

The phylloporid sea cucumbers of southern Australia (Echinodermata: Holothuroidea: Dendrochirotida: Phylloporidae)

P. MARK O'LOUGHLIN¹, SHARI BARMOS² AND DIDIER VANDENSPIEGEL³

¹ Marine Biology Section, Museum Victoria, GPO Box 666, Melbourne, Victoria 3001, Australia (pmoloughlin@edmundrice.org)

² Marine Biology Section, Museum Victoria, GPO Box 666, Melbourne, Victoria 3001, Australia (shari_barmos@hotmail.com)

³ Musée royal de l'Afrique centrale, Section invertébrés non-insectes, B-3080, Tervuren, Belgium (dvdspiegel@africamuseum.be)

Abstract

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A new monotypic Phylloporidae (Phylloporinae) genus *Phyllostauros*, with author O'Loughlin, is erected for *Thyone vercoi* Joshua and Creed. We raise *Phyllophorella* Heding and Panning (subgenus of *Phyllophorus* Grube) to generic rank. The holotype and three paratypes of *Phyllophorus ventripes* Joshua and Creed are conspecific with *Thyone vercoi* Joshua and Creed. We make *Phyllophorus ventripes* Joshua and Creed a subjective junior synonym of *Thyone vercoi* Joshua and Creed. One paratype of *Phyllophorus ventripes* Joshua and Creed is conspecific with *Phyllophorus thyonoides* H. L. Clark. We reject the synonymy of *Thyone okeni* Bell with *Thyone venusta* Selenka. Twelve new species of Phylloporidae are described for southern Australia, with author O'Loughlin: *Lipotrachea eichleri*, *Lipotrachea litusi*, *Massinium melanieae*, *Massinium vimsi*, *Massinium watsonae*, *Phyllophorella notialis*, *Thyone flindersi*, *Thyone joshuai*, *Thyone kerkosa*, *Thyone spenceri*, *Thyone tourvillei*, *Thyonidiella kungi*. Phylloporidae species reported previously for southern Australia are reviewed: *Lipotrachea ventripes* (Joshua and Creed); *Lipotrachea vestiens* (Joshua); *Neothyonidium dearmatum* (Dendy and Hindle); *Phyrella thyonoides* (H. L. Clark); *Thyone nigra* Joshua and Creed; *Thyone okeni* Bell; *Thyone vercoi* Joshua and Creed. Species *Phyrella thyonoides* (H. L. Clark) is re-assigned to genus *Phyllophorella* Heding and Panning. A key is provided for the southern Australian species of Phylloporidae. We acknowledge the rejection for nomenclatorial purposes by the ICZN (Opinion 417) of the publication by Oken 1815, and hence the current invalid status of genus *Thyone* Oken. A petition has been sent to the ICZN for re-validation of *Thyone* Oken and we retain the use of *Thyone* Oken provisionally. The petition includes a similar request for re-validation of *Psolus* Oken.

Keywords

Sea cucumber, Dendrochirotida, Phylloporidae, *Lipotrachea*, *Massinium*, *Neothyonidium*, *Phyllophorella*, *Phyrella*, *Psolus*, *Thyone*, *Thyonidiella*, new genus, new species, synonymies, Australia, key, ICZN.

Introduction

The first phylloporid species described for southern Australia (Victoria) was *Phyllophorus vestiens* Joshua, 1914. This species subsequently became the type species for *Lipotrachea* H. L. Clark, 1938. The following year species *Phyllophorus ventripes* Joshua and Creed, 1915 and *Thyone nigra* Joshua and Creed, 1915 were erected for South Australia. *Phyrella thyonoides* H. L. Clark, 1938 was erected for southwest Australian specimens. A second *Thyone* Oken, 1815 species occurring in the rocky shallows of southern Australia has been mistakenly identified as the New South Wales (Port Jackson) species *Thyone okeni* Bell, 1884. And Joshua (1914) and Hickman (1978) mistakenly identified specimens from southeast Australia as the New Zealand species *Neothyonidium dearmatum* (Dendy and Hindle, 1907). Thus at the time of writing six phylloporid species have

been reported for southern Australian waters, two with mistaken identities. We review the systematic status of these species.

During 1981 the former Victorian Institute of Marine Sciences conducted a survey of the benthic fauna of eastern Bass Strait using the Taiwanese FRV *Hai Kung* and the then New Zealand Oceanographic Institute RV *Tangaroa*. Collecting and sorting yielded specimens as small as a few millimeters in length. Many small phylloporid specimens were collected, representing four new phylloporid species. We describe the new species in this work. The Museum Victoria south-east Australia continental slope survey on RV *Franklin* yielded a small phylloporid from off the Freyehinet Peninsula in eastern Tasmania that is described here. During 1986 and 1987 the South Australian Department of Fisheries collected many small phylloporid specimens from the upper Spencer Gulf that are lodged in the South Australia Museum and were available for

this study. We describe two new species from this collection. And we examined relevant collections of southern Australian phylloporid specimens from the Australian Museum, South Australian Museum, Western Australian Museum and Tasmanian Museum and Art Gallery.

Recently the new phylloporid genus *Massinium* Samyn and Thandar, 2003 was erected for some former *Neothyonidium* Deichmann, 1938 species. We have found three new species of *Massinium* in southern Australian waters. There has been considerable uncertainty about the systematic status of the two species *Phyllophorus ventripes* Joshua and Creed, 1915 and *Thyone vercoi* Joshua and Creed, 1915 and we have attempted to resolve the issues.

We are attempting a comprehensive review of southern Australian phylloporid species and have therefore described new species based in some cases on limited and damaged specimens that nonetheless have distinguishing morphological characters. We have recognized and noted some cases of what we consider to be inappropriate species assignments to higher taxa such as species to genera and genera to sub-families, but we have generally refrained from altering current assignments until more comprehensive revisions are possible with the aid of emerging genetic data. One such current revision that we are aware of is a review by François Michonneau and Gustav Paulay (University of Florida) of genus *Phyrella* Heding and Panning, 1954.

We have noticed throughout this work that for a particular species the number of polian vesicles and the form of the calcareous ring may vary considerably for individual specimens. These realities are significant for attempts to distinguish species systematically.

We acknowledge the rejection for nomenclatorial purposes by the ICZN (Opinion 417, 42 pp., 1956) of the publication by Oken 1815, and hence the current invalid status of genus *Thyone* Oken, 1815. Pawson and Miller 1981 consequently referred *Thyone* to author Jaeger 1833 with type species *Holothuria fusus* Müller, 1776 (following Jaeger 1833). This maintained the type species of Oken for *Thyone*. But the first author after Oken to use genus *Thyone* validly was Lesson 1830, not Jaeger 1833. Lesson 1830 used *Thyone* as a sub-genus in *Holothuria* for one new Aspidochirotida species (*Holothuria* (*Thyone*, Oken) *edulis*) and for a new Echiura (spoon-worm) species (*Holothuria* (*Thyone*, Oken) *eaouari*). Neither species would be satisfactory as a type species for *Thyone*. Rowe (in Rowe and Gates 1995) retained Oken 1815 as author of *Thyone* as a *nomen conservandum*, following H. L. Clark 1946. This retention has not been validated by the ICZN. On the grounds of anticipating considerable uncertainty and instability in holothuroid literature if *Thyone* Oken remains invalid and has to be replaced, a petition has been sent by Gustav Paulay and Mark O'Loughlin (July 2012) to the ICZN for validation of *Thyone* Oken, 1815. Reasons have been given in this petition for the re-validation also of *Psolus* Oken, 1815. We retain the use of *Thyone* Oken provisionally.

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

aluminum stubs, and coating with gold. Observations were made using a JEOL JSM-6480LV SEM. Measurements were made with Smile view software. Photos of the preserved specimens were taken by Shari Barmos with a Nikon 300s DSLR camera, using a Nikkor 105 mm lens and 2x adaptor / teleconverter. The photo of a live juvenile specimen of *Lipotrabeza vestiens* was taken by Leon Altoff and Audrey Falconer using a Pentax K10D with bellows mounted Olympus 38mm lens and dual flashes. The photo of a live specimen of *Thyone nigra* was taken by John Eichler using a Pentax W30.

Abbreviations

AM	Australian Museum (registration number prefix J).
ICZN	Appropriately the International Commission on Zoological Nomenclature, or the International Code of Zoological Nomenclature.
MRG	Marine Research Group of the Field Naturalists Club of Victoria.
NMV	Museum Victoria (registration number prefix F).
NIWA	New Zealand National Institute of Water and Atmospheric Research (est. 1992).
PPS	Port Phillip Survey (1957–1963).
SAM	South Australian Museum (registration number prefix K, photo index number prefix PK).
TMAG	Tasmanian Museum and Art Gallery (registration number prefix H).
VIMS	Victorian Institute of Marine Sciences (1974–1998).
WAM	Western Australian Museum (registration number prefix Z).

Numbers in brackets after registrations refer to numbers of specimens in lots.

Order **Dendrochirotida** Grube, 1840

Family **Phylloporidae** Östergren, 1907 (sensu Pawson and Fell 1965)

Diagnosis (after Pawson and Fell 1965). Dendrochirotida with calcareous ring composite with posterior extensions to the plates, the extensions composed of small pieces.

Remarks. Pawson and Fell 1965 abandoned tentacle number as the principal diagnostic criterion for family Phylloporidae, and based their new diagnosis on the presence of a composite calcareous ring as described in the diagnosis above.

Key to southern Australian species of Phylloporidae (sensu Pawson and Fell 1965)

1. Tentacles 20 or 15 **2**
 - Tentacles 10, 8 large, 2 small ventral **11**
genus *Thyone* Oken
2. Tentacles 15, 5 outer pairs large, 5 single small inner ones *Thyonidiella kungi*
O'Loughlin sp. nov. (Bass Strait offshore)

- Tentacles 20 genera *Lipotrapeza* H. L. Clark, *Massinium* Samyn and Thandar, *Phyllophorella* Heding and Panning, *Phyllostaurus* O'Loughlin gen. nov. **3**
- 3. Outer tentacles 15, variable sizes, 5 single small inner ones genus *Phyllophorella* Heding and Panning **4**
- Tentacles 5 pairs large, 5 pairs small . genera *Lipotrapeza* H. L. Clark, *Massinium* Samyn and Thandar, *Phyllostaurus* O'Loughlin gen. nov. **5**
- 4. Table ossicle discs regular, never incomplete; tube foot support ossicles sometimes tables with curved discs, never dumbbell-shaped rods *Phyllophorella notialis* O'Loughlin sp. nov. (south New South Wales)
- Table ossicle discs frequently irregular, frequently incomplete; tube foot support ossicles frequently dumbbell-shaped rods *Phyllophorella thyonoides* (H. L. Clark) (South Australia and south Western Australia)
- 5. Calcareous ring composite, long, tubular, plates joined posteriorly by continuous calcareous band of small plates creating posterior inter-radial oblong non-calcareous spaces *Massinium* Samyn and Thandar **6**
- Calcareous ring with posterior prolongations not joined by continuous band of small plates; not long, not tubular; posterior composite extensions short, free genera *Lipotrapeza* H. L. Clark, *Phyllostaurus* O'Loughlin gen. nov. **8**
- 6. Large and small tube feet uniformly distributed; 4 polian vesicles; anal body wall with table ossicles *Massinium melanieae* O'Loughlin sp. nov. (Great Australian Bight)
- Tube feet not uniformly distributed; fewer than 4 polian vesicles; anal body wall lacking table ossicles **7**
- 7. Body wall soft; tube feet scattered dorsally, concentrated ventrally; peri-oral table discs with up to 20 perforations; tentacles with rods and some rosettes; endplate support ossicles perforate rods *Massinium vimsi* O'Loughlin sp. nov. (Bass Strait offshore)
- Body wall thin, firm; tube feet more concentrated along longitudinal muscles; peri-oral table discs with up to 40 perforations; tentacles with rare fine rods, lacking rosettes; endplate support ossicles rare *Massinium watsonae* O'Loughlin sp. nov. (SE Tasmania)
- 8. Adult mid-body wall ossicles lacking . genus *Lipotrapeza* H. L. Clark **9**
- Mid-body wall ossicles crosses *Phyllostaurus vercoi* (Joshua and Creed) (South Australia)
- 9. Tube feet ossicles include abundant rosettes intergrading with few small plates *Lipotrapeza litusi* O'Loughlin sp. nov. (SW Australia)
- Tube feet never with rosette ossicles **10**
- 10. Body reddish-brown; tube feet usually concentrated ventrally, scattered dorsally; tube foot endplate support ossicles and tentacle ossicles predominantly dumbbell-shaped *Lipotrapeza eichleri* O'Loughlin sp. nov. (SE Australia)
- Body pale brown / flesh-pink; tube feet usually evenly distributed around body; tentacle ossicles predominantly rods with small distal widening; tube foot endplate support ossicles irregular narrow perforated plates *Lipotrapeza vestiens* (Joshua) (across southern Australia)
- 11. Adult body wall with table ossicles **12**
- Adult mid-body wall lacking table ossicles **16**
- 12. Table ossicles with spires comprising 2 pillars; anterior third at least of calcareous ring tubular **13**
- Table ossicles with predominantly single pillar spires; none of calcareous ring tubular *Thyone tourvillei* O'Loughlin sp. nov. (eastern Tasmania, Bass Strait)
- 13. No adult body wall table discs with more than 30 perforations **14**
- Many adult body table discs with more than 30 perforations **15**
- 14. Tentacles with rod and rosettes ossicles; adult body wall table discs with predominantly 4 and often 8 perforations, discs typically about 56 μm long *Thyone joshuai* O'Loughlin sp. nov. (South Australia, SE Australia)
- Tentacles with rosette ossicles only; adult body wall table discs rarely with 4 perforations, discs frequently about 88 μm long *Thyone nigra* Joshua and Creed (SE to SW southern Australia)
- 15. Adult body wall table discs small to large, large discs sometimes narrow with solid distal extensions, spires long with long splayed distal ends *Thyone kerkosa* O'Loughlin sp. nov. (Recherche Archipelago)
- Adult body wall table discs round to oval, uniform size, spires short *Thyone spenceri* O'Loughlin sp. nov. (Upper Spencer Gulf)
- 16. Peri-oral table ossicles with irregular discs, up to 72 μm long, fewer than 40 perforations, spires with 2 pillars; tentacles branches with thin rods, distally with fine branches or few perforations, some rods with sigmoid form, some straight, rods up to 88 μm long *Thyone flindersi* O'Loughlin sp. nov. (southern Australia)
- Peri-oral table ossicles with regular discs, up to 192 μm diameter/length, up to more than 60 small perforations, table spires thick short columnar mesh; tentacle branches with stout rods, some dumbbell-shaped, rods up to 320 μm long *Thyone okeni* Bell (New South Wales)

Subfamily **Phyllophorinae** Heding and Panning, 1954

Diagnosis. Radial plates of the calcareous ring with posterior prolongations composed of a few large pieces, prolongations sometimes arising jointly from radial and inter-radial plates; inter-radial plates frequently lacking any posterior prolongation; ring not tubular.

Southern Australia genera. *Lipotrachea* H. L. Clark, 1938; *Phyllophorella* Heding and Panning, 1954; *Phyllostaurus* O'Loughlin gen. nov. (below); *Thyonidiella* Heding and Panning, 1954.

Remarks. We raise subgenus *Phyllophorella* Heding and Panning, 1854 (subgenus of *Phyllophorus* Grube, 1840) to generic rank.

***Lipotrachea* H. L. Clark, 1938**

Lipotrachea H. L. Clark, 1938: 494–495.—H. L. Clark 1946: 411.—Heding and Panning, 1954:173–175.

Diagnosis. Dendrochirote holothuroids with 20 tentacles, 5 pairs large, 5 pairs small; tube feet around body, not radial, sometimes concentrated ventrally and scattered dorsally; calcareous ring stout with paired short tapered posterior composite prolongations arising from radial (early development) or jointly from radial and inter-radial plates (later development); mid-body wall of adults lacking ossicles; mid-body wall of juveniles with tables, spires with 4 pillars; tube feet with endplates and endplate supporting ossicles, sometimes with rosettes and small plates.

Type species. *Phyllophorus vestiens* Joshua, 1914 (original designation).

Other species. *Lipotrachea ambigua* Cherbonnier, 1988 (Madagascar); *L. capilla* Cherbonnier, 1958 (Sierra-Leone); *L. eichleri* O'Loughlin sp. nov. (SE Australia); *L. incurva* Cherbonnier, 1988 (Madagascar); *L. japonica* Heding and Panning, 1954 (Japan); *L. litusi* O'Loughlin sp. nov. (SW Australia).

Remarks. We make *Lipotrachea ventripes* (Joshua and Creed, 1915) a subjective junior synonym of *Phyllostaurus vercoi* (Joshua and Creed, 1915) (see below). Cherbonnier 1988 referred five small specimens (up to 20 mm long) from Madagascar to *Lipotrachea ventripes* (Joshua and Creed, 1915). This referral is discussed under *Lipotrachea vestiens* (below).

Lipotrachea ambigua Cherbonnier, 1988, erected for 12 specimens from Madagascar, is described as having 10 large outer tentacles and two inner circles of five small ones, a calcareous ring with paired composite radial posterior prolongations and composite inter-radial posterior prolongations, and some tables in the adult anal body wall. We judge that the species does not fit the diagnostic characters of *Lipotrachea* H. L. Clark, 1938.

Lipotrachea capilla Cherbonnier, 1958, erected for two specimens from Sierra-Leone, is described as having a tentacle arrangement of 15 outer tentacles comprising five pairs of large with a very small tentacle between each pair, and five inner tentacles. There are rosette and plate ossicles in the mid-body wall, and long paired composite posterior radial elongation of

the calcareous ring. We judge that the species does not fit the diagnostic characters of *Lipotrachea* H. L. Clark, 1938.

Lipotrachea incurva Cherbonnier, 1988, erected for eight specimens from Madagascar, is described as having 10 large outer tentacles and 10 very small ones in two inner circles. On this character we judge that the species does not fit the diagnostic characters of *Lipotrachea* H. L. Clark, 1938, although for most characters it does.

We also query the inclusion of the northern *Lipotrachea japonica* Heding and Panning, 1954, specifically for the presence of three series of tentacles (10 + 5 + 5) and the form of the calcareous ring with discrete paired posterior radial prolongations (as illustrated by Heding and Panning 1954).

The current referrals of species to *Lipotrachea* H. L. Clark, 1938 suggest to us that from a morphological viewpoint the genus is currently polyphyletic and requiring review.

***Lipotrachea eichleri* O'Loughlin sp. nov.**

Figures 1a, b, 2

Material examined. Holotype. Victoria, Phillip I., Kitty Miller Bay, rocky shallows, M. O'Loughlin and J. Monagle, 20 Apr 1987, NMV F174906.

Paratypes. Type locality and date, NMV F161502 (4); Westernport Bay, Phillip I., McHaffie Reef, sea-grass beds, J. Eichler and V. Stajsic, 1 Mar 2008, NMV F157403 (1).

Other material. Cape Paterson, 4 m, 13 Mar 2001, NMV F97432 (2); Westernport Bay, Shoreham, 16 Feb 1972, NMV F45265 (1); Honeysuckle reef, 21 Mar 1976, NMV F161493 (1); Port Phillip Bay, Point Lonsdale, J. Kershaw, Jan 1902, NMV F76558 (3); Portland, Anderson Point, 23 Feb 2007, NMV F125359 (1 juvenile).

Diagnosis. Up to 75 mm long, up to 25 mm diameter (preserved, tentacles withdrawn), cylindrical body, narrow rounded oral and anal ends, thin firm body wall minutely papillate; external anal scales not detected; 20 tentacles, 5 large pairs, alternating with 5 small pairs; complete cover of tube feet, crowded ventrally, scattered dorsally, diameter about 0.5 mm; calcareous ring with 10 posterior composite tapering projections arising from both radial and inter-radial plates, posterior ends free thin tails, ring not tubular, length of plates with anterior projections sub-equal with posterior composite prolongations, form of the plates and composite components variable; short stone canal, madreporite close to vascular ring; 1–3 tubular polian vesicles, variable lengths; longitudinal muscles flat, lacking longitudinal indentation centrally; gonad tubules arise in series along gonoduct on each side of dorsal mesentery, tubules not branched.

Adult mid-body wall lacking ossicles; tube foot ossicles endplates and support rods only; endplates with denticulate margin, irregular perforations similar size, diameters up to 480 μ m; tube foot support ossicles predominantly dumbbell-shaped, enlarged distally, perforate, denticulate margin, up to 192 μ m long; peri-oral region with abundant rosettes about 40 μ m long; tentacles with rods and rosettes, larger rods dumbbell-shaped with small perforations and denticulate margin distally, up to 208 μ m long, few small rosettes up to 40 μ m long; anal ossicles tube foot endplates and support rods, tentacle-like rods, rosettes, some large up to 64 μ m long.

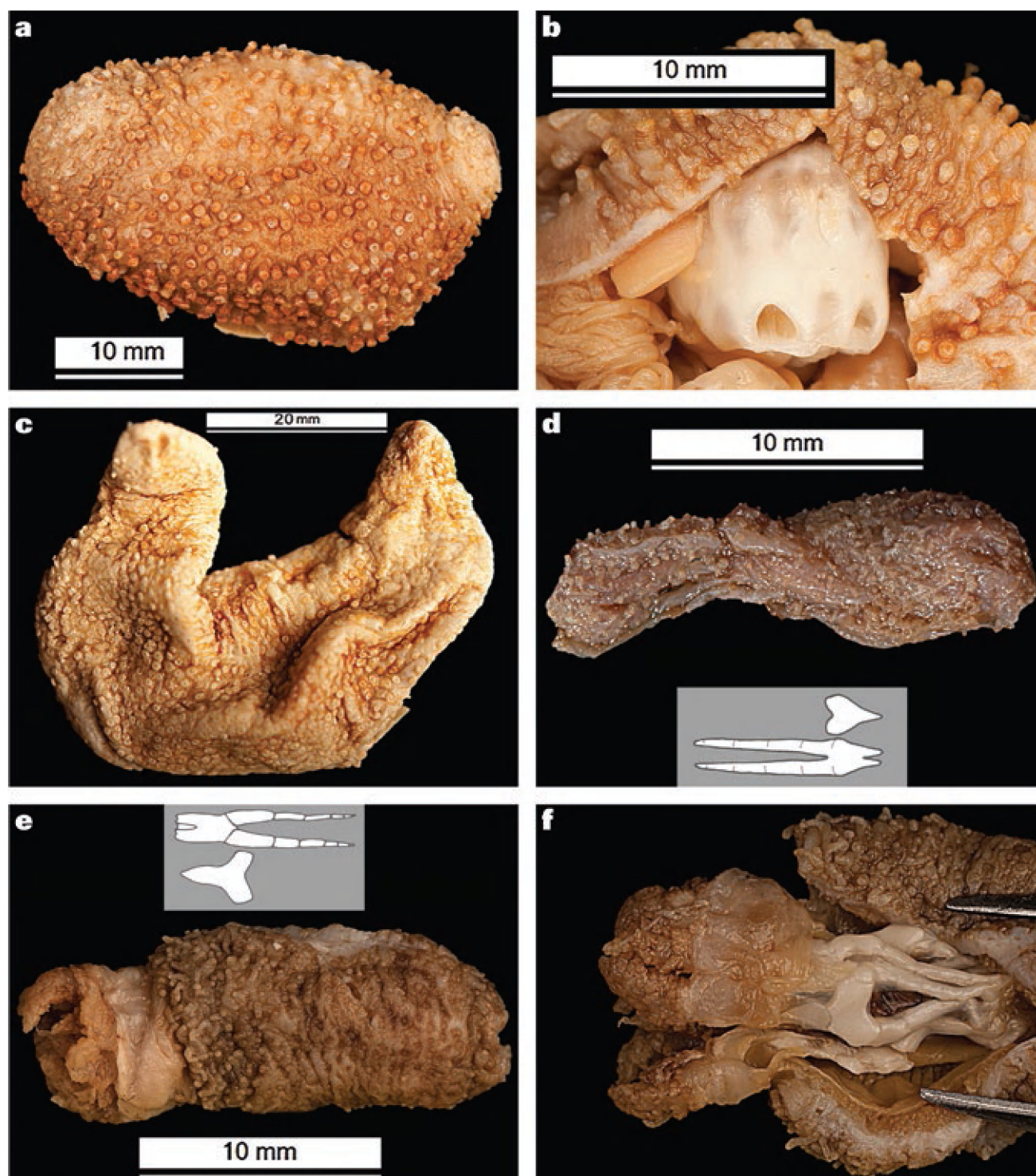


Figure 1. Photos of preserved type specimens. a, *Lipotrapeza eichleri* O'Loughlin sp. nov. (holotype NMV F174906); b, *Lipotrapeza eichleri* calcaeous ring (paratype NMV F161502); c, *Lipotrapeza litusi* O'Loughlin sp. nov. (holotype WAM Z13475); d, *Thyonidiella kungi* O'Loughlin sp. nov. (holotype NMV F76637) (insert: form of the calcaeous ring plates); e, *Phyllophorella notialis* O'Loughlin sp. nov. (holotype NMV F132691) (insert: form of the calcaeous ring plates); f, *Phyllophorella notialis* calcaeous ring (holotype).

