

## New dendrochirotid sea cucumbers from northern Australia (Echinodermata: Holothuroidea: Dendrochirotida)

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### Abstract

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A new genus in the sub-family Semperiellinae is described: *Triasemperia* O'Loughlin. Six new species of dendrochirotid sea cucumbers are described with O'Loughlin as author: *Actinocucumis solanderi*, *Cladolabes arafurus*, *Globosita elnazea*, *Massinium bonapartum*, *Massinium keesingi*, *Triasemperia stola*. Genera *Actinocucumis* Ludwig, *Cladolabes* Brandt, *Globosita* Chéron and *Massinium* Samyn and Thandar are discussed. Species listed by Heding and Panning as synonyms of *Actinocucumis typica* Ludwig are raised out of synonymy: *Actinocucumis cornus* (Heding); *Actinocucumis difficilis* Bell; *Actinocucumis longipedes* Clark; *Pseudocucumis quinquangularis* Sluiter; *Actinocucumis simplex* (Sluiter). *Actinocucumis donnani* Pearson is *incertae sedis*. We provide a table of some distinguishing morphological characters for species of *Globosita*, and a key for distinguishing the species of *Massinium*.

### Keywords

Northern Australia, Cladolabidae, Semperiellinae, Thyonidiidae, *Actinocucumis*, *Cladolabes*, *Globosita*, *Massinium*, *Triasemperia*, new genus, new species, synonymies

### Introduction

Four recent marine surveys off northern Australia, detailed below, have collected many sea cucumber specimens. We have identified these, and specimens sent to us for identification by Geoscience Australia have been lodged with permission in Museum Victoria. A selection of specimens sent on loan by the Western Australian Museum has also been lodged with permission in Museum Victoria. Additional material from off northern Australia, held in Museum Victoria, has been studied in conjunction with these collections. The surveys referred to above are:

1. Geoscience Australia and the Australian Institute of Marine Science conducted collaborative Survey SOL4934 on the seabed environments of the eastern Joseph Bonaparte Gulf off Northern Australia in August and September 2009 on AIMS RV *Solander*. A *Post-survey Report* has been provided by Heap et al. (2010).

2. The Australian Institute of Marine Science, Geoscience Australia, the University of Western Australia and the Museum

and Art Gallery of the Northern Territory conducted marine biodiversity survey SOL5650 on the Oceanic Shoals Commonwealth Marine Reserve (Timor Sea) in September and October 2012 from AIMS RV *Solander*. A *Post-survey Report* has been provided by Nichol et al. (2013).

3. The Museum and Art Gallery of the Northern Territory, in collaboration with Geoscience Australia, the Northern Territory government, and the Australian Institute of Marine Science, undertook a biological acquisition program SS2012t07 during the transit of CSIRO RV *Southern Surveyor* between Darwin and Cairns in October 2012. A *Post-survey Report* has been provided by Przeslawski et al. (2013).

4. The Commonwealth Scientific and Industrial Research Organization, in collaboration with the French *Total Foundation*, conducted a survey of the biota off the mouth of the King George River in the Kimberley region of northern Australia in June 2013 on AIMS RV *Solander*. The project leader was John Keesing, CSIRO Senior Principal Research Scientist.

In this paper one new genus and six new species of dendrochirotidids are described, and additional new species await description. Tissue samples from all of the recently collected sea cucumber specimens have been sent to the University of Florida as part of a continuing project with Gustav Paulay to obtain global genetic data for sea cucumbers.

## Methods

Scanning electron microscope (SEM) images were taken by Didier VandenSpiegel after clearing the ossicles of associated soft tissue in commercial bleach, air-drying, mounting on aluminium stubs, and coating with gold. Observations were made using a JEOL JSM-6480LV SEM. Measurements were made with Smile view software.

Photos of specimens were taken in Museum Victoria by Melanie Mackenzie, in collaboration with Mark O'Loughlin, using an SLR Nikon D300S digital camera with 60 mm Nikkor lens. Photos of live specimens were taken by the on-board scientists on the King George River expedition.

## Abbreviations

AIMS	Australian Institute of Marine Science
CSIRO	Commonwealth Scientific and Industrial Research Organization
GA	Geoscience Australia
KGR	King George River
MAGNT	The Museum and Art Gallery of the Northern Territory
MOLAF	Prefix for code number of tissues provided to the University of Florida for sequencing
NHMUK	British Museum of Natural History
NMV	Museum Victoria, Australia, with registration number prefix F
UF	University of Florida
WAM	Western Australia Museum, with registration number prefix Z

## Order *Dendrochirotida* Grube, 1840

Family *Cladolabidae* Heding and Panning, 1954 (*sensu* Smirnov 2012)

*Remarks.* Heding and Panning (1954) initially described the Cladolabinae as a sub-family within the Phyllophoridae Östergren, 1907. Pawson and Fell (1965) transferred the Cladolabinae to be a sub-family within the Sclerodactylidae Panning, 1949. Smirnov (2012) raised Cladolabinae to family status as Cladolabidae, based on the very short segmented or unsegmented posterior prolongations on the radial plates of the calcareous ring. The variety of ossicle form in the species of Cladolabidae suggested to Smirnov (2012) that the family might be polyphyletic.

## *Cladolabes* Brandt, 1835

*Cladolabes* Brandt, 1835: 35.—Heding and Panning, 1954: 121.—Thandar, 1989: 299.—Liao and Clark, 1995: 488–489.

*Urodemas* Selenka 1867: 352.—H. L. Clark, 1938: 497–499.—1946: 410.

*Pseudococumis* Ludwig, 1875: 90.—H. L. Clark, 1946: 405.

*Diagnosis.* Up to large size (150 mm long); 20 tentacles in two (15+5) or three (10+5+5) circles; tube feet scattered over the body, or confined to the radii; calcareous ring not composite, radial and inter-radial plates of ring high, posterior paired radial prolongations distinct but short, not fragmented; ossicles either tables with rudimentary disc and tall two-pillared spires or rudimentary spires, or irregular short thick variably spinous rods and clubs related to tables; rosettes frequently present.

*Type species.* *Cladolabes limaconotus* Brandt, 1835 (by monotypy) (NW Pacific)

*Other species, with distributions.* *Cladolabes aciculus* (Semper, 1867) (Fiji, tropical Indo-West Pacific); *C. arafurus* O'Loughlin, sp. nov. (below) (NE Australia); *C. bifurcatus* (Deichmann, 1944) (Natal, South Africa); *C. crassus* (H. L. Clark, 1938) (Hong Kong); *C. hamatus* (Sluiter, 1914) (Indo-Malayan Archipelago); *C. perspicillus* (Selenka, 1867) (E Australia); *C. pichoni* Cherbonnier, 1988 (Madagascar); *C. roxasi* (Domantay, 1934) (Philippines); *C. schmeltzii* (Ludwig, 1875) (NE Australia to S China).

*Remarks.* We have emended the earlier diagnoses of Heding and Panning (1954), Thandar (1989) and Liao and Clark (1995) to include the presence of rudimentary table spires that are present in our new species (below). We noted above that the variety of ossicle form in the species of Cladolabidae suggested to Smirnov (2012) that the family might be polyphyletic. We endorse this view for the same reason. For this same reason, and the added reason of the variation in tube foot distribution, we judge that *Cladolabes* might also be polyphyletic.

## *Cladolabes arafurus* O'Loughlin, sp. nov.

*Zoobank LSID.* <http://zoobank.org:act:AB27AA20-F074-4C3B-BABE-242616AD4A2F>

Figures 1, 2.

*Material examined.* Holotype. N Australia, Arafura Sea, GA cruise SS2012t07, stn/site 01BS01, sample 110, 11.23°S 134.73°E, RV *Southern Surveyor*, benthic sled, 31 m, B. Alvarez de Glasby et al., 16 Oct 2012, NMV F202989 (UF tissue lot MOLAF1530).

Paratype. NE Australia, Queensland, Yeppoon, dredged off Middle Island, 23.13°S 150.74°E, 9–37 m, B. J. Smith, 6 Sept 1967, NMV F204070 (1).

*Description.* Form sub-spherical, up to 63 mm long (preserved), slightly convex dorsally, deeply convex ventrally, mouth anterior dorsal, anus posterior dorsal, slightly developed oral and anal cones (preserved); dorsal body wall thicker than ventral wall, creased, covered closely with numerous tube feet, diameters about 0.5 mm; ventral body wall thin, scattered cover of tube feet; lacking anal scales; 20 dendritic tentacles, 15 large (variable sizes) in outer circle, 5 smaller (not

significantly smaller) in inner circle (proximal peri-oral); calcareous ring not composite, radial and inter-radial plates of ring high, narrow anteriorly, posterior paired radial prolongations distinct, short, not fragmented; single polian vesicle; gonad tubules branched basally; respiratory trees extending throughout coelom.

Ossicles sparsely scattered in mid-body dorsal and ventral body wall, small plates, rods and rosettes; plates frequently regular, oval with 2 large central perforations and single smaller perforation at each end (judged to be reduced table discs), short blunt pillar frequently projecting from centre of plate (judged to be reduced spires), plates 56–90  $\mu\text{m}$  long; rods related to plates, 1 or 2 perforations, sometimes with central short pillar, up to 70  $\mu\text{m}$ . Peri-anal body wall ossicles plates, rods, rosettes and small scales; plates similar to mid-body wall (judged to be reduced tables); rods irregular, many branched, distal ends of rod and branches widened and perforate, up to 120  $\mu\text{m}$  long; multi-layered anal scale about 320  $\mu\text{m}$  long. Tube feet endplate diameters up to 400  $\mu\text{m}$ , tube foot and endplate support ossicles elongate perforated curved plates up to 160  $\mu\text{m}$  long. Tentacles with rod ossicles and rosettes; rods fine to thick, ends widened with few perforations, rods up to 400  $\mu\text{m}$  long. Oral disc and introvert with abundant rosettes, rosette rods and rare plates.

Preserved body colour off-white with fine brown flecking and spotting, tube feet brown.

*Distribution.* N Australia, Arafura Sea to Yeppoon, 9–37 m.

*Etymology.* Named for the Arafura Sea from which the type specimen was collected.

*Remarks.* We had considerable difficulty in finding a genus to which we should refer this new species, but we did not feel justified in establishing yet another new dendrochirotid genus. We refer the new species to *Cladolabes* with major reservations. We judge that the plates with short central pillars of *Cladolabes arafurus* O’Loughlin sp. nov. are related to table discs and spires, the latter very reduced. This would account for the unusual ossicle forms. We have emended the diagnosis of *Cladolabes* to include this character. But we recognize that the reduced tables in species currently referred to *Cladolabes* are generally characterized by a rod-like spire and reduced disc, the opposite to *Cladolabes arafurus*. The forms of the calcareous ring in species currently referred to *Cladolabes* are

quite variable but generally the inter-radial plates have posterior prolongations and are not truncate posteriorly as in *Cladolabes arafurus*. We anticipate that emerging genetic data will result in a major revision of family Cladolabidae and await this evidence as to where the new species belongs generically. The form of the ossicles is distinctive, especially what we judge to be the reduced tables, and distinguishes *Cladolabes arafurus* from all other species in the genus.

#### *Globosita* Cherbonnier, 1958

*Sphaerella* Heding and Panning, 1954: 111 (occupied generic name).

*Globosita* Cherbonnier, 1958: 198 (replacement name).

*Diagnosis.* Cylindrical to ovoid dendrochirotid species, up to 100 mm long (preserved), sometimes with short oral and anal cones; mouth anterior dorsal, anus posterior dorsal; lacking anal teeth; 20 dendritic tentacles, 15 large, 5 inner small; radial plates of calcareous ring with paired composite posterior prolongations, each comprising up to about 6 discrete segments; inter-radial plates truncate or with notch posteriorly, lacking posterior prolongations; tube feet scattered over whole body, more numerous dorsally or ventrally; gonad tubules in 2 tufts, branched.

Body wall ossicles thick plates, irregularly round to oval to sub-rectangular, up to 90  $\mu\text{m}$  long, perforations very small or lacking, sometimes finely knobbed on margin and surface, plates sometimes with 4 larger central perforations, sometimes with one large central perforation surmounted by a cross; tables with four pillars sometimes present in body wall, spires sometimes incomplete; rosettes may be present; tentacles with rods, perforated distally.

*Type species.* *Globosita argus* (Heding and Panning, 1954) (type locality Java).

*Other species, with distributions.* *Globosita dobsoni* (Bell, 1883) (Honduras); *G. elnazae* O’Loughlin sp. nov. (N Australia); *G. murrea* Cherbonnier, 1988 (Madagascar).

