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New tropical caudinid and synaptid sea cucumbers from the Johor Straits (Echinodermata: Holothuroidea)

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Abstract. Two new sea cucumber species are described from the Comprehensive Marine Biodiversity Survey (CMBS) of the Johor Straits, Singapore: the caudinid *Acaudina rosettis*, new species, and synaptid *Protankyra scaphia*, new species. The type species for *Acaudina* H. L. Clark is discussed. The species assigned to *Acaudina* are listed. Figures are provided for *Acaudina leucoprocta* (H. L. Clark). *Acaudina rosettis* differs from the existing species of *Acaudina* by having a semi-translucent grey to opaque white body wall and abundant posterior body wall ossicles that are rosettes and thick smooth rods with a distinct waist. *Protankyra assymmetrica* (Ludwig) is also discussed. *Protankyra scaphia* differs from the existing species of *Protankyra* by the combination of form and size of the anchors and anchor plates, and the form and size of the symmetrical shallow bowls and comb ossicles in the body wall. New ossicle descriptive terms "rosette plate" and "comb" are introduced.

Key words. Singapore, CMBS, new species, Caudinidae, Synaptidae, *Acaudina*, *Protankyra*.

INTRODUCTION

In October 2010 the National Parks Board and National University of Singapore launched the first Comprehensive Marine Biodiversity Survey (CMBS) of Singapore waters. This five-year project comprised three phases that focused on the different habitats. The first phase was an intertidal mudflat survey, the second a seabed survey using dredges, epibenthic sleds and trawls, and the third an intertidal and subtidal reef survey. A marine expedition, based on the Pulau [=Island] Ubin in the East Johor Straits, surveyed the mudflat, intertidal, and seabed habitats in the Straits. The survey was carried out from 15 October 2012 to 2 November 2012 with the collaboration of local research teams from the National University of Singapore, overseas scientists, and the participation of National Parks Board volunteers and staff.

The Johor Strait separates Peninsular Malaysia from the island of Singapore and extends from west (1.12N 103.39E) to east (1.17N 104.05E). In the north the Straits are about 5 km wide. The deepest part of the channel is less than 25 meters. The Straits substrate comprises principally mud, sand and gravel with some rock outcrop. Occasionally mass fish deaths have been reported in the Johor Straits that may have been due to either the sudden adverse water and weather conditions or harmful algal blooms (Gin et al., 2000; Lee, 2014; Naqqiuddin et al., 2014). The input of fresh water from rivers creates a varying estuarine effect on the marine habitats (Wood et al., 1997; Gin et al., 2000). The 1-km long Malaysia–Singapore Causeway was completed in 1923 at 1.45N 103.77E to link Malaysia and Singapore across the Johor Strait, which effectively divided it into the East and West Johor Strait. There is only limited exchange of seawater between the east and west regions of the Straits.

During July of 2014 the project brought Mark O'Loughlin from Museum Victoria in Australia to the TMSI to work with Ong Joo Yong and Helen Wong Pei San on the Johor Straits sea cucumber collection. All identifications were completed at this time.

The Johor Straits collection of sea cucumbers comprises 193 lots with 29 species, 10 of them new to science. Two of the new species that are each represented by only one specimen have lost their tentacles and calcareous ring. Generic assignments have been made but the specimens are inadequate for new species descriptions. Many species collected in the Johor Straits were represented either by single specimens or a few specimens. This suggests a diverse but sparse fauna, as well as the possibility that there are more species to be found in the Straits. A preliminary CMBS checklist for the Johor Straits is published in this volume (Ong & Wong, 2015). This paper describes two of the new species. A further six new dendrochirotid species will be described in subsequent works that are in preparation.

MATERIAL AND METHODS

Sea cucumbers were collected by hand along the intertidal shore during low spring tide, and by dredge and trawl offshore. All specimens were fixed and preserved in 75%

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denatured ethanol. Specimens of new species described in this study were collected in the Johor Straits from 15 October to 2 November 2012. A number of conspecific specimens from the ZRC (Zoological Reference Collection) of the Lee Kong Chian Natural History Museum (LKCNHM) were included in the study. Specimens were housed and processed at the University's Tropical Marine Science Institute on St John's Island and deposited in the Lee Kong Chian Natural History Museum (LKCNHM; formerly the Raffles Museum of Biodiversity Research) at the National University of Singapore.

Ossicles obtained from specimens were first cleared of associated soft tissue in commercial bleach. These were washed with distilled water (three changes) and 70% ethanol (two changes), air-dried, mounted on aluminium stubs, and coated with gold for viewing under a JEOL JSM 6510 scanning electron microscope (SEM). Measurements were made with the built-in SEM software. Ossicles were similarly mounted on glass slides in DPeX® for light microscopy. Light micrographs of ossicles on slides were taken using an Olympus DP21 digital camera mounted on an Olympus compound microscope BX43. Photographs of living and preserved whole specimens were taken using either a DSLR Nikon D90/D800E with a 105 mm lens or with an Olympus DP21 digital camera mounted on an Olympus stereomicroscope SZX10.

Tissue samples from living specimens were taken by the CMBS cryogenic collection team during the CMBS Johor Straits workshop and deposited in the cryogenic collection of LKCNHM. Tissue samples were also taken from preserved specimens and sent to Gustav Paulay at the University of Florida.

ABBREVATIONS

CMBS	Comprehensive Marine Biodiversity Survey
LKCNHM	Lee Kong Chian Natural History Museum
MRH	Prefix for catalogue number of cryogenic collection of LKCNHM
NParks	National Parks Board
NUS	National University of Singapore
TMSI	Tropical Marine Science Institute
UF_JY	Prefix for code number of tissues provided to the University of Florida for sequencing
WoRMS	World Register of Marine Species
ZRC	Zoological Reference Collection of LKCNHM
ZRC.ECH.	LKCNHM catalogue number prefix

TAXONOMY

Order Molpadida Haeckel 1896 (sensu O'Loughlin et al., 2011)

Caudinidae Heding, 1931 (sensu O'Loughlin et al., 2011)

Acaudina Clark, 1908

Type species and locality. *Molpadia demissa* Sluiter, 1901 (by original monotypy) (Madura Strait, Java, 330 m; 160 mm long preserved specimen) = *Haplodactyla molpadioides* Semper, 1867 (opinion but not formal synonymy by Deichmann, 1940)

Eight other assigned species, distributions and synonyms.

