RAFFLES BULLETIN OF ZOOLOGY Supplement No. **36**: 451–468
Date of publication: 6 August 2021
DOI: 10.26107/RBZ-2021-0047
http://zoobank.org/urn:lsid:zoobank.org:pub:2527F83C-1696-4CA8-A620-BFA0CA08B38B

Holothuroids collected during the South Java Deep-Sea biodiversity cruise 2018, with emphasis on the order Elasipodida

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Abstract. Fifteen species of deep-sea holothuroids were recorded from the South Java Deep-Sea (SJADES) Biodiversity Expedition 2018 from depths between 100–1,700 m. Of these, the following five species are new records for Indonesian waters: *Zygothuria oxysclera* (R. Perrier, 1899); *Bathyplotes natans* (M. Sars, 1868); *Paelopatides gelatinosus* (Walsh, 1891); *Benthothuria funebris* R. Perrier, 1898; and *Pelagothuria natatrix* Ludwig, 1893. Most of the 15 species were only observed from a single station, but several were found at two or more stations. The following five elasipodid sea cucumbers are described in detail here: *Laetmogone violacea* Théel, 1879, *Pannychia* cf. *moseleyi* Théel, 1882, *Benthodytes sibogae* Sluiter, 1901, *Enypniastes eximia* Théel, 1882, and *Pelagothuria natatrix* Ludwig, 1893.

Key words. deep-sea holothuroid, new records, South Java Deep-Sea (SJADES) Biodiversity Expedition, Sunda Strait, Indian Ocean, Indonesia

INTRODUCTION

The Indonesian deep-sea holothurian fauna has received much less attention than species inhabiting shallow waters (Clark, 1907; Clark & Rowe, 1971; Jangoux & Sukarno, 1974; Azis, 1976, 1980; Massin & Lane, 1991; Massin, 1996, 1999; Massin & Tomascik, 1996; Wirawati et al., 2007, 2019; Purwati & Wirawati, 2008, 2009, 2011, 2012; Setyastuti, 2009, 2011, 2018; Wirawati & Purwati, 2012; Setyastuti & Wirawati, 2018; Setyastuti et al., 2018, 2019; Jasmadi et al., 2020). Our knowledge of the biodiversity of this marine realm in Indonesian waters is poor because of limited biodiversity survey capabilities and the lack of awareness of the possible benefits hidden in the deep sea. One of the great challenges of our age is to document the biosphere as completely as possible, including the deep-water ecosystem, before it deteriorates further under the impact of human activities (Michonneau et al., 2013). As notable macro-invertebrates that are conspicuous, charismatic, and have important ecological, economical, and medicinal roles, holothuroids deserve greater attention.

Most published records of deep-sea holothuroids from Indonesia are based on the Challenger (Théel, 1882, 1886a), Siboga (Sluiter, 1901a, b), Galathea (Hansen, 1956), and Snellius (Massin, 1987; Jangoux et al., 1989) expeditions. The Challenger expedition explored deep waters around the world's oceans and was not focused specifically on Indonesian waters. However, the first two deep-sea sea cucumbers from eastern Indonesia were collected during the Challenger expedition: *Deima fastosum* Théel, 1879 (a synonym of *Deima validum validum* Théel, 1879) and *Ilyodaemon maculatus* Théel, 1879 (now *Laetmogone maculata* (Théel, 1879)). Subsequently, Sluiter (1901a, b) described more than 25 new species from Indonesia collected by the Siboga expedition. More than half a century later, Hansen (1956) described seven deep-sea holothuroid species collected from the Sunda and Banda trench by the Galathea expedition at depths exceeding 6,000 m. The last major deep-sea cruise that passed through Indonesia was the Snellius expedition, which identified 13 species of holothuroids, eight of which were new (Massin, 1987; Jangoux et al., 1989). These expeditions mostly covered the northeastern and eastern regions of Indonesia.

To further explore Indonesian deep-water biodiversity, The South Java Deep-Sea (SJADES) Biodiversity Expedition was conducted in March–April 2018. As the first expedition to explore the deep-sea benthic biodiversity in the area, the SJADES cruise was an important mission to uncover the deep-water life there, using either a beam trawl or Warèn dredge to collect animals living on the sea floor including holothuroids across a depth range of 100–1,700 m.