*Remarks.* Cherbonnier (1958) recognized that the genus name *Sphaerella* was occupied, and provided the replacement name *Globosita*. Cherbonnier (1988) examined the holotype of *Globosita argus* and observed ‘pseudo-tables’. Deichmann (1930) expressed the opinion that the juveniles of *Globosita dobsoni* would have tables.

Table 1. Some distinguishing morphological characters of *Globosita* species.

<i>Globosita</i> species Type locality	Largest specimen	Tube foot distribution	Rosette ossicles	Plate perforations	Plate ossicles
<i>G. argus</i> Java	92 mm long sub-spherical	more dense ventrally	absent	few, minute to absent	smooth
<i>G. dobsoni</i> Honduras	80 mm long ovoid form	more dense ventrally	present	commonly 4 small centrally	finely knobbed
<i>G. elnazae</i> North Australia	100 mm long sub-spherical	more dense dorsally	absent	some numerous, some large centrally	finely knobbed
<i>G. murrea</i> Madagascar	40 mm long ovoid form	more dense ventrally	present	some numerous, not large centrally	knobbed on margin

*Globosita elnazae* O'Loughlin sp. nov.

Zoobank LSID. <http://zoobank.org:act:4E654BA2-1AC4-41AE-A52D-B6891E620792>

Figures 3, 4, table 1.

*Material examined.* Holotype. NW Australia, Joseph Bonaparte Gulf, Kimberley region, off King George River, 13.79°S 127.24°E, RV *Solander*, 55 m, J. Keesing, 10 Jun 2013, WAM Z27872 (KGR lot 23426; UF tissue lot MOLAF1484).

Paratypes. Off King George River, 13.85°S 127.29°E, RV *Solander*, 45 m, J. Keesing, 6 Jun 2013, WAM Z27861 (1) (KGR lot 23322; UF tissue lot MOLAF1459); 13.82°S 127.32°E, 73 m, 12 Jun 2013, WAM Z27853 (1) (KGR lot 29381; UF tissue lot MOLAF1442); 13.90°S 127.33°E, 11 m, 7 Jun 2013, NMV F202999 (2) (KGR lot 23425; UF tissue lots MOLAF1468, 1469).

Other material. NE Australia, Queensland, near Cairns, Machans Beach, 16.85°S 145.73°E, on beach after cyclone, B. Collins, 25 Dec 1996, NMV F203014 (1).

*Description.* Form sub-spherical, up to 100 mm long (preserved), slightly convex dorsally, deeply convex ventrally,

mouth anterior dorsal, anus posterior dorsal, slightly developed oral and anal cones (preserved); lacking anal scales; thin soft body wall, slightly thicker dorsally; tube feet scattered over body, closer dorsally, clusters of numerous tube feet around mouth and anus, diameters about 0.4 mm; 20 dendritic tentacles, 15 large outer, 5 small inner (proximal peri-oral); calcareous ring composite, radial plates with paired tapered posterior prolongations comprising about 3 discrete segments; inter-radial plates pointed anteriorly, deep notch posteriorly, lacking posterior prolongations; single polian vesicle; madreporite multi-lobed, near posterior end of calcareous ring; gonad tubules short with numerous branches; respiratory trees extending the length of the coelom.

Ossicles scattered sparsely in dorsal and ventral body wall, regular to irregular thick oval plates and incomplete tables; larger regular dorsal plates oval to rounded sub-rectangular in form, some with large central perforation with cross and 4 truncate pillars (not amongst ossicles illustrated), large and small surrounding perforations, surface sometimes finely knobbed,

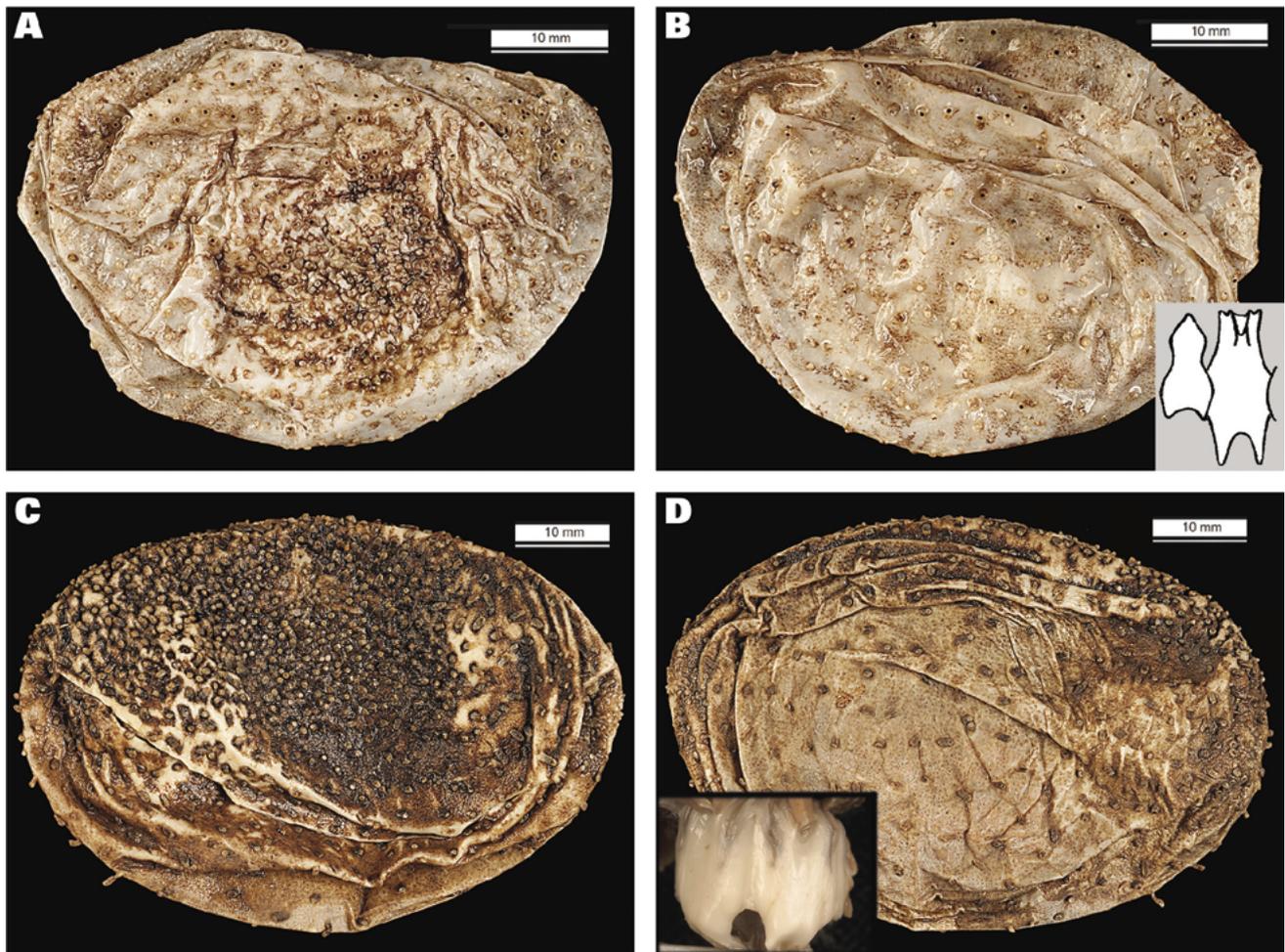


Figure 1. Photos of preserved and collapsed specimens of *Cladolabes arafurus* O'Loughlin sp. nov. A, dorsal view of holotype (NMV F202989, 50 mm long); B, ventral view of holotype; insert with sketch of the calcareous ring of the holotype; C, dorsal view of paratype (NMV F204070, 63 mm long); D, ventral view of paratype; insert with photo of the calcareous ring of the paratype.

margin finely spinous, plates up to  $90\ \mu\text{m}$  long; smaller irregular dorsal plates round to irregular in form, frequently with small perforations, sometimes with 2 large central perforations, surface variably finely knobbed, margin irregular to finely spinous, plates  $40\text{--}70\ \mu\text{m}$  long. Ventral body wall with some tables, oval discs up to  $100\ \mu\text{m}$  long, spires low, 4 pillars, sometimes not connected distally, sometimes with connecting distal bridge with short blunt spines. Tube feet endplate diameters about  $250\ \mu\text{m}$ , tube foot and endplate support ossicles elongate

perforated curved plates up to  $160\ \mu\text{m}$  long. Peri-anal body wall with tables, endplates, tube foot support rod-plates; table discs irregularly round to rounded square, up to  $80\ \mu\text{m}$  wide, spires with 4 pillars, short spines distally; endplates about  $100\ \mu\text{m}$  diameter; tube foot support ossicles short, thick curved, rod-plates, about  $100\ \mu\text{m}$  long. Tentacles with rod ossicles only, rods smooth, ends widened with few perforations and denticulate margin, rods up to  $120\ \mu\text{m}$  long. Rosette ossicles not observed in tentacles or peri-anal body wall.

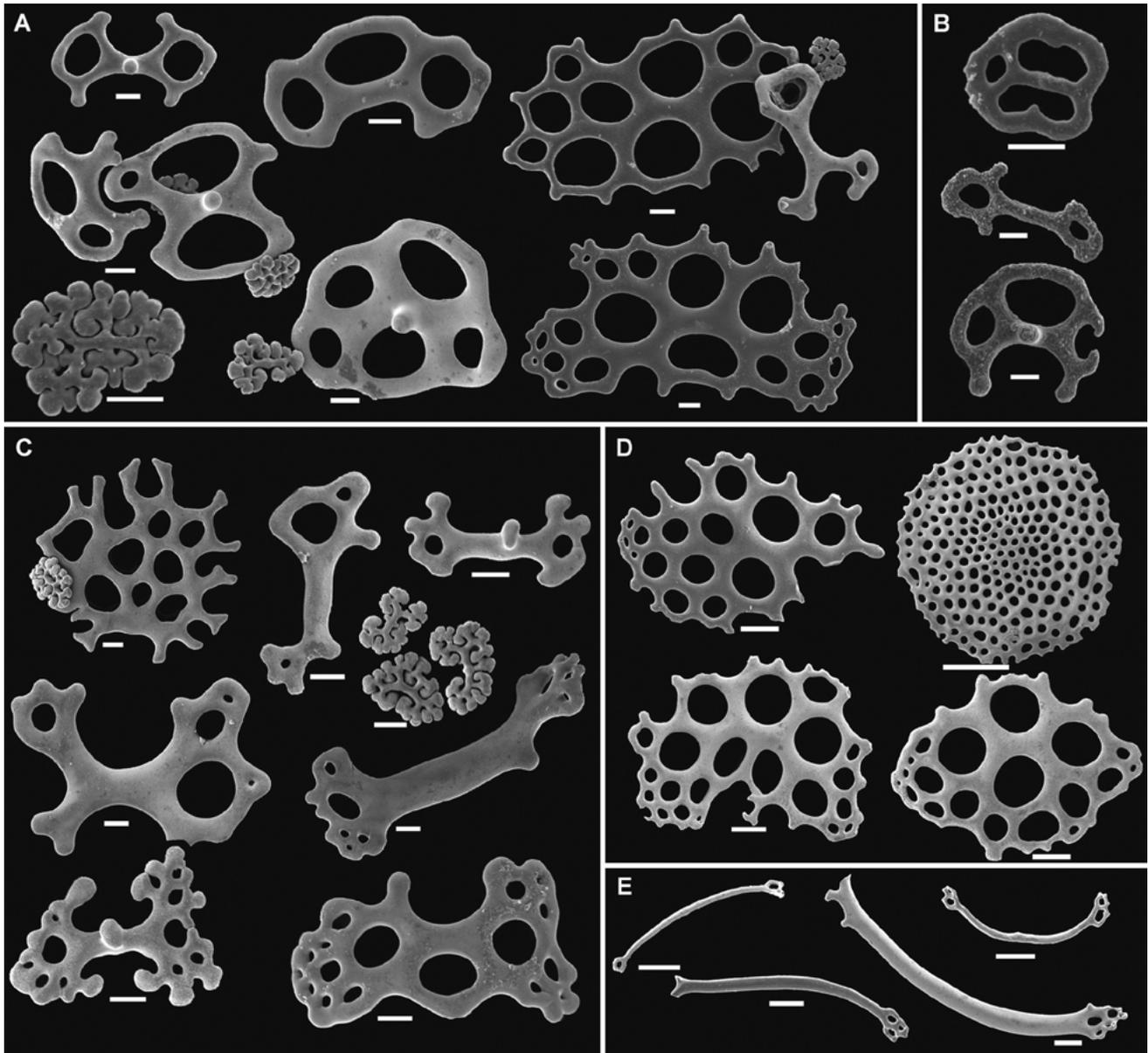


Figure 2. SEM images of ossicles from the holotype of *Cladolabes arafurus* O'Loughlin sp. nov. (NMV F202989). A, mid-dorsal body wall and tube feet small plates (reduced table discs), some with central short pillar (reduced spires), rosettes, and tube feet support plates (large, right) (scale bars  $10\ \mu\text{m}$ ); B, ventral mid-body wall reduced tables (scale bars  $10\ \mu\text{m}$ ); C, peri-anal body wall small endplate (top left), reduced tables with central short pillar, rods, and rosettes (scale bars  $10\ \mu\text{m}$ ); D, ventral tube foot endplate (top right, scale bar  $100\ \mu\text{m}$ ), and tube foot support plates (scale bars  $20\ \mu\text{m}$ ); E, tentacle rods (scale bars  $20\ \mu\text{m}$ ).