Acaudina australis (Semper, 1868) (Ceylon, Papua New Guinea) (junior synonyms: *Haplodactyla andamanensis* Bell, 1887 and *Haplodactyla holothurioides* Selenka (non Cuvier), 1868; both synonymies by Clark, 1908);
A. bacilla Cherbonnier & Féral, 1981 (Philippines);
A. hualoeides (Sluiter, 1880) (Indonesia, S. China);
A. leucoprocta (H. L. Clark, 1938) (China, Iranian Gulf, N Australia) (jun. syn. *Aphelodactyla irania* Heding, 1940; synonymy by Liao, 1984);
A. molpadioides (Semper, 1867) (Ceylon, China, Indonesia, Philippines) (jun. syns: *Haplodactyla molpadioides sinensis* Semper, 1867 by Clark, 1908; *Haplodactyla molpadioides jagorii* Semper, 1868 by Cherbonnier & Féral, 1981; *Haplodactyla andamanensis* Bell, 1887 by Cherbonnier & Féral, 1981; *Haplodactyla ecalcarea* Sluiter, 1901 by Clark, 1908; *Aphelodactyla delicata* H. L. Clark, 1938 by Liao, 1984);
A. pellucida (Semper, 1867) (Indonesia, Philippines);
A. punctata (Sluiter, 1887) (Indonesia);
A. suspecta Cherbonnier & Féral, 1981 (Philippines).

Remarks. Deichmann (1940) remarked that "*Acaudina demissa* (Sluiter) may possibly be found to be merely a very large individual of the common East Indian species, *Acaudina molpadioides* (Semper)". Cherbonnier & Féral (1981) examined a slide of ossicles from the type of *A. demissa* and found predominantly very irregular and often sub-spherical ossicles, together with very spinous or finely spinous rods with enlarged ends. In their synonymy for *A. molpadioides* they did not include *A. demissa*. WoRMS currently lists *A. demissa* as a species of *Acaudina*.

Liao & Clark (1995) reported an examination of many specimens of *Acaudina* from the waters of southern China and the morphological variations led them to agree with the conclusion by Sluiter (1912), after a study of numerous specimens, that all the species of *Acaudina* described from the Philippines and East Indies are junior synonyms of *A. molpadioides*.

H. L. Clark (1908) judged that *Haplodactyla australis* Semper, 1867 is a valid species, but Cherbonnier & Féral (1981) judged that it is a junior synonym of *Acaudina molpadioides*. WoRMS currently lists *A. australis* as a species of *Acaudina*.

Cherbonnier & Féral (1981) listed *A. hualoeides* Sluiter, 1880 in their synonymy for *A. molpadioides* but with a question mark. The small 35 mm long type specimen is described as "glassy" in appearance, and rosette-like ossicles from the anal papillae and thin rods with short and long lateral branches from the posterior body wall are illustrated. There

is no indication of the presence of short thick smooth rods in straight or dumbbell or curved or doughnut form as would be anticipated for a small specimen of *A. molpadioides*. We agree that *A. hualoeides* is a dubious synonym of *A. molpadioides*. WoRMS lists *A. hualoeides* as a valid species.

Conflicting opinions remain for some of the species currently assigned to *Acaudina*.

Acaudina rosettis, new species
(Figs. 1, 2)

Material examined. Holotype: ZRC.ECH.0163, MRH109002, UF_JY008, Johor Straits East, off Pulau Serangoon, CMBS spec. no. JS-0117, stn. DW37, beam trawl, 1°24.822'N 103°55.613'E, 15 m, coll. Bertrand Richer de Forges et al., 19 October 2012; Paratypes: ZRC.ECH.0162, MRH108763, UF_JY007, Johor Straits West, Tuas, shore at 60 Tuas West Drive, CMBS spec. no. JS-0022, stn. SW26, 1°19.765'N 103°37.848'E, shore, sand/some mud/rocky coral, collected by hand, coll. Ng Heok Hee and Helen Wong, 17 October 2012 ; ZRC.ECH.0164, UF_JY009, Johor Straits East, Changi, CMBS spec. no. JS-4006, stn. DW117, 100 m from shore off Changi beach towards CAFHI Jetty, beam trawl, 1°23.619'N 103°59.441'E to 1°23.564'N 103°59.855'E, 5.3–9.9 m, mud, coll. Bertrand Richer de Forges et al. 29 October 2012; ZRC.ECH.0348, UF_JY006, Johor Straits East, Changi, 21 December 1987; ZRC.ECH.0349, UF_JY005, Changi Car Park 1, soft inshore sediments, 10 April 2014; ZRC.ECH.0157, UF_JY011, Johor Strait West, Tuas, CMBS spec. no. JS-0947, stn. SW16, shore at 60 Tuas West drive, 1°19.771'N 103°37.842'E, sandy/a little muddy with lots of algae, collected by hand, coll. Helen Wong et al., 16 October 2012. Other material: ZRC. ECH.0156, UF_JY010, Johor Straits East, Changi, CMBS spec. no. JS-0600, stn. DW87, Changi East off restricted area, beam trawl, 1°20.178'N 104°02.322'E to 1°19.732'N 104°02.507'E, 7.3-8.1 m, mud, coll. Bertrand Richer de Forges et al., 25 October 2012.

Description. Body elongate, distinct oral and more pronounced anal tapers; distinct dorsal/ventral symmetry, with slight ventral 'belly' and dorsally orientated oral and anal ends; live body wall thin, semi-translucent; preserved body up to 105 mm long, up to 30 mm wide mid-body (Fig. 1A). Tentacles 15, each with one pair of distal lateral digits (Fig. 1B); tentacle ampullae extend posteriorly about one posterior radial plate extension length beyond the end of the radial plate extensions. Calcareous ring radial plates with anterior notch, close pair of short posterior prolongations about the width of the inter-radial plate long; inter-radial plates more broad than radials, longitudinal ridge along center of plate, two anterior notches separated by a short anterior prolongation (Fig. 1C). One polian vesicle. Gonad tubules long, thin, white, branched. Anal papillae soft, in finger-like radial groups (Fig. 1A insert).

