

The sea cucumbers of Camden Sound in northwest Australia, including four new species (Echinodermata: Holothuroidea)

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Abstract

O'Loughlin P.M., Harding, C. & Paulay, G. 2016. The sea cucumbers of Camden Sound in northwest Australia, including four new species (Echinodermata: Holothuroidea). *Memoirs of Museum Victoria* 75: 7–52.

All sea cucumbers collected from Camden Sound by the *Kimberley Marine Research Program* in 2015 are reported, with live colour illustrations of the species. Four new species are described, with O'Loughlin as author: *Holothuria (Metriatyla) keesingi*; *Neothyonidium(?) insolitum*; *Plesiocolochirus minaeus*; *Protankyra torquea*. *Colochirus quadrangularis* Troschel, the type species of *Colochirus* Troschel, is reviewed and a *sensu stricto* diagnosis is provided for *Colochirus*. *Plesiocolochirus spinosus* (Quoy & Gaimard), the type species of *Plesiocolochirus* Cherbonnier, is reviewed and a *sensu stricto* diagnosis is provided for *Plesiocolochirus*. *Colochirus robustus* Östergren is confirmed for NW Australia, but not for Camden Sound. *Pseudocolochirus axiologus* (H. L. Clark) is raised out of synonymy with *Pseudocolochirus violaceus* (Théel). *Thyone papuensis* Théel is reported from Camden Sound and the species is reviewed and illustrated. We report *Thyone pedata* Semper from Joseph Bonaparte Gulf in northern Australia, but not for Camden Sound. The WA Naturalists Club visited “Camden Harbour” in 1990 and Marsh reported on the marine invertebrates. Two sea cucumber species from this report are included here. A phylogenetic tree is provided with sequences for species of *Colochirus* and *Plesiocolochirus*. A table is provided with a list of all sea cucumbers collected from Camden Sound. Tissue samples for genetic analysis were taken from all specimens, and tissue data are listed in two tables. Two Pilumnidae crabs were found in the coelom of the new species *Plesiocolochirus minaeus*.

Keywords

Kimberley; Camden Sound; *Colochirus*; *Metriatyla*; *Neothyonidium*; Pilumnidae; *Plesiocolochirus*; *Protankyra*; *Pseudocolochirus*; *Thyone*.

Introduction

Camden Sound, in the Kimberley Region of northwest Western Australia, is southwest of Augustus Island (-15.40 124.63) and west of Kuri Bay and Brecknock Harbour (“Camden Harbour”). In 2012 the Western Australia State Government created the *Camden Sound Marine Park*. Subsequently the *Western Australian Marine Science Institution* informs the management and monitoring of the Region through the *Kimberley Marine Research Program*. A ship-based expedition to Camden Sound was conducted in March 2015 under the auspices of WAMSI's Kimberley Benthic Biodiversity Project using AIMS's RV *Solander* and CSIRO's RV *Linnaeus*. All holothuroid echinoderm (sea cucumber) specimens were sent to Museum Victoria for determination, and the collection is the subject of this report. Colour photographs of live sea cucumber specimens were taken

during the KMRP expedition, principally by John Keesing (CSIRO), and photographs of all the species are published in this work. The Camden Sound sea cucumber collections are lodged in the Western Australian Museum.

The WA Naturalists Club visited “Camden Harbour” in 1990. Marsh (2011) reported on the marine invertebrates. Holothuroid species from Adele Island and Montgomery Reef were reported but both locations are remote from Camden Sound. The two species collected from Slate Island at the southern edge of Camden Sound are included in this work: *Holothuria (Halodeima) atra* Jaeger, 1833; *Holothuria (Mertensiothuria) leucospilota* (Brandt, 1835).

We note that the ICZN (Opinion 417, 42 pp., 1956) rejected for nomenclatorial purposes the publication by Oken 1815, and as a consequence the genera *Psolus* Oken, 1815 and *Thyone* Oken, 1815 became invalid. The Commission has now ruled in

Table 1. Sea cucumber species collected from Camden Sound.

Order	Family	Subfamily	Taxon
Aspidochirotida	Holothuriidae		¹ <i>Holothuria (Halodeima) atra</i> Jaeger, 1833 (Slate Island; WAM Z58692)
			¹ <i>Holothuria (Mertensiothuria) leucospilota</i> (Brandt, 1835) (Slate Island; WAM Z58735)
			<i>Holothuria (Metriatyla) keesingi</i> O'Loughlin sp. nov.
			<i>Holothuria (Thymiosycia) gracilis</i> Semper, 1868
	Stichopodidae		<i>Stichopus</i> unresolved species complex including <i>Stichopus herrmanni</i> Semper, 1868
Dendrochirotida	Cladolabidae		<i>Globosita elnazae</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel 2014)
	Cucumariidae	Colochirinae	<i>Cercodemus anceps</i> Selenka, 1867
			<i>Colochirus quadrangularis</i> Troschel, 1846
			<i>Leptopentacta grisea</i> H. L. Clark, 1938
			<i>Plesiocolochirus</i> sp. 1, unresolved species complex including <i>P. australis</i> (Ludwig, 1875)
			<i>Plesiocolochirus minaeus</i> O'Loughlin sp. nov.
			<i>Pseudocolochirus axiologus</i> (H. L. Clark, 1914)
	Phyllophoridae		<i>Phyllophorus (Urodemella) holothurioides</i> Ludwig, 1875
			<i>Phyllophorella spiculata</i> (Chang, 1935)
	Sclerodactylidae		<i>Havelockia versicolor</i> (Semper, 1867)
	Thyonidae	Semperiellinae	<i>Massinium bonapartum</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
			<i>Neothyonidium(?) insolitum</i> O'Loughlin sp. nov.
		Thyoninae	<i>Hemithyone semperi</i> (Bell, 1884)
			<i>Stolus canescens</i> (Semper, 1867)
			<i>Thyone papuensis</i> Théel, 1886
	Thyonidiidae		<i>Actinocucumis longipedes</i> H. L. Clark, 1938
			<i>Actinocucumis solanderi</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
			<i>Actinocucumis typica</i> Ludwig, 1875
			<i>Mensamaria intercedens</i> (Lampert, 1885)
Molpadida	Molpadiidae		<i>Molpadia scabrum</i> (Sluiter, 1901)
Synaptida	Synaptidae	Rynkatorpinae	<i>Protankyra insolens</i> (Théel, 1886)
			<i>Protankyra torquea</i> O'Loughlin sp. nov.
			<i>Protankyra verrilli</i> (Théel, 1886)
			Synaptinae
			<i>Synaptula recta</i> (Semper, 1867)

¹WAM specimens collected at Slate Island by WANC in July 1990, and reported by Marsh (2011).

favour of their availability (Opinion 2367) in response to an application to the ICZN by Paulay & O'Loughlin (Case 3598) for both *Psolus* Oken, 1815 and *Thyone* Oken, 1815 to be made available.

Abbreviations

AIMS Australian Institute of Marine Science
 CSIRO Commonwealth Scientific and Industrial Research Organization
 GA Geoscience Australia

KMRP Kimberley Marine Research Project
 LKCNHM Lee Kong Chian Natural History Museum
 MOL AF Prefix for code number of tissues provided to the University of Florida for sequencing
 MRAC Royal Museum for Central Africa, Tervuren
 NMV Museum Victoria, with specimen registration prefix F
 NUS National University of Singapore
 PH University of the Philippines
 PMCP Pilbara Marine Conservation Program

TMSI	Tropical Marine Science Institute (Singapore)
UF	University of Florida
USNM	United States National Museum (Smithsonian Institution)
WAM	Western Australian Museum, with specimen registration prefix Z
WAMSI	Western Australian Marine Science Institution
WANC	The Western Australian Naturalists Club
ZRC	Zoological Reference Collection of LKCNHM
ZRC.ECH	LKCNHM catalogue number prefix (echinoderms)

Methods.

All specimens were preserved in 100% ethanol on the vessel by WAM staff, and databasing and weighing of specimens was done by CSIRO. The colour photos of live specimens published here were taken at the time of collection, principally by John Keesing (CSIRO) using a Nikon D300 digital SLR camera. Some specimens were photographed without a scale. We have estimated that there is about 25% shrinkage of soft-bodied specimens when preserved in 100% ethanol, and no shrinkage in hard-bodied specimens. We have thus been able to provide an estimated live colour size in the captions when there is no scale bar for the live photos of the now preserved specimens. Most of the macro images of preserved specimens were taken by Caroline Harding, with Mark O'Loughlin, using a Canon 5D mark ii camera mounted on a camlift Visionary Digital auto stepper. A Zerene Image Stacker, Adobe Lightroom and Photoshop were used for image processing and editing. Macro images of the preserved holotype of *Neothyonidium(?) insolitum* were taken by Melanie Mackenzie (NMV) with a Leica DC500 high resolution digital camera system with Auto Montage software. The photos of ossicles were taken by Caroline Harding, with Mark O'Loughlin, using a LEICA DM5000 B microscope, Leica application software, and Helicon Focus montage software.

Tissues were sent to Gustav Paulay (UF) for sequencing, and specimen source locations, tissue codes, catalogue numbers and GenBank Accession numbers are recorded in Appendices 1 and 2. A 655 bp portion of the mitochondrial gene cytochrome oxidase subunit 1 (COI) was sequenced from selected specimens using the echinoderm barcoding primers COIceF (5'-ACTGCCACGCCCTAGTAATGATATTTTTT ATGGTNATGCC-3') and COIceR (5'-TCGTGTGTCTACGT CCATTCTACTGTRACATRTG-3') (Hoareau & Boissin 2010), as described in Michonneau & Paulay 2014. We note that these echinoderm specific primers amplify positions 242 to 898 in COI compared with positions 74 to 733 amplified by Folmer primers. COI sequences were aligned by eye and analyzed using Maximum Likelihood with 100 bootstrap replicates, implemented in MEGA 6.06 (Tamura *et al.* 2013). Sequences have been submitted to GenBank (See Appendix 2).

Terminology.

For small concave plates, with two large central and two smaller distal perforations, and sometimes with additional small outer perforations, we use the term bowl, not cup or basket.

Order **Aspidochirotida** Grube, 1840

Holothuriidae Burmeister, 1837

Holothuria (*Metriatyla*) Rowe, 1969

Holothuria (*Metriatyla*) *keesingi* O'Loughlin sp. nov.

Zoobank *LSID*. <http://zoobank.org/urn:lsid:zoobank.org:act:ED316CAC-695D-4EB7-97DD-8999F2CD33CF>

Table 1; appendix 1; figures 2a, b, 3, 4

Material examined. Holotype. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002938, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89006.

Paratypes. Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_107, WAM station no 1, barcode 10000043, from -15.514826 124.183111 46 m to -15.514503 124.183774 45 m, 14 Mar 2015, WAM Z89000 (1 specimen); RV *Solander*, sled, site no SOL_8, WAM station no 7, barcode 10000403, from -15.313929 124.112518 47 m to -15.313336 124.111992 48 m, 16 Mar 2015, WAM Z89001 (3); RV *Solander*, sled, site no LIN_36, WAM station no 17, barcode 10001168, from -15.220444 124.320894 50 m to -15.220159 124.320648 50 m, 18 Mar 2015, WAM Z89002 (2); RV *Solander*, sled, site no SOL_32, WAM station no 19, barcode 10001320, from -15.253592 124.203038 45 m to -15.253318 124.202302 45 m, 19 Mar 2015, WAM Z89003 (1); RV *Solander*, sled, site no SOL_24, WAM station no 23, barcode 10001821, from -15.40642783 124.1259284 42 m to -15.40693704 124.1253687 42 m, 20 Mar 2015, WAM Z89004 (2); RV *Solander*, sled, site no SOL_87, WAM station no 24, barcode 10001954, from -15.448727 124.153629 36 m to -15.44933 124.154105 36 m, 20 Mar 2015, WAM Z89005 (2); RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002963, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89007 (1).

Description (*preserved in 95% ethanol*). Up to 60 mm long, 18 mm wide, 12 mm high; body surface finely nodulose; body arched dorsally, with rounded ventro-lateral margins, low convex ventrally; strongly tapered anteriorly and posteriorly; dorsal and lateral papillae irregularly distributed, conical, with tapered to pointed ends, of variable sizes, up to 3 mm long; about eight papillae across body transversely, longest on dorso-lateral radii, about 40 ventro-lateral papillae in close irregular series on each margin; tube feet digitiform, up to 2 mm long, scattered on ventrum but in recognizable irregular longitudinal series, paired irregular series latero-ventrally, paired irregular series on each side of bare mid-ventrum; mouth antero-ventral, with 20 tentacles, mouth surrounded by a ring of about 16 conical papillae, up to 1 mm long; calcareous ring solid, widths of radial and inter-radial plates sub-equal, inter-radials half the height of the radials, with undulating posterior edge, lacking posterior prolongations.

Body wall ossicles large tables and buttons, buttons more abundant than tables; table discs of variable size, shallow concave, irregularly round to rounded square to oval, margin smooth, discs 48–240 μ m across, disc perforations from 8 to more than 50, perforations very small marginally; table spires of variable height, up to 176 μ m long, 4 pillars, up to 8 cross bridges, spire rounded distally with cluster of small spinelets, sometimes spinelets extend along distal sides of spire; buttons

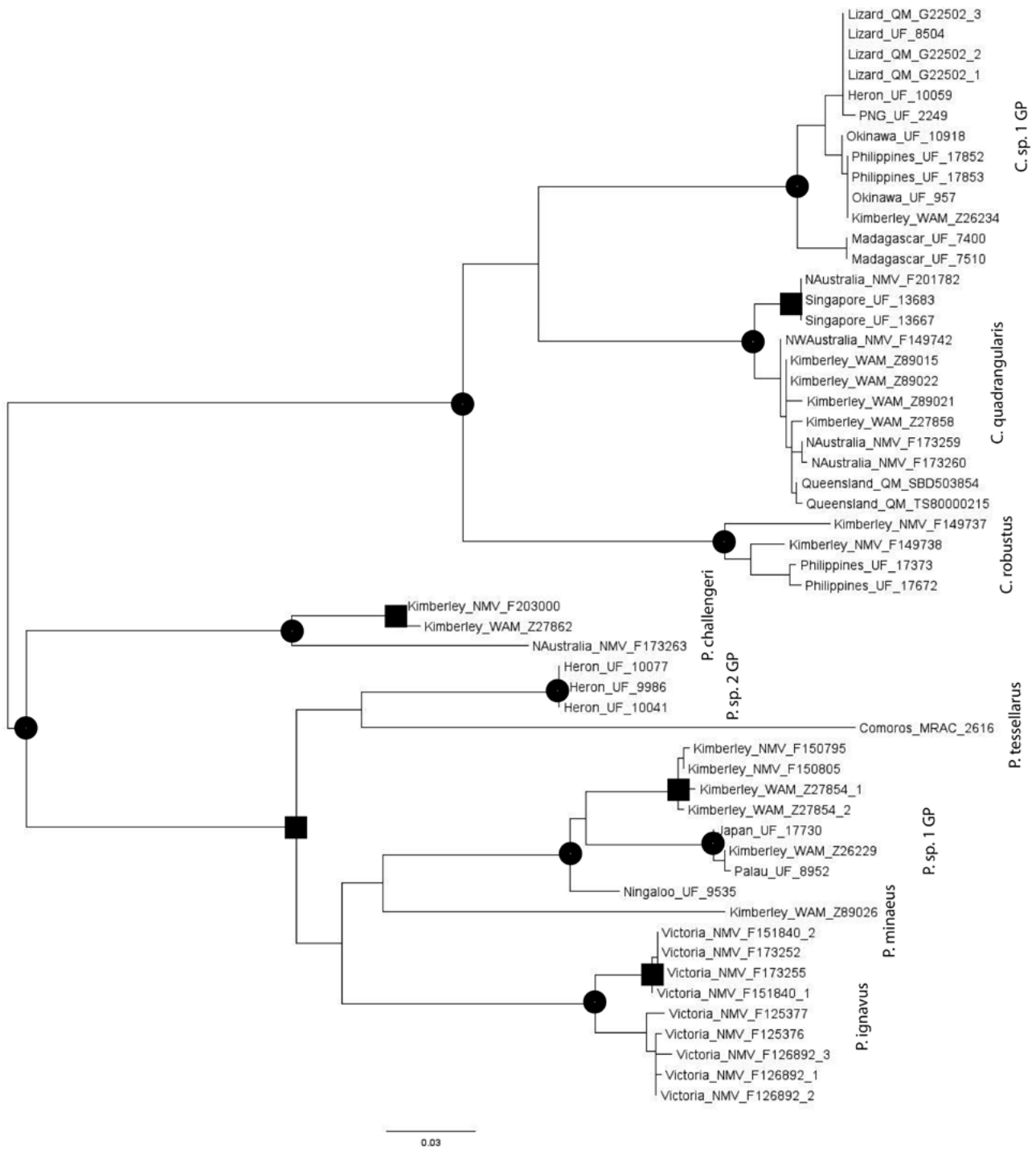


Figure 1. Maximum likelihood tree of *Colochirus*-*Plesiocolochirus* COI data, with mid-point rooting. Bootstrap support (100 replicates) indicated by circles (100%) and rectangles (>95%).

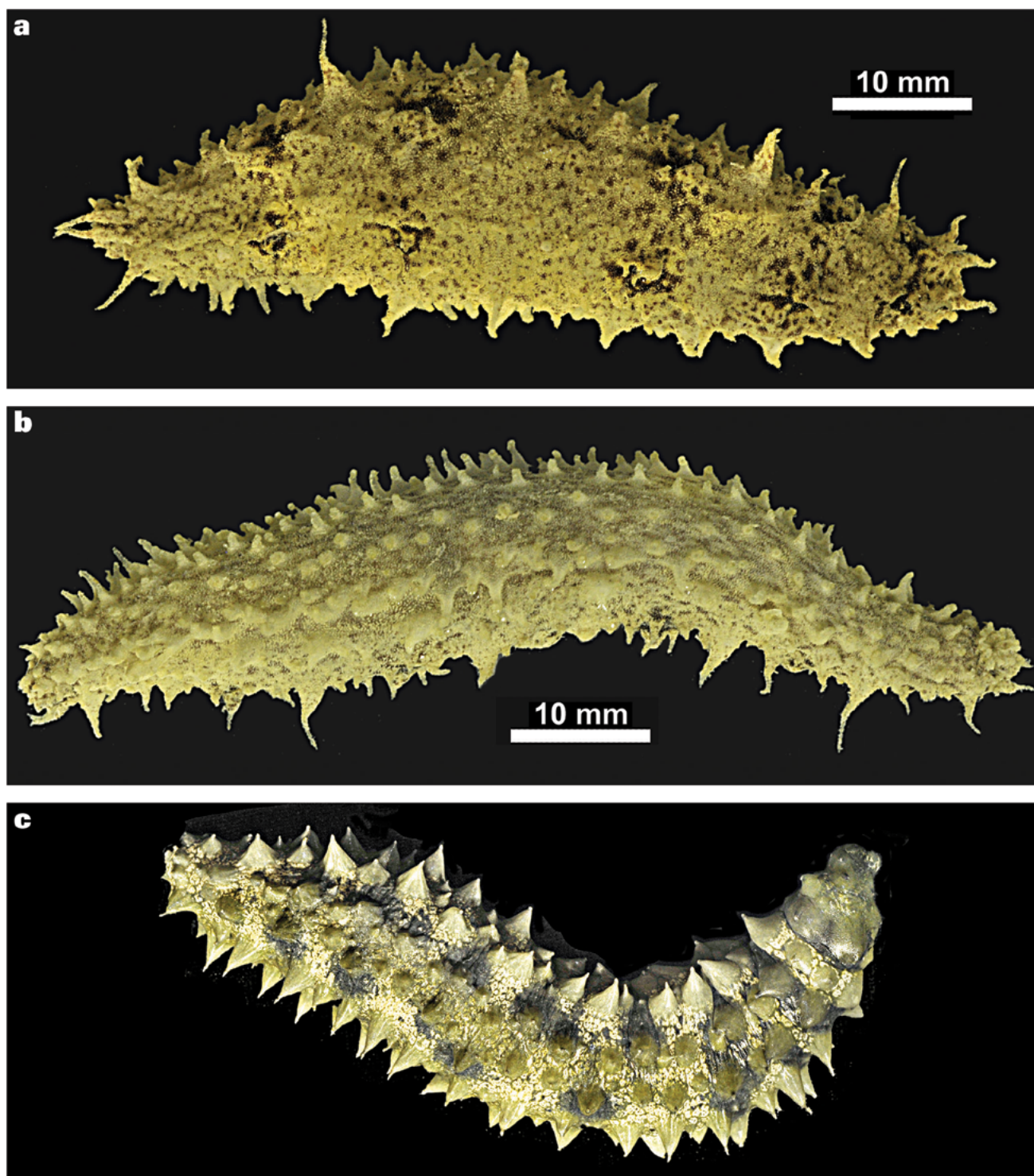


Figure 2. a, b, photos of live holotype specimen of *Holothuria (Metriatyla) keesingi* O'Loughlin sp. nov. (WAM Z89006): a, dorso view; b, latero-ventral view with ventrum and tube feet along upper side, dorsal papilla underneath. c, photo of dorsal view of live specimen of *Holothuria (Thymiosycia) gracilis* Semper, 1868 (WAM Z89008; estimated 125 mm long live).

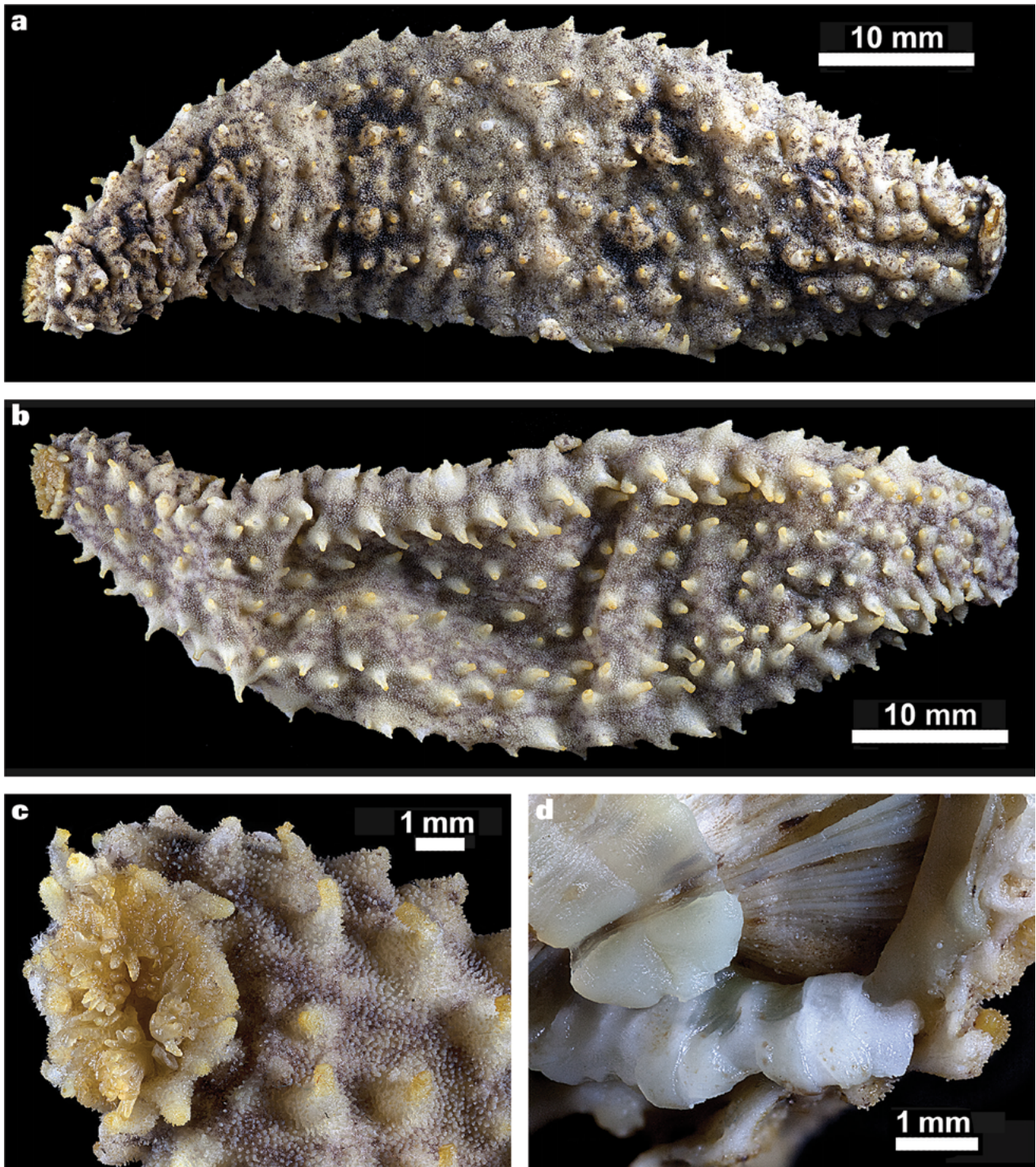


Figure 3. Preserved holotype of *Holothuria (Metriatyla) keesingi* O'Loughlin sp. nov. (WAM Z89006): a, dorsal view; b, ventral view; c, tentacles with surrounding ring of papillae; d, calcareous ring with radial plate right, inter-radial plate left.