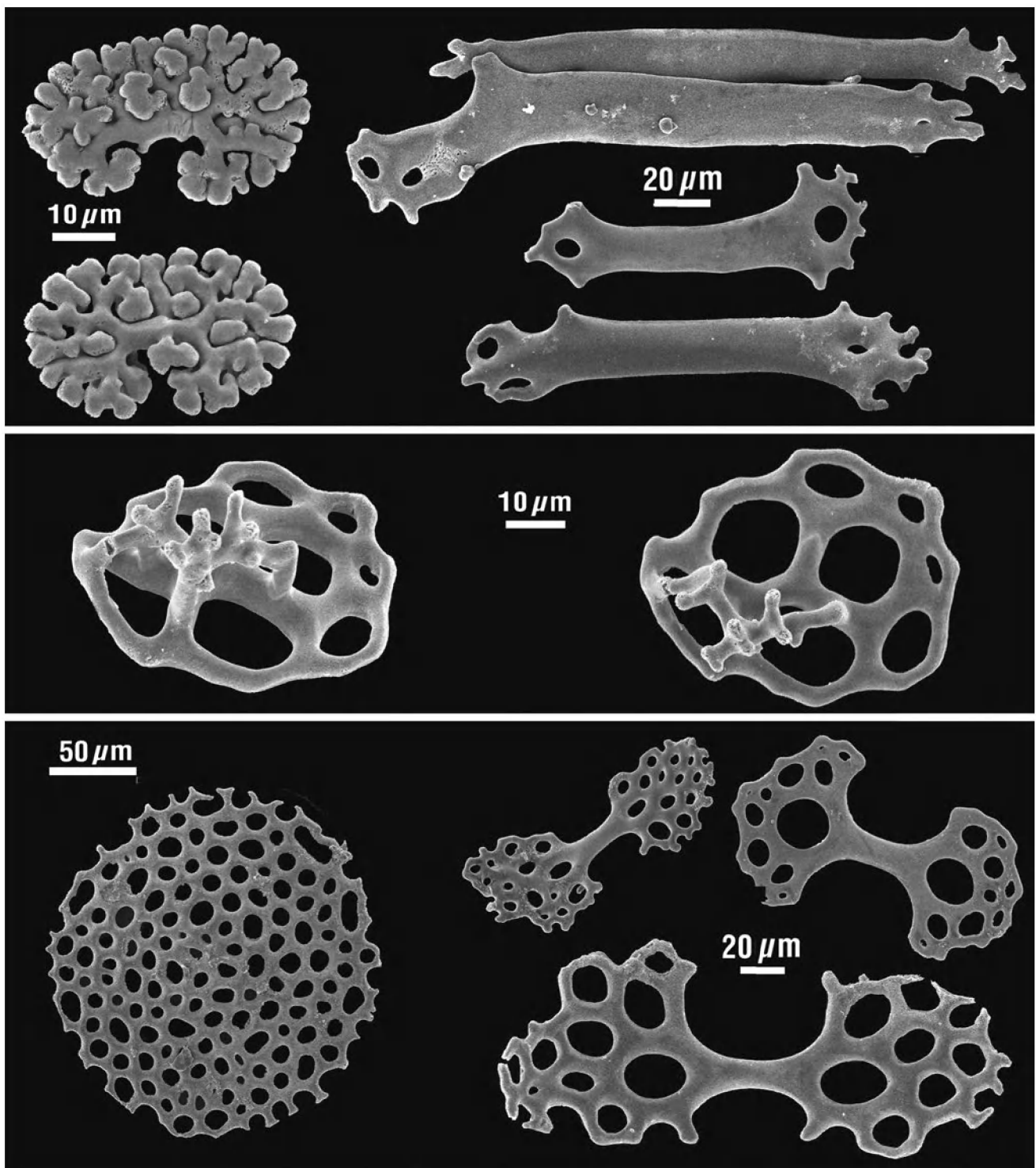


Figure 2. SEM images of ossicles from specimens of *Lipotrapeza eichleri* O'Loughlin sp. nov. Top, rods and rosettes from tentacles (holotype NMV F174906); middle, tables from juvenile (NMV F161502, 5 mm long); bottom, endplate and dumbbell-shaped endplate support ossicles from same juvenile (NMV F161502).

Juvenile (5 mm long) with mid-body wall tables and tube foot endplates and support rods; tables with irregular discs up to 60 μm long, short irregular 4-pillared spires; endplates up to 180 μm diameter, dumbbell-shaped endplate support rods up to 240 μm long.

Colour (preserved). Body dark brown to grey-brown with variable red colouration, dark grey-brown oral end, white anal end; many tube feet red; tentacles pale brown.

Distribution. South-east Australia, Victoria, Cape Paterson to Portland, rocky shallows and sea-grass, 0–4 m.

Etymology. Named for John Eichler, with appreciation of his contribution to Museum Victoria through the MRG, and his discovery and field photograph of a paratype of this new species.

Remarks. We note that unlike the other two species of *Lipotrachea* H. L. Clark, 1938 the large and small pairs of tentacles in *Lipotrachea eichleri* O'Loughlin sp. nov. alternate in one series, not inner and outer series. *Lipotrachea eichleri* is distinguished from other *Lipotrachea* species in the key (above).

***Lipotrachea litusi* O'Loughlin sp. nov.**

Figures 1c, 3

Material examined. Holotype. Western Australia, Cottesloe Beach, 32°00'S 115°45'E, beach washed, L. M. Marsh, Aug 1990, WAM Z13475.

Diagnosis. Up to 70 mm long, 22 mm diameter (preserved, tentacles withdrawn); form cylindrical, upturned oral and anal rounded tapers; 20 tentacles, 5 outer pairs large, 5 inner pairs small; tube feet all around body, scattered dorsally, close ventrally, across introvert, diameters up to 0.7 mm; calcareous ring stout, irregular, with some short posterior composite projections arising jointly from radial and inter-radial plates, not tubular, lacking thin radial composite posterior elongations; short stone canal, madreporite close to vascular ring; single polian vesicles; thin branched gonad tubules arise in series along gonoduct on each side of dorsal mesentery.

Mid-body wall lacking ossicles; tube feet with endplates, support rods, abundant rosettes, few small plates; endplate diameters up to 536 μm ; support rods stout, distally enlarged and perforate, up to 144 μm long; rosettes oval, up to 48 μm long, intergrade with small plates; small plates irregular, perforate, denticulate margin, up to 104 μm long; tentacles with rods and rosettes, rods stout, distally enlarged and perforate, up to 200 μm long, abundant rosettes up to 64 μm long.

Colour (preserved). Body off-white, body and tube feet with some residual red; tentacle trunks white, branches pale brown.

Distribution. Southwest Australia, Cottesloe beach, off-shore sediments.

Etymology. Named from the Latin *litus* (beach) with reference to the beach-washed source of the type specimen.

Remarks. *Lipotrachea litusi* O'Loughlin sp. nov. is distinguished from other *Lipotrachea* species in the key (above). The single specimen that this species is based on was found on a beach and the species presumably lives in off-shore sediments.

***Lipotrachea vestiens* (Joshua, 1914)**

Figures 4, 5a, 6

Phyllophorus vestiens Joshua, 1914: 5, pl. 1 fig. 2a–f.

Lipotrachea vestiens.—H. L. Clark, 1938: 496–497.—H. L. Clark, 1946: 412.—Heding and Panning, 1954: 176, fig. 84 (from Joshua 1914).—Rowe, 1982: 462, pl. 31.2.—Rowe and Gates, 1995: 311.—Edgar, 1997: 369.—Gowlett-Holmes, 2008: 263.

Material examined. Holotype. Victoria, Torquay, NMV F45144.

Paratypes. Torquay, NMV F45145 (1); slide of body wall, NMV F45146 (mounted body wall, 33 mm long, 20 mm wide, not from either type specimen, endplates and support rods only).

Other material (selection). Victoria, Cape Conran, 2 Oct 1988, NMV F73832 (1); Walkerville south, Bear Gully, 7 Mar 1982, NMV F73838 (1); Cape Paterson Survey (CPA), 1982, Petrel Rock, NMV F73823 (1); Shack Bay, NMV F73824 (1); Cape Paterson, NMV F73825 (1); Harmers Haven, NMV F73822 (1); Westernport Bay Survey by MRG, 1969–71, Merricks, NMV F45239 (3); 29 Oct 1980, NMV F75976 (many); 28 Jan 1983, NMV F73831 (2); Shoreham, NMV F73854 (1); Flinders, 26 Feb 1977, NMV F74235 (5); 10 Mar 1980, NMV F73830 (many); Port Phillip Bay, Beaumaris, Ricketts Point, 25 Apr 2008, NMV F157402 (1); Cheltenham beach after storm, 20 Jul 1891, NMV F73856 (6); Mordialloc beach, May 1897, NMV F73857 (4); Sandringham, Jul 25 1891, NMV F73858 (4; no. 60642–5; det. by Joshua 1914; det. as *Phyllophorus ventripes* by F. W. E. Rowe 1976); Kennett River, 29 Dec 1982, NMV F73827 (2); Marengo, 26 Mar 1977, NMV F73850 (2); Portland, MRG, 23 Feb 2007, NMV F125356 (1).

Tasmania. Bass Strait, Lulworth, 22 Nov 1982, NMV F174904 (13); North Head, mouth of Tamar River, 28 Aug 1978, NMV F97070 (1).

South Australia. Gulf St Vincent, Willunga Reef, 23 Nov 1976, SAM K2583 (1); Cape Jervis, 3–5 m, 22 Apr 2005, SAM K2590 (1, PK0296); S side of Kangaroo I., Hanson Bay, rocky shallows, 6 Mar 1978, AM J12559 (3); Whittlebee Point, 1 Mar 1975, SAM K2591 (4); Baird Bay, 27 Feb 1975, SAM K2596 (3).

Western Australia, Two Peoples Bay, 5 Dec 1968, WAM Z31964 (1); Cape Naturaliste, 31 Dec 1971, WAM Z31971 (1); Yanchep, 31°33'S 115°41'E, reef flat, 1959, WAM Z8994 (1).

Diagnosis. Up to 175 mm long, up to 35 mm diameter (preserved, tentacles withdrawn, largest WAM Z8994), cylindrical body with slight anal taper, thick soft body wall; external anal scales not detected; 20 tentacles, 5 outer pairs large, 5 inner pairs small; complete cover of close tube feet, not contiguous, sometimes more concentrated ventrally than dorsally, diameter about 0.7 mm, radial to scattered tube feet cross introvert; calcareous ring with 10 posterior composite tapering projections arising predominantly from radial plates but sometimes jointly from both radial and inter-radial plates, posterior ends free thin tails comprising small elongate plates, ring not tubular, posterior projections shorter than combined height of plates and anterior projections, form of plates and composite components variable; short stone canal, madreporite multi-lobed, close to vascular ring; up to 5 polian vesicles, variable sizes, frequently one; longitudinal muscles flat, longitudinal indentation along centre of muscle; gonad tubules arise in series along gonoduct on each side of dorsal mesentery, tubules not branched.

Mid-body wall lacking ossicles; tube foot ossicles endplates and support rods and narrow plates only; endplates with denticulate or smooth margin, irregular perforations similar size, endplate diameters up to 480 μm ; endplate support rods

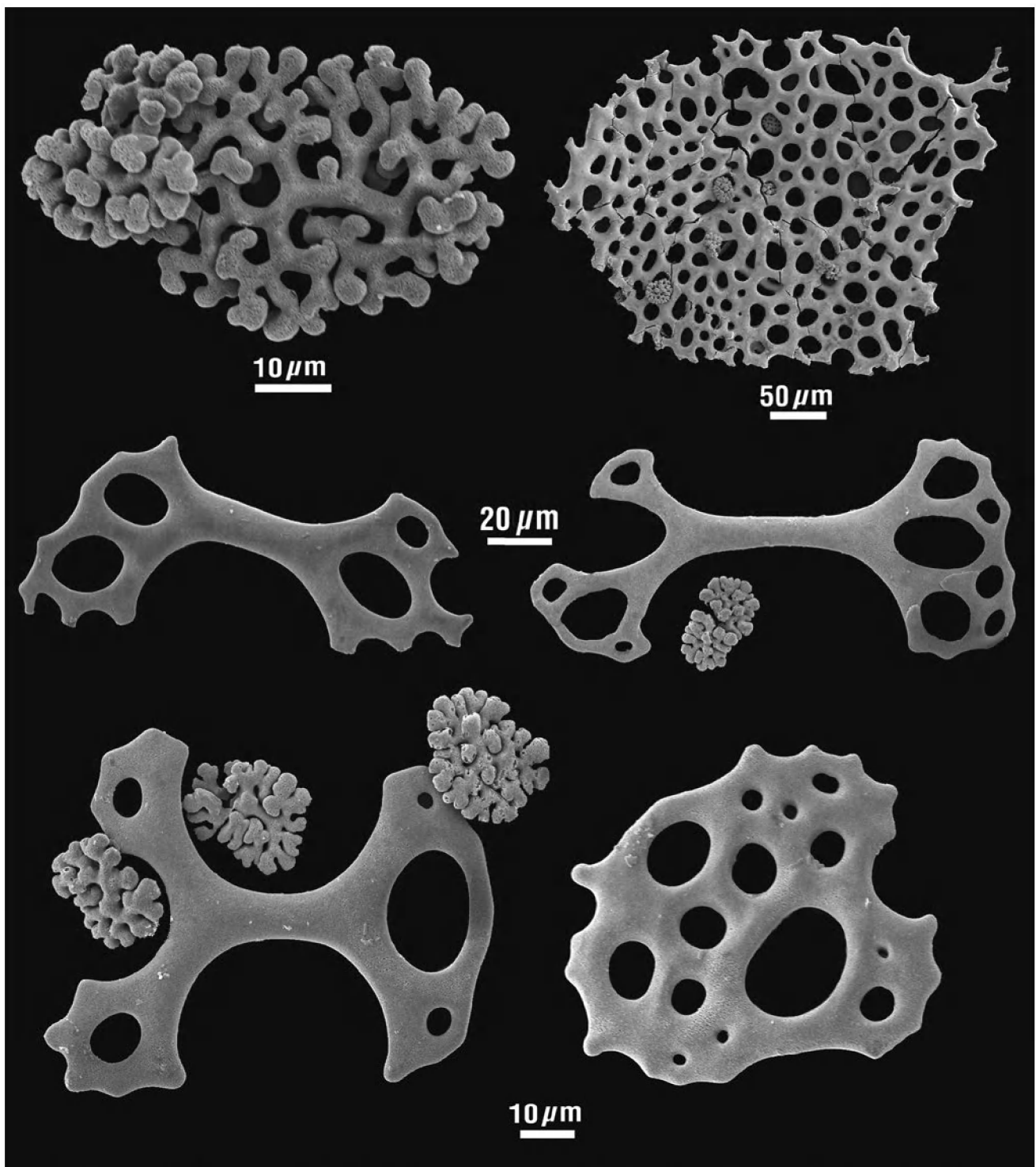


Figure 3. SEM images of ossicles from holotype of *Lipotrapeza litusi* O'Loughlin sp. nov. (WAM Z13475). Tube foot endplate (top right), rosettes, endplate support rods, rare perforated plate (bottom right).

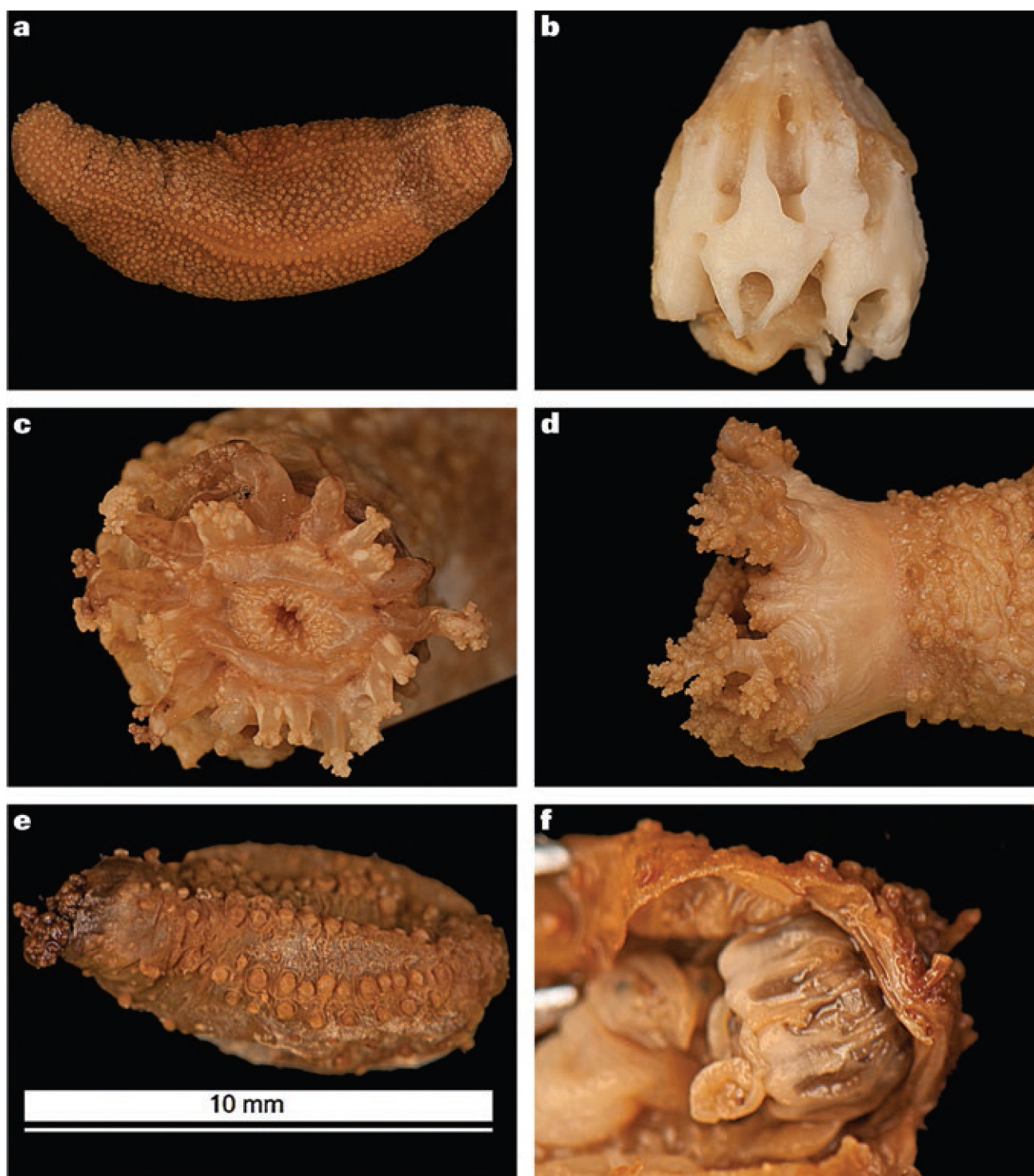


Figure 4. Photos of preserved specimens of *Lipotrapeza vestiens* (Joshua, 1914). a, adult specimen with tentacles withdrawn, close cover of tube feet, paired series of tube feet along interior longitudinal muscle attachment (NMV F73830, 80 mm long); b, calcareous ring with posterior prolongations arising from both radial and inter-radial plates (NMV F73830); c, oral view of tentacle crown with inner and outer rings of 5 paired small and 5 paired large tentacles (NMV F75976); d, lateral view of bare introvert and tentacle crown showing outer paired large and inner paired small tentacles (NMV F73830); e, juvenile with radial paired series of tube feet (NMV F75976); f, juvenile cucumariid-like calcareous ring lacking posterior prolongations (NMV F75976).

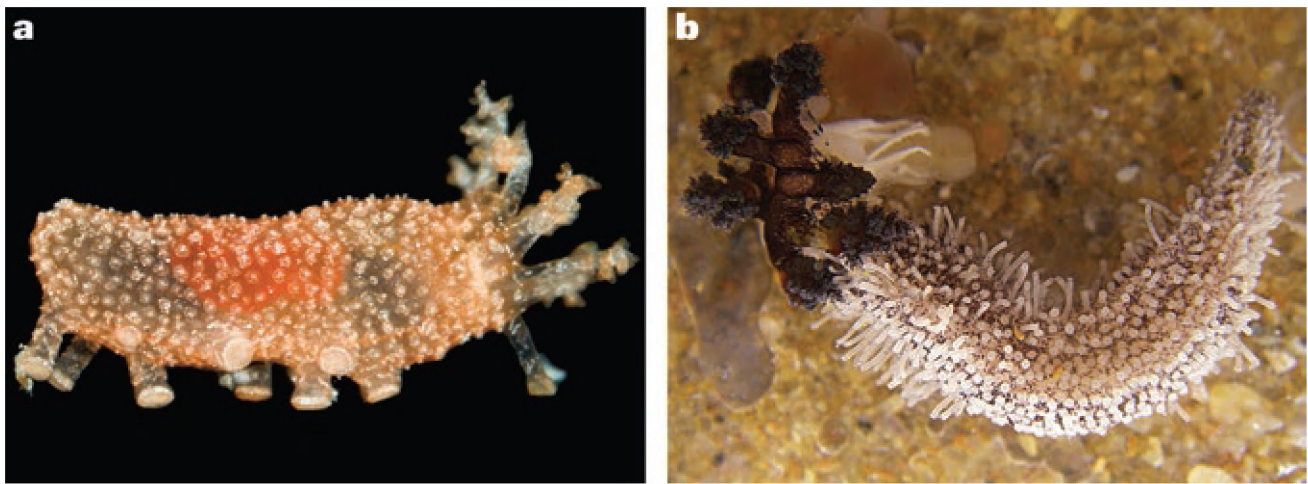


Figure 5. Photos of live specimens. a juvenile of *Lipotrachea vestiens* (Joshua, 1914) from Eagles Nest, coast of Victoria, with body wall tables and ventral tube feet only (3 mm long; photo by Leon Altoff); b, specimen of *Thyone nigra* Joshua and Creed, 1915 from McHaffie Reef, Westernport Bay, with calcareous ring eviscerated (NMV F151855, photo by John Eichler).

and narrow plates straight to curved, larger ossicles perforate and denticulate, up to 200 μm long; tentacles with rods and rosettes, larger rods branched and denticulate distally, sometimes with small perforations, up to 160 μm long, rosettes oval to irregular, up to 80 μm long; peri-oral region with tentacle-like rods and rosettes; introvert with rosettes, fine rods up to 80 μm long; anal ossicles tube foot endplates and support rods, tentacle-like rods, rosettes, 5 scales with base up to 320 μm wide and digitiform column up to 360 μm long, base and column comprising massed short branched rods.

Juveniles. For specimen 20 mm long tentacles 20; for specimen 10 mm long tube feet radial only; for specimen 15 mm long calcareous ring cucumariid-like, lacking posterior projections, not composite; for specimens 7 mm long and smaller, tables present in mid-body wall, discs regular and irregular with frequently 8 perforations, lobed margin, discs typically 72 μm long, spires with 4 pillars, spires up to 64 μm long.

Colour (preserved). Body pink-brown, dark brown orally and anally; tube feet off-white; large tentacle branches dark brown, trunks off-white, small tentacles off-white.

Distribution. Southern Australia, from E Victoria, Cape Conran, west to S Western Australia (Yanchep); rocky shallows, 0–5 m.

Remarks. Cherbonnier 1988 referred five small specimens (up to 20 mm long) from Madagascar to *Lipotrachea ventripes* (Joshua and Creed, 1915). As noted above and discussed below we make *Lipotrachea ventripes* (Joshua and Creed, 1915) a subjective junior synonym of *Phyllostaurus vercoi* (Joshua and Creed, 1915). In his observations Cherbonnier 1988 based his referral of these specimens to *Lipotrachea ventripes* on Clark 1938. We judge from their descriptive remarks that both authors are referring to *Lipotrachea vestiens* (Joshua, 1914). The Madagascar specimens have the diagnostic characters of the presence of tentacle rods, the form of the calcareous ring,

presence of tube foot endplates and support rods, and absence of ossicles in the mid-body wall that characterize *Lipotrachea vestiens*. But *Lipotrachea vestiens* specimens attain a much larger size (up to 175 mm long), have five distinct pairs of inner small tentacles (not two circles of five), do not normally have fewer dorsal than ventral tube feet, and lack the “pseudo-plates” referred to by Cherbonnier 1988. We judge that the Madagascar specimens are not *Lipotrachea vestiens*. *Lipotrachea vestiens* (Joshua, 1914) is distinguished from the other species of *Lipotrachea* in the key (above).

Phyllophorella Heding and Panning, 1954

Diagnosis (after Heding and Panning 1954). Dendrochirote holothuroids with 20 tentacles in 2 series of 15 variably large outer and 5 small inner; body covered with tube feet; calcareous ring with 5 paired short composite tapering posterior extensions, arising principally from the radial plates but sometimes jointly from the radial and inter-radial plates; body wall ossicles tables with 4-pillared spires.

Type species. *Phyllophorus* (*Phyllophorella*) *robusta* Heding and Panning, 1954 (original designation; locality Thailand).

Other species. *P. contractura* Cherbonnier, 1988; *P. drachi* Cherbonnier and Guille, 1968; *P. dubius* Cherbonnier, 1961; *P. kohkutiensis* Heding and Panning, 1954; *P. liuwutiensis* (Yang, 1937); *P. longipeda* (Semper, 1867); *P. notialis* O'Loughlin sp. nov.; *P. perforata* (H. L. Clark, 1932); *P. purpureopunctata* (Sluiter, 1901); *P. rosetta* Thandar, 1994; *P. roseus* Cherbonnier and Féral, 1981; *P. spiculata* (Chang, 1935); *P. thyonoides* (H. L. Clark, 1938).

