k). References by Panning (1949, 1971) to *S. brevidentis* are generally applicable to the strawberry, white and yellow species, but the two specimens from Cook Strait described and illustrated by Panning (1949: 437–438, fig. 32) are the white species described below.

Ludwig (1898) considered *Colochirus calcareus* Dendy, 1897 to be a junior synonym of *C. brevidentis*, and was followed by Perrier (1905), Dendy and Hindle (1907) and Dendy (1909). Mortensen (1925) and subsequent authors recognised *C. calcareus*.

In assigning the species *brevidentis* to *Pentacta* Goldfuss, 1820, and diagnosing the genus, Panning (1971: 38–39) recognised that the genus was not homogeneous and that *brevidentis* occupied an uncertain place. And in fact, he was dealing with a different species (see next species). Recently Rowe (in Rowe and Gates, 1995: 271) has discussed the diagnosis of *Pentacta*. Panning considered appendages confined to the radii, growths on the radii surmounted by tube feet or papillae, bridges across knobbed ossicles, and four or five-edged body form, to be characteristic of *Pentacta*. None of these features occurs in *S. brevidentis* which is assigned here to *Squamocnus* as diagnosed above.

Pawson (1968, 1970) did not recognise var. *carnleyensis* and in describing *S. brevidentis* referred to the strawberry species (Pawson, 1970: ossicles fig. 8C are characteristic of *brevidentis*) and white species (Pawson, 1968: dark dorsal colour occurs in the white but not red species), and included a distribution around the North Island where the red species has not been collected. Pawson (1968: 26–27) recorded *S. brevidentis* from Macquarie Island. Mortensen (1925: 335) had cast some doubt on the basis for this record. A recent study of the echinoderm fauna of Macquarie Island (O'Hara, 1999) did not confirm the occurrence of *S. brevidentis* in the Macquarie Island fauna. Mortensen (1925) reported *S. brevidentis* from the Auckland and Campbell Islands as var. *carnleyensis*.

One of the specimens from the Antipodes Islands collected on 27 November has eggs which are 0.7 mm long in the gonad tubules, while no specimen from southern New Zealand collected

in August and November has similar macroscopically discernible eggs. This indicates a probable variation in the reproductive cycle across the geographical range of *S. brevidentis*. It was also noted that regular buttons with four holes are more common in specimens of *S. brevidentis* from the subantarctic islands than from southern New Zealand. These observations indicate that speciation may be occurring across the geographical range of this brood-protecting species.

S. brevidentis is distinguished from other species of *Squamocnus* by its relatively large size and pale-spotted strawberry-red colour (live), by the presence of tube feet on the ventral interradii, by the presence in the body wall of shallow slightly concave and finely knobbed perforated plates commonly 0.1 mm long, by the presence of digitate spinelets on the smallest cups, and by a habit of seasonal winter brood-protection under the body (Alcock, 1999). Characteristic ossicle form can be distinguished in juveniles as small as 5 mm long.

Squamocnus niveus sp. nov.

Figure 3a-l

Cucumaria brevidentis.—Dendy and Hindle, 1907: 99–100 [probably part].—Mortensen, 1925: 331–332, fig. 26 a–b.—Dawbin, 1950: 38, fig. 10 [part].

Ocnus brevidentis.—Panning, 1949: 437–438, fig. 32.—Pawson, 1968: 9, 11, 21–22, 25–27 [part].—1970: 39–40, fig. 8, pl. 2(1) [part].

Pentacta brevidentis.—Panning, 1971: 38–39.

Material examined. Holotype (MNZ EC7487). Stewart Island, Paterson Inlet, S side of Faith Hope and Charity Group, granite or diorite rock substrate covered in pink coralline alga, solitary under rocks, 0–4 m, N. Alcock, 30 Mar 1998.

Paratypes. Type locality and date, NMV F82783 (5), NMV F83406 (1, brood-protecting); 21 Jan 1998, NMV F82777 (3); 26 Sep 1998, MNZ EC7488 (6); NIWA (6).

Other material. North Island, Cape Maria van Diemen, MPE, 4 Jan 1915, ZMUC (58); Slipper Island, 37° S, 176° E, MPE, 20 Dec 1914, ZMUC (11); Auckland Islands, Masked Island, Carnley Harbour, MPE, 3 Dec 1914, ZMUC (105); Bounty Platform, 49°40' S, 178°50' E, 37 m, 9 Nov 1962, NIWA stn A743 (1); 49°40' S, 178°47' E, 63 m, 9 Nov 1962, NIWA stn A738 (1).

Description. Body up to 28 mm long (live, tentacles fully extended); body wall thick, firm to hard; body tubular, domed dorsally, flat ventrally, distinct ventrum, not sole; mouth anterior, slightly upturned, 5 weakly-developed radial oral valves; long upturned anal cone on many specimens; 5 microscopic anal scales; 10 dendritic tentacles,

ventral 2 smaller; calcareous ring solid, fine tapering anterior projections radially and interradially, posterior notches radially, wide indentations interradially, lacking posterior prolongations; single left ventral polian vesicle.

Tube feet in zig-zag to double rows on ventral radii, extending from introvert to anus, ventral interradii bare; absent from introvert; irregular double dorsolateral rows or scattered dorsally and laterally in midbody, double radial rows near introvert, single very extensible radial tube feet at introvert, bases of tube feet sometimes swollen creating small tubercles.

Body wall ossicles cups, buttons and multi-layered ossicles; cups regular cruciform, rarely with tripartite centrepiece, cups typically 0.028–0.056 mm long, typically 4–8 very rarely up to 14 holes (very small peripherally), cup spinelets dense and knobbed to bluntly denticulate rarely semidigitate on larger cups, spinelets always on centrepiece and pointing up or in all directions from cup rim; cups intergrade with buttons; buttons with discrete knobs regular and irregular, commonly 3–6 rarely up to 14 holes, buttons typically 0.08 mm long; about 1 in 4 buttons regular, 4 uniform holes, 8–10 uniform large peripheral knobs, 2 central knobs sometimes larger; numerous multilayered ossicles up to 0.8 mm long. Introvert with typical cups and elongate very shallow concave finely knobbed plates up to 0.14 mm long. Tentacle ossicles elongate, narrow, straight or bent, curved, thickened, irregularly-perforated plates up to 0.4 mm long; bent curved perforated rods typically 0.15 mm long; irregular curved and convex denticulate perforated plates typically 0.06 mm long; lacking rosettes. Tube feet with endplates up to 0.22 mm diameter, irregular thin denticulate perforated curved to convex plates typically 0.07 mm long, irregularly triangular to elongate centrally-widened bent curved perforated plates typically 0.15 mm long, cups, buttons. Anal ossicles typical body wall ossicles and large perforated plates; perforated plates thick, irregularly elongate or pear-shaped, part single-layered not knobbed, extensive parts with knobs and secondary layers, frequently bluntly denticulate at end(-s), rarely sharply denticulate, plates up to 0.65 mm long.

Colour (live). Body white; large ossicles in body wall create greyish spotting; tentacles pink, rarely pale orange; dark brown to black on tentacle trunks, introvert, anteriorly and sometimes dorsally and anally; sometimes fine black flecking dorsally (dark markings persist on preserved material); rare brown spotting dorsally and ventrally.

Reproduction. Gonads (preserved) orange to white; long, thin, unbranched tubules; separate sexes; seasonal autumn and winter internal brood-protection in coelomic sacs; numerous eggs or embryos 0.7–0.8 mm long in sacs in March; coelomic embryos uniformly 1.0 mm long showing differentiation and ossicle development by July; no brood-protection evident by September.

Etymology. From the Latin *niveus* (white as snow), referring to the live body colour.

Distribution (confirmed here). New Zealand. North, South, Stewart and Auckland Islands, Bounty Platform. 0–63 m.

Remarks. This white species was assumed to be *S. brevidentis* by Dendy and Hindle (1907), Mortensen (1925) and Panning (1949, 1971). In recognising var. *carnleyensis* (the true *brevidentis*), Mortensen (1925) distinguished it from *S. niveus* (assumed to be *S. brevidentis*). Mortensen (1925: 333) noted less scattered dorsolateral tube feet on Masked Island material and expressed doubt about referring this material to *S. brevidentis*. Panning (1949) described *S. niveus* from Cook Strait material (as *Pentacta brevidentis*). Many of the small ZMUC specimens (MPE) from Cape Maria van Diemen exhibit a deep midbody constriction, suggesting the possibility of fissiparity, but no anal body ends were present. The type species of the genus, *Squamocnus aureoruber*, is fissiparous. *S. niveus* is distinguished from the other species in *Squamocnus* by its white colour (live), grey to black anterior and posterior and sometimes dorsal coloration, absence of ventral interradial tube feet, absence in the body wall of shallow concave finely knobbed perforated plates, buttons which fairly commonly are regular with four even holes and 8–10 peripheral and two central knobs, and brood-protection in intra-coelomic sacs. Characteristic ossicle form can be distinguished in juveniles as small as 5 mm long.

