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New apodid species from southern Australia (Echinodermata: Holothuroidea: Apodida)

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Abstract O'Loughlin, P. M., and VandenSpiegel, D. 2007. New apodid species from southern Australia (Echinodermata: Holothuroidea: Apodida). *Memoirs of Museum Victoria* 64: 53–70

A new chiridotid genus is erected: *Archedota* O'Loughlin gen. nov. In addition, seven apodid species, new to science, are described (O'Loughlin as author) for the rocky shallows, continental shelf and continental slope of southern Australia: chiridotids *Archedota lapidea*, *Taeniogyrus papillis*, *Taeniogyrus tantulus, Trochodota epiphyka*; myriotrochids *Prototrochus burni, Prototrochus staplesi, Prototrochus taniae*. *Taeniogyrus heterosigmus* Heding, *Taeniogyrus roebucki* (Joshua), *Trochodota allani* (Joshua) and *Trochodota shepherdi* Rowe are discussed. Keys are provided for southern Australian species of *Taeniogyrus* Semper and *Trochodota* Ludwig. A table is provided distinguishing Tasman Sea myriotrochid species.

Keywords Echinodermata, Holothuroidea, Apodida, Chiridotidae, Myriotrochidae, new genus, new species, taxonomy, keys

Introduction

H. L. Clark (1946), A. M. Clark and Rowe (1971), and Rowe (1995) summarized an incomplete knowledge of the Australian apodid fauna. These apodids fall broadly into two groups: tropical fauna in the north, with species of *Chiridota* Eschscholtz, *Polycheira* H.L Clark, *Scoliorhapis* H.L Clark, *Taeniogyrus* Semper, *Trochodota* Ludwig, *Euapta* Östergren, *Leptosynapta* Verrill, *Opheodesoma* Fisher, *Polyplectana* H.L. Clark, *Protankyra* Östergren, *Rynkatorpa* Rowe and Pawson, *Synapta* Eschscholtz, *Synaptula* Örsted; temperate fauna across the southern Australian coast, with the nine species *Chiridota gigas* Dendy and Hindle, *Scoliorhapis theeli* (Heding), *Taeniogyrus cidaridis* Ohshima, *Taeniogyrus heterosigmus* Heding, *Taeniogyrus roebucki* (Joshua), *Trochodota allani* (Joshua), *Trochodota shepherdi* Rowe, *Leptosynapta dolabrifera* (Stimpson), *Rynkatorpa hickmani* Rowe and Pawson. The record of *Taeniogyrus cidaridis* Ohshima (type locality Japan) for southern Australia is based on a single specimen taken off Rottnest I. near Perth in Western Australia in 1931. H.L. Clark (1946) doubted the reliability of this determination. Australian museums hold many specimens of undescribed apodid species from tropical and temperate waters. The focus of this paper is a selection of some chiridotid material from the rocky shallows and off-shore sediments of southern Australia, and the first reported myriotrochid material from the eastern continental slope of Australia.

Material and methods

Material examined here is principally in the Museum Victoria collection, with single specimens examined from the Western Australian Museum and Zoological Museum in Hamburg. Mark O'Loughlin is the author of the new taxa and systematic comments. For scanning electron microscope (SEM), ossicles were cleared of associated soft tissues in commercial bleach. They were then air-dried, mounted on aluminium stubs, and coated with gold. Observations were done by Didier VandenSpiegel using a JEOL JSM-6480LV SEM, and Tania Bardsley and Phil Bock using a Philips XL20 SEM. SEM measurements were made on large myriotrochid wheel ossicles by Didier VandenSpiegel with Smile view software. Four measurements were taken on each wheel: h = hub diameter, s = spoke length, t = tooth length, w = wheel diameter (see fig. 10d). Photographs of the smallest type specimens were taken by Chris Rowley using a Leica MZ16 stereomicroscope, Leica DC500 digital camera, and "Auto-Montage" software for composition of images. Compound microscope photos were taken by Mark O'Loughlin using an Olympus BX50 compound microscope and Nikon D70 digital camera.

Abbreviations: NMV—Museum Victoria, registration number prefix F; WAM—Western Australian Museum, prefix Z; ZMH—Zoologisches Museum für Hamburg, prefix E.

Throughout this paper Rowe (in Rowe and Gates, 1995) is referred to as Rowe (1995), Dr. Frank W. E. Rowe being the systematic authority in that work.

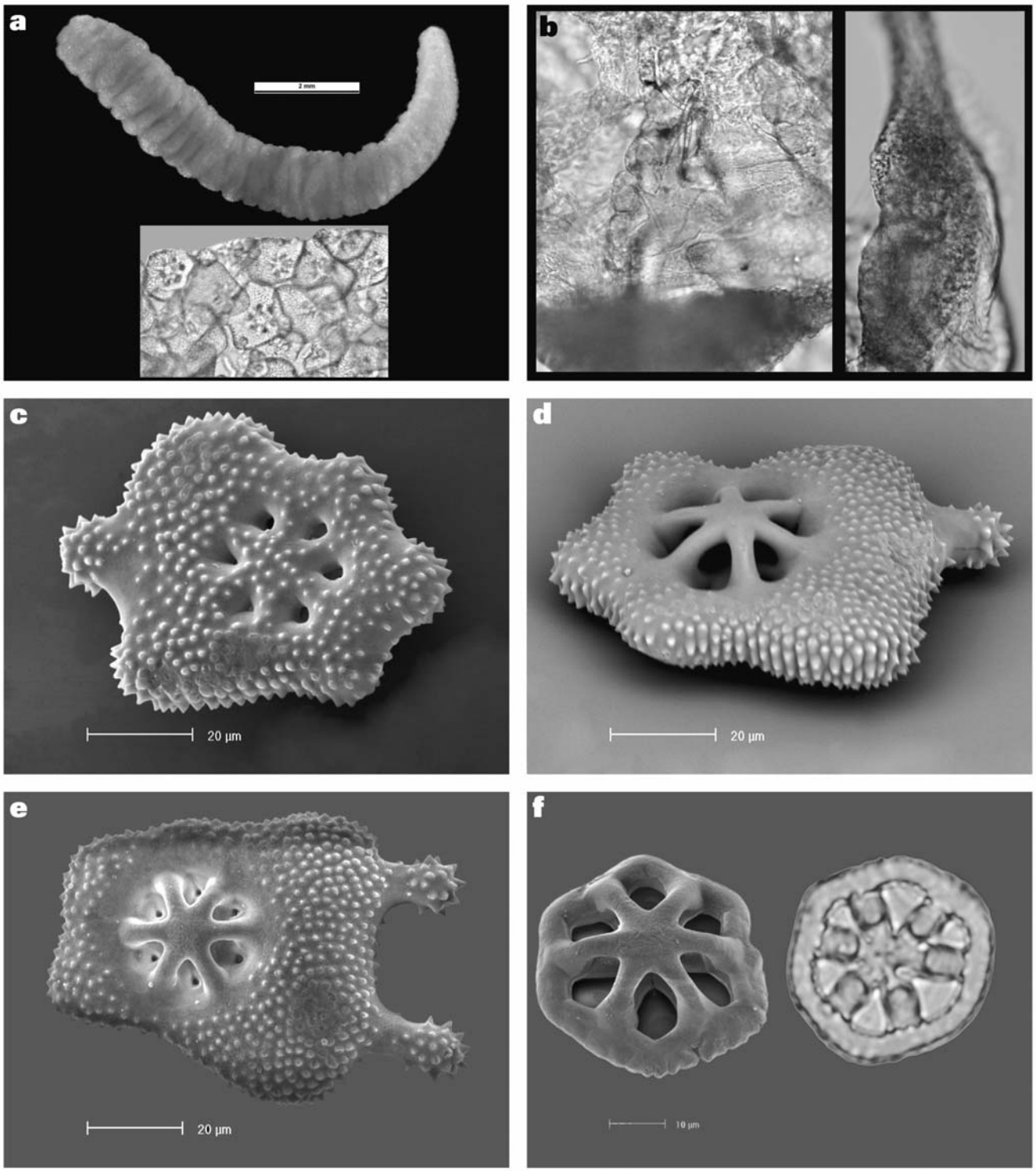

Figure 1. *Archedota lapidea* O'Loughlin sp. nov. from Bass Strait. a, holotype NMV F59193, body wall ossicles in situ (insert). b (left), 2 tentacles (vertical) with contracted digits evident left, and smooth rods at top (paratype F59194); b (right), fused plates of calcareous ring, radial plate (below) with anterior indentation (left), interradial plate with anterior and posterior concave indentations (above) (paratype F59194). c–e, spinous wheel-hub plates from body wall, with complex hubs and lateral projections (holotype F59193; SEM by Tania Bardsley and Phil Bock). f, rare wheels from body wall, with complex hub and continuous teeth on inner rim (holotype SEM image left, paratype optical image right).

Order **Apodida** Brandt, 1835 (sensu Östergren, 1907)

Suborder **Synaptina** Smirnov, 1998

Diagnosis (Smirnov, 1998). Plates of calcareous ring without prominent anterior projections; excavations for tentacular ampullae lie on outer side of calcareous ring. Madreporite situated far from water ring at end of long stone canal. Ciliated funnels present. One to many polian vesicles. Body wall ossicles may be wheels of chiridotid type with 6 spokes and a complex hub and/or sigmoid hooks, or anchors and anchor plates. Wheels of larvae and juveniles with more spokes and small denticles on inner side of rim.

Chiridotidae Östergren, 1898

Diagnosis (Smirnov, 1998). Synaptina with 10, 12 or 18 peltato-digitate, pinnate or bifurcate tentacles. Juveniles with bifurcate tentacles. Body wall ossicles wheels of chiridotid type and/or sigmoid hooks. Chiridotid type wheels with 6 spokes, numerous small denticles on inner side of rim and a complex hub; on lower side of each spoke a branch leans against the lower end of the hub forming a star structure. Ossicles in tentacles usually rods with branched ends.

Subfamily **Taeniogyrinae** Smirnov, 1998

Diagnosis (Smirnov, 1998). Chiridotidae with 10 or 12 tentacles. Body wall ossicles wheels of chiridotid type and sigmoid hooks or sigmoid hooks only. Radial plates of calcareous ring not perforated but sometimes slightly notched in anterior (upper) face for passage of nerves.

Remarks. The characters of the new genus below accord best with the subfamily Taeniogyrinae, but exceptional characters of the new genus are an absence of sigmoid hooks, and presence of spinous plates with wheel-spoked perforations. Smirnov (1998) included in his new subfamily Taeniogyrinae the genera to which new species are assigned below: *Taeniogyrus* Semper, 1868 and *Trochodota* Ludwig, 1892.

Archedota O'Loughlin gen. nov.

Figure 1

Diagnosis. Taeniogyrid genus with body wall ossicles irregular thick spinous plates with wheel-spoked perforations with complex hubs, and rare chiridotid wheels; lacking sigmoid hooks.