Remarks. We re-assign species *Phyllophorus thyonoides* H. L. Clark, 1938 from *Phyrella* Heding and Panning, 1954 to *Phyllophorella* Heding and Panning, 1954 on the basis of having 15 variably large outer tentacles and 5 small inner ones, and frequent cases of the posterior prolongations of the

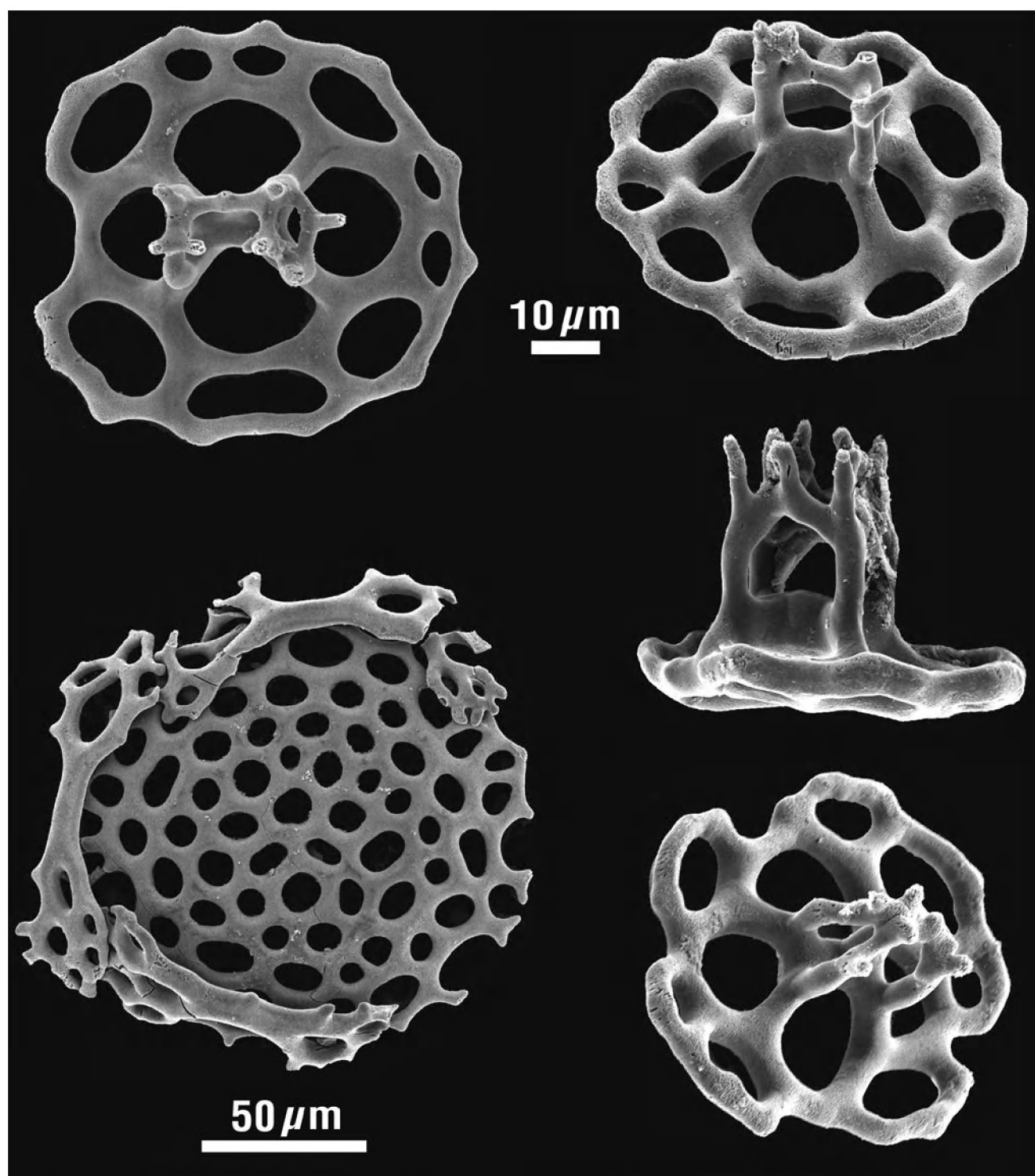


Figure 6. SEM images of ossicles from juvenile of *Lipotrapeza vestiens* (Joshua, 1914). Mid-body wall tables with 4-pillared spires, irregular discs with about 12 perforations, endplate with support rods (5 mm long, NMV F125356).

calcareous ring arising from both radial and inter-radial plates (as illustrated by Heding and Panning 1954 for most *Phyllophorella* species). We note that Rowe (in Rowe and Gates 1995) made *Phyllophorus parvipedes* H. L. Clark, 1938 (type locality Broome in NW Australia) a subjective junior synonym of *Phyllophorus spiculata* Chang 1935 (type locality China).

***Phyllophorella notialis* O'Loughlin sp. nov.**

Figures 1e, f, 7

Material examined. Holotype. SE Australia, New South Wales, Disaster Bay, RV *Southern Surveyor* SS0404 stn 102, 37°17.22'S 150°4.15'E, 79 m, 28 April 2004, NMV F132691.

Description. Body 20 mm long, diameter up to 7 mm (preserved, tentacles slightly extended, part of posterior body missing); 20 tentacles in 2 series, 15 outer variable sizes from large to medium, 5 inner very small; complete cover of tube feet, diameter about 0.3 mm; calcareous ring not tubular, radial plates with paired composite tapering tails; inter-radial plates not composite, lacking posterior extensions, truncate, less than half total length of radial plates; single polian vesicle; lacking gonad tubules.

Mid-body ossicles tables only, table discs variably round to oval, margins smooth and slightly lobed, disc lengths variable from 64 µm to 192 µm, frequently 96 µm, table spires short, about 24 µm long, predominantly 4 pillars, rarely 5, blunt apical spines; endplates up to 144 µm diameter, endplate support ossicles tables with curved discs, discs up to 136 µm long; tentacle ossicles abundant small, fine rods, intergrading with stout rods with swollen multi-perforate and bluntly denticulate ends, each end with a large and up to 10 small marginal perforations, rods up to 176 µm long.

Colour. Body grey-brown, introvert white, tentacles pale brown with some dark brown markings.

Distribution. Australia, south coast of New South Wales, Disaster Bay, 79 m.

Etymology. Named from the Latin *notialis* (southern), for the research vessel *Southern Surveyor*.

Remarks. *Phyllophorella notialis* O'Loughlin sp. nov. is distinguished from other southern Australian species of Phyllophoridae in the key (above).

***Phyllophorella thyonoides* (H. L. Clark, 1938)**

Figures 9, 10, 13f

Phyllophorus thyonoides H. L. Clark, 1938: 492–494, fig. 48.—H. L. Clark, 1946: 409.

Phyllophorus ventripes Joshua and Creed, 1915: 19, pl. 2 fig. 1, pl. 3 fig. 5. (part).

Lipotrapeza ventripes.—H. L. Clark, 1938: 495–496.—H. L. Clark, 1946: 412.—Heding and Panning, 1954: 175, fig. 83 (from Joshua and Creed 1915).—Smith, 1970: 94.—Rowe, 1982: 464.—Rowe and Gates, 1995: 311. (part).

Phyrella thyonoides.—Heding and Panning, 1954: 183–184, fig. 88 (from H. L. Clark 1938).—Rowe and Gates, 1995: 313–314.

Material examined. *Phyllophorus ventripes* Joshua and Creed, 1915. Paratype. South Australia, J. C. Verco, SAM K1375 (1; earliest label

“type material”; recent label “type”; judged here to be a paratype; determined as *Phyrella thyonoides* by F. W. E. Rowe 1977; confirmed here).

Other material. South Australia, J. C. Verco, SAM K2597 (1; determined as *Phyllophorus (Phyllophorella) thyonoides* by F. W. E. Rowe 1977; confirmed here).

Western Australia, Garden I., Careening Bay, intertidal sand flats, 26 Nov 1961, WAM Z31837 (1); sand flats, 20 Dec 1969, WAM Z31962 (1); Cockburn Sound, Woodman's Point, seagrass bank, 1 Dec 1957, WAM Z31834 (2); 1 m, 18 Mar 1972, WAM Z31975 (1); 100 km S of Geraldton, Cliff Head, seagrass rhizomes, 2 m, 2 Sep 1985, WAM Z21214 (2); 3 Jun 1986, AM J21716 (4).

Diagnosis. Up to 60 mm long, up to 25 mm diameter (preserved, tentacles withdrawn), curved cylindrical body tapered to rounded upturned ends orally and anally, variably with ventral belly, thick firm body wall; external anal scales not detected; 20 tentacles, 15 variably large outer, 5 inner small; complete spaced cover of large and small tube feet, larger and more numerous ventrally, disc ends up to 0.7 mm diameter, smaller dorsally, orally, anally, radial to scattered tube feet cross introvert, spaced paired posterior radial series; calcareous ring with 10 posterior composite tapering projections arising from radial plates only (smaller specimens) or jointly from both radial and inter-radial plates (larger specimens), ring not tubular, posterior ends free tapering tails generally sub-equal with anterior plates and projections, spaces between posterior prolongations extending anteriorly to similar extents radially and inter-radially, form of plates and composite components variable; short stone canal, multi-lobed madreporite close to vascular ring; 1–3 polian vesicles; gonad tubules arise in series along gonoduct on each side of dorsal mesentery, tubules not branched.

Mid-body wall with scattered tables, discs regular to irregular in form, some with appearance of being incomplete, rounded quadrangular to oval, commonly 96 µm long, frequently up to 112 µm long, rarely up to 144 µm long, margin lobed, lobes smooth or denticulate, commonly central and about 8 outer perforations, sometimes many perforations anally, spires frequently with 4 pillars up to 48 µm high, rarely 3, 5, 6 pillars; tube foot ossicles endplates and endplate support ossicles only; endplates with denticulate margin, irregular perforations similar size, diameters up to 600 µm; endplate support ossicles up to 184 µm long, dumbbell-shaped rods with rounded ends with large and small perforations and denticulate margin, and narrow multi-perforate plates with denticulate margin; tentacles with rods and rosettes, larger rods dumbbell-shaped, widened and perforate distally with denticulate margin, up to 320 µm long, rosettes up to 104 µm long; introvert with some rosettes up to 48 µm long; peri-oral region with tentacle-like rods and rosettes; anal ossicles tube foot endplates and support rods, tentacle-like rods, rosettes, 5 scales comprising base up to 320 µm wide with digitiform column up to 360 µm long, base and column comprising massed short branched rods.

Specimen 4 mm long with radial tube feet; cucumariid ring lacking posterior prolongations; mid-body ossicles typical solid 4-pillared tables, some margins closely denticulate, rare larger irregular tables with discs up to 120 µm wide.

Colour (preserved). Body off-white with close grey-brown/black flecking creating dark grey/black appearance, body

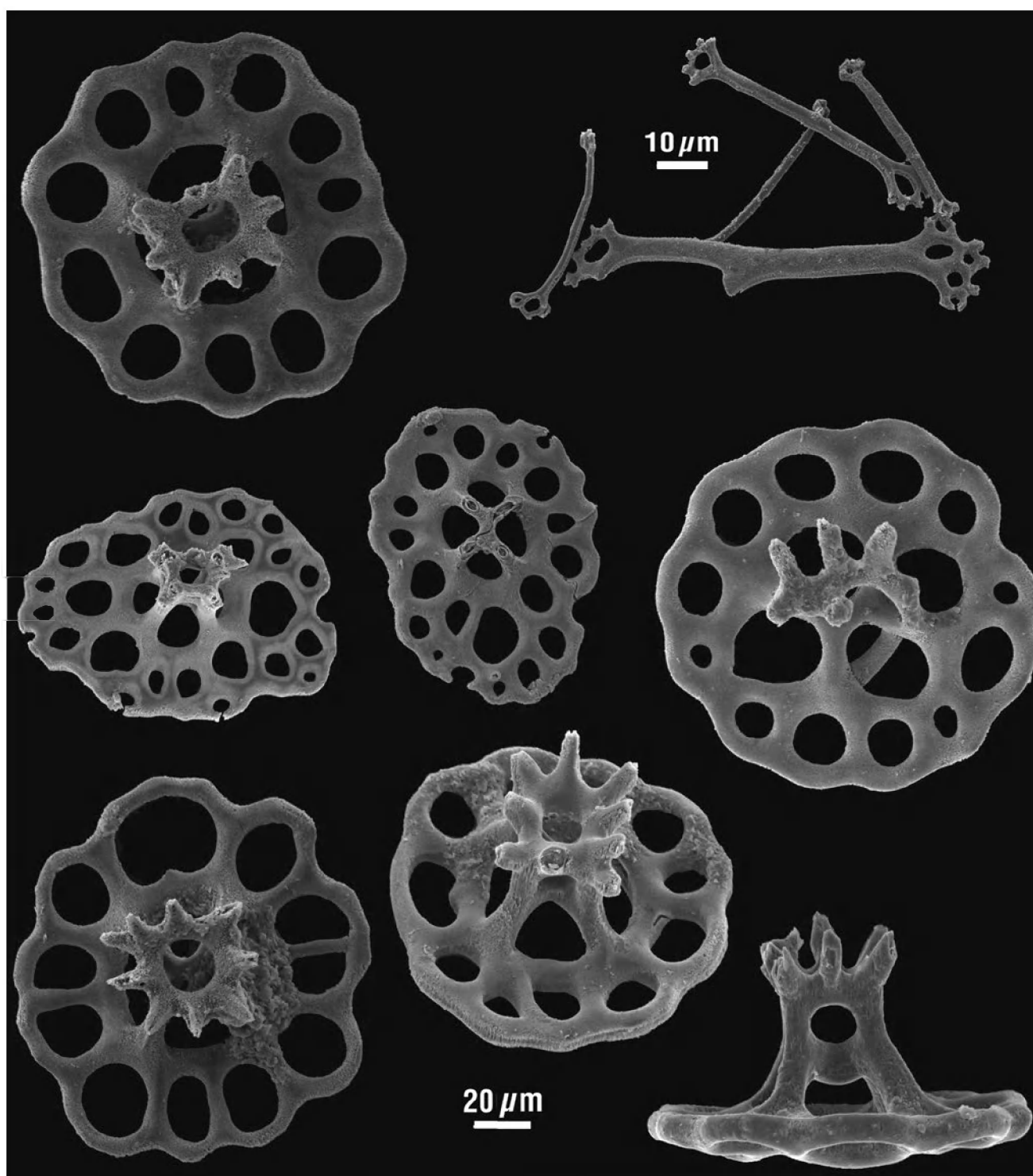


Figure 7. SEM images of ossicles from holotype of *Phyllophorella notialis* O'Loughlin sp. nov. (NMV F132691). Tentacle rods (top right) and 4-pillared tables from the body wall.

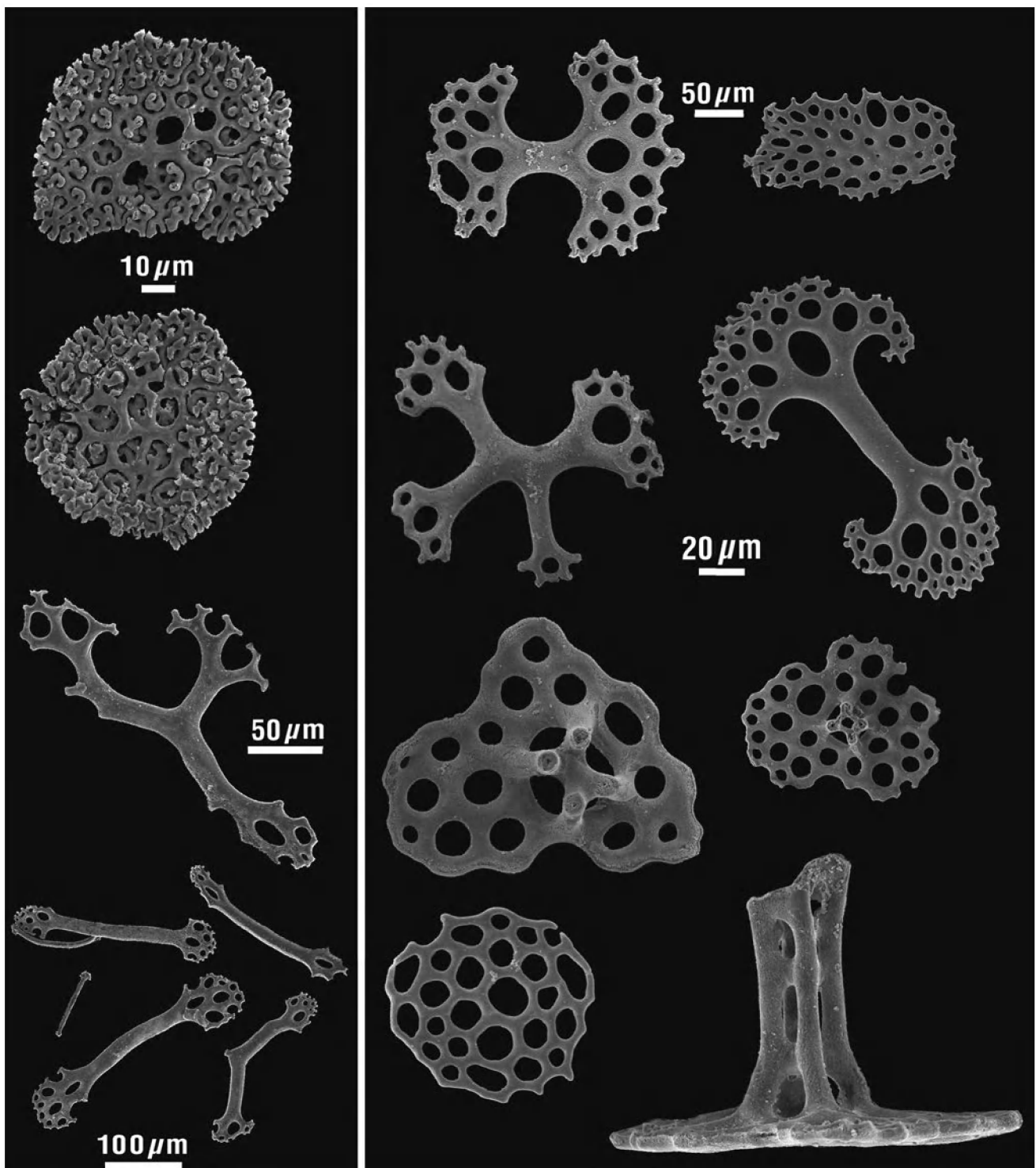


Figure 8. SEM images of ossicles from specimens of *Thyonidiella kungi* O'Loughlin sp. nov. Tentacle rosettes and rods (left; holotype NMV F76637); endplate, dumbbell-shaped endplate support ossicles, and 4-pillared tables, from body wall of a juvenile (3 mm long; NMV F76639).

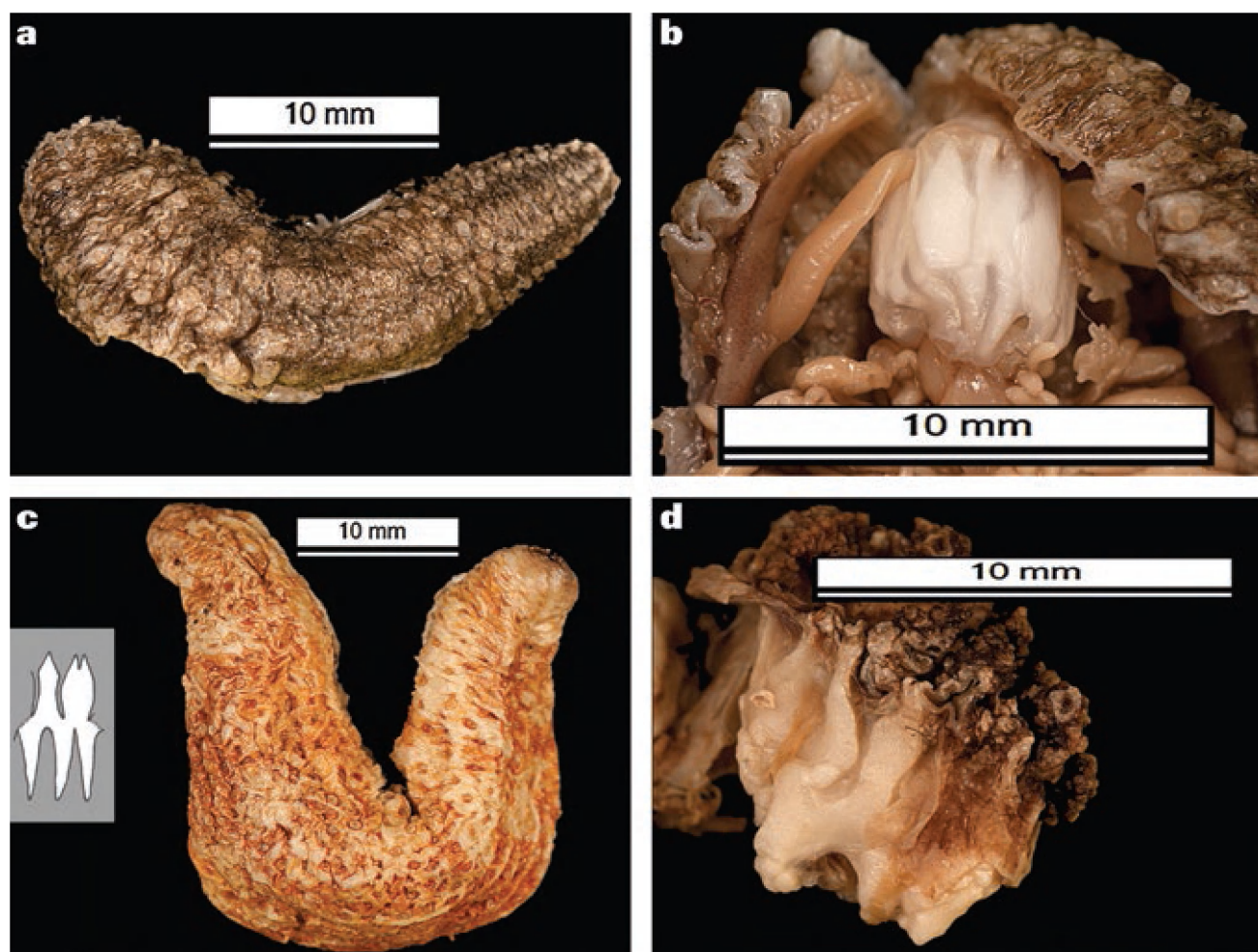


Figure 9. Photos of preserved specimens of *Phyllophorella thyonoides* (H. L. Clark, 1938). a, specimen from Western Australia (AM J21716); b, calcareous ring with posterior prolongations from radial plate only (AM J21716); c, specimen from South Australia (SAM K2597); d, calcareous ring with posterior prolongations jointly from radial and inter-radial plates (paratype of *Phyllophorus ventripes* Joshua and Creed, 1915, SAM K1375).

sometime red-brown to orange, not darker orally and anally; tube feet off-white, sometimes red; tentacle branches dark brown, white lumps (rosette ossicle clusters) on trunks.

Distribution. St. Vincent Gulf (South Australia) to Cliff Head (100 km S of Geraldton) (Western Australia), intertidal and offshore sediments, seagrass beds, 0–2 m.

Remarks. Specimen SAM K1374 is judged here (and so reported by Rowe and Gates 1995) to be the holotype for *Phyllophorus ventripes* Joshua and Creed, 1915. Thus specimens of *Phyllophorus ventripes* SAM K1375 (labelled “type material”) and NMV F45143 (3 specimens labelled “syntypes”, and so reported by Smith 1970) are judged here to be paratypes. Rowe and Gates 1995 listed four paratype specimens of *Phyllophorus ventripes* in lot SAM K1375. We found only one specimen in this lot. The three missing specimens may be those registered as syntypes (NMV F45143). We examined these SAM and NMV

type specimens. The holotype of *Phyllophorus ventripes* Joshua and Creed, 1915 and the three NMV paratypes are conspecific with *Thyone vercoi* Joshua and Creed, 1915, described in the same paper and based on a single specimen (see below under *Phyllostaurus vercoi*). The remaining SAM K1375 paratype of *Phyllophorus ventripes* is conspecific with *Phyllophorus thyonoides* H. L. Clark, 1938.