Colour live pale yellow to off-white; colour preserved off-white to pale brown, tube feet mostly with brown rim.

*Distribution.* N Australia, off King George River, Kimberley region, north Western Australia, to near Cairns, Queensland, 11–73 m.

*Etymology.* Named *elnazae* for Elnaz Tavancheh (Museum Victoria Volunteer), with appreciation of Elnaz's generous and skilled assistance with sea cucumber systematics.

*Remarks.* The distinguishing characters of *Globosita elnazae* O'Loughlin sp. nov. are the more abundant tube feet dorsally and the presence of a large central perforation surmounted by a cross in some plate ossicles. We note that for Cherbonnier 1988 fig. 93, illustrating the ossicle for *Globosita murrea*, fig. "E" illustrating rosettes should be "H" and fig. "H" illustrating tables should be "K". In *Globosita elnazae* we did not observe rosettes. *Globosita elnazae* sp. nov. is distinguished from the other species in the genus by the combination of morphological characters summarized in Table 1.

Family **Thyonidae** Panning, 1949 (sensu Smirnov 2012)

Sub-family **Semperiellinae** Heding and Panning, 1954

*Diagnosis* (emended from O'Loughlin et al. (2012) and Smirnov (2012)). Dendrochirotid species with 20 dendritic tentacles; calcareous ring composite, comprising a mosaic of small pieces or discrete segments; radials and inter-radials prolonged posteriorly, prolongations frequently merge to create a tubular ring; radials frequently with median division for most of the length creating 2 narrow posterior prolongations that sometimes fuse with inter-radials, distal ends sometimes cross-linked; body wall tables with 2 or 3 or 4 spires.

*Remarks.* Smirnov (2012) raised the sub-family Thyoninae Panning, 1949 to family status as Thyonidae, with a diagnostic emphasis on the mosaic structure of the composite and frequently tubular calcareous ring. He included the two sub-families Thyoninae (with 10 tentacles) and Semperiellinae (with 15 or 20 tentacles). O'Loughlin et al. (2012) noted that Rowe and

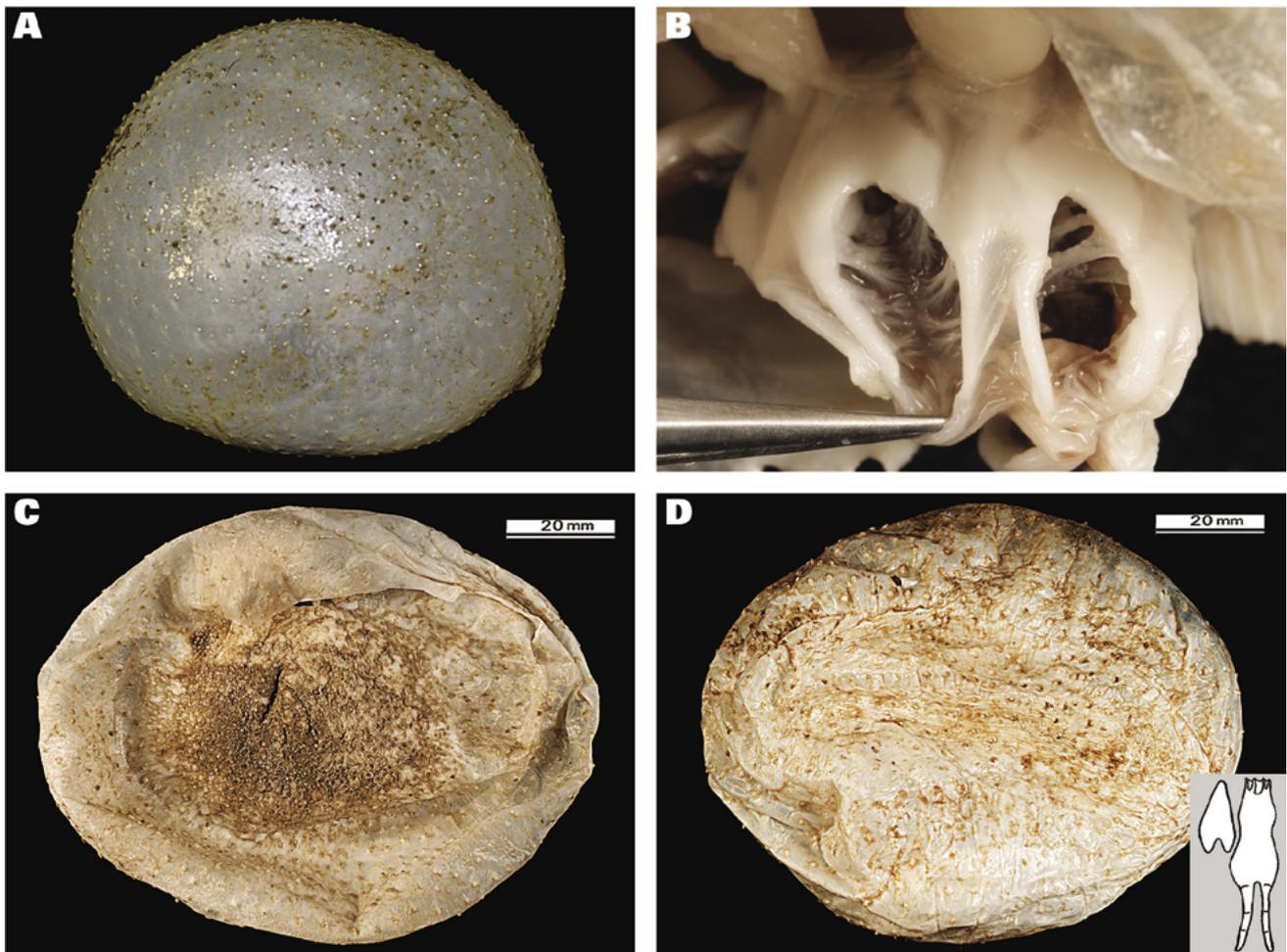


Figure 3. Photos of live, and preserved and collapsed, holotype specimen of *Globosita elnazae* O'Loughlin sp. nov. (WAM Z27872). A, ventro-lateral view of the live holotype specimen; B, photo of the calcareous ring of the holotype; C, dorsal view of the preserved holotype (100 mm long); D, ventral view of the preserved holotype; insert with sketch of the calcareous ring of the holotype.

Richmond (2004) judged that *Semperiella* Heding and Panning, 1954 (in the then new sub-family Semperiellinae) is a junior synonym of *Thyonidiella* Heding and Panning, 1954 (in the then new sub-family Phyllophorinae). As a consequence genera of the sub-family Semperiellinae have 20 tentacles. We have emended the diagnosis of Semperiellinae to include this fact, to include species with tables that have three pillars in each spire (see new genus and species below), and to provide a more detailed description of the calcareous ring. Michonneau and Paulay (2014) judged that *Semperiella* and *Thyonidiella* are junior synonyms of *Phyrella* Heding and Panning, 1954, and referred *Phyrella* to the Phyllophoridae Östergren, 1907. They suggested that a phylogenetic re-assessment of the family Phyllophoridae remains unresolved. We recognize that molecular genetic data will be crucial to resolving the many emerging issues.

### *Massinium* Samyn and Thandar, 2003

*Massinium* Samyn and Thandar, 2003: 136.—Samyn et al., 2010: 2.

**Diagnosis.** Frequently semi-spherical species with oral and anal dorsal orientations; 20 dendritic tentacles arranged in two circles of 10 large outer and 10 small inner (proximal peri-oral); tube feet distributed all over mid-body; calcareous ring elongate, tubular, with both radial and inter-radial plates fragmented into a mosaic of small pieces, and posterior prolongations linked distally to form inter-radial oval non-calcified spaces beneath the water vascular ring; polian vesicles from 1 to 4; ossicles variably include granuliform rods, rosettes, pseudo-buttons and tables; table spires with 1 or 2 or 3 or reduced pillars.

**Type species.** *Massinium maculosum* Samyn and Thandar, 2003 (original designation) (South Africa).

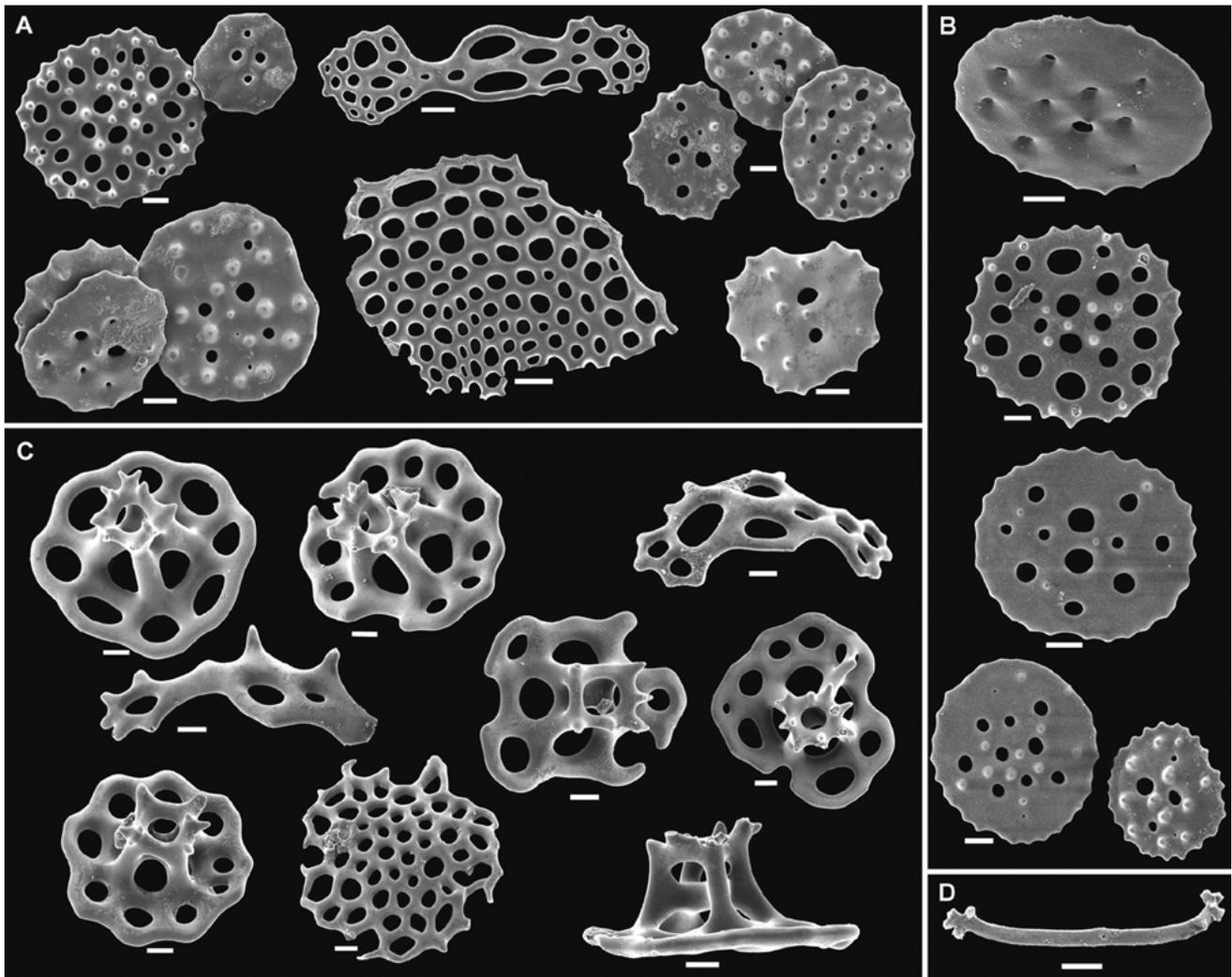


Figure 4. SEM images of ossicles from the holotype of *Globosita elnazae* O'Loughlin sp. nov. (WAM Z27872). A, dorsal mid-body wall and tube feet small knobbed plates, tube foot support plate (centre top), and endplate fragment (centre bottom) (scale bars 10  $\mu$ m); B, ventral mid-body wall knobbed plates (scale bars 10  $\mu$ m); C, peri-anal body wall tables, small endplate, and tube foot support rod-plates (scale bars 10  $\mu$ m); D, tentacle rod (scale bar 10  $\mu$ m).