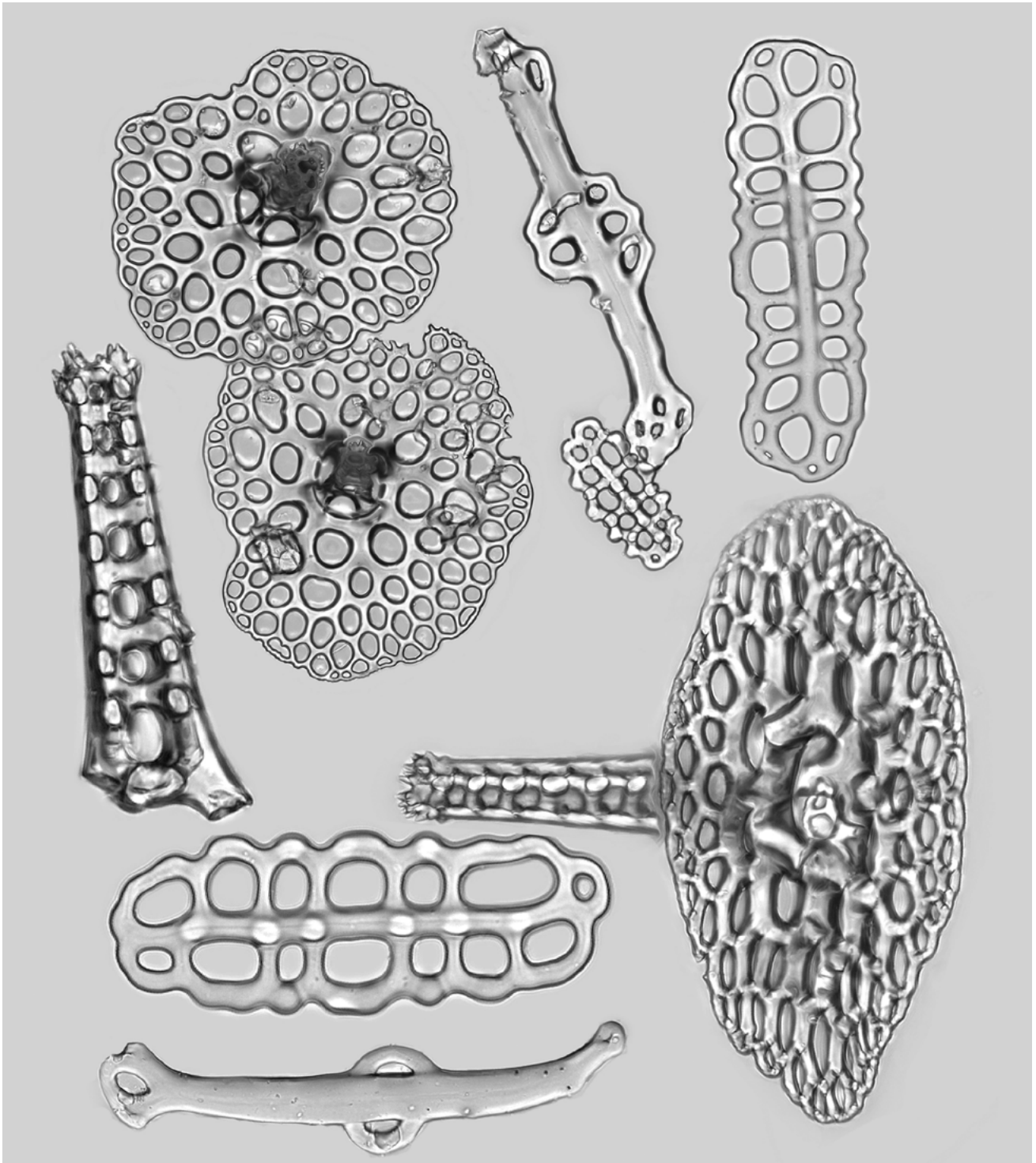


Figure 4. Ossicles from holotype (WAM Z89006; rods and small button mid-top and bottom) and paratype (WAM Z89005; tables, buttons) specimens of *Holothuria (Metriatyla) keesingi* O'Loughlin sp. nov. (in specimens table discs up to 240 μm across; table spires up to 176 μm long; buttons up to 200 μm long; rods up to 336 μm long).

predominantly elongate with up to about 7 irregularly paired perforations, some buttons with 1–3 pairs of perforations, button sizes 50–200 μm long, buttons smooth and variably knobbed. Dorsal papillae with tables, buttons and thick perforated rods; rods thick, mid-rod widened with perforations, distal ends widened with small perforations, rods up to 336 μm long. Ventral tube feet with endplates, thick endplate support rods, tables and buttons; endplates slightly convex, central perforations slightly larger, margin bluntly digitiform, endplate diameters about 300 μm ; thick rods curved, widened and perforated mid-rod and distally, up to 264 μm long. Tentacles with minutely spinous, non-perforate, curved rods, rods up to 320 μm long.

Colour (preserved). Body pale mottled brown to off-white, dorsal and lateral irregular fine brown-black flecks and spots, about 4 dorso-lateral pairs of large irregular brown-black patches that are partly merged at the anterior end; tentacles and distal papillae and tube feet yellow. Live colour similar but the body base colour yellow.

Distribution. NW Western Australia, Kimberley Region, Camden Sound, mud, 35–50 m.

Etymology. Named for John Keesing of the CSIRO Oceans and Atmosphere, and The Western Australian Marine Science Institution, with appreciation of his live colour photography of Camden Sound sea cucumbers used in this work, and his gracious collaboration with data.

Remarks. The morphology of *Holothuria (Metriatyla) keesingi* O'Loughlin sp. nov. satisfies the diagnosis of the *Holothuria* sub-genus *Metriatyla* Rowe, 1969:

1. 20 tentacles;
2. collar of papillae around the base of the tentacles;
3. large conical, irregularly arranged papillae dorsally, a lateral flange sometimes evident;
4. tube feet irregularly arranged on the ventrum;
5. body arched dorsally, flattened ventrally;
6. size small to large;
7. body wall thin to thick;
8. calcareous ring well developed;
9. table ossicles with smooth disc and spire of moderate height to high, terminating in a few to many small spines;
10. buttons simple, with moderate-sized irregularly arranged knobs and 3–10 pairs of relatively large holes.

We qualify the diagnostic characters of Rowe (1969) to include the possibility of species with a large body and thick body wall (as in *Holothuria (Metriatyla) scabra* Jaeger, 1833).

Rowe (in Rowe & Gates 1995) synonymised *Holothuria bowensis* Ludwig, 1875 (type from Bowen, NE Australia) and *Holothuria subverta* H. L. Clark, 1921 (type from Torres Strait, NE Australia) with *Holothuria (Metriatyla) martensii* Semper, 1868 (type from Amboina, Indonesia). Of the species referred to sub-genus *Metriatyla*, the new species resembles

Holothuria (Metriatyla) martensii. However, the new species *Holothuria (Metriatyla) keesingi* O'Loughlin is significantly different in the following ways:

1. smaller species with numerous preserved specimens up to only 60 mm long;
2. preserved colour with yellow papilla and tube foot and tentacle ends, and dorsal body with four irregular longitudinal paired dark brown patches;
3. larger tables, with discs up to more than 200 μm across, disc perforations up to more than 40, spires up to more than 150 μm high;
4. larger smooth and knobbed buttons, predominantly about 7 irregular pairs of perforations, up to 200 μm long.

Théel (1886) referred two specimens to *Holothuria (Metriatyla) martensii*, one from Indonesia and one from the Philippines. Sizes were 150 mm and 85 mm long. Buttons were up to 140 μm long. Table disc perforations were fewer than 30. Colours are described with no reference to brown dorsal patches. These morphological characters of *Holothuria (Metriatyla) martensii* (*sensu* Théel 1886) are significantly different to those of *Holothuria (Metriatyla) keesingi* O'Loughlin sp. nov.

The buttons in *H. (Metriatyla) horrida* Massin, 1987 are similar to those in *Holothuria (Metriatyla) keesingi* O'Loughlin. And the high table spires of *H. (Metriatyla) horrida* are also similar but significantly shorter (up to 120 μm long). The table discs in *H. (Metriatyla) horrida* are significantly smaller (up to 140 μm across), the table disc perforations significantly fewer (up to 16), and the colour reported as grey.

Frank Rowe (*pers. comm.*) suggested that the size and form of the ossicles in the relatively small specimens appear somewhat paedomorphic. But the mature gonads that are present confirm that the specimens are adult.

Holothuria (Thymiosycia) gracilis Semper, 1868

Table 1; appendix 1; figure 2c

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, Ngalanguru Island, 25 Mar 2015, WAM Z89008 (1).

Remarks. This species identity was established by François Michonneau (UF, *pers. comm.*).

Stichopodidae Haeckel, 1896

Stichopus sp.

Table 1; appendix 1; figure 5

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, Montgomery Island reef flat, barcode 10003037, 24 Mar 2015, WAM Z89009 (1); barcode 10003038, 24 Mar 2015, WAM Z89010 (1).

Remarks. The taxonomy of *Stichopus* is challenging today. Based on the living appearance of this animal it could represent *Stichopus horrens* Selenka, 1867, or a specimen in the

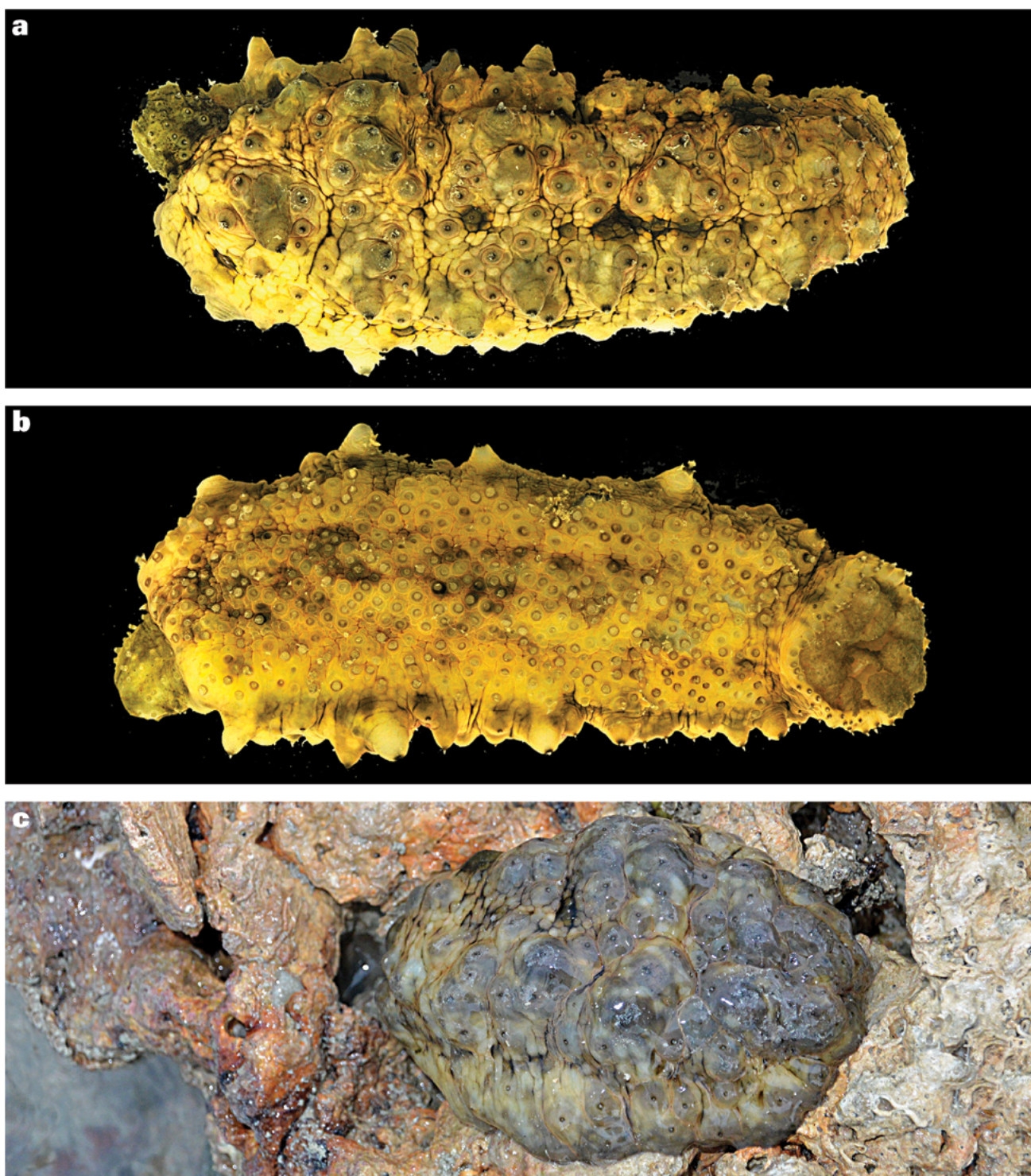


Figure 5. Photos of live specimen belonging to a *Stichopus* unresolved species complex (WAM Z89009; estimated 110 mm long live): a, dorsal view; b, ventral view; c, *in situ* view.

S. monotuberculatus (Quoy & Gaimard, 1834) or *S. herrmanni* Semper, 1868 species complexes. Specimens from NW Australia identified by Mark O'Loughlin previously as *Stichopus herrmanni* are now revised to “*Stichopus* unresolved species complex”.

Order **Dendrochirotida** Grube, 1840

Family **Cladolabidae** Heding & Panning, 1954 *sensu* Smirnov 2012

Remarks. See O'Loughlin, Mackenzie & VandenSpiegel 2014.

Globosita Cherbonnier, 1958

Remarks. See O'Loughlin, Mackenzie & VandenSpiegel 2014.

Globosita elnaza O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel 2014)

Table 1; appendix 1; figures 6a, b

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_116a, WAM station no 18, barcode 10001261, from -15.261423 124.275183 41 m to -15.261716 124.275827 40 m, 18 Mar 2015, WAM Z89011 (1); same data, barcode 10001262, WAM Z89012 (1).

Family **Cucumariidae** Ludwig, 1894

Diagnosis (after Smirnov 2012). Ten dendritic tentacles; calcareous ring lacking segmented posterior prolongations; tube feet most commonly restricted to the radii, or may also be scattered in the dorsal and lateral inter-radii; ossicles in body wall perforated plates, sometimes rods, sometimes bowls, never tables.

Subfamily **Colochirinae** Panning, 1949

Diagnosis. Cucumariidae with plate and bowl ossicles.

Cercodemus Selenka, 1867

Cercodemus Selenka, 1867: 343.—Rowe (in Rowe & Gates), 1995: 271.

Remarks. Rowe (in Rowe & Gates 1995) raised genus *Cercodemus* out of synonymy.

Cercodemus anceps Selenka, 1867

Table 1; appendix 1; figures 6c, d

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_43, WAM station no 26, barcode 10002087, from -15.488461 124.201824 46 m to -15.488309 124.201113 46 m, 21 Mar 2015, WAM Z89013 (1).

Remarks. We note that in relation to *Colochirus* Troschel, 1846 (below) and *Plesiocolochirus* Cherbonnier, 1946 (below), the monotypic *Cercodemus* Selenka, 1867 has body wall ossicles comprising deep bowls, deep bowls bridged over rim to create hollow ellipsoids, and multi-layered scales, but lacks shallow bowls and knobbed buttons.

Colochirus Troschel, 1846

Figure 1; appendices 1, 2

Colochirus Troschel, 1846: 64.—Semper, 1867: 56.—Ekman, 1918: 5–6.—Panning, 1949: 439.—Panning, 1971: 42–43, fig. 5.—Liao & Clark, 1995: 474.—Rowe (in Rowe & Gates), 1995: 272.

Type species. *Colochirus quadrangularis* Troschel, 1846 (monotypy)

Other currently assigned, accepted species (with type locality added). *Colochirus crassus* Ekman, 1918 (NW Australia; junior synonym *Colochirus quadrangularis* var. *australoides* Panning, 1949 by Rowe in Rowe & Gates 1995); *C. cylindricus* Semper, 1867 (Philippines); *C. pusillus* Helfer, 1912 (Gulf of Suez); *C. robustus* Östergren, 1898 (S Korea; junior synonym *Colochirus squamatus* Sluiter, 1901 by Rowe in Rowe & Gates 1995).

Diagnosis (sensu stricto, based on type species only, described below). Body quadrangular in mid-body section, slightly tapered towards oral and anal ends; body and papillae firm, densely packed with ossicles; preserved length up to 98 mm, dorsal and ventro-lateral radii slightly raised, each with prominent, conical papillae in irregular zig-zag rows; five oral valves, each with a terminal papilla and sometimes 1 or 2 additional papillae; five anal scales, some small peri-anal papillae, 5 longer proximal anal radial papillae. Ten dendritic tentacles, 8 large, 2 ventral small. Calcareous ring plates not forked posteriorly, lacking posterior prolongations. Dorsal and lateral inter-radii lacking tube feet; tube feet in discrete bands in ventro-lateral and mid-ventral radii, each band about 4 podia wide, ventral inter-radii usually lacking tube feet, inter-radii similar in width to the radial bands of tube feet.

Ossicles of body wall of six recognizable but inter-grading forms:

1. small, shallow bowls, margin smooth to finely knobbed or finely spinous, variably bridged across margins or not;
2. abundant rounded-rectangular to oval to irregular shallow bowls, one short or long margin prominently spinous, bowls variably partly bridged or not;
3. some rounded-rectangular to oval larger shallow bowls, sometimes partly bridged;
4. larger shallow bowls bridged on one side to create smooth, hollow, irregular ellipsoids;
5. shallow bowls, frequently thick-walled, bridged to create irregular ellipsoids with inner bridging, not hollow;
6. enlarged inner-bridged ellipsoids inter-grade with multi-layered scales.

Tentacle ossicles rod-plates, rods, rosettes.

Remarks. Rowe (in Rowe & Gates 1995) restricted *Colochirus* to three assigned species *Colochirus crassus*, *C. quadrangularis* and *C. robustus*, leaving the status of *C. cylindricus*, *C. pusillus* and *C. viridis* Semper, 1867 (considered to be *nomen dubium*) as uncertain, as they were not assigned to other genera.

With the support of COI sequence data (Figure 1), we confirm Ekman's report (1918) of the occurrence of *Colochirus robustus* in NW Australia.

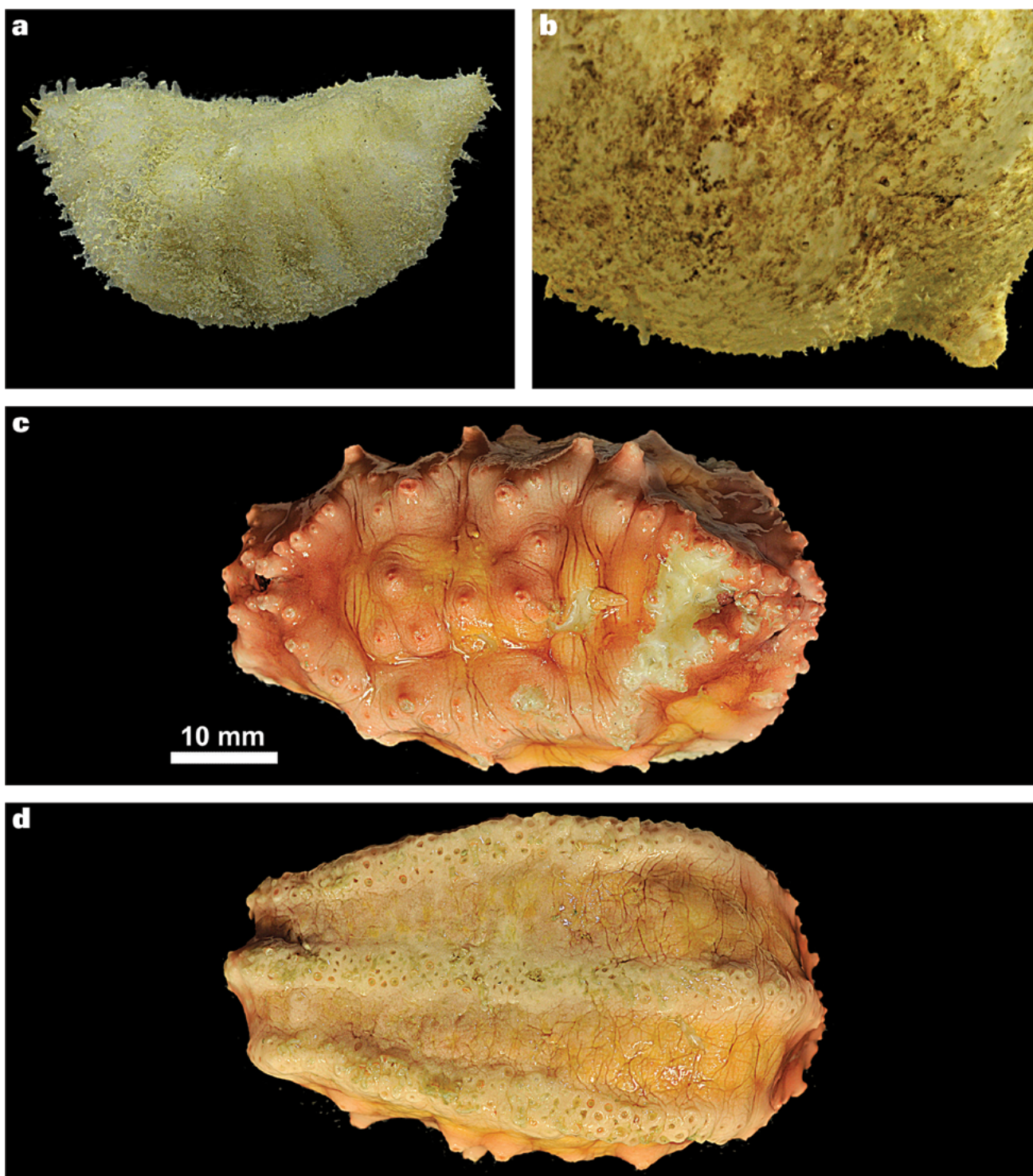


Figure 6. a, b, photos of live specimens of *Globosita elnaza* O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel 2014): a, lateral view (WAM Z89011; estimated 25 mm long live); b, posterior dorsal view (WAM Z89012; estimated 90 mm long live). c, d, photos of live specimen of *Cercodemus anceps* Selenka, 1867 (WAM Z89013): c, dorsal view; d, ventral view.

A phylogenetic analysis based on CO1 sequence data shows that species currently assigned to *Colochirus* and *Plesiocolochirus* fall in two well-supported clades (Figure 1). The *Colochirus* cluster includes *Colochirus quadrangularis* (from Singapore, near the type locality, and across tropical Australia), *Colochirus robustus* (from NW Australia and the Philippines), and *Colochirus* species 1 (from N Australia, Japan, the Philippines, and Madagascar). This unassigned species is morphologically close to specimens that have frequently been identified as *Plesiocolochirus australis* (Ludwig, 1875). After examining type material, Rowe (in Rowe & Gates 1995) synonymised *Colochirus minutus* Ludwig, 1875 with *Plesiocolochirus australis* (Ludwig, 1875). We hope to examine the type specimens of both of these species and then be in a position to assign the unidentified *Colochirus* species in a subsequent work.

Panning (1971) observed that some shallow bowls (up to 107 µm long) were bridged on both sides to create irregular ellipsoids with an inner shallow bowl layer, and thus not hollow. We have not been able to support this observation by Panning (1971) as all solid ellipsoids appear to be built up on the concave side only of the shallow bowls with the outer surface supported by an inner network. Shallow bowls bridged on one side only but without an inner bridging network create irregular hollow ellipsoids. We note that *Cercodemus anceps* Selenka, 1867 has deep bowls that may be bridged to create such more regular hollow ellipsoids.

Colochirus Troschel, 1846 (type species *Colochirus quadrangularis* Troschel, 1846, above) is distinguished *sensu stricto* from *Plesiocolochirus* Cherbonnier, 1946 (type species *Plesiocolochirus spinosus* (Quoy & Gaimard, 1834), below), by:

1. absence of large imbricating external scales on distal anal cone, on proximal oral valves, and on lateral papillae;
2. absence, usually, of inter-radial tube feet;
3. absence of knobbed single-layered button ossicles in the body wall;
4. presence of tentacle rosettes.

Colochirus quadrangularis Troschel, 1846

Table 1; appendices 1, 2; figures 1, 7, 8, 9

Colochirus quadrangularis Troschel, 1846: 64–66 (*non Holothuria quadrangularis* Lesson, 1830: 90–91, pl. 31 fig. 1).—Théel, 1886: 81–82, 120–121, pl. 6 fig. 7, pl. 14 figs 7, 8.—Erwe, 1913: 353–355, fig. 2a–g.—Ekman, 1918: 21–26, pl. 1 figs 7–10, pl. 3 figs 13–15.—Panning, 1949: 446–447, figs 46, 47.—Liao & Clark, 1995: 474–475, fig. 286.—Rowe (in Rowe & Gates), 1995: 272–273.

Colochirus coeruleus Semper, 1867: 59, pl. 11 fig. 1, pl. 13 fig. 18 (synonymy by H. L. Clark 1946).