There are no labels or other records of where and when Dr. J. C. Verco collected the specimens for which *Thyone vercoi* and *Phyllophorus ventripes* were erected as new species. However H. L. Clark 1938 records Le Fevre Peninsula (sandy shallows 15 km NW of Adelaide in Gulf St. Vincent) as the precise locality for the collection of two loan specimens of *Thyone vercoi* (information presumably *pers. comm.*). Apart from the original specimens collected by Dr. Verco there are no other SAM specimens of either of these two species. WAM specimens of *P. thyonoides* collected from sea grass beds and

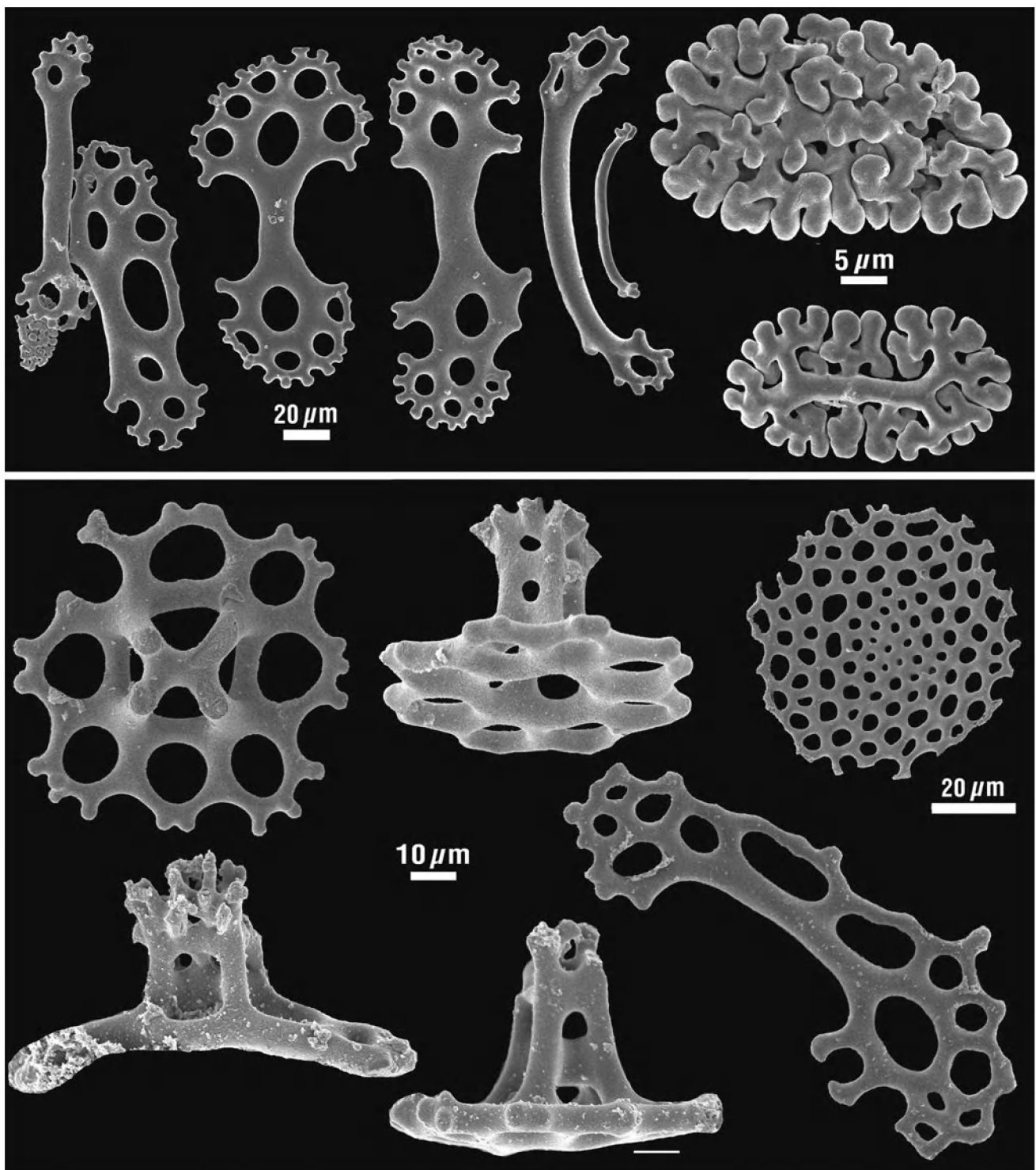


Figure 10. SEM images of ossicles from specimen of *Phyllophorella thyonoides* (H. L. Clark, 1938) (AMJ21716). Tentacle rods, some dumbbell-shaped, and rosettes (top); mid-body wall tables and tube foot endplate and support plate ossicle (bottom).

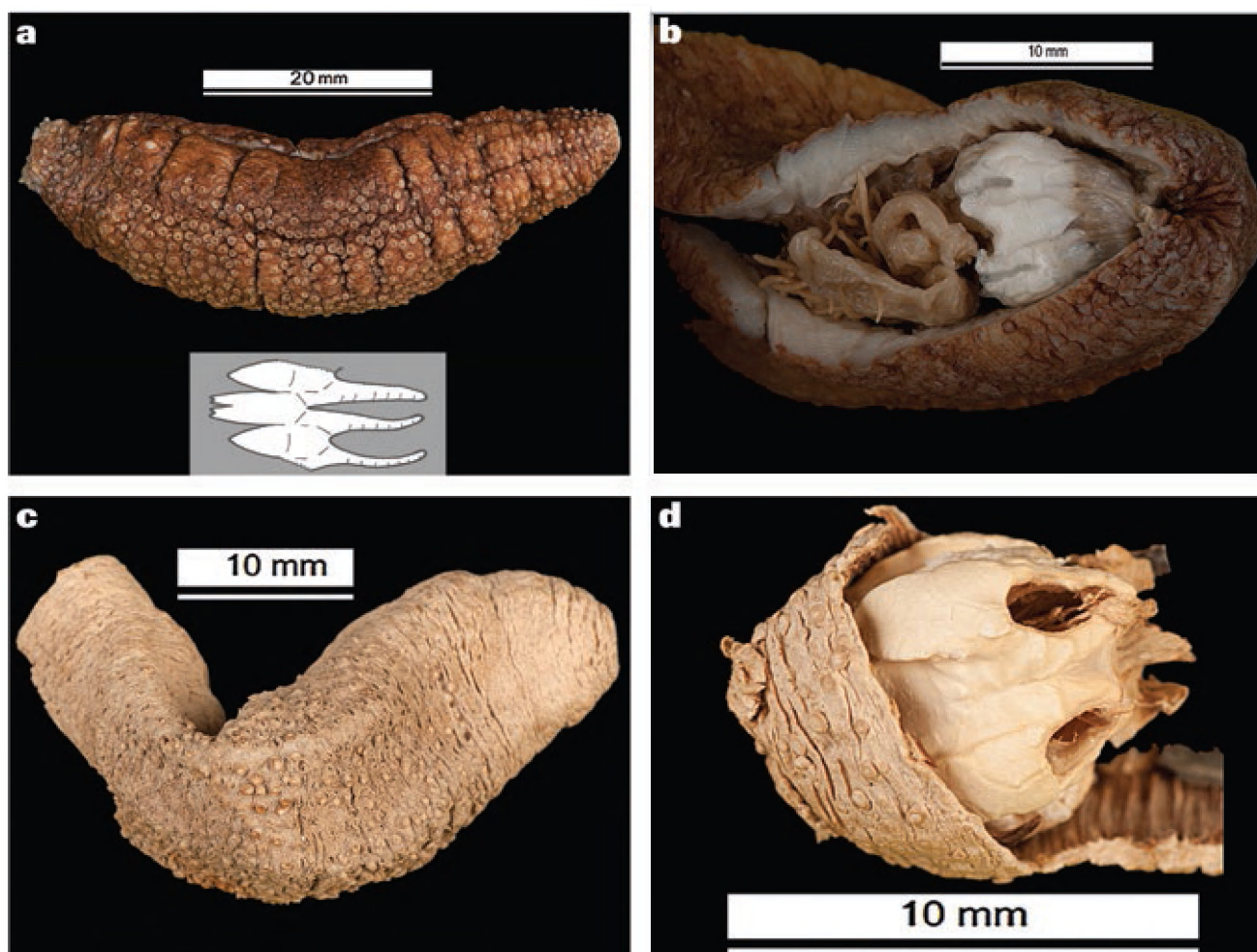


Figure 11. Photos of preserved specimens of *Phyllostauros vercoi* (Joshua and Creed, 1915). a, lateral view showing tube feet close ventrally and ventro-laterally, and sparse dorsally (paratype of *Phyllophorus ventripes* Joshua and Creed, 1915; NMV F45143) (insert: form of the calcareous ring plates); b, calcareous ring (NMV F45143); c, ventro-lateral view (holotype of *Phyllophorus ventripes* Joshua and Creed, 1915, dry, oral end detached, SAM K1374); d, calcareous ring (SAM K1374).

the sandy Le Fevre Peninsula provide evidence of the eco-niche for both *P. thyonoides* and *P. vercoi*.

The drawing of the calcareous ring for *Phyllophorus ventripes* Joshua and Creed, 1915 (*P. thyonoides* and *P. vercoi* here) is somewhat misleading as it shows posterior prolongations arising from the radial plates only, whereas in many specimens they arise jointly from radial and inter-radial plates. H. L. Clark 1938 noted for *Phyllophorus thyonoides* “obviously the lines of division between radial and inter-radial pieces of the calcareous ring are indefinite and arbitrary”. We agree. We noted that in one specimen of *Phyllophorella thyonoides* (WAM Z31975, illustrated in fig. 13f) the posterior prolongations of the calcareous ring are joined as in genus *Massinium* Samyn and Thandar, 2003 species (see below).

The dorsal tube feet are deeply buried in pits for *Phyllophorus ventripes* paratype SAM K1375 (*P. thyonoides* here), and this presumably led the original authors to describe the species as lacking tube feet dorsally.

Phyllostauros O’Loughlin gen. nov.

Diagnosis. Dendrochirote holothuroids with 20 tentacles, 5 large pairs alternating and 5 small pairs; body covered with tube feet; calcareous ring with 5 paired composite posterior tapering prolongations, arising jointly from the radial and inter-radial plates; body wall ossicles crosses with bifurcate ends, 1 or 2 surface spines near the ends.

Type species. *Thyone vercoi* Joshua and Creed, 1915 (monotypic).

Distribution. Central southern Australia.

Etymology. From the first part *Phyllo* of the relevant family name Phylloporidae, with *stauros* (Greek for cross) referring to the body wall ossicle form.

Remarks. *Thyone vercoi* Joshua and Creed, 1915 was erected for one specimen that is now dry and in poor condition (holotype, SAM K1374). The authors made three permanent

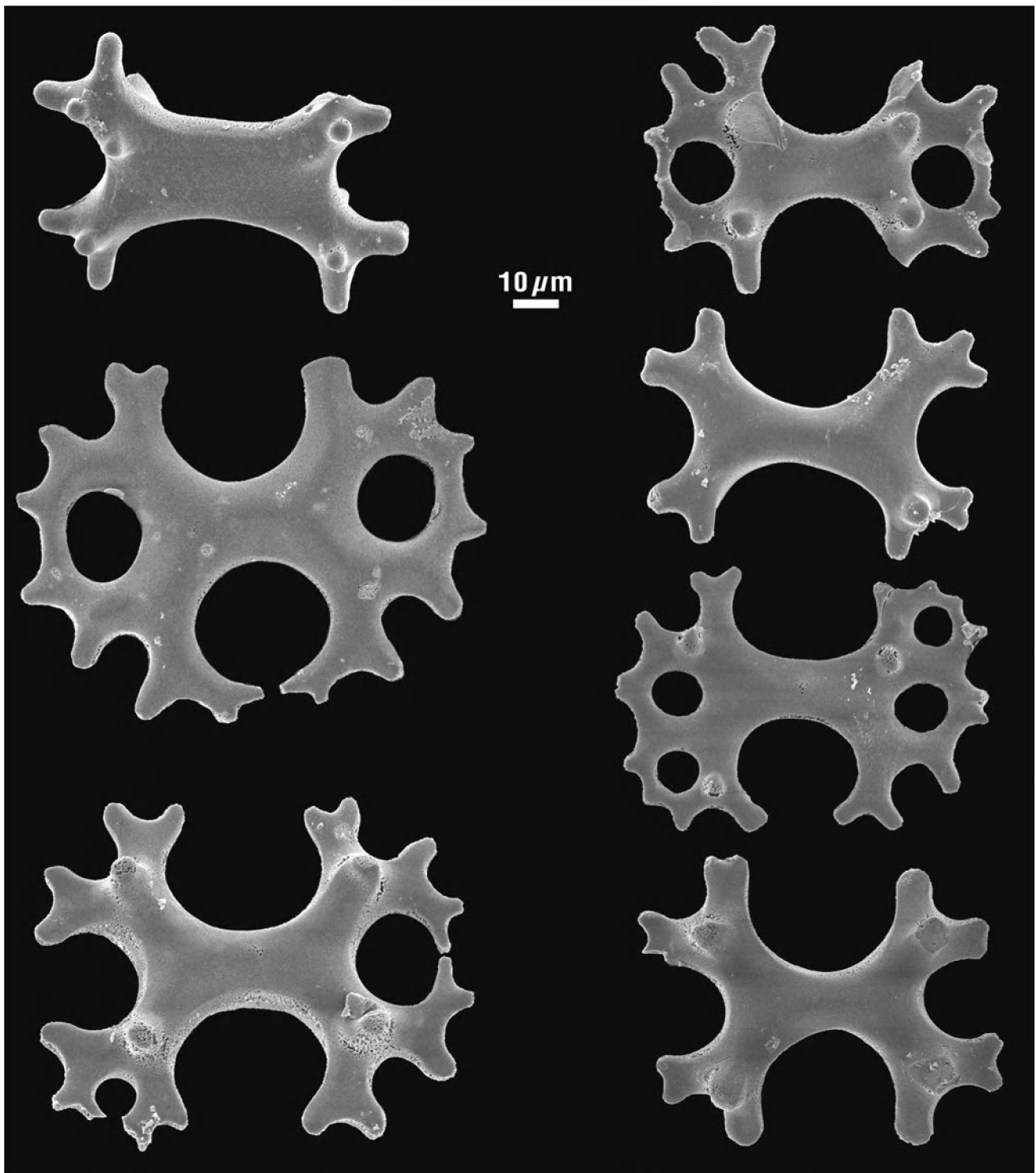


Figure 12. SEM images of ossicles of specimen of *Phyllostauros vercoi* (Joshua and Creed, 1915) (from paratype of *Phyllophorus ventripes* Joshua and Creed, 1915; NMV F45143). Surface-knobbed crosses from the body wall.

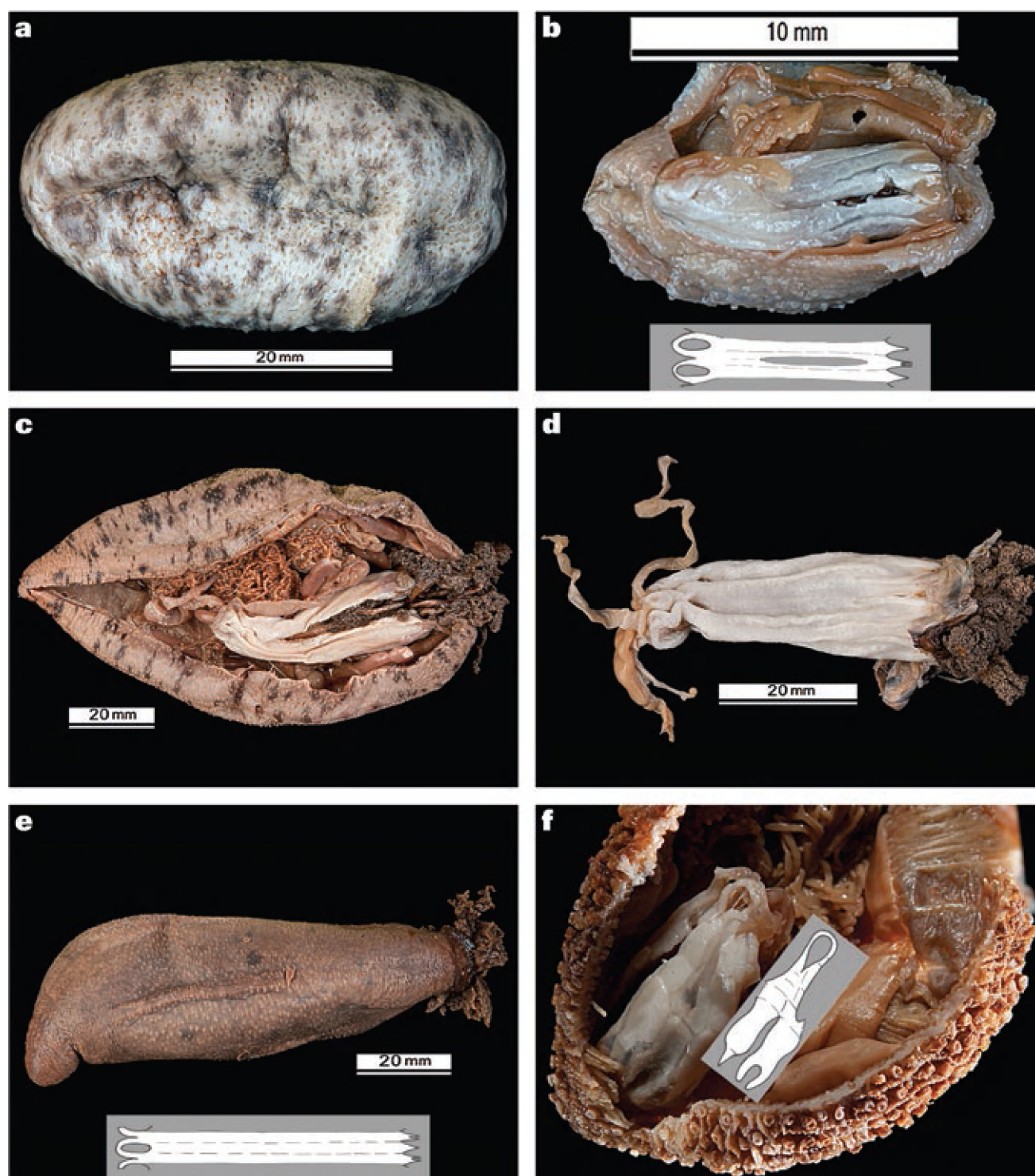


Figure 13. Photos of preserved specimens. a, *Massinium melanieae* O'Loughlin sp. nov. (holotype NMV F174897); b, *Massinium vimsi* O'Loughlin sp. nov. (holotype, NMV F76629) (insert: form of the calcareous ring plates); c, *Massinium watsonae* O'Loughlin sp. nov. (holotype, NMV F97435); d, calcareous ring, stone canal (along alimentary canal) and madrepore, and 2 polian vesicles (top left corner) of *Massinium watsonae* (TMAG H1988); e, colour morph of *Massinium watsonae* (NMV F174899) (insert: form of the calcareous ring plates); f, exceptional calcareous ring from specimen of *Phyllophorella thyonoides* (H. L. Clark, 1938) with posterior prolongations joined as in *Massinium* species (WAM Z31975) (insert: form of the calcareous ring plates).

microscope slides from parts of the dorsal body wall, pharynx and a tentacle. These slides are in good condition, and held by SAM. H. L. Clark 1946 refers to additional slides held in MCZ. The tentacle crown is damaged, but there are more than the 10 tentacles reported originally, and close to 20. The calcareous ring is composite with posterior prolongations, but is not tubular as in southern Australian *Thyone* Oken, 1815 species.

Based on the cross ossicles in the body wall H. L. Clark 1946 referred *Thyone vercoi* to *Staurothyone* H. L. Clark, 1938, but with reservations. He noted that Deichmann thought that the species was identical with *Lipotrachea vestiens* (Joshua, 1914). Genus *Staurothyone* is in family Cucumariidae. *Thyone vercoi* has close to 20 tentacles, composite posterior extensions to the plates of the calcareous ring, and tube feet all over the body (close ventrally, scattered and sparse dorsally). *Thyone vercoi* belongs in family Phyllophoridae, not Cucumariidae, and cannot be retained in *Staurothyone*. *Thyone vercoi* is unique amongst Phyllophoridae species for the presence of body wall cross ossicles and absence of table ossicles. Rowe 1982, and Rowe in Rowe and Gates 1995, anticipated the need for a new genus. *Phyllostauros* O'Loughlin gen. nov. is erected here as a monotypic genus, and is referred to family Phyllophoridae and sub-family Phyllophorinae with reservations because of the unique cross ossicles in the body wall.

***Phyllostauros vercoi* (Joshua and Creed, 1915)**

Figures 11, 12

Thyone vercoi Joshua and Creed, 1915: 19–20, pl. 2 figs 2–4, pl. 3 fig. 1, pl. 4.—H. L. Clark, 1938: 463–464.

Phyllophorus ventripes Joshua and Creed, 1915: 19, pl. 2 fig. 1, pl. 3 fig. 5. (part).

Lipotrachea ventripes.—H. L. Clark, 1938: 495–496.—H. L. Clark, 1946: 412.—Heding and Panning, 1954: 175, fig. 83 (from Joshua and Creed 1915).—Rowe, 1982: 464.—Rowe and Gates, 1995: 311. (part).

Staurothyone vercoi.—H. L. Clark, 1946: 397–398.—A. M. Clark, 1966: 345.—Rowe and Gates, 1995: 281.

'*Staurothyone*' *vercoi*.—Rowe, 1982: 464, fig. 10.29b.

Material examined. Holotype. South Australia, SAM K517 (with microscope slides of "skin", tentacle, and pharynx; specimen strongly contracted, dry).

Phyllophorus ventripes Joshua and Creed, 1915. Holotype. South Australia coast, SAM K1374 (specimen dry; oldest labels "type M.S.S.", "*Phyllophorus* sp. n. type", "holotype"; determined as "*Staurothyone*" *vercoi* by F. W. E. Rowe 1977). Paratypes. South Australia coast, 18 Sep 1913, NMV F45143 (3; no. 60676–8; labelled syntypes; determined by Joshua and Creed in 1914; from SAM "in exchange" 19 Sep 1919; AM label "*Staurothyone*" *vercoi*; judged here to be paratypes).

Diagnosis. Up to 50 mm long, up to 15 mm diameter (preserved, tentacles withdrawn), cylindrical body tapered to rounded slightly upturned ends orally and anally, distinct ventral surface, thick firm body wall; external anal scales not detected; 20 tentacles, 5 large pairs alternating with 5 small pairs; complete cover of tube feet, larger and concentrated ventrally, disc ends about 0.7 mm diameter, smaller and scattered dorsally, orally, anally, disc ends about 0.4 mm diameter; tube feet cross introvert; calcareous ring with 10 posterior composite

digitiform projections arising jointly from both radial and inter-radial plates, projections each comprise about 6 end-to-end plates, projections close radially creating long narrow gap extending higher anteriorly into the radial plates than the wide inter-radial gap, ring not tubular, posterior prolongations subequal in length with plates and anterior projections, form of plates and composite components variable; short stone canal, multi-lobed madreporite close to vascular ring; 1 tubular polian vesicle; longitudinal muscles with mid-muscle groove; gonad tubules in series along gonoduct on each side of dorsal mesentery, not branched.

Mid-body wall with abundant crosses, typically 64 μm long, some with 1 or 2 blunt surface spines near bifurcate ends, rare large crosses 88 μm long with bifurcations joined to create large perforations; tube foot ossicles endplates and support rods only, endplates with denticulate margin, irregular perforations similar size, diameters up to 320 μm , endplate support ossicles predominantly dumbbell-shaped, up to 104 μm long, rounded ends with large and small perforations and denticulate margin; tentacles with rods and rosettes, larger rods dumbbell-shaped, widened and perforate distally with denticulate margin, up to 240 μm long, rosettes up to 40 μm long; pharynx with abundant rosettes, typically 32 μm long.

Colour. Body red-brown, rusty, not darker orally and anally; tube feet disc ends off-white; tentacles with white lumps (rosettes), trunks white, branches pale brown.

Distribution. South Australia, Gulf St. Vincent, intertidal and offshore sediments.

Remarks. The new generic referral and unique diagnostic characters of *Phyllostauros vercoi* (Joshua and Creed, 1915) are discussed above under the new genus *Phyllostauros* O'Loughlin.

As the basis of their erection of this new species Joshua and Creed 1915 refer specifically to a single specimen collected by Dr. J. C. Verco, "considerably contracted" and 36 mm long (SAMK517). H. L. Clark 1938 refers to a loan of two specimens of *Thyone vercoi*, 50 and 14 mm long. He further notes that both came from Le Fevre Peninsula (15 km NW of Adelaide in Gulf St. Vincent), and thus from sandy shallows. Curiously H. L. Clark 1946 makes no mention of these two specimens in discussing *Staurothyone vercoi*.

The two oldest labels with the holotype specimen of *Phyllophorus ventripes* (SAM K1374) record "type M.S.S." and "type, SA coast, Dr. Verco". Other recent labels indicate "holotype". Rowe and Gates 1995 record "holotype". We accept that this specimen is the holotype. A determination by F. W. E. Rowe in 1977 indicates '*Staurothyone*' *vercoi*. We agree with this species determination and synonymy. Although the specimen is dry it is still possible to extract cross ossicles from the body wall.

Furthermore we have found that the three paratypes of *Phyllophorus ventripes* Joshua and Creed 1915 (NMV F45143) are conspecific with *Thyone vercoi* (type status of paratypes discussed above under *Lipotrachea thyonoides*).

The holotype specimen of *Thyone vercoi* is dry and in poor condition but there is an excellent set of slides from the

type available. The species itself has unique characters within Phylloporidae, has never been uncertain in terms of type status, has not been erroneously reported in the literature, and has received considerable attention in the literature (see above under *Phyllostaurus*). On the other hand, for *Phyllophorus ventripes*, considerable confusion has surrounded the history of the status and identity and description of the type specimens, and subsequent determination of other material. Thus as “first revisers” (see ICZN Article 24.2.2) we give name precedence to *Thyone vercoi* over *Phyllophorus ventripes* in Joshua and Creed 1915. *Phyllophorus ventripes* is a subjective junior synonym of *Thyone vercoi*.

Thyonidiella Heding and Panning, 1954

Diagnosis (after Heding and Panning 1954). Dendrochirote holothuroids with 15 tentacles in 2 series, 10 large outer and 5 small inner; body covered with tube feet; calcareous ring with composite tapering posterior extensions comprising discrete single series of plates, arising principally from radial plates but sometimes also joined with inter-radial plate posterior extensions; body wall ossicles tables with 4-pillared spires, sometimes only present in juveniles; endplates with support plates, not support tables.

Type species. *Thyonidiella tenera* (Ludwig, 1875) (senior synonym of original type species *Thyonidiella oceana* Heding and Panning, 1954).

Other species. *T. cherbonnieri* Rowe and Richmond, 2004; *T. drozdovi* (Levin and Stepanov, 1999); *T. exigua* Cherbonnier, 1988; *T. kungi* O’Loughlin sp. nov.

Remarks. Rowe and Richmond (2004) commented in detail on genus *Thyonidiella* Heding and Panning, 1954. They noted that *Thyonidiella oceana* Heding and Panning, 1954 is a junior synonym of *Thyonidiella tenera* (Ludwig, 1875), and that *Semperiella* Heding and Panning, 1954 is a junior synonym of *Thyonidiella* Heding and Panning, 1954. They further judged that *Thyonidiella exigua* was probably based on a juvenile specimen of *Selenkiella paradoxa* Cherbonnier, 1970.