Squamocnus luteus sp. nov.

Figure 4a–i

Material examined. Holotype (MNZ EC7489). New Zealand, Fiordland, Preservation Inlet, exposed rock surfaces, amongst *Squamocnus brevidentis* colonies, 2–15 m, J. Duncan, 3 Feb 1998.

Paratypes. Type locality and date, NMV F82776 (7); type locality, 30 Jul 1997, NMV F81955 (4); Stewart Island, Paterson Inlet, S side of Faith Hope and Charity Group, 2–4 m, 30 Mar 1998, NMV F83407 (1); 0–5 m, 26 Sep 1998, MNZ EC7490 (2).

Other material. Fiordland, Preservation Inlet, Feb–Mar 1998, NIWA (8).

Description. Body up to 20 mm long, 6 mm wide (preserved, tentacles extended); thin calcareous body wall; body tubular; distinct ventrum, not sole; mouth anterior, 5 weakly developed radial oral valves; upturned anal cone, 5 microscopic anal scales; 10 dendritic tentacles, ventral 2 smaller; calcareous ring solid, slender tapering anterior projections and posterior indentations radially and interradially, lacking posterior prolongations; single left lateral polian vesicle.

Tube feet scattered dorsally and laterally in midbody, bases slightly swollen, double radial series near introvert, sometimes also evident in irregular dorsolateral series; double to zig-zag rows on ventral radii, extending from introvert to anus, ventral interradial bare; absent on introvert; 5 radial anal tube feet.

Body wall ossicles cups, buttons, and multi-layered ossicles; cups shallow, predominantly regular, cruciform, some triradiate, frequently digitate to semidigitate spinelets or fine knobs on rim pointing in all directions from rim and centre-piece, sometimes pointing up only on smallest cups, always on centre-piece, cups 0.024–0.056 mm long, typically 0.032–0.040 mm long, 4–8, very rarely up to 20 holes, holes very small peripherally, smallest cups regularly oval to rectangular, largest cups less regular around cruciform centre-piece; buttons predominantly irregular, 0.06–0.12 mm long, very rarely regular with as few as 4 holes and 2 central and 8–12 peripheral knobs, commonly 5–7, ranging 3–16 holes, peripheral knobs relatively numerous and usually discrete and not merging; numerous multilayered ossicles up to 0.8 mm long. Introvert with typical cups, some elongate up to 0.07 mm long intergrading with some very shallow concave finely knobbed plates up to 0.07 mm long. Tentacle ossicles elongate, narrow, curved, predominantly bent, some centrally widened, perforated plates up to 0.27 mm long; irregular convex denticulate perforated plates typically 0.08 mm long; lacking rosettes. Tube feet with convex endplates up to 0.16 mm diameter, irregularly oval thin curved denticulate perforated plates typically 0.08 mm long, irregularly oval to elongate narrow centrally-widened curved perforated knobbed plates typically 0.12 mm long, cups, buttons. Anal ossicles typical body wall ossicles and large perforated plates; perforated plates thick, irregularly pear-shaped, part single-layered not knobbed, part with knobs and secondary layers, bluntly denticulate in places at edges, plates up to 0.56 mm long.

Colour (live). Body and tentacles yellow; dark

grey to black markings frequently on tentacle trunks, anteriorly and posteriorly. Yellow quickly fades to white in alcohol; dark coloration persists.

Reproduction. Sexes separate; gonad tubules unbranched; tubules with macroscopically distinguishable eggs up to 0.6 mm long in February; no evidence of fissipary or brood-protection in February, July and October.

Etymology. From the Latin *luteus* (yellow), referring to the live colour of the body.

Distribution. New Zealand, Fiordland, Preservation Inlet; Stewart Island, Paterson Inlet. 0–15 m.

Remarks. After preservation in alcohol specimens quickly become white, frequently with persistent anterior and posterior dark grey to black markings, and are indistinguishable in appearance from *S. niveus*. *S. luteus* is distinguished from *S. niveus* by its smaller size and yellow colour (live), absence of a coelomic brood-protecting habit in autumn-winter, larger cups frequently with digitate to semidigitate spinelets, and largest elongate tentacle plates bent and curved but rarely straight and curved. It is distinguished from *S. brevidentis* by its smaller size and yellow colour (live), absence of interradial tube feet ventrally, absence of concave knobbed body wall plates, and presence of dark coloration anteriorly and posteriorly. Ossicle form is consistent from small to large specimens.

Australocnus gen. nov.

Comparative material examined. *Ocnus planci* (Brandt). Western Mediterranean off Banyuls-sur-mer, 50–85 m, NMV F82971 (6) (Figure 5g–l).

Diagnosis. Cucumariidae with thick, firm, friable, body wall; body rounded to slightly pentagonal in transverse section; 10 dendritic tentacles, ventral 2 smaller; tube feet in double rows on all 5 radii, series extending ventrally from introvert to anus, sparsely present on dorsal and lateral interradia, absent on introvert. Body wall ossicles abundant buttons with discrete knobs, cruciform cups, rare plates; buttons frequently regular with 2 larger central and 2 terminal holes, 12 peripheral knobs; cups small shallow regular cruciform, finely knobbed to spinous, 4–8 holes; rare large flat elongate to irregularly oval, smooth or knobbed, perforated, single-layered plates; lacking multilayered ossicles.

Type species. *Colochirus calcarea* Dendy, 1897.

Species. *A. calcareus* (Dendy, 1897), *A. occidentalis* (O'Loughlin and O'Hara, 1992).

Etymology. From the Latin *austral* meaning southern, with *Ocnus*, referring to the southern hemisphere occurrence of this *Ocnus*-like genus.

Distribution of genus. Coastal New Zealand, Stewart Island. Australia, Macquarie Island and south-western Australia. Juan Fernandez; 0–433 m.

Remarks. The *Ocnus planci* specimens examined have a pentagonal body; no interradial tube feet; irregular very small spinous cups with both cruciform and triradial centrepieces and weakly developed rims with digitate spinelets; and irregular buttons frequently with three or four central knobs. Based on this material and the descriptions of species of *Ocnus* by McKenzie (1984, 1991), *Australocnus* differs from the European genus *Ocnus* Forbes and Goodsir, 1841 (in Forbes) by being rounded in transverse section, having some tube feet scattered on dorsal and lateral interradia, and having predominantly regular cruciform cups and buttons with two central knobs. *Australocnus* differs from the European genus *Aslia* Rowe, 1970 by having shallow cups with frequently more than four perforations, not deep cups with distinct rim and cruciform centrepiece with unbranched arms. *Australocnus* differs from *Squamocnus* by lacking multilayered ossicles, and by having elongate buttons which frequently have 12 small peripheral knobs and two larger central holes.

Australocnus calcareus (Dendy) comb. nov.

Figure 5a–f

Colochirus calcarea Dendy, 1897: 38–40, pl. 5 figs 44–53.—Farquhar, 1898: 325.

Colochirus brevidentis.—Ludwig, 1898: 442–444, pl. 26 figs 22–29 [non *Squamocnus brevidentis* (Hutton, 1872)].

Cucumaria calcarea.—Mortensen, 1925: 335–337, fig. 26c–d.—Dawbin, 1950: 38, pl. 2 fig. 11.

Ocnus calcarea.—Panning, 1949: 437.—Pawson, 1970: 39, pl. 1 fig. 5.—Fenwick and Horning, 1980: 443.—McKnight, 1984: 145.

Ocnus calcareus.—Panning, 1949: 438.—Pawson, 1963: 27.—1968: 21.—Panning, 1971: 30, 36.—O'Loughlin and O'Hara, 1992: 247–248, fig. 7e–f.—Rowe (in Rowe and Gates, 1995): 279.

Material examined. Neotype (MNZ EC7491). New Zealand, Cook Strait, Makara, rocky shallows, 0–1 m, O'Loughlin and Alcock, 20 Sep 1998.

Other material. Neotype locality and date, NMV F83526 (1); Stewart Island, Paterson Inlet, S side of Faith Hope and Charity Group, rocky substrate, 0–5 m, 30 Mar 1998, NMV F82782 (2); 26 Sep 1998, MNZ EC7492 (6), NIWA (4), NMV F83404 (2); Cook Strait,

Porirua Harbour, Whitireia Headland, rocky shallows, 2 May 1998, NMV F83405 (1) [photograph live NMV 62-8]; Fiordland, Preservation Inlet, Feb-Mar. 1998, NIWA (2).