Type species. Archedota lapidea O'Loughlin sp. nov. (below; monotypic)

Distribution. Australia, Victoria, western Bass Strait, 39°S 143°E, 92–85 m.

Etymology. From the Greek *arche* (old, beginning), referring to the apparently primitive form of the wheel-spoked perforated plates, with *dota* from the family name Chiridotidae (feminine).

Remarks. The characters of this new apodid genus *Archedota* O'Loughlin gen. nov. are in accord with the above diagnoses of suborder, family and subfamily, with the exception of the presence of spinous plates with wheel-spoked perforations. This significant diagnostic character difference supports the erection of new higher taxa (suborder, family, subfamily), but on the basis of having only 2 specimens, and in the absence of molecular genetic data, I am limiting my response to the erection of a new genus only. *Archedota lapidea* O'Loughlin sp. nov. (below) differs only in ossicle form from the other genera of Chiridotidae. The presence of wheel-spoked single perforations in thick, closely spinous plates is a unique character amongst the chiridotids. Rare chiridotid-type wheels are present amongst the abundant, massed, perforated wheel-spoked plates. Absence of sigmoid hooks is also exceptional within the diagnosis of Taeniogyrinae. I acknowledge that in subjectively describing (etymology) the plate ossicles as "primitive", and perhaps precursors to wheel ossicles, the form of the plates may in fact indicate a regressive condition or wheel ossicles with secondary developments.

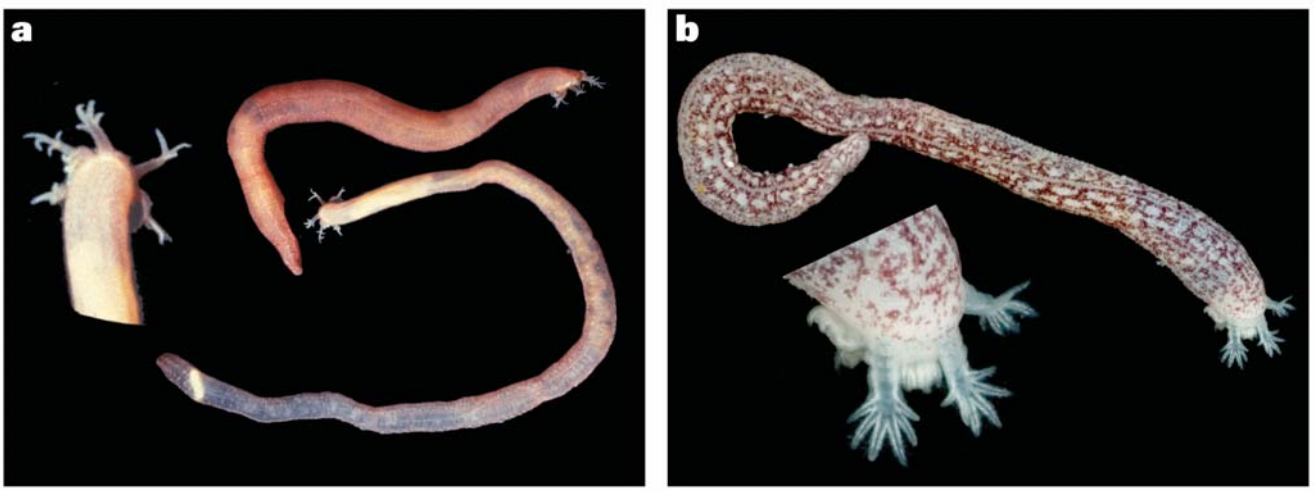

Figure 2. Photos of live taeniogyrid specimens. a, *Taeniogyrus roebucki* (Joshua, 1914) from Flinders rocky shallows, with 2 pairs of digits per tentacle (NMV F73591; photo by Ian Kirwan). b, *Trochodota epiphyka* O'Loughlin sp. nov. from Cape Bridgewater rocky shallows, with 3 pairs of digits per tentacle (F125372; 32 mm long live; photo by Leon Altoff and Audrey Falconer).

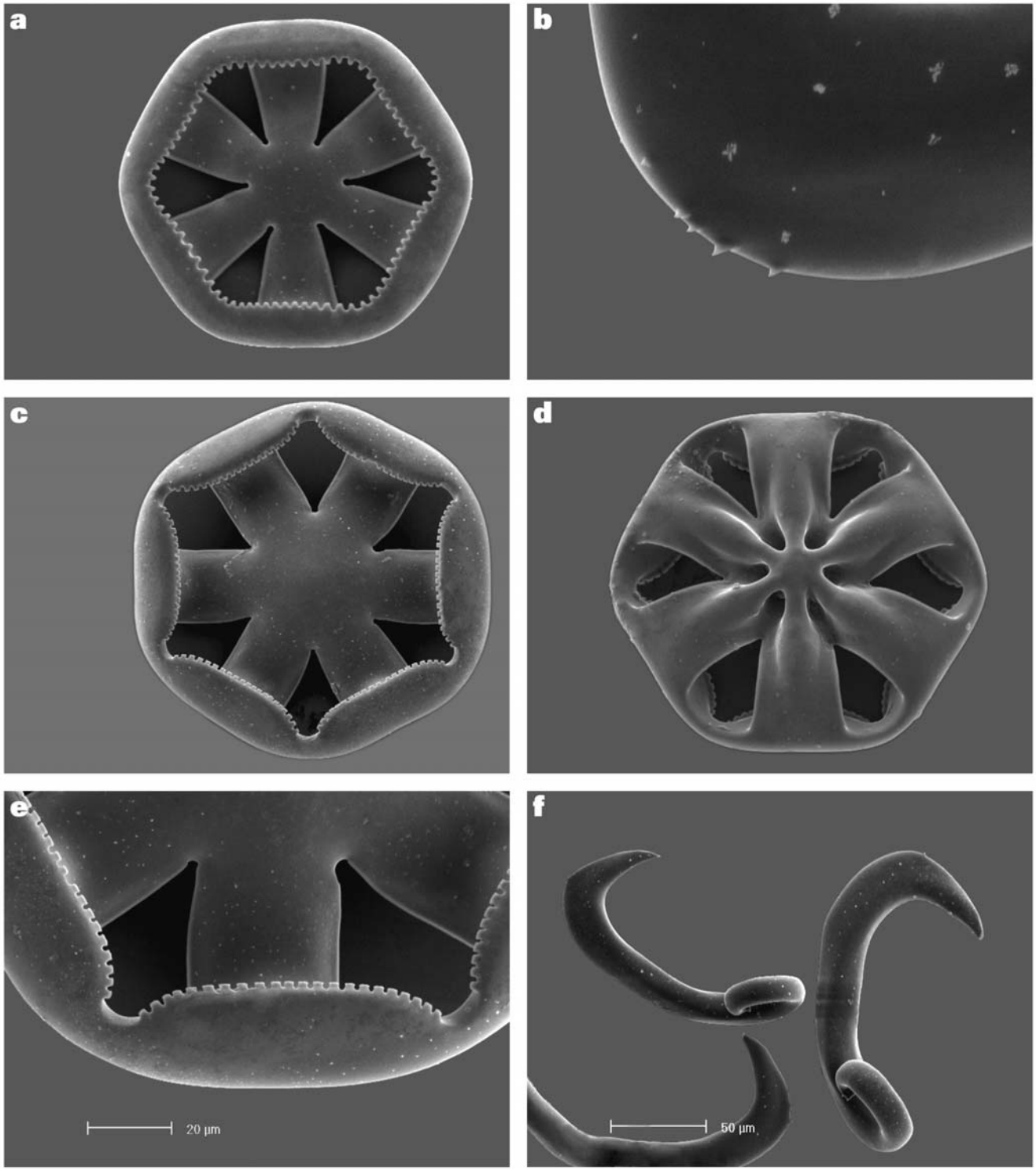

Figure 3. Body wall ossicles of specimens of *Taeniogyrus* Semper, 1868 and *Trochodota* Ludwig, 1891 (SEM by Tania Bardsley and Phil Bock). a, b, *Taeniogyrus roebucki* (Joshua, 1914), NMV F82716: a, wheel with continuous series of teeth on inner rim; b, outer curved edge of hook with minute spinelets. c–f, *Trochodota allani* (Joshua, 1912), F82705: c–e, wheels with discontinuous series of teeth on inner rim, and complex hub; f, sigmoid hooks with minute spinelets on outer curved edge.