Colochirus jagorii Semper, 1867: 60.—Panning, 1971: 42 (type locality Singapore; synonymy by Rowe (in Rowe & Gates) 1995).

Colochirus tristis Ludwig, 1875: 87–88 (type locality Zanzibar; synonymy of *Colochirus jagorii* by Panning 1971).

Pentacta quadrangularis.—H. L. Clark, 1946: 391.—Cannon & Silver, 1986: 30.

Pentacta coerulea.—H. L. Clark, 1932: 227.—H. L. Clark, 1938: 449–450, pl. 16 fig. 4.

Pentacta jagorii.—H. L. Clark, 1932: 228–229.—H. L. Clark, 1946: 391–392.

Pentacta coerulea var. *rubra* H. L. Clark, 1938: 451, pl. 16 fig. 5 (single specimen from Broome, NW Australia)

Type locality. Coast of Malacca (southern region of the Malay Peninsula, near Singapore).

Material examined. Singapore, Johor Strait, dredge, channel between Beting Bronok and Chek Jawa channel, 1.41 103.98 1.5–2.4 m, mud, coll. Tan Koh Siang *et al.*, 29 Jun 2011, NMV F210388 (1) (former registration ZRC.ECH.0208; donated to Museum Victoria); west end of Jurong island (composite new island), 1.22 103.67 23.1–24.4 m, dredge, rock, sand and mud, coll. Lim Swee Cheng *et al.*, 19 Dec 2013, NMV F210389 (1) (former registration SEA–3046; donated to Museum Victoria).

Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_107, WAM station no 1, barcode 10000001, from -15.514826 124.183111 46 m to -15.514503 124.183774 45 m, 14 Mar 2015, WAM Z89014 (1); RV *Solander*, sled, site no SOL_60, WAM station no 9, barcode 10000582, from -15.311436 124.162869 42 m to -15.311705 124.162473 42 m, 16 Mar 2015, WAM Z89015 (1); RV *Solander*, sled, site no SOL_60, WAM station no 9, barcode 10000647, from -15.311436 124.162869 42 m to -15.311705 124.162473 42 m, 16 Mar 2015, WAM Z89016 (1); RV *Solander*, sled, site no LIN_36, WAM station no 17, barcode 10001114, from -15.220444 124.320894 50 m to -15.220159 124.320648 50 m, 18 Mar 2015, WAM Z89017 (5); RV *Solander*, sled, site no SOL_32, WAM station no 19, barcode 10001331, from -15.253592 124.203038 45 m to -15.253318 124.202302 45 m, 19 Mar 2015, WAM Z89018 (6); RV *Solander*, sled, site no SOL_56, WAM station no 20, barcode 10001420, from -15.376537 124.192773 35 m to -15.376196 124.192071 35 m, 19 Mar 2015, WAM Z89019 (1); RV *Solander*, sled, site no SOL_84, WAM station no 21, barcode 10001560, from -15.414697 124.059193 36 m to -15.415001 124.059918 36 m, 20 Mar 2015, WAM Z89020 (1); RV *Solander*, sled, site no SOL_24, WAM station no 23, barcode 10001767, from -15.406428 124.125928 42 m to -15.406937 124.125369 42 m, 20 Mar 2015, WAM Z89021 (1); RV *Solander*, sled, site no SOL_160, WAM station no 25, barcode 10001971, from -15.428534 124.273164 17 m to -15.428908 124.273525 17 m, 21 Mar 2015, WAM Z89022 (2); RV *Solander*, sled, site no SOL_109a, WAM station no 33, barcode 10002500, from -15.711677 124.2303 25 m to -15.711054 124.229793 25 m, 23 Mar 2015, WAM Z89023 (1); RV *Solander*, sled, site no SOL_73, WAM station no 38, barcode 10002692, from -15.945442 124.366373 29 m to -15.945268 124.367171 28 m, 25 Mar 2015, WAM Z89024 (1); RV *Solander*, sled, site no SOL_69, WAM station no 41, barcode 10002871, from -15.747648 124.146502 43 m to -15.747285 124.14634 43 m, 26 Mar 2015, WAM Z89025 (1).

Joseph Bonaparte Gulf, cruise SOL 4934, station 33, sample 29024, -11.65 129.83 24 m, NMV F201791 (11) (tissue code MOL AF 1516); NMV F173258; NMV F173259; NMV F173260; NMV F173261; NMV F201781; NMV F201782; NMV F201788; NMV F201789; NMV F201790; NMV F201792; NMV F203004

Other Northern Australia, NMV F95253; NMV F95254; NMV F95255; NMV F95256; NMV F112191; NMV F112192; NMV F113573; NMV F113574; NMV F113575; NMV F113576; NMVF113577; NMVF113578; NMV F113579; NMV F113580; NMV F113581; NMV F149742.

Great Australian Bight, NMV F113582; NMV F199464.

Description. Body quadrangular in section, slightly tapered towards oral and anal ends, anal end slightly upturned, preserved body (excluding tentacles) up to 98 mm long, body surface with tessellated appearance or smooth; body and

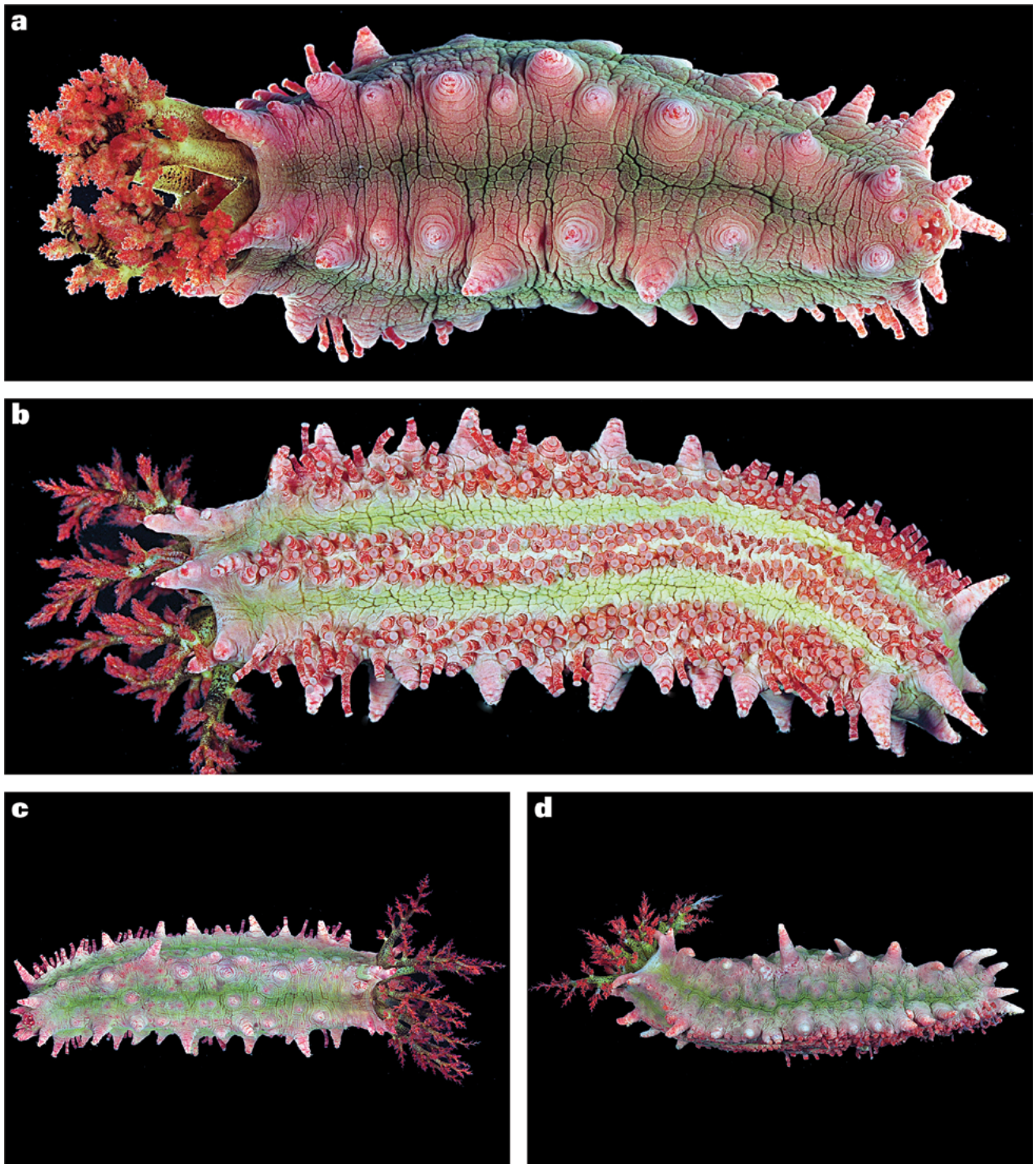


Figure 7. Photos of live specimens of *Colochirus quadrangularis* Troschel, 1846 from Singapore waters, provided by Helen Pei San Wong and Joo Yong Ong (TMSI of NUS; specimens estimated to be up to 60 mm long): a, dorsal view showing anal scales and absence of warts; b, ventral view; c, dorsal view showing warts; d, lateral view.

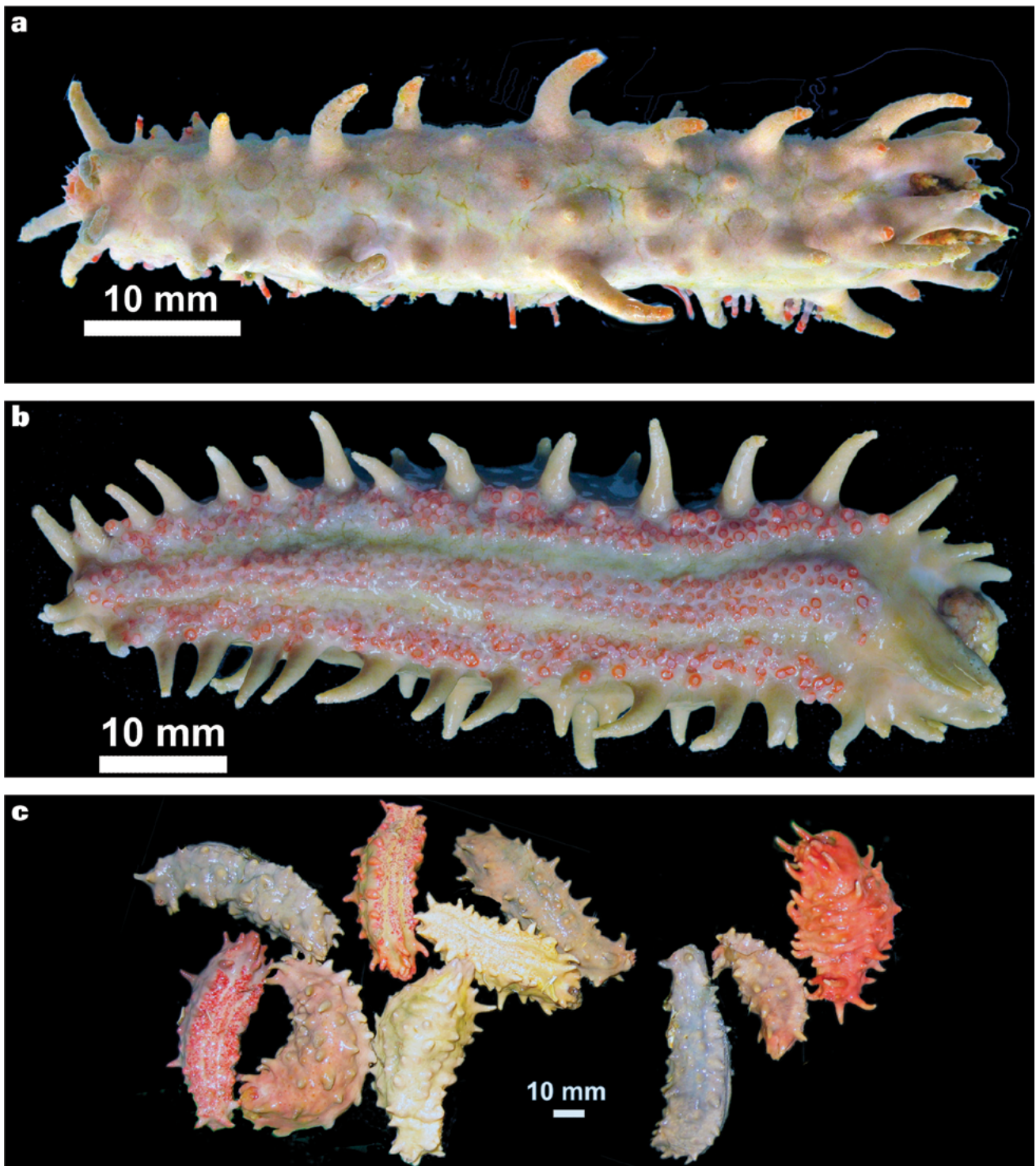


Figure 8. Photos of live specimens of *Colochirus quadrangularis* Troschel, 1846 from northern Australia: a, dorsal view (WAM Z89021, from Camden Sound); b, ventral view (WAM Z89015, from Camden Sound); c, colour morphs from Joseph Bonaparte Gulf (NMV F201791).

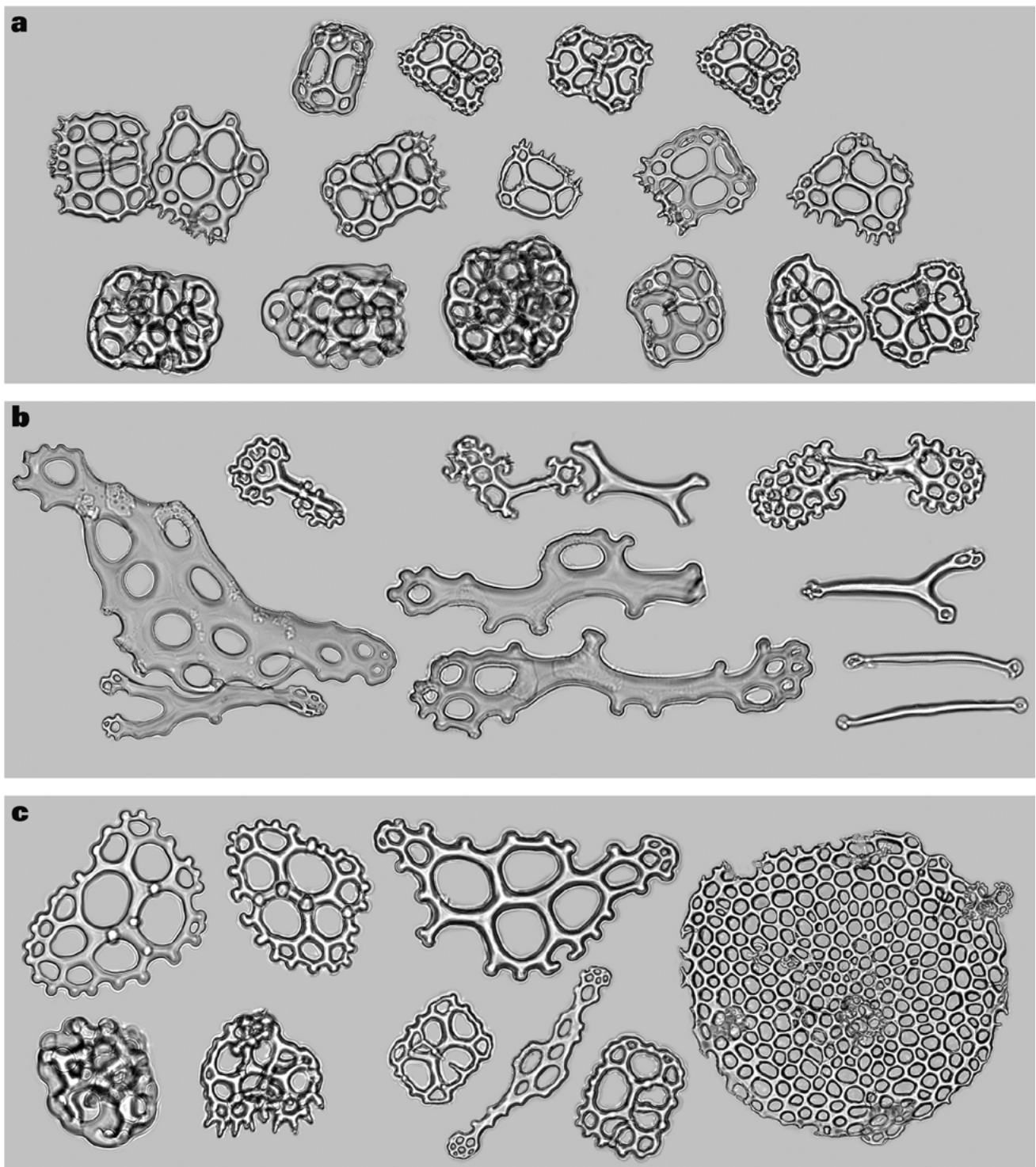


Figure 9. Ossicles from specimens of *Colochirus quadrangularis* Troschel, 1846 from Singapore: a, dorsal and peri-anal body wall bowls up to 56 μm long (three with single bridge) (top row), bowls with one spinous margin up to 80 μm long (three with single bridge) (middle row), hollow ellipsoids up to 88 μm long, and ellipsoids with inner bridges up to 88 μm long (bottom row) (from Singapore specimen NMV F210388); b, tentacle rods and rod-plates up to 440 μm long, rosettes up to 96 μm long (from NMV F210388); c, ventral tube foot endplate up to 400 μm diameter (right), support rod-plates up to 272 μm long, small bowls, spinous-edge bowl with bridging, and ellipsoid with internal bridging (bottom left) (from NMV F210389).

papillae firm, densely packed with ossicles; dorsal and ventro-lateral radii slightly raised, each with about 12 conical papillae in irregular zig-zag rows, papilla lengths variable up to about 10 mm long, papillae variably straight to curved, surmounted by tube feet ventro-laterally and sometimes dorsally, anterior and posterior ventral radii all with papillae; dorsal and lateral inter-radii slightly depressed, variably with or lacking scattered short conical or wart-like protuberances, lacking tube feet; 5 anterior oral valves, each with a terminal papilla and sometimes 1 or 2 additional papillae; 5 inner anal scales, some small peri-anal papillae, 5 longer proximal anal radial papillae; 10 dendritic tentacles, ventral 2 smaller; calcareous ring plates not forked posteriorly and lacking posterior prolongations; tube feet in discrete bands on ventral radii, each band about 4 wide, discrete inter-radii usually lacking tube feet, ventral inter-radii similar in width to the radial bands of tube feet.

Intergrading ossicle forms of dorsal mid-body wall (from NMV F210388):

1. on body wall surface, irregular oval to rounded-rectangular shallow bowls, long margins sometimes indented, four large central perforations, usually four small corner perforations, sometimes additional smaller marginal perforations, rim variably smooth or with fine knobs or fine blunt spines, bowls with or lacking bridges across rim, bowls up to rarely 56 μm long;
2. outer body wall, abundant rounded-rectangular to oval to irregular shallow bowls, four large central perforations, smaller peripheral perforations, one short or long margin prominently spinous, bowls variably partly bridged or not, up to 80 μm long;
3. inner body wall, some rounded-rectangular to oval shallow bowls, 4 large central perforations, smaller peripheral perforations, margin smooth, up to 96 μm long, sometimes partly bridged;
4. inner body wall, shallow bowls bridged on one side to create smooth, hollow irregular ellipsoids, up to 88 μm long;
5. inner body wall, shallow bowls, frequently thick-walled, bridged to create an upper surface and hollow ellipsoid, and inner-bridged irregular ellipsoids, not hollow, typically up to 88 μm long, rarely up to 136 μm long, some becoming enlarged and inter-grading with multi-layered scales;
6. underlying, multi-layered plates (scales), irregularly round to oval, up to at least 1.6 mm across/long.

Tentacle ossicles (from NMV F210388) elongate, thick, smooth, perforated rod-plates, curved and bent, up to 440 μm long; fine distally perforate rods; rosettes, up to 96 μm long.

Tube feet ossicles (from NMV F210389) endplates, uniform slightly irregular perforations, 400 μm diameter; endplate support rod-plates, narrow to elongate oval, to rounded triangular, smooth or knobbed, curved and bent, up to 272 μm long; spinous-edge bowls, variably bridged, as in dorsal body wall; shallow small bowls, variably knobbed, as in dorsal body wall; shallow larger bowls, margin and surface knobbed, two large and two smaller central perforations, smaller peripheral perforations, up to 88 μm long; hollow and inner-layered irregular ellipsoids as in dorsal body wall.

Live colour: radii and papillae variably red; dorsal and lateral inter-radii variably greenish; ventral inter-radii pale green; dendritic tentacles ends red; tentacle trunks greenish yellow with dark brown to black flecking; ventral tube feet red. Preserved colour: pale to dark grey.

Distribution. Through the tropical Indo-West-Pacific, from Zanzibar to Malaysia and Australia; 0–115 m (depth from Rowe & Gates 1995).

Remarks. We have observed specimens from Singapore waters that we judge to be *Colochirus quadrangularis*. Because of the proximal continuity of Singapore waters with those of the Straits of Malacca, we judge that the Singapore specimens are conspecific with those of the type locality. The live colour photos of *Colochirus quadrangularis* from Singapore waters that we have included here were provided for our work by our colleagues Wong Pei San Helen and Joo Yong Ong (NUS TMSI). The specimens studied here were donated to Museum Victoria by the Lee Kong Chian Natural History Museum in Singapore, the donation facilitated by our colleagues Wong Pei San Helen and Joo Yong Ong. The description above incorporates observations by these colleagues of 139 specimens of this species in the Lee Kong Chian Natural History Museum.

The conspicuous and distinctive ossicle form in the upper body wall of *Colochirus quadrangularis* is the irregular shallow sub-rectangular bowl with one strongly spinous edge.

Leptopentacta grisea H. L. Clark, 1938

Table 1; appendix 1; figure 10a

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Linnaeus*, sled, site no LIN_50, barcode 53713, from -15.37072 124.69674 9 m to -15.36572 124.6978 9 m, 16 Mar 2015, WAM Z89027.

Plesiocolochirus Cherbonnier, 1946

Figure 1; appendices 1, 2

Acolochirus H. L. Clark, 1946: 395.—Panning, 1971: 41 (synonymy by Rowe in Rowe & Gates 1995)

Apentacta H. L. Clark, 1946: 395 (synonymy by Panning 1971, and Clark & Rowe 1971)

Plesiocolochirus Cherbonnier, 1946: 286.—Panning, 1949: 448–449.—Panning, 1971: 42.—Rowe (in Rowe & Gates), 1995: 277.

Type species. *Plesiocolochirus spinosus* (Quoy & Gaimard, 1834) (original designation)

Type species locality. Eastern Australia, New South Wales, Port Jackson.

Other assigned species (with type locality added). *Plesiocolochirus armatus* (Marenzeller von, 1881) (China); *P. australis* (Ludwig, 1875) (NE Australia, Bowen); *P. challengerii* (Théel, 1886) (N Australia, Torres Strait); *P. dispar* (Lampert, 1889) (NW Australia, Mermaid Strait); *P. ignavus* (Ludwig, 1875) (S Australia, Gulf St Vincent); *P. inornatus* (Marenzeller von, 1881) (China); *P. minaeus* sp. nov. (NW Australia, Camden Sound, below); *P. minutus* (Ludwig, 1875) (NE Australia, Bowen); *P. tessellarus* (Cherbonnier, 1970) (Mozambique Channel).