Ossicles detected principally in the posterior/caudal body wall, near the anus, and in the anal papillae, sometimes present anteriorly and in mid-body. In the caudal body wall near the anus, and in the anal papillae, abundant rods (Figs. 1E, 2C) and abundant rosettes (Figs. 1D, 2A) are present separately and consistently in small to large specimens. Rods are thick, short and smooth with form varying from straight with rounded ends, to curved, to wavy, to thick C-shaped, frequently narrowed mid-rod to create a dumbbell shape, some rods with central rounded knob, some with ends back-curved, some with ends knobbed, rarely with a distal perforation, rarely doughnut-shaped; various forms of 'rods' are 11–38 µm long, rarely up to 45 µm long, rods frequently about 28 µm long, 13 µm wide. Rosettes typically a thin stem with up to about four rosette knobs along each side and three at each end, sometimes along one side only, rosettes straight or frequently curved, rosettes 25–45 µm long. A few rosettes show extended branching to create irregular perforated rosette plates (Figs. 1D insert, 2B).

Ossicles not detected in the tentacles, or oral disc, or gonad tubules, but many orange to black phosphatic residues seen in the tentacles and oral disc.

Colour of living specimens semi-translucent grey with slight yellowing due to phosphatizing of calcareous ossicles (Figs. 1A, 2A, 2B). Preserved body colour white (larger specimens), grey (smaller specimen). Largest specimens never with any dark coloration. Preserved tentacles and anterior white body wall show some faint yellowing as a result of phosphatizing of the calcareous ossicles (Fig. 1B).

Distribution. Singapore, Johor Straits; Tuas and Changi, 0–15 m

Etymology. Named *rosettis,* meaning "with rosettes", referring to the distinctive abundance of rosette ossicles in the caudal body wall of this species.

Remarks. The three morphological characters that distinguish the new species *Acaudina rosettis* from other *Acaudina* species are the combination of: abundant thick smooth rods and rosette ossicles that occur separately in the caudal body wall, and that do not alter in form from juvenile to adult; phosphatizing of ossicles; and a semi-translucent grey to opaque white body wall with only slight yellowing colour for small to large specimens.

Some rosettes show extended branching to create irregular perforated plates for which we have introduced the term "rosette plate" (Figs. 1D insert, 2B). These are few in number in the body wall.'

In tissue preparations we found that rosettes and short thick rod ossicles (frequently dumbbell-shaped) always occurred separately. And sometimes the rosette ossicles were not detected. We suspect that the rosette ossicles occur in the soft outer body wall that is frequently lost during capture and handling.

Rosette-like ossicles are reported and illustrated for only *A. hualoeides* amongst *Acaudina* species. They are illustrated for the anal papillae of *A. hualoeides*, but only thin rods with