Among the six orders of the class Holothuroidea (Miller et al., 2017) that are known to occur in Indonesian waters, Elasipodida are unique in being confined to the deep sea (Hansen, 1975; Gebruk, 1994; Solis-Marin, 2003). The uniqueness is not only in their morphological appearance, but also in having the ability to swim, a trait possessed by as many as one-half of the approximately 110 species

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ISSN 2345-7600 (electronic) | ISSN 0217-2445 (print)

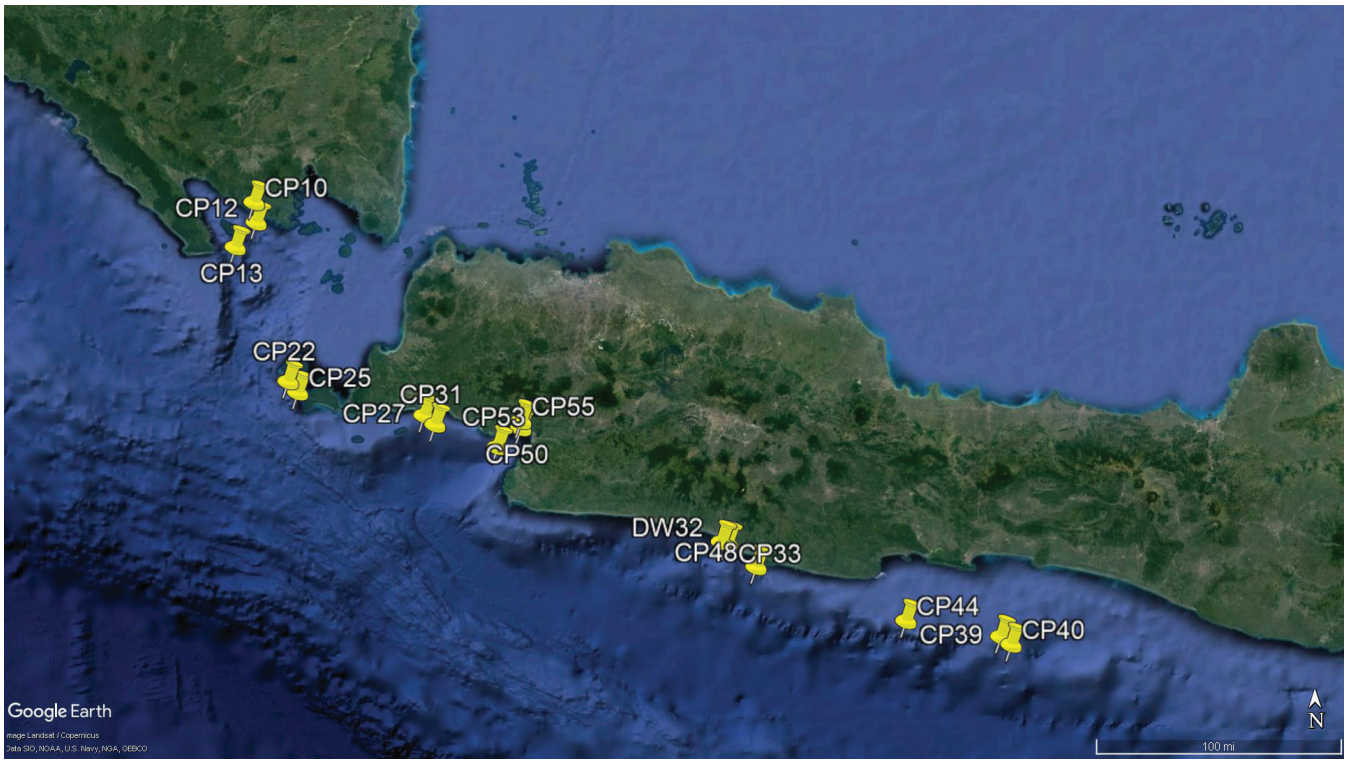

Fig. 1. Deep-sea collection stations in the Sunda Strait and off the coast of South Java where holothuroids were obtained. They were collected using either the beam trawl (CP) or dredge (DW).

in this order, although so far only about ten species have been captured in the water column (Pawson, 1976; Miller & Pawson, 1990). Furthermore, all specimens that belong to this order which were collected during the expedition interestingly were the most well preserved compared to those from other groups. Here we provide detailed descriptions of five elasipodid species collected in the Sunda Strait and off the coast of the western half of south Java.