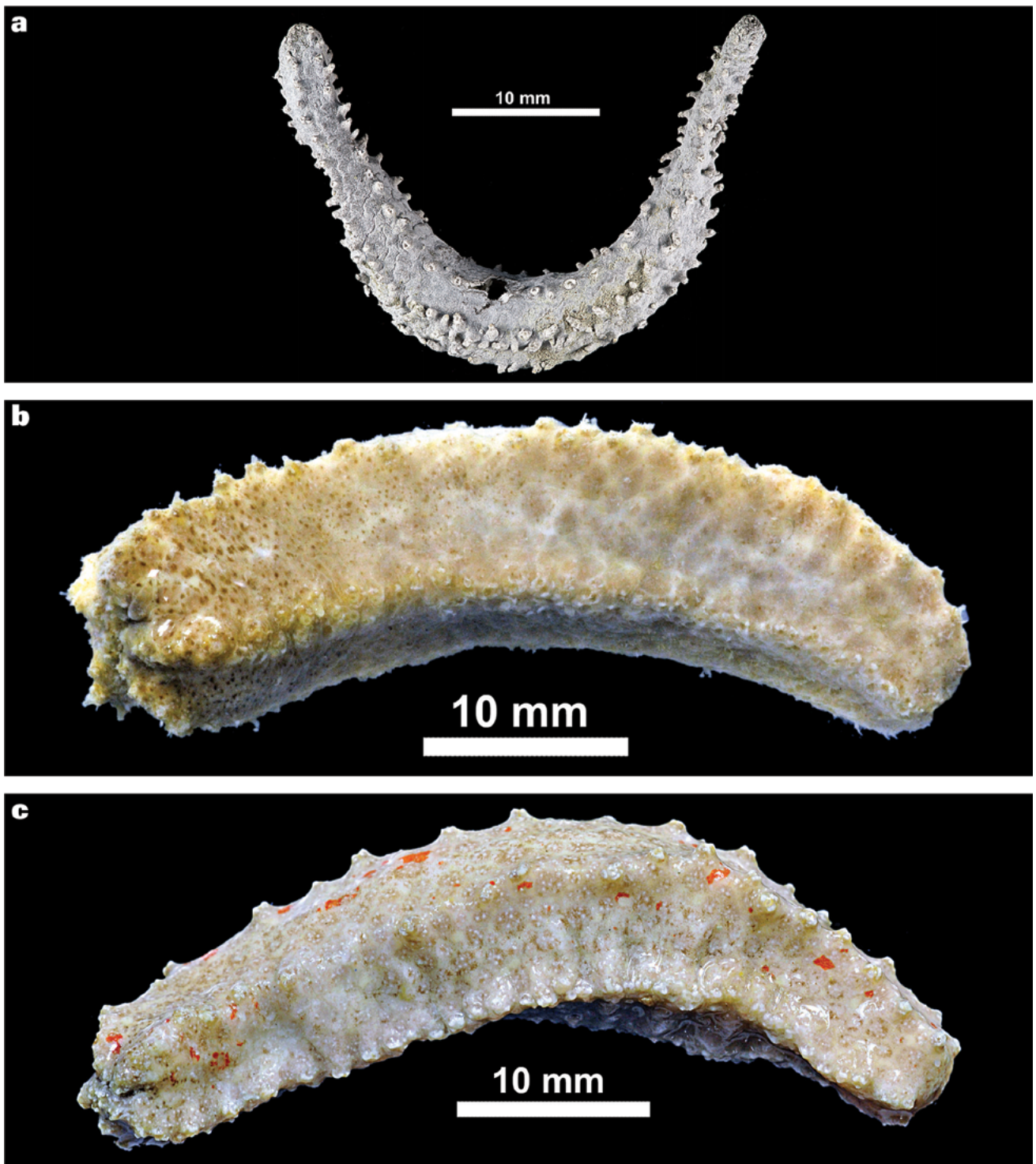


Figure 10. a, photo of lateral view of preserved specimen of *Leptopentacta grisea* H. L. Clark, 1938 (WAM Z89027). b, c, photos of live specimens of *Plesiocolochirus* species 1: b, dorsal view (WAM Z89028); c, lateral view (WAM Z89030).

Diagnosis (sensu stricto, based on type species only, described below). Body firm, packed with calcareous ossicles, fusiform with upturned oral and anal ends, long posterior taper, body oval in mid-body section, axial (not curved) length up to 64 mm; lateral edges of body with prominent, firm, conical papillae with imbricating scales; five conical oral valves, with imbricating scales distally; anal cone with large imbricating scales distally, large non-imbricating scales anterior to imbricating ones; small anal scales; small ossicles clustered into contiguous lumps in mid-body to create pseudo-scales, each with central passage/perforation for withdrawn tube feet, pseudo-scales about 1.00 mm across. Ten dendritic tentacles, 8 large, 2 small. Calcareous ring cucumariid-like, plates solid, higher than broad, lacking posterior prolongations. Tube feet scattered irregularly over body, inconspicuous, small, appear to penetrate pseudo-scales, more numerous ventrally than dorsally, mid-ventral radius with irregular paired rows, narrow space on each side of mid-ventral radius lacking tube feet.

Three intergrading ossicle forms of body wall:

1. surface layer of finely knobbed, shallow bowls, variably bridged across margins to sometimes create hollow, irregular, ellipsoid-like ossicles;
2. layer of flat, thickly knobbed buttons, some developing secondary layers to become small scales;
3. deeper layer of multi-layered scales.

Lateral papillae and tube feet with terminal endplates. Tentacle ossicles rods; lacking rosettes.

Remarks. Cherbonnier (1946) proposed that the following species be assigned to his new genus *Plesiocolochirus*: *Colochirus challengerii* Théel, 1886; *Colochirus gazellae* Lampert, 1889 (subsequently referred to *Loisettea* Rowe & Pawson, 1985); *Colochirus inornatus* von Marenzeller, 1881; *Thyone papillata* Sluiter, 1887 (subsequently referred to *Stolus* Selenka, 1867); *Colochirus squamatus* Sluiter, 1901 (subsequently synonymised with *Colochirus robustus* Östergren, 1898 by Rowe in Rowe & Gates 1995). Subsequently other species have been assigned to *Plesiocolochirus*: *Colochirus armatus* Marenzeller von, 1881 (China); *Colochirus australis* Ludwig, 1875 (NE Australia, Bowen); *Colochirus dispar* Lampert, 1889 (NW Australia, Mermaid Strait); *Cucumaria ignava* Ludwig, 1875 (S Australia, Gulf St Vincent); *Plesiocolochirus minaeus* sp. nov. (NW Australia, Camden Sound, below); *Colochirus minutus* Ludwig, 1875 (NE Australia, Bowen); *Pentacta tessellata* Cherbonnier, 1970 (Mozambique Channel).

Rowe (in Rowe & Gates) 1995 referred *Ocnus occiduus* O'Loughlin & O'Hara, 1992 to *Plesiocolochirus*, with reservations. This species was subsequently referred to *Australocnus* O'Loughlin & Alcock, 2000. In the same work Rowe judged that *Colochirus minutus* is a junior synonym of *Plesiocolochirus australis*. We provisionally raise *Colochirus minutus* out of synonymy for further consideration.

Phylogenetic data based on CO1 sequences (Figure 1) recover a clade of six species that appear to correspond to

Plesiocolochirus: *P. challengerii* (N Australia); *P. ignavus* (SE Australia); *P. minaeus* sp. nov. (below) (NW Australia); *P. tessellatus* (Comoros); *Plesiocolochirus* species 1 from NW Australia and Palau; *Plesiocolochirus* species 2 from NE Australia. The two unassigned species are close to specimens that have frequently been referred to *Plesiocolochirus australis* and *Plesiocolochirus minutus*, as well as to *Colochirus* sp. 1 mentioned above. A detailed study of these species, including study of relevant type specimens, is needed to determine the identity of these species and morphological boundaries of the *Colochirus* – *Plesiocolochirus* complex.

Unfortunately genetic data are not currently available for *Plesiocolochirus spinosus*, the type species of the genus. Morphologically this species is close to *Plesiocolochirus challengerii*. We anticipate from morphological observations that *Plesiocolochirus spinosus*, *Plesiocolochirus challengerii*, *Loisettea amphictena* Rowe & Pawson, 1985 and *Loisettea gazellae* will fall together in a clade distinct from the remaining species assigned to *Plesiocolochirus*.

Plesiocolochirus Cherbonnier, 1946 (based on type species *Plesiocolochirus spinosus* (Quoy & Gaimard, 1834), below) is distinguished *sensu stricto* from *Colochirus* Troschel, 1846 (based on type species *Colochirus quadrangularis* Troschel, 1846, above) by the following characters:

1. presence of large imbricating scales on distal anal cone, on proximal oral valves, and on lateral papillae;
2. presence of numerous inter-radial tube feet;
3. presence of knobbed button body wall ossicles;
4. absence of tentacle rosette ossicles.

Determination of the morphological limits of the clades corresponding to these genera awaits further study.

Plesiocolochirus spinosus (Quoy & Gaimard, 1834)

Figures 11, 12

Holothuria spinosa Quoy & Gaimard, 1834: 118–120, pl. 7 figs 1–10.

Cladolabes spinosus.—Brandt, 1835: 74.

Stolus firmus Selenka, 1867: 356, pl. 20 figs 118–119.

Ocnus spinosus.—Semper, 1867: 55.

Colochirus spinosus.—Selenka, 1868: 117.—von Marenzeller, 1881: 129–132.—Théel, 1886.—Lampert, 1889: 825–826.

Thyone spinosa.—Semper, 1869: 238.—Lampert, 1885: 157.

Stereoderma validum Bell, 1884: 150–151, pl. 9 figs Ea–f. (synonymy by H. L. Clark 1946)

Apentacta spinosa.—H. L. Clark, 1946: 395.

Plesiocolochirus spinosus.—Cherbonnier, 1946: 280–286, fig.—Rowe (in Rowe & Gates), 1995: 279.

Type locality. Australia, New South Wales, Port Jackson.

Material examined. S Queensland, Kimbla K4/69, -26.05 153.75 68 m, 1969, NMV F204081 (3); off Yeppoon, -24.05 151.45 9–37 m, 6 Sep 1967, NMV F204080 (1); off Yeppoon, Keppel Bay, -23.07 150.89 9 m, 6 Sep 1967, NMV F95257 (1).

Description. Body firm, packed with calcareous ossicles, fusiform with upturned oral and anal ends, long posterior taper,

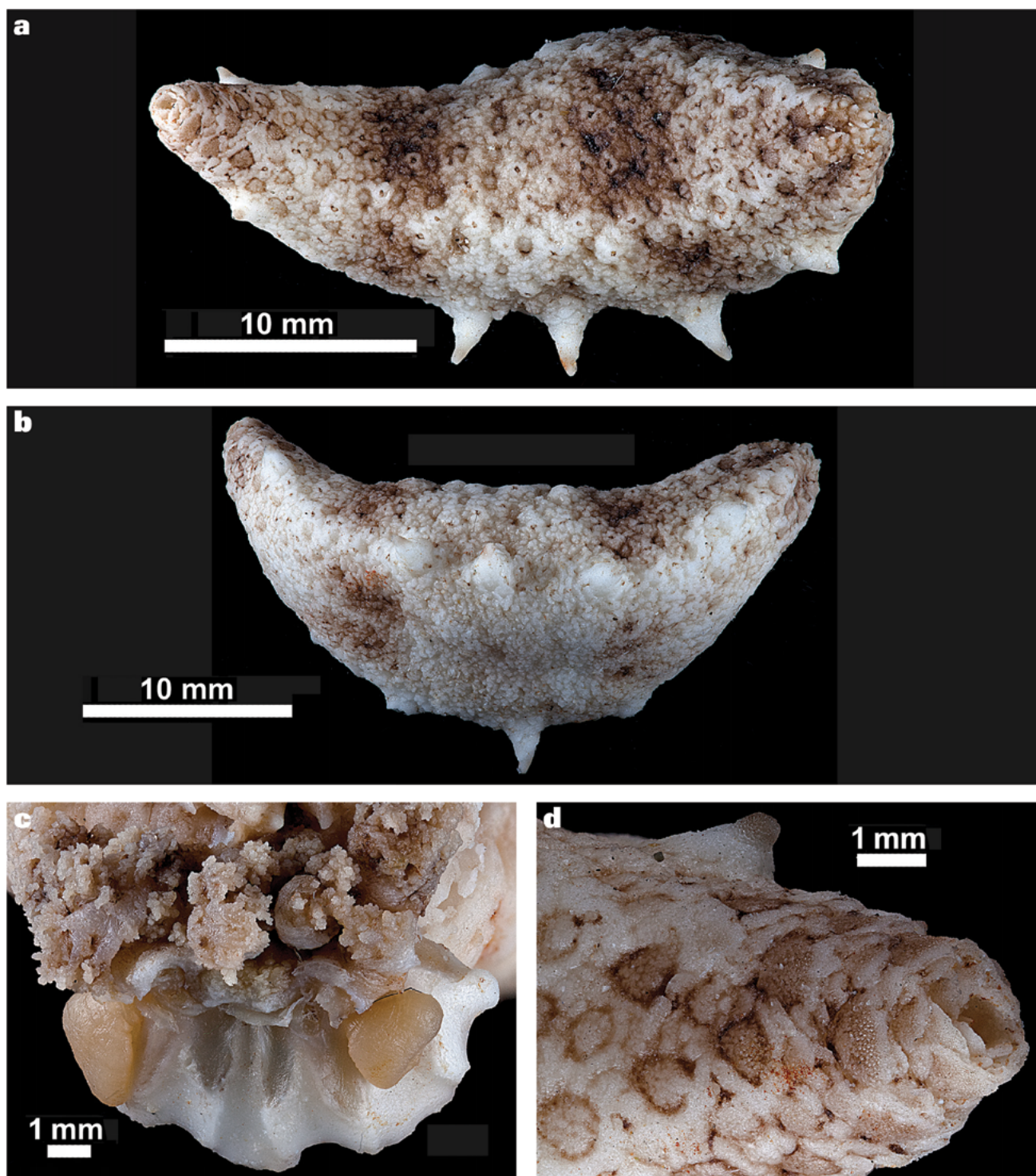


Figure 11. Photos of preserved specimen of *Plesiocolochirus spinosus* (Quoy & Gaimard, 1834) (NMV F204081): a, dorso-lateral view; b, ventro-lateral view; c, inter-radial and radial plates of the calcareous ring; d, peri-anal view with imbricating scales.

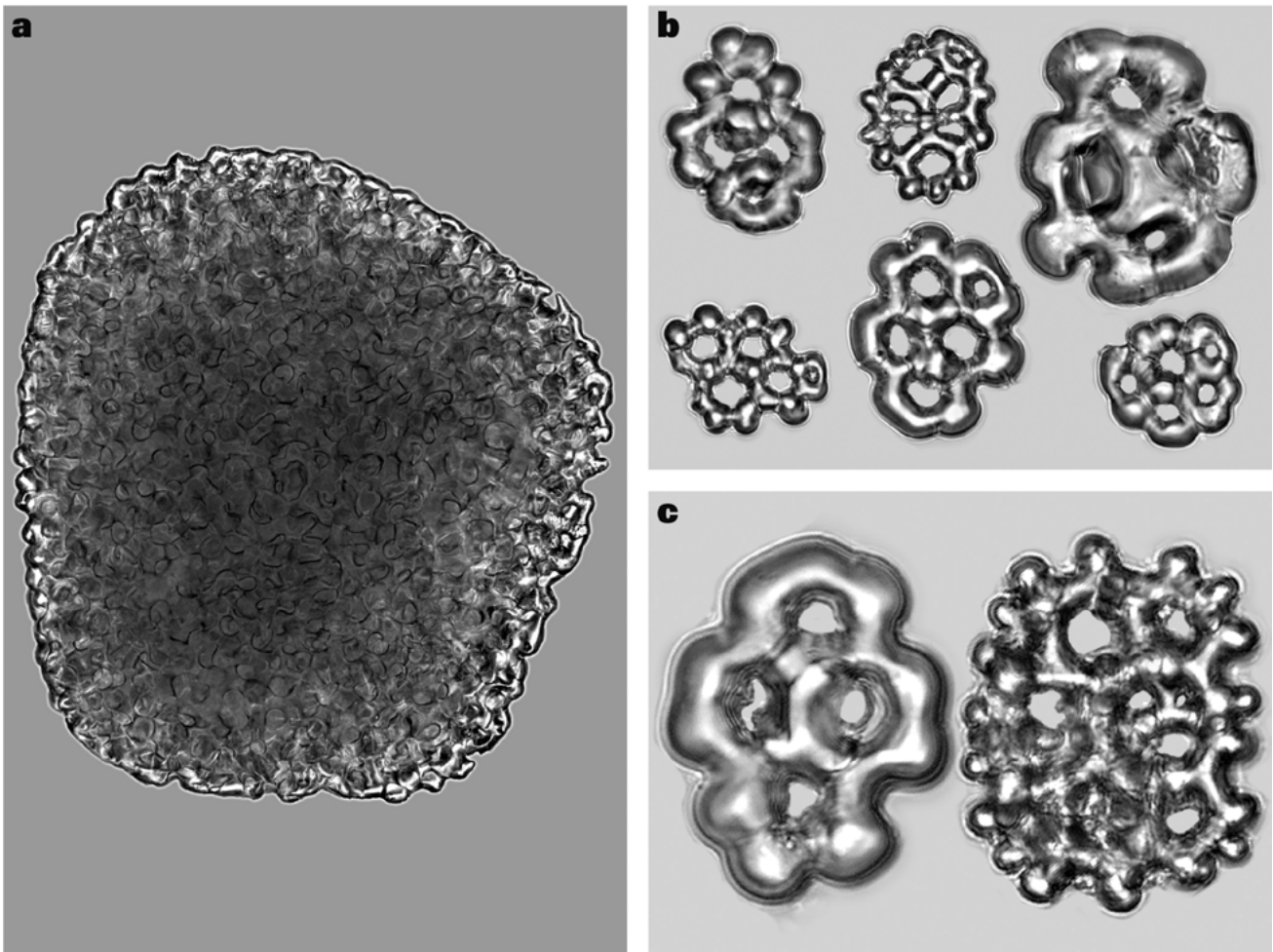


Figure 12. Ossicles from specimen of *Plesiocolochirus spinosus* (Quoy & Gaimard, 1834) (NMV F204081): a, multi-layered scale ossicle from body wall, up to 1.5 mm long; b, body wall thick buttons, up to 120 μm long, and fine knobbed bowls with (top center) and without (bottom left) a bridge, up to 70 μm long; c, body wall bridged ellipsoid-like bowl (right), up to 70 μm long, and thick button (left).

body oval in mid-body section, dorsal length shorter than ventral length, axial (not curved) length up to 64 mm; lateral edges of body with 3–12 firm conical papillae with large imbricating true scales, longest papillae mid-body, up to 6 mm long; five conical oral valves, each with two prominent spines distally, imbricating true scales distally; distal anal cone with large imbricating true scales, interspersed with small ossicle clumps; small anal scales; small ossicles clustered into contiguous lumps in mid-body to create pseudo-scales, each with central passage/perforation for withdrawn tube feet, pseudo-scales about 1.00 mm across. Ten dendritic tentacles, 8 large, 2 small. Calcareous ring cucumariid-like, plates solid, higher than broad, lacking posterior prolongations. Tube feet scattered irregularly over body, frequently withdrawn and inconspicuous, small, more numerous ventrally than dorsally, mid-ventral radius with irregular paired rows, narrow space on each side of mid-ventral radius lacking tube feet, tube feet appear to penetrate pseudo-scales.

Three inter-grading ossicle forms of body wall:

1. surface layer of finely knobbed bowls, oval to rounded rectangular in form, shallow concave, 4 central perforations, variable number of additional corner perforations, finely knobbed over surface, variably bridged from margins to sometimes create hollow, irregular, ellipsoid-like ossicles, 40–70 μm long;
2. layer of thickly knobbed buttons, flat, large marginal and central knobs, frequently 4 perforations but varying from 3–8, buttons 50–120 μm long, some buttons developing secondary layers to become small scales, up to about 216 μm long;
3. deeper layer of multi-layered scales, up to 1.5 mm long, developed from additional layers on knobbed plates.

Lateral papillae and tube feet with terminal endplates, fairly uniform perforations, about 120 μm .

Tentacle ossicles rods, lacking rosettes: large rods/rod-plates thick, curved, bent, perforated along rod, variable form, up to

480 μm long; small, irregularly-branched rods, some H-shaped, some distally perforate; fine very small distally perforate rods, not branched.

Live colour (Cherbonnier 1946, based on Quoy & Gaimard 1834): red dorsally, grey ventrally, lateral spines purple, tentacles red with brown spots at the base of the trunks. Preserved colour (this work): off-white to pale brown with some residual red flecks, two broad irregular transverse dark brown bands around mid-body.

Distribution (Rowe & Gates 1995). Eastern Australia, Queensland to Victoria, 9–90 m.

***Plesiocolochirus* species 1 (unresolved species complex)**

Table 1; appendices 1, 2; figures 1, 10b, c

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_4, WAM station no 22, barcode 10001662, from -15.446441 124.083021 62 m to -15.445955 124.083173 62 m, 20 Mar 2015, WAM Z89028 (1); RV *Solander*, sled, site no SOL_24, WAM station no 23, barcode 10001822, from -15.406428 124.125928 42 m to -15.406937 124.125369 42 m, 20 Mar 2015, WAM Z89029 (1); RV *Solander*, sled, site no SOL_43, WAM station no 26, barcode 10002101, from -15.488461 124.201824 46 m to -15.488309 124.201113 46 m, 21 Mar 2015, WAM Z89030 (1).

Remarks. We remarked under genus *Plesiocolochirus* (above) that the phylogenetic tree (Figure 1) supports two discrete and geographically separate *Plesiocolochirus* species clades from NE Australia (*Plesiocolochirus* species 2) and NW Australia (*Plesiocolochirus* species 1). Either clade might be representative of *Plesiocolochirus australis* or *Plesiocolochirus minutus*. Identification of the Camden species awaits morphological examination of the relevant types and additional phylogenetic data

***Plesiocolochirus minaeus* O’Loughlin sp. nov.**

Zoobank LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:189703BE-67E5-4212-B337-8C5B2F39D1E8>

Table 1; appendices 1, 2; figures 1, 13, 14;

Material examined. Holotype. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL 117, WAM station no 31, barcode 10002268, from -15.674833 124.279779 39 m to -15.674794 124.279012 39 m, 22 Mar 2015, WAM Z89026.

Description (preserved in 95% ethanol). Body hard, packed with calcareous ossicles, elongate, square in transverse section, 70 mm long, 10 mm high and wide; surface of body wall creased, imbricating scales around tips of papillae only; five anterior oral valves, lobed terminal papillae on each valve; each dorso-lateral margin with about 15 spaced, zig-zag, pyramidal, hard papillae, up to 2 mm high; ventro-lateral margin lacking papillae, except for 2–3 smaller papillae on each of the three ventral oral radii, and one on each of the three ventral anal radii; five tongue-like, radial anal scales/teeth; five pyramidal, radial, anal papillae, not as high as dorso-lateral papillae; dorsal and lateral inter-radii with scales evident,

irregular form and size, up to about 1.5 mm long. Ventral surface flat with three broad, raised radii with lace-like network of oblong scales each about 1 mm long, tube feet mostly deeply retracted, ventro-lateral radial tube feet band about four wide, mid-ventral band about five wide. Typical cucumariid calcareous ring, undulating posteriorly, lacking posterior prolongations. Ten dendritic tentacles, two ventral smaller. Single polian vesicle, gonad tubules not branched.

Dorsal body wall and dorso-lateral papillae ossicles of six intergrading types:

1. surface layer of deep bowls with tapering rounded base and bluntly to sharply spinous or knobbed marginal rim, some bridged internally, bowls typically about 55 μm wide 48 μm deep;
2. thick and thin walled shallow bowls, irregularly rectangular, many with smooth rims, many with indented lateral rims, variably bridged to create irregular hollow ellipsoids, frequently 55 μm long, up to 144 μm long;
3. smooth, irregularly round to oval, hollow ellipsoids, up to 64 μm across;
4. some regular, four-holed, thickened, flat buttons, up to 72 μm long;
5. abundant knobbed and thickened irregular flat buttons, many with incipient secondary layering, inter-grading with small multi-layered scales, up to about 176 μm long;
6. multi-layered ossicles/scales, irregularly oval, up to at least 1.00 mm long.

Dorso-lateral papillae lacking apical tube feet and endplates.

Ventral tube feet ossicles of four forms (lacking multi-layered ossicles and buttons):

1. endplates with fairly uniform perforations, smallest centrally, endplates up to at least 280 μm diameter;
2. straight and curved, smooth, tube foot support rod-plates, typically widened and perforated mid-rod and distally, some marginally denticulate, rod-plates up to 200 μm long;
3. knobbed oval to rectangular shallow bowls, margins knobbed to bluntly spinous, variably bridged to create irregular hollow ellipsoids, bowls up to 55 μm long;
4. shallow bowls of variable size, not bridged, some with marginal and surface knobs, bowls up to 128 μm long.

Tentacle ossicles of four inter-grading forms:

1. thick, smooth, perforated rod-plates up to 440 μm long;
2. smooth rods, variably perforated and branched
3. fine thin rods with distal perforations, typically about 60 μm long;
4. knobbed, branched rod rosettes, some perforated plates with knobbed margin, up to 50 μm long.