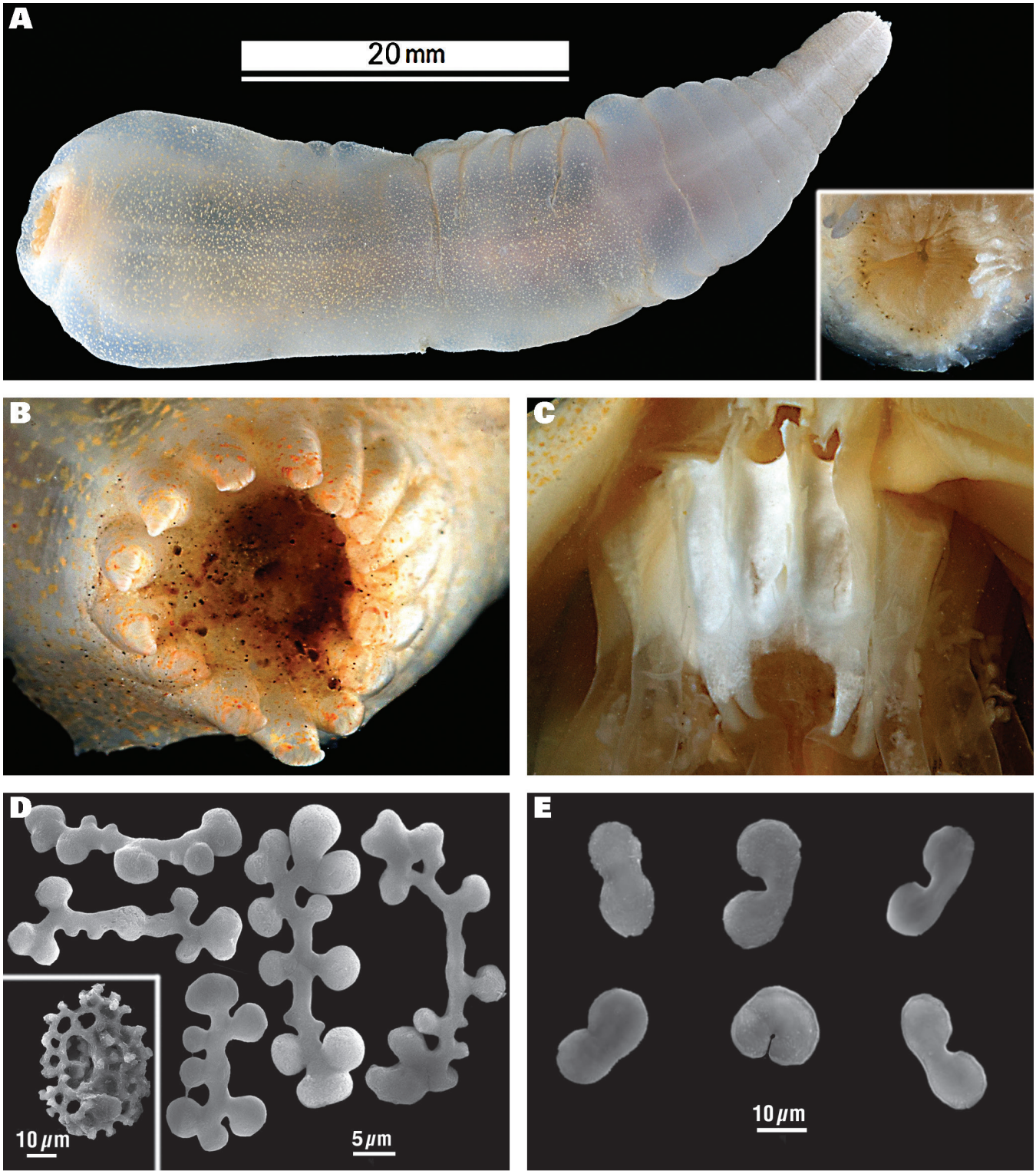

Fig. 1. *Acaudina rosettis*, new species. A, living, semi-translucent holotype (specimen ZRC.ECH.0163), with limited yellowing due to phosphatising of calcareous ossicles; A (insert), peri-anal region showing anal papillae (right) (paratype ZRC.ECH.0164); B, oral view showing 15 tentacles with distal pair of digits, and colouration due to phosphatising of ossicles (paratype ZRC.ECH.0164); C, calcareous ring stripped of tissue showing central wide inter-radial plate with longitudinal ridge, and radial plates on each side, each with paired posterior prolongations (paratype ZRC.ECH.0348); D, SEM images of rosette ossicles from anal papillae (paratype ZRC.ECH.0164); D (insert), SEM image of rosette plate from mid-body wall (paratype ZRC.ECH.0164); E, SEM images of dumbbell rod ossicles from caudal body wall (holotype ZRC.ECH.0163). Photograph of live specimen by Arthur Anker.

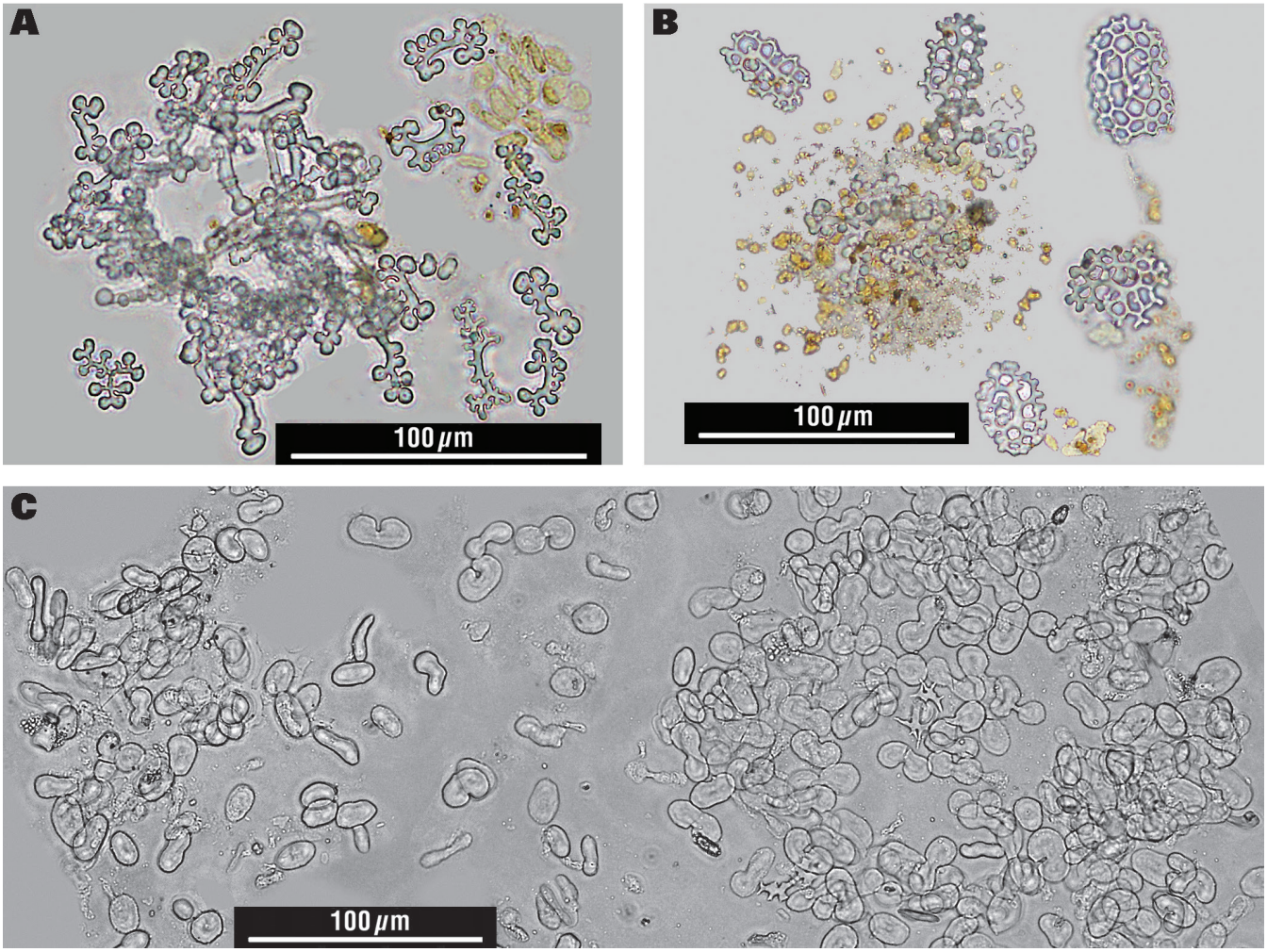

Fig. 2. *Acaudina rosettis*, new species, microscope slides with dissolved tissue preparations. A, caudal body wall rosette ossicles with some yellow phosphatic residues (paratype ZRC.ECH.0164); B, caudal rosette plate ossicles with yellow phosphatic residues (paratype ZRC.ECH.0164); C, caudal dumbbell and other forms of short smooth rod ossicles (paratype ZRC.ECH.0164).

lateral short and long branches are reported for the peri-anal body wall. Short thick rods in straight or dumbbell or curved or doughnut form are not reported. Semper (1867) did not illustrate rosette-like ossicles for *A. molpadioides*. This species has thick, bluntly spinous, irregularly oval, sometimes perforated, large plates (up to about 150 µm long) present abundantly in the body wall of larger specimens, and the colour is reddish-violet or purplish. Rosette-like ossicles have not been reported or illustrated for *A. leucoprocta*. None of these species is conspecific with *A. rosettis*.