Thyonidiella kungi O’Loughlin sp. nov.

Figures 1d, 8

Material examined. Holotype. Australia, Bass Strait, VIMS 81–T–1, NZOI RV *Tangaroa* stn 176, 38°54.3’S, 147°13.4’E, 58 m, coarse shell, 18 Nov 1981, NMV F76637.

Paratypes. Type locality and date, NMV F174910 (1); VIMS 81–T–1 stn 171, 38°53.7’S, 147°55.2’E, 71 m, shelly sand, 17 Nov 1981, NMV F76635 (3); VIMS 81–T–1 stn 177, 38°53.7’S, 147°06.5’E, 58 m, coarse shell, 18 Nov 1981, NMV F76638 (5).

Other material. VIMS 81–T–1 stn 161, 39°47.3’S, 147°19.3’E, 60 m, muddy shell, 14 Nov 1981, NMV F76636 (1); VIMS 81–T–1 stn 174, 39°14.8’S, 147°31.5’E, 57 m, muddy shell, 18 Nov 1981, NMV F76639 (5, very small).

Diagnosis. Up to 16 mm long, up to 5 mm diameter (preserved, tentacles withdrawn), cylindrical body, rounded end orally, tapered to rounded end anally, thick soft body wall; external anal scales not detected; 15 tentacles in 2 series, 5 outer pairs

large, 5 single inner small; complete spaced cover of tube feet, diameter up to about 0.2 mm; calcareous ring with 10 posterior composite tapering projections arising in pairs from radial plates only, posterior projections free thin tails each comprising about 5 elongate plates, ring not tubular, anterior radial plate narrowing slightly with deep central split, lacking lateral small notches, interradial plates not composite; single polian vesicle; longitudinal muscles flat, not divided.

Mid-body dorsal wall lacking ossicles; tube foot ossicles endplates and support ossicles only, endplates with denticulate margin, irregular sub-equal perforations, diameters up to 184 μ m, endplate support ossicles dumbbell-shaped, distally perforate with denticulate margin, up to 120 μ m long; tentacles with rods and rosettes, larger rods dumbbell-shaped, widened and perforate distally with denticulate margin, up to 304 μ m long, rosettes up to 88 μ m long; anal ossicles tube foot endplates and support rods, tentacle-like rods, rosettes, 5 scales comprising base up to 320 μ m wide with digitiform column up to 240 μ m long, base and column comprising massed short branched rods.

Specimen 3 mm long with radial tube feet; cucumariid ring lacking posterior prolongations; mid-body ossicles solid 4-pillared tables, irregular multi-perforate discs up to 184 μ m long, high spires with 4 cross connections, up to 136 μ m high; mid-body tube feet with endplates up to 152 μ m diameter, perforations small centrally, large peripherally, margin denticulate, endplate support rods dumbbell-shaped, up to 184 μ m long.

Colour (preserved). Body pale brown.

Etymology. Named for the Taiwanese FRV *Hai Kung* that conducted part of the survey of the benthic marine fauna of eastern Bass Strait for the former Victorian Institute of Marine Sciences.

Distribution. Eastern Bass Strait, 38–40°S, 147–148°E, 58–71 m, coarse shell, mud and sand.

Remarks. *Thyonidiella kungi* O’Loughlin sp. nov. is distinguished from other southern Australia Phylloporidae species in the key (above).

Subfamily *Semperiellinae* Heding and Panning, 1954

Diagnosis. Calcareous ring tubular with long posterior prolongations, both ring and projections made up of a mosaic of small pieces; tentacles 20; body wall ossicles tables, each with a spire of 2 or 4 pillars.

Genera. *Cladolella* Heding and Panning, 1954; *Massinium* Samyn and Thandar, 2003; *Neopentadactyla* Deichmann, 1944; *Neothyonidium* Deichmann 1938; *Pentadactyla* Hutton, 1879; *Phyrella* Heding and Panning, 1954.

Remarks. We note that Rowe and Richmond (2004) judged that *Semperiella* Heding and Panning, 1954 (family Semperiellinae Heding and Panning, 1954) is a junior synonym of *Thyonidiella* Heding and Panning, 1954 (family Phylloporinae). This refines the diagnosis for genera of subfamily Semperiellinae, removing the inclusion of genera with 15 tentacles. We query

the inclusion in Semperiellinae of genus *Phyrella* Heding and Panning, 1954 with its calcareous ring that is not tubular and is similar to that in genera of Phyllophorinae. We note that *Cladolella* Heding and Panning, 1954 has a *Massinium*-like calcareous ring (see illustration in Heding and Panning 1954), 20 tentacles, and tables with 2-pillar spires, and might be considered to be a senior synonym of *Massinium* Samyn and Thandar, 2003 with its variety of body wall ossicles, although the tube feet are radial in *Cladolella*.

***Massinium* Samyn and Thandar, 2003**

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

Material examined. *Massinium granulosum* Samyn and Thandar, 2010. Holotype and paratype. Queensland, Moreton Bay, Stradbroke I., intertidal seagrass, 14 Nov 1977, AM J13578 (2); Queensland, 32 km NNE of Double Island, AM J2093 (1).

Massinium magnum (Ludwig, 1882). Queensland, Heron I., 10 m, sandy rubble, 21 Nov 1974, AM J9490 (1).

Diagnosis (Samyn et al. 2010). Dendrochirotid holothuroids with 20 tentacles arranged in two circles of 10 + 10; anus usually encircled by calcareous teeth; calcareous ring elongate, tubular, with both radial and interrational plates fragmented into a mosaic of small pieces and prolonged posteriorly, with the posterior processes distally linked to processes of neighbouring plates forming a loop beneath the water vascular ring; polian vesicles elongate, usually 4; ossicles of mid-body wall comprise granuliform rods, and/or rosette-shaped deposits; tables present in juveniles or occasionally in adults as scarce reduced deposits.

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

Other species. *Massinium albicans* Samyn et al. 2010; *M. arthroprocessum* (Thandar, 1889); *M. dissimilis* (Cherbonnier, 1988); *M. granulosum* Samyn et al., 2010; *M. magnum* (Ludwig, 1882); *M. melanieae* O'Loughlin sp. nov.; *M. vimsi* O'Loughlin sp. nov.; *M. watsonae* O'Loughlin sp. nov.

Remarks. We have not further emended the generic diagnosis in Samyn et al. 2010 but note the possibly polyphyletic nature of *Massinium* Samyn and Thandar, 2003, with the variety of body wall ossicle forms in the assigned species that include tables with 2-pillar spires, pseudobuttons, and thick granuliform rods.

***Massinium melanieae* O'Loughlin sp. nov.**

Figures 13a, 14

Material examined. Holotype. Southern Australia, Great Australian Bight, *Southern Surveyor* cruise SS01/00 stn 378, 31°50'S 130°46'E, 55 m, 13/14 May 2000, NMV F174897.

Diagnosis. *Massinium* species up to 42 mm long, up to 24 mm diameter (preserved, tentacles withdrawn), slight oral to anal taper, thin firm body wall; exterior anal scales not detected; 20 tentacles, 5 pairs of large, 5 pairs of small; complete uniform cover of small and large tube feet, diameter up to 0.4 mm; white tubular composite calcareous ring 25 mm long; radials up to 3 mm wide, anterior taper with apical notch; inter-radials up to 2 mm wide, taper to anterior point, distal indentation

closed by narrow calcareous posterior bridge creating oblong non-calcareous section; 4 polian vesicles, shorter than calcareous ring; stone canal extending from end of calcareous ring with madreporite free in coelom (dissected condition); cylindrical longitudinal muscles, not divided; gonad tubules thin, branched.

Lacking mid-body wall ossicles; tube feet with endplates only, diameter up to 320 μ m, irregular perforations, small central, larger peripheral; tube feet lacking support ossicles; peri-oral region with abundant regular tables, discs oval to rounded rectangular, up to 96 μ m long, 4 large central and numerous small peripheral perforations, spires up to 24 μ m long, 2 pillars each with up to 5 blunt apical spines, some bifid; tentacle branches with thin rods, knobbed or finely perforate distally, up to 104 μ m long; tentacle trunks lacking ossicles; inner wall of tubular calcareous ring with rods up to 104 μ m long, widened and rounded distally, each end with up to 8 perforations; anal ossicles scales, endplates, tables; scales single-layered, thick, irregular, perforated; endplates about 160 μ m diameter; tables irregular, frequently about 16 disc perforations, 3 or 4 large central, small peripheral, 2 pillars, each with blunt apical spines, most discs up to 72 μ m long, pillars about 40 μ m high.

Colour (preserved). Body off-white with grey-brown irregular patches; tentacle trunks grey, branches grey-brown.

Type locality. Southern Australia, Great Australian Bight, 55 m.

Etymology. Named for Melanie Mackenzie, collection curator in the Department of Marine Biology in Museum Victoria, and valued colleague in echinoderm systematic research.

Remarks. *Massinium melanieae* O'Loughlin sp. nov. is erected for a single specimen in good condition. The type locality is unlikely to be sampled again in the foreseeable future and we judge that it is important to erect this species. The distinguishing combination of diagnostic characters for *Massinium melanieae* O'Loughlin is given in the key (above).

***Massinium vimsi* O'Loughlin sp. nov.**

Figures 13b, 15

Material examined. Holotype. Australia, eastern Bass Strait, VIMS, NZOI RV *Tangaroa* 81-T-1 stn 174, 39°16.8'S 147°32.2'E, 57 m, mud / shell, 18 Nov 1981, NMV F76629.

Diagnosis. *Massinium* species 12 mm long, 5 mm diameter (preserved, tentacles withdrawn), form cylindrical with rounded ends, soft body wall; exterior anal scales not detected; 20 tentacles, 5 pairs of large, 5 pairs of very small; complete cover of tube feet, more prominent ventrally, up to 0.2 mm diameter; tubular composite calcareous ring 9 mm long, plates up to 1 mm wide, posterior radial notch, posterior deep inter-radial indentation closed posteriorly by continuous band of small plates to create elongate non-calcareous space; radials tapered anteriorly with anterior notch; inter-radials tapered to anterior point; single tubular polian vesicle; stone canal and madreporite lying anteriorly on calcareous ring; cylindrical longitudinal muscles, not divided; lacking gonad tubules.

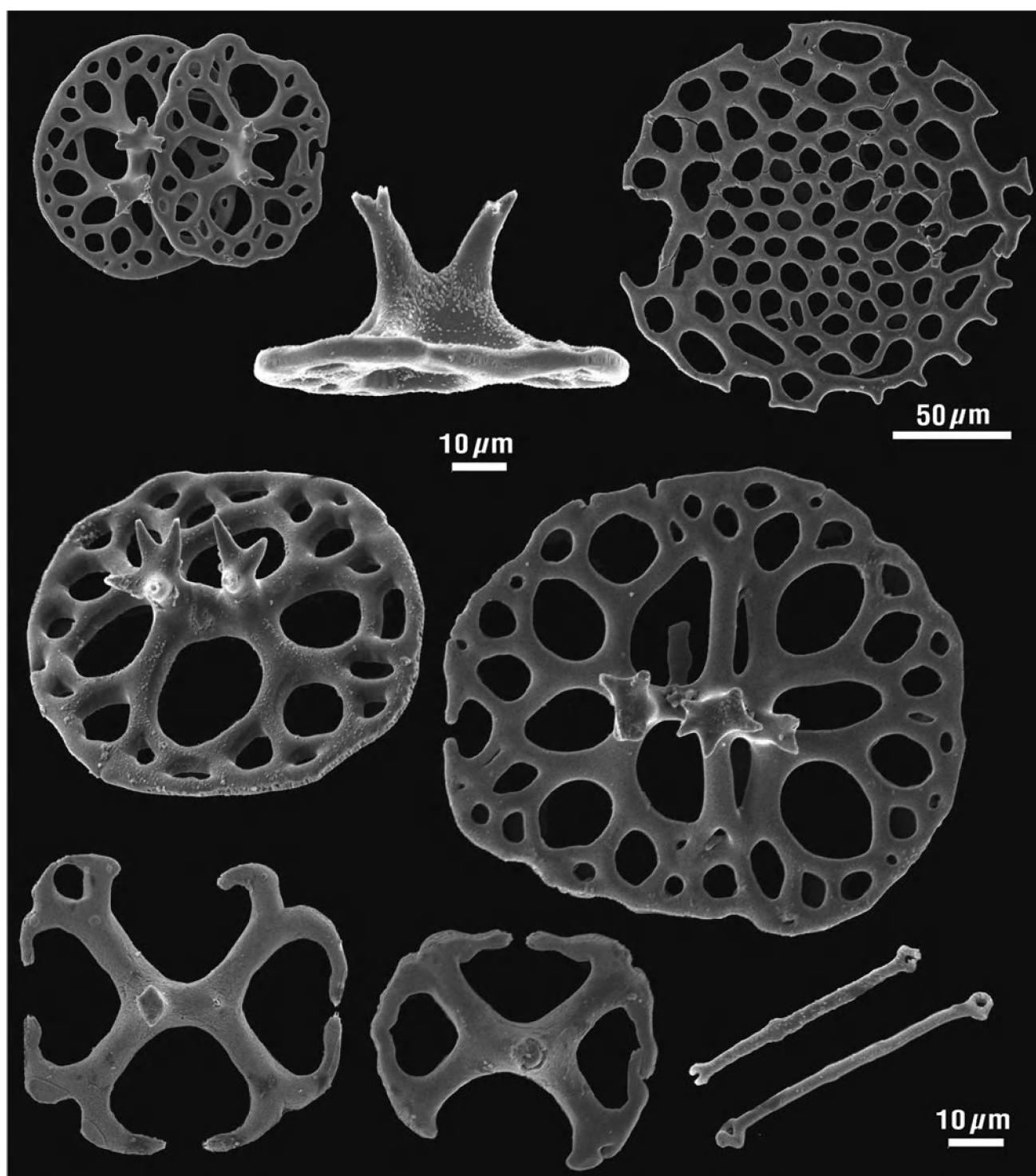


Figure 14. SEM images of ossicles from holotype of *Massinium melanieae* O'Loughlin sp. nov. (NMV F174897). Regular tables from peri-oral body wall (top left); mid-body tube foot endplate (top right); large irregular table from anal region (central right); thin rods from tentacle branches (bottom right).

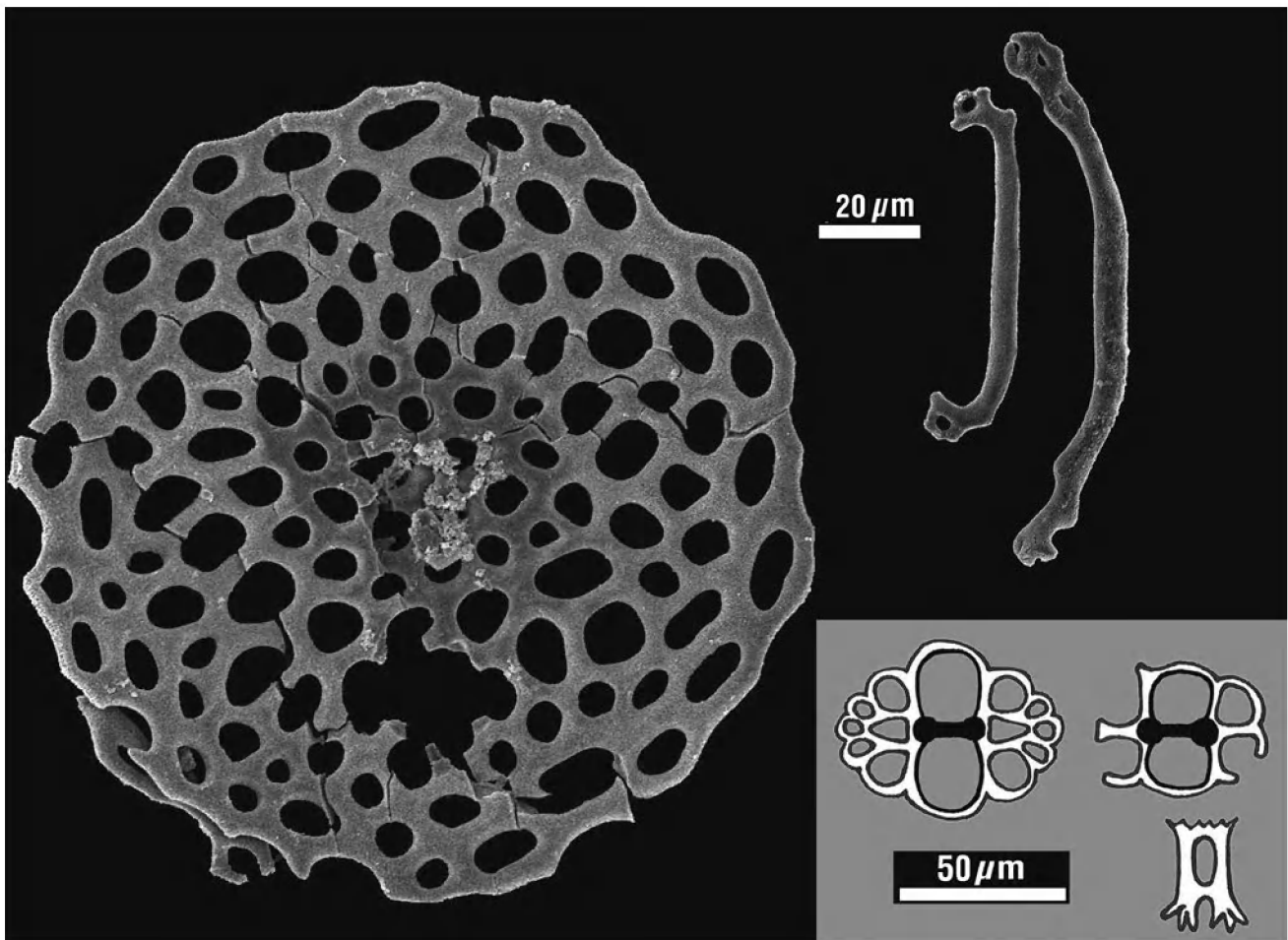


Figure 15. SEM images of ossicles from holotype of *Massinium vimsi* O'Loughlin sp. nov. (NMV F76629). Tube foot endplate (left); tentacle rods (right); (insert: drawings of table disc, developing disc, and table spire from peri-oral body wall table ossicles).

Lacking mid-body wall ossicles; tube feet endplates up to 184 μm diameter with irregular small perforations and slightly undulating to denticulate margin, rod-like support plates around margin of endplates, narrow, curved, perforations distally, sometimes along rod, large central, small distal, rods up to 96 μm long; peri-oral region with tables, discs up to 72 μm long, lobed margin, up to about 18 perforations, spires about 32 μm long, 2 pillars each with 2–3 sometimes bifid spines distally, single cross-bridge; introvert ossicles endplates, endplate support rods and rosettes, endplates up to 136 μm diameter with irregular small perforations, rods up to 80 μm long, straight to slightly bracket-shaped, slightly swollen distally with 1–2 terminal perforations, rosettes rare; tentacles ossicles rods and rare rosettes, rods up to 96 μm long, curved, ends of rods swollen, smooth or denticulate, 1–2 distal perforations; anal ossicles endplates and endplate support rods, anal endplates up to 144 μm diameter, undulating margin, some with slightly larger peripheral perforations, support rods perforated as in tube feet, up to 80 μm long.

Colour (preserved). Body pale brown; tentacles dark brown.

Type locality and distribution. Southeast Australia, eastern Bass Strait, 57 m.

Etymology. Named for the former Victorian Institute of Marine Sciences (VIMS), with appreciation of the thoroughness of the 1981 benthic survey of eastern Bass Strait with a significant contribution of specimens to this study.

Remarks. *Massinium vimsi* O'Loughlin sp. nov. is erected for a single specimen in good condition. The small specimen size and absence of gonad tubules suggest that it is probably a juvenile. The type locality is unlikely to be sampled again in the foreseeable future and we judge that it is important to erect this species. The distinguishing combination of diagnostic characters for *Massinium vimsi* O'Loughlin is given in the key (above).

Massinium watsonae O'Loughlin sp. nov.

Figures 13c, d, e, 16

Lipotrachea dearmatus.—H. L. Clark, 1938: 494.—H. L. Clark, 1946: 411–412. (part; Australian material non *Phyllophorus dearmatus* Dendy and Hindle, 1907).

Neothyonidium dearmatum.—Heding and Panning, 1954: 191–192 (part; Australian material non *Phyllophorus dearmatus* Dendy and Hindle).—Hickman, 1978: 32, pl. 1, figs 15–24 (non *Phyllophorus dearmatus* Dendy and Hindle).

Neothyonidium sp.—Rowe, 1982: 466, pls 31.5, 31.6.

Neothyonidium ? *dearmatum*.—Edgar, 1997: 369 (with photo of tentacles).

Material examined. Holotype. Southeast Tasmania, Bruny Island, Simpsons Bay, 43°17'S 147°18'E, 11 m, 15 Feb 1972, J. E. Watson, NMV F97435.

Paratypes. Type locality and date, NMV F174898 (1); NMV F174899 (1); off Bruny Island, D'Entrecasteaux Channel, 12 m, Feb 1972, J. E. Watson, NMV F97420 (2).

Other material. D'Entrecasteaux Channel, off Green Island, 56 m, D. F. Turner, 21–25 July 1948, TMAG H169 (1; det. F. W. E. Rowe 1974 as *Neothyonidium dearmatum*); Derwent River, Blackmans Bay, on beach after storm, E. Turner, 12 Jun 1988, TMAG H1988 (1, tentacle crown and ring only); Kettering, 43°08'S 147°15'E, 10 m, A. J. Dartnall and T. Sward, 29 Mar 1977, AM J12385 (1; as *Lipotrachea dearmatus*; ring damaged posteriorly prohibiting type status); slides for AM J12385 specimen prepared by V. V. Hickman, tentacles and body wall TMAG H2089, introvert TMAG H2090, dorsal body wall TMAG H2091, mid-body wall TMAG H2092, anal TMAG H2093, posterior TMAG H2094, anal papilla TMAG H2095, cloaca TMAG H2096; Eastern Tasmania, Great Oyster Bay, no other data, AM J1538 (1). “New South Wales”, no other data, AM J18132 (1; presumed locality error, SE Tasmania distribution).

Neothyonidium dearmatum (Dendy and Hindle, 1907). New Zealand, near Cook Strait, 40°S 174°E, 67 m, NIWA 4187 (2); 55 m, NIWA 73992 (1); off Christchurch, 43°S 173°E, 59 m, NIWA 28443 (1); 44°S 173°E, 54 m, NIWA 76793 (1); 64 m, NIWA 73987 (4); off Stewart I., 47°S 168°E, 33 m, NIWA 45522 (2).

Diagnosis. *Massinium* species up to 110 mm long, up to 40 mm diameter (preserved, tentacles withdrawn), wide orally, tapered to rounded end anally, thin firm body wall; exterior anal scales not detected; 20 tentacles, 5 outer pairs large, 5 inner pairs small; complete cover of tube feet, single series of close tube feet on each side of longitudinal muscle interior attachment, scattered inter-radially, across introvert in irregular paired radial series, diameters up to 0.4 mm; white leathery tubular composite calcareous ring up to 50 mm long; radials with anterior taper and notch, posterior notch; inter-radials tapered to anterior point, posterior inter-radial indentation closed by continuous band of small plates to create oblong non-calcareous space; 1–2 tubular polian vesicles, as long and longer than calcareous ring; long thin stone canal with globular madreporite attached by mesentery to pharynx; cylindrical longitudinal muscles, not divided; gonad tubules long thin.

Ossicles disappear with age / size; peri-oral tables only in 110 mm long holotype; eroded ossicle remnants only in 70 mm long paratype (NMV F97420); in specimen 65 mm long (AM J12385), mid-body wall lacking ossicles; tube feet with few endplates up to 216 μ m diameter, irregular small perforations, larger peripherally, rare curved support rods up to 80 μ m long

around endplate margin; peri-oral region with tables, sometimes rosettes, table discs oval to rounded, irregular, up to 144 μ m long, up to about 40 perforations, spires with 2 pillars, distal cross-bar sometimes perforated, pillars with few blunt spines apically; introvert ossicles tables with oval to rounded rectangular discs, sometimes rosettes, table discs up to 96 μ m long, up to 24 perforations, 4 large central perforations, many smaller surrounding ones, spires up to 48 μ m long, 2 (rarely 1) pillars with 2–3 blunt spines apically; larger specimens tentacles lacking ossicles in trunks and branches, 50 mm long specimen with rare rods, up to 80 μ m long, few distal perforations; posterior/anal body with tube foot endplates up to 192 μ m diameter, rare curved endplate support rods up to 80 μ m long; anal papilla with anal scale fragments, tube foot endplates, rods and rosettes; anal scales comprising multi-layered base with digitiform calcareous papilla about 800 μ m long comprising mass of thick linear, X, Y, H shaped rods; anal tube foot endplates up to 152 μ m diameter; numerous short irregular anal rods intergrading with rosettes, up to 48 μ m long.

Colour (preserved). Variable, body pale pinkish-brown with dark brown patches to uniform pale brown, tentacle trunks brown to dark brown, branches dark brown to grey-brown.

Type locality. Tasmania, Bruny Island, Simpsons Bay, 11 m.

Distribution. Southeast Tasmania, D'Entrecasteaux Channel to Derwent Estuary; 11–56 m.

Etymology. Named for Jan E. Watson, Honorary Associate of Museum Victoria, hydroid systematist, significant contributor to the marine invertebrate collections of Museum Victoria, and collector of the types of this species.