MATERIAL AND METHODS

Holothuroid samples were obtained from 16 stations (out of a total of 63 stations; see Chim et al., 2021 for details) that extended from the Sunda Strait, West Java to South of Cilacap, Central Java (Fig. 1). Specimens were collected using a beam trawl and Warèn dredge, after which they were sorted, labelled, photographed, and preserved in 96% ethanol. Morphological and ossicle composition observations were made for species identification. The ossicles were isolated following Setyastuti & Purwati (2015). All specimens are deposited at the Research Center for Oceanography, Indonesian Institute of Sciences, and at the Lee Kong Chian Natural History Museum, National University of Singapore.

RESULTS

A total of 49 specimens referable to 15 species of holothuroids was collected from 16 stations (Figs. 2, 3). These specimens belonged to 11 genera: *Mesothuria*, *Zygothuria*, *Amphigymnas*, *Bathyplotes*, *Paelopatides*, *Benthothuria*, *Laetmogone*, *Pannychia*, *Benthodytes*, *Enypniastes*, *Pelagothuria*. New records and nomenclature updates are presented in systematic order below.

SYSTEMATIC ACCOUNT

Order Holothuriida

Family Mesothuriidae Smirnov, 2012

Mesothuria Ludwig, 1894

Mesothuria murrayi (Théel, 1886)

(Fig. 2A, B)

Holothuria murrayi Théel, 1886a: 185–186, pl. 10, figs. 16–18.
Mesothuria murrayi—Sluiter, 1901b: 24; Fisher, 1907: 683–685, pl. 71, figs. 1, 1a–h; Ohshima, 1915: 226; Hansen, 1956: 45–46, fig. 14b, d, e; Jangoux et al., 1989: 163 (list), 165–166, text-fig. 3, figs. A–D; Solis-Marin, 2003: 180–182; Gebruk et al., 2012: 303–307, fig. 11.
Mesothuria murrayi var. *parva* Théel, 1886a: 186–187, pl. 9, fig. 2, pl. 16, figs. 4–5.
Mesothuria murrayi var. *parva*—Augustin, 1908: 18–20, text-fig. 14.
Mesothuria murrayi (var.?)—Théel, 1886a: 187, pl. 9, fig. 3.
Mesothuria parva Théel, 1886—Fisher, 1907: 686–687, pl. 71, figs. 2, 2a–c; Ohshima, 1915: 226; Thandar, 1984: 341–343, text-fig. 63; Thandar, 1992: 161–163, fig. 1a–h; Samyn & Vandenspiegel, 2016: 471, fig. 13A–B.
Mesothuria deani Mitsukuri, 1912: 40–42, text-fig. 9.

Material. RCO.ECH.2338 (1 ex), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl,