*Other species, with distributions.* *Massinium albicans* Samyn et al., 2010 (New Caledonia); *M. arthroprocessum* (Thandar, 1989) (South Africa); *M. bonapartum* O'Loughlin sp. nov. (NW Australia); *M. dissimilis* (Cherbonnier, 1988) (Madagascar); *M. granulosum* Samyn et al., 2010 (NE Australia); *M. keesingi* O'Loughlin sp. nov. (NW Australia); *M. magnum* (Ludwig, 1882) (Indonesia); *M. melanieae* O'Loughlin in O'Loughlin et al., 2012 (S Australia); *M. vimsi* O'Loughlin in O'Loughlin et al., 2012 (SE Australia); *M. watsonae* O'Loughlin in O'Loughlin et al., 2012 (SE Australia).

*Remarks.* We have emended the diagnosis of *Massinium* from that in Samyn et al. (2010) to reflect our observations in this review.

#### Key to the species of *Massinium*

1. Ossicles present in the mid-body wall ..... **2**
  - Mid-body wall lacking ossicles ..... **9**
2. Mid-body wall with table ossicles of some form present ... **3**
  - Mid-body wall lacking any form of table ossicles ..... **6**
3. Mid-body wall ossicles tables only ..... **4**
  - Mid-body wall ossicles tables and additional ossicle forms ..... **5**
4. Peri-oral table spires well developed, typically with long, splayed, pointed apical spines .....
  - ..... *M. bonapartum* sp. nov. (NW Australia)
  - Peri-oral table spires frequently absent or reduced, few short apical spines .....
    - ..... *M. keesingi* sp. nov. (NW Australia)
5. Mid-body with rare but developed table ossicles; tentacles with table ossicles; up to 2 polian vesicles .....
  - ..... *M. dissimilis* (Madagascar)
  - Mid-body with reduced table ossicles; tentacles with rosettes only; typically 4 polian vesicles .....
    - ..... *M. magnum* (Indonesia)
6. Mid-body wall with rosettes present ..... **7**
  - Mid-body wall lacking rosettes ..... **8**
7. Introvert table discs irregular with predominantly 4 central perforations and single ring of smaller outer perforations; tentacles with rods and rosettes .....
  - ..... *M. maculosum* (South Africa)
  - Introvert table discs irregular with predominantly 4 central perforations and up to 3 rings of smaller outer perforations; tentacles with elongate rod-rosettes .....
    - ..... *M. albicans* (New Caledonia)
8. Mid-body ossicles predominantly short, thick, irregular, rarely perforate, granuliform rods; tentacles with rosette ossicles only ..... *M. granulosum*. (NE Australia)
  - Mid-body ossicles predominantly U-shaped, distally perforate rods; tentacles with rod ossicles only .....
    - ..... *M. arthroprocessum* (South Africa)
9. Large and small tube feet uniformly distributed; 4 polian vesicles; peri-anal body wall with table ossicles .....
  - ..... *Massinium melanieae* (Great Australian Bight)
  - Tube feet not uniformly distributed; fewer than 4 polian vesicles; peri-anal body wall lacking table ossicles ..... **10**
10. Tube feet scattered dorsally, more prominent ventrally; peri-oral table discs with up to 20 perforations; tentacles with rods and rare rosettes .....
  - ..... *Massinium vimsi* (Bass Strait, SE Australia)
  - Tube feet more concentrated along longitudinal muscles; peri-oral table discs with up to 40 perforations; tentacles with rare fine rods, lacking rosettes .....
    - ..... *Massinium watsonae* (SE Tasmania, Australia)

#### *Massinium bonapartum* O'Loughlin sp. nov.

*Zoobank LSID.* <http://zoobank.org:act:C34C417F-9A65-4346-8145-ED9E350D7E21>

Figures 5, 6, key.

*Material examined.* Holotype. NW Australia, Joseph Bonaparte Gulf, Kimberley region, off King George River, 13.85°S 129.29°E, RV *Solander*, 45 m, J. Keesing, 6 Jun 2013, WAM Z27860 (KGR lot 23323; UF tissue lot MOLAF1457).

Paratype. Joseph Bonaparte Gulf, 11.54°S 129.83°E, RV *Solander*, 173 m, Geosciences Australia, 14 Sep 2009, NMV F202985 (1) (GA lot SOL4934 35BS24; UF tissue lot MOLAF1519).

*Description.* Form sub-spherical, slightly elongate, up to 43 mm long (preserved), mouth anterior dorsal, anus posterior dorsal, slightly developed oral and anal cones; firm leathery body wall; tube feet scattered over body, withdrawn, diameters about 0.2 mm, sparse dorsally, close cover ventrally and around mouth and anus; 20 dendritic tentacles, 5 pairs large in an outer ring, 5 pairs very small in an inner ring (proximal circum-oral); calcareous ring long, tubular, composite; radial plates blunt anteriorly with 2 lateral shallow notches and deeper central notch, radial plates lacking median un-calcified section; inter-radial plates pointed anteriorly, large oval un-calcified posterior section closed distally by thin calcified link; 2 polian vesicles; short branched gonad tubules; respiratory trees extending the length of the coelom.

Ossicles in mid-body wall tables only, sparse dorsally, more numerous ventrally; table disc outlines irregularly round, typically 4 larger central and some small outer perforations, margin smooth or spinous, discs up to 112  $\mu$ m wide; spires with 2 frequently fused pillars, low or residual, few thick blunt apical spines. Oral disc with abundant tables with discs up to 112  $\mu$ m long, irregularly oval, many perforations, margins smooth; spires discrete, up to 70  $\mu$ m long, 2 partly fused pillars, rarely single, 1 to 3 median perforations, long apical spines typically widely splayed. Peri-anal body wall with abundant tables similar to those in the mid-body wall; some rods with distal perforations, rods up to 80  $\mu$ m long; small multi-layered anal scales about 200  $\mu$ m long. Tube feet with endplates, up to 320  $\mu$ m diameters, margin thick, lacking support ossicles; body wall type tables. Tentacles with abundant rods and rosette-like rod ossicles and some tables;

rods up to 70  $\mu\text{m}$  long with ends widened with few perforations; rosette-like rods up to 88  $\mu\text{m}$  long with short rod widened distally with many small perforations created by dendritic branch fusing; few tables, similar to those in peri-oral disc.

Colour live off-white to pale yellow; colour preserved off-white to pale brown, tube feet brown; tentacle dendritic branches black, trunks off-white to grey.

*Distribution.* NW Australia, Joseph Bonaparte Gulf, Kimberley region, off King George River, 45–173 m.

*Etymology.* Named with reference to the *Joseph Bonaparte Gulf* from which the type specimens were collected.

*Remarks.* A distinctive character of *Massinium bonapartum* O'Loughlin sp. nov. is the widely splayed long apical spines frequently present on the tables. We observed the five pairs of small tentacles to be in an inner ring. *Massinium bonapartum* sp. nov. is distinguished from other species in the genus by the combination of morphological characters shown in the key.

*Massinium keesingi* O'Loughlin sp. nov.

*Zoobank LSID.* <http://zoobank.org:act:BDDF31E0-C687-4932-9541-A2C40266126C>

Figures 7, 8, key.

*Material examined.* Holotype. NW Australia, Joseph Bonaparte Gulf, Kimberley region, off King George River, 13.85°S 127.29°E, RV *Solander*, large epibenthic sled, 45 m, J. Keesing, 6 Jun 2013, NMV F203008 (KGR lot 23324; UF tissue lot MOLAF1458).

*Description.* Form sub-spherical, 40 mm long (preserved), mouth anterior dorsal, anus posterior dorsal, slightly developed oral and anal cones (preserved); firm leathery body wall; tube feet scattered over body, withdrawn, sparse dorsally, more numerous ventrally, diameters about 0.2 mm; 20 dendritic tentacles, 5 pairs large in an outer ring, 5 pairs very small in an inner ring (proximal circum-oral); calcareous ring long, tubular, composite; radial plates blunt anteriorly with 2 lateral small notches and deeper central notch, most of radial plates

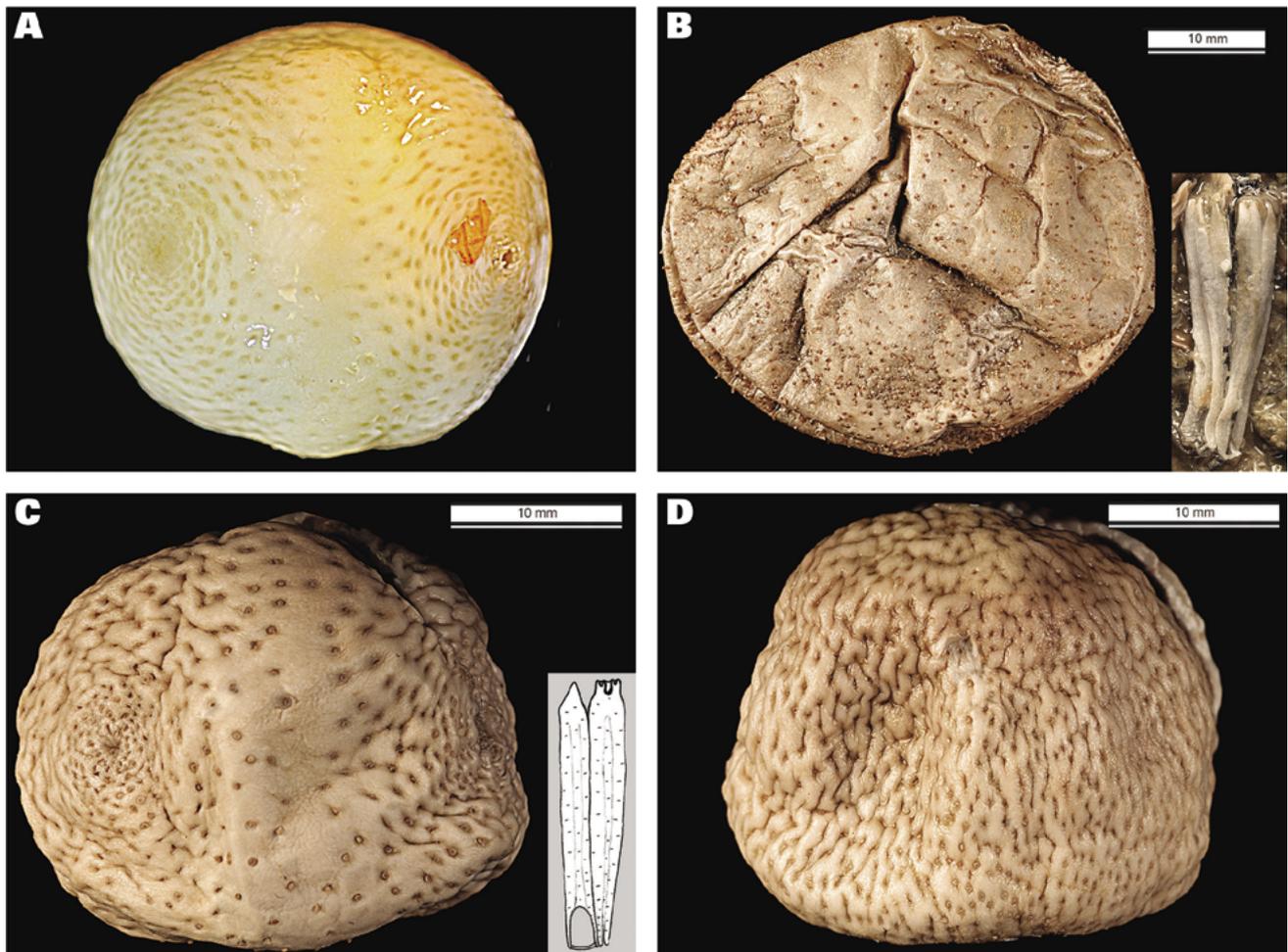


Figure 5. Photos of live and preserved specimens of *Massinium bonapartum* O'Loughlin sp. nov. A, dorsal view of live holotype specimen (WAM Z27860); B, lateral view of preserved paratype (NMV F202985, 43 mm long); insert with photo of the calcareous ring of the paratype; C, dorsal view of preserved holotype (30 mm long); insert with sketch of the calcareous ring of the holotype; D, ventral view of the preserved holotype.

with long median un-calcified section; inter-radial plates pointed anteriorly, small oval un-calcified section posteriorly; 1 polian vesicle; gonad tubules long, branched; respiratory trees extending the length of the coelom.