Four specimens of *Acaudina leucoprocta* (Fig. 3) were found in the Johor Straits collection and are reported by Ong & Wong in this volume of The Raffles Bulletin of Zoology, ZRC.ECH.0150, UF_JY004, CMBS spec. no. MF24024, 90 mm long (preserved); ZRC.ECH.0151, MRH108882, UF_JY001, CMBS spec. no. JS–1202, 133 mm long (preserved); ZRC.ECH.0152, UF_JY003, CMBS spec. no. JS-4011, 40 mm long (preserved); ZRC.ECH.0153, UF_JY002, CMBS spec. no. SEA–6121, 83 mm long (preserved).

One specimen of *Acaudina molpadioides* was found in the Johor Straits collection (ZRC.ECH.0154, UF_JY017, CMBS spec. no. JS–4012, 25 mm long (preserved)). We observed two thin C-shaped ossicles (25 and 35 µm long respectively) in a posterior body wall sample from this small specimen, similar to the one illustrated by Semper (1867). This form of ossicle was seen only in the *A. molpadioides* specimen amongst the many *Acaudina* specimens that we examined. The small *A. molpadioides* specimen had a few dumbbell-shaped ossicles in the posterior body wall together with many phosphatic residues.

Subclass Synaptacea Cuénot, 1891 (sensu Smirnov 2012)

Order Synaptida Cuénot, 1891 (sensu Smirnov 2012)

Synaptidae Burmeister, 1837

Protankyra Östergren, 1898

Protankyra assymmetrica (Ludwig, 1875)

Synapta assymmetrica Ludwig, 1875: 88–79, pl. 6 fig. 2.
Synapta asymmetrica.—Théel, 1886: 28.

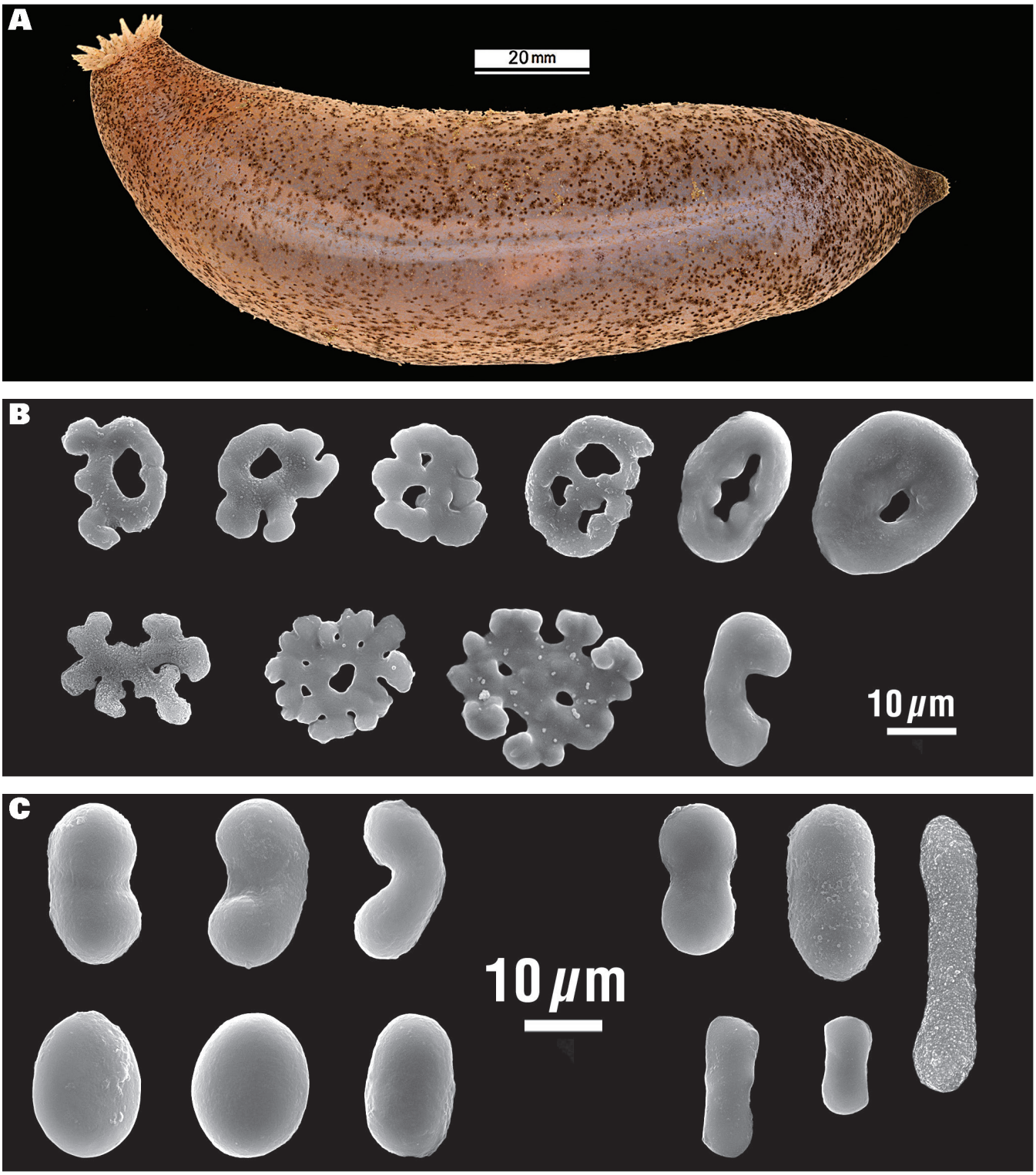

Fig. 3. *Acaudina leucoprocta* (H. L. Clark, 1938). A, living, semi-translucent specimen with dark colouration due to extensive phosphatizing of ossicles (ZRC.ECH.0151); B, SEM images of ossicles from posterior body wall (specimens ZRC.ECH.0151 and ZRC.ECH.0153); C, SEM images of ossicles from mid-body wall (specimen ZRC.ECH.0153). Photograph of live specimen by Jose Christopher Escano Mendoza.