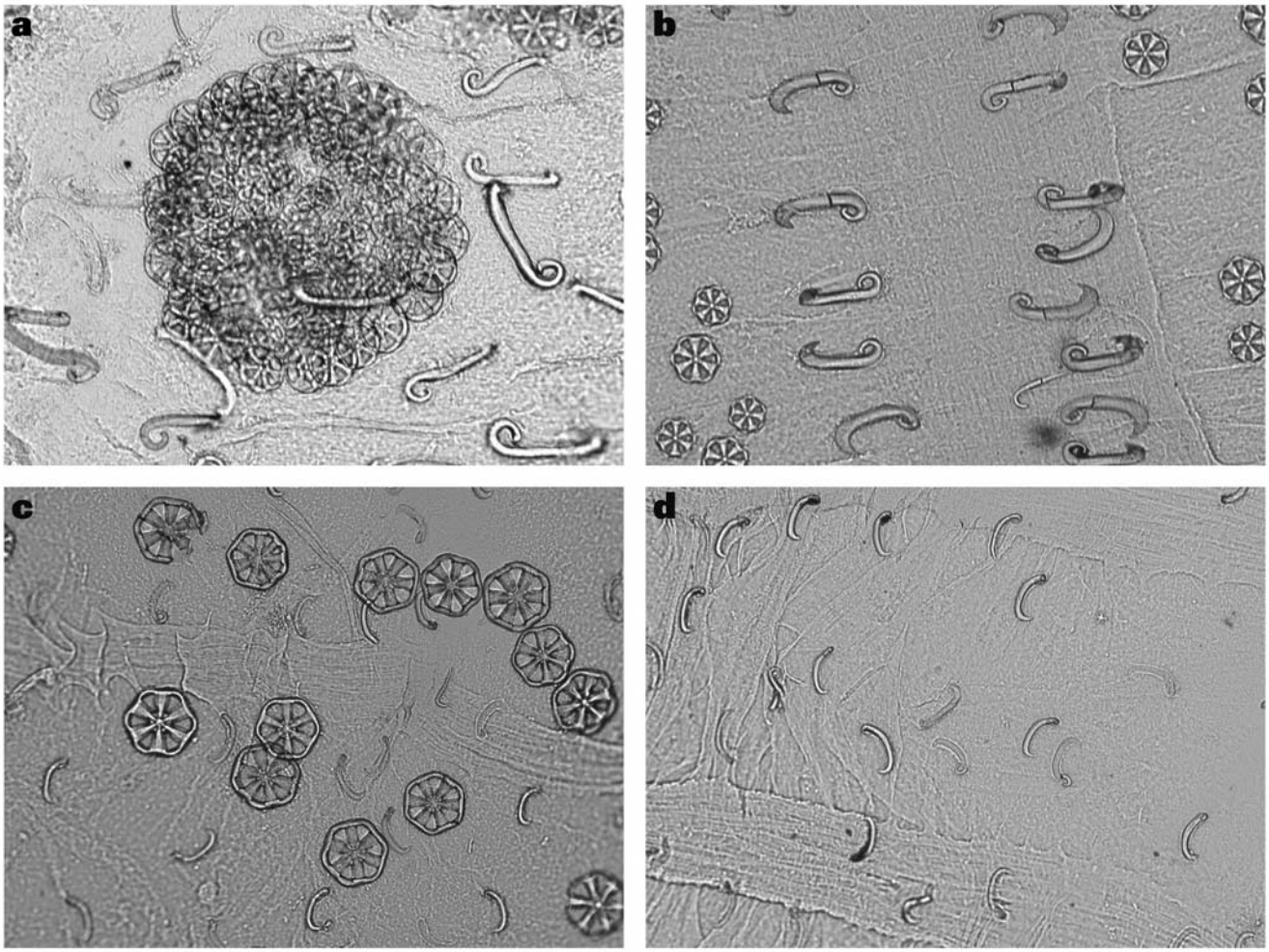

Figure 4. Body wall ossicles in body mounts from *Taeniogyrus* Semper species. a, dense wheel clusters and large hooks in *Taeniogyrus heterosigmus* Heding, 1931, NMV F82707; b, parallel rows of large hooks along edges of longitudinal muscles in body wall of *Taeniogyrus roebucki* (Joshua, 1914), F73607; c–d, *Taeniogyrus tantulus* O'Loughlin sp. nov., paratype F59199: c, dorsal body wall with scattered wheels and subequal hooks; d, ventral body wall with hook ossicles only.

Archedota lapidea O'Loughlin sp. nov.

Figure 1

Material examined. Holotype: Victoria, western Bass Strait, VIMS, NZOI RV *Tangaroa*, cruise 81-T-1, BSS stn 205G, 39°13'36"S, 143°55'36"E, fine sandy shell, 85 m, 23 Nov 1981, NMV F59193 (with microscope slide of ossicles).

Paratype: Western Bass Strait, *Hai Kung*, cruise 81-Hk-1, BSS stn 119G, 39°06'42"S, 143°28'42"E, fine sand with abundant sponges, 92 m, 31 Jan 1981, F59194 (1; with 4 microscope slides).

Description. Up to 17 mm long, 2 mm diameter (paratype); body wall hard, calcareous; anterior dorsal body and tentacles overhang ventral body and tentacles; tentacles withdrawn (both specimens), tentacles digitate, 10, each with predominantly 5 pairs of digits, longest pair distally, shortest pair proximally; calcareous ring with 5 radial 5 interradial plates all fused to form narrow ring; radial plates low, with anterior indentation, rounded posteriorly; interradial plates with concave anterior and posterior indentations; single dorsal madreporite; 1 polian vesicle, ventral; few ciliated funnels along dorsal alimentary canal/mesentery attachment; 2 unbranched gonad tubules, thick, 1 on each side of dorsal mesentery, joined dorsally at shared gonoduct.

Body wall ossicles plates and wheels, lacking hooks: plates densely massed throughout body wall, thick, closely spinous rim and surface, form irregularly oval with 0–6 lobed projections on rim, single wheel-spoked perforation with complex hub, typically 6 spokes, plates 48–88 μm wide; wheels sparsely present among plate ossicles, intergrade in form with wheel-spoked plates, some with rounded hexagonal form, 6 spokes, inner margin of rim parallel to outer margin, inner margin with continuous teeth, wheel diameter 48 μm. Tentacles with rod ossicles, ends bifurcate, curved, swollen centrally, tapering distally, rods lacking side branches or denticulations, rods 56 μm long.

Colour (preserved). Off-white.

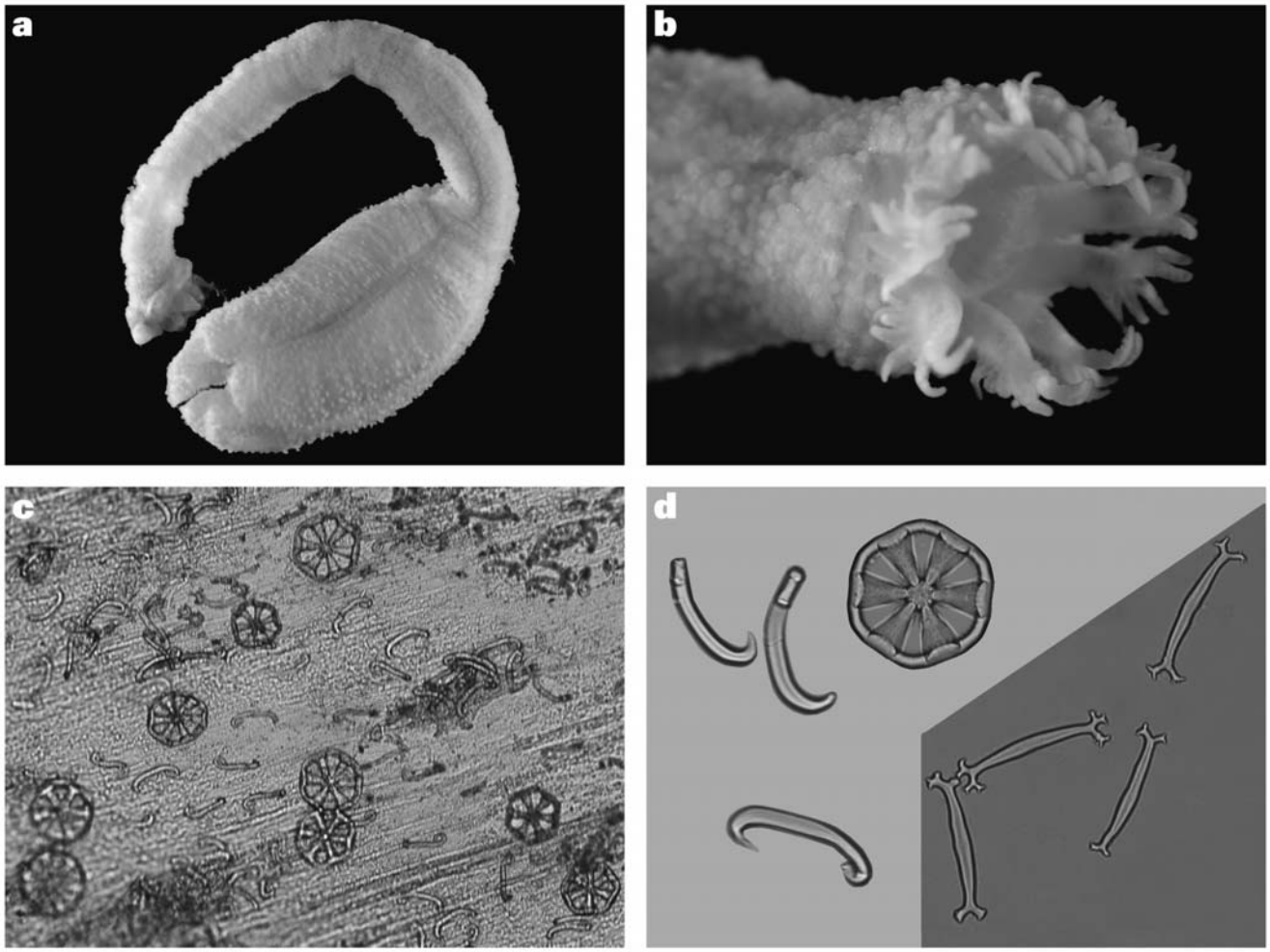

Figure 5. *Taeniogyrus papillis* O'Loughlin sp. nov. a, holotype (preserved) from Beachport, with soft papillate body wall, NMV F59195; b, tentacle crown, with predominantly 5 pairs of digits per tentacle, paratype F59197; c, holotype, section of body wall mount, with scattered subequal wheels and hooks; d, body wall hooks and wheel (left), and tentacle rods (right), all subequal (from types).

Distribution. Western Bass Strait, 39°S 143°E, 92–85 m.

Etymology. From the Latin *lapideus* (of stone), referring to the stone-like ossicles in the body wall (feminine).

Remarks. The body wall ossicle combination of rare chiridotid wheels, irregular spinous plates with single wheel-spoked perforation, and absence of hooks distinguishes *Archedota lapidea* O'Loughlin sp. nov. from all other chiridotid species.

Taeniogyrus Semper, 1868

Figures 2a, 3a,b, 4–7

Diagnosis (as emended by Rowe, 1976). Chiridotid genus with wheels and sigmoid ossicles present, scattered, or in groups or clustered into papillae; wheels with serrations continuous around the inner margin; tentacles 10 or 12.

Species in southern Australia. *Taeniogyrus heterosigmus* Heding, 1931; *T. papillis* O'Loughlin sp. nov.; *T. roebucki* (Joshua, 1914); *T. tantulus* O'Loughlin sp. nov.