Remarks. The diagnostic description of ossicles is based principally on the comprehensive set of V. V. Hickman slides (see Material examined) of a smaller Kettering specimen (65 mm long, up to 15 mm diameter) registered to the Australian Museum (AM J12385). The presence and form of tables in the introvert and absence of ossicles in the tentacles are consistent with the Blackmans Bay part-specimen, except that there are also rosettes in the introvert. The presence or absence of rosettes is judged to be variable in specimens of some phylloporid species.

H. L. Clark 1938 referred *Phyllophorus dearmatus* Dendy and Hindle, 1907 to his new genus *Lipotrachea* with considerable reservation, based on the entirely different calcareous ring. In the same year Deichmann erected the genus *Neothyonidium* to which Heding and Panning 1954 subsequently referred *Phyllophorus dearmatus*. No specimen of *Neothyonidium dearmatum* (Dendy and Hindle, 1907) has been found in Australian waters. Material determined by Joshua (1914) to be *Phyllophorus dearmatus* has been examined and found to represent our new species *Thyone flindersi* O'Loughlin sp. nov. (below). Deichmann (in H. L. Clark 1946) correctly judged that the Joshua specimens should be referred to *Thyone*.

Hickman (1978) reported a specimen of *Neothyonidium dearmatum* from Kettering on the D'Entrecasteaux Channel in southeast Tasmania, but noted some differences from the descriptions of this New Zealand species. The specimen is not

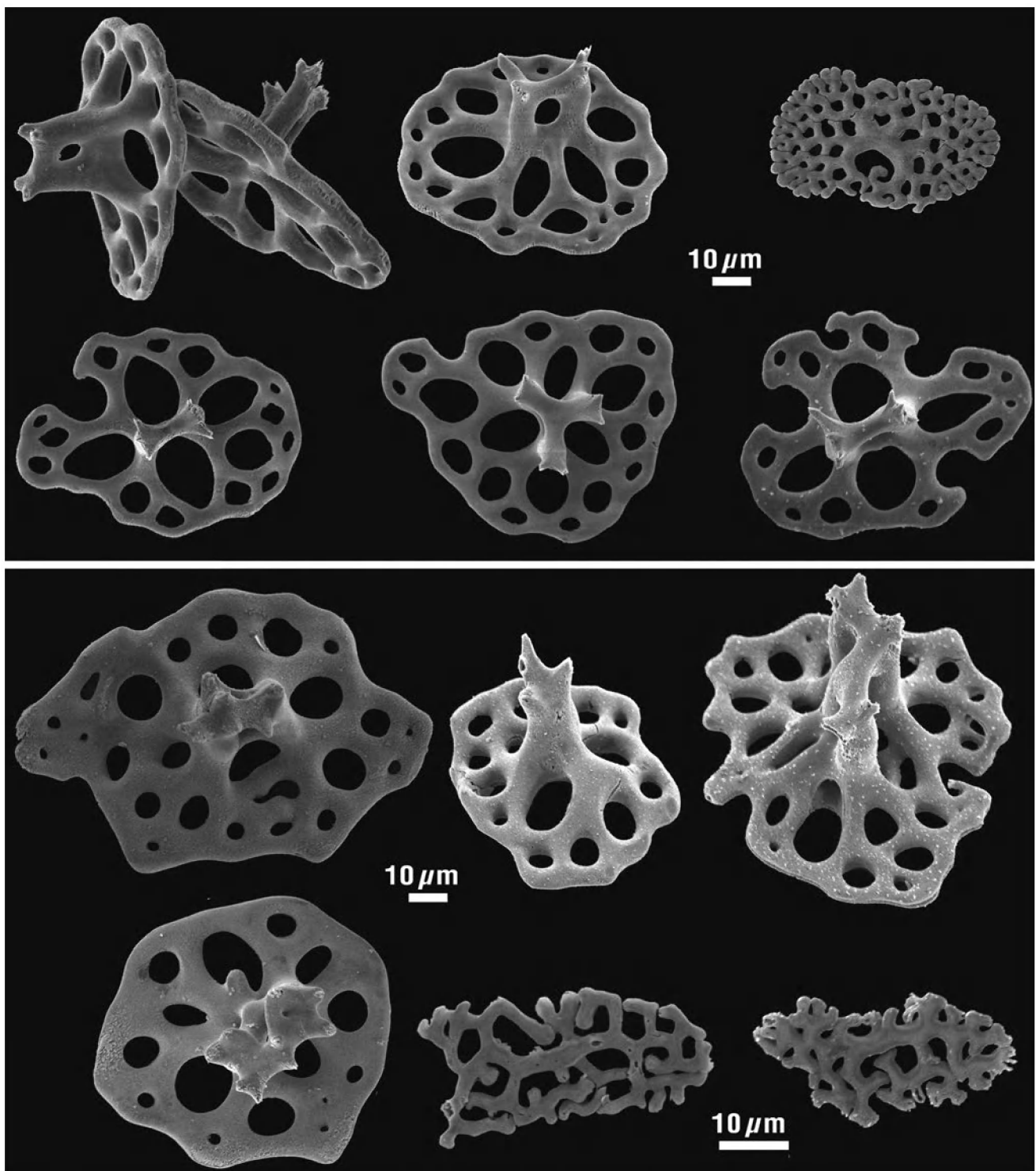


Figure 16. SEM images of ossicles from specimen of *Massinium watsonae* O'Loughlin sp. nov. (TMAG H1988). Tables and rosette from introvert (top); tables and rosettes from peri-oral body wall (bottom).

held in the TMAG but ossicle slides prepared by Hickman are available and were examined by us. The specimen is now held by the AM and has been examined here. Based on the description by Hickman (1978) and the ossicle slides, the Kettering specimen is conspecific with specimens referred here to our new species *Massinium watsonae* O'Loughlin sp. nov. (above). Rowe (1982) referred to the Kettering specimen as *Neothyonidium* sp.

Based on the descriptions by Dendy and Hindle (1907), Mortensen (1925), and Pawson (1970) and our observations the diagnostic characters that distinguish *Neothyonidium dearmatum* (Dendy and Hindle) from *Massinium watsonae* O'Loughlin sp. nov. (characters in bracket) are: size up to 65 mm long (up to 110 mm); tentacle rod ossicles present (lacking tentacle ossicles); inter-radial plates of calcareous ring divided for most of their length by non-calcareous space (short distal closed oblong non-calcareous space); distal end of each inter-radial plate with two narrowing tails that may be contiguous but not joined by small plates (distal end of calcareous ring a continuous collar of small plates, the generic diagnostic character for *Massinium* Samyn and Thandar, 2003); single polian vesicle (2 polian vesicles); if present tables in anterior and posterior body wall (in introvert only); table disc lengths average 75 μ m (average about 90 μ m); perforations in table discs usually 8 (up to 24). The combination of unique diagnostic characters of *Massinium watsonae* O'Loughlin sp. nov. is given in the key (above).

Subfamily **Thyoninae** Panning, 1949

Thyone Oken, 1815

Diagnosis (emended from Pawson and Miller 1981). Tentacles 10; tube feet scattered on body wall, never restricted to radii; calcareous ring tubular with long posterior prolongations comprising a mosaic of small pieces; body wall ossicles tables with a spire of one or two pillars.

Type species. *Holothuria fusus* Müller, 1776 (monotypy).

Southern Australian species. *Thyone flindersi* O'Loughlin sp. nov.; *Thyone joshuai* O'Loughlin, sp. nov.; *Thyone kerkosa* O'Loughlin sp. nov.; *Thyone nigra* Joshua and Creed, 1915; *Thyone okeni* Bell, 1884; *Thyone spenceri* O'Loughlin sp. nov.; *Thyone tourvillei* O'Loughlin sp. nov.

Remarks. We acknowledge the current invalid status of *Thyone* Oken, 1815 and our provisional retention is discussed in the Introduction. We emend the diagnosis of *Thyone* Oken to include tables with one pillar in the spire to accommodate a new species described in this work. Pawson and Miller 1981 remarked on the need for a revision of the "supergen" *Thyone*. This need continues for what will be a major undertaking. The revision should await further supportive evidence from emerging genetic data.

Thyone flindersi O'Loughlin sp. nov.

Figures 17a, 18

Phylloporus dearmatus.—Joshua, 1914: 4–5 (non *Phylloporus dearmatus* Dendy and Hindle, 1907).

Thyone sp. —Joshua and Creed, 1915: 20.

Thyone okeni.—Rowe, 1982: 462 ("provisional referral"; Port Phillip and Westernport Bays specimens non *Thyone okeni* Bell, 1884).—Rowe and Gates, 1995: 316 (southern coast specimens non *Thyone okeni* Bell, 1884).—Gowlett-Holmes, 2008: 263 (southern coast specimens non *Thyone okeni* Bell, 1884).

Material examined. Holotype. Victoria, Flinders ocean platform, intertidal rocky shallows, 17 Feb 2008, M. O'Loughlin and E. Whitfield, NMV F151847.

Paratypes. Westernport Bay, McHaffie Reef, 38°28'S 145°10'E, MRG, 16 Feb 2008, NMV F151848 (1); Shoreham, Honeysuckle Point, sieved from root of *Amphibolus*, A. Falconer (MRG), 12 May 2012, NMV F174912 (1); MRG, 12 Apr 2012, NMV F174909 (1); Flinders, Mushroom Reef, 17 Feb 1990, NMV F73805 (1).

Other material (selection). Westernport Bay, Merricks, rocky shallows, 27 May 1989, NMV F73804 (1); Westernport Bay Survey, stn 57/02/69, Merricks, 22 Feb 1969, NMV F45261 (1; determined by D. Pawson 1974 as *Thyone okeni* Bell, 1884); Shoreham, rocky shallows, Jun 1979, NMV F73806 (1); San Remo, 28 Jan 1909, NMV F73819 (1) (no. 60641; determined in Joshua 1914 as *Phylloporus dearmatus* Dendy and Hindle, 1907).

Tasmania, Bass Strait, Waterhouse Passage, 40°49'S 147°38'E, rocky shallows, 23 Nov 1982, NMV F97430 (1).

South Australia, J. C. Verco, Jan 1914, NMV F97433 (1; as *Thyone* sp. by Joshua and Creed 1915); Gulf St Vincent, off Adelaide, between North Haven and Largs Bay, seagrass, 1 Dec 1980, SAM K2585 (2); Willunga Reef, 23 Nov 1976, SAM K2582 (1); Aldinga Reef, 22 Nov 1979, SAM K2584 (3); Yorke Peninsula, Port Giles jetty, 15 m, Jan 1983, SAM K2595 (1); Wool Bay, 4 m, sand, AM J16647 (2); Edithburgh Jetty, 3–4 m, in sand, 14 Mar 1994, SAM K2600 (1), SAM PK0072; Kangaroo Island, Kingscote Jetty, 3–4 m, in sand, 1 May 1999, SAM K2598 (1), SAM PK0191; 3 May 1999, SAM K2599 (2), SAM PK0183; Sir Joseph Banks Group, Smith Rocks, 28 Jan 1986, SAM K2607 (3); Waterloo Bay, seagrass, 5 m, 1980, SAM K2586 (2); Great Australian Bight, Point Westall, near Streaky Bay, 15 Jan 1991, NMV F97427 (1); near Ceduna, Cape Vivonne, 32°12'S 133°41'E, rocky shallows, 16 Jan 1991, NMV F97428 (1).

Western Australia, Albany, 35°03'S 117°02'E, 2 m, Jan 1988, AM J24966 (2); Bunbury, 13 Apr 1963, WAM Z31974 (1); Cockburn Sound, rubble and muddy sand, 29 Apr 1989, WAM Z31977 (1); Jervoise Groyne, 1 Jan 1958, 3 m, WAM Z31969 (1); Garden I., 29 Apr 1989, WAM Z31984 (1); Mangles Bay, 31 Jul 1988, WAM Z31961 (2); Woodman's Point, WAM Z31982 (2).

Diagnosis. *Thyone* species up to 100 mm long, up to 15 mm diameter (relaxed, preserved, excluding tentacles, introvert; WAM Z31984), wide mid-body, tapered to upturned rounded oral and anal ends, thick firm body wall; external anal scales not detected; 10 tentacles, 8 large, 2 much smaller ventrally; complete cover of spaced tube feet, contiguous paired series on each side of longitudinal muscle interior attachments, more scattered inter-radially, more abundant ventrally than dorsally, diameter about 0.2–0.3 mm; tubular composite calcareous ring, posterior ends of composite radial plates not joined; radials tapered anterior with terminal split, divided posterior into paired narrowing composite tails, tails sometimes split; inter-radials tapered to anterior point, posterior ends truncate at a point anterior to the division of each radial; short stone canal and globular split-pea-like madreporite lie on the calcareous ring; single elongate thin polian vesicle; longitudinal muscles cylindrical to flat, undivided; gonad tubules unbranched.

Mid-body wall lacking ossicles; tube feet with endplates only, endplates with irregular perforations, distinctly larger peripherally,

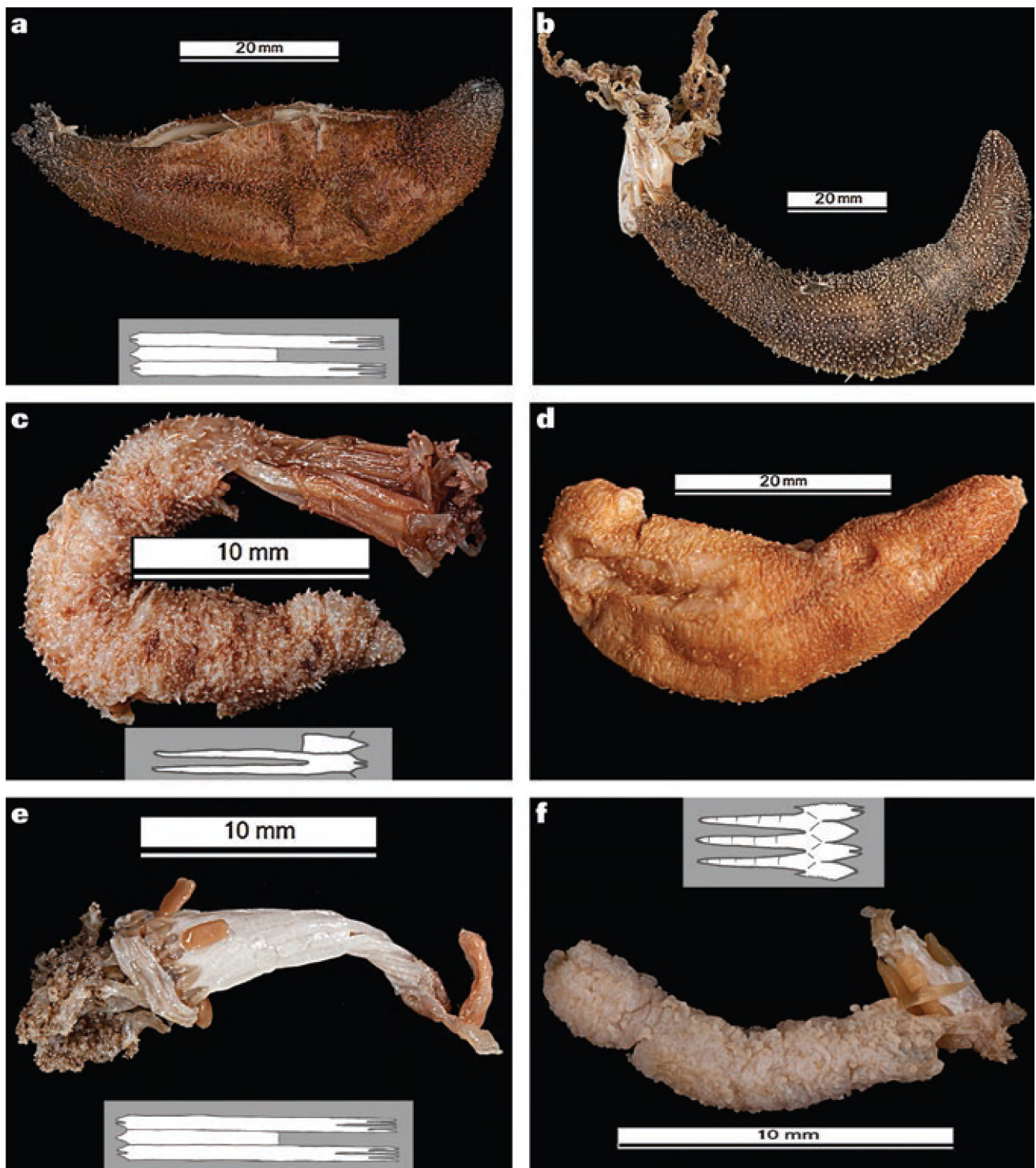


Figure 17. Photos of preserved specimens. a, holotype of *Thyone flindersi* O'Loughlin sp. nov. (NMV F151847) (insert: form of the calcareous ring plates); b, specimen of *Thyone okeni* Bell, 1884 (AM J10868); c, holotype of *Thyone joshuai* O'Loughlin sp. nov. (SAM K2566) (insert: form of the calcareous ring plates); d, holotype of *Thyone kerkosa* O'Loughlin sp. nov. (WAM Z31838); e, holotype of *Thyone spenceri* O'Loughlin sp. nov. (SAM K2562) (insert: form of the calcareous ring plates); f, holotype of *Thyone tourvillei* O'Loughlin sp. nov. (NMV F174902) (insert: form of the calcareous ring plates).

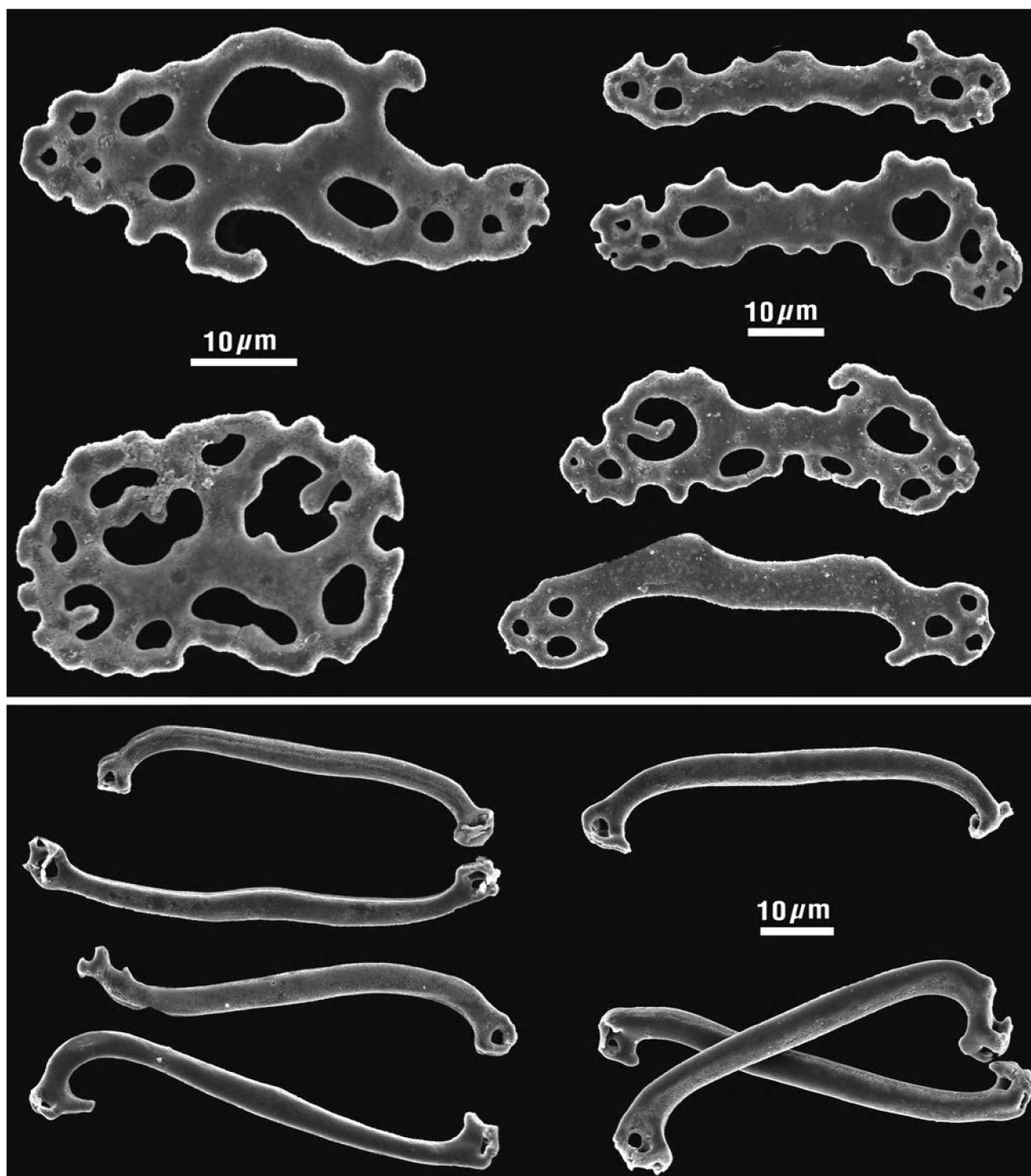


Figure 18. SEM images of ossicles from paratype of *Thyone flindersi* O'Loughlin sp. nov. (NMV F174909). Ossicles from peri-oral body wall (top); rods from tentacles (bottom).

diameters up to 160 μm ; lacking endplate support rods or plates or tables; per-oral body wall with tables and sometimes rosettes, table discs irregular, rounded rectangular to oval to rounded triangular, up to 35 perforations, discs up to 72 μm long, spires with 2 pillars, single cross connection, blunt spines distally, spires up to 32 μm high, rosettes predominantly oval up to 40 μm long; anal ossicles scales with spires, tube foot endplates, rosettes, rods, sometimes tables; scales thick, single-layered with lace-like thickening, fragment 440 μm long, multilayered spire 424 μm long, anal endplate diameters up to 136 μm , rosettes up to 48 μm long, rods with finely perforated ends, some with short branching distally, up to 96 μm long, table discs up to 56 μm long, up to > 8 perforations, spires with 2 pillars; tentacles branches with rods predominantly bracket-shaped, distally with lumps or fine branches or few perforations, some rods with sigmoid form, some straight, rods up to 88 μm long, tentacle trunks sometimes with rosettes, round to oval to rod-like, up to 56 μm long.

Colour (live and preserved). Body brown to dark reddish brown, body frequently dark grey orally and anally, introvert brown; tube feet red to dark brownish red, off-white orally and anally; tentacle trunks brown, lacking white spots (rosette clusters), tentacle branches dark grey.

Distribution. Southern Australia, east to San Remo (Westernport Bay), northern Tasmania (Bass Strait), west to Cockburn Sound (Western Australia near Perth), rocky shallows, seagrass; 0–15 m.

Etymology. Named for the type locality, Flinders, in Victoria, in turn named for the English explorer Matthew Flinders who first charted the coastline of Victoria.

Remarks. The specimen reported in Joshua and Creed 1915 as *Thyone* sp. is registered to Museum Victoria and determined as *Thyone flindersi* O'Loughlin sp. nov. A specimen from San Remo collected in 1909 and reported in Joshua 1914 as *Phyllophorus dearmatus* Dendy and Hindle, 1907 was examined and determined as *Thyone flindersi*. Rowe 1982 "provisionally" referred Port Phillip and Westernport Bay specimens to *Thyone okeni* Bell. *Thyone flindersi* is distinguished from other southern Australia *Thyone* species in the key (above).

Thyone joshuai O'Loughlin sp. nov.

Figures 17c, 19

Material examined. Holotype. South Australia, Upper Spencer Gulf, Whyalla, 33°02'S 137°40'E, 12 m, E. Oks, Sep 1987, SAM K2566.

Paratypes. South Australia, Upper Spencer Gulf, SA Department of Fisheries, Backy Point W, 18 m, Sep 1987, SAM K2560 (1); Feb 1986, SAM K2563 (1); East Shoal NE, 8 m, Feb 1986, SAM K2569 (3); Lowly Point W, 24 m, Sep 1987, SAM K2571 (4); Feb 1987, SAM K2572 (2); False Bay, 10 m, Sep 1987, SAM K2573 (1); Cockle Spit W, 7 m, Aug 1976, SAM K2574 (1); Ward Spit S, 9 m, Feb 1987, SAM K2576 (1); Douglas Bank NE, 11 m, Feb 1987, SAM K2578 (1); Fairway Bank W, 13 m, Sep 1987, SAM K2580 (1); Whyalla, 12 m, Sep 1987, SAM K2581 (1); Port Bonython, 15 m, Sep 1987, SAM K2622 (1).

Other material. Victoria, Eastern Bass Strait, 38–40°S 143–149°E; VIMS, FRV *Hai-Kung* 81–HK–1, stn 119, 92 m, 31 Jan 1981, NMV F76632 (2); stn 120, 84 m, sand, 31 Jan 1981, NMV F76630 (4); VIMS, NZOI RV *Tangaroa* 81–T–1 stn 162, 51 m, shell, 14 Nov 1981, NMV

F76631 (1); 81–T–1 stn 167, 124 m, mud/fine sand, 14 Nov 1981, NMV F76633 (1; 2.5 mm long); stn 170, 140 m, muddy sand, 15 Nov 1981, NMV F76624 (3; up to 5 mm long); 81–T–1 stn 174, 57 m, mud/shell, 18 Nov 1981, NMV F76628 (1); stn 174, 57 m, mud/shell, 18 Nov 1981, NMV F76634 (1; 3 mm long); stn 180, 65 m, mud/sand, 18 Nov 1981, NMV F76626 (1; 1.5 mm long); stn 200, 48 m, sand/shell, 22 Nov 1981, NMV F76625 (1; 2 mm long).

New South Wales, Disaster Bay, RV *Southern Surveyor* SS0404 stn 102, 37°17.22'S 150°04.15'E, 79 m, 28 Apr 2004, NMV F132693 (1); Port Hacking, Jibbon Head, 34.0708°S 151.1306°E, 23 m, Sep 1976, AM J22366 (1).