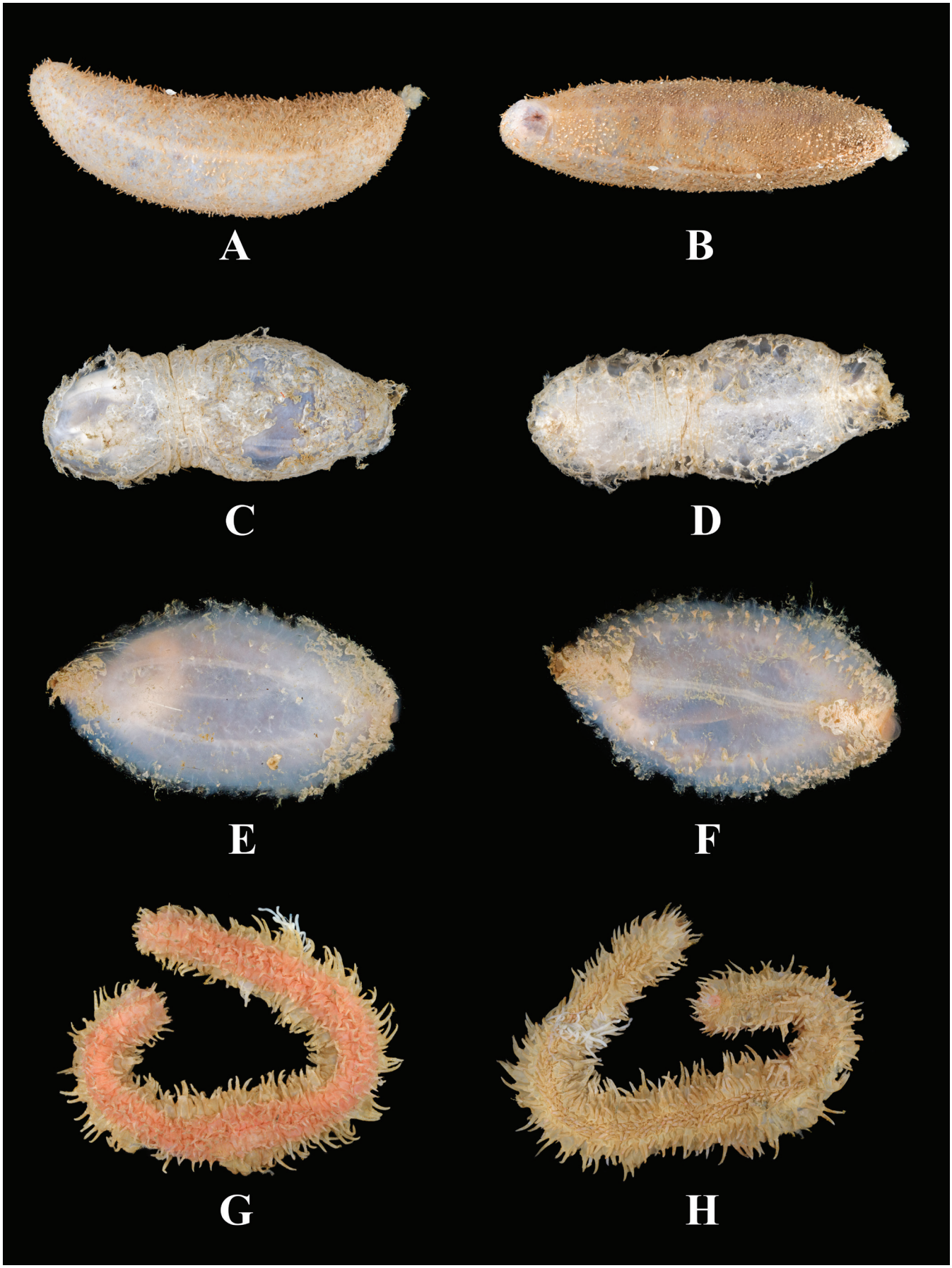

Fig. 2. Deep-sea holothuroids from SJADES, photographed immediately after sorting on the vessel deck. A, C, E, G, dorsal view; B, D, F, H, ventral view. A, B, *Mesothuria murrayi* (Théel, 1886), RCO.ECH.2338; C, D, *Zygothuria lactea* (Théel, 1886), RCO.ECH.2363; E, F, *Zygothuria* cf. *oxysclera* (R. Perrier, 1899), RCO.ECH.2351; G, H, *Amphigymnas woodmasoni* (Walsh, 1891).