Remarks. An abundance of *T. roebucki* (Joshua) material from southern Australia, including the types, is present in the collections of Museum Victoria and was available for comparative examination. *T. roebucki* differs from the other 3 *Taeniogyrus* species in southern Australia in having only 2 pairs of digits per tentacle. Rowe (1995) reported *T. heterosigmus* Heding as known only from the type locality (Koombana Bay in SW Australia). I have found specimens at Normanville in Gulf St. Vincent in South Australia, in the rock and sediment shallows (NMV F74612 (1), F82706 (4), F82707 (5)), and confirmed their identity with the type (ZMH E.5032). *T. heterosigmus* differs in 3 significant ways from the other 3 species of *Taeniogyrus* in southern Australia: dense round clusters of wheels in the body wall; 2 series of ciliated funnels along the coelomic wall, in the left lateral and right ventral interradii; multiple branching gonad tubules. *T. heterosigmus* is similar to *T. roebucki*: sigmoid hooks significantly larger than wheels; tentacle rods with lateral

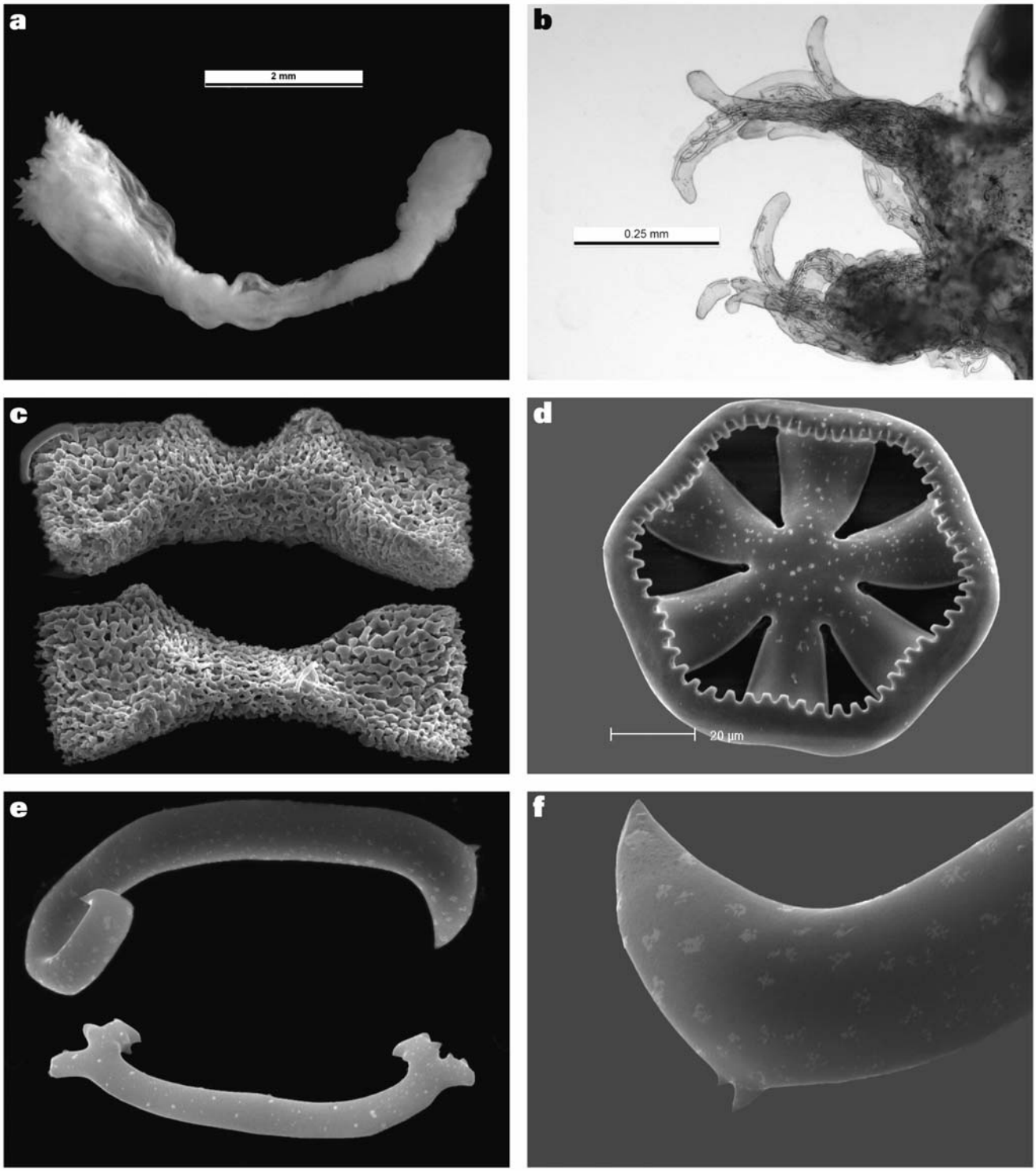

Figure 6. *Taeniogyrus tantulus* O'Loughlin sp. nov. (SEM by Tania Bardsley and Phil Bock). a, holotype (preserved) from East Gippsland, NMV F59198; b, 2 tentacles and digits, with smooth-sided rods, paratype F59199; c, calcareous ring plates from paratype, F59199: radial plate above, interradial plate below; d, wheel from body wall, with continuous series of teeth on inner edge of rim, paratype F59199; e, hook from body wall (above), and rod from tentacle, lacking lateral denticulations (below), paratype F59199; f, end of hook from paratype, with spines on outer curved edge, paratype F59199.

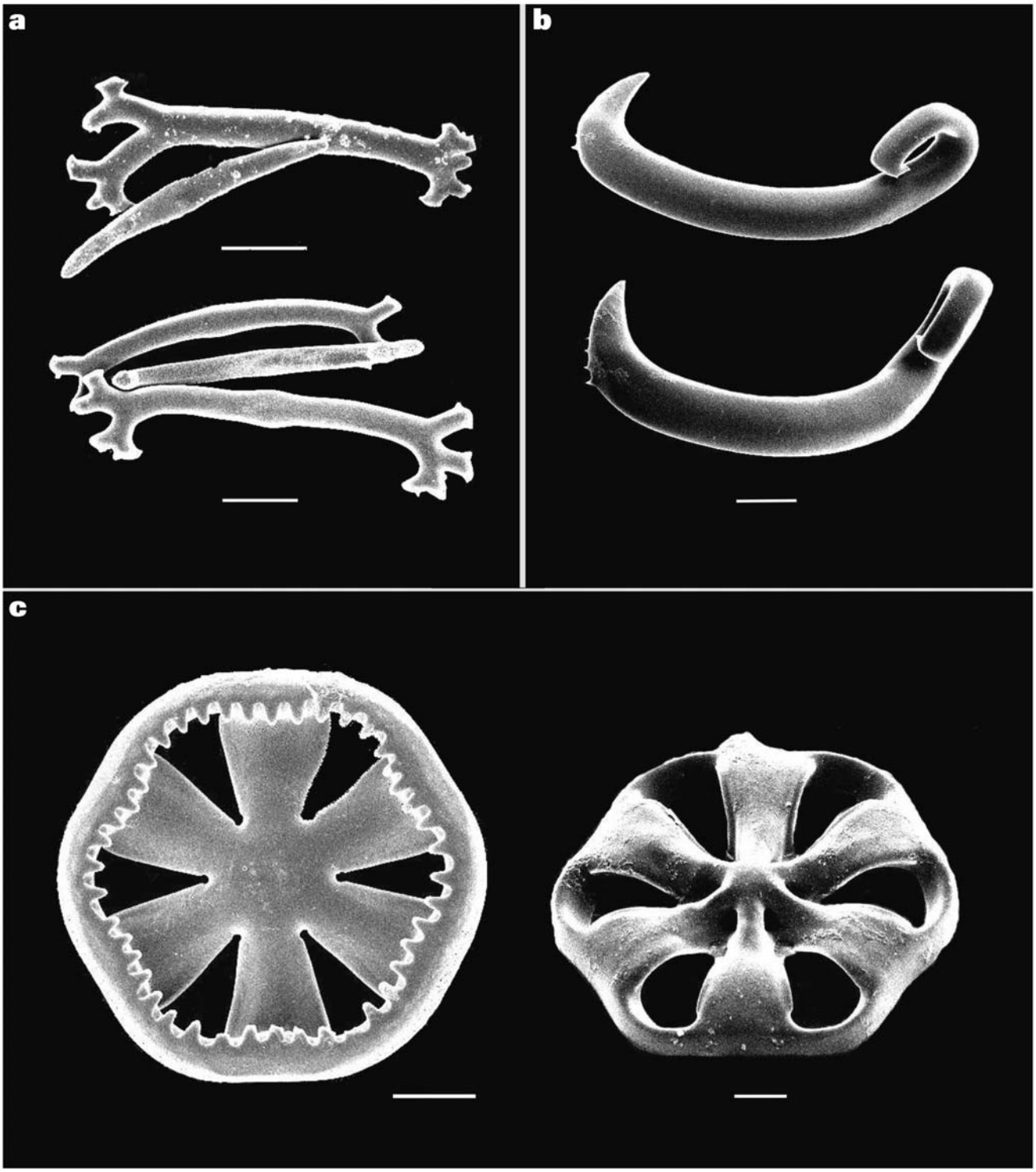

Figure 7. *Taeniogyrus tantulus* O'Loughlin sp. nov. (SEM by Didier VandenSpiegel; paratype NMV F59199; all scale bars 10 μm). a, tentacle rods, lacking lateral denticulations; b, hooks from body wall, with spines on outer curved edge; c, wheels from body wall, with continuous series of teeth on inner rim, and complex hub.

denticulations that are papillate or sub-columnar, never with additional fine spinelets apically. In *T. heterosigmus* the wheels are in rounded dense clusters; in *T. roebucki* wheels are in close irregular bands adjacent to the longitudinal muscles, and sparse mid-interradially. In *T. heterosigmus* the hooks are scattered in all interradii; in *T. roebucki* hooks are aligned transversely in paired series over the edges of longitudinal muscles.

Key to the southern Australia species of *Taeniogyrus* Semper, 1868

1. Body wall with calcareous white spots comprising clustered wheel ossicles; gonad tubules with multiple branching; 2 series of ciliated funnels, not dorsal ..... ***T. heterosigmus*** Heding

— Body wall lacking white spots of clustered wheel ossicles; gonad tubules not branched; 1 series of ciliated funnels, dorsal 2

2. Tentacles each with 2 pairs of digits; sigmoid hooks significantly larger than wheels; tentacle rods with lateral denticulations ..... ***T. roebucki*** (Joshua)

— Tentacles each with predominantly 4–5 pairs of digits; sigmoid hooks not significantly larger than wheels; tentacle rods smooth laterally 3

3. Large, up to 60 mm long (preserved); relaxed body wall covered with non-calcareous discrete papillae; papillae dark red; outer curved side of projecting end of hooks smooth; tentacle rods widened mid-rod and tapering distally ..... ***T. papillis*** O'Loughlin sp. nov.

— Small, up to 11 mm long (preserved); relaxed body wall not covered with discrete papillae; body white; outer curved side of projecting end of hooks minutely spinous; tentacle rods not widened mid-rod ..... ***T. tantulus*** O'Loughlin sp. nov.

Taeniogyrus papillis O'Loughlin sp. nov.

Figure 5

Material examined. Holotype: SE South Australia, Beachport, "Salmon Hole", shallow sub-littoral, in sand under rock with *Taeniogyrus roebucki*, M. O'Loughlin, 29 Jan 1989, NMV F59195 (1, with 5 microscope slides).

Paratypes: SE South Australia, Cape Northumberland, algal "scrapings", M. Mackenzie, R. McIntosh, M. O'Loughlin, 6 Jan 2001, F94119 (1 in 2 pieces, with 1 microscope slide). Victoria, Marengo (SW of Apollo Bay), M. O'Loughlin, 11 Jan 1980, F59197 (1, with 1 microscope slide); Cape Paterson, rocky shallows, M. O'Loughlin, M. Nyhuis, 29 Jan 1988, F59196 (1, with 2 microscope slides).

Other material. SE South Australia, Cape Banks, W side, off *Caulerpa*, 1 m, CRUST 74, 11 May 1990, F94706 (1, fragment).