Protankyra asymmetrica.—Østergren, 1898: 117, fig. 8.—Sluiter, 1901: 129–130, pl. 10 fig. 13.—Clark, 1908: 107, pl. 5 figs 35, 36.—Heding, 1928: 273–275, fig. 53.—Yang, 1937: 31, fig. 18.—Chang, 1948: 86, fig. 23.—Cherbonnier, 1961: 133–135, fig. 7f–j.—Chang et al., 1964: 49.—Clark & Rowe, 1971: 186.—Liao & Clark, 1995: 534, fig. 328.

Remarks. We note that all the authors who subsequently referred to Ludwig's species spelled the species name incorrectly. We restore the correct spelling here. We did not find *Protankyra assymmetrica* (Ludwig, 1875) in the Johor Straits collection but this species has been reported from off China and South Vietnam and in Indonesia and shares morphological similarities with the new species we have described below. The reports of *P. assymmetrica* are in most cases based on one or a few specimens as has been necessary for our new species below that is based on a single specimen. Uncertainty thus exists around possible variations is ossicle form and size that may be associated with variations in specimen size. We have examined the descriptions and figures provided by the authors who have reported *P. assymmetrica* and found what we judge to be significant inconsistencies. We judge that there appear to be four lots of specimens currently but questionably referred to *P. assymmetrica* by Sluiter (1901), Heding (1928), Yang (1937) and Cherbonnier (1961). It will require more specimens and genetic analysis to resolve the uncertainties.

Ludwig (1875) did not report what we are calling below "comb ossicles" (Fig. 5A insert) in his description of *P. assymmetrica*. Clark (1908) judged that Ludwig would have noticed them if present in his single colourless 40 mm long type specimen from Banka Island in the Java Sea. We agree. We observed some asymmetry of the anchor forms of our new species below, principally angles between shaft and lateral barbs at the apical end (Fig. 5B). The shaft and basal end are not as asymmetrical in our new species as they are in the figure by Ludwig (1875). Unfortunately there is no record of anchor and anchor plate sizes in Ludwig (1875). Clark (1908) reported anchor and anchor plate sizes for Ludwig's *P. assymmetrica* but took these sizes from Sluiter (1901) on the assumption that the specimens from Sulawesi examined by Sluiter were conspecific with Ludwig's specimen. These anchor and plate sizes of 500 µm and 400 µm respectively are almost twice the sizes of the ossicles we found in our new species below. We judge that our new species below is probably not *P. assymmetrica*.

Sluiter (1901) referred three specimens from Sulawesi to *P. assymmetrica*. He did observe and illustrate 54 µm long "comb ossicles" but they differ significantly in form to those we observed in our new species below. The lateral projections are very short. As noted above, Sluiter reported the anchor and plate sizes to be 500 µm and 400 µm respectively, almost twice the sizes of those in our new species. These specimens are not conspecific with our new species, and it is doubtful if they are conspecific with Ludwig's type for *P. assymmetrica*.

Heding (1928) assigned nine specimens, most incomplete, from off China and up to 145 mm long to *P. assymmetrica*. He illustrates anchor plates that are more than 300 µm long, compared with our new species where they are up to 310 µm long. And the anchor plates appear to be more spinous and have more numerous small perforations. Heding (1928) illustrates bowls that are sometimes very irregular and up to about 33 µm long, compared with our species where they are regular and typically 50 µm long. The "combs" that are illustrated by Heding (1928) do not have discrete digitiform lateral projections that are characteristic of our new species (Fig. 5A insert). In our new species we did not observe the very irregular rod-like inter-ambulacral granules that are illustrated by Heding (1928). These specimens are not conspecific with our new species or with Sluiter's specimens, and it is doubtful if they are conspecific with Ludwig's type for *P. assymmetrica*.

Yang (1937) referred a specimen fragment 10 mm long from off North Fukien to *P. assymmetrica*, but with reservation because he observed "comb" ossicles. The "comb" ossicles illustrated are quite asymmetrical and different to those in our new species. Yang (1937) reports significantly larger anchors (up to 480 µm long v 337 µm) and anchor plates (up to 360 µm v 310 µm) than in our new species below. His "accessory plates", that we refer to as "shallow bowls", have surface spinelets rather than spinous perforations. This specimen is not conspecific with the specimens of Sluiter (1901) and Heding (1928) and our Johor Straits specimen, and it is doubtful if it is conspecific with Ludwig's type for *P. assymmetrica*.

Cherbonnier (1961) referred three damaged specimens up to 23 mm long from south Vietnam to *P. assymmetrica*. "Combs" are reported but only up to 23 µm long and lacking digitiform lateral projections and with rugose ends, compared with the new species below where the combs are up to 42 µm long, have smooth ends and digitiform lateral projections. As illustrated by Cherbonnier (1961) the shallow bowls are similar (60 µm long vs up to 59 µm), the anchors are significantly shorter (160 µm long v up to 337 µm), and the anchor plates are significantly shorter (140 µm vs up to 310 µm) than in our new species below. And as illustrated by Cherbonnier the base of the anchor lacks the lateral notches that are evident in the new species below. These specimens are not conspecific with the specimens of Sluiter (1901), Heding (1928), Yang (1837) and our Johor Straits specimen, and it is doubtful if they are conspecific with Ludwig's type for *P. assymmetrica*.