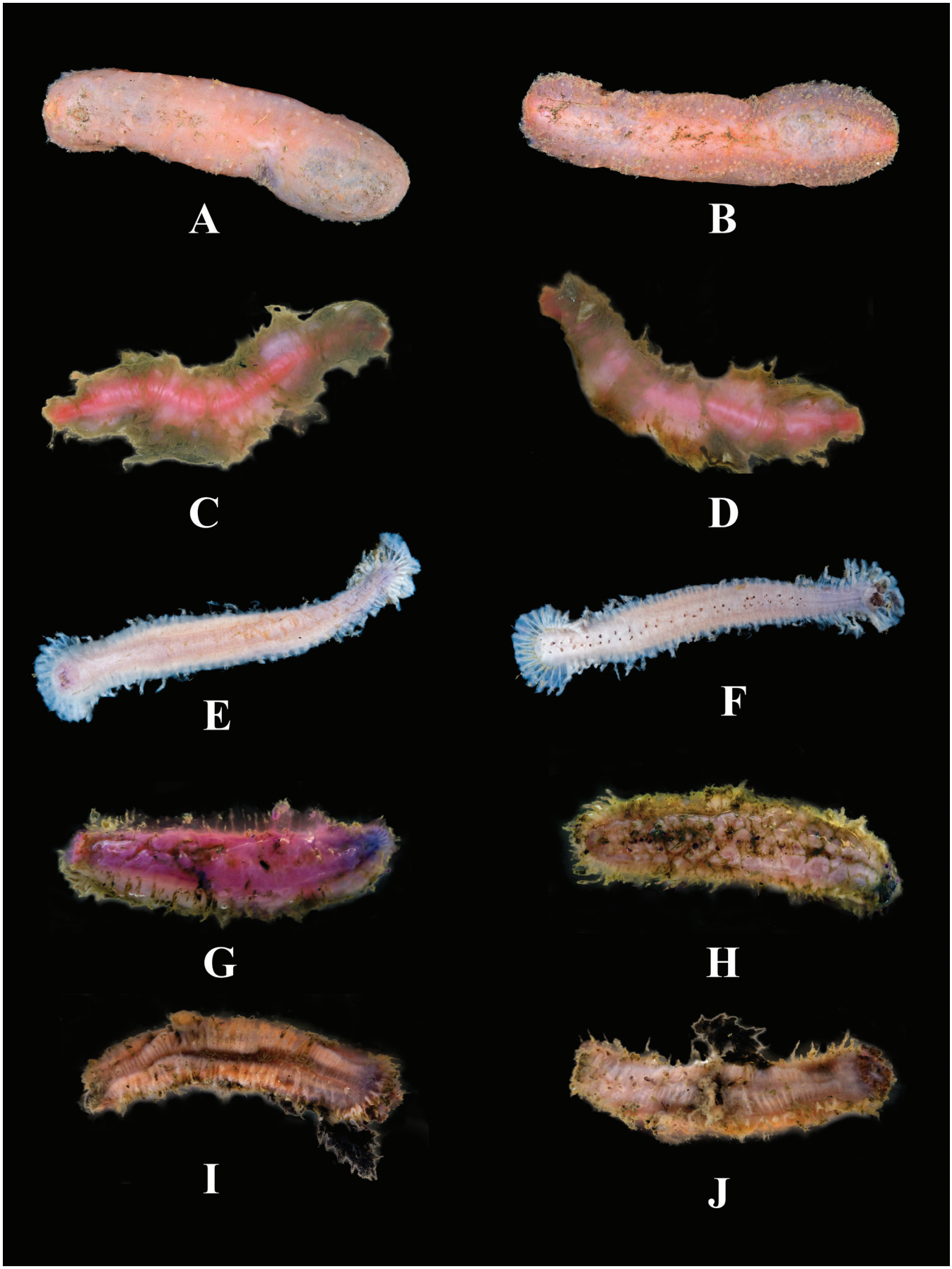

Fig. 3. Deep-sea holothuroids from SJADES, photographed immediately after sorting on the vessel deck. A, C, E, G, I, dorsal view; B, D, F, H, J, ventral view. A, B, *Bathyplotes natans* (M. Sars, 1868), RCO.ECH.2362; C, D, *Bathyplotes* cf. *phlegmaticus* Sluiter, 1901a, RCO. ECH.2390; E, F, *Paelopatides gelatinosus* (Walsh, 1891), RCO.ECH.2353; G, H, *Paelopatides* sp. 1, RCO.ECH2349; I, J, *Paelopatides* sp. 2, RCO.ECH.2354.

coll. SJADES Team, 30 March 2018; RCO.ECH.2339 (1 ex), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl, coll. SJADES Team, 30 March 2018; RCO.ECH.2340 (3 exx), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl, coll. SJADES Team, 30 March 2018; RCO.ECH.2346 (2 exx), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl, coll. SJADES Team, 30 March 2018; RCO.ECH.2365 (1 ex), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl, coll. SJADES Team, 30 March 2018; RCO.ECH.2369 (1 ex), stn. CP39, South of Cilacap (Indian Ocean), 8°15.885′S–8°16.060′S, 109°10.163′E–109°10.944′E, 528–673 m, beam trawl, coll. SJADES Team, 30 March 2018; RCO.ECH.2373 (1 ex), stn. CP40, 8°18.642′S–8°18.888′S, 109°13.767′E–109°14.476′E, 1078–1091 m, beam trawl, coll. SJADES Team, 30 March 2018.

Distribution. Hawaiian Islands; Japan; Chile; Philippines; Natal; South East Africa; Indonesia: Banda Sea, Flores Sea, Sulu Sea, Indian Ocean (South Java).