Description of material. Body up to 20 mm long, 5 mm wide (live, tentacles fully extended); body wall friable; rounded dorsolateral and ventrolateral edges; anal cone upturned, oral end slightly elevated; 10 dendritic tentacles, ventral 2 smaller; tube feet in double radial rows ventrally extending from introvert to anus, dorsolaterally in radial double to zig-zag rows with a few present interradially in midbody, absent on introvert, very extensible single radial tube feet at introvert on ends of weakly developed oral valves, 5 present anally; 5 microscopic anal scales. Dorsal body wall ossicles predominantly buttons and cups, rare large plates; buttons oval, elongate, with discrete knobs, frequently with 2 central knobs larger than 12 peripheral ones, 2 middle holes larger than end ones, buttons typically 0.08 mm long; shallow concave cups with small knobs to blunt spines on rim and centrepiece, mostly pointing in all directions from cup rim, sometimes pointing up only, cups with predominantly 4 holes (up to 8), 0.024–0.040 mm long; large single-layered plates rare, irregularly oval to elongate to triangular, thickened, perforated, knobbed, rarely with bridges joining knobs to create very limited secondary layer development, up to 0.5 mm long. Lacking multilayered ossicles and tentacle rosettes.

Colour (live). Body white; tentacles yellow with dark brown markings variably evident; no dark markings anteriorly or anally; dorsal, and anterior and posterior ventral, tube feet with distal ends red.

Reproduction. Eggs in gonad tubules 0.7 mm long in February; gonads present but eggs not evident macroscopically in September.

Distribution. New Zealand, Slipper Island (37° S, 176° E), Cook Strait, Fiordland, Stewart Island; Australia, Macquarie Island; Juan Fernandez Islands. 0–433 m.

Remarks. No reference to type material has been found for this species. A neotype is established here from Cook Strait, the locality referred to in the description of the species. Dendy (1897: 41) noted an absence of "large reticulate nodules" (multilayered ossicles) in *A. calcareus* but recognised their presence in *S. brevidentis*. Dendy and Hindle (1907: 100) considered *A. calcareus* to be juvenile specimens of *S. brevidentis*, noting the

presence of "large calcareous nodules" (multilayered ossicles) in the large specimens but noting them "very sparingly" in small specimens. Large multilayered ossicles are always present in small specimens of *S. brevidentis*, and the large ossicles sparsely present in *A. calcareus* are single-layered perforated plates. Mortensen (1925: 337) stated that "larger plates" (not distinguishing perforated plates and multilayered ossicles) were rare or absent in *A. calcareus*, but present in *S. brevidentis*. Large multilayered ossicles are never present in *A. calcareus*, and this characteristic provides a diagnostic distinction between *Australocnus* to which *A. calcareus* is assigned here and *Squamocnus* O'Loughlin and O'Hara, 1992 to which *S. brevidentis* is assigned above.

Panning (1949: 438) was initially uncertain whether *A. calcareus* was a species distinct from *S. brevidentis*. Subsequently Panning (1971: 38) reassigned *brevidentis* to *Pentacta* but with reservations. Panning (1971: 30, 36) retained *A. calcareus* in a restricted *Ocnus*.

The Juan Fernandez occurrence is based on a re-determination as *A. calcareus* by Mortensen (1925: 337) of material referred to *S. brevidentis* by Ludwig (1898) who considered *A. calcareus* to be a junior synonym of *S. brevidentis*. McKnight (1984: 145) reported *A. calcareus* from Macquarie Island (71–433 m), but the authors were not able to confirm this record. Mortensen (1925) reported *A. calcareus* from Slipper Island.

A. calcareus is distinguished from the Australian species *A. occiduus* O'Loughlin and O'Hara by its small size, red dorsal tube feet when live, rare large perforated plates which are knobbed, and absence of tentacle rosettes. O'Loughlin and O'Hara (1992: 248) observed swollen bases of tube feet (tubercles) in *calcareus* specimens, but these were not evident in material examined subsequently. There is no geographical continuity for these similar species, neither occurring in south-eastern Australia.

Australocnus occiduus (O'Loughlin and O'Hara) comb. nov.

Ocnus calcareus.—Rowe, 1982: 446, fig. 10:32a.—Marsh, 1991: 472, 477.—Marsh and Pawson, 1993: 295 [non *Australocnus calcareus* (Dendy, 1897)].

Ocnus occiduus O'Loughlin and O'Hara, 1992: 247–248, table 1, fig. 7a–d; pls 1h, 9a–f.

Plesiocolochirus occiduus.—Rowe (in Rowe and Gates, 1995): 279.

Material examined. See O'Loughlin and O'Hara, 1992: 247.

Comparative material. *Plesiocolochirus spinosus* (Quoy and Gaimard, 1833), NMV F45021 (3).

Description of material. Body up to 32 mm long (tentacles withdrawn); rounded to slightly pentagonal in transverse section; thin-walled ventrum; double radial rows of tube feet extending from introvert to anus, irregular rows dorsolaterally, rare small dorsal and lateral ones interradially. Dorsal body wall ossicles abundant buttons and cups, rare plates; buttons with discrete knobs, commonly regular with 12 peripheral knobs uneven with midlateral and midterminal knobs often smaller, 2 central knobs not normally larger, largest buttons typically 0.09 mm long; shallow cruciform cups with small knobs on rim and centrepiece pointing in all directions, predominantly 4–8 holes, cups typically 0.04 mm long; large single-layered plates rare, irregularly oval to elongate, smooth to lumpy, perforated, not knobbed, up to 0.4 mm long; lacking multilayered ossicles. Tentacles with rosettes.

Colour (live). White, grey on thin ventral surface and sometimes laterally; tentacle trunks dark brown to black; fine tentacle branches pale yellow.

Distribution. Australia. Rottneest Island, Western Australia, to Yorke Peninsula, South Australia; 0–30 m.

Remarks. Rowe (1995: 277, 279) referred this species with reservations to *Plesiocolochirus* Cherbonnier, 1946, considering it to be not congeneric with *Ocnus* Forbes, 1841 but possibly requiring allocation to a new genus. The specimens of *Plesiocolochirus spinosus*, the type species for *Plesiocolochirus*, have evenly distributed radial and interradiial tube feet, distinctive small paired pointed posterior projections on the radial plates of the calcareous ring, lateroventral tubercles, multilayered ossicles, and frequently bridges across the rim of cups. *Australocnus occiduus* has none of these features. *A. occiduus* is distinguished from the New Zealand *A. calcareus* by its significantly larger size, absence of red coloration of dorsal tube feet, rare large plates which are smooth to lumpy and not knobbed, and the presence of tentacle rosettes.

Psolidocnus gen. nov.

Figure 61

Diagnosis. Cucumariidae with contiguous body wall scales dorsally and laterally; body rounded in transverse section with flattened ventrum, mouth and anus at least slightly upturned or situated dor-

sally; 10 dendritic tentacles, ventral 2 smaller; tube feet in three radial series ventrally, series not extending to introvert or anus, not continuous around ventrum to create sole, absent or sparsely present dorsally; body wall ossicles large multilayered sometimes towered ossicles (scales) up to at least 0.8 mm long, irregular lumpy more than discretely knobbed buttons, regular shallow cruciform spinous cups up to 0.05 mm long with predominantly 4 holes, sometimes multiradiate concave ossicles up to 0.03 mm long.

Type species. *Cucumaria amokurae* Mortensen, 1925.

Species. *P. amokurae* (Mortensen, 1925), *P. farquhari* (Mortensen, 1925), *P. sacculus* (Pawson, 1983).

Etymology. From the family name Psolidae, referring to psolid-like characteristics, with *Ocnus*, the genus to which two species were referred.

Distribution of genus. New Zealand. South Island; Stewart Island; Auckland Islands. 9–660 m.

Remarks. Panning (1971: 36) did not include *P. farquhari* in *Ocnus*, but did not reassign it. Pawson (1983: 227), O'Loughlin and O'Hara (1992: 237) and Rowe (in Rowe and Gates 1995: 279) questioned whether *Ocnus* was a suitable genus for one or both of the species *P. farquhari* and *P. sacculus*. A pentagonal body form, radial rows of ventral tube feet extending to introvert and anus, numerous triradiate cups, and absence of multilayered ossicles distinguish *Ocnus* (Figure 5g–l) from *Psolidocnus*.

Panning (1949: 426) assigned *P. amokurae* to *Trachythyone* Studer, 1876 with a question. O'Loughlin and O'Hara (1992: 237, 239) and O'Loughlin (1994: 542) noted that *Trachythyone* was an unsuitable genus for *P. amokurae* with its multilayered ossicles. Panning (1949, 1964) diagnosed *Trachythyone* as having cups and smooth plates in the body wall, and the absence of multilayered ossicles and lumpy to knobbed buttons distinguishes *Trachythyone* from *Psolidocnus*. In *Psolidocnus* the presence of large contiguous scales dorsally and laterally, presence of buttons and cups in the body wall, upturning of or dorsally situated oral and anal ends, and ventral radial tube feet series not extending to introvert and anus are psolid-like features, but there is not a distinct sole with peripheral tube feet as in the Psolidae. *Psolidocnus* is distinguished from *Squamocnus* and *Australocnus* by the ventral radial tube feet series not continuing to the introvert or anus, by the form of the cups which are

predominantly four-holed and up to 0.05 mm long, by the form of the buttons which are predominantly lumpy as distinct from discretely knobbed, and by the presence dorsally and laterally of macroscopically distinguishable contiguous sometimes towered scales up to at least 0.8 mm long.