Description. Up to 60 mm long, 2 mm diameter (preserved); body wall with close cover of discrete domed projections (papillae) present in extended and contracted specimens; anterior dorsal body and tentacles overhang ventral body and tentacles; tentacles digitate, 10, each with predominantly 5 pairs of digits, longest pair distally, shortest pair proximally; calcareous ring with 5 radial 5 interradial plates all fused to form narrow ring; plates low, with concave indentations anteriorly and posteriorly, some plates asymmetrical anteriorly with low blunt anterior projection on one side of indentation; single dorsal madreporite; 1 polian vesicle, ventral; narrow band of ciliated funnels along mid-dorsal interradius, on both sides of mesentery attachment; 2 unbranched gonad tubules, 1 on each side of dorsal mesentery, joined dorsally at shared gonoduct.

Body wall ossicles wheels, sigmoid hooks: wheels scattered in interradii of body wall, sparse ventrally, rounded hexagonal form, 6 spokes, inner margin of rim parallel to outer margin, inner margin with continuous teeth, wheel diameters 64–96 μm; sigmoid hooks over and adjacent to longitudinal muscles, more numerous and slightly smaller than wheels, outer curved side of hook smooth, hook lengths 64–80 μm. Papillae lacking concentrations of ossicles. Tentacles with rod ossicles: rods curved, swollen centrally, tapering distally, ends with short lobed to blunt branches, rods lacking side branches or denticulations, rods 56–96 μm long.

Colour (live). Body translucent with close cover of dark red papillae. Preserved holotype with red flecking on vascular ring, polian vesicles and longitudinal muscles.

Etymology. From the Latin *papilla* (small swelling, bud, nipple), referring to the close cover of small domed protuberances on the body surface.

Distribution. Victoria (Cape Paterson) to SE South Australia (Beachport); rocky shallow sub-littoral, 0–1 m.

Remarks. *Taeniogyrus papillis* sp. nov. is distinguished in the key (above) from the 3 other species of *Taeniogyrus* Semper in southern Australia. The holotype has 3 anterior tubular growth infestations arising near the vascular ring, 2 with short branches distally.

Taeniogyrus tantulus O'Loughlin sp. nov.

Figures 4c,d, 6, 7

Material examined. Holotype: Victoria, East Gippsland, Ninety Mile Beach, off McGaurans Beach, 800 m offshore, 10 m, fine sand, strong currents, LVWSB: SWOP 1, stn 7, Site 2, 31 Dec 1979, data from J. Carey and J. Watson, NMV F59198.

Paratypes: Type locality and date, F59199 (11, with many microscope slides).

Other material. Type locality and date, F82710 (many); stn 6, 31 Oct 1979, F80938 (many).

Description. Up to 11 mm long, 2 mm diameter at oral and anal ends (preserved); preserved form commonly with oral and anal ends swollen, mid-body contracted and narrow, anterior dorsal body and tentacles overhang ventral body and tentacles; tentacles digitate, 10, each with 4–5 pairs of digits, longest pair distally, shortest pair proximally; calcareous ring with 5 radial 5 interradial plates fused to form narrow ring; radial plates low, with anterior narrow indentation between 2 low rounded projections, shallow concave posterior indentation; interradial plates with anterior indentation with 1 lateral low rounded projection, shallow concave posterior indentation; single dorsal stone canal, madreporite; 1 polian vesicle, ventral; narrow band

of ciliated funnels along mid-dorsal interradius, on both sides of mesentery attachment; 2 unbranched gonad tubules, 1 on each side of dorsal mesentery, joined dorsally at shared gonoduct.

Body wall ossicles wheels, sigmoid hooks: wheels adjacent to longitudinal muscles in interradii of body wall, sparse in ventral interradii, wheels only ossicles anteriorly, wheels with rounded hexagonal form, 6 spokes, inner margin of rim parallel to outer margin, inner margin with continuous teeth, wheel diameters 40–104 μm; sigmoid hooks absent anteriorly, scattered throughout interradii in mid-body, more numerous and slightly smaller than wheels, outer curved side of some hooks with spinelets, hook lengths 60–80 μm. Tentacles with rod ossicles: rods not swollen centrally, ends with short lobed branches, rods lacking side branches or denticulations, rods 40–64 μm long.

Colour (preserved). White, translucent.

Distribution. Eastern Victoria, East Gippsland, offshore sediments; 11 m.

Etymology. From the Latin *tantulus* (so small), referring to the very small size of specimens of this species.

Remarks. T. tantulus sp. nov. is distinguished in the key (above) from the other species of *Taeniogyrus* Semper in southern Australia. It is a very small holothuroid, extremely abundant in the off-shore sublittoral sediments of east Gippsland. Data from Jan Watson (pers. comm.) gives estimated populations at Stns 6 and 7 of 13,870 per square m. Jan noted (pers. comm.) that nearby sites had only a few individuals. There was no evidence of internal brood-protection or fissiparity in the many individuals examined, but such reproductive strategies could be seasonal. The only material examined here was collected in mid-summer.

Trochodota Ludwig, 1891

Figures 2b, 3c–f, 8, 9

Diagnosis (as emended by Rowe, 1976). Chiridotid genus with wheels and sigmoid ossicles present scattered or in groups, wheels with serrations on the inner margin in well defined groups; tentacles 10.

Species in southern Australia. Trochodota allani (Joshua, 1912); *T. epiphyka* O'Loughlin sp. nov.; *T. shepherdi* Rowe, 1976.

Remarks. An abundance of *T. allani* (Joshua) material from southern Australia, including the types, is present in the collections of Museum Victoria and was available for comparative examination. Rowe (1995) reported *T. shepherdi* Rowe as known only from South Australia (the Gulfs and Kangaroo I.). Museum Victoria holds specimens from eastern Victoria (Nooramunga, NMV F82694 (3); Corner Inlet, F82704 (5)) and South Australia (Port Lincoln, 15 m, F82703 (1)). No specimens of *T. shepherdi* have been found on the thoroughly examined coast between Wilsons Promontory (Victoria) and the Gulfs (South Australia). In addition to the form of the wheel ossicles, *T. allani* and *T. shepherdi* are similar in each having: tentacle rods with denticulations on the sides, variable in form from low papillate to columnar to flared or bifurcate distally, often with a small apical spinelet; 3 series of ciliated funnels, in the dorsal, left lateral and right ventral interradii; spinelets on the outer curved side of hook ossicles, more evident in *T. shepherdi*.

Rowe (1976) emended the diagnosis of *Trochodota* Ludwig, 1891. Subsequently Rowe (1995) discussed in detail the uncertain validity of the generic name *Trochodota*. Smirnov (1997) rejected the emended diagnosis of *Trochodota* by Rowe (1976), without reference to the uncertain validity of *Trochodota* raised by Rowe (1995). Smirnov (1997) reverted to the diagnosis of *Trochodota* by H. L. Clark (1921), while recognizing that "Clark's system itself needs revision". Rowe (pers. comm.) indicates that he disagrees with Smirnov (1997) on the identification of the type species of *Trochodota*, namely *Chirodota studerii* Théel, 1886, sensu Ludwig, 1891 = *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 (not Théel, 1886 = *Taeniogyrus contortus* Ludwig, 1874) (subsequent designation by Rowe, 1995). Resolution of these issues will be undertaken elsewhere, and the emended diagnosis of *Trochodota* by Rowe (1976) is followed here.

Key to the southern Australia species of *Trochodota* Ludwig, 1891

1. Live colour uniform black; wheels grouped in a band along all mid-interradii ..... ***Trochodota shepherdi*** Rowe

— Live colour never uniform black; wheels scattered, sparse to absent in the 2 ventral interradii 2

2. Smaller, up to 14 mm long (preserved); found predominantly in shallow sublittoral algal growth; live colour white with dark purple to black flecks, consistent; 2 longitudinal seriesof ciliated funnels (left lateral, right ventral interradii); wheel diameters smaller, 40–160 μm; sigmoid hooks shorter, 88–136 μm, outer side of curved hooks with paired series of spinelets ..... ***Trochodota epiphyka*** O'Loughlin sp. nov.

— Larger, up to 80 mm long (live); found predominantly in deep sublittoral sediments; live colour predominantly solid carmine, blood red, variable; 3 longitudinal series of ciliated funnels (dorsal, left lateral, right ventral interradii); wheel diameters larger, 40–184 μm; sigmoid hooks longer, 136–184 μm, outer side of curved hooks with single series of spinelets ..... ***Trochodota allani*** (Joshua)

Trochodota epiphyka O'Loughlin sp. nov.

Figure 2b, 8b, e–f, 9

Trochodota allani.—O'Loughlin, 1984: 155.—Rowe, 1995: 268 (part) (non *Trochodota allani* (Joshua, 1912))

Material examined. Holotype: Victoria, Flinders, Mushroom Reef, sieved from *Amphibolus* in rocky shallows, A. Falconer, 20 Apr 2007, NMV F132690 (photo live by Leon Altoff).

Paratypes: (all paratype specimens from algal scrapings in the rocky shallows, collected by M. O'Loughlin). Flinders, West Head, M. Benavides-Serrato, D. Maric, M. O'Loughlin, 27 Jan 2007, F121896 (1); F121897 (1); Flinders, ocean platforms, 13 Apr 1985, F73564 (1); 13 Jul 1990, F73565 (1); 16 Nov 1980, F73566 (3);