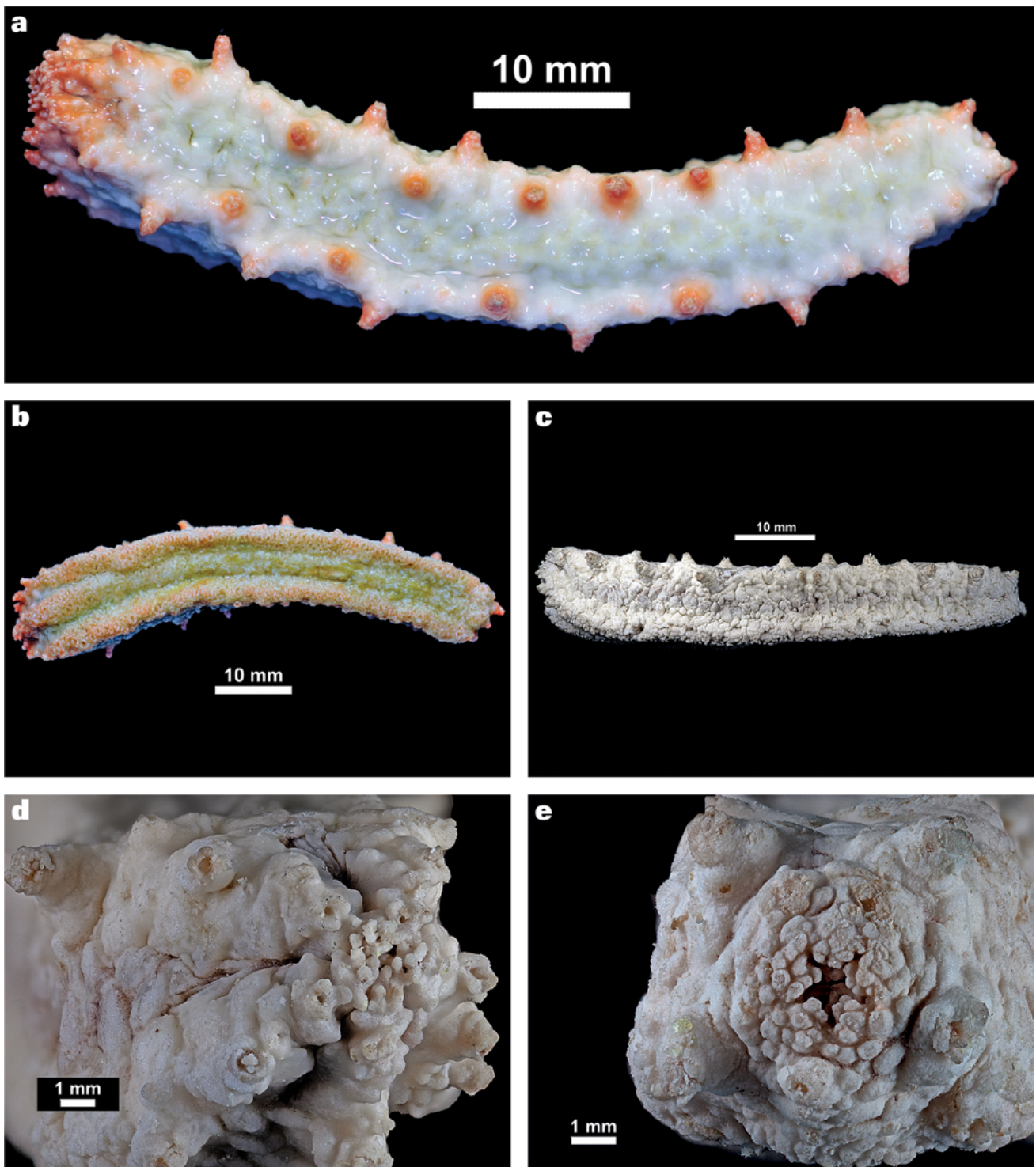


Figure 13. a, b, photos of live specimen of holotype of *Plesicolochirus minaeus* O'Loughlin sp. nov. (WAM Z89026): a, dorsal view; b, ventral view. c–e, photos of preserved holotype: c, lateral view; d, oral view; e, anal view.

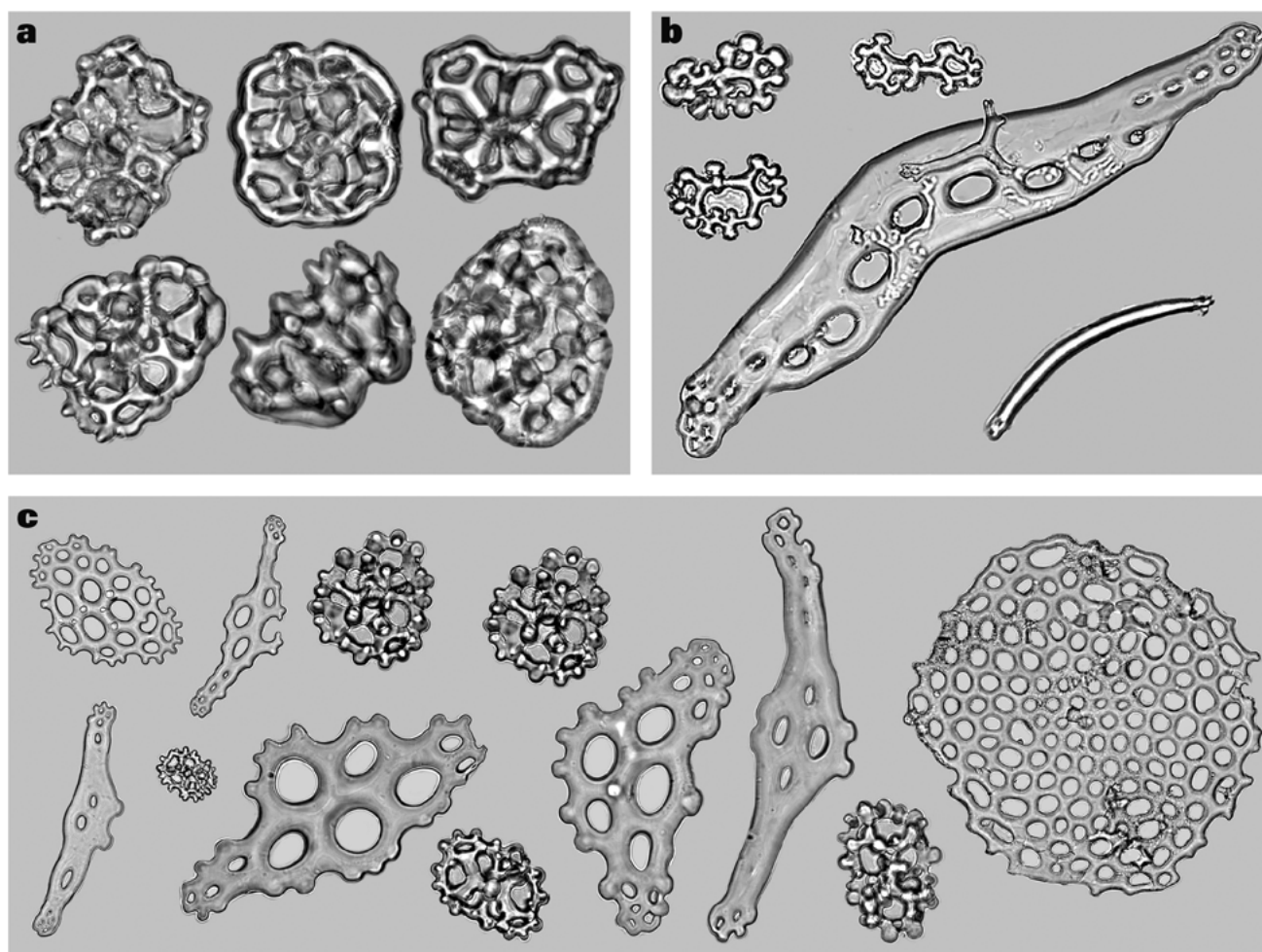


Figure 14. Ossicles from holotype of *Plesiocolochirus minaeus* O'Loughlin sp. nov. (WAM Z89026): a, dorsal body wall deep bowls with spinous rims about $55\ \mu\text{m}$ wide $48\ \mu\text{m}$ deep (bottom left and bottom center), shallow bowls variably bridged to create irregular hollow ellipsoids up to $144\ \mu\text{m}$ long (top row), knobbed button with secondary layering up to $176\ \mu\text{m}$ long (bottom right); b, tentacle fine rod and thick perforated rod up to $440\ \mu\text{m}$ long, rosettes up to $50\ \mu\text{m}$ long; c, ventral tube foot endplate up to at least $280\ \mu\text{m}$ long (right), support perforated rod-plates up to $200\ \mu\text{m}$ long, small shallow knobbed bowls variably bridged to create irregular hollow ellipsoids up to $55\ \mu\text{m}$ long, large shallow bowl not bridged up to $128\ \mu\text{m}$ long (top left).

Live body colour very pale yellow to off-white, dorso-lateral papillae and oral valves reddish-orange, ventral radii greenish yellow; preserved colour off-white.

Distribution. Northwest Western Australia, Kimberley Region, Camden Sound, 39 m.

Etymology. From the Latin *minae* (“parapets”), with reference to the parapet-like hard papillae on the dorso-lateral margins of the body in lateral view.

Remarks. The phylogenetic tree (Figure 1) includes a COI sequence for the new species, *Plesiocolochirus minaeus* O'Loughlin, within the congeneric clade of *Plesiocolochirus* species. This sequence is understandably remote from the *Plesiocolochirus challengerii* clade that we anticipate on morphological grounds will be a clade close to *Plesiocolochirus spinosus*.

The morphological characters that distinguish *Plesiocolochirus minaeus* O'Loughlin sp. nov. from other *Plesiocolochirus* species are the:

1. pyramidal, firm, dorso-lateral papillae;
2. complete absence of a ventro-lateral raised firm papillae;
3. absence of inter-radial tube feet;
4. presence of imbricating scales at tips of dorso-lateral papillae only;
5. abundance of knobbed and thickened irregular buttons in the body wall, many with incipient secondary layering, intergrading with small multi-layered scales;
6. ventral tube feet surrounded by a ring of about four ellipsoidal scales, not penetrating scales;

7. live colour of red dorso-lateral papillae on off-white body.

We note the presence of tentacle rosettes in the new species. This indicates that the presence or absence of tentacle rosettes is not a sound generic diagnostic character for genera *Colochirus* and *Plesiocolochirus*.

We also note the presence of two Pilumnidae crabs in the coelom of the holotype of the new species.

Pseudocolochirus axiologus (H. L. Clark, 1914)

Table 1; appendix 1; figures 15, 16

Colochirus axiologus H. L. Clark, 1914: 171–173, pl. 25.—Ekman, 1918: 26–28, pl. 2 fig. 1, pl. 3 figs 16–19.

Pseudocolochirus axiologus (H. L. Clark, 1938): 456–457.—1946: 394.

Pseudocolochirus violaceus (Théel, 1886).—Cherbonnier, 1988: 174–177, figs 73, 74 (part; N Australia specimens are *P. axiologus*).—Rowe (in Rowe & Gates), 1995: 280 (part; N Australia specimens are *P. axiologus*).

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no LIN_35, WAM station no 23, barcode 10000760, from -15.363088 124.44389 37 m to -15.362756 124.443995 37 m, 17 Mar 2015, WAM Z89031 (1); RV *Solander*, sled, site no SOL_49, WAM station no 32, barcode 10002389, from -15.668951 124.357909 41 m to -15.669007 124.357529 42 m, 22 Mar 2015, WAM Z89032 (1).

WA, northwest shelf, -12.84 125.68 88–97 m, 2 Apr 1981, NMV F112187 (1); -12.90 125.58 84–88 m, 2 Feb 1981, NMV F112188 (2); -12.90 125.59 83 m, 2 Apr 1981, NMV F112189 (2); -12.83 125.7 91 m, 1 Apr 1981, NMV F112190 (1).

Northern Territory, Joseph Bonaparte Gulf, -11.54 129.82 60 m, 12 Sep 2009, NMV F202986 (1) (tissue code MOL AF 1512); -10.31 129.62 89 m, 1 Sep 2009, NMV F202987 (1) (tissue code MOL AF 1504); -11.01 129.79 55 m., 6 Sep 2009, NMV F202988 (2) (tissue code MOL AF 1507).

Queensland, Gulf of Carpentaria, -11.37 141.42 35 m, 9 Sep 1982, NMV F95259 (1) (tissue code MoV 4627).

Remarks. H. L. Clark (1914) noted the following features for the type of his *Colochirus axiologus*:

1. 90 mm axial (horizontal) length;
2. tube feet confined to ventral ambulacra;
3. absence of ossicles in the body wall;
4. bright purple colour around the tentacle aperture;
5. body colour purplish-rose.

When describing additional specimens, H. L. Clark (1938) referred his species to *Pseudocolochirus* Pearson, 1910, and confirmed the absence of tube feet other than on the ventral ambulacra, and the absence of ossicles in the body wall. H. L. Clark (1938) acknowledged that Ekman (1918) found and illustrated distinctive ossicles in the body wall of small specimens (41–49 mm long) of what he judged to be *Colochirus axiologus*, and Clark concluded that ossicles disappear with increase in size of specimens.

We examined a small specimen (40 mm axial preserved length) from Joseph Bonaparte Gulf (NMV F202988) that

lacked ossicles in the mid-body wall but did have a few almost inconspicuous tube feet on the dorsal anterior radii (that H. L. Clark 1938 had also noted on his specimens). We also found endplate support rod-plates in the ventral tube feet, and distinctive small thick plates in the nearby body wall with very small to no perforations. These ossicles were frequently dumbbell-shaped and lacked perforations, or had up to three very small ones. The plates varied in size from 40–90 μm long. We found similar small plates near the ventral tube feet in a larger specimen (100 mm axial preserved length) from Camden Sound (WAM Z89032). These buttons were larger, up to 200 μm long, and more irregular in form. There were a few anterior dorsal radial hard papillae in which we found multi-layered ossicles fragments, and large single-layered perforated plate fragments up to 440 μm long.

We judge that the specimens examined by H. L. Clark (1914, 1938), Ekman (1918) and us are conspecific and belong to *Pseudocolochirus axiologus* (H. L. Clark, 1914). We acknowledge that this species is similar to *Pseudocolochirus violaceus* (Théel, 1886). We do not accept the synonymy of these two species by Cherbonnier (1988). *Pseudocolochirus violaceus* has the following differing characters:

1. the whole body, both radial and inter-radial, is covered with small papillae;
2. tube feet are clearly evident on the dorsal radii;
3. the distinctive plates are present in the mid-body wall;
4. prominent anterior and posterior papillae are more numerous.

We raise *Pseudocolochirus axiologus* (H. L. Clark, 1914) out of synonymy (by Cherbonnier 1988) with *Pseudocolochirus violaceus* (Théel, 1886). Rowe (in Rowe & Gates, 1995) followed Cherbonnier (1988) who considered all *Pseudocolochirus* species to be synonyms, with *Pseudocolochirus violaceus* the senior synonym. We judge that northern Australian specimens are *Pseudocolochirus axiologus*, not *P. violaceus* (see synonymy above).

Family **Phyllophoridae** Östergren, 1907 (*sensu* Pawson & Fell 1965)

Phyllophorella spiculata (Chang, 1935)

Table 1; appendix 1; figure 17b

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_32, WAM station no 19, barcode 10001306, from -15.253592 124.203038 45 m to -15.253318 124.202302 45 m, 19 Mar 2015, WAM Z89033 (1).

Remarks. We note that O'Loughlin *et al.* (2012) raised *Phyllophorella* to generic status.

Phyllophorus (Urodemella) holothurioides Ludwig, 1875

Table 1; appendix 1; figure 17a

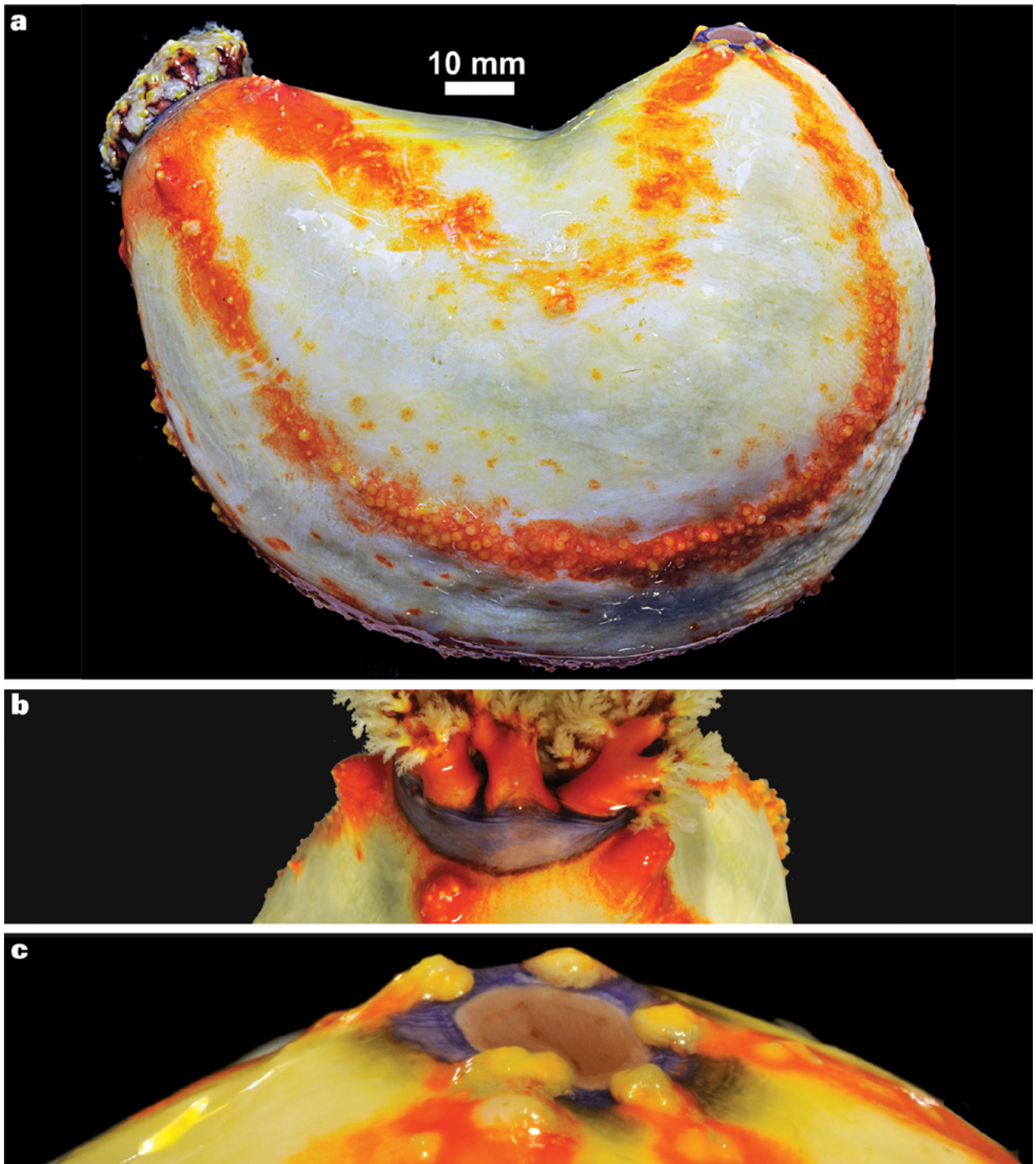


Figure 15. Photos of live specimen of *Pseudocolochirus axiologus* (H. L. Clark, 1914) (WAM Z89032): a, lateral view; b, peri-oral view; c, peri-anal view.

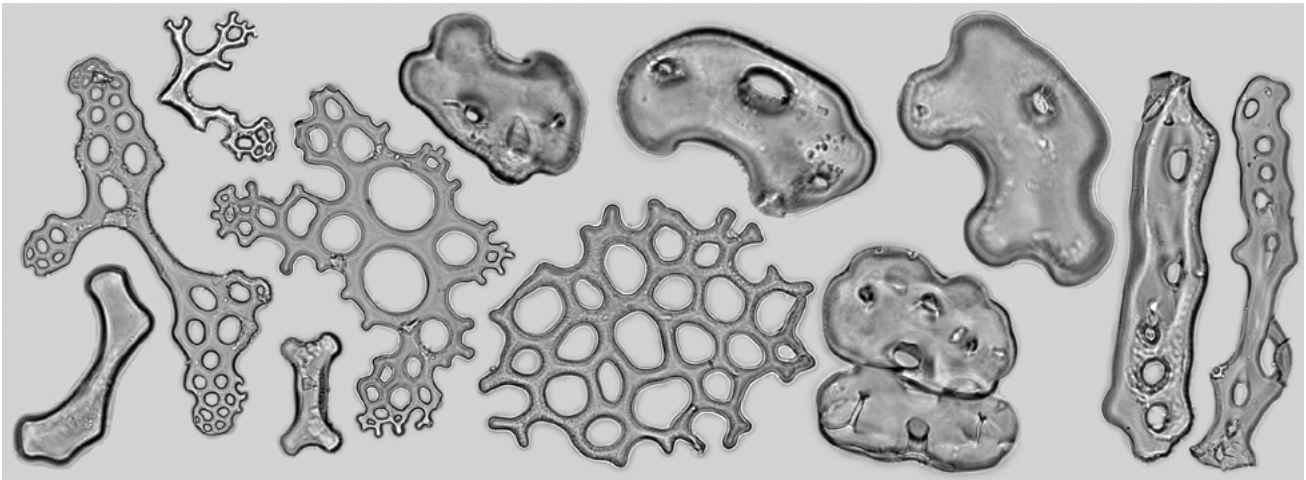


Figure 16. Ossicles from specimen of *Pseudocolochirus axiologus* (H. L. Clark, 1914) (WAM Z89031). From ventral tube feet and ventral body wall near tube feet: thick irregular oval to elongate plates with small perforations, plates up to 200 μm long; tube foot thick and thin support plates with distal small perforations, plates up to 256 μm long; small endplate (mid-lower).

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no LIN_46, WAM station no 3, barcode 10000113, from -15.399083 124.345337 41 m to -15.398828 124.345572 42 m, 15 Mar 2015, WAM Z89034 (1); RV *Solander*, sled, site no SOL_116a, WAM station no 18, barcode 10001277, from -15.261423 124.275183 41 m to -15.261716 124.275827 41 m, 18 Mar 2015, WAM Z89035 (1).

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

Havelockia Pearson, 1903

Havelockia Pearson, 1903: 198.—Panning, 1949: 466, 468.—Rowe (in Rowe & Gates), 1995: 310.

Pentathylone Clark, H. L., 1938: 458–459.—1946: 386, 396.—Panning, 1949: 459.

Diagnosis (after Thandar 1989). Calcareous ring short, stout, only anterior projections of radial and inter-radial plates free; posterior paired process of radial plates divided into several pieces. Body wall ossicles tables with squarish to oval discs, usually perforated by four large central and four smaller peripheral perforations, that are sometimes reduced or absent; spire of two pillars joined at apex and terminating in a few blunt teeth.

Remarks. Thandar (1989) has discussed the above generic synonymy by Panning (1949), and the replacement of the type species *Havelockia herdmanni* Pearson, 1903 by the senior synonym *Havelockia versicolor* (Semper, 1867).

Havelockia versicolor (Semper, 1867)

Table 1; appendix 1; figures 18a–d

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_120, WAM station no 5, barcode 10000277, from -15.37669 124.248319 53 m to -15.377306 124.248179 53 m, 15 Mar 2015,

WAM Z89036 (1); RV *Solander*, sled, site no LIN_35, WAM station no 11, barcode 10000776, from -15.363088 124.44389 37 m to -15.362756 124.443995 37 m, 17 Mar 2015, WAM Z89037 (1); RV *Solander*, sled, site no LIN_6, WAM station no 16, barcode 10001220, from -15.27505 124.36988 46 m to -15.27543 124.369177 46 m, 18 Mar 2015, WAM Z89038 (1); RV *Solander*, sled, site no LIN_36, WAM station no 17, barcode 10001124, from -15.220444 124.320894 50 m to -15.220159 124.320648 50 m, 18 Mar 2015, WAM Z89039 (1); RV *Solander*, sled, site no SOL_32, WAM station no 19, barcode 10001321, from -15.253592 124.203038 45 m to -15.253318 124.202302 45 m, 19 Mar 2015, WAM Z89040 (1); RV *Solander*, sled, site no SOL_56, WAM station no 20, barcode 10001417, from -15.376537 124.192773 35 m to -15.376196 124.192071 35 m, 19 Mar 2015, WAM Z89041 (1); RV *Solander*, sled, site no SOL_4, WAM station no 22, barcode 10001637, from -15.446441 124.083021 62 m to -15.445944 124.083173 62 m, 20 Mar 2015, WAM Z89042 (1); RV *Solander*, sled, site no SOL_24, WAM station no 23, barcode 10001924, from -15.406428 124.125928 42 m to -15.406937 124.125369 42 m, 20 Mar 2015, WAM Z89043 (1); RV *Solander*, sled, site no SOL_49, WAM station no 32, barcode 10002314, from -15.668951 124.357909 41 m to -15.669007 124.357529 42 m, 22 Mar 2015, WAM Z89044 (1); RV *Solander*, sled, site no SOL_49, WAM station no 32, barcode 10002323, from -15.668951 124.357909 41 m to -15.669007 124.357529 42 m, 22 Mar 2015, WAM Z89045 (1); RV *Solander*, sled, site no SOL_73, WAM station no 38, barcode 10002688, from -15.945442 124.366373 29 m to -15.945268 124.367171 28 m, 25 Mar 2015, WAM Z89046 (1); RV *Solander*, sled, site no SOL_73, WAM station no 38, barcode 10002689, from -15.945442 124.366373 29 m to -15.945268 124.367171 28 m, 25 Mar 2015, WAM Z89047 (1); RV *Solander*, sled, site no SOL_97, WAM station no 39, barcode 10002752, from -15.782865 124.378047 32 m to -15.782335 124.378553 33 m, 25 Mar 2015, WAM Z89048 (1); RV *Solander*, sled, site no SOL_69, WAM station no 41, barcode 10002838, from -15.747648 124.146502 43 m to -15.747285 124.14634 43 m, 26 Mar 2015, WAM Z89049 (1); RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002939, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89050 (1).