Zygothuria Perrier, 1898

Zygothuria lactea (Théel, 1886)
(Fig. 2C, D)

Holothuria lactea Théel, 1886a: 183–184, pl. 9, fig. 15; Théel, 1886b: 6–7.
Zygothuria lactea—Perrier, 1898: 1665; Perrier, 1899: 246; Perrier, 1902: 322–327; Deichmann, 1930: 108–111, pl. 8, figs. 8–9; Deichmann, 1940: 190–191; Deichmann, 1954: 386; Gebruk et al., 2012: 310–312, 320–321, figs. 13, 14.
Mesothuria lactea—Sluiter, 1901b: 25; Hérouard, 1902: 21–23, pl. 1, figs. 17–19; 1923: 13–15, pl. 4, figs. 1–3; Mortensen, 1927: 382–383, fig. 227.
Mesothuria (*Zygothuria*) *lactea*—Heding, 1940: 340–341, fig. 7.
Mesothuria (*Zygothuria*) *lactea lactea*—Heding, 1942: 9–10, fig. 9.

Material. RCO.ECH.2363 (1 ex), stn. CP22, South of Panaitan Island (Sunda Strait), 6°46.458′S–6°47.450′S, 105°07.068′E–105°07.613′E, 864–870 m, beam trawl, coll. SJADES Team, 27 March 2018.

Distribution. Cosmopolitan species, from North Atlantic, south-east Atlantic, off west Africa, Indo-Malayan archipelago, and New Zealand (Gebruk et al., 2012); Indonesia: Pacific Ocean (Sluiter, 1901b) and Indian Ocean (South Java).

Remarks. Ossicle shape and composition of present material are very distinctive compared to its other congeners. It has tables with a high spire, table disc hexagonal-shaped or flower-like shape with rounded rim, always with six large holes that surround the small triangular central hole.

Zygothuria cf. *oxysclera* (R. Perrier, 1899)
(Fig. 2E, F)

Zygothuria lactea var. *oxysclera* Perrier, 1899: 246; Perrier, 1902: 323–327, pl. 17, figs. 7–10.
Zygothuria oxysclera—Gebruk et al., 2012: 327–331, fig. 19.

Material. RCO.ECH.2351 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018.

Distribution. East Atlantic, Caribbean Sea (Gebruk et al., 2012) and Indian Ocean (South Java).

Remarks. Compared to the diagnosis of the original description (in Gebruk et al., 2012), several differences occur in the present material. (1) Body wall thickness of present material is about 1–2 mm, single-layered, soft and smooth to the touch, whereas the *Zygothuria oxysclera* usually has double-layered body wall. (2) Ossicles of present material are triradiate tables with a single very short spire, robust, usually ending in several small spines. These appear to be slightly different from the *Zygothuria oxysclera* ossicles described by Perrier (1899) and Gebruk et al. (2012) which are triradiate tables with high spire, robust, often bearing minute spines.

Order Synallactida

Family Synallactidae Ludwig, 1894

Amphigymnas Walsh, 1891

Amphigymnas woodmasoni (Walsh, 1891)
(Fig. 2G, H)

Pannychia Wood–Masoni Walsh, 1891: 198–199.
Amphigymnas multipes Walsh, 1891: 199.
Synallactes Wood–Masoni—Koehler & Vaney, 1905: 14–16, pl. 9, figs. 26–30.
Synallactes reticulatus Sluiter, 1901b: 46–48, pl. 3, figs. 1–2, pl. 8, fig. 9.
Amphigymnas woodmasoni—Samyn & Vandenspiegel, 2016: 474, fig. 15A–B.

Material. RCO.ECH.2393 (1 ex), stn. CP50, Pelabuhan Ratu Bay (Indian Ocean), 7°03.322′S–7°03.762′S, 106°26.673′E–106°26.334′E, 383–425 m, beam trawl, coll. SJADES Team, 02 April 2018; RCO.ECH.2396 (1 ex), stn. CP55, Pelabuhan Ratu Bay (Indian Ocean), 7°01.013′S–7°01.116′S, 106°26.772′E–106°26.421′E, 378–379 m, beam trawl, coll. SJADES Team, 03 April 2018; RCO.ECH.2398 (1 ex), stn. CP50, Pelabuhan Ratu Bay (Indian Ocean), 7°03.322′S–7°03.762′S, 106°26.673′E–106°26.334′E, 383–425 m, beam trawl, coll. SJADES Team, 02 April 2018; ZRC.ECH.1689 (1 ex), stn. CP50, Pelabuhan Ratu Bay (Indian Ocean), 7°03.322′S–7°03.762′S, 106°26.673′E–106°26.334′E, 383–425 m, beam trawl, coll. SJADES Team, 02 April 2018; ZRC.