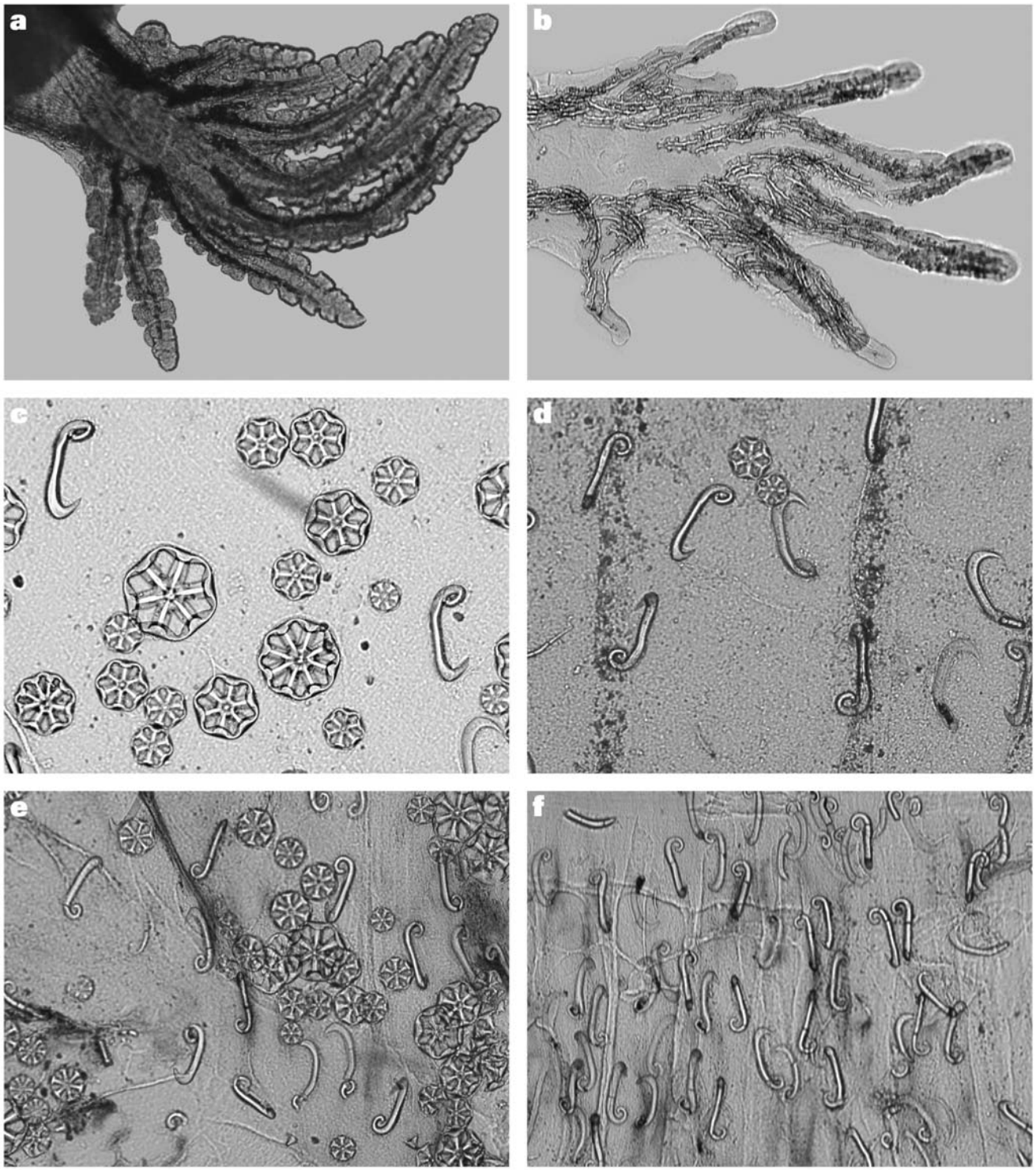

Figure 8. *Trochodota* Ludwig, 1891 species. a, tentacle mount of *Trochodota allani* (Joshua, 1912) with 5 pairs of digits, NMV F45031. b, tentacle mount of *Trochodota epiphyka* O'Loughlin sp. nov. with 3 pairs of digits, and rods with lateral denticulations, paratype F73587. c–f, part body wall mounts at same magnification: c, d: *Trochodota allani*, F82705; c, dorsal body wall with larger wheels and hooks; d, ventral body wall with hooks and rare wheels. e, f, *Trochodota epiphyka*, F73584: e, dorsal body wall with smaller wheels and hooks; f, ventral body wall with hooks, lacking wheels.

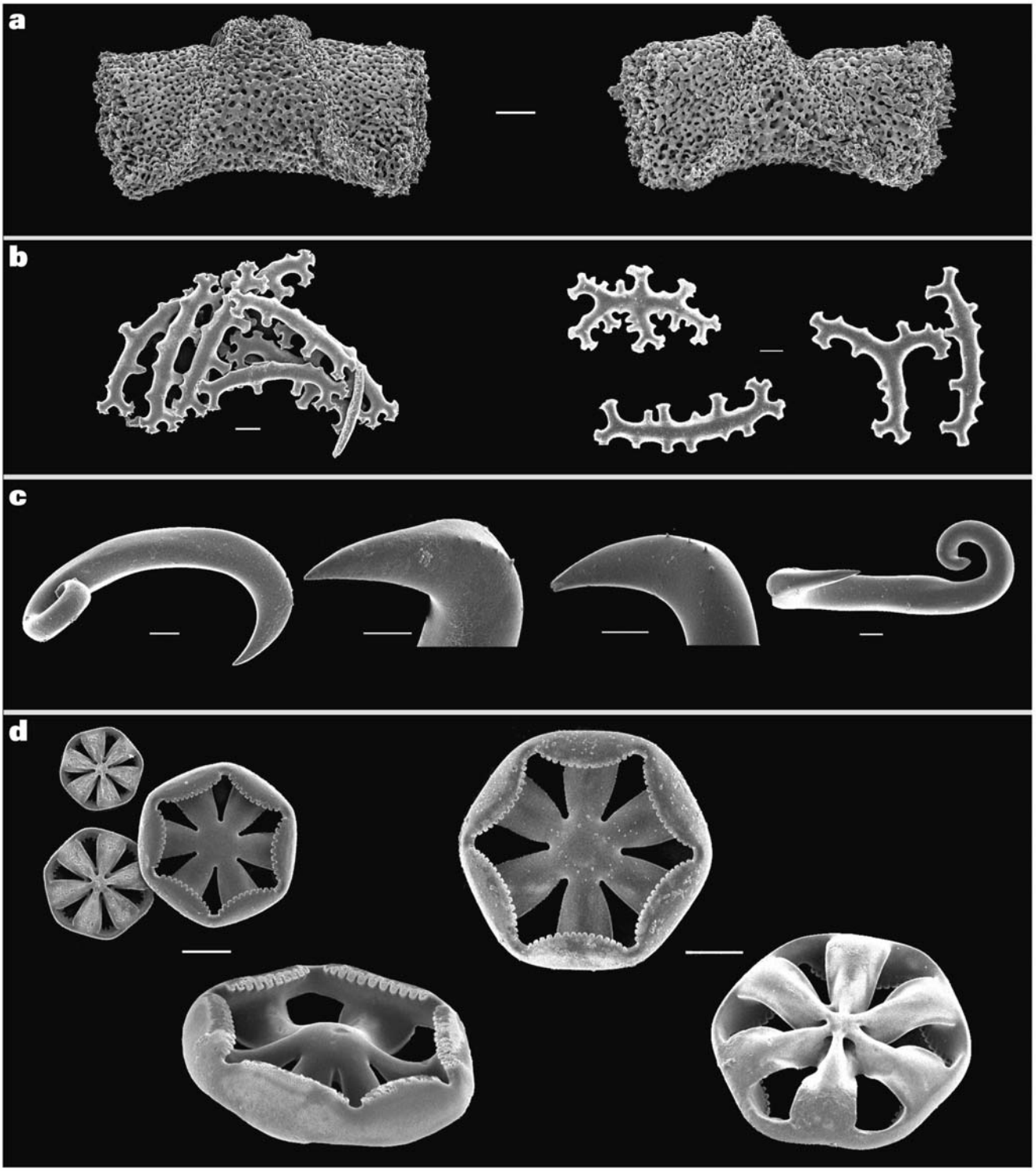

Figure 9. *Trochodota epiphyka* O'Loughlin sp. nov., paratype NMV F73586 (SEM by Didier VandenSpiegel) a, radial and interradial plates of calcareous ring (scale bar 50 μm); b, tentacle rods with lateral denticulations (scale bars 10 μm); c, hooks from body wall, with short paired rows of small spinelets on outer curved edges (scale bars 10 μm); d, wheels from body wall, with discontinuous series of teeth on inner margin of rim, and complex hub (scale bars 20 μm).

Table 1. Wheel ossicle characters for the species of *Prototrochus* Beljaev and Moronov, 1982 from the Tasman Sea: *P. australis* (Beljaev and Mironov, 1981); *P. burni* O'Loughlin sp. nov.; *P. staplesi* O'Loughlin sp. nov.; *P. taniae* O'Loughlin sp. nov. (optical measurements by Mark O'Loughlin)

Species (depth)	Diameter (average)	Spokes (average)	Teeth (average)	Spokes/ teeth ratio	Hub/wheel (diameters)	Rim
P. australis 1500 m	226 μm (155–297) (n = 51)	9 (7–11)	26 (23–30)	34% (25–42)	Not given	Round
P. burni 2900 m	272 μm (240–336) (n = 21)	10 (8–12)	31–35	25–31%	22–25%	Round
P. staplesi 1119 m	136 μm (112–152) (n = 10)	8 (7–9)	18–20	40–50%	14–16%	Scalloped
P. taniae 996 m	232 μm (192–248) (n = 37)	9 (7–10)	24–28	33%	19–20%	Angular

Table 2. Measurements (μm) for 10 "large" wheels of *Prototrochus taniae* O'Loughlin sp. nov. (paratype NMV F59192; SEM measurements by Didier VandenSpiegel; wheel parameters in fig. 10d).

Wheel diameter (averages at bottom)	Hub diameter	Spoke length	Tooth length
179.9	39.5	50.4	20.3
170.8	49.5	49.8	18.0
188.7	45.3	50.0	17.7
184.7	47.6	50.1	20.4
193.8	47.3	57.3	19.9
291.6	54.1	56.0	21.5
212.0	54.3	60.3	23.4
176.6	43.0	48.3	20.5
184.3	42.4	52.8	24.7
191.2	46.9	55.4	23.4
188.4 μm	47.0 μm	53.0 μm	21.0 μm

10 Mar 1980, F73567 (1); 7 Apr 1980, F73568 (3); 6 Mar 1982, F73586 (1, photo by I. Kirwan); 17 Feb 1990, F73587 (5).

Other material (selection). Victoria, Cape Paterson, 25 Jan 1992, F59230 (2); 18 Jan 1980, F73590 (4); Mullet Holes (10 km NE of Apollo Bay), 2 Jan 1988, F73584; Portland, W side of Bridgewater Bay, 25 Feb 2007, F125372 (1, photo live by Leon Altoff). N Tasmania, Lulworth, Black Rock Point, 22 Nov 1982, F82765 (5). South Australia, Robe, 10 Jan 1988, F82766 (3); Victor Harbor, The Bluff, 9 Nov 1988, F82720 (4); Cape Jervis, 10 Nov 1988, F82769 (1); Kangaroo I., Emu Bay, 17 Jan 1990, F82768 (3). Western Australia, Cape Naturaliste, Eagle Bay, 25 Feb 1975, WAM Z464–76 (1).

Description. Up to 14 mm long, 2 mm diameter (preserved); anterior dorsal body and tentacles overhang ventral body and tentacles; tentacles digitate, 10, each with predominantly 3 pairs of digits, longest pair distally, shortest pair proximally; calcareous ring with 5 radial 5 interradial plates all fused to form narrow ring; radial plate subrectangular with narrow short truncate anterior projection, shallow concave posterior indentation; interradial plate asymmetrical with mid-anterior small notch and short projection, concave indentation posteriorly; single dorsal stone canal, hook-shaped madreporite; 1 polian vesicle, ventral; 2 narrow bands of ciliated funnels along left lateral interradius adjacent to left ventrolateral muscle, and along right ventral interradius adjacent to midventral muscle; 2 unbranched gonad tubules, 1 on each side of dorsal mesentery, joined dorsally at shared gonoduct.