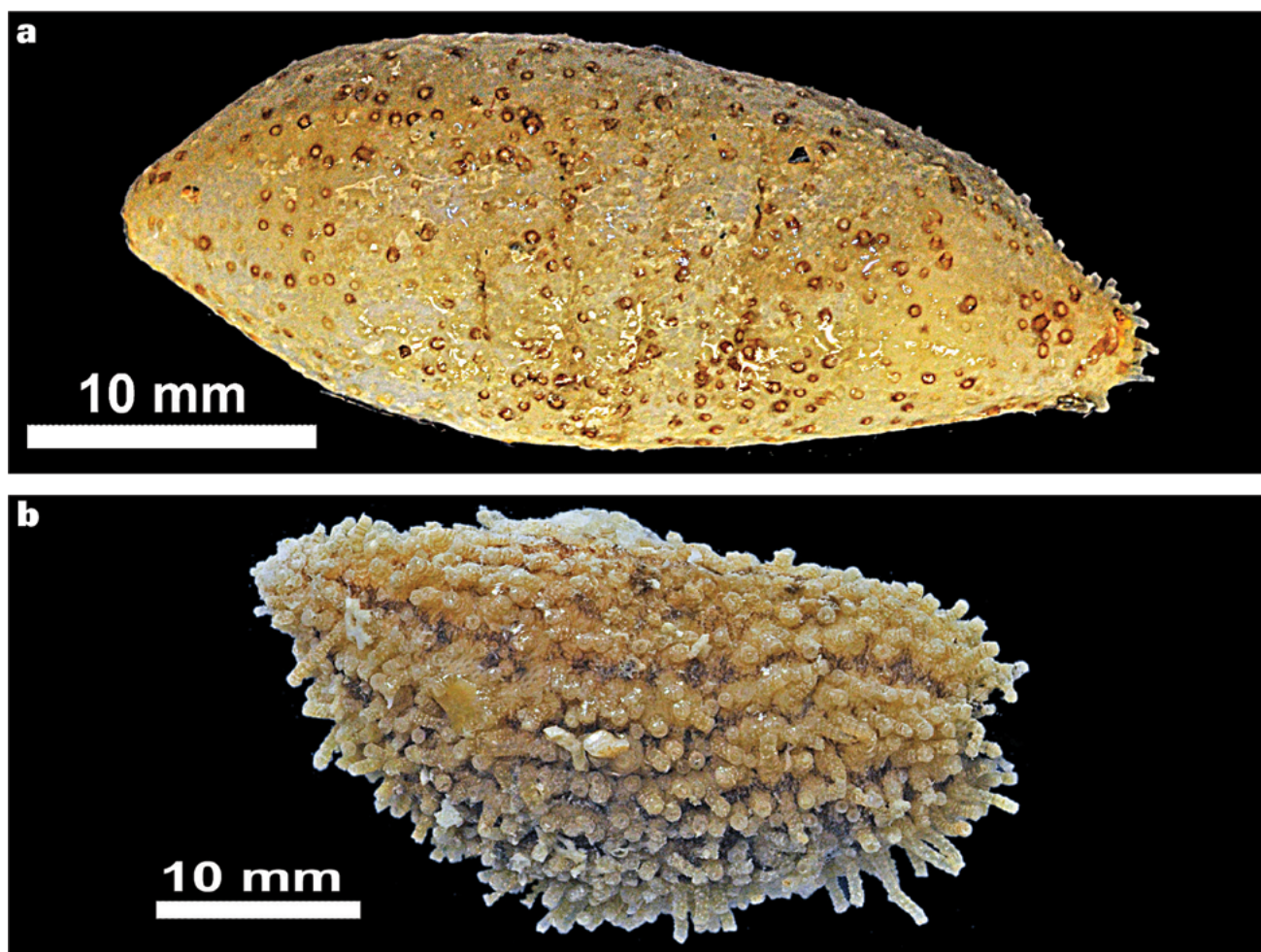


Figure 17. a, photo of dorsal view of live specimen of *Phyllophorus (Urodemella) holothuroides* Ludwig, 1875 (WAM Z89035). b, photo of lateral view of live specimen of *Phyllophorella spiculata* (Chang, 1835) (WAM Z89033).

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

Subfamily **Semperiellinae** Heding & Panning, 1954

Diagnosis. See O'Loughlin, Mackenzie & VandenSpiegel 2014.

Remarks. See O'Loughlin, Mackenzie & VandenSpiegel 2014.

Massinium Samyn & Thandar, 2003

Massinium Samyn and Thandar, 2003: 136.—Samyn *et al.*, 2010: 2.—O'Loughlin *et al.*, 2012: 290.

Diagnosis (O'Loughlin, Mackenzie & VandenSpiegel 2014). Frequently semi-spherical species with oral and anal dorsal orientations; 20 dendritic tentacles arranged in two circles of 10 large outer and 10 small inner (proximal peri-oral); tube feet distributed all over mid-body; calcareous ring elongate, tubular, with both radial and inter-radial plates fragmented into a mosaic of small pieces, and posterior prolongations linked

distally to form inter-radial oval non-calcified spaces beneath the water vascular ring; polian vesicles from 1 to 4; ossicles variably include granuliform rods, rosettes, pseudo-buttons and tables; table spires with 1 or 2 or 3 or reduced pillars.

Remarks. See O'Loughlin, Mackenzie & VandenSpiegel 2014.

Massinium bonapartum O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel 2014)

Table 1; appendix 1; figure 19d

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_2, WAM station no 30, barcode 10002243, from -15.711306 124.315779 28 m to -15.71207 124.31566 28 m, 22 Mar 2015, WAM Z89051 (1); RV *Solander*, sled, site no SOL_73, WAM station no 38, barcode 10002725, from -15.945442 124.366373 29 m to -15.945268 124.367171 28 m, 25 Mar 2015, WAM Z89052 (1); RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002966, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89053 (1).

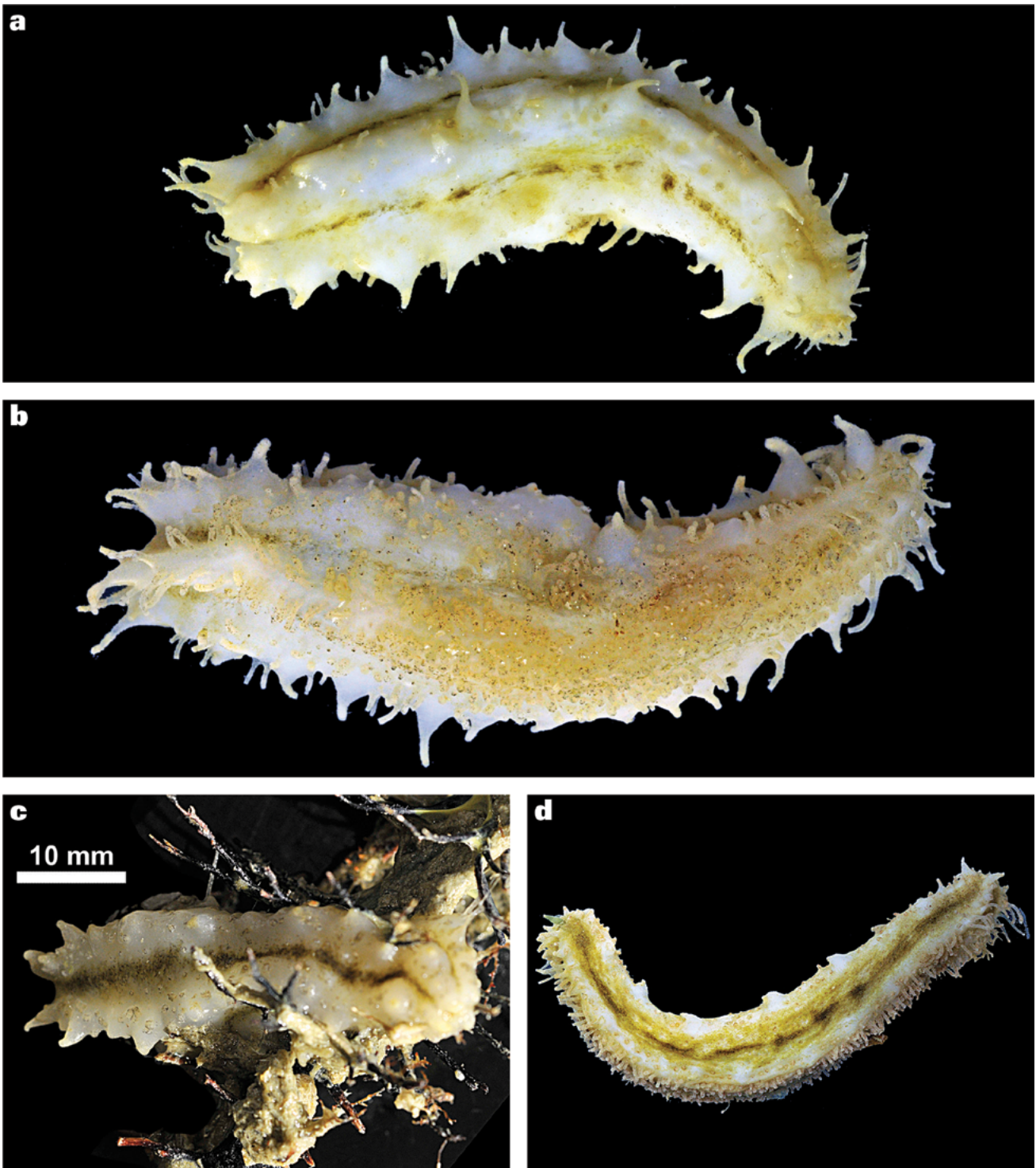


Figure 18. Photos of live specimens of *Havelockia versicolor* (Semper, 1867) (estimated 35–40 mm long live). a, dorsal view (WAM Z89047); b, ventral view (WAM Z89047); *in situ* view (WAM Z89043); d, lateral view (WAM Z89048).

Neothyonidium(?) insolitum O'Loughlin sp. nov.

Zoobank LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:7FCA7216-B862-4A4E-A829-07CA9DC0E23D>

Table 1; appendix 1; figures 19a–c, 20

Material examined. Holotype. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002958, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89054.

Description. Body fusiform, cylindrical mid-body, tapered and rounded oral end, tapered anally to narrow end, live body variably 50 mm long, 13 mm diameter, body (preserved in 95% ethanol) 26 mm long, up to 14 mm diameter; complete cover of tube feet, more numerous ventrally than dorsally, tube feet diameters about 0.2 mm; tentacles in inner circle of five very small, outer circle of 13 large; calcareous ring elongate, tubular, with both radial and inter-radial plates fragmented into a mosaic of small pieces; inconspicuous anal scales detected; single polian vesicle.

Ossicles of mid-body wall numerous *Thyone*-like oval tables, discs with most frequently four perforations, sometimes with an additional four smaller corner perforations to create a rounded rectangular disc, discs up to 80 μm long; spires two short pillars with one distal cross-bridge, two distal splayed spines at base of each pillar, spire height about 24 μm . Tube feet endplates with variable diameters up to 224 μm , irregular perforations and margin; rare tube foot support tables with elongate discs up to 80 μm long; some tube foot support rods, similar to tentacle rods, sometimes forked distally with enlarged rounded ends with few small perforations. Peri-oral wall with tables similar to mid-body wall, but discs generally smaller, up to 55 μm long. Peri-anal body wall with tables similar to mid-body wall, but smaller as in peri-oral region; small rosettes present; anal multi-layered scales present. Tentacles with thick and thin rods, distal ends swollen with small perforations; thick rods sometimes branched distally into widened ends with small perforations, thick rods up to 160 μm long; thin rods up to 90 μm long.

Live colour off-white to grey, semi-translucent; preserved colour off-white.

Distribution. Northwest Western Australia, Kimberley Region, Camden Sound, 35–36 m.

Etymology. From the Latin *insolitum* (meaning unusual), with reference to the unusual combination of characters for the genus *Neothyonidium*.

Remarks. We refer the new species to *Neothyonidium* Deichmann, 1938 on the basis of the body form, cover of tube feet, near 20 tentacles of two sizes, form of the composite calcareous ring, and body wall table ossicles with two pillars. But we do so with reservation because of the atypical combination of two morphological characters: five very small tentacles and 13 larger ones; *Thyone*-like table ossicles in the body wall. These two characters distinguish *Neothyonidium(?) insolitum* O'Loughlin from all other *Neothyonidium* species.

Subfamily **Thyoninae** Panning, 1949*Hemithyone semperi* (Bell, 1884)

Table 1; appendix 1; figure 21

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_56, WAM station no 20, barcode 10001531, from -15.376537 124.192773 35 m to -15.376196 124.192071 35 m, 19 Mar 2015, WAM Z89055 (1).

Remarks. We have retained *Hemithyone semperi* (Bell, 1884) in family *Thyonidae* and subfamily *Thyoninae*, but with major reservations. The species does have a composite calcareous ring, but the tube feet are radial and the species lacks table and cup ossicles and has predominantly very open fenestrated ellipsoids in the body wall. Smirnov (2012) remarked “it is possible that *Hemithyone* Pawson, 1963 does not belong to *Thyonidae*”. We await generic evidence for a review of its higher taxon referral.

Stolus canescens (Semper, 1867)

Table 1; appendix 1; figure 22

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_2, WAM station no 30, barcode 10002195, from -15.711306 124.315779 28 m to -15.71207 124.31566 28 m, 22 Mar 2015, WAM Z89056 (1).

Thyone Oken, 1815

Diagnosis (emended in O'Loughlin et al. 2012 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* O. F. Müller, 1776 (monotypy).

Northern Australia species of Thyone reported in Rowe & Gates 1995 (type locality added). *T. axiologa* H. L. Clark, 1938 (Broome); *T. dura* Koehler & Vaney, 1908 (W India) (junior synonym *T. alba* H. L. Clark, 1938, by Heding 1940 (Broome)); *T. grisea* H. L. Clark, 1938 (Cape Bossut, N Australia); *T. micra* H. L. Clark, 1938 (Broome); *T. papuensis* Théel, 1886 (Torres Strait).

Remarks. We note in the Introduction the recent ruling by the ICZN that *Thyone* Oken, 1815 is now an available taxon. Pawson & Miller (1981) remarked on the need for a revision of the “supergen” *Thyone*. Arumugam (2012) has provided a morphological approach to the “management” of this “supergen”.

Liao & Clark (1995) noted that the holotype specimen of *Thyone papuensis* is now very damaged and completely decalcified. The original description and illustrations of the species are not sufficient for diagnostic comparisons and we thus provide (below) a description of specimens that we judge to be *Thyone papuensis*.

We add *Thyone pedata* Semper, 1867 to northern Australia species of *Thyone* on the basis of a specimen identified by us from Joseph Bonaparte Gulf (NMV F173267; UF tissue lot MOL AF 1537). We note that Rowe (in Rowe & Gates 1995)

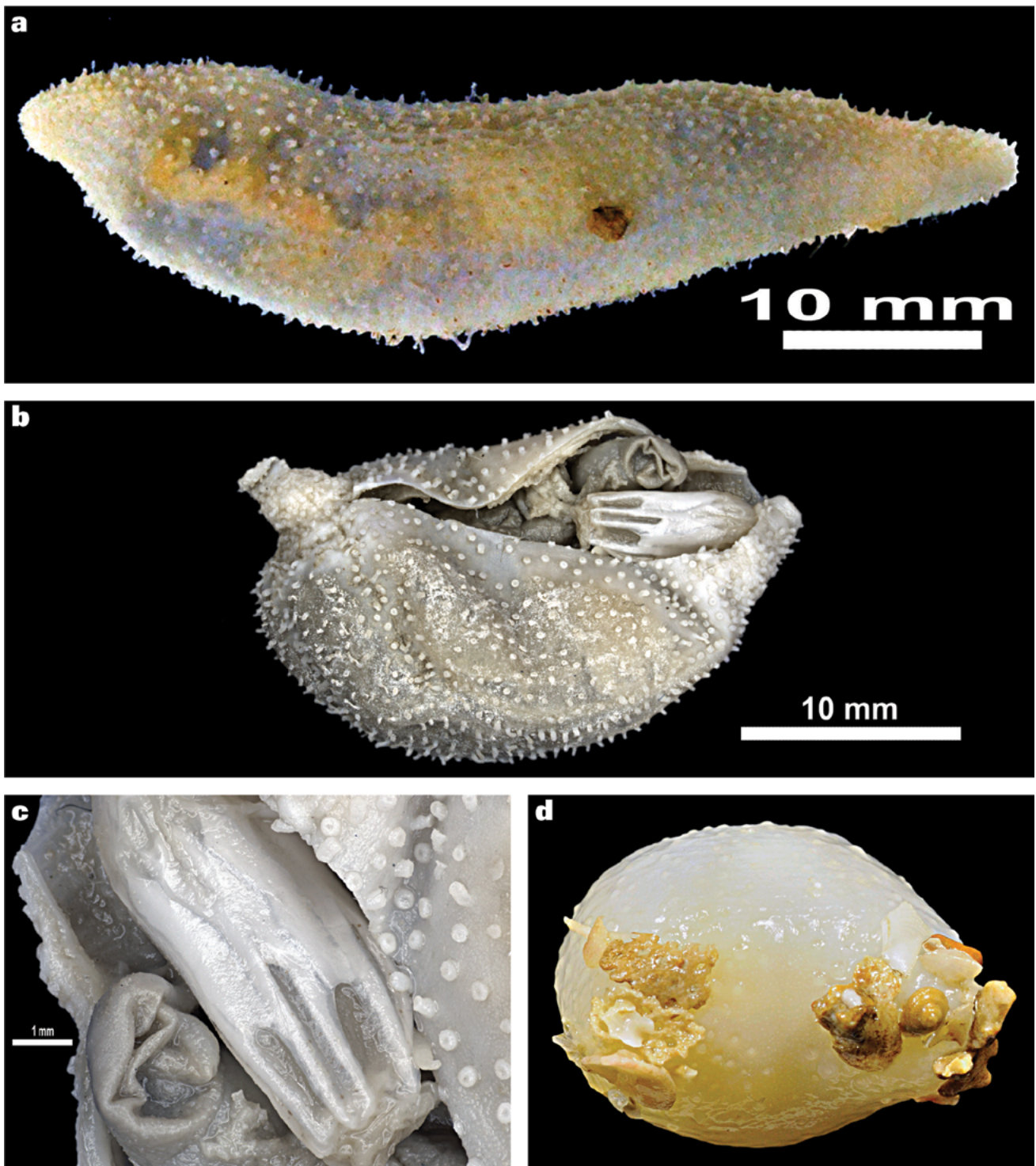


Figure 19. a–c, photos of holotype of *Neopsolidium(?) insolitum* O'Loughlin sp. nov. (WAM Z89054): a, photo of dorsal view of live holotype; b, photo of lateral view of preserved holotype; c, photo of calcareous ring of preserved holotype. d, photo of live specimen of *Massinium bonapartum* O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014) (WAM Z89051; estimated 20 mm long live).

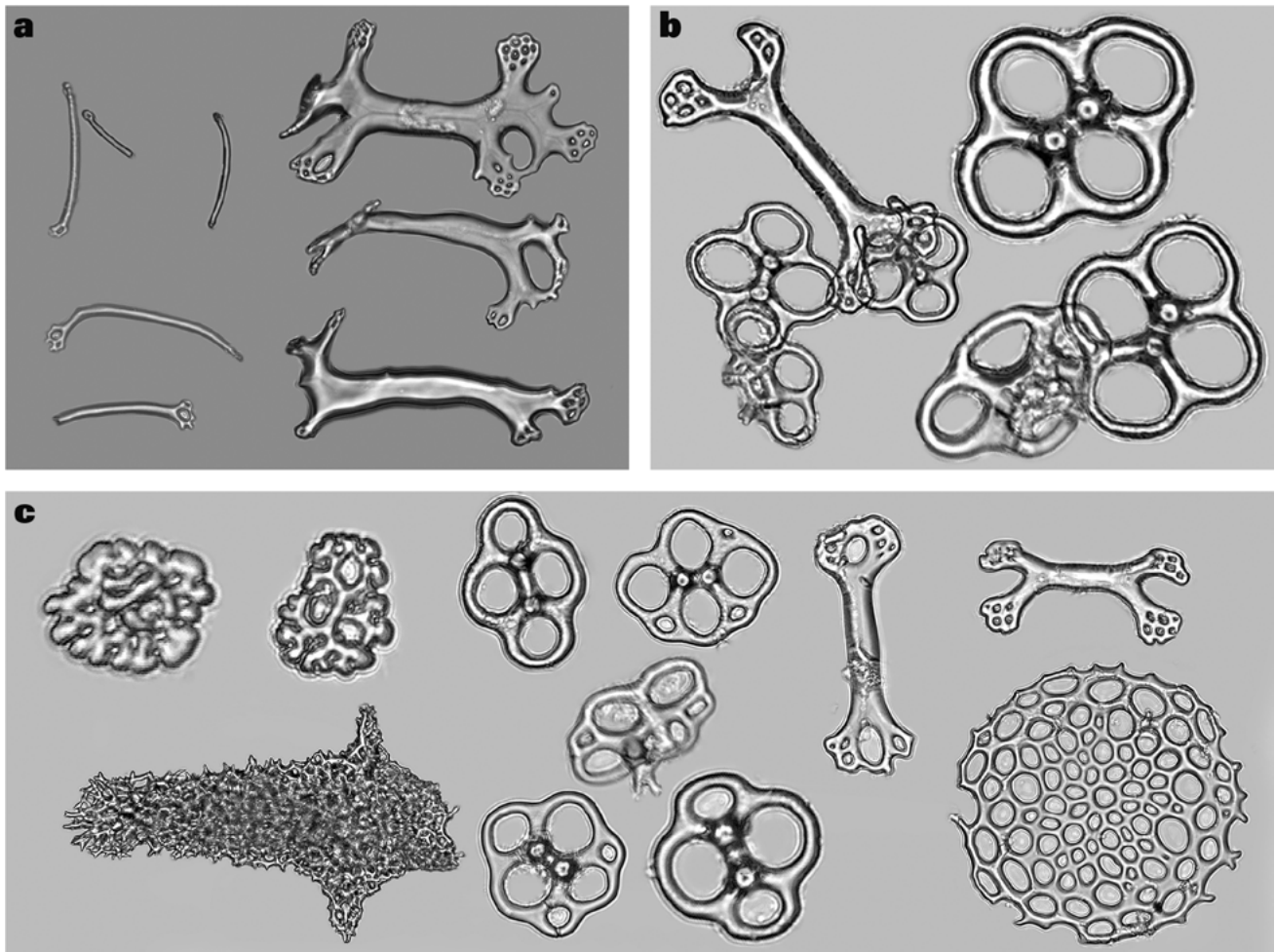


Figure 20. Ossicles from holotype of *Neopsolidium(?) insolitum* O'Loughlin sp. nov. (WAM Z89054): a, from tentacle, thick rods with widened and branched perforate ends up to 160 μm long, thin rods up to 90 μm long; b, from dorsal body wall, table discs up to 80 μm long, low two-pillar spires, distinctive tube foot support rod with bifurcate perforate ends; c, from posterior body wall, multi-layered scale fragment (bottom left), endplate up to 224 μm diameter (bottom right), distally widened and perforate tube foot support rods (top right), table discs up to 55 μm long (center), rosettes (top left).

referred *Thyone perissa* H. L. Clark, 1938 (WA) to *Massinium magnum* (Ludwig, 1882), and *Thyone minuta* H. L. Clark, 1938 to *Stolus minutus* (H. L. Clark, 1938).

***Thyone papuensis* Théel, 1886**

Table 1; appendix 1; figures 23, 24

Thyone fusus var. *papuensis* Théel, 1886: 92, pl. 7 fig. 1.

Thyone papuensis H. L. Clark, 1921: 167.—1932: 221.—1946: 399.—Clark & Rowe, 1971: 182.—A. M. Clark, 1982: 489, 495, fig. 2.—Cannon & Silver, 1986: 32, fig. 9g.—Liao & Clark, 1995: 504, fig. 306.—Rowe (in Rowe & Gates), 1995: 316.

Type locality. Torres Strait.

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no LIN_6, WAM station no 16, barcode 10001097, from -15.27505 S 124.36988

E 46 m to -15.27543 S 124.36918 E 46 m, 18 Mar 2015, WAM Z89057 (1); RV *Solander*, sled, site no SOL_116a, WAM station no 18, barcode 10001259, from -15.26142 S 124.27518 E 41 m to -15.26172 S 124.27583 E 40 m, 18 Mar 2015, WAM Z89058 (1); RV *Solander*, sled, site no SOL_43, WAM station no 26, barcode 10002102, from -15.488461 124.201824 46 m to -15.488309 124.201113 46 m, 21 Mar 2015, WAM Z89059 (1) (ring eviscerated and lost); RV *Solander*, sled, site no SOL_77, WAM station no 34, barcode 10002542, from -15.725854 S 124.166978 41 m to -15.726405 124.16756 41 m, 23 Mar 2015, WAM Z89060 (1).

North Kimberley Region, near mouth of King George River, RV *Solander*, Sled 06, lot number (barcode) 023319, -13.8505 127.28868 45 m, 6 June 2013, WAM Z27863 (1) (UF tissue lot MOL AF 1463).