Psolidocnus is similar to *Apsolidium* O'Loughlin and O'Hara, 1992 in having ventral radial series of tube feet not extending to introvert and anus, and by having a body wall ossicle combination of multilayered ossicles, lumpy to knobbed buttons, and cups. *Psolidocnus* differs in lacking a distinct sole; having significantly fewer tube feet dorsally, laterally and ventrally; having very large scale-like contiguous multilayered ossicles; and having shallow cups. *Apsolidium alvei* O'Loughlin and O'Hara, 1992 was assigned to its genus with reservations since it lacks a distinct sole, and the large plates with secondary layers are not typical multilayered ossicles. The form of the large plates and deep cups of *alvei* indicate that it would be no more suitably assigned to *Psolidocnus*.

Psolidocnus amokuræ (Mortensen) comb. nov.

Figure 6a–g

Cucumaria amokuræ Mortensen, 1925: 341–343, figs 29, 30a.—Dawbin, 1950: 38, pl. 2 fig. 13.

Trachythyone amokuræ.—Panning, 1949: 426.—Pawson, 1970: 38.—O'Loughlin and O'Hara, 1992: 237, 239.—O'Loughlin, 1994: 539–542, fig. 1.

Material examined. Three syntypes (ZMUC). New Zealand, Auckland Islands, Carnley Harbour, sandy mud, 82 m, MPE, 6 Dec 1914; syntype (MNZ EC532), type locality and date (1).

Other material. Stewart Island, Paterson Inlet, mud, 9–27 m, MPE, 17 Nov 1914, ZMUC (2); Kaikoura, 42° S, 173° E, 69 m, 7 Dec 1982, MNZ EC6951 (2); 120–130 m, 11 Dec 1982, MNZ EC6907 (2), EC6922 (11), EC7493 (2); 100–112 m, 14 Dec 1982, MNZ EC6925 (8); 95–98 m, 21 Dec 1982, MNZ EC7494 (1); Kaikoura, 91 m, 14 Jun 1961, NIWA stn C653 (1, brood-protecting); 556 m, 18 Oct 1965, NIWA stn E434 (1).

Distinguishing features. Body up to 17 mm long, 11 mm wide (tentacles withdrawn); body calcareous, towered contiguous scales dorsally and laterally, smooth contiguous scales ventrally; body domed dorsally, flat ventrally, mouth anterodorsal, anus posteriodorsal; 10 dendritic tentacles, ventral 2 smaller; tube feet sparse dorsolaterally between scales, present in 3 double radial rows on flattened ventrum, ventral rows not continuing to introvert or anus, not continuous around ventrum

to create sole, lateroventral row continuous, ventrolateral row discontinuous. Dorsal body wall ossicles large contiguous multilayered ossicles, irregularly oval, up to 1.5 mm long, some bluntly towered at one edge; small, concave, shallow multiradiate ossicles in epidermis, up to 0.03 mm long, arms sometimes bifid distally, some joined at rim to form incomplete cups; concave cruciform oval cups, normally 4, rarely up to 7, perforations, knobbed cruciform centrepiece, rim with semidigitate spinelets pointing up from cup rim, cups typically 0.04 mm long; lumpy to knobbed buttons, predominantly irregular, typically 6 (4–10) holes, typically 0.07 (0.07–0.12) mm long.

Colour. Yellow to red (live); white (alcohol) (Mortensen, 1925).

Reproduction. Brood-protects four juveniles up to 2.2 mm long in dorsal coelomic chamber.

Distribution. New Zealand, Kaikoura; Stewart Island, Paterson Inlet; Auckland Islands, Carnley Harbour. 9–556 m.

Remarks. O'Loughlin and O'Hara (1992) and O'Loughlin (1994) remarked that with large multilayered ossicles this species was not a *Trachythyone*, but was close to both *Squamocnus* and the *Psolidae*. O'Loughlin (1994) described coelomic brood-protection, by a mode similar to *P. sacculus*. Within the new genus *P. amokuræ* is unique in having small concave epidermal multiradiate ossicles in addition to the common ossicle combination. It is similar to *P. farquhari* in having towered dorsal and lateral scales, but is distinguished by having dorsal tube feet and the multiradiate ossicles. It is similar to *P. sacculus* in its mode of brood-protection, but is distinguished by having towered scales, dorsal tube feet and multiradiate ossicles.

Psolidocnus farquhari (Mortensen) comb. nov.

Figure 6h–i

Cucumaria farquhari Mortensen, 1925: 343–345; figs 30b, 31a–e.—Dawbin, 1950: 38, pl. 2 fig. 12.

Ocnus farquhari.—Panning, 1949: 437.—Pawson, 1970: 39.—1983: 227–229.—O'Loughlin and O'Hara, 1992: 237.

Material examined. Syntype (ZMUC). New Zealand, 2 mi E of North Cape, hard bottom, 100 m, MPE, 2 Jan 1915.

Distinguishing features. Body up to 13 mm long (extended); body cylindrical, slightly flattened ventrally, anal cone upturned, mouth slightly upturned; body calcareous, knobbed scales dor-

sally and laterally; 10 dendritic tentacles, ventral 2 smaller; tube feet in double series on 3 ventral radii, not extending to introvert and anus, not continuous around ventrum to form sole, absent dorsally and laterally. Dorsal body wall ossicles large multilayered perforated ossicles (scales), up to 0.8 mm long, with towers; irregular lumpy to knobbed buttons, 4–8 perforations, frequently with large central swelling, typically 0.1 mm long; cruciform concave cups, predominantly regular with 4 holes, some with 4 additional small corner holes, centrepiece lumpy, cups spinous to digitate to knobbed, spinelets mostly pointing up from cup rim, cups 0.032–0.048 mm long.

Colour. White, blackish dorsally especially anteriorly and posteriorly (Mortensen, 1925).

Reproduction. Genital tubules unbranched, few eggs linearly, 'eggs' up to 1.0 mm long. A few ossicles, representing early stages of cup and button development, were found in one 'egg' from a gonad tubule, suggesting early embryo development and vivipary.

Distribution. New Zealand, two miles east of North Cape; 100 m.

Remarks. Mortensen (1925) reported a blackish colour dorsally at the anterior and posterior ends. The syntype examined is white and lacks any black coloration. *P. farquhari* is similar to *P. amokurae* in having towered scales. It is distinguished from *P. amokurae* by lacking dorsal tube feet and multiradiate ossicles. *P. farquhari* is distinguished from *P. sacculus* by having towered multilayered ossicles, and double rows of ventral radial tube feet. The species is known from only the two type specimens.

Psolidocnus sacculus (Pawson) comb. nov.

Figure 6j–k

Ocnus sacculus Pawson, 1983: 227–230, 2 figs.—O'Loughlin and O'Hara, 1992: 237.—Rowe (in Rowe and Gates, 1995): 279.—O'Loughlin, 1994: 540.

Material examined. Two paratypes (USNM E27994). New Zealand, Taiaroa Canyon, 45°46' S, 171°05' E, 600–660 m, 25 Mar 1974.

Distinguishing features. Body up to 17 mm long; body calcareous, contiguous scales dorsally and laterally; body cylindrical, slightly flattened ventrum, mouth and anus slightly upturned; 10 dendritic tentacles, ventral 2 smaller; tube feet in single rows on ventral radii, zig-zag midventrally, not extending to introvert and anus, not continuous around ventrum to create sole, absent dorsally

and laterally except at introvert, single radial tube feet at introvert. Dorsal body wall ossicles large thin multilayered ossicles, irregularly oval, up to 1.0 mm long, evident macroscopically as scales [about 9 longitudinally and 9 transversely (excluding ventrum) in 9 mm long specimen]; lumpy to knobbed buttons, predominantly irregular, 3–9 perforations, 0.11–0.17 mm long; cruciform concave spinous cups, predominantly regular with 4 holes, some with 4 additional small corner holes, spinelets pointed to semidigitate, pointing up only or in all directions from rim, distinct cruciform centrepiece sometimes with fine knobs, cups 0.03–0.05 mm long; ventral ossicles similar to dorsal.

Colour (live). White (Pawson, 1983).

Reproduction. Gonads comprise long unbranched tubules, sexes separate, long genital papilla slightly anterior to dorsal tentacle pair on male paratype dissected; brood-protects in 3 anterior dorsal and lateral interradiate closed internal pouches (Pawson, 1983).

Distribution. Taiaroa Canyon, south-eastern New Zealand; 600–660 m.

Remarks. *P. sacculus* is similar to *P. farquhari* in lacking dorsal and lateral tube feet. It is distinguished from *P. farquhari* by having multilayered ossicles without towers, single rows of ventral radial tube feet, and a closed coelomic sac mode of brood-protection. It is distinguished from *P. amokurae* by lacking dorsal tube feet, lacking towers on the body wall scales, and lacking multiradiate ossicles. The species is known from only the 13 type specimens.