Diagnosis. *Thyone* species up to 21 mm long, up to 8 mm diameter (preserved, tentacle withdrawn), body fusiform, tapered to rounded end orally and anally, short tail anally, soft thin body wall; external anal scales not detected; 10 tentacles, 8 large, 2 ventral small; tube feet in close single paired series on radii, scattered inter-radially, diameter about 0.15 mm; composite calcareous ring, anterior third tubular, posterior ends of composite radial plates not joined, radials tapered anteriorly with terminal split, deep posterior division more than half composite plate length, paired composite ends thin, narrow, free; inter-radials tapered to anterior point, truncate posteriorly about where the radial plates split, inter-radial composite plates about one third the length of the radial plates; gonad tubules unbranched; long stone canal, globular madreporite; single polian vesicle, elongate, tubular; longitudinal muscles sub-cylindrical.

Mid-body wall ossicles scattered tables, discs regular, oval, margin slightly lobed, perforations typically 4 large central, frequently 4 small corner, discs 56–64 μm long, spires with 2 pillars, distally spinous, single distal cross connection, spires up to 32 μm long; tube feet with endplates, variably with and lacking tube foot support tables, endplates with distinct outer ring of large perforations, small central perforations, endplate diameters up to 160 μm , if present tube foot support tables with curved narrow discs up to 112 μm long; tentacles ossicles stout and fine rods and rosettes, rods irregular, up to 200 μm long, frequently with 1 or 2 side branches bluntly spinous distally, widened perforated ends, rosettes up to 64 μm long, some inter-grade with rods; anal ossicles tables and scales, tables as in mid-body wall, scales single and multi-layered.

Small specimens (10 mm long): abundant mid-body tables, discs with typically 4 perforations, regular, lobed margin, 40 μm long; tube feet with endplates, ring of outer large perforations, 88 μm diameter, tube foot support tables with narrow curved discs, 72 μm long; anal tables as in larger specimen mid-body.

Smallest specimens (1.5–3 mm long): mid-body tables regular with 8 perforations and irregular with many more than 8 perforations, discs up to 128 μm long, spires up to 48 μm long; tube feet table discs curved and narrow with more than 8 perforations, discs up to 112 μm long, large mesh endplates, 112 μm diameter.

Colour (preserved). Body off-white, sometimes fine brown flecking; tentacles brown to pale brown.

Distribution. Off-shore sediments, Victoria, eastern Bass Strait, 39–40°S 143–149°E, 48–140 m; New South Wales, Disaster Bay, Port Hacking, 34–37°S 150–151°E, 23–79 m; South Australia, Upper Spencer Gulf, 32–33°S 137°E, 7–24 m.

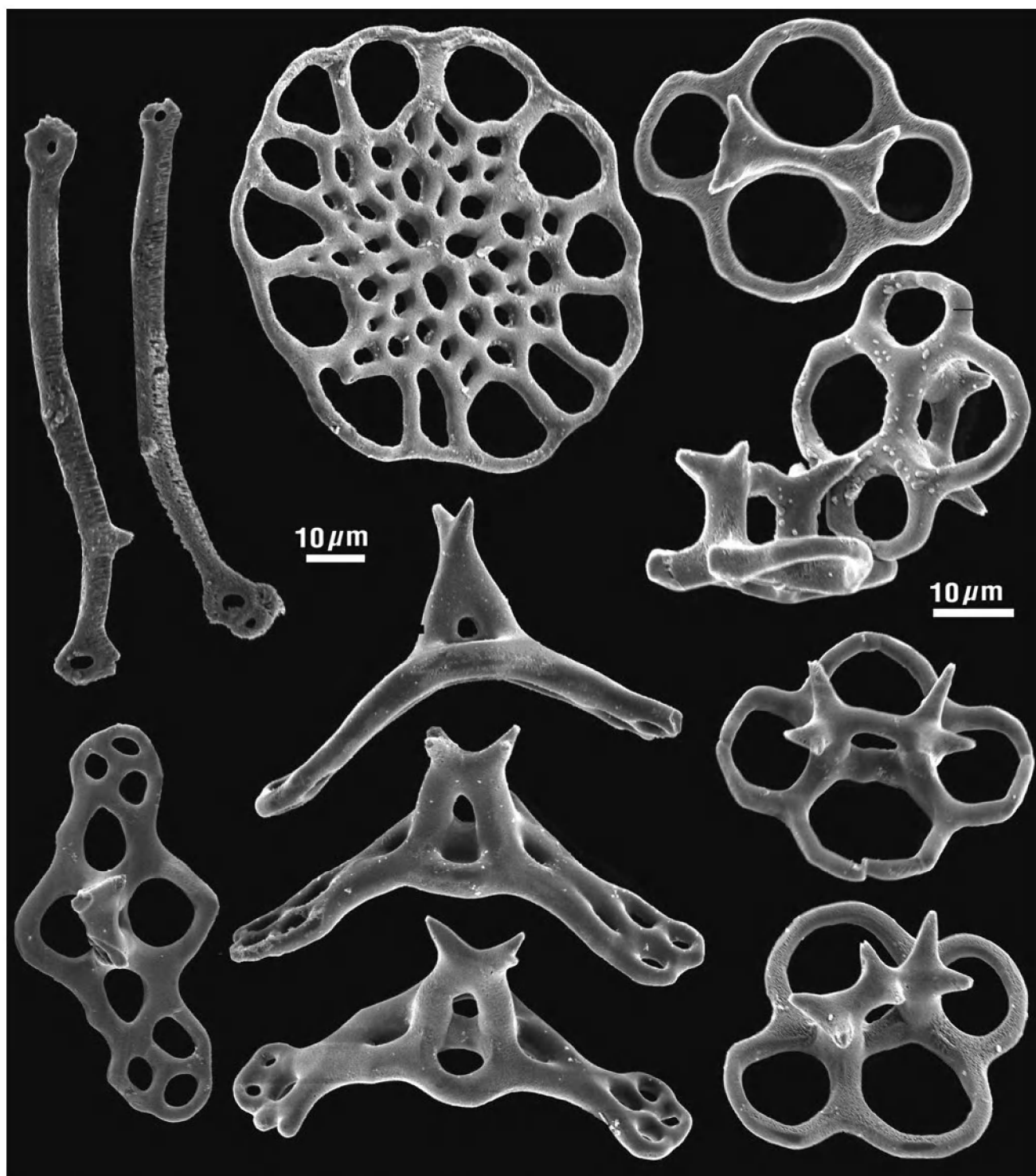


Figure 19. SEM images of ossicles from specimens of *Thyone joshuai* O'Loughlin sp. nov. Tables from mid-body wall (right), tube foot endplate (top), and tube foot support tables (central and left bottom) (from holotype, SAM K2566); rods from tentacles (top left) (specimen NMV F76631).

Etymology. Named for E. C. Joshua, who described the first phylloporid species on the coast of southern Australia.

Remarks. Significant changes with age/size in body wall and tube foot ossicle forms are recorded in the diagnosis (above). Notable changes are the increase in size and number of perforations in tables with decreasing size of specimen, the mesh-like form of endplates with decrease in specimen size, and the loss of tube foot support tables with increasing specimen size. The morphological characters that distinguish *Thyone joshuai* O'Loughlin sp. nov. from other southern Australian *Thyone* species are given in the key (above).

Thyone kerkosa O'Loughlin sp. nov.

Figures 17d, 20

Material examined. Holotype. Southern Australia, Recherche Archipelago, Sandy Hook Island, 34°02'S 122°00'E, *Scallop Trawl Survey* 1986, L.F.B.E. *Triumph*, D. Richards et al., 26 July 1986, WAM Z31838 (body with tentacles and ring eviscerated and lost).

Diagnosis. Body 45 mm long (preserved), up to 15 mm diameter, cylindrical, tapered to rounded oral and anal ends, body wall soft, thick; external anal scales not detected; tentacles lost; complete close cover of small tube feet, diameter 0.3 mm; calcareous ring lost.

Body wall with table ossicles only, tables range greatly in form and inter-grade; numerous small tables with discs rounded rectangular with smooth lobed margins, smallest with typically 8 perforations, discs 48–56 μm long, spires with 2 pillars, short blunt pointed spines apically, spires 16 μm long; medium-sized tables with elongate oval discs, sometimes bi-lobed, up to about 40 small perforations, no perforations between disc margin and 2 large central perforations adjacent to spire, discs up to 144 μm long, spires with 2 pillars, up to 3 cross-connections, spires up to 64 μm long; large tables with irregular narrow tapered discs, 2 large central perforations, up to about 30 small perforations, ends of disc sometimes extended into solid non-perforate 'tail', sometimes solid digitiform side branches off discs, discs and tails up to 124 μm long, spires with 2 pillars, solid, up to 3 small perforations, 2 long laterally extended apical points together as wide as disc length, pillars 48 μm long; tube feet with endplates and table support ossicles; endplates up to 120 μm diameter; tables with curved discs; anal ossicles tables, single and multi-layered scales.

Colour (preserved). Body pale brown.

Distribution. SW Australia, Recherche Archipelago.

Etymology. Named from the Greek *kerkos* (tail), with reference to the elongate tail-like extensions on some narrow table discs and some table spires apically.

Remarks. We are conscious of the limited morphological data available for the single damaged specimen on which we are erecting *Thyone kerkosa* O'Loughlin sp. nov. But we judge that it is important to establish this distinctive species in a work that is attempting a comprehensive treatment of southern Australian phylloporid species. We are confident that the species belongs to genus *Thyone* Oken because of the distribution and size of

tube feet, and similarity of the tables to those of another new *Thyone* species from the Upper Spencer Gulf that has a characteristic *Thyone* ring and tentacles (see below). *Thyone kerkosa* is distinguished from other southern Australian *Thyone* species in the key (above).

Thyone nigra Joshua and Creed, 1915

Figures 5b, 21

Thyone nigra Joshua and Creed, 1915: 20–21, pl. 3 figs 3a–c, 4. — H. L. Clark, 1946: 401. — A. M. Clark, 1966: 347–348, figs 10b, c. — Rowe, 1982: 462, fig. 10.29a. — Rowe and Gates, 1995: 316.

Material examined. Holotype. South Australia, Dr. Verco, SAM K1376 (specimen and slide).

Other material. Victoria, Westernport Bay, McHaffie Reef, 16 Feb 2008, NMV F151855 (1; photo live); Port Phillip Bay, Corio Bay, PPS, Area 26 stn 300–301, 6 m, 16 May 1963, NMV F73807 (2); PPS, Corio Bay, Area 27 stn 41, 3 m, 16 Feb 1958, NMV F73808 (1).

Tasmania, Bass Strait, Waterhouse Passage, 40°49'S 147°38'E, rocky shallows, 23 Nov 1982, NMV F97425 (2); 26 Feb 1991, NMV F174901 (1).

South Australia, Upper Spencer Gulf, Backy Point, 18 m, Sep 1987, SAM K2561 (1); Ward Spit, 9 m, Feb 1986, SAM K1799 (1); Eyre Peninsula, Elliston, 33°39'S 134°53'E, rocky shallows, 18 Jan 1991, NMV F97426 (1); Point Westall (near Streaky Bay), 32°55'S 134°04'E, 0 m, 15 Jan 1991, NMV F97427 (1); Great Australian Bight, Point Sinclair, 32°06'S 132°59'E, 10 May 1973, NMV F97424 (3).

Western Australia, Busselton, 1 Mar 1962, WAM Z31985 (1); Cockburn Sound, Woodman's Point, 13 Feb 1972, WAM Z31983 (4); 1 m, 25 Aug 1971, WAM Z31963 (2); Jervoise Groyne, 2 m, 1 Nov 1959, WAM Z31835 (1); Perth, Ocean Reef boat harbour, 10–14 m, May 1990, WAM Z31981 (1).

Diagnosis. *Thyone* species up to 35 mm long, up to 11 mm diameter (preserved; NMV F151855 specimen 42 mm long live, 17 mm long preserved), body fusiform, tapered to rounded end orally and anally, sometimes oral and anal ends upturned, thick firm body wall; external anal scales not detected; 10 tentacles, 8 large, 2 ventral small; complete cover of spaced tube feet, paired to multiple series of contiguous tube feet radially, scattered inter-radially, diameter about 0.2 mm; tubular composite calcareous ring, posterior ends of composite plates not joined; radials tapered anteriorly with terminal split, deep posterior division about half composite plate length, paired composite ends narrow, free; inter-radials tapered to anterior point, truncate posteriorly, inter-radial composite plate extending about half the length of the radial plate; stone canal attached to side of calcareous ring, split pea madreporite form; single polian vesicle, elongate, tubular; longitudinal muscles cylindrical; gonad tubules unbranched.

Mid-body wall ossicles tables, discs irregularly oval to rounded rectangular with 4 central large perforations, 4 and up to about 26 outer smaller perforations, small table discs typically 80 μm long, large table discs up to 120 μm long, tables inter-grade with endplate support tables with narrow curved discs up to 136 μm long, table spires with 2 pillars, single cross-bar, spinous distally, spire height up to 32 μm ; tube feet with endplates, endplate support tables (above); endplates with irregular perforations, small centrally, large marginally, up to about 160 μm diameter; peri-oral body wall

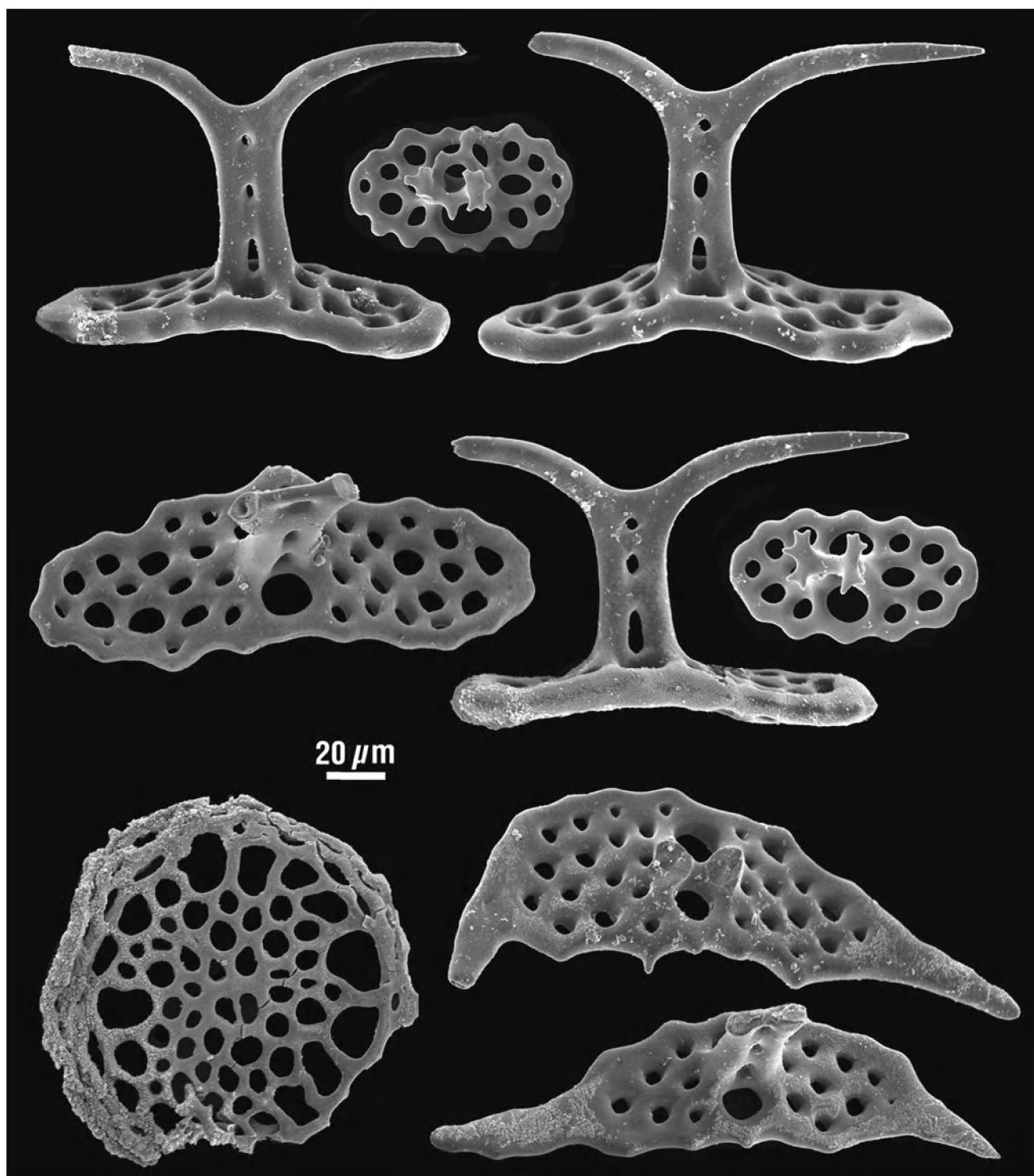


Figure 20. SEM images of ossicles from holotype of *Thyone kerkosa* O'Loughlin sp. nov. (WAM Z31838). Mid-body wall tables small and large tables with attenuated discs and distal spires, and tube foot endplate (bottom left).

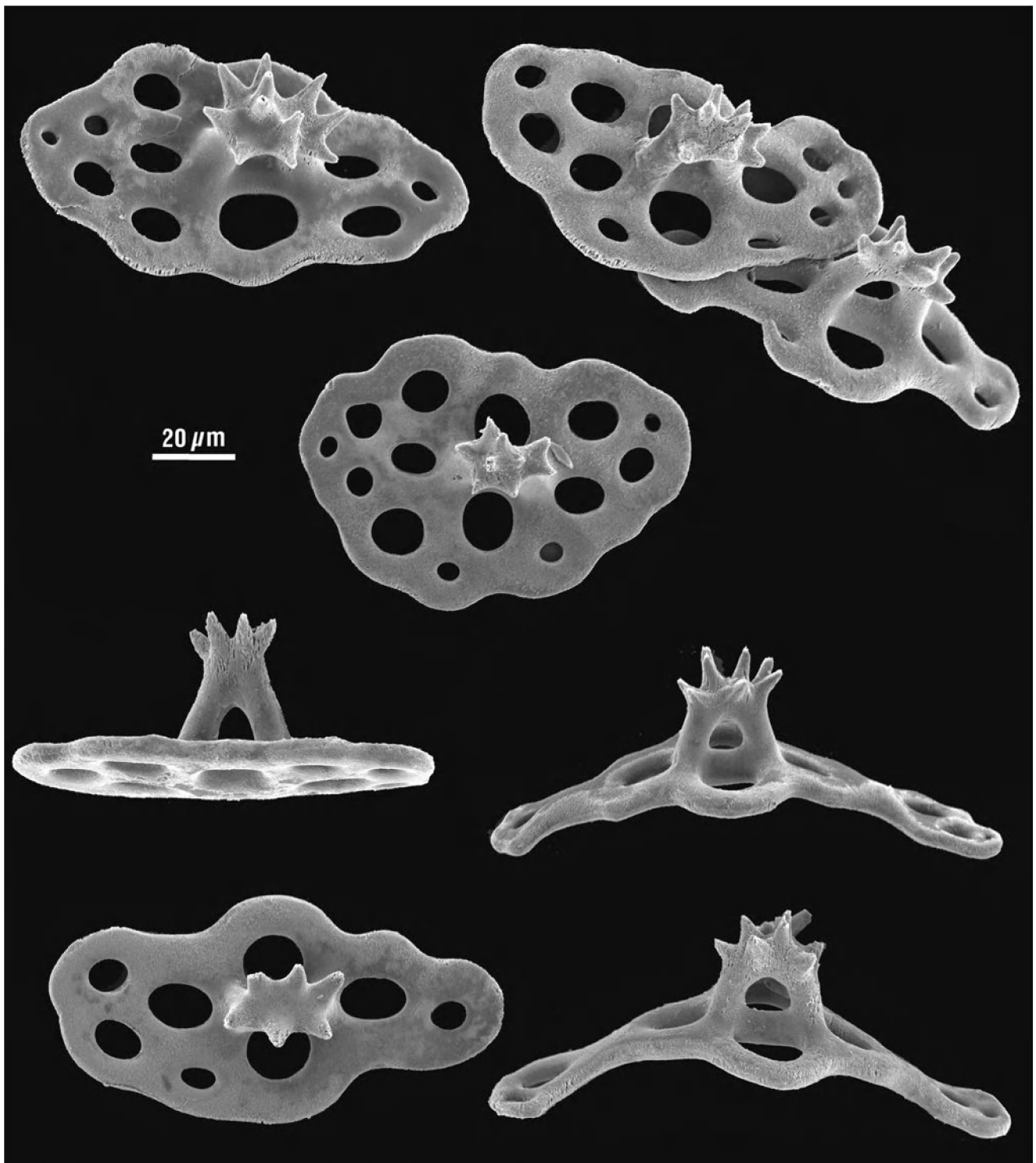


Figure 21. SEM images of ossicles from specimen of *Thyone nigra* Joshua and Creed, 1915 (NMV F151855). Mid-body wall tables and tube foot support tables with narrow curved discs.

ossicles tables, rosettes, tables irregularly oval to elongate, 2 pillars, up to 30 disc perforations, discs up to 90 μm long, rosettes oval to bi-lobed, up to 50 μm long; tentacles rarely with rods, perforated ends, predominantly straight and curved more than bracket-shaped, up to 72 μm long, rods inter-grade with rosettes, rosettes abundant, many linear.

Colour (preserved). Body white with dark brown flecking/blotching, darker to black orally and anally, tube feet white with rare dark brown flecks; tentacle trunks brown with white spots (clusters of rosettes), tentacle branches dark grey.

Type locality. South Australia (precise collecting locality not recorded by collector Dr J. C. Verco).

Distribution. Southern Australia, east to Westernport Bay, north Tasmania (Bass Strait), west to Perth (Western Australia), rocky shallows and offshore sediments, 0–18 m.

Remarks. *Thyone nigra* Joshua and Creed, 1915 is distinguished from other southern Australia *Thyone* species in the key (above).

Thyone okeni Bell, 1884

Figures 17b, 22

Thyone okeni Bell, 1884: 149–150, pl. 9D.—H. L. Clark, 1921: 167.—H. L. Clark, 1946: 402.—Rowe, 1982: 462 (non specimens from Port Phillip and Westernport in Victoria).—Rowe and Gates, 1995: 316 (non specimens from southern Australia).

Material examined. Australia, New South Wales, Port Jackson, AM J16905 (1); Vacluse, Bottle and Glass Rock, under boulders, 21 Nov 1968, AM J7731 (1); 5 m, 29 Aug 1977, AM J10868 (2); mid-tide rock pools, 23 Oct 1968, NMV F174900 (1); off Nielsen Park, dredged, 21 Jan 1951, AM J16869 (1); Newcastle, Swansea Channel, 5 m, 21 May 1987, AM J20267 (1).

Diagnosis. *Thyone* species up to 75 mm long, up to 20 mm diameter (preserved, tentacle withdrawn; 85 mm long by Bell 1884); body cylindrical, oral and anal ends tapered, upturned; typically 10 tentacles, 8 large, 2 small ventral; body closely covered with tube feet, about 0.3–0.4 mm diameter, not more concentrated radially; no external evidence of anal scales or papillae; calcareous ring composite, tubular, no evidence of discrete plates for most of length, posterior composite tails not joined distally; radial plates with split anterior point, posterior end divided into two thin composite tails posterior to the end of the inter-radial plates; inter-radial plates tapered to anterior point, truncate posteriorly, about two thirds the length of radial plates; single long tubular polian vesicle; stone canal and madreporite lie anteriorly from attachment along calcareous ring; longitudinal muscles cylindrical, distinctly divided by deep groove mid-body.

Mid-body wall lacking ossicles; tube feet with endplates only, up to 240 μm diameter lacking any support rods or tables or plates, endplate with irregular perforations, large marginally small centrally, slightly denticulate margin; peri-oral body wall with numerous tables, discs round to slightly oval, up to 192 μm diameter/length, up to > 100 small perforations, spires thick short columnar mesh; tentacles branches with stout dumbbell-shaped ossicles, few to about 12 distal perforations, rods up to 320 μm long, tentacle trunks lacking ossicles, no

rosettes seen; introvert ossicles rosettes; anal ossicles rods as in tentacles, rosettes as in introvert, single and multi-layered scale fragments, tube foot endplate diameters up to 200 μm .

Colour (preserved). Body brown to dark brown to grey-brown; tube feet off-white to grey to speckled to red; tentacle trunks off-white with brown patches, branches dark brown.

Type locality. New South Wales, Port Jackson.

Distribution. New South Wales, Port Jackson to Newcastle; 0–5 m.

Remarks. The distribution extensions of *Thyone okeni* Bell, 1884 to Thursday Island off Cape York in northern Queensland (H. L. Clark 1921) and to Guam in the eastern Pacific (Rowe and Doty 1977) are not confirmed. Thandar 1990 followed the comment by Rowe and Doty 1977 that *Thyone okeni* Bell was “probably distributed throughout the western Pacific area”, and without examining specimens was “inclined to think that *T. venusta* Selenka, 1868 and *Thyone okeni* were conspecific” and then formally relegated *Thyone okeni* Bell, 1884 to junior synonymy with *Thyone venusta* Selenka, 1868 (type locality the Red Sea). In the key in his paper Thandar (1990) described the body of *Thyone venusta* Selenka, 1868 as being violet at both ends, and the tube feet as lacking ossicles. Neither character is true of *Thyone okeni* Bell, 1884. There are distinctive dumbbell-shaped endplate support rods in the tube feet of *Thyone okeni* Bell. We reject this synonymy on the basis of inadequate systematic evidence for these two species with widely separated type localities. *Thyone okeni* Bell, 1884 is distinguished from other southern Australia *Thyone* species in the key (above).