Description (Kimberley specimens; preserved in 95% ethanol). Body fusiform, narrow, with long tapers to narrow oral and anal ends, oral and anal ends may be slightly upturned, body (live) up to 35 mm long, up to 17 mm diameter; complete cover

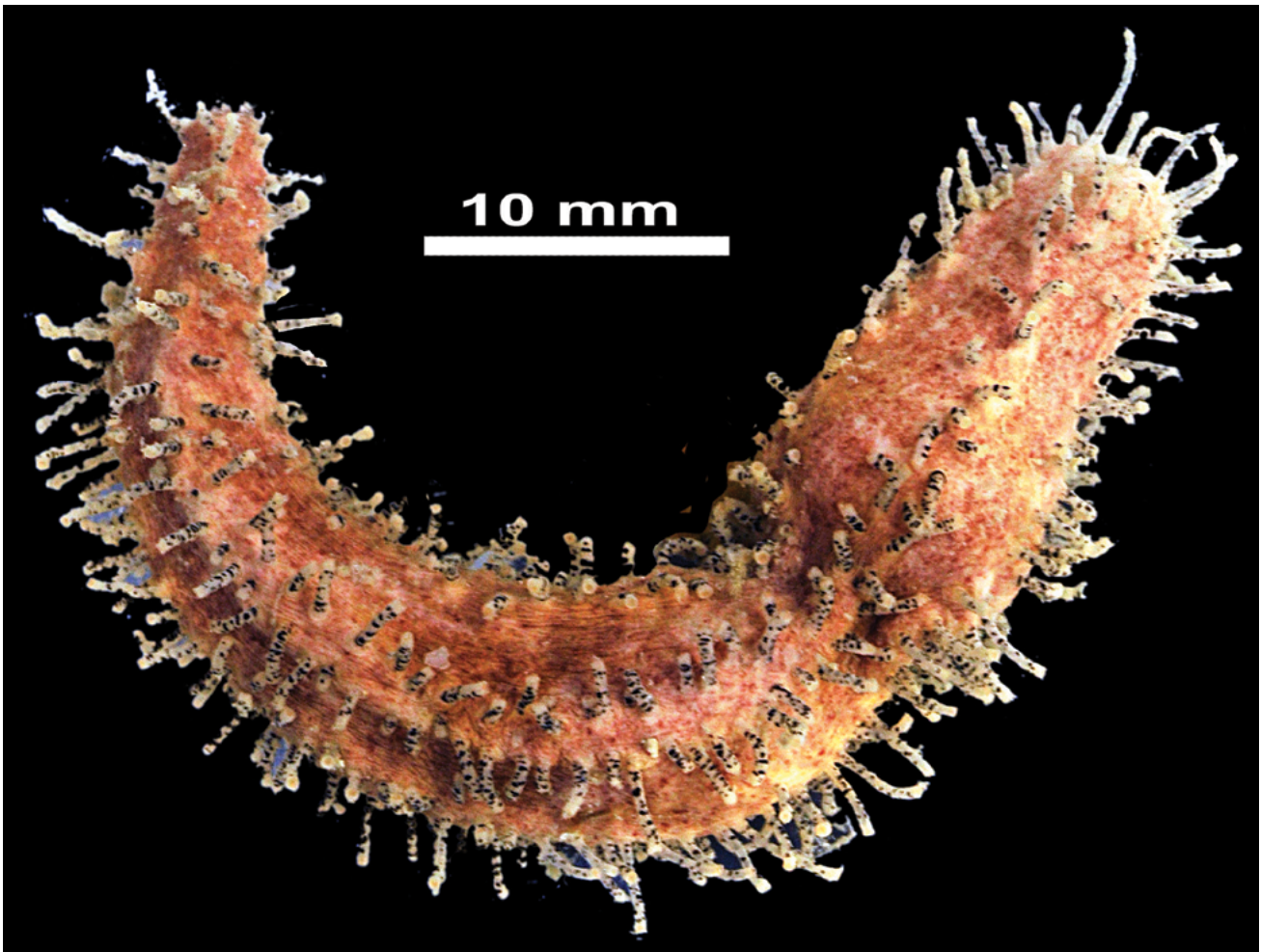


Figure 21. Photo of live specimen of *Hemithyone semperi* (Bell, 1884) (WAM Z89055).

of small tube feet, diameters about 0.2 mm, some in longitudinal series; 10 dendritic tentacles, two ventral small; calcareous ring tubular with long posterior prolongations comprising a mosaic of small pieces; inconspicuous anal scales present comprising thick single-layered plates with small perforation, multi-layered components, meshed rods component; single polian vesicle; gonad tubules not branched.

Mid-body ossicles scattered small tables with a spire of two pillars, discs with predominantly four perforations in smaller specimens, two larger central, two smaller distal, many discs in larger specimens with four or more smaller additional perforations, disc lengths commonly 50–55 μm , spire heights 23 μm , spires of two pillars, single apical bridge, apex of spire with two short pillar ends, each with a few blunt spines, spines sometimes with additional secondary spinelet. Tube feet endplates *Thyone*-like with small central perforations, outer ring of large perforations, marginal rim of small transversely oval perforation, endplates up to 110 μm diameter; support tables in tube feet with elongate, curved

discs up to about 120 μm long, four central perforations, single small perforation distally; spires with two pillars, joined apically with few blunt apical spines. Peri-anal body wall with single and multi-layered scale ossicles, tables with multi-perforate discs, tube foot support tables differing from mid-body. Tentacles and introvert with fine rods, tables and rosettes; largest rods with bifurcate ends, rods up to 90 μm long; table discs with many perforations, up to about 20; rosettes typically oval, about 30 μm long; rods and rosettes inter-grade in form.

Live colour pale brown to yellow with irregular red to brown patches on body and some tube feet; preserved colour off-white with red-brown to brown patches on body and some tube feet.

Distribution. North Western Australia, Kimberley Region, Camden Sound and King George River region, 40–46 m (this work); Houtman Abrolhos, WA, to Double Island Point, Queensland, 0–60 m (Rowe & Gates 1995).



Figure 22. Photo of live specimen of *Stolus canescens* (Semper, 1867) (WAM Z89056).

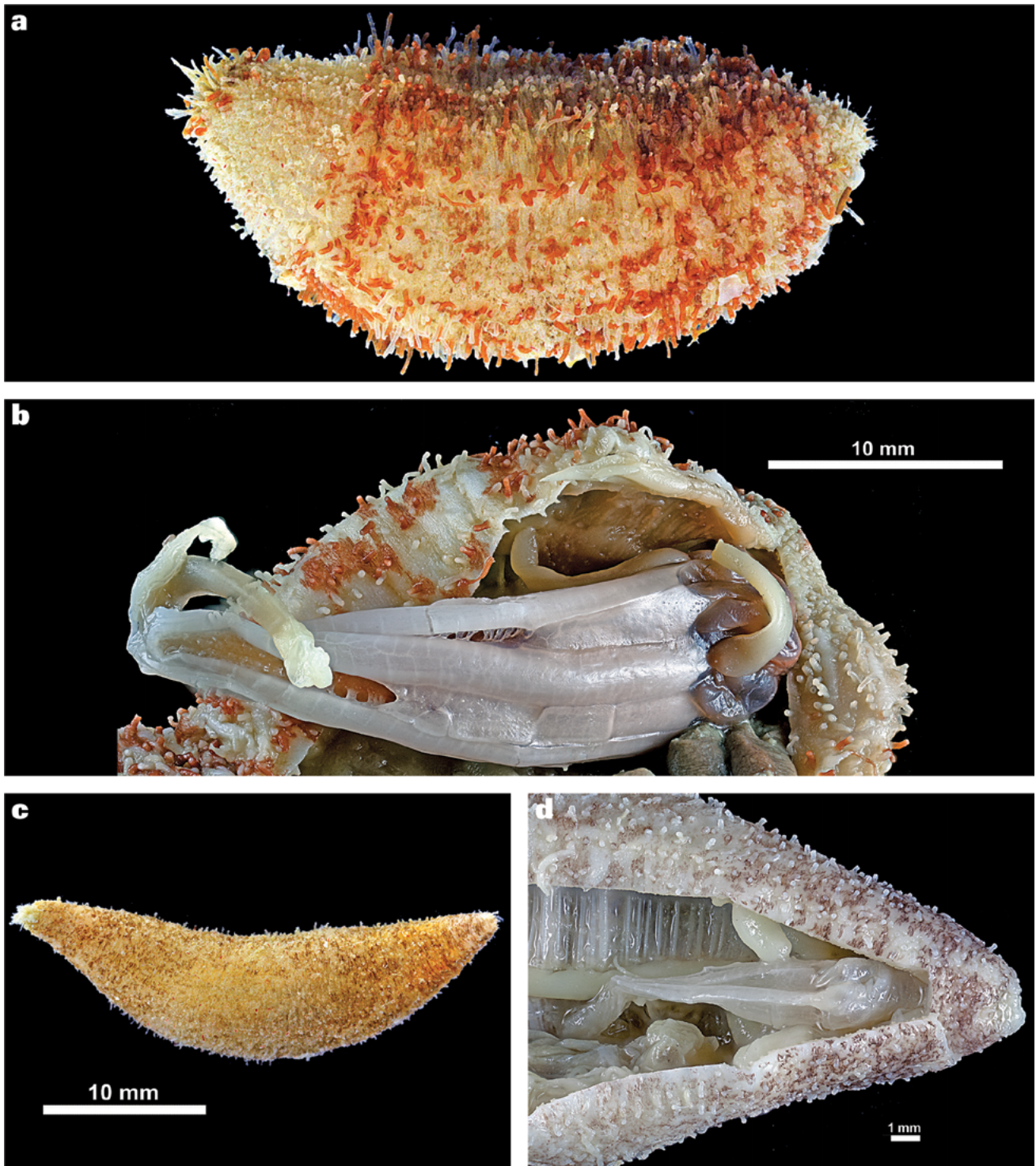


Figure 23. Photos of specimens judged to be *Thyone papuensis* Théel, 1886. a, lateral view of live specimen (WAM Z89060); b, calcareous ring of the same specimen preserved; c, lateral view of live specimen (WAM Z89058); d, calcareous ring of same specimen preserved (ring is relatively very small and is probably regenerating).

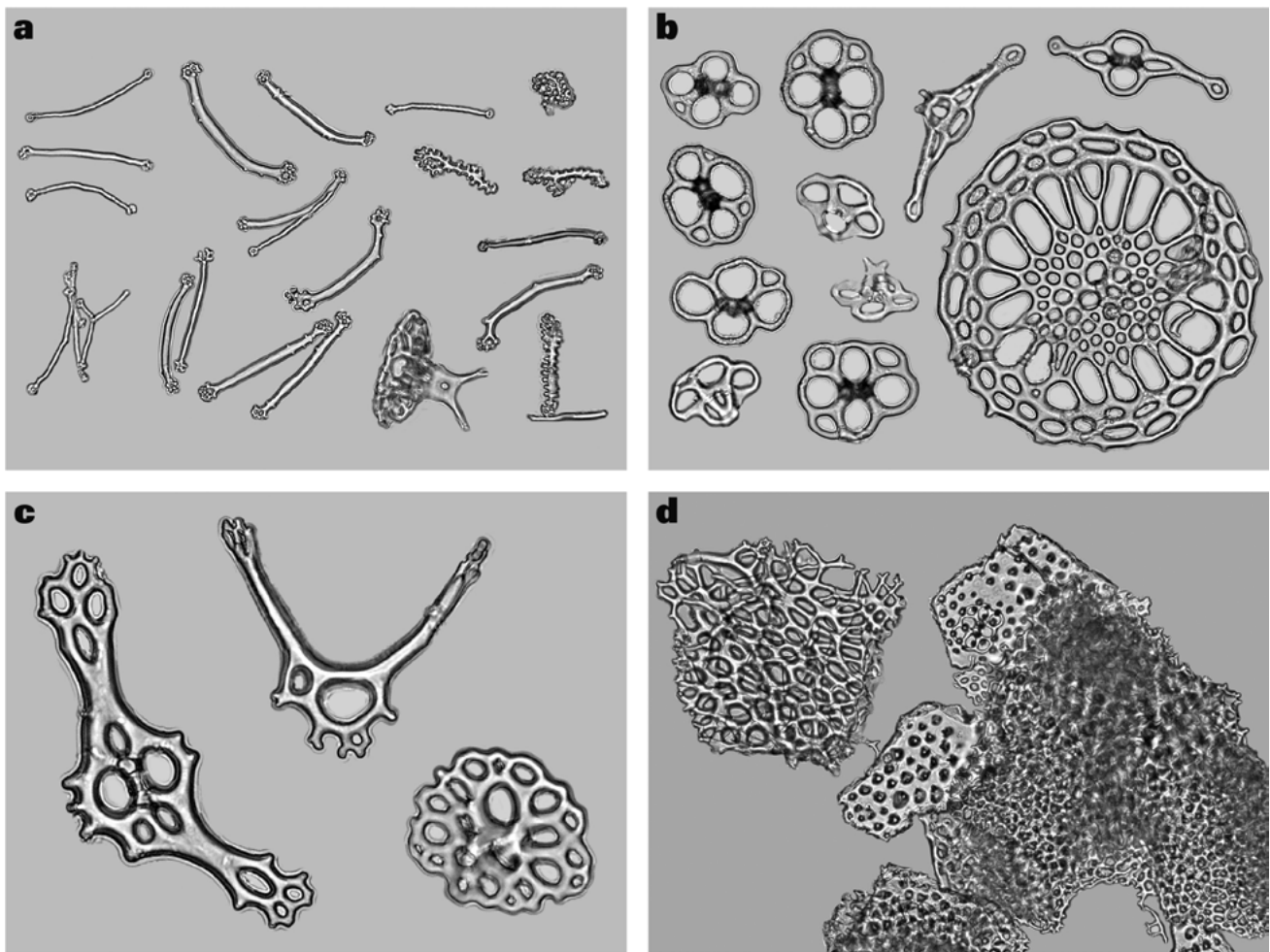


Figure 24. Photos of ossicles from *Thyone papuensis* Théel, 1886 specimens (WAM Z89057, WAM Z89058, WAM Z89059). a, from tentacle and introvert, fine rods (up to 90 μm long), rosettes (frequently about 30 μm long), table with multi-perforate disc and two spires; b, from mid-body wall and tube foot, table discs (frequently 50–55 μm long) and spires (about 23 μm high), endplate (up to 110 μm diameter), endplate support tables with single distal disc perforations (curved discs up to about 120 μm long); c, from peri-anal body wall, table with multi-perforate disc 56 μm across, tube foot support tables differing from body wall, upper one 80 μm between distal ends, lower left one 120 μm long; d, from peri-anal body wall, single and multi-layered fragments of scale ossicle.

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

Remarks. See O’Loughlin, Mackenzie & VandenSpiegel, 2014.

Actinocucumis Ludwig, 1875

Remarks. See O’Loughlin, Mackenzie & VandenSpiegel, 2014.

Actinocucumis longipedes H. L. Clark, 1938

Table 1; appendix 1; figure 25a

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_40, WAM station no 10, barcode 10000683, from -15.339415 124.160692 46 m to -15.33941 124.161459 46 m, 16 Mar 2015, WAM Z89061 (1).

Actinocucumis solanderi O’Loughlin, 2014 (in O’Loughlin, Mackenzie & VandenSpiegel, 2014)

Table 1; appendix 1; figure 25b

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no LIN_46, WAM station no 3, barcode 10000111, from -15.399083 124.345337 41 m to -15.398828 124.345572 42 m, 15 Mar 2015, WAM Z89062 (1); RV *Solander*, sled, site no LIN_36, WAM station no 17, barcode 10001112, from -15.220444 124.320894 50 m to -15.220159 124.320648 50 m, 18 Mar 2015, WAM Z89063 (1); RV *Solander*, sled, site no SOL_69, WAM station no 41, barcode 10002832, from -15.747648 124.146502 43 m to -15.747285 124.14634 43 m, 26 Mar 2015, WAM Z89064 (1).

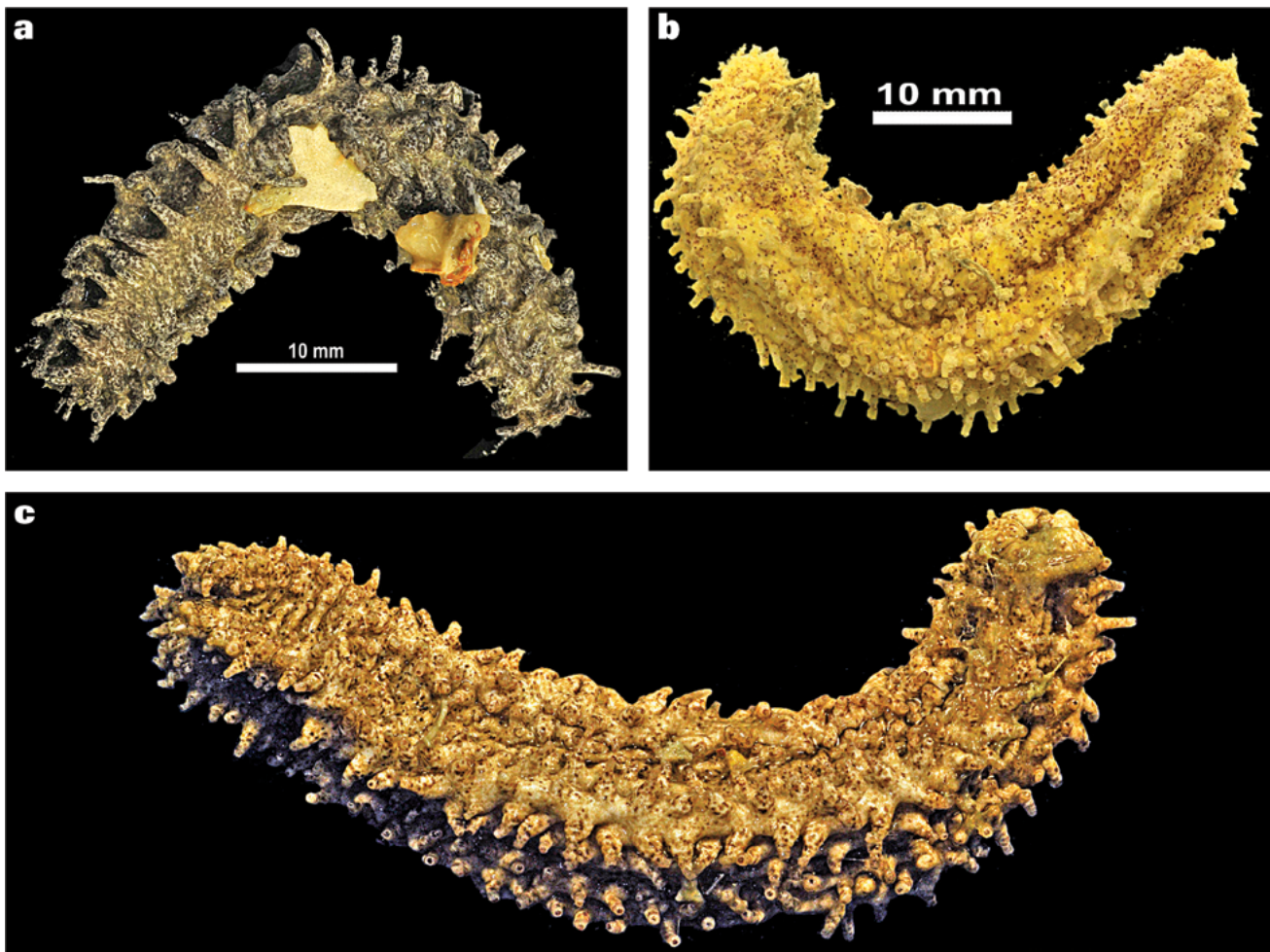


Figure 25. Photos of lateral views of live specimens of three species of *Actinocucumis* Ludwig, 1875: a, *Actinocucumis longipedes* H. L. Clark, 1938 (WAM Z89061); b, *Actinocucumis solanderi* O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014) (WAM Z89063); c, *Actinocucumis typica* Ludwig, 1875 (WAM Z89065; estimated 25 mm long live).

***Actinocucumis typica* Ludwig, 1875**

Table 1; appendix 1; figure 25c

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_101, WAM station no 35, barcode 10002613, from -15.753636 124.270741 34 m to -15.75404 124.271287 34 m, 23 Mar 2015, WAM Z89065 (1); RV *Solander*, sled, site no SOL_97, WAM station no 39, barcode 10002792, from -15.782865 124.378047 32 m to -15.782335 124.378553 33 m, 25 Mar 2015, WAM Z89066 (1).

***Mensamaria intercedens* (Lampert, 1885)**

Table 1; appendix 1; figure 26

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_40, WAM station no 10, barcode 10000685, from -15.339415 124.160692 46 m to -15.33941 124.161459 46 m, 16 Mar 2015, WAM Z89067 (1); RV *Solander*, sled, site no SOL_32, WAM station no 19, barcode

10001307, from -15.253592 124.203038 45 m to -15.253318 124.202302 45 m, 19 Mar 2015, WAM Z89068 (1).

Order **Molpadida** Haeckel, 1896

Family **Molpadiidae** J. Müller, 1850

***Molpadia scabrum* (Sluiter, 1901)**

Table 1; appendix 1; figure 27a

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Linnaeus*, sled, site no LIN_48, barcode 53720, from -15.32474 124.42657 28 m to -15.32183 124.42742 12 m, 19 Mar 2015, WAM Z89069 (1).

Subclass **Synaptaea** Cuénot, 1891 (*sensu* Smirnov 2012)

Order **Synaptida** Cuénot, 1891 (*sensu* Smirnov 2012)

Family **Synaptidae** Burmeister, 1837 (*sensu* Östergren 1898)

Subfamily **Rynkatorpinae** Smirnov, 1989

Protankyra Östergren, 1898

Diagnosis (after Clark 1908). Tentacles digitate, 10–12, rarely 13 or 14; digits two on each side (rarely one only). Cartilaginous ring wanting. Polian vesicles 2–10, rarely one only. Stone canal usually single, rarely several. Stock of anchors more or less branched or only finely toothed; arms usually serrate; vertex of anchors without knobs. Anchor plates without a handle; with numerous irregular perforations, never with two large central perforations; with a more or less imperfectly developed bow across outer surface of posterior end; plates and perforations with either smooth or dentate margins.

Remarks. We have added “never with two large central perforations” to the diagnosis of anchor plates to distinguish *Protankyra* from genus *Rynkatorpa* Rowe & Pawson, 1967.

Protankyra insolens (Théel, 1886)

Table 1; appendix 1; figure 27b

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_107, WAM station no 1, barcode 10000038, from -15.514826 124.183111 46 m to -15.514503 124.183774 45 m, 14 Mar 2015, WAM Z89070 (1).

Protankyra torquea O’Loughlin sp. nov.

Zoobank LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:94FD3258-AAE8-48F3-939F-444D8ECC70FD>

Table 1; appendix 1; figure 28

Material examined. Holotype. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_48, WAM station no 4, barcode 10000142, from -15.39822 124.28823 23.2 m to -15.39864 124.28950 28.6 m, 15 Mar 2015, WAM Z89071.

Description (preserved in 95% ethanol). Anterior end only of synaptid species, 26 mm long, up to 16 mm diameter; body wall firm to hard, thick, opaque, not translucent; tentacles 12, trunks elongate, each with two pairs of closely placed distal digits, distal end of tentacles with short, thick papilla-like end; four polian vesicles detected; ciliated funnels not detected at base of dorsal mesentery or along coelomic inter-radii; longitudinal muscles broad, thick, rounded, undivided.

Body wall ossicles anchors, anchor plates, short rods, miliary granules. Anchors irregular in form, similar sizes, up to 304 μm long, base of stocks variably indented, variably finely toothed, lateral ends of stock with raised rounded elevations, shaft variably constricted near base, anchor vertex lacking knobs, arms with 3–5 outer anteriorly pointed spines. Anchor plates irregularly heart-shaped, breadth and height sub-equal, size slightly variable, plates 230–260 μm long, perforations (excluding basally) up to about 30, irregular in size, basal perforations numerous and small, fine teeth on inner margin of perforations numerous to rare to absent, plates

lacking significantly larger central perforations, margin of plates incomplete and irregular, irregular bow across posterior end of plates. Short curved rods abundant, of variable form, some curved inwards distally, some with distal swellings, some bluntly denticulate on inner margin, rods up to about 30 μm long. Some miliary ‘granules’ found in body wall, not abundant, thin oval flat plates, some dumbbell shaped, up to about 30 μm long. Tentacles with miliary ‘granules’ and rods, as in body wall. Longitudinal muscles with abundant miliary ‘granules’ only, ‘granules’ as in body wall and tentacles.

Live body colour off-white with irregular red-brown transverse patches, tentacle trunks as for body, digits pale yellow; preserved body colour off-white with irregular pale brown patches.

Distribution. Northwest Western Australia, Kimberley Region, Camden Sound, 23–29 m.

Etymology. Named *torquea* from the Latin *torqueo* (irregular), with reference to the irregular form of the typically incomplete margin of anchor plates, and irregular form of the anchor stock bases.

Remarks. The specimen comprises an anterior end only, is strongly contracted, and the alimentary canal and mesentery are mostly eviscerated. These factors might account for the apparent absence of ciliated funnels. Three *Protankyra* species are reported from northern Australia by Rowe (in Rowe & Gates 1995): *P. insolens* (Théel, 1886) (type locality Arafura Sea, north of Camden Sound); *P. similis* (Semper, 1867) (type locality the Philippines); *P. verrilli* (Théel, 1886) (type locality Torres Strait, NE Australia). Both *P. insolens* and *P. verrilli* were found in Camden Sound and are reported here. Each fits well with the description and illustration by Théel (1886). Amongst *Protankyra* species, *Protankyra torquea* O’Loughlin sp. nov. is closest to *P. verrilli* in morphological characters, but *P. verrilli* lacks rods in the body wall, is smaller, has a thin body wall, and lacks colour in the preserved state.