Ossicles in mid-body wall tables only, sparse, scattered, tables abundant in oral disc and peri-anally; table discs oval to round, variable sizes, up to 90  $\mu\text{m}$  long, margin smooth or slightly undulating, not spinous, 4 large central perforations, variable number of smaller outer perforations, some very

small; spires rare or reduced, if present 1 or 2 pillars, spires up to half disc length long, few short spines apically. Oral disc with rods as in tentacles and abundant tables with multi-perforate discs and predominantly single pillar spires, discs oval to sub-rectangular, 4 large central perforations, numerous smaller outer perforations, discs up to 96  $\mu\text{m}$  long, spires with 1 or 2 pillars, few short apical spines, length about half disc length. Tube feet with endplates, diameters about 150  $\mu\text{m}$ , lacking support ossicles. Tentacles with rod ossicles only, up to

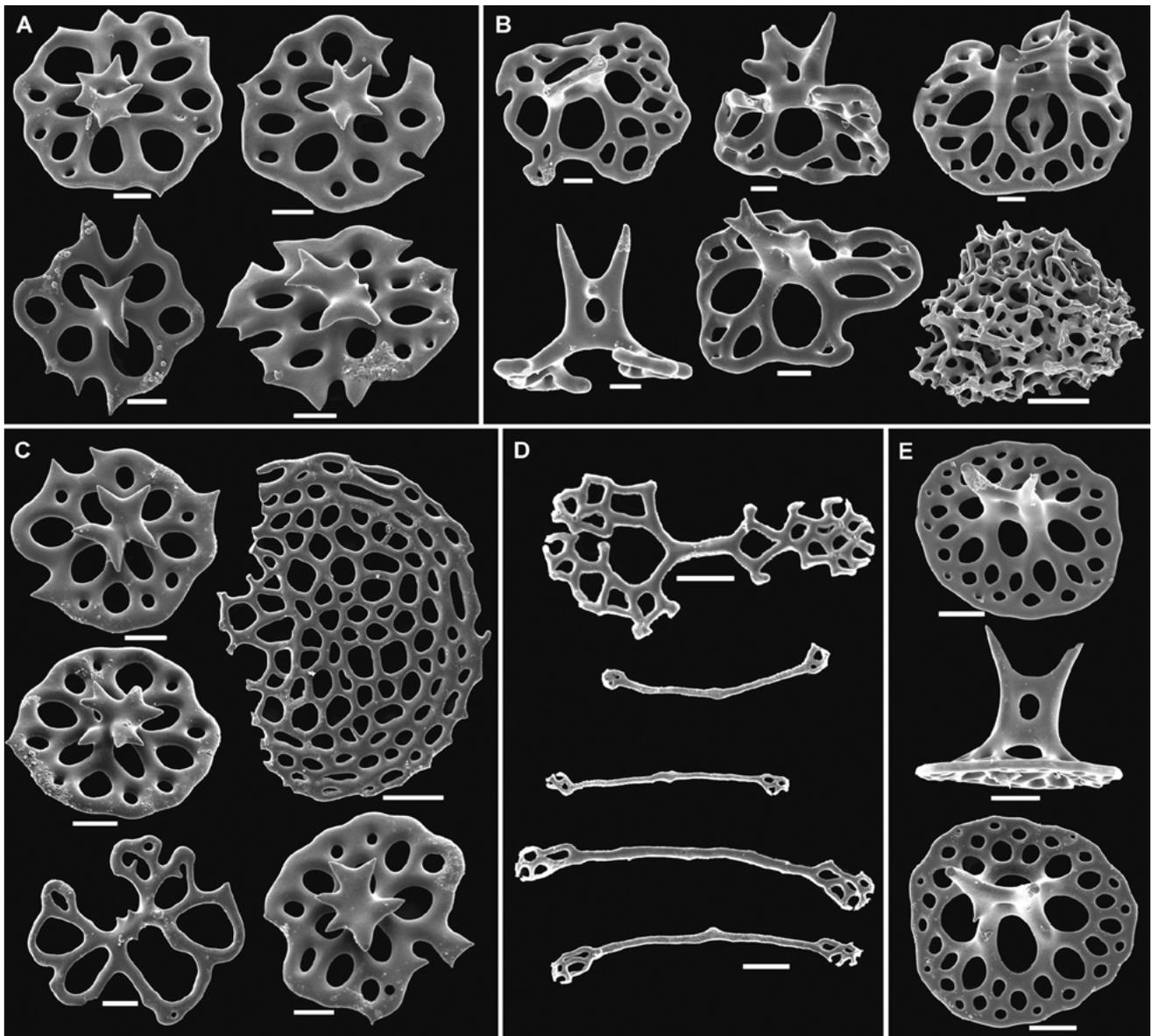


Figure 6. SEM images of ossicles from the holotype of *Massinium bonapartum* O'Loughlin sp. nov. (WAM Z27860). A, mid-dorsal body wall tables, spires short with fused pillars (scale bars 20  $\mu\text{m}$ ); B, peri-anal body wall scale fragment (bottom right, scale bar 50  $\mu\text{m}$ ), and irregular tables with 2 discrete or fused pillars (scale bars 20  $\mu\text{m}$ ); C, mid-ventral body wall tables (scale bars 20  $\mu\text{m}$ ), and fragment of endplate with thickened margin (scale bar 50  $\mu\text{m}$ ); D, tentacle rods and rosette-like rod (scale bars 10  $\mu\text{m}$ ); E, oral disc tables, table discs irregularly oval with many perforations, spires with 2 pillars partly fused and with long splayed distal spines (scale bars 20  $\mu\text{m}$ ).

90  $\mu\text{m}$  long, smooth, ends widened with few perforations and denticulate margin. Rosette ossicles not observed in tentacles or oral disc or body wall.

Colour preserved off-white; tube feet pale brown.

*Distribution.* NW Australia, Joseph Bonaparte Gulf, Kimberley region, off King George River, 45 m.

*Etymology.* Named *keesingi* for John Keesing (CSIRO), the leader of the King George River Expedition, with appreciation of John's gracious and helpful collaboration in our work with the sea cucumber collection.

*Remarks.* A distinctive character of *Massinium keesingi* O'Loughlin sp. nov. is the frequent presence of table spires with a single pillar. We observed the five pairs of small tentacles to be in an inner ring. *Massinium keesingi* sp. nov. is distinguished from other species in the genus by the combination of morphological characters as detailed in the key.

*Triasemperia* O'Loughlin gen. nov.

*Zoobank LSID.* <http://zoobank.org:act:5140E273-FE8D-4F8A-A66D-F94B74771FE8>

*Diagnosis.* Dendrochirotid species with mouth anterior, anus posterior, lacking anal teeth; tube feet scattered over body; 20 dendritic tentacles, 15 large, 5 inner small; calcareous ring composite, comprising small calcareous pieces, radial and inter-radial composite plates adjoin to create tubular ring, radial plates elongate with thin posterior distal prolongations adjoining inter-radial plate elongations, radial plates with median division for most of the length, inter-radial plates with deep posterior notch; ossicles throughout the body wall tables, discs triangular, typically with 6 large marginal knobs and 6 small perforations, spires with three pillars; tentacles with rods, rosettes, few tables.

*Type species.* *Triasemperia stola* O'Loughlin sp. nov. (monotypic).

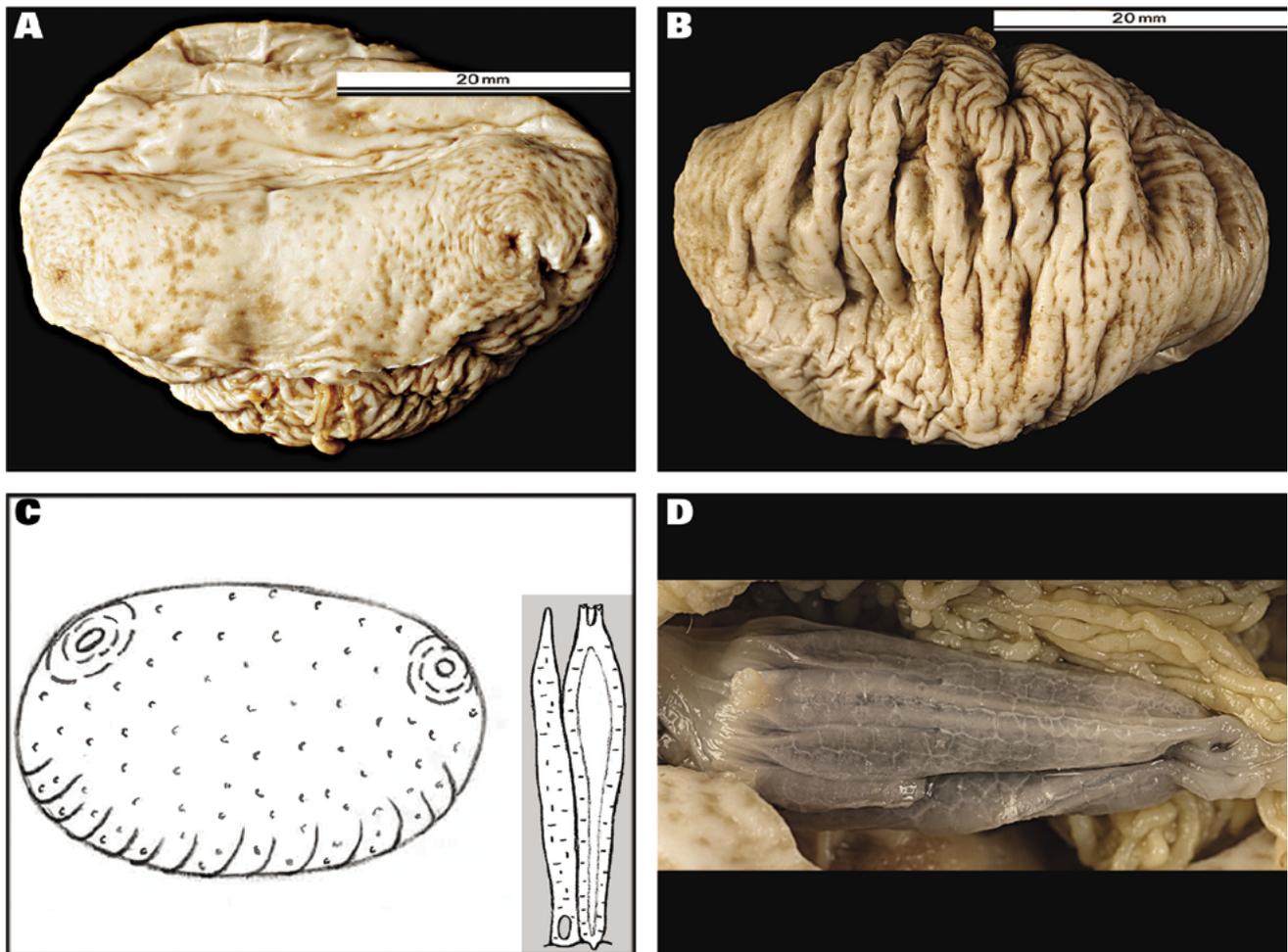


Figure 7. Holotype specimen of *Massinium keesingi* O'Loughlin sp. nov. (NMV F203008). A, dorsal view of preserved holotype (40 mm long); B, ventral view of preserved holotype; C, sketch of dorso-lateral view of the holotype; insert with sketch of the calcareous ring; D, photo of the calcareous ring of the holotype.

**Etymology.** From the Greek *tria* (three), referring to the three pillars of the table spires, with *semperia*, referring to the sub-family Semperiellinae and in turn to the esteemed biologist Carl Gottfried Semper.

**Remarks.** The new genus *Triasemperia* is referred to the sub-family Semperiellinae on the bases of the presence of 20 dendritic tentacles and composite tubular calcareous ring. The new genus is distinguished from the other genera of the Semperiellinae by the presence of table spires with three pillars.

***Triasemperia stola* O'Loughlin sp. nov.**

**Zoobank LSID.** <http://zoobank.org:act:B8F02EEE-7711-4519-BC96-DE02BD4433F3>

Figures 9, 10.

**Material examined.** Holotype. N Australia, Joseph Bonaparte Gulf, 12.32°S 129.94°E, shell and sand substrate, RV *Solander*, 46 m, AIMS & GA, 5 Aug 2010, NMV F174889 (GA specimen 29084, SOL 5117, 013BS010; UF tissue lot MOLAF1541).

Paratypes. NE Australia, Queensland, Yeppoon, dredged off Middle Island, 23.13°S 150.74°E, 9–37m, B. J. Smith, 6 Sept 1967, NMV F204083 (1); same data, NMV F204088 (1).