Thyone spenceri O’Loughlin sp. nov.

Figures 17e, 23

Material examined. Holotype. South Australia, Upper Spencer Gulf, Backy Point – West, 32°50'S 137°50.52'E, 18 m, SA Fisheries Department, Sep 1987, SAM K2562 (ring, tentacle crown, anterior part of body wall).

Paratype. Upper Spencer Gulf, Port Bonython, 33°01'S 137°45'E, 15 m, SA Fisheries Department, Sep 1987, SAM K2565 (1, ring, tentacle crown, anterior part of body wall).

Diagnosis. Anterior body and calcareous ring 13 mm long (preserved), body wall soft; 10 tentacles, 8 large 2 ventral small; complete close cover of small tube feet; calcareous ring composite, tubular, posterior ends of composite plates not joined; radial plates tapered anterior with terminal split, long paired composite posterior prolongations separated for most of length, narrowing and further divided distally for about a quarter of total plate length, not joined; inter-radial plates composite, tapered to anterior point, truncate posteriorly; stone canal attached to alimentary canal mesenterly, ‘split-pea’ madreporite form; single polian vesicle.

Anterior body wall with abundant tables, tables regular, discs round to oval to triangular, up to 96 μm long, 2 large central perforations, smaller perforations nearer margin, predominantly 40–50 small perforations, spires with 2 pillars, 24 μm long, 2 tapered ends distally; some table discs rosette-like; some table discs curved for tube foot support; tentacles

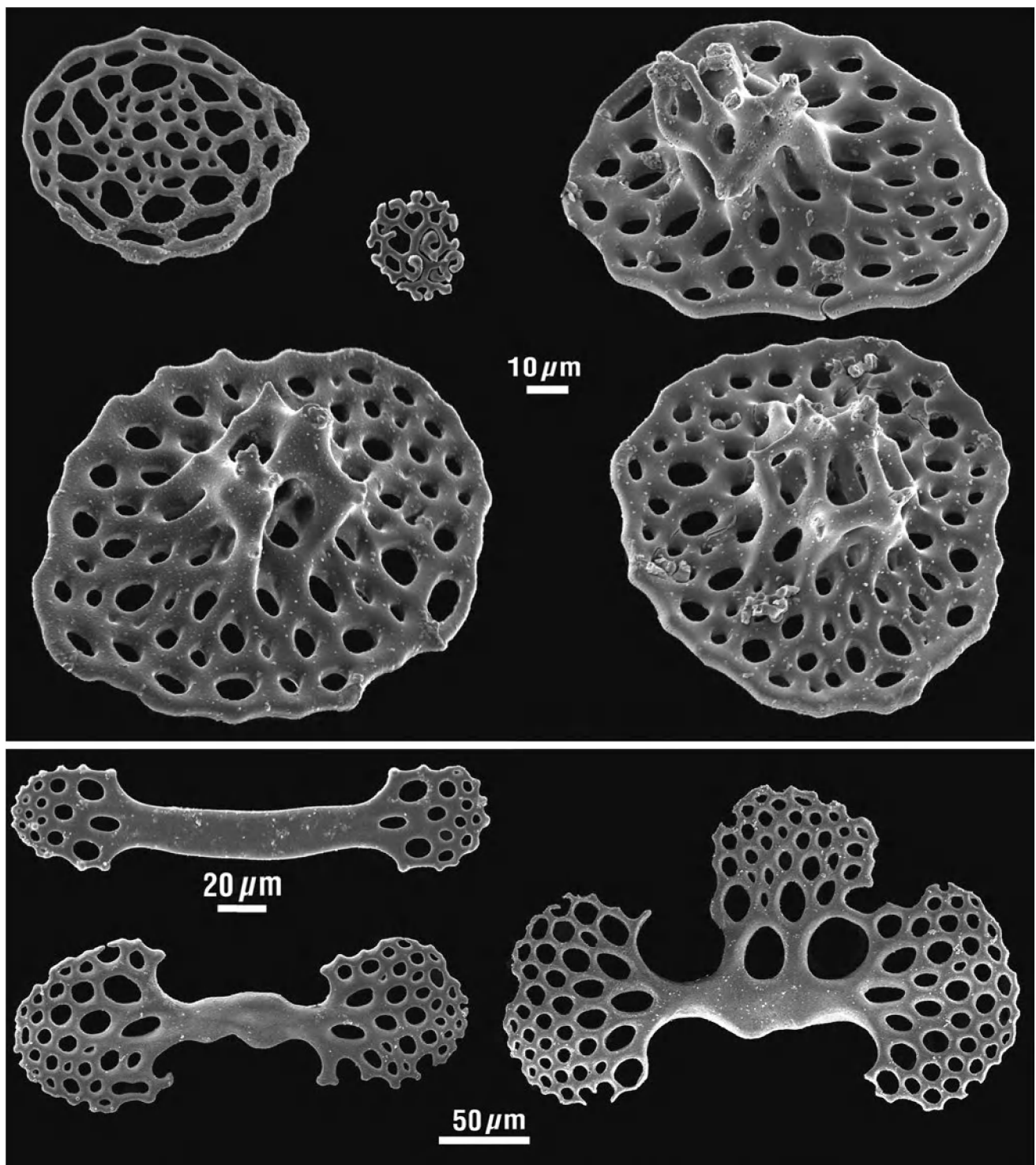


Figure 22. SEM images of ossicles from specimen of *Thyone okeni* Bell, 1884 (AM J7731). Peri-oral body wall rosette and tables with multi-branched spires (top); dumbbell-shaped ossicles from tentacles (bottom).

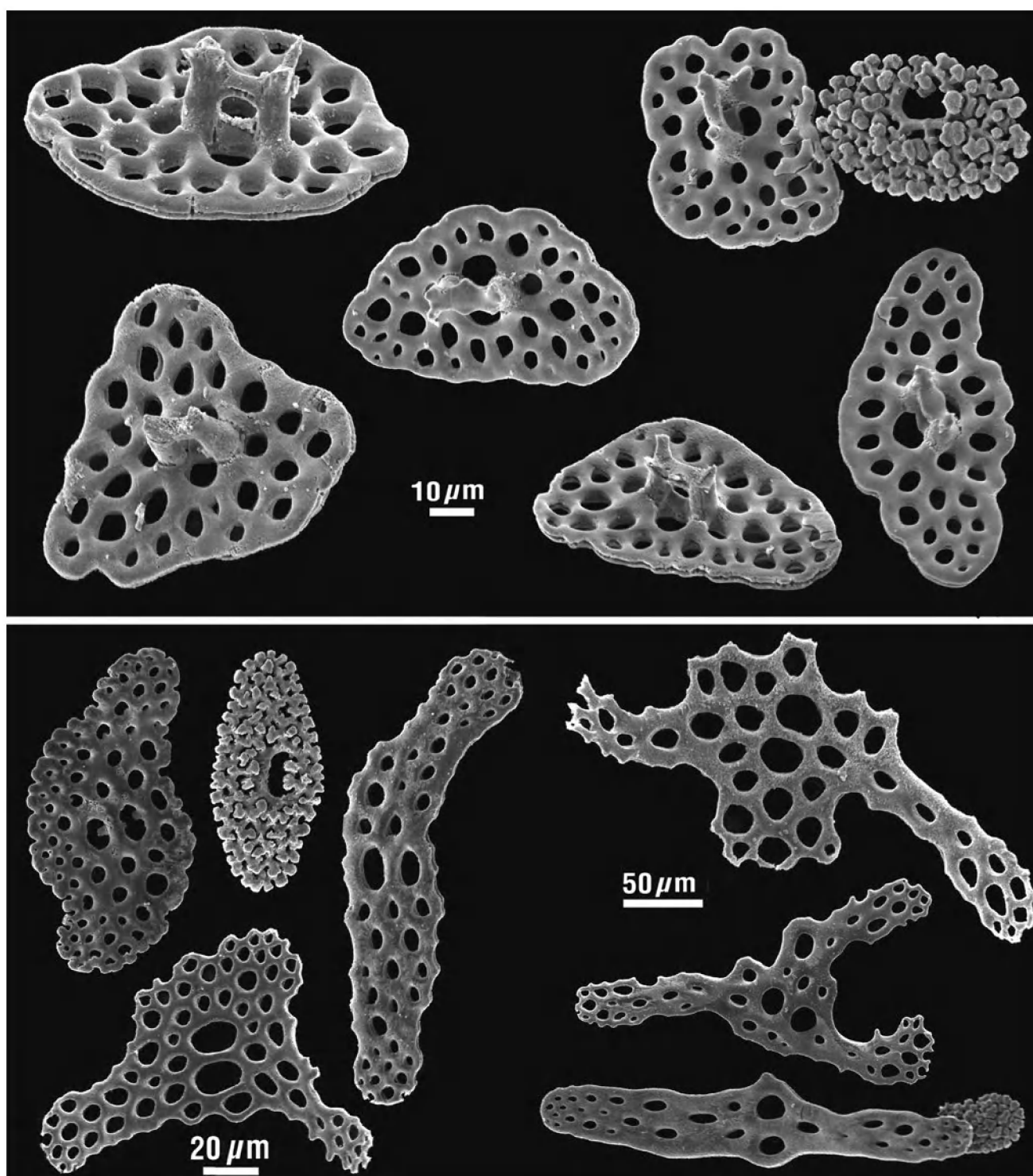


Figure 23. SEM images of ossicles from paratype of *Thyone spenceri* O'Loughlin sp. nov. (SAM K2565). Tables from anterior body wall (top); plates and rosettes from tentacles (bottom).

with abundant perforated plates, rosettes; plates variable in shape, some plates narrow, elongate with large perforations and distal blunt teeth, sometimes small branches along margin of plate, plates up to 280 μm long, some plates cross-shaped with perforate arms, some plates oval with four large central perforations, smaller surrounding ones and distal blunt teeth, plates up to 160 μm long, some plates curved with denticulate margin and numerous small perforations, plates up to 120 μm long; rosettes oval, up to 88 μm long; peri-oral body wall with tables and rods; tables with 2 spires, discs with 2 central large perforations, small perforations between central large ones and disc margin, each disc with up to more than 30 small perforations, discs about 104 μm long; peri-oral ossicles irregular wide perforated rods, up to 272 μm long, sometimes crosses.

Colour (preserved). Body off-white; tentacles brown with dark brown to black markings.

Distribution. South Australia, Upper Spencer Gulf, 15–18 m.

Etymology. Named with reference to Spencer Gulf in South Australia where the type specimens were collected.

Remarks. Both the holotype and paratype of *Thyone spenceri* O'Loughlin sp. nov. are damaged and most of the body wall has been lost. But there are good morphological systematic characters for the erection of this new *Thyone* Oken species. *Thyone spenceri* is distinguished from other southern Australian *Thyone* species in the key (above).

Thyone tourvillei O'Loughlin sp. nov.

Figures 17f, 24

Material examined. Holotype. Eastern Tasmania, 37 km NE of Cape Tourville, RV *Franklin* stn SLOPE 85, 41°56'S 148°35'E, upper continental slope, 124 m, G. C. B. Poore et al., 30 Oct 1988, NMV F174902 (1, small, damaged, 15 mm long).

Paratype. Eastern Bass Strait, VIMS, RV *Tangaroa*, 81–T–1 stn 170, 38°52.6'S 148°25.2'E, 140 m, mud / sand, 15 Nov 1981, NMV F76627 (1, small, damaged, 6 mm long).

Diagnosis. *Thyone* species 15 mm long (preserved body and partly extended tentacles), up to 3 mm diameter, body cylindrical, rounded ends, body wall soft; external anal scales not detected; 11 tentacles (some lost in holotype), large pairs, small singly; complete close cover of tube feet, single contiguous series on each side of longitudinal muscle interior attachments, more scattered inter-radially, diameter about 0.2 mm; composite calcareous ring; radial plates tapered anteriorly with terminal split, long paired composite posterior prolongations, narrowing distally; inter-radial plates tapered to anterior point, not composite, lacking posterior extensions, contiguous postero-laterally with composite radial posterior extensions; stone canal and madreporite lie on calcareous ring; single polian vesicle.

Mid-body wall with tables, regular, discs oval, up to 64 μm long, 4 narrow perforations in cross formation centrally, 4 larger corner perforations, single pillar spire with apical spines, spire 24 μm long; tube feet with endplates and endplate support tables and plates; endplates with small central perforations, transversely elongate perforations marginally, marginal denticulations, diameters up to 144 μm ; tube foot support tables

with curved narrow disc, frequently 4 central perforations, 2 distally, discs up to 88 μm long, single pillar spire 24 μm long; tube foot support plates, slightly curved, sub-rectangular, larger perforations centrally, smaller distally, digitiform projections on one edge, up to 160 μm wide; tentacles with rods, tables, rosettes; rods up to 280 μm long, up to 4 distal perforations, up to 2 spines along shaft; rosettes up to 80 μm long.

Colour (preserved). Body and tube feet off-white, tentacles pale brown.

Type locality. Eastern Tasmania, off Cape Tourville, 124 m.

Distribution. Eastern Bass Strait and Tasmania, 124–140 m.

Etymology. Named for the type locality, Cape Tourville, in eastern Tasmania; in turn named for the French naval commander Comte de Tourville by the explorer Nicolas Baudin.

Remarks. Both the holotype and paratype of *Thyone tourvillei* O'Loughlin sp. nov. are damaged, but calcareous components are well-preserved and the specimens sufficiently intact to provide distinctive diagnostic characters for the new species. The diagnostic characters of this new species are not those of any current phylloporid genus.

Thandar 1989 erected subfamily Sclerothyoninae Thandar, 1989 with two monotypic genera *Sclerothyone* Thandar, 1989 and *Temparena* Thandar, 1989 to accommodate two previously erected species. In both genera the calcareous ring is not tubular and is similar to that in the new species *Thyone tourvillei*. But in both Thandar genera the tube foot distribution is radial only, there are eight large and two small tentacles, and the tables have spires with two pillars. Neither genus is suitable for referral of the new species.

We refer this new species to *Thyone* Oken on the basis of tube feet and ossicle characters, but with considerable reservation because of the single pillar spire tables, Sclerothyoninae-like calcareous ring, and uncertain tentacle state. We are reluctant to erect a new genus on damaged and very small specimens, with uncertainty about tentacle characters, and with a major revision needed of genus *Thyone*. *Thyone tourvillei* is distinguished from other southern Australian *Thyone* species in the key (above).

Acknowledgments

We are most grateful for the invaluable contribution to our work of the following: Stephen Keable (AM), Kareen Schnabel, Niki Davey and Sadie Mills (NIWA), Thierry Laperousaz (SAM), Liz Turner and Ruth Mollison (TMAG), Mark Salotti and Jane Fromont (WAM) for their gracious assistance with loan materials; Leon Altoff, Audrey Falconer and John Eichler (MRG) for providing live specimen photographs; Melanie Mackenzie and Chris Rowley for their technical assistance in the Marine Invertebrate Department (NMV); Ben Boonen for the preparation of the figures; Gustav Paulay and Francois Michonneau (University of Florida), David Pawson (Smithsonian Institution), Frank Rowe (Australian Museum), and Ahmed Thandar (University of KwaZulu-Natal) for their helpful and valued communications on systematic issues. We are especially grateful for the review advice offered by Dr. F. W. E. Rowe (Australian Museum).

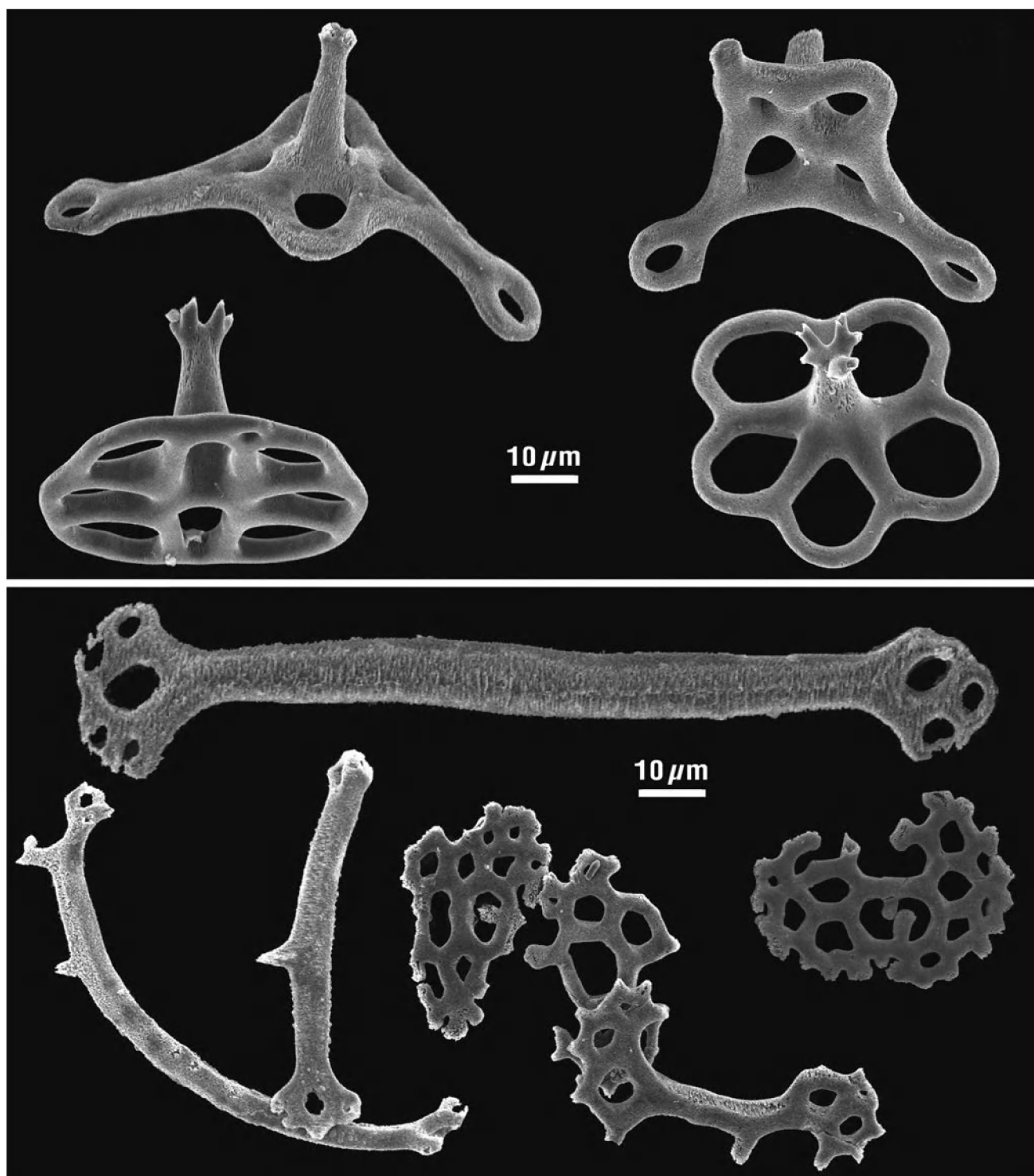


Figure 24. SEM images of ossicles from holotype of *Thyone tourvillei* O'Loughlin sp. nov. (NMV F174902). Mid-body wall tables with single pillar spires (top); rods and rosettes from tentacles (bottom).

References

- Bell, F. J. 1884. Echinodermata. Pp. 117–177 in *Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. Alert 1881–2*. Taylor and Francis: London.
- Cherbonnier, G. 1958. Holothurians des côtes de Sierra-Leone. *Bulletin du Muséum national d'Histoire naturelle, Paris* (2) 30 (3): 294–299.
- Cherbonnier, G. 1988. Echinodermes: Holothurides. *Faune de Madagascar, Paris: Editions de l'ORSTOM* 70. 292 pp.
- Clark, A. M. 1966. Port Phillip Survey, 1957–1963. Echinodermata. *Memoirs of the National Museum of Victoria* 27: 289–384, 10 figs, 4 pls, 3 tables 1 chart.
- Clark, H. L. 1921. The echinoderm fauna of Torres Strait: its composition and its origin. *Publication of the Carnegie Institution of Washington No. 214*: i–viii, 1–223 pp, 38 pls.
- Clark, H. L. 1938. Echinoderms from Australia. An account of collections made in 1929 and 1932. *Memoir of the Museum of Comparative Zoology, Harvard University* 55: 1–596.
- Clark, H. L. 1946. The Echinoderm Fauna of Australia: Its composition and origin. *Publications Carnegie Institute* 566. 567 pp.
- Deichmann, E. 1938. Holothurians from the Western Coasts of Lower California and Central America, and from the Galapagos Islands. Eastern Pacific Expeditions of the New York Zoological Society. *Zoologica* 23(4)(18): 361–387, figs 1–15.
- Dendy, A. and Hindle, E. 1907. Some additions to our knowledge of the New Zealand holothurians. *Journal of the Linnean Society (Zoology)* 30: 95–125, pls 11–14.
- Edgar, G. J. 1997. *Australian Marine Life*. 544 pp. Reed Books: Victoria. (updated at: <<http://www.utas.edu.au/docs/zoology/edgar.html>>)
- Gowlett–Holmes, K. 2008. *A field guide to the marine invertebrates of South Australia*. 333 pp. Tasmania, Hobart, notomares.
- Heding, S. G. and Panning, A. 1954. Phyllophoridae. Eine bearbeitung der polytentaculaten dendrochiroten holothuriens des zoologischen museums in Kopenhagen. *Spolia Zoologica Musei Hauniensis* 13: 209 pp.
- Hickman, V. V. 1978. Notes on three species of Tasmanian sea cucumbers including one species that broods its young in the coelome. (Holothuroidea: Phyllophoridae, Caudinidae). *Papers and Proceedings of the Royal Society of Tasmania* 112: 29–37, figs 1–44, 2 pls.
- Jaeger, G. F. 1833. *De Holothuriis*. Pp. 1–42, 3 pls. Turin.
- Joshua, E. C. 1914. Victorian Holothuroidea, with descriptions of new species. *Proceedings of the Royal Society of Victoria* 27(1): 1–11, 1 pl.
- Joshua E. C. and Creed, E. 1915. South Australian Holothuroidea, with descriptions of new species. *Transactions and Proceedings of the Royal Society of South Australia* 39: 16–24, pls 2–4.
- Lesson, R. P. 1830. *Centurie Zoologique, ou Choix d'Animaux Rares, Nouveaux ou Imparfaitement Connues*. 254 pp., 80 pls. Paris: Levrault.
- Mortensen, Th. 1925. Echinoderms of New Zealand and the Auckland-Campbell Islands. III–V. Asteroidea, Holothuroidea, Crinoidea. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kobenhavn* 79(29): 261–420, text figs 1–70, pls 12–14.
- Oken, L. 1815. *Lehrbuch der Naturgeschichte. Part 3: Zoologie* 3. xxviii, 850, xviii. (Rejected by ICZN, 1956, opinion 417).
- Pawson, D. L. 1970. The marine fauna of New Zealand: Sea cucumbers (Echinodermata: Holothuroidea). *Bulletin of the New Zealand Department of Scientific and Industrial Research* 201: 7–65, 10 figs, 2 pls.
- Pawson, D. L. and Fell, H. B. 1965. A revised classification of the dendrochirote holothurians. *Breviora* 214: 1–7.
- Pawson, D. L. and Miller, J. E. 1981. Western Atlantic sea cucumbers of the genus *Thyone*, with description of two new species (Echinodermata: Holothuroidea). *Proceedings of the Biological Society of Washington* 94(2): 391–403.
- Rowe, F. W. E. 1982. Sea-cucumbers (class Holothuroidea). In Shepherd, S. A. and Thomas, I. M. (eds), *Marine Invertebrates of Southern Australia* 1: 454–476, figs 10: 26–10:37, pls 29–32. Adelaide, South Australian Government Printer.
- Rowe, F. W. E. and Doty, J. E. 1977. The shallow-water holothurians of Guam. *Micronesica* 13: 217–250.
- Rowe, F. W. E. and Gates, J. 1995. Echinodermata. In Wells, A. (ed.), *Zoological Catalogue of Australia* 33: i–xiii, 1–510. CSIRO, Melbourne.
- Rowe, F. W. E. and Richmond, M. D. 2004. A preliminary account of the shallow-water echinoderms of Rodrigues, Mauritius, western Indian Ocean. *Journal of Natural History* 38: 3273–3314.
- Samyn, Y. and Thandar, A. 2003. *Massinium*, a new genus in the family Phyllophoridae (Echinodermata: Holothuroidea: Dendrochirotida) with description of a new south-west Indian Ocean species *M. maculosum*. *Belgian Journal of Zoology* 133(2): 135–142.
- Samyn, Y., Thandar, A. S., and VandenSpiegel, D. 2010. Two new species in the phyllophorid genus *Massinium* (Echinodermata: Holothuroidea) with redescription of *Massinium magnum*. *Zootaxa* 2399: 1–19.
- Selenka, E. 1868. Nachtrag zu den Beiträgen zur Anatomie und Systematik der Holothurien. *Zeitschrift für Wissenschaftliche Zoologie* 18: 109–119 pl. 8.
- Smith, B. J. 1970. Catalogue of echinoderm types in the National Museum of Victoria, Australia. *Memoirs of the National Museum Victoria* 31: 91–96.
- Thandar, A. S. 1989. The sclerodactylid holothurians of southern Africa, with the erection of one new subfamily and two new genera (Echinodermata: Holothuroidea). *South Africa Journal of Zoology* 24(4): 290–304.
- Thandar, A. S. 1990. The phyllophorid holothurians of southern Africa with the erection of a new genus. *South Africa Journal of Zoology* 25(4): 207–223.