Protankyra verrilli (Théel, 1886)

Table 1; appendix 1; figure 27c

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_47, WAM station no 42, barcode 10002967, from -15.612805 124.073033 36 m to -15.612437 124.072883 35 m, 26 Mar 2015, WAM Z89072 (1).

Subfamily **Synaptinae** Burmeister, 1837 (*sensu* Smirnov 1989)

Synaptula lamperti Heding, 1928

Table 1; appendix 1; figure 29a

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no SOL_56, WAM station no 20, barcode 10001534, from -15.376537 124.192773 35 m to -15.376196 124.192071 35 m, 19 Mar 2015, WAM Z89073 (1).

Synaptula recta (Semper, 1867)

Table 1; appendix 1; figure 29b

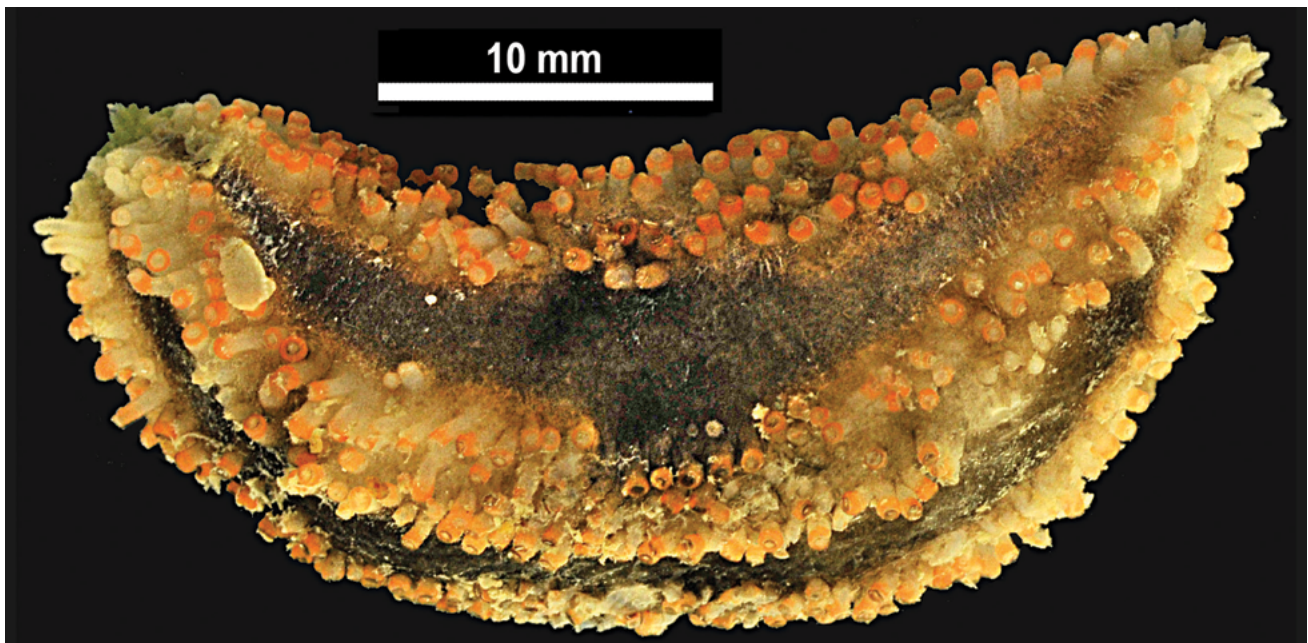


Figure 26. Photo of live specimen of *Mensamaria intercedens* (Lampert, 1885) (WAM Z89067).

Material examined. Northwest Western Australia, Kimberley Region, Camden Sound, WAMSI 1.1.1, RV *Solander*, sled, site no LIN_35, WAM station no 11, barcode 10000777, from -15.363088 124.443893 37 m to -15.362756 124.443995 37 m, 17 Mar 2015, WAM Z89074 (1); same data, barcode 10000919, WAM Z89075 (1).

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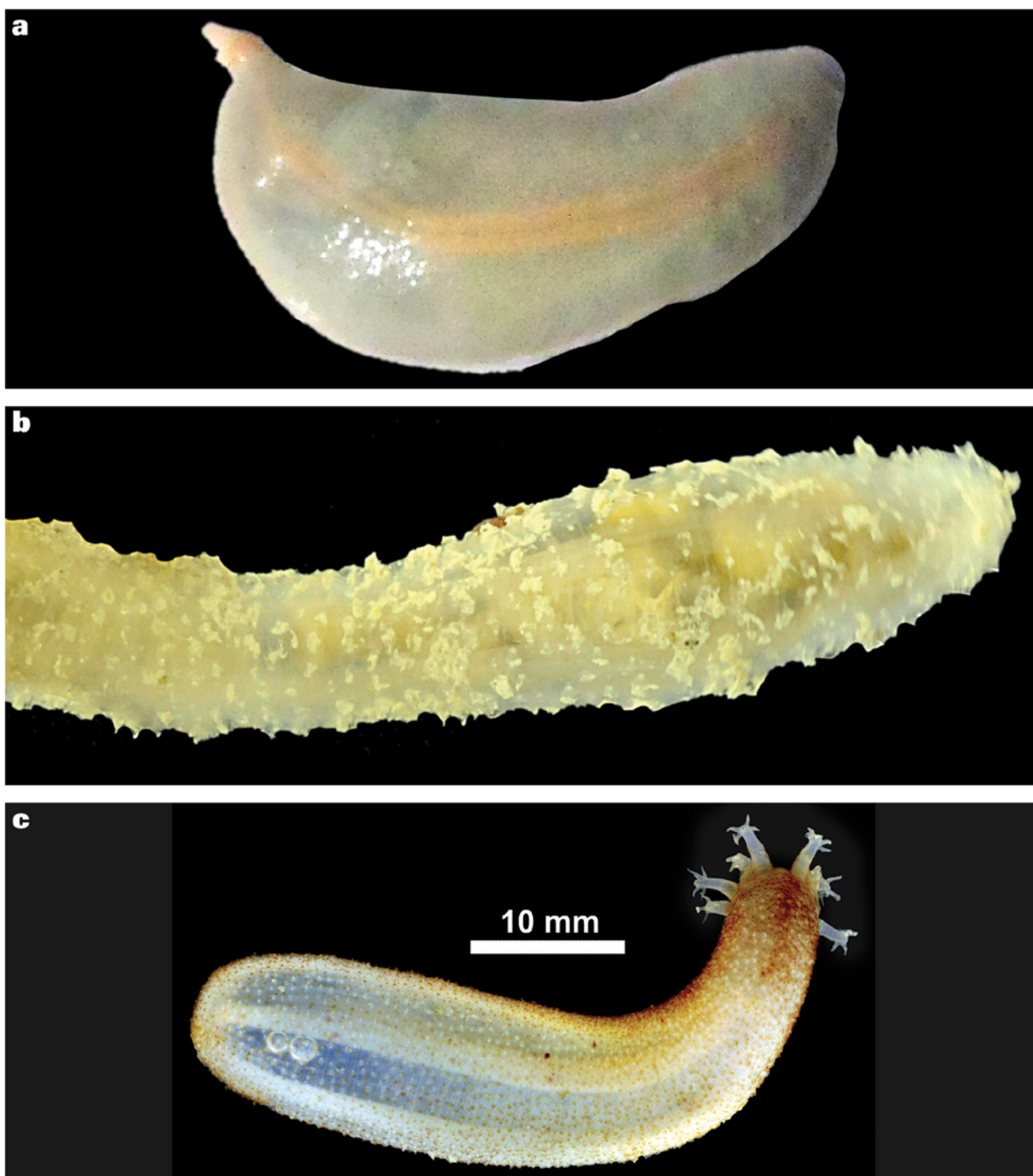


Figure 27. Photos of live specimens. a, *Molpadia scabrum* (Sluiter, 1901) (WAM Z89069; estimated 38 mm long live); b, *Protankyra insolens* (Théel, 1886) (WAM Z89070; estimated 24 mm long live); c, *Protankyra verrilli* (Théel, 1886) (WAM Z89072).

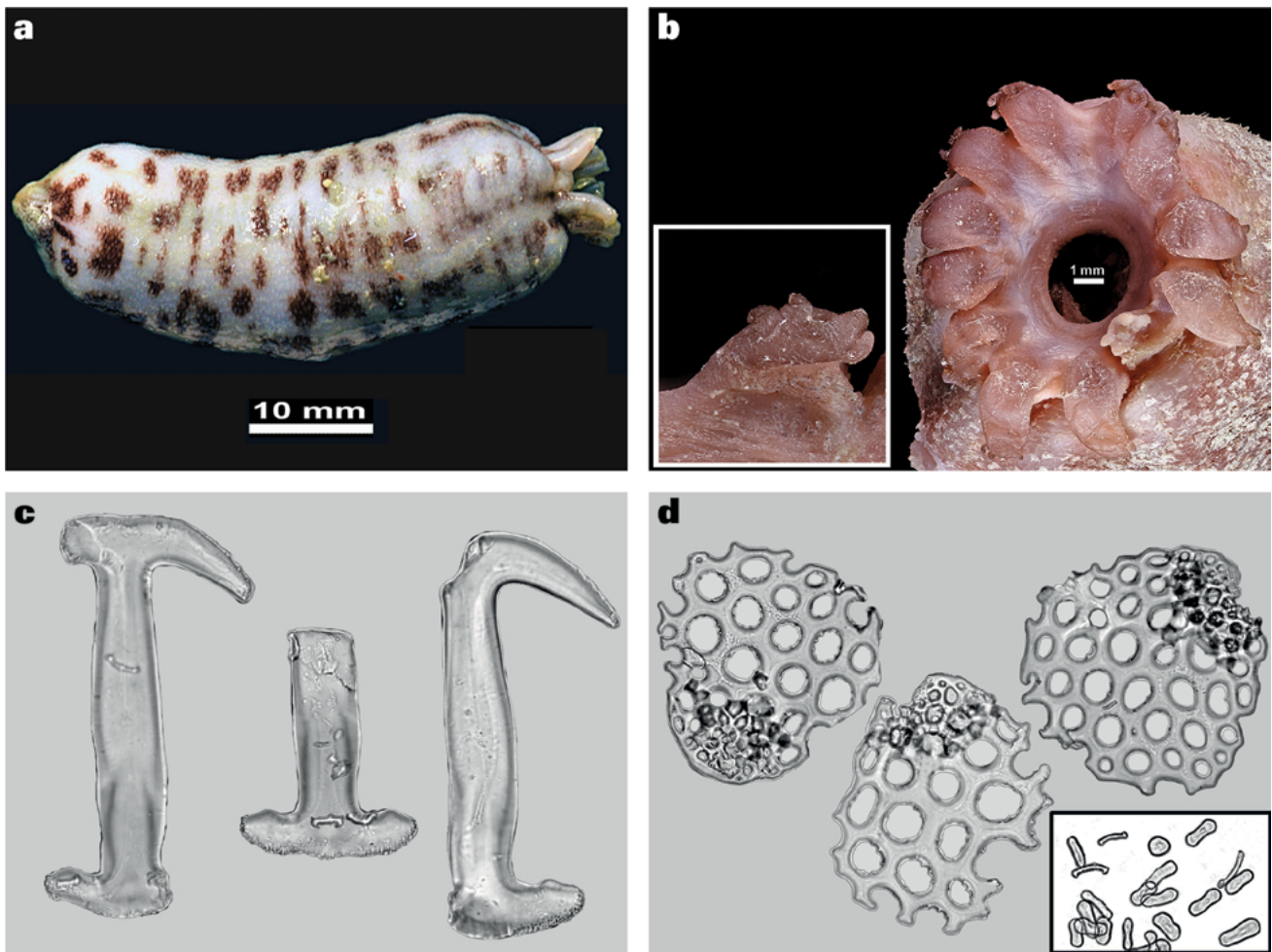


Figure 28. Photos of holotype of *Protankyra torquea* O'Loughlin sp. nov. (WAM Z89071): a, live holotype anterior fragment; b, photo of tentacle ring of preserved holotype (insert with a photo of one tentacle with two pairs of digits). c, d, ossicle photos from body wall of holotype: c, broken anchors, with some residual rods on surfaces (anchors up to 304 μm long); d, anchor plates (anchor plates 230–260 μm long); d insert, rods and miliary 'granules' about 30 μm long.

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Figure 29. Photos of live specimens: a, *Synaptula lamperti* Heding, 1928 (WAM Z89073); b, *Synaptula recta* (Semper, 1867) (WAM Z89074).

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Appendix 1. Tissue samples for genetic data from Camden Sound sea cucumbers.

Registration	Barcode	Type	Tissue	Taxa
WAM	CSIRO		MOL AF	
Z89000	10000043	paratype	1759	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89001	10000403	paratype	1760	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89002	10001168	paratype	1761	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89003	10001320	paratype	1762	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89004	10001821	paratype	1763	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89005	10001954	paratype	1764	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89006	10002938	holotype	1765	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89007	10002963	paratype	1766	<i>Holothuria (Metriatyla) keesingi</i> O’Loughlin sp. nov.
Z89008	No no.		1767	<i>Holothuria (Thymiosycia) gracilis</i> (Semper, 1868)
Z89009	10003037		1768	<i>Stichopus</i> unresolved species complex including <i>Stichopus herrmanni</i> Semper, 1868
Z89010	10003038		1769	<i>Stichopus</i> unresolved species complex including <i>Stichopus herrmanni</i> Semper, 1868
Z89011	10001261		1770	<i>Globosita elnaeae</i> O’Loughlin, 2014 (in O’Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89012	10001262		1771	<i>Globosita elnaeae</i> O’Loughlin, 2014 (in O’Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89013	10002087		1772	<i>Cercodemus anceps</i> Selenka, 1867
Z89014	10000001		1773	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89015	10000582		1692	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89016	10000647		1774	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89017	10001114		1775	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89018	10001331		1776	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89019	10001420		1777	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89020	10001560		1778	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89021	10001767		1690	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89022	10001971		1691	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89023	10002500		1779	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89024	10002692		1780	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89025	10002871		1781	<i>Colochirus quadrangularis</i> Troschel, 1846
Z89026	10002268	holotype	1688	<i>Plesiocolochirus minaeus</i> O’Loughlin sp. nov.
Z89027	53713		1782	<i>Leptopentacta grisea</i> H. L. Clark, 1938
Z89028	10001662		1783	<i>Plesiocolochirus</i> sp. 1, unresolved species complex including <i>P. australis</i> (Ludwig, 1875)
Z89029	10001822		1784	<i>Plesiocolochirus</i> sp. 1, unresolved species complex including <i>P. australis</i> (Ludwig, 1875)
Z89030	10002101		1785	<i>Plesiocolochirus</i> sp. 1, unresolved species complex including <i>P. australis</i> (Ludwig, 1875)
Z89031	10000760		1786	<i>Pseudocolochirus axiologus</i> (H. L. Clark, 1914)
Z89032	10002389		1787	<i>Pseudocolochirus axiologus</i> (H. L. Clark, 1914)
Z89033	10001306		1788	<i>Phyllophorus (Phyllophorella) spiculata</i> Chang, 1935

Registration	Barcode	Type	Tissue	Taxa
WAM	CSIRO		MOL AF	
Z89034	10000113		1789	<i>Phyllophorus (Urodemella) holothurioides</i> Ludwig, 1875
Z89035	10001277		1790	<i>Phyllophorus (Urodemella) holothurioides</i> Ludwig, 1875
Z89036	10000277		1791	<i>Havelockia versicolor</i> (Semper, 1867)
Z89037	10000776		1792	<i>Havelockia versicolor</i> (Semper, 1867)
Z89038	10001220		1793	<i>Havelockia versicolor</i> (Semper, 1867)
Z89039	10001124		1794	<i>Havelockia versicolor</i> (Semper, 1867)
Z89040	10001321		1795	<i>Havelockia versicolor</i> (Semper, 1867)
Z89041	10001417		1796	<i>Havelockia versicolor</i> (Semper, 1867)
Z89042	10001637		1797	<i>Havelockia versicolor</i> (Semper, 1867)
Z89043	10001924		1798	<i>Havelockia versicolor</i> (Semper, 1867)
Z89044	10002314		1799	<i>Havelockia versicolor</i> (Semper, 1867)
Z89045	10002323		1800	<i>Havelockia versicolor</i> (Semper, 1867)
Z89046	10002688		1801	<i>Havelockia versicolor</i> (Semper, 1867)
Z89047	10002689		1802	<i>Havelockia versicolor</i> (Semper, 1867)
Z89048	10002752		1803	<i>Havelockia versicolor</i> (Semper, 1867)
Z89049	10002838		1804	<i>Havelockia versicolor</i> (Semper, 1867)
Z89050	10002939		1805	<i>Havelockia versicolor</i> (Semper, 1867)
Z89051	10002243		1806	<i>Massinium bonapartum</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89052	10002725		1807	<i>Massinium bonapartum</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89053	10002966		1808	<i>Massinium bonapartum</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89054	10002958	holotype	1809	<i>Neothyonidium(?) insolitum</i> O'Loughlin sp. nov.
Z89055	10001531		1810	<i>Hemithyone semperi</i> (Bell, 1884)
Z89056	10002195		1811	<i>Stolus canescens</i> (Semper, 1867)
Z89057	10001097		1812	<i>Thyone papuensis</i> Théel, 1886
Z89058	10001259		1813	<i>Thyone papuensis</i> Théel, 1886
Z89059	10002102		1814	<i>Thyone papuensis</i> Théel, 1886
Z89060	10002542		1815	<i>Thyone papuensis</i> Théel, 1886
Z89061	10000683		1816	<i>Actinocucumis longipedes</i> H. L. Clark, 1938
Z89062	10000111		1817	<i>Actinocucumis solanderi</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89063	10001112		1818	<i>Actinocucumis solanderi</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89064	10002832		1819	<i>Actinocucumis solanderi</i> O'Loughlin, 2014 (in O'Loughlin, Mackenzie & VandenSpiegel, 2014)
Z89065	10002613		1820	<i>Actinocucumis typica</i> Ludwig, 1875
Z89066	10002792		1821	<i>Actinocucumis typica</i> Ludwig, 1875
Z89067	10000685		1822	<i>Mensamaria intercedens</i> (Lampert, 1885)
Z89068	10001307		1823	<i>Mensamaria intercedens</i> (Lampert, 1885)
Z89069	53720		1824	<i>Molpadia scabrum</i> (Sluiter, 1901)
Z89070	10000038		1825	<i>Protankyra insolens</i> (Théel, 1886)
Z89071	10000142	holotype	1826	<i>Protankyra torquea</i> O'Loughlin sp. nov.
Z89072	10002967		1827	<i>Protankyra verrilli</i> (Théel, 1886)
Z89073	10001534		1828	<i>Synaptula lamperti</i> Heding, 1928
Z89074	10000777		1829	<i>Synaptula recta</i> (Semper, 1867)
Z89075	10000919		1830	<i>Synaptula recta</i> (Semper, 1867)
Z89076	10002614		1831	indeterminate unknown species (ring and tentacles eviscerated)

Appendix 2. List of tissues (with tissue sample code numbers, specimen repositories, specimen registration numbers, specimen source locations, and GenBank Accession numbers) from *Colochirus* Troschel, 1846 and *Plesiocolochirus* Cherbonnier, 1946 specimens with sequences in the phylogenetic tree.

Genus	species	Tissue code	Museum	Registration	Location	GenBank
<i>Colochirus</i>	species 1 GP	UF 10059	UF	10059	Heron Island	KX844560
<i>Colochirus</i>	species 1 GP	MOL AF 1263	QM	G22502 (1)	Lizard Island	KX844598
<i>Colochirus</i>	species 1 GP	MOL AF 1264	QM	G22502 (2)	Lizard Island	KX844574
<i>Colochirus</i>	species 1 GP	MOL AF 1265	QM	G22502 (3)	Lizard Island	KX844583
<i>Colochirus</i>	species 1 GP	UF 8504	UF	UF8504	Lizard Island	KX844613
<i>Colochirus</i>	species 1 GP	UF 2249	UF	UF2249	PNG	KX844564
<i>Colochirus</i>	species 1 GP	UF 10918	UF	UF10918	Okinawa	KX844566
<i>Colochirus</i>	species 1 GP	PH-28	UF	17852	Philippines	KX844572
<i>Colochirus</i>	species 1 GP	PH-34	UF	17853	Philippines	KX844573
<i>Colochirus</i>	species 1 GP	UF 957	UF	957	Okinawa	KX844569
<i>Colochirus</i>	species 1 GP	MOL AF 1200	WAM	Z26234 (11)	Kimberley	KX844568
<i>Colochirus</i>	species 1 GP	UF 7400	UF	7400	Madagascar	KX844611
<i>Colochirus</i>	species 1 GP	UF 7510	UF	7510	Madagascar	KX844609
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1693	NMV	F201782	N Australia	KX844576
<i>Colochirus</i>	<i>quadrangularis</i>	UF 13683	UF	13683	Singapore	KX844595
<i>Colochirus</i>	<i>quadrangularis</i>	UF 13667	UF	13667	Singapore	KX844565
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1692	WAM	Z89015	Kimberley	KX844610
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 398	NMV	F149742	Kimberley	KX844559
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1691	WAM	Z89022	Kimberley	KX844596
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1690	WAM	Z89021	Kimberley	KX844594
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1453	WAM	Z27858	Kimberley	KX844605
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1209	NMV	F173259	N Australia	KX844601
<i>Colochirus</i>	<i>quadrangularis</i>	MOL AF 1210	NMV	F173260	N Australia	KX844562
<i>Colochirus</i>	<i>quadrangularis</i>	QM09 058	QM	SBD503854	Queensland	KX844586
<i>Colochirus</i>	<i>quadrangularis</i>	QM09 074	QM	TS80000215	Queensland	KX844577
<i>Colochirus</i>	<i>robustus</i>	MOL AF 396	NMV	F149737	Kimberley	KX844579
<i>Colochirus</i>	<i>robustus</i>	MOL AF 397	NMV	F149738	Kimberley	KX844606
<i>Colochirus</i>	<i>robustus</i>	UF 17373	UF	17373	Philippines	KX844561
<i>Colochirus</i>	<i>robustus</i>	UF 17672	UF	17672	Philippines	KX844582
<i>Plesiocolochirus</i>	<i>challengeri</i>	MOL AF 1460	NMV	F203000	Kimberley	KX844597
<i>Plesiocolochirus</i>	<i>challengeri</i>	MOL AF 1461	WAM	Z27862	Kimberley	KX844570
<i>Plesiocolochirus</i>	<i>challengeri</i>	MOL AF 1213	NMV	F173263	N Australia	KX844587
<i>Plesiocolochirus</i>	species 2 GP	UF 10077	UF	10077	Heron Island	KX844571
<i>Plesiocolochirus</i>	species 2 GP	UF 9986	UF	9986	Heron Island	KX844563
<i>Plesiocolochirus</i>	species 2 GP	UF 10041	UF	10041	Heron Island	KX844607
<i>Plesiocolochirus</i>	<i>tessellarus</i>	MRAC 2005 39	MRAC	2616	Comoros	KX844590
<i>Plesiocolochirus</i>	species 1 GP	MOL AF 394	NMV	F150795	Kimberley	KX844567
<i>Plesiocolochirus</i>	species 1 GP	MOL AF 395	NMV	F150805	Kimberley	KX844604
<i>Plesiocolochirus</i>	species 1 GP	MOL AF 1444	WAM	Z27854 (1)	Kimberley	KX844584
<i>Plesiocolochirus</i>	species 1 GP	MOL AF 1443	WAM	Z27854 (2)	Kimberley	KX844578
<i>Plesiocolochirus</i>	species 1 GP	MOL AF 1196	WAM	Z26229 (3)	Kimberley	KX844585
<i>Plesiocolochirus</i>	species 1 GP	UF 8952A	UF	8952A	Palau	KX844589
<i>Plesiocolochirus</i>	species 1 GP	UF 9535	UF	9535	Ningaloo	KX844612
<i>Plesiocolochirus</i>	species 1 GP	UF 17730	UF	17730	Japan	KX844575
<i>Plesiocolochirus</i>	<i>minaeus</i> sp. nov.	MOL AF 1688	WAM	Z89026	Kimberley	KX844602

Genus	species	Tissue code	Museum	Registration	Location	GenBank
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 430	NMV	F151840 (1)	Victoria	KX844592
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 431	NMV	F151840 (2)	Victoria	KX844603
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 1175	NMV	F173252	Victoria	KX844593
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 1177	NMV	F173255 (2)	Victoria	KX844588
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 453	NMV	F125377	Victoria	KX844591
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 454	NMV	F125376	Victoria	KX844580
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 450	NMV	F126892 (1)	Victoria	KX844600
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 451	NMV	F126892 (2)	Victoria	KX844581
<i>Plesiocolochirus</i>	<i>ignavus</i>	MOL AF 452	NMV	F126892 (3)	Victoria	KX844599