**Description.** Form cylindrical, elongate, upturned oral and anal ends, tapered orally, long taper anally, U-shape up to 45 mm wide (preserved); hard, thick, calcareous body wall, 'prickly' to touch; mouth anterior, anus posterior, lacking anal teeth; tube feet scattered over body, withdrawn, inconspicuous (preserved), diameters about 0.2 mm, paired radial series of tube feet on withdrawn introvert; 20 dendritic tentacles, 15 large, 5 inner small; calcareous ring composite, comprising small calcareous pieces, radial and inter-radial composite plates adjoin to create tubular ring, radial plates elongate with thin posterior distal prolongations adjoining inter-radial plate elongations, radial plates with median division for most of the length, inter-radial plates with deep posterior notch; single polian vesicle; gonad tubules with numerous branches; respiratory trees extending throughout the coelom.

Ossicles throughout body wall densely crowded thick tables, table discs triangular, typically with 6 large marginal knobs and 6 small perforations, discs 80–120  $\mu\text{m}$  wide, spires with 3 pillars and 6 pointed spines distally, disc width and spire height sub-equal. Introvert and tube feet with tables, rods, endplates; tables smaller, irregular, some lacking spires, perforations up to 19, discs up to 56–104  $\mu\text{m}$  wide; smooth rods with distal ends

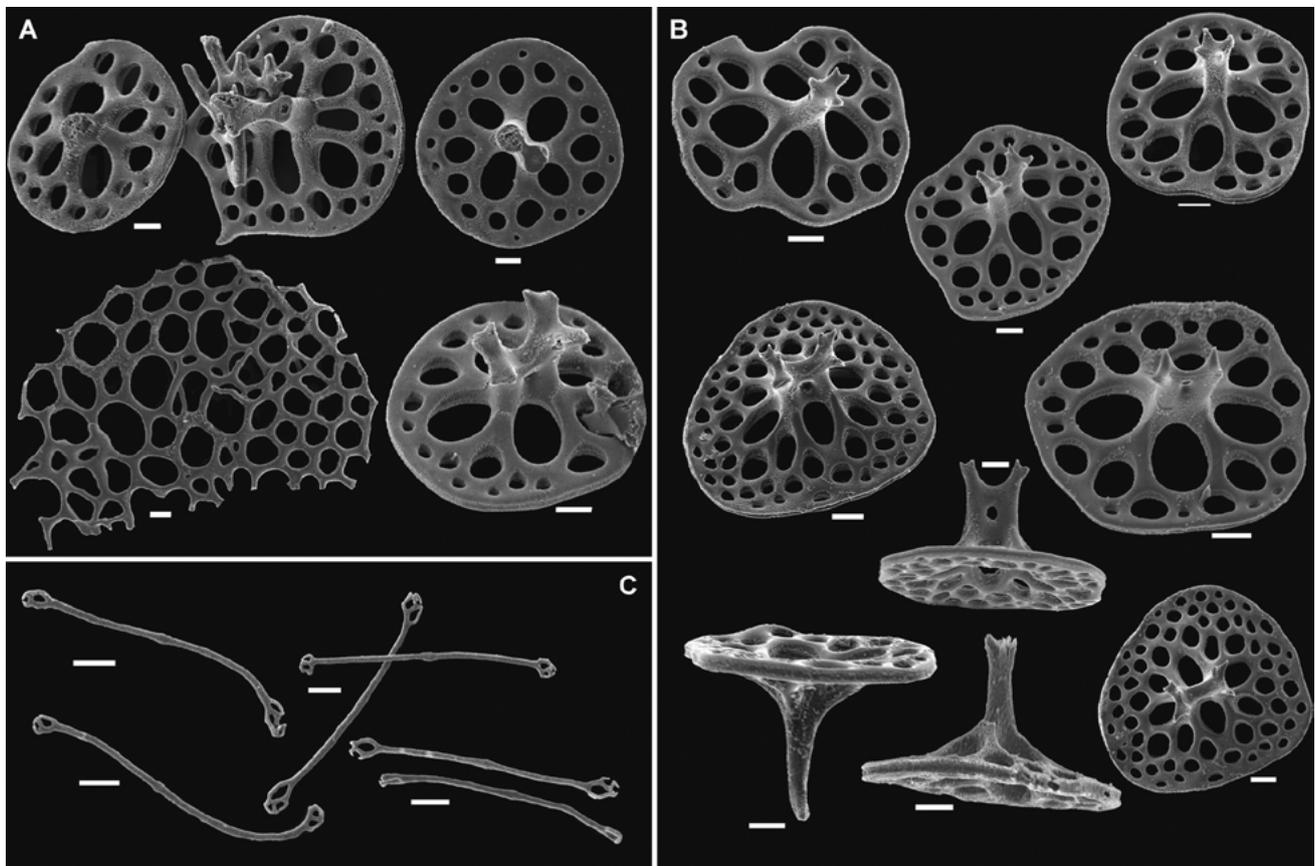


Figure 8. SEM images of ossicles from the holotype of *Massinium keesingi* O'Loughlin sp. nov. (NMV F203008). A, peri-anal body wall tables and endplate fragment, discs with smooth margins, spires with 1 or 2 pillars (scale bars 10  $\mu\text{m}$ ); B, oral disc tables, table discs with smooth margin, spires with single or 2 partly fused pillars, apical spines short and blunt (scale bars 10  $\mu\text{m}$ ); C, tentacle rods (scale bars 10  $\mu\text{m}$ ).

enlarged and perforated, up to 120  $\mu\text{m}$  long; endplates with diameters about 136  $\mu\text{m}$ , tube foot support ossicles tables only. Tentacles with rods, rosettes, tables; fine to thick smooth rods with swollen perforated ends; tables rare, form regular or irregular, some not knobbed, discs up 96  $\mu\text{m}$  wide.

Live colour red-brown to brown, preserved colour brown to off-white with residual violet colouration.

**Distribution.** Northern Australia, from Joseph Bonaparte Gulf to Yeppoon Queensland, 9–53 m.

**Etymology.** Named *stola* with reference to the genus *Stolus* that has species with heavily knobbed button-like ossicles that are similar to the table discs of this species.

**Remarks.** The distinguishing morphological character of *Triasemperia stola* is the presence of table spires with three pillars. The calcareous ring and ossicles are similar to those of *Stolus crassus* Liao and Pawson, 2001, but *S. crassus* from the South China Sea is described as having 10 tentacles and only 2 pillars in the table spires.

Family **Thyonidiidae** Heding and Panning, 1954 (*sensu* Smirnov 2012)

**Remarks.** Heding and Panning (1954) initially described the Thyonidiinae as a sub-family within the Phyllophoridae Östergren, 1907. Based on the absence of posterior segmented prolongations on the calcareous ring Pawson and Fell (1965) transferred the Thyonidiinae to a sub-family within the Cucumariidae Ludwig, 1894. Based on the presence of more than 10 tentacles and table ossicles Smirnov (2012) raised Thyonidiinae to family status as Thyonidiidae. The plate ossicles in *Parathyonidium* Heding (in Heding and Panning), 1954 and “reduced” ossicles in *Athyonidium* Deichmann, 1941 and *Patallus* Selenka, 1868 suggested to Smirnov (2012) that these genera were probably unrelated to the genera with tables.

***Actinocucumis*** Ludwig, 1875

*Actinocucumis* Ludwig, 1875: 91.—Théel, 1886: 125.—H. L. Clark, 1946: 402–403.—Heding and Panning, 1954: 70–72.—A. M. Clark and Rowe, 1971: 204.

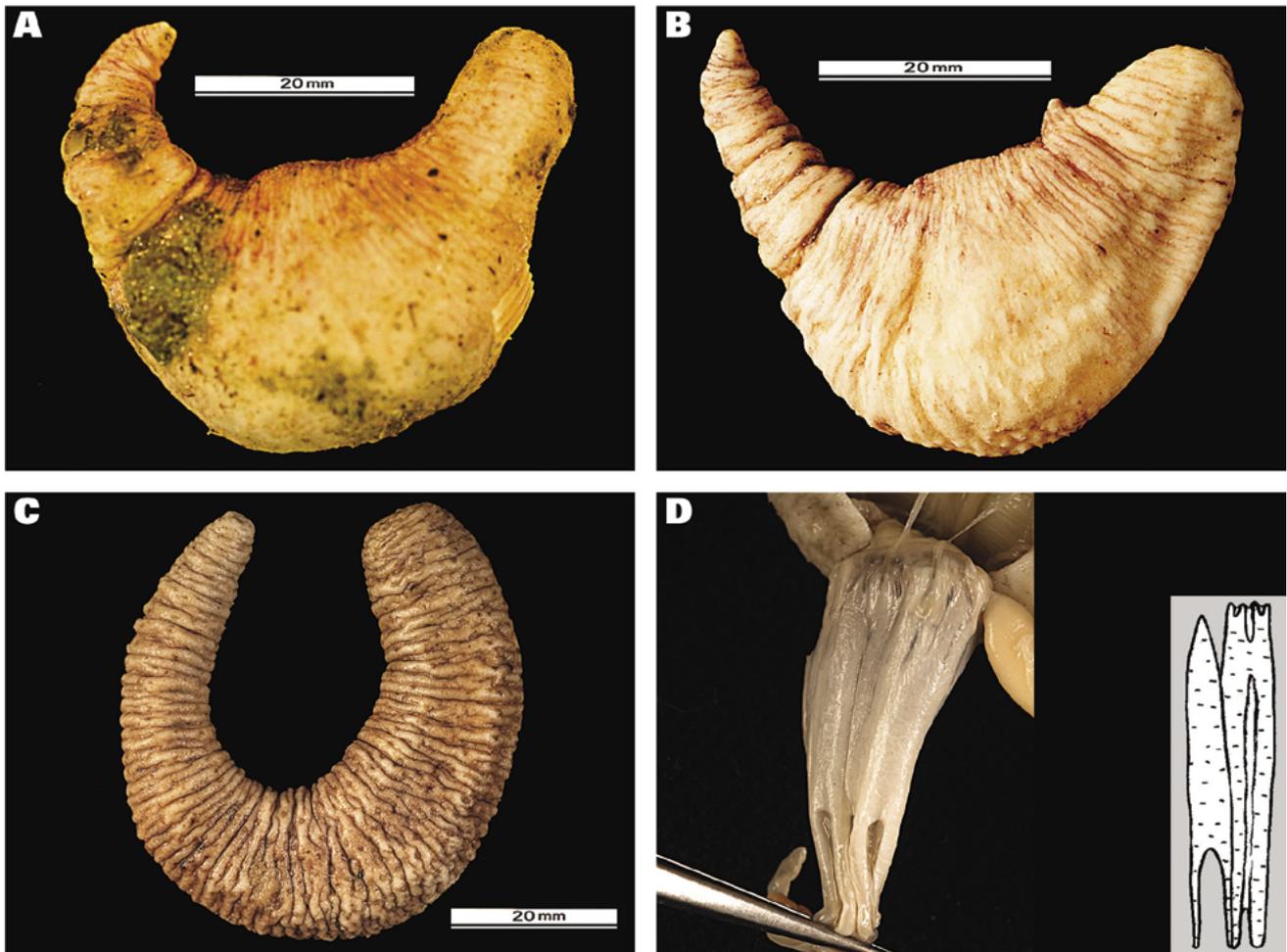


Figure 9. Photos of live and preserved specimens of *Triasemperia stola* O’Loughlin sp. nov. A, lateral view of live holotype specimen (mouth right; NMV F174889); B, lateral view of preserved holotype (mouth right, lateral view width 45 mm); C, lateral view of preserved paratype (mouth right, lateral view width 50 mm, NMV F204088); D, photo of the calcareous ring of the holotype; insert with sketch of the calcareous ring.

*Type species.* *Actinocucumis typica* Ludwig, 1875 (type locality Queensland, Bowen, 20°S 148°E)

*Other species and type localities.* *Actinocucumis chinensis* Liao and Pawson, 2001 (off Hainan, South China Sea); *A. cornus* (Heding, 1934) (Hong Kong); *A. difficilis* Bell, 1884 (Torres Strait, north-east Australia); *A. longipedes* Clark, 1938 (Broome, north-west Australia); *A. simplex* (Sluiter, 1914) (Indonesia); *A. solanderi* O'Loughlin sp. nov. (off King George River, northern Australia) (see below).

*Remarks.* Heding and Panning (1954) listed numerous synonymies for *Actinocucumis typica*, with lengthy discussion. We have not examined the relevant type specimens but based on the figures and descriptions in the literature, and on our *sensu stricto* diagnosis of *A. typica* below, we raise all of these species out of synonymy.