This evidence suggests four lots of specimens from different localities that are not conspecific, and are not conspecific with our new species below. We judge that none of them is conspecific with *P. assymmetrica*.

***Protankyra scaphia*, new species**

(Figs. 4–6)

Material examined. Holotype: ZRC.ECH.0292, UF_JY018, Singapore, CMBS spec. no. JS–0840, stn. DW4, Johor Straits

East, 400 m southeast of Pulau Sekudu, rectangular dredge, 1°24.176'N 103°59.489'E to 1°24.132'N 103°59.686'E, 6.9–7.3 m, coarse sand / dead shell, coll. Bertand Richer de Forges et al., 16 October 2012.

Description. Body vermiform, preserved body 15 mm long; live body wall thin, semi-translucent (Fig. 4A); 12 tentacles, each with two pairs of distal digits.

Four ossicle forms occur in the body wall:

1. Anchors and anchor-plates (Figs. 4B, 5): anchors are frequently asymmetrical apically with different angles between the shaft and the lateral barbs, rounded basally, usually with two lateral shallow indentations, the basal surface is finely spinous, the distal apex is smooth, each pointed side arm has about 10 upward-directed sharp teeth on the outer edge, anchors are of variable size 282–337 µm long; anchor-plates are symmetrically pear-shaped, narrower at the anchor attachment end, the margins of plates are predominantly continuous and smooth, most perforations have inner teeth, a coarse bridge crosses the plate at the beginning of the narrowed end, anchor-plates of variable size are 253–310 µm long.

2. Shallow symmetrical oval bowls are abundant (Fig. 6): bowls predominantly have two larger perforations centrally, two smaller perforations at the ends, teeth are present or lacking around the inner margin of the perforations, bowls are 41–59 µm long.

Fig. 4. *Protankyra scaphia*, new species, holotype (ZRC.ECH.0292). A, live, semi-translucent holotype, white spots indicating the presence of anchors and anchor plates, tentacles with two pairs of digits; B, body wall showing anchors and anchor plates, and abundant small shallow bowls, in situ. Photograph of live specimen by Nguyen Thanh Son.

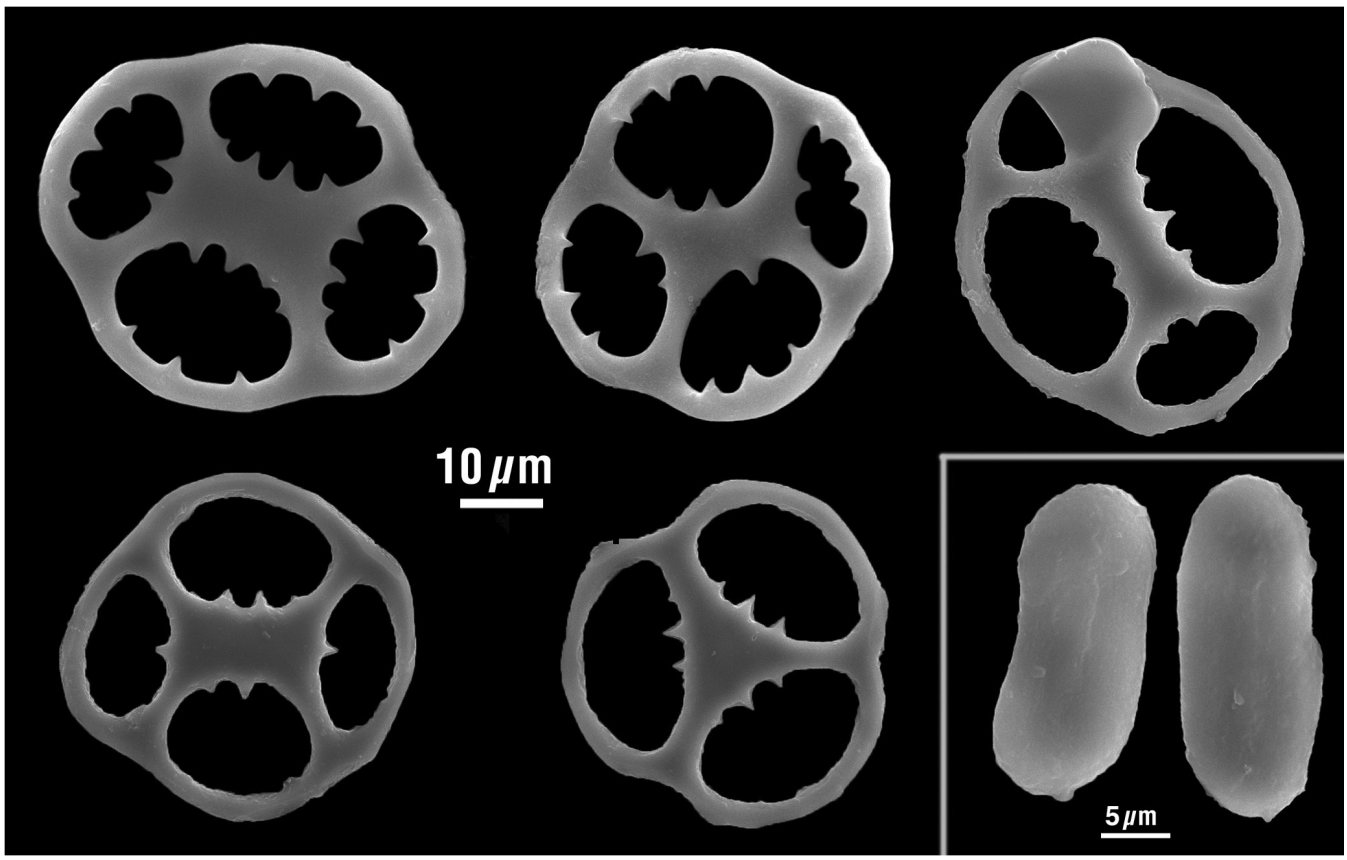

Fig. 6. *Protankyra scaphia*, new species, holotype (ZRC.ECH.0292). SEM images of shallow bowl ossicles with toothed perforations; insert with granules.