Plesiocolochirus ignavus (Ludwig)

Figure 4j–l

Cucumaria ignava Ludwig, 1874: 81.—Lampert, 1885: 142.—Théel, 1886: 107.

Pentacta australis.—H.L. Clark, 1946: 390, 392 (part) [non *Plesiocolochirus australis* (Ludwig, 1874)].

Trachythyone ignava.—Panning, 1949: 426.

Leptopentacta ignava.—Panning, 1966: 60–62, fig. 6.

Pentacta ignava.—Rowe, 1982: 459, 466, fig. 10.30d.—O'Loughlin and O'Hara, 1992: 227, 229.

Pentacta sp. cf. *minuta*.—Marsh, 1991: 471–472.—Marsh and Pawson, 1993: 295, fig. 2B.

Plesiocolochirus ignava.—Rowe (in Rowe and Gates, 1995): 278–279.

Material examined. New Zealand, North Island, Hauraki Gulf, off Tiri Tiri Island, 20 m, S. O'Shea, 10 Jun 1992, NMV F82775 (17); South Island, Fiordland,

Dusky Sound, Beach Harbour, 11–18 m, W.H. Dawbin, 5 May 1950, MNZ EC6705 (1). Southern Australia, abundant NMV material.

Comparative material. *Plesiocolochirus spinosus* (Quoy and Gaimard, 1833), NMV F45021 (3); *Leptopentacta grisea* H.L.Clark, 1938, NMV F82972 (1).

Distinguishing features. Body up to 50 mm long; body hard, box-like, prominent raised dorsolateral edges, distinct ventrum not a sole, lateral and dorsal surfaces with lumps and ridges, smooth ventrally, oral end with 5 pointed triangular flaps (valves); 3 double radial rows of tube feet ventrally, zig-zag rows dorsolaterally, all rows extending from introvert to anus, no tube feet interradially; dorsolateral tube feet and all tube feet on tapering oral and anal ends surmount low wreaths of encircling ridges of ossicles; radial plates of the calcareous ring with no posterior prolongations; body wall ossicles large multi-layered knobbed perforated scales up to 1.5 mm long, regular and irregular knobbed perforated buttons, shallow spinous cruciform cups of a range of sizes and frequently with bridging connections across rim.

Colour. Live body colour dorsally and laterally mottled reddish-brown, brown, cream and white with dorsally a few bright red markings and mauve coloration; walls of tube feet orange on all radii; white ventrally; tentacle trunks dark brown with some white at bases, branches cream. Preserved colour residual mottled dark reddish brown on interradiial dorsal and lateral surfaces, white ventrally and on dorsolateral edges.

Distribution. New Zealand, Hauraki Gulf, Dusky Sound; southern Australia. 0–36 m (Rowe in Rowe and Gates, 1995).

Remarks. The specimens from Hauraki Gulf have residual brown coloration, are less than 10 mm long, and were initially identified as *Ocnus brevidentis*. S. O'Shea reported (pers. comm.) observing this species in north-eastern New Zealand, and that it had red coloration. Morton and Miller (1968: pl. 29–4) published a coloured photo of *Ocnus brevidentis* but the mottled pale brown with red and violet colours indicates *P. ignavus*. This species is reported here for the first time for New Zealand. It occurs abundantly in the rocky shallows across southern Australia.

The generic placement of this species is problematic. *Plesiocolochirus spinosus* (Quoy and Gaimard), the type species for *Plesiocolochirus* Cherbonnier, 1946, has evenly distributed radial and interradiial tube feet, distinctive small paired pointed posterior projections on the radial plates

of the calcareous ring, and lateroventral tubercles. *P. ignava* has none of these features. *Leptopentacta grisea* H.L.Clark, the type species for *Leptopentacta*, has large posterior prolongations on the radial plates of the ring, lacks connecting bridges across the rim of cup ossicles, and lacks body wall growths on any of the radii. *P. ignavus* differs in these characters. In diagnosing *Pentacta* Goldfuss, Panning (1971: 38–39) considered appendages confined to the radii, growths on the radii surmounted by tube feet or papillae, bridges across knobbed ossicles, and four- or five-edged body form to be amongst the characteristics. *P. ignavus* does have these characters, but Rowe (in Rowe and Gates, 1995: 271) has queried the diagnosis of *Pentacta*. There are affinities and discrepancies for *P. ignavus* in relation to *Leptopentacta*, *Plesiocolochirus* and *Pentacta*. A review of the assignment of *P. ignava* and related species to appropriate genera is beyond the scope of this work.

Psolidiella nigra Mortensen

Psolidiella nigra Mortensen, 1925: 360–362, figs 42–43.—Dawbin, 1950: 35, pl. 1 fig. 3.—Panning, 1949: 415.—1957: 35.—1961: 192–194, figs 1–6.—Hickman, 1962: 52.—Pawson, 1970: 36–38, fig. 7.—Panning, 1971: 45.—Fenwick and Horning, 1980: 441, 443.—O'Loughlin, 1994: 541–543, fig. 2.—Rowe (in Rowe and Gates, 1995): 280.

Cucumaria bollonsi Mortensen, 1925: 345–346, fig. 32.—Dawbin, 1950: 38, fig. 9. syn. nov.

Trachythyone bollonsi.—Panning, 1949: 426.—Pawson, 1970: 38–39.

Material examined. Holotype, 2 paratypes [ZMUC]. New Zealand, Stewart Island, Paterson Inlet, rocky shore, 6 Apr 1924.

Other material. The Snares, Boat Harbour, covered by plant detritus in rock pools, 18 Dec 1976, MNZ EC4061 (10); AM J12281 (4).

Syntype of *Trachythyone bollonsi* (Mortensen, 1925). North Island, Cape Maria van Diemen, MPE, 4 Jan. 1915, ZMUC Eh 304–258 (1).

Distinguishing features. Body up to 28 mm long (tentacles withdrawn), 11 mm diameter; body rounded, distinct oval sole, oral cone and upturned anal cone; oral cone wrinkled, folded, pocketed on female specimens; 5 anal scales; 10 dendritic tentacles, ventral 2 smaller. Small tube feet scattered dorsally, laterally, around oral and anal cones; tube feet in 3 radial series ventrally, not continuing to introvert and anus, bordering sole to varying degrees anteriorly and posteriorly, up to 4 rows wide lateroventrally, up to 2 rows wide midventrally; absent from introvert. Dorsal

body wall ossicles absent or sparse thick smooth buttons, typically 4 perforations, up to 0.1 mm long (tube foot endplates and support plates present dorsally). Ventral body wall ossicles abundant thick smooth perforated plates, irregularly oval, up to 16 perforations typically about 8, up to 0.24 mm long; fewer buttons similar to dorsal ones; numerous regular and irregular concave crosses, arms frequently bifid and knobbed distally, typically 0.06 mm long, rarely partly or fully closed around rim to form cups.

Colour (preserved). Body pale brown to very dark brown, grey, black; sole pale brown to cream; tube feet ends white; introvert and tentacles dark brown.

Distribution. New Zealand, North Island (Cape Maria van Diemen), South Island (Banks Peninsula and Otago Peninsula), Stewart Islands and The Snares; south-eastern Australia; rocky shallows.

Remarks. O'Loughlin (1994) reported numerous knobbed and concave crosses and rare cup ossicles in the type specimens of *P. nigra*, and Panning (1961) illustrated these ossicles for *P. nigra* material from Banks Peninsula. Mortensen (1925) described and illustrated these ossicles for the type specimens of *T. bollonsi*, but did not observe them in *P. nigra*. The body wall ossicle combination of rare cups, concave knobbed crosses, smooth perforated plates and smooth buttons is the same in *P. nigra* and *T. bollonsi*, as is the tentacle number and form, dorsal black and ventral white colour, and habitat niche. The tube foot distribution described for *T. bollonsi* is consistent with the very small specimens being juveniles of *P. nigra*.

The syntype of *C. bollonsi* which was examined was 5 mm long, 2.5 mm in diameter, and a large part of the dorsal body wall had been removed. No ossicles were detected, and they have presumably dissolved from the thin body wall. The tube feet in the ventral radial series were large, did not continue to the anus, were four rows wide laterally and two rows wide mid-ventrally, and single large ventral interradial tube feet were present anteriorly and posteriorly creating a distinct sole. Smaller tube feet were present around a slightly upturned anal cone (oral cone was fully withdrawn). There was some residual brown colour evident anteriorly, posteriorly and dorsally. These observations are also consistent with the small syntype of *T. bollonsi* being a juvenile of *P. nigra*.

The type specimens of *C. bollonsi* are small

juveniles, and diagnostic ossicles could no longer be detected. For these reasons the authors have chosen to act under the "Principle of the First Reviser" [ICZN Article 24(a)] and make *C. bollonsi* a junior synonym of *P. nigra* although *C. bollonsi* has page precedence over *P. nigra* in Mortensen (1925). O'Loughlin (1994) has described the brood-protecting habit of *P. nigra*, and has observed this species in south-eastern Australia (O'Loughlin, 2000).