We note that in discussing their synonymies Heding and Panning (1954) observed in their slide preparations from *Actinocucumis typica* and *Actinocucumis cornus* specimens small elongate plates with two long mid-plate perforations and two small distal ones. This form of ossicle was illustrated by H. L. Clark (1938) for *Actinocucumis longipedes*. Ludwig (1875) did not illustrate this form of ossicle and we have never observed such ossicles in our preparations from specimens of *A. typica* from the region of the type locality and across northern Australia. It appears to us that Heding and Panning were not examining specimens of *A. typica*.

Two ossicles are drawn for *Actinocucumis typica* in Clark and Rowe (1971; fig. 95 e and e'). We have seen only the left

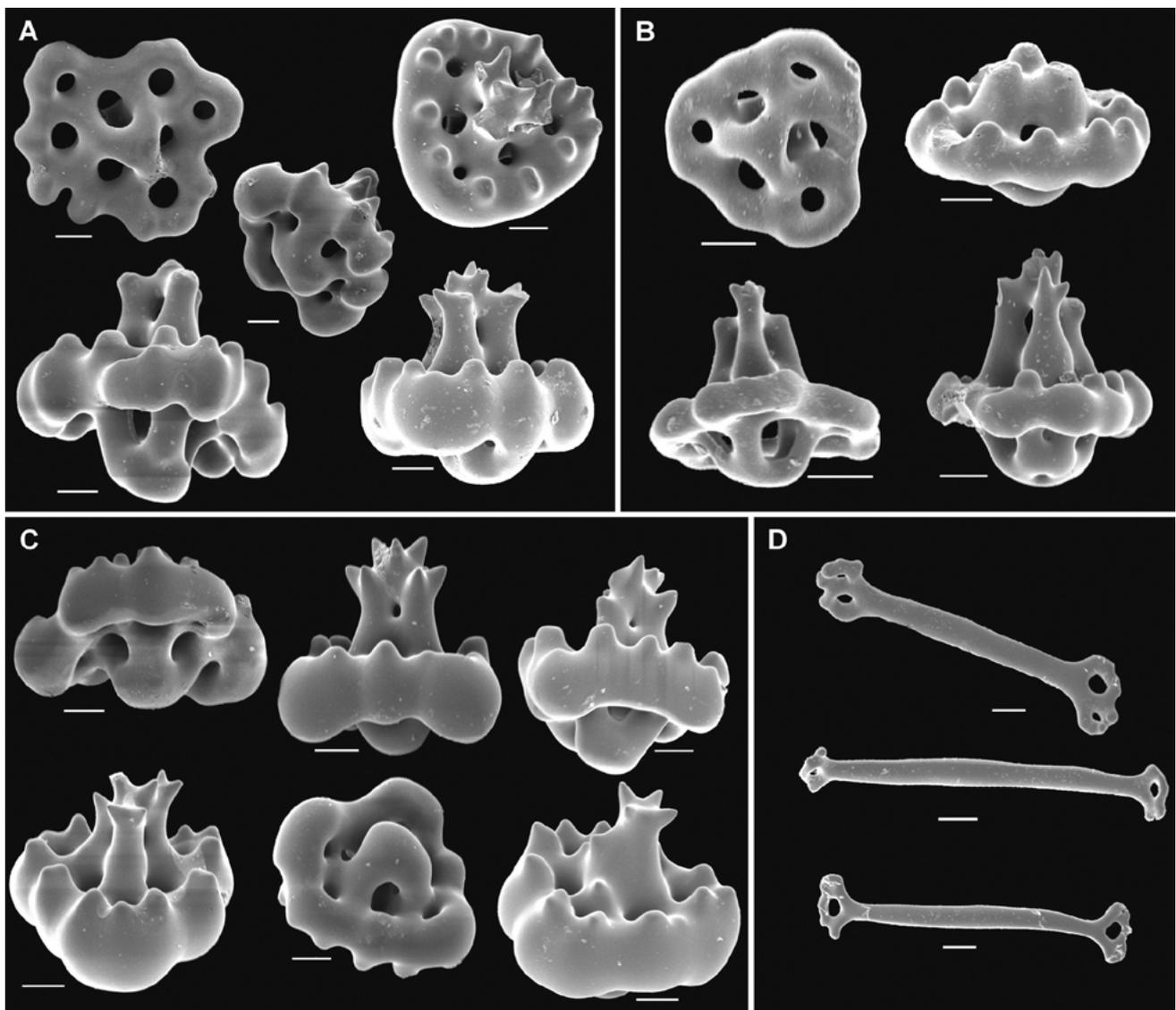


Figure 10. SEM images of ossicles from the holotype of *Triasemperia stola* O'Loughlin sp. nov. (NMV F174889). A, mid-dorsal body wall tables, spires with 3 pillars (scale bars 20  $\mu$ m); B, peri-anal body wall tables (scale bars 20  $\mu$ m); C, tube foot tables (scale bars 20  $\mu$ m); D, tentacle rods (scale bars 20  $\mu$ m).

hand side form (e) in the specimens of *A. typica* that we have examined, and this is the only form in the original description by Ludwig (1875). The right hand side form (e') appears to be typical of *Actinocucumis longipedes* and was referred to by Heding and Panning (1954) above. The two ossicle forms appear to have been drawn from a specimen of *A. longipedes*.

We note that the Clark and Rowe (1971) illustration of ossicles from *A. typica* (pl. 30 fig. 4) is in fact from a type specimen of *Actinocucumis difficilis* Bell that was judged to be a con-specific with *A. typica*. The ossicles appear to us to exemplify *A. typica*, and that adds weight to the probability of a synonymy (NHMUK type information confirmed by Andrew Cabrinovic). There are no small elongate plates with two long mid-plate perforations and two small distal ones in this preparation.

The single type specimen from Hong Kong of *Phyllophorus cornus* Heding, 1934 has tube feet all over the body, five inner tentacles and 15 outer, and five anal teeth. Ossicles from the type of *Actinocucumis cornus* were used for the illustration in Heding and Panning (1954, fig. 19) of the ossicles of *A. typica*. The original illustration of ossicles for *A. cornus* (Heding 1934) did not show fenestrated ellipsoids. That in Heding and Panning (1954) did show fenestrated ellipsoids. Neither illustrated the small plates with two long and two small distal perforations that Heding and Panning (1954) indicated were present. We judge that the status of *A. cornus* as conspecific with *A. typica* remains uncertain, and we raise it out of synonymy as an *Actinocucumis* species.

*Pseudocucumis quinqueangularis* Sluiter, 1901 from Indonesia has posterior prolongations on the radial plates of a composite calcareous ring, 12 large outer and six small inner tentacles, and an absence of figure-8 ossicles and fenestrated ellipsoids. It is not a species of *Actinocucumis* and we raise the species out of synonymy in the original combination to await further study.

The single small type specimen from Ceylon of *Actinocucumis donnani* Pearson, 1903 does not have the tentacles present, has a composite calcareous ring with long posterior prolongations on the radial plates, and has body wall ossicles that are not fenestrated ellipsoids or any form of table. It is not an *Actinocucumis* species. In the absence of tentacles it is not possible to re-assign the species that we regard as *incertae sedis*.

The illustrations for *Phyllophorus simplex* Sluiter, 1914 indicate ossicles that do not include fenestrate ellipsoids and typical figure-8 plates, and the description reports tube feet covering the body. It is not conspecific with *Actinocucumis typica*, and we raise it out of synonymy with reservations as an *Actinocucumis* species.

H. L. Clark (1938, 1946) examined numerous specimens of *Actinocucumis* from northern Australia and was convinced of the existence of four species: *A. typica*, *A. difficilis*, *A. longipedes*, *A. quinqueangularis*. We reject *A. quinqueangularis* as an *Actinocucumis* species (above), but accept the judgment by Clark who recognized the other three species. We raise *A. difficilis* and *A. longipedes* out of synonymy here. In the case of *A. difficilis* we defer to the experience of H. L. Clark (1938, 1946) who had an abundance of material to examine, but we

also judge that the morphological characters that he used to distinguish this species are probably variable characters. We think that a confirmed synonymy requires more consideration. The presence in *A. longipedes* of small elongate plates with two long mid-plate perforations and two small distal ones is apparently systematically distinctive.

We note the absence of fenestrated ellipsoids and radial papillae in *Actinocucumis chinensis* and continue to refer this species to *Actinocucumis* with reservation, as did Liao and Pawson (2001).

### *Actinocucumis typica* Ludwig, 1875

*Actinocucumis typica* Ludwig, 1875: 91, fig. 24 a–d.—Lampert, 1885: 177.—Théel, 1886: 84, 125, pl. 12 figs 4, 5.—Ludwig, 1888: 817.—Erwe, 1913: 364–365, pl. 6 fig. 10a, b.

*Actinocucumis typicus*.—H. L. Clark, 1921: 170.—Clark, 1938: 479.—Clark, 1946: 403.—Heding and Panning, 1954: 72–74, figs 19, 20 (part).—A. M. Clark and Rowe, 1971: fig. 95 e, pl. 30 fig. 4 (part).—Liao and Clark, 1995: 481–482, fig. 290, pl. 23 fig. 10 (part).

*Material examined*. NE Australia, Queensland: Yeppoon, dredged off Middle Island, 23.13°S 150.74°E, 9–37m, B. J. Smith, 6 Sept 1967, NMV F204078 (1); Mackay harbour, 21.15°S 149.18°E, Ian Kirwan, 14 Jul 1982, NMV F206362 (1); near Cairns, Machans Beach, 16.85°S 145.73°E, on beach after cyclone, B. Collins, 25 Dec 1996, NMV F203016 (2); N Australia, Joseph Bonaparte Gulf, 11.55°S 129.82°E, RV *Solander*, 48 m, AIMS & GA, 26 Aug 2010, NMV F173265 (1) (GA lot SOL5117 lot 082BS040; UF tissue lot MOLAF1552); NW Australia, Dampier Archipelago, 1.3 km E of Eaglehawk I., FRV *Flinders*, DA2/73/01, 20.67°S 116.46°E, coarse sand, 13 m, 24 Jul 1999, NMV F209501(1).

*Diagnosis (sensu stricto)*. Dendrochirotid species, uniform brown colour (NMV F204078), or yellowish brown with some red patches and fine black flecking (NMV F173265), or pale brown to cream with fine brown flecking on body and larger brown patches on tube feet (NMV F206362); body pentagonal in section with raised radial ridges; five thick oral valves; about 20 dendritic tentacles, variable in arrangement and size, ventral pair smallest; tube feet confined to radii, small papillae and tube feet also on radii and encroaching inter-radially; tube feet in 4–6 rows (80 mm long specimen, Ludwig 1875), or in paired rows (smaller 35–44 mm long specimens, this work); calcareous ring not composite, radial plates with vertical sides, radial and inter-radial plates lacking posterior prolongations.

Body wall ossicles abundant, crowded, small plates and ellipsoids, and rare, thick large plates; bi-perforate plates (figure-8 form, “acorn” plates in Ludwig 1875 and Clark 1938, 1946) predominate, up to about 40–50  $\mu\text{m}$  long with one central and 5 marginal knobs, the apical knob typically projecting; bi-perforate plates inter-grade with abundant but less numerous irregularly ovoid fenestrated ellipsoids, up to about 40–55  $\mu\text{m}$  long; large plates thick, irregular in outline, perforation sizes irregular, plates frequently more than 150  $\mu\text{m}$  long. Tube feet with endplates and support tables; large endplate diameters about 240  $\mu\text{m}$ , small endplate diameters about 120  $\mu\text{m}$ ; table discs elongate, up to 160  $\mu\text{m}$  long, narrow, widened centrally and distally, spires with 4-pillar base, pillars frequently joined to form an arch, arches frequently with single, long, thick, pointed, apical spine. Introvert with

abundant tables, spires with four-pillar base and pillars fused with distal narrow arch or long spine or 2 short blunt spines. Papillae with body wall ossicles, rare tables, and lacking endplates. Lacking anal scales.

**Remarks.** Because uncertainty remains about the assignment of species to this genus we provide a *sensu stricto* diagnosis of *Actinocucumis typica*, based on the morphological characters of the type species. We examined six northern Australian specimens of *Actinocucumis* (listed above). We confidently judge that four of these specimens are *Actinocucumis typica* as all of their morphological characters closely fit the original description and illustrations by Ludwig (1875). These characters are detailed in the generic diagnosis above. With less confidence we judge that the two beach-washed specimens are also *A. typica* (NMV F203016).

The ossicles of specimens from the Philippines that are illustrated by Reyes-Leonardo et al. (1985) appear to us to be

close to those illustrated for *Actinocucumis longipedes*, although the description refers to the presence of fenestrated ellipsoids and irregular tables with pointed spires. The descriptive reference to “wart-like” podia scattered all over the body” is not characteristic of *A. typica*.