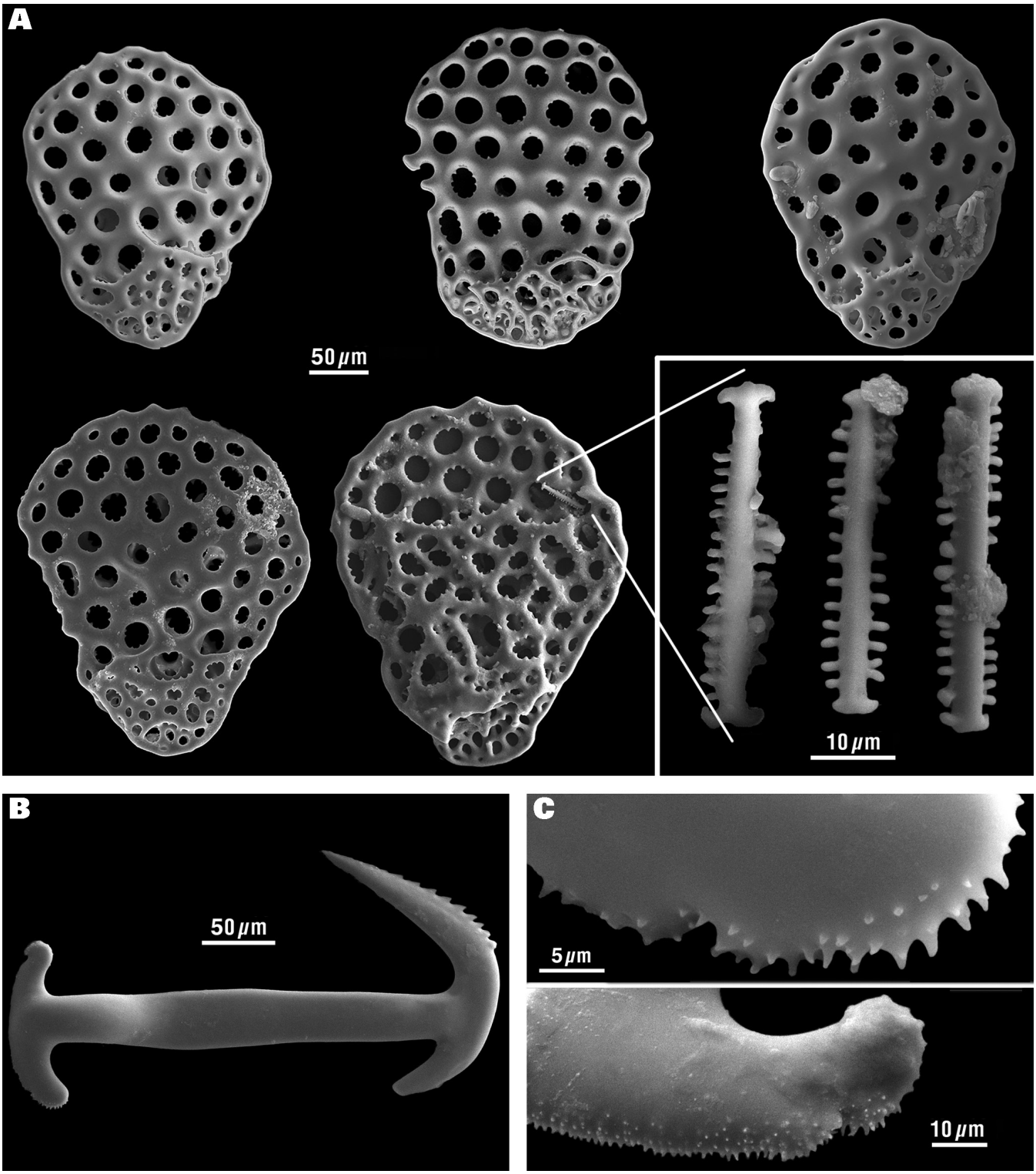

Fig. 5. SEM ossicle images for *Protankyra scaphia*, new species, holotype (ZRC.ECH.0292). A, anchor plates from the body wall (the two lines indicate that one small comb on the surface of an anchor plate has been enlarged for the insert); A insert, comb ossicles from the body wall; B, anchor from the body wall; C, parts of bases of anchors, upper showing fine spinelets and basal lateral notch, lower showing spinelets across anchor base.

3. Granules are abundant (Fig. 6 insert): form is oblong to slightly dumbbell-shaped, 23–30 μm long.

4. Small combs are sparse (Fig. 5A insert): they consists of a thick shaft with about 15–20 short digitiform or knob projections on each side and smooth wide rounded ends, combs are 27–42 μm long.

Live body and tentacle colour semi-translucent white, with white spots showing the presence of anchor plates and anchors (Fig. 4A); preserved body colour white.

Distribution. Singapore, Johor Straits, 400 m off southeast Pulau Sekudu, 7 m depth.

Etymology. Named *scaphia*, from the Latin *scaphium sciphus* meaning "bowl", with reference to the shallow bowl ossicles that occur in this species.

Remarks. The combination of morphological characters that distinguish *Protankyra scaphia*, new species, from the 38 other species of *Protankyra* listed in WoRMS are: the finely spinous rounded base with lateral notches and size range of the anchors; the continuous smooth margin, symmetrical form, and size range of the anchor plates; the presence in the body wall of numerous small, symmetrical, shallow bowls with four perforations, with inner teeth present or absent in the perforations; the size and form of the comb ossicles in the body wall. *P. scaphia* is closest in morphological characters to *Protankyra assymmetrica* (Ludwig, 1875) that is discussed in detail above and distinguished from our new species.

The live and preserved holotype specimen has a body constriction near the posterior end that may be a result of trauma or evidence of a fissiparous habit. The single small holotype was not dissected for additional morphological characters as the ossicle forms distinguish the new species from all other *Protankyra* species. A single specimen of *Protankyra pseudodigitata* (Semper, 1867), ZRC.ECH.0291, UF_JY019, CMBS spec. no. JS-0840, in this Johor Straits collection is reported by Ong & Wong (2015).

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