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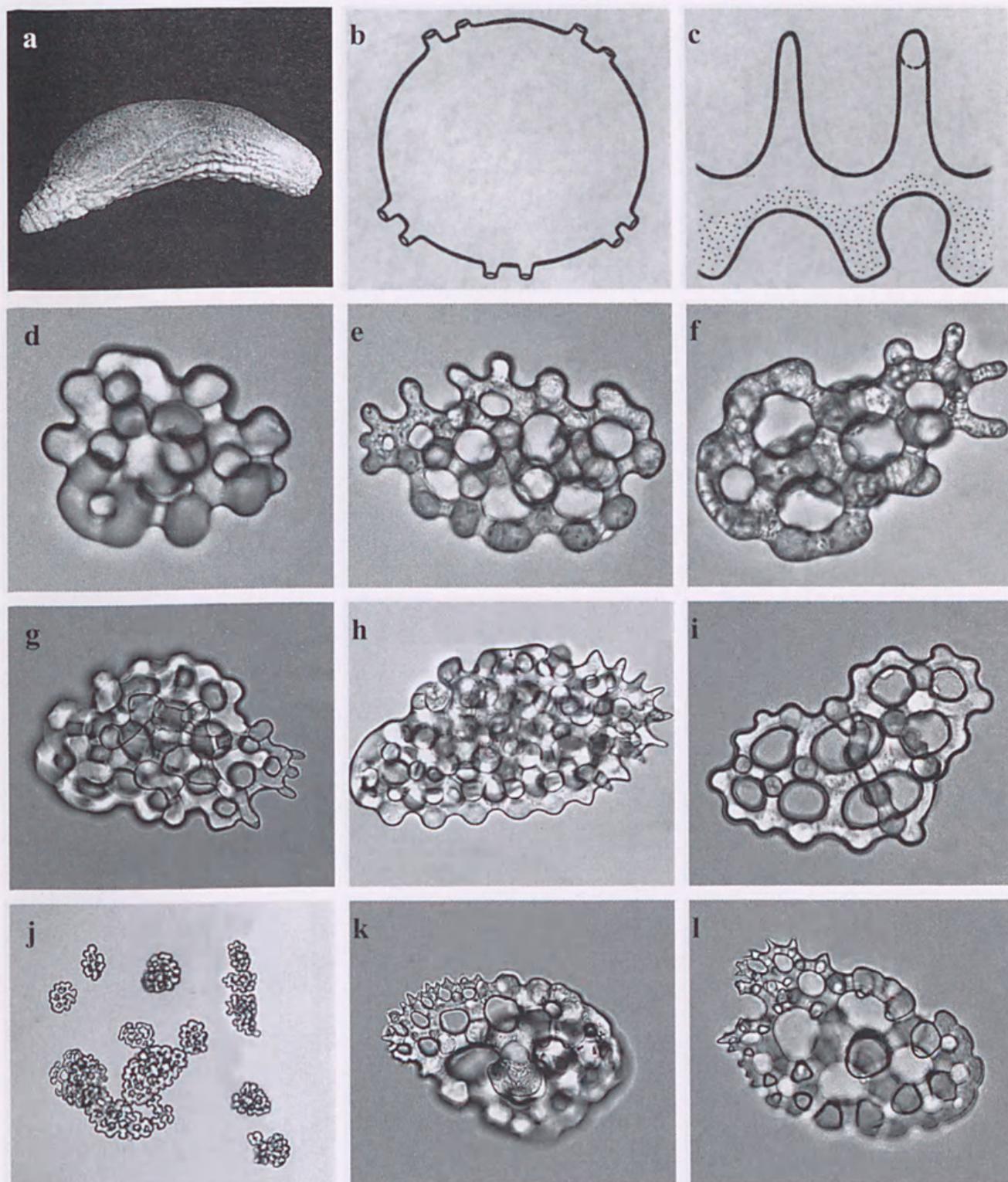


Figure 1. a-j, *Pseudocnus sentus* sp. nov. (ossicles from holotype EC7483). a, right lateral body of holotype (27 mm long); b, midbody section; c, two plates of calcareous ring; d, button (0.08 mm long); e, digitate button (0.10 mm long); f, digitate button (0.10 mm long); g, digitate plate with secondary layering (0.16 mm long); h, denticulate multilayered ossicle (0.22 mm long); i, bridged introvert plate (0.09 mm long); j, tentacle rosettes.

k-l, *Pseudocnus leoninoides* (Mortensen) (ZMUC syntype), denticulate plates (0.14 mm long).

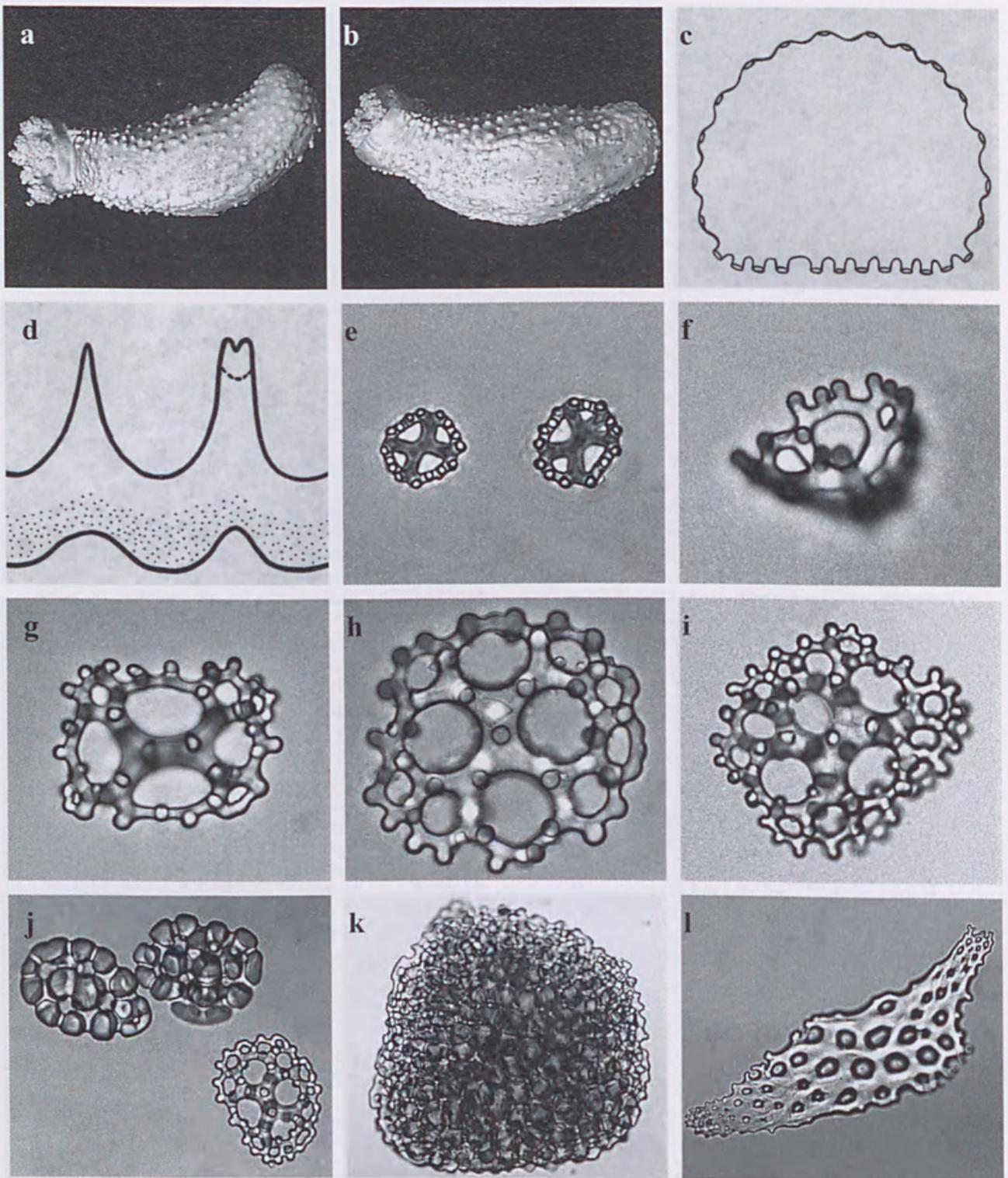


Figure 2. *Squamocnus brevidentis* (Hutton) (ossicles from F81957 and F82779 and NIWA A729). a, lateral body of F81958 (36 mm long); b, left ventral; c, midbody section; d, two plates of calcareous ring; e, smallest cups (0.03 mm long); f, side of cup (0.03 mm long); g, medium cup (0.06 mm long); h, knobbed concave plate (0.1 mm long); i, knobbed concave plate (0.1 mm long); j, knobbed concave plate and buttons (0.1 mm long); k, multilayered ossicle (0.6 mm long); l, tentacle plate (0.6 mm long).

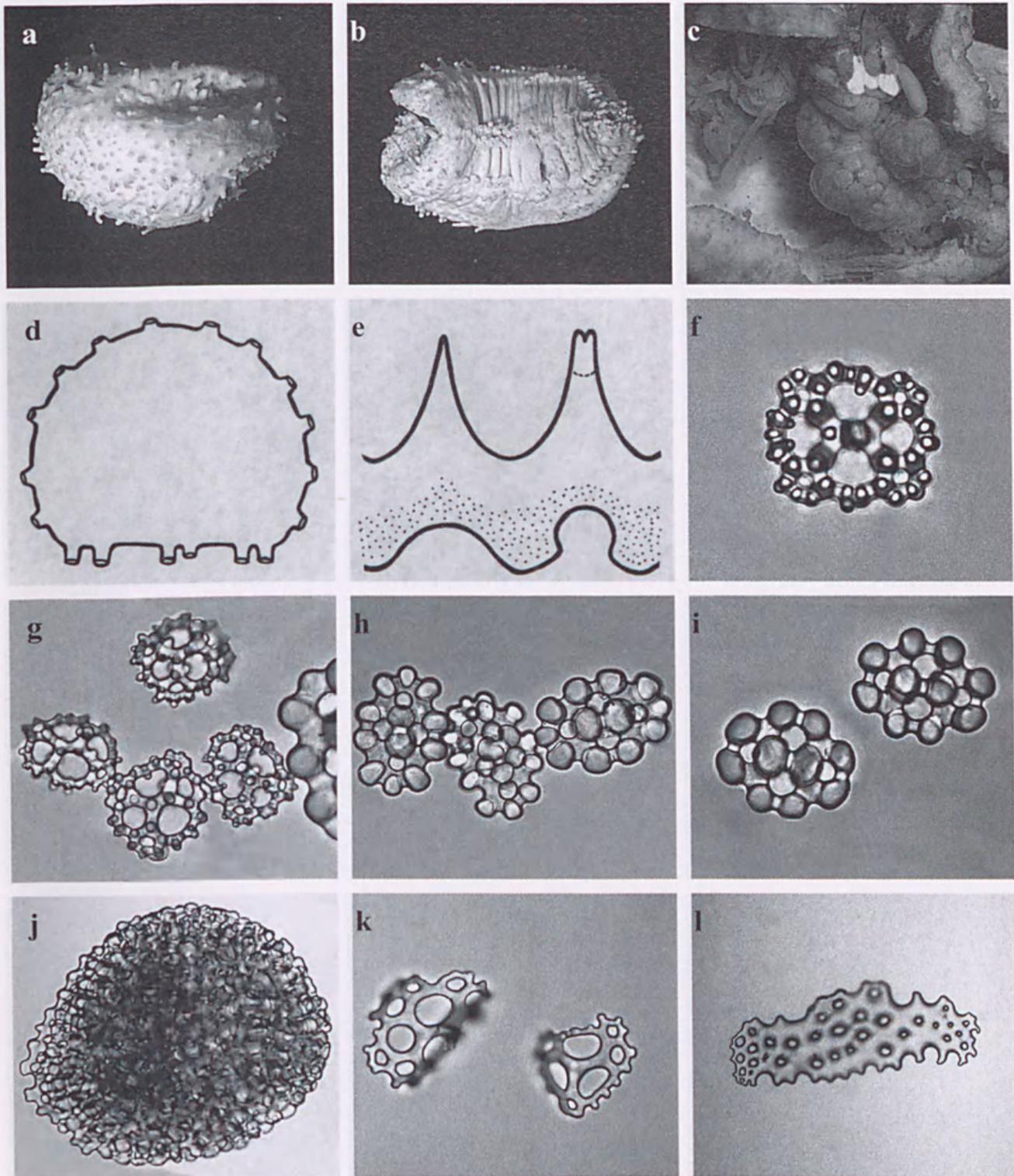


Figure 3. *Squamocnus niveus* sp. nov. (ossicles from paratypes F82777 and F82783). a, dorsal body of holotype, EC7487 (20 mm long); b, ventral; c, dorsal view of ventral coelomic brood sacs and calcareous ring and empty gonad upper left (14 mm long specimen, F83406); d, midbody section; e, two plates of calcareous ring; f, cup (0.04 mm long); g, cups (0.05 mm long); h, buttons (0.09 mm long); i, buttons (0.08 mm long); j, multilayered ossicle (0.6 mm long); k, curved and convex denticulate tentacle plates (0.06 mm long); l, straight and curved elongate tentacle plate (0.4 mm long).

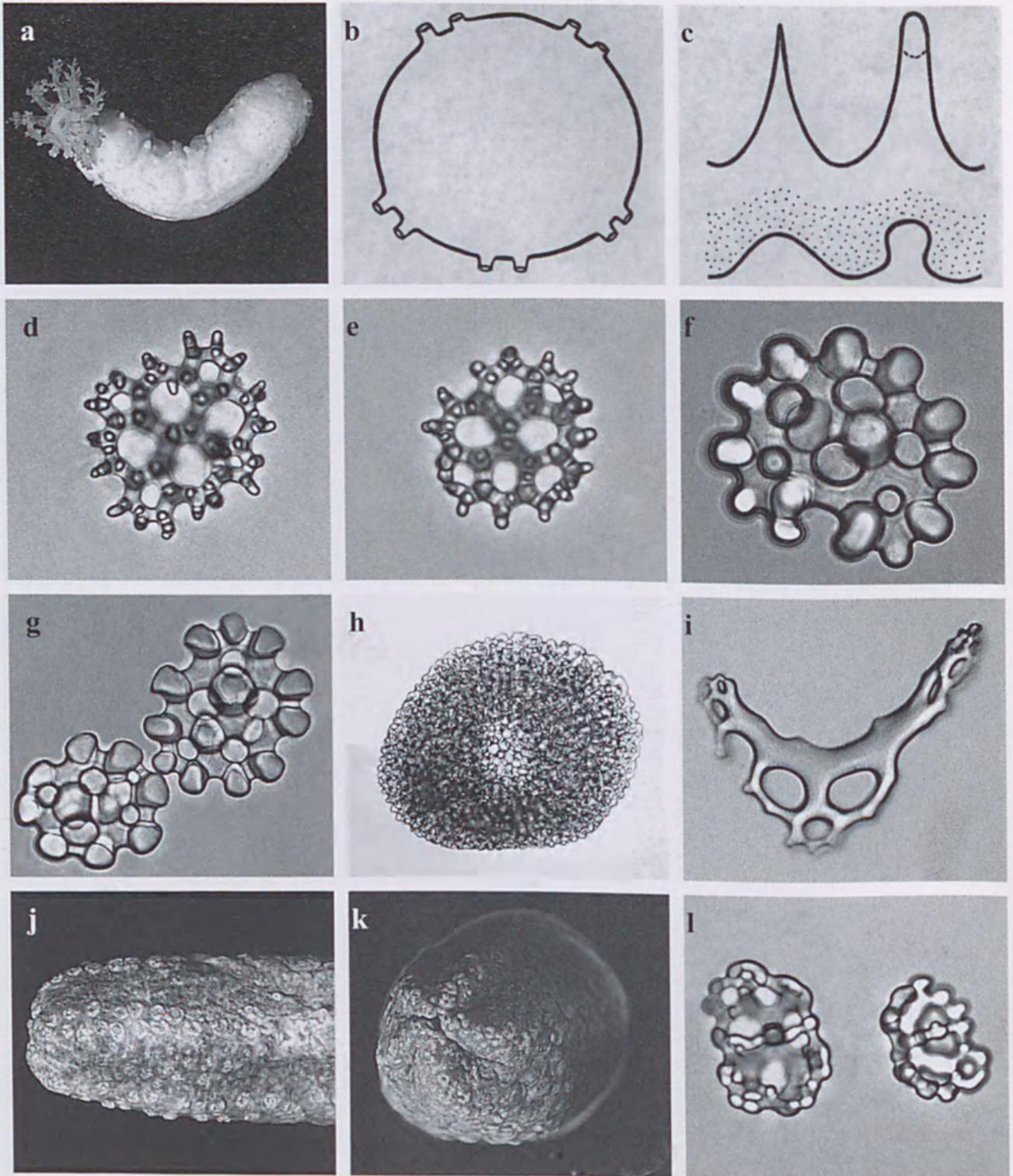


Figure 4. a-i, *Squamocnus luteus* sp. nov. (ossicles from paratypes F82776). a, left lateral body and tentacles of holotype, EC7489 (20 mm long); b, midbody section; c, two plates of calcareous ring; d, cup with semidigitate spinelets (0.05 mm long); e, cup (0.05 mm long); f, button (0.08 mm long); g, buttons; h, multilayered ossicle (0.8 mm long); i, bent and curved elongate tentacle plate (0.25 mm long).

j-l, *Plesiocolochirus ignavus* (Ludwig). j, anterior dorsolateral body of 48 mm long specimen showing radial tubercle wreaths around tube feet (F76516); k, anterior oral valves; l, bridged cups (F82775).