Body wall ossicles wheels, sigmoid hooks: wheels in dorsal and lateral interradii, no wheels in 2 ventral interradii, not grouped into papillae, wheels with 6 spokes, rarely more, outer rim of wheels with rounded hexagonal form, inner rim not parallel to outer rim, undulating, wide across spokes with continuous teeth, narrow between spokes and lacking teeth at narrowest part, wheel diameters 40–160 μm; sigmoid hooks evenly distributed around body, outer side of curved hooks with short parallel series of

minute spinelets, hook lengths 88–136 μm. Tentacles with rod ossicles: rods curved, slightly tapering distally, ends with short lobed branches, rods with irregular side denticulations, papillate to short columnar to bifurcate, some flared distally, often with small spinelet apically, rod lengths 64–80 μm.

Colour (live). Body white, cream or grey, with dark flecks or broken bands of purple, brown or black; tentacles white.

Distribution. From Cape Paterson (eastern Victoria) to Cape Naturaliste (south-western Australia), northern Tasmania; shallow sub-littoral on algae.

Etymology. From the Greek *epi* (upon) and *phykos* (seaweed, alga), referring to the microhabitat of the species (feminine).

Remarks. In contrast with the small size and broken colours of *Trochodota epiphyka* O'Loughlin sp. nov., Joshua (1912) reported *T. allani* to be 80 mm long and 6 mm wide, and described the live colour as carmine and blood red (Joshua, 1914). *T. epiphyka* is distinguished in the key above from the other two species of *Trochodota* in southern Australia.

Suborder **Myriotrochina** Smirnov, 1998

Diagnosis (Smirnov, 1998). Ten or 12 digitate or peltato-digitate tentacles. Plates of calcareous ring with large anterior projections; excavations for tentacular ampullae are on anterior side of calcareous ring. Madreporite placed close to water ring. No ciliated funnels. One polian vesicle. Body wall ossicles represented by wheels with large numbers of spokes (8–25) and without a complex hub (only Family Myriotrochidae).

Myriotrochidae Théel, 1877

Diagnosis. As for suborder.

Prototrochus Beljaev and Mironov, 1982

Figures 10, 11; Tables 1, 2

Diagnosis (after Gage and Billett, 1986). Myriotrochid with 10 tentacles; calcareous ring symmetrical, with dorsal and ventral plates subequal in size; dorsolateral radial plates with single anterior projection; wheels with teeth distributed regularly, pointing towards centre of hub; rods absent from body wall, sometime occurring in and around tentacles.

Remarks. Beljaev and Mironov (1982) referred 12 species to their new genus *Prototrochus*. Only *Prototrochus australis* (Beljaev and Mironov, 1981) occurs near eastern Australia, the holotype coming from south of Lord Howe I. in the northern Tasman Sea at 1500 m. Beljaev and Mironov (1981) noted that their new species *Myriotrochus australis* was the smallest known myriotrochid. The 7 specimens comprise 2 complete and 5 incomplete specimens, none longer than 2.8 mm. The holotype (Stn 1244; oral end part specimen; less than 2 mm long) diagnostic characters of the "larger wheels" given by Beljaev and Mironov (1981) are summarized in Table 1. These characters vary greatly across the specimens of *Prototrochus australis* analysed by Beljaev and Mironov (1981), as do the distribution (5 locations from east of New Zealand to northern Tasman Sea) and depth range (570–3013 m), suggesting to me the probability of more than 1 species. Beljaev and Mironov (1981) acknowledged that their new species might well comprise "two or more species or subspecies". The 3 new species from eastern Australia described below are diagnosed against the "larger wheels" data and illustrations given for the holotype of *P. australis* (Stn 1244). The 3 new species described below are the first myriotrochid records for Australian continental waters.

Prototrochus burni O'Loughlin sp. nov.

Figure 10e; Table 1

Material. Holotype: Eastern Australia, E Victoria, 96 km S of Point Hicks, 38°40'S, 149°17'E, 2900 m, lower continental slope, compacted clay, stn SLOPE 66, RV *Franklin*, G.C.B. Poore et al., 25 Oct 1988, NMV F94697 (with 2 microscope slides of wheel ossicles).

Description. Anterior body part; length 2.0 mm; calcareous ring diameter 1.0 mm; 10 peltato-digitate tentacles; calcareous ring symmetrical, 10 plates, dorsal and ventral plates subequal, radial and interradial plates with single long anterior spire, radially digitiform and distally narrowly rounded, interradially narrower and distally pointed, all plates with posterior indentations, lacking posterior projections.

Body wall ossicles massed wheels only: average (21) wheel diameter 272 μm (range 240–336 μm); spokes thick, average 10 per wheel (range 8–12); wheel rim slightly undulating, not angular rounded, not scalloped or straight across each tooth; wheel hubs simple, not perforated; hub diameter 56 μm for wheel diameter 256 μm (22%), hub diameter 80 μm for wheel diameter 320 μm (25%); wheel teeth subequal in size, distributed regularly around inner rim, not aligned with spokes, bluntly rounded, all pointing towards hub; small 8 spoke wheel with 32 teeth (25%), large 11 spoke wheel with 35 teeth (31%); tooth length 3 μm for wheel diameter 30 μm (10%), tooth length 6 μm for wheel diameter 42 μm (14%). Tentacles lack ossicles.

Colour. Off-white, translucent; tentacles with large brown spot distally, small pair proximally.

Distribution. Eastern Australia, E Victoria, S of Point Hicks, lower continental slope; 2900 m.

Etymology. Named for Robert Burn (Marine Research Group of Victoria; Honorary Associate of Museum Victoria), in appreciation of his decades of generous and dedicated contribution to marine research and Museum Victoria, and his invaluable service to the Marine Research Group.

Remarks. *Prototrochus burni* O'Loughlin sp. nov. is based on a single small part-specimen. Tentacles, calcareous ring, and wheel ossicles are all present, and adequate for a specific diagnosis. The symmetrical calcareous ring, with single long anterior projection on each plate and 10 tentacles, wheels with evenly distributed teeth pointing towards the hub, and absence of rod ossicles, identify the new species as a *Prototrochus* Beljaev and Mironov, 1982. The large diameter of the wheels and high number of teeth per wheel distinguish *P. burni* sp.

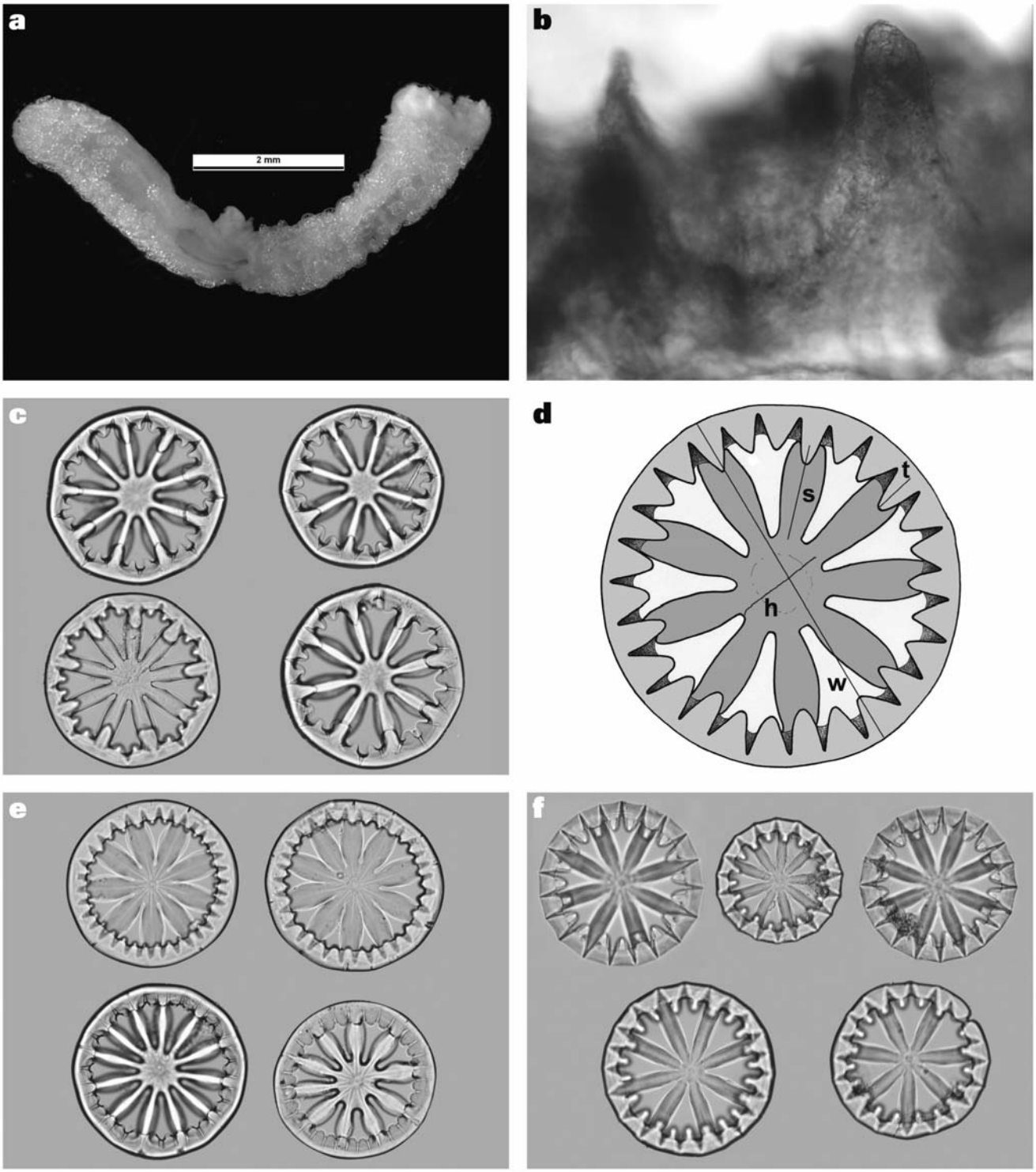

Figure 10. Species of *Prototochus* Beljaev and Mironov, 1981. a–d, *Prototrochus taniae* O'Loughlin sp. nov.: a, holotype (preserved), NMV F59191; b, anterior projections of interradial and radial plates of calcareous ring, paratype F59192; c, wheels from body wall, with longer teeth over spokes, and angular margin almost flat over spokes, holotype F59191; d, wheel parameters measured by Didier VandenSpiegel for data in Table 2. e, *Prototrochus burni* O'Loughlin sp. nov., wheels from body wall with rounded rim, subequal teeth and more than 8 spokes, holotype F94697. f, *Prototrochus staplesi* O'Loughlin sp. nov., wheels from body wall with flat or shallow concave outer rim over each tooth, subequal teeth, holotype F94698.

nov. from *P. australis* (Beljaev and Mironov), *P. staplesi* sp. nov. (below) and *P. taniae* sp. nov. (below). In the data given by Beljaev and Mironov (1981) the "bigger" wheel diameters of the holotype of *P. australis* are significantly larger than for any of their other *P. australis* specimens. All are significantly smaller than the *P. burni* wheels. *P. burni* occurs at a significantly greater depth (2900 m) than the holotype of *P. australis* and the other new species (below) (Table 1).