***Actinocucumis solanderi* O’Loughlin sp. nov.**

*Zoobank LSID.* <http://zoobank.org:act:804F4A5E-37B6-441B-BBC7-BBA118E61036>

Figures 11, 12.

**Material examined.** Holotype. N Australia, Joseph Bonaparte Gulf, 13.82°S 127.32°E, 73 m, 12 Jun 2013, WAM Z27850 (KGR specimen 29384; UF tissue lot MOLAF1438).

Paratype. Joseph Bonaparte Gulf, 11.04°S 129.81°E, RV *Solander*, 52 m, Geoscience Australia, 9 Jun 2009, NMV F202991 (1) (GA lot SOL4934 lot 23BS14; UF tissue lot MOLAF1508).

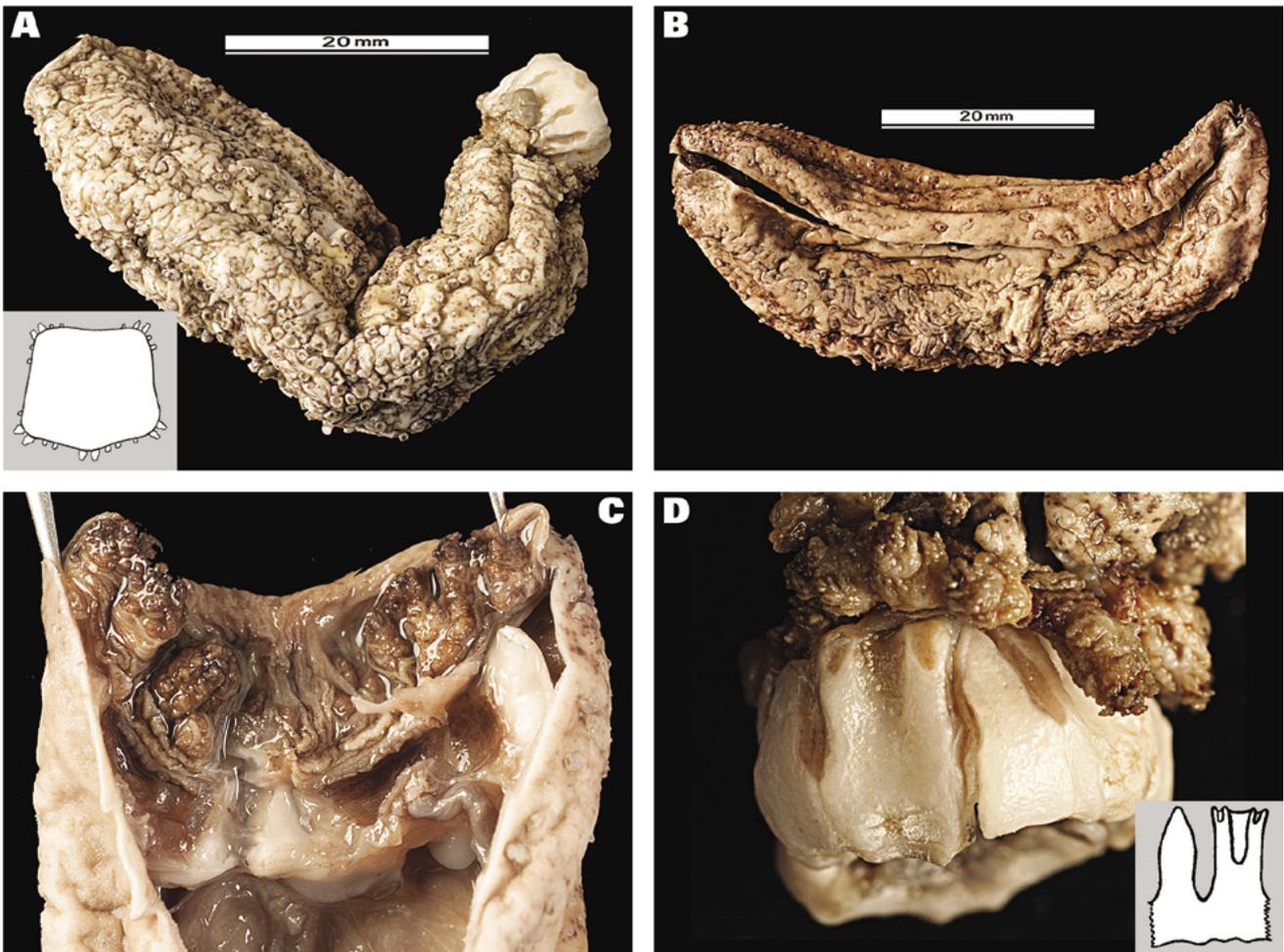


Figure 11. Photos of preserved specimens of *Actinocucumis solanderi* O’Loughlin sp. nov. A, right lateral view of the preserved holotype (mouth right, 45 mm long, WAM Z27850); insert with sketch of a transverse section of the new species showing slight radial ridges and large and small tube feet and papillae; B, right lateral view of the preserved paratype (mouth left, 55 mm long, NMV F202991); C, dorsal view of tentacle crown with small tentacles ventrally (paratype NMV F202991); D, photo of the calcareous ring of the holotype; insert with sketch of the calcareous ring.

*Description.* Form elongate, sub-cylindrical, slightly pentagonal with raised radial ridges tending to create 5 oral and 5 anal valves, mouth anterior, anus posterior, slightly tapered and up-turned orally and anally, up to 55 mm long

(preserved); hard, thick, calcareous body wall; 20 dendritic tentacles, about 10 large dorsally, about 10 small ventrally; tube feet conspicuous, extended, predominantly on radii in irregular paired series, largest in mid-body on radii, diameters about 1.0

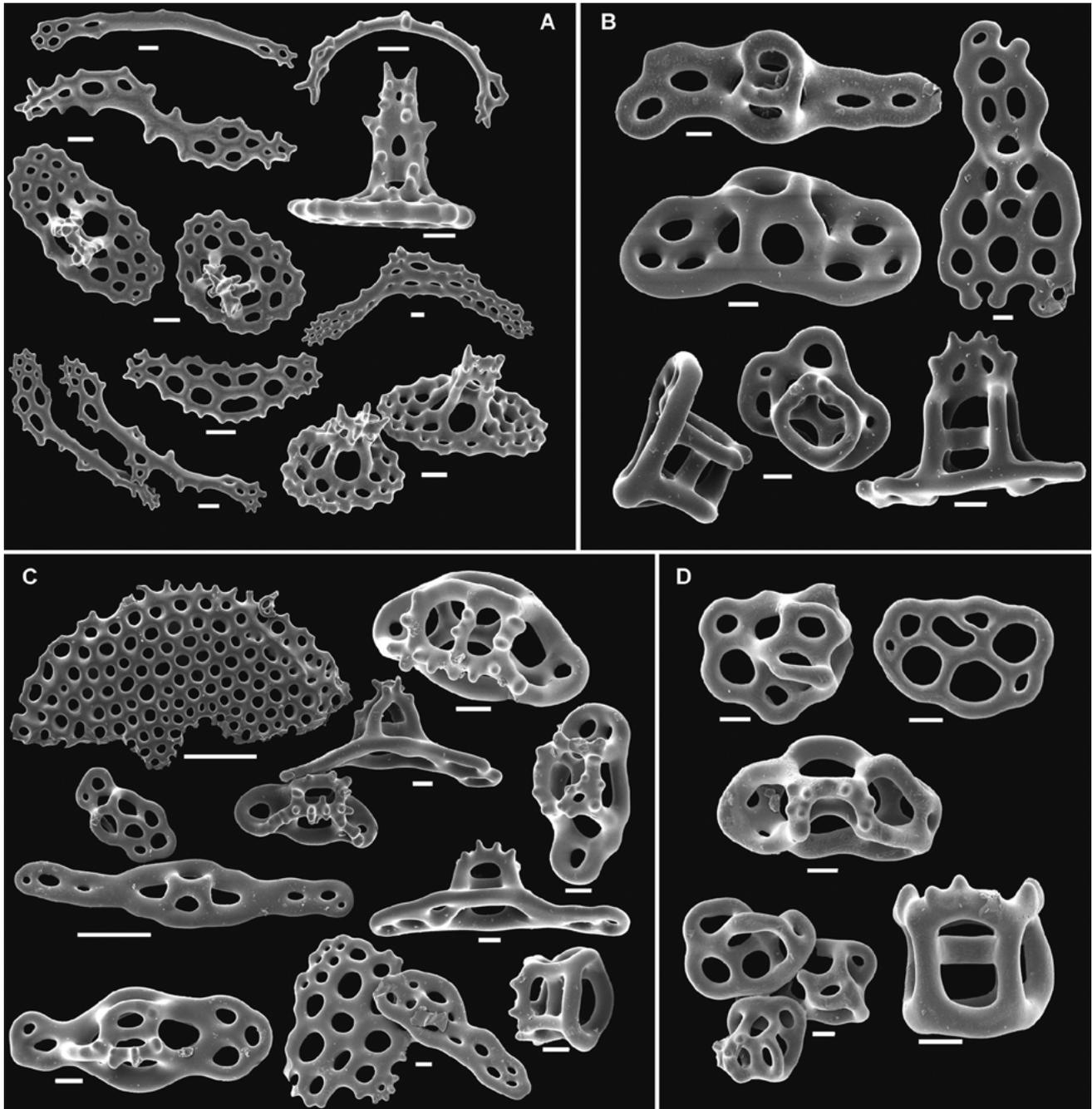


Figure 12. SEM images of ossicles from the holotype of *Actinocucumis solanderi* O'Loughlin sp. nov. (WAM Z27850). A, oral disc and tentacle tables, spires with 4 pillars, and tentacle rods and curved perforated rod-plates (scale bars 10  $\mu\text{m}$ ); B, mid-dorsal body wall reduced tables with four pillar spires (scale bar 10  $\mu\text{m}$ ); C, mid-ventral body wall tables, and tube foot elongate support tables and endplate fragment (two top left long scale bars 100  $\mu\text{m}$ , short bars 10  $\mu\text{m}$ ; typical box-like table bottom right); D, peri-anal body wall reduced tables (scale bars 10  $\mu\text{m}$ ; typical box-like table bottom right).

mm, small tube feet (with endplates) and papillae (lacking endplates) on radii and encroaching on inter-radii, diameters about 0.3 mm; lacking anal scales; calcareous ring comprising non-fragmented radial and inter-radial plates, lacking posterior prolongations, radial plates sub-rectangular with larger anterior median notch and smaller lateral notches, inter-radial plates with long anterior taper to blunt point; single polian vesicle; gonad tubules with multiple branches; respiratory trees extending throughout the coelom.

Ossicles throughout the dorsal, ventral and peri-anal body wall are densely crowded small, thick irregular tables and reduced tables, and large, elongate smooth perforated plates; tables frequently box-like with round disc about 30–40  $\mu\text{m}$  wide with single perforation, disc width similar to spire height, spires about 25–35  $\mu\text{m}$  high with 4 pillars joined mid-spire and apically, short blunt spines apically, tables often reduced with incompletely formed and irregular disc and spire; body wall tables inter-grade in form with elongate tube foot support tables; perforated plates numerous in body wall, surface and margin smooth, up to about 240  $\mu\text{m}$  long. Tentacles with tables, rods and rod-plates, lacking rosettes; table discs irregularly round to elongate oval, central disc single perforation and few large or many small outer perforations, disc margin undulating to denticulate, discs up to about 80  $\mu\text{m}$  long, spires well-developed with four-pillar base, blunt spines distally and sometimes along spire, spires up to 50  $\mu\text{m}$  high; curved rods perforated along rod, margin denticulate; rod-plates thick, wide, perforate distally, sometimes bifid distally, up to 440  $\mu\text{m}$  long. Tube feet with endplates about 450  $\mu\text{m}$  in diameter; tube foot support ossicles elongate tables with narrow curved discs up to 450  $\mu\text{m}$  long and four pillar spires variably developed. Invert with abundant tables as in tentacles.

Colour preserved off-white to grey to pale brown with a hint of residual crimson dorsally, dark brown to black small spots spaced all over body; tube feet off-white with brown disc.

*Distribution.* N Australia, Joseph Bonaparte Gulf, 52–73 m.

*Etymology.* Named for the research vessel of the Australian Institute of Marine Science, the RV *Solander*, from which the King George River expedition and cruise SOL 4934 were conducted and these type specimens collected.

*Remarks.* The distinguishing morphological character of *Actinocucumis solanderi* O'Loughlin sp. nov. is the presence in the body wall of abundant small, thick, box-like tables and tables that are reduced to varying degrees.

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