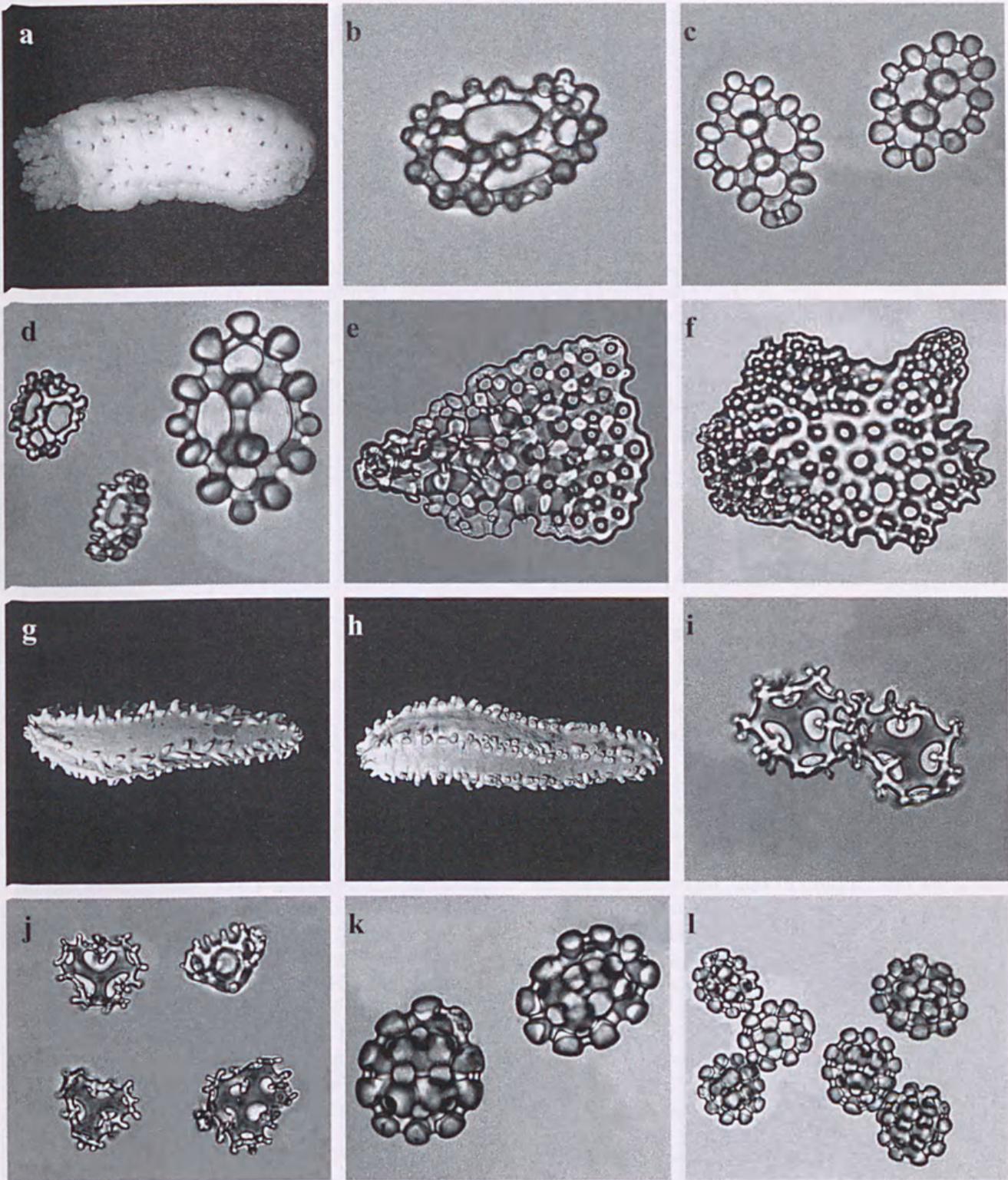


Figure 5. a-f, *Australocnus calcareus* (Dendy) (ossicles from F82782). a, dorsal body of F83405 (7 mm long); b, cup (0.035 mm long); c, buttons (0.08 mm long); d, button and cups; e, plate (0.3 mm long); f, plate (0.5 mm long).
 g-l, *Ocnus planci* (Brandt) (F82971). g, dorsal body (40 mm long); h, ventral; i, cups (0.025 mm long); j, cups (0.025 mm long); k, buttons (0.08 mm long); l, buttons (0.08 mm long).

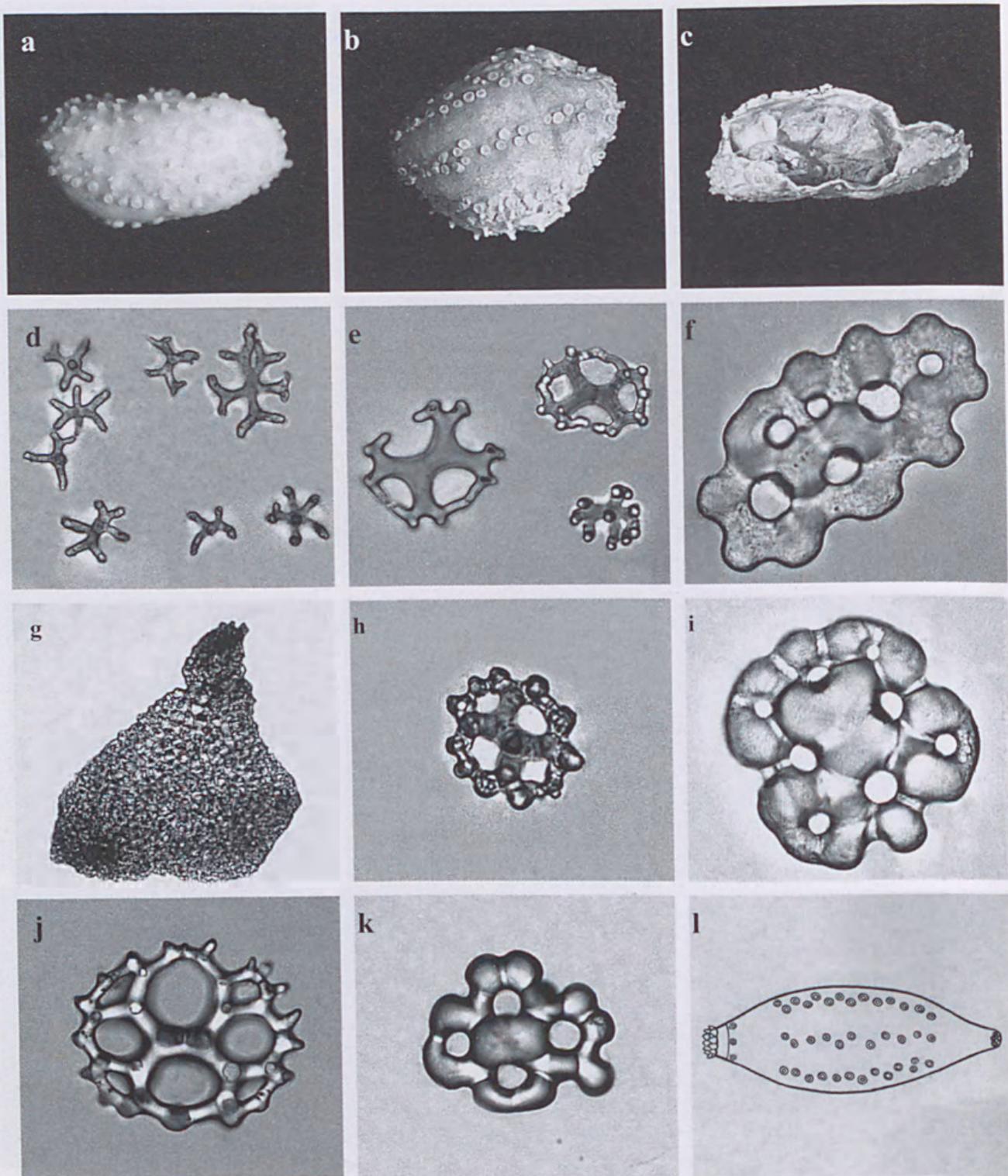


Figure 6. a-g, *Psolidocnus amokurae* (Mortensen) (ossicles from syntype, ZMUC and NIWA C653 specimens). a, lateral body of syntype (9 mm long); b, ventral; c, four dorsal coelomic brood juveniles in 12 mm long specimen (NIWA C653); d, concave multiradiate ossicles (0.02–0.03 mm long); e, multiradiate ossicle and cups (0.02–0.04 mm long); f, button (0.12 mm long); g, towered multilayered ossicle (1.2 mm long).

h–i, *Psolidocnus farquhari* (Mortensen) (ZMUC syntype). h, cup (0.04 mm long); i, button (0.1 mm long).

j–k, *Psolidocnus sacculus* (Pawson) (paratype E27994). j, cup (0.05 mm long); k, button (0.11 mm long).

l, *Psolidocnus* gen. nov. Drawing of ventral tube foot distribution.



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