Prototrochus staplesi O'Loughlin sp. nov.

Figure 10f; Table 1

Material. Holotype. Eastern Australia, Victoria, 67 km S of Point Hicks, 38°24'S, 149°16'E, 1119 m, upper continental slope, fine mud, stn SLOPE 67, RV *Franklin*, G.C.B. Poore et al., 25 Oct 1988, NMV F94698 (microscope slide of wheel ossicles).

Description. Anterior body part; length 1.2 mm; calcareous ring diameter 1.0 mm; 10 peltato-digitate tentacles; calcareous ring symmetrical, 10 plates, dorsal and ventral plates subequal, radial and interradial plates with single long anterior spire, radially digitiform and distally narrowly rounded, interradially narrower and distally pointed, all plates with posterior indentations, lacking posterior projections.

Body wall ossicles massed wheels only: average (10) wheel diameter 136 μm (range 112–152 μm); spokes thin, average 8 per wheel (range 7–9); wheel rim slightly scalloped to straight across each tooth; wheel hubs simple, not perforated; hub diameter 24 μm for wheel diameter 152 μm (16%), hub diameter 16 μm for wheel diameter 112 μm (14%); wheel teeth subequal in size, distributed regularly around inner rim, not aligned with spokes, bluntly rounded, all pointing towards hub; teeth large, small 9 spoke wheel with 18 teeth (50%), large 8 spoke wheel with 20 teeth (40%); tooth length 16 μm for wheel diameter 112 μm (14%), tooth length 24 μm for wheel diameter 152 μm (16%). Tentacles lack ossicles.

Colour. Off-white, translucent; tentacles lacking brown spots.

Distribution. Eastern Australia, off eastern Victoria, upper continental slope; 1119 m.

Etymology. Named for David Staples (Marine Research Group of Victoria; Honorary Associate of Museum Victoria), in appreciation of his decades of generous and dedicated contribution to marine research and Museum Victoria, and his invaluable service to the Marine Research Group.

Remarks. *Prototrochus staplesi* O'Loughlin sp. nov. is based on a single small part-specimen. Tentacles, calcareous ring, and wheel ossicles are all present, and adequate for a specific diagnosis. The symmetrical calcareous ring, with single long anterior projection on each plate and 10 tentacles, wheels with evenly distributed teeth pointing towards the hub, and absence of rod ossicles, identify the new species as a *Prototrochus* Beljaev and Mironov, 1982. The small diameter of the wheels, wheel rims slightly scalloped or straight across each tooth, small wheel hubs, and large teeth distinguish *P. staplesi* sp. nov. from *P. australis* (Beljaev and Mironov), *P. burni* sp. nov. and *P. taniae* sp. nov. (below) (Table 1).

Prototrochus taniae O'Loughlin sp. nov.

Figures 10a–d, 11; Tables 1, 2

Material. Holotype: Eastern Australia, New South Wales, 54 km ESE of Nowra, 34°53'S, 151°17'E, 996–990 m, upper continental slope, mud, fine sand, fine shell, stn SLOPE 53, RV *Franklin*, G.C.B. Poore et al., 22 Oct 1988, NMV F59191 (with microscope slide of ossicles).

Paratypes: Type locality and date, F59192 (4, with 2 microscope slides of ossicles and 1 anterior body mount).

Description. Up to 7 mm long; calcareous ring and body diameter 1.0 mm; 10 peltato-digitate tentacles, each with 3 pairs of digits; calcareous ring symmetrical, dorsal and ventral plates subequal, 10 plates, radial and interradial plates with single long anterior spire, radially digitiform and distally rounded, interradially narrower and distally pointed, all plates with posterior indentations, lacking posterior projections; single dorsal madreporite; single ventral polian vesicle; branched gonad tubules.

Body wall ossicles massed wheels only, present dorsally and laterally, absent ventrally: average (37) wheel diameter 232 μm (range 192–248 μm); spokes thin, average 9 per wheel (7–10); wheel rim slightly angular rounded, not scalloped, rounded angles between spokes, flat across spokes; wheel hubs simple, lacking perforations, hub diameter 48 μm for wheel diameter 248 μm (20%), hub diameter 40 μm for wheel diameter 208 μm (19%); teeth distributed regularly around inner rim, all pointing towards hub, bluntly rounded, 2 sizes, longer teeth aligned with spokes, shorter teeth between spokes; for wheel diameter 240 μm longer teeth 40 μm, shorter teeth 32 μm; when 9 spokes 27 teeth (33%), when 8 spokes 24 teeth (33%). Tentacles lacking ossicles.

Colour. Off-white, translucent; tentacles each with brown lateral bands.

Distribution. Eastern Australia, off southern NSW, upper continental slope; 996 m.

Etymology. Named for Tania Bardsley (formerly of the Marine Science Section of Museum Victoria), in appreciation of her personal collaboration in my holothuroid research, and her significant contribuiton to marine science systematics.

Remarks. *Prototrochus taniae* O'Loughlin sp. nov. is based on 1 complete and 5 small part-specimens. The symmetrical calcareous ring, with single long anterior projection on each plate, and 10 tentacles, wheels with evenly distributed teeth pointing towards the hub, and absence of rod ossicles, identify the new species as a *Prototrochus* Beljaev and Mironov, 1982. The angular rounded wheel rims, and 2 sizes of teeth, the longer teeth aligned with spokes, distinguish *P. taniae* sp. nov. from *P. australis* (Beljaev and Mironov), *P. burni* sp. nov. and *P. staplesi* sp. nov(Table 1). In the SEM images of the larger wheels in *P. taniae* Didier observed rare ones with rounded rims and subequal teeth, but the wheels were predominantly as described and illustrated with longer teeth over the spokes. Beljaev and Mironov (1981) reported no such character. Rare small wheels were observed in the SEM images of the paratype of *P. taniae*, some with a rim like *P. staplesi* sp. nov. and with more numerous spokes. The

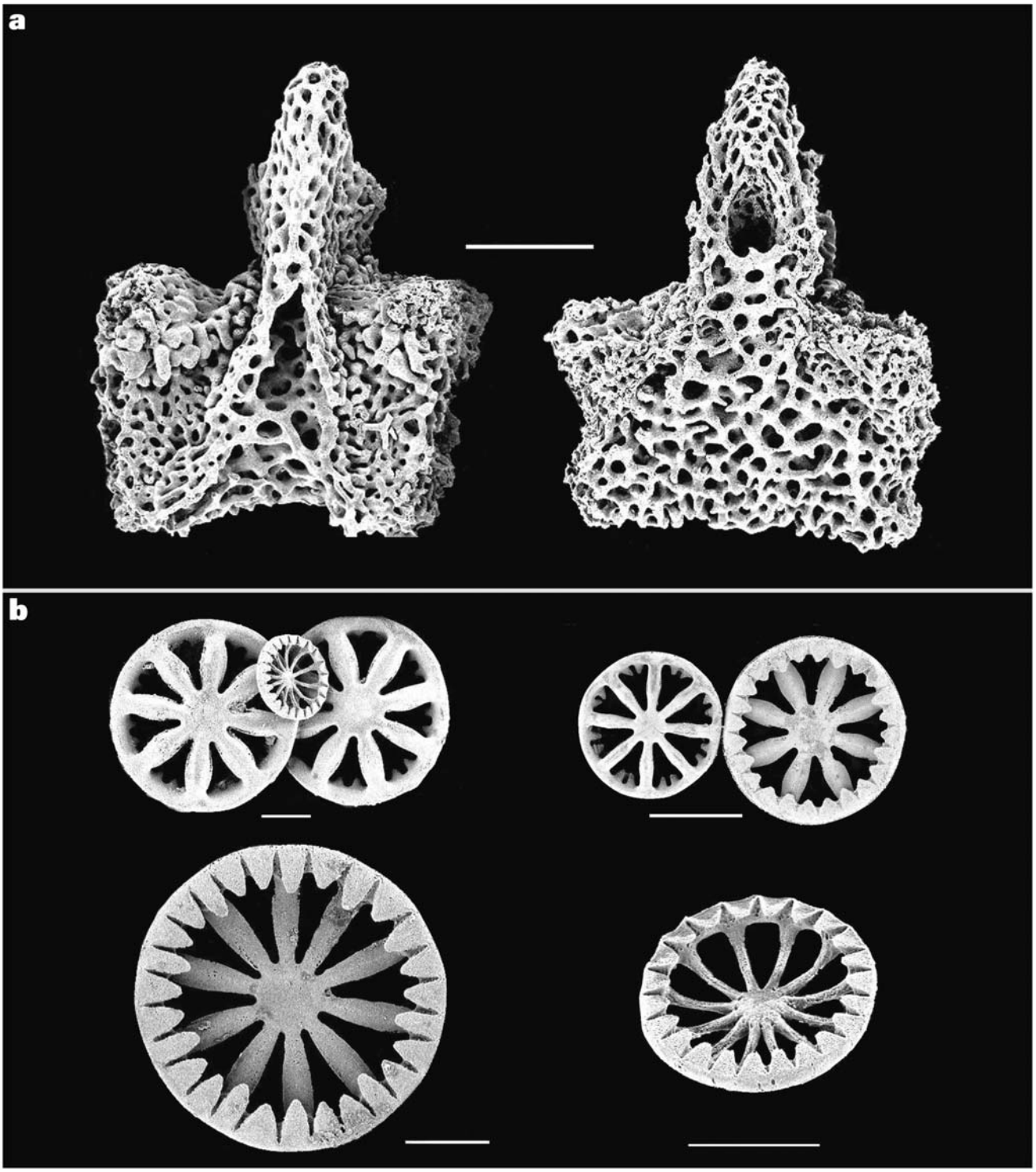

Figure 11. *Prototrochus taniae* O'Loughlin sp. nov., paratype NMV F59192 (SEM by Didier VandenSpiegel). a, radial plates of calcareous ring with canal (outer view left, inner view right; scale bar 100 μm); b, wheels from body wall (scale bars 50 μm except bottom right bar 20 μm).

diagnosis here is based on large wheel comparisons. The lengths of the wheel teeth in the description above were measured to the edge of the rim (for wheel diameter 240 μm longer teeth 40 μm, shorter teeth 32 μm). The SEM measurements (average 21.0 μm) were measured to the inner rim (see fig. 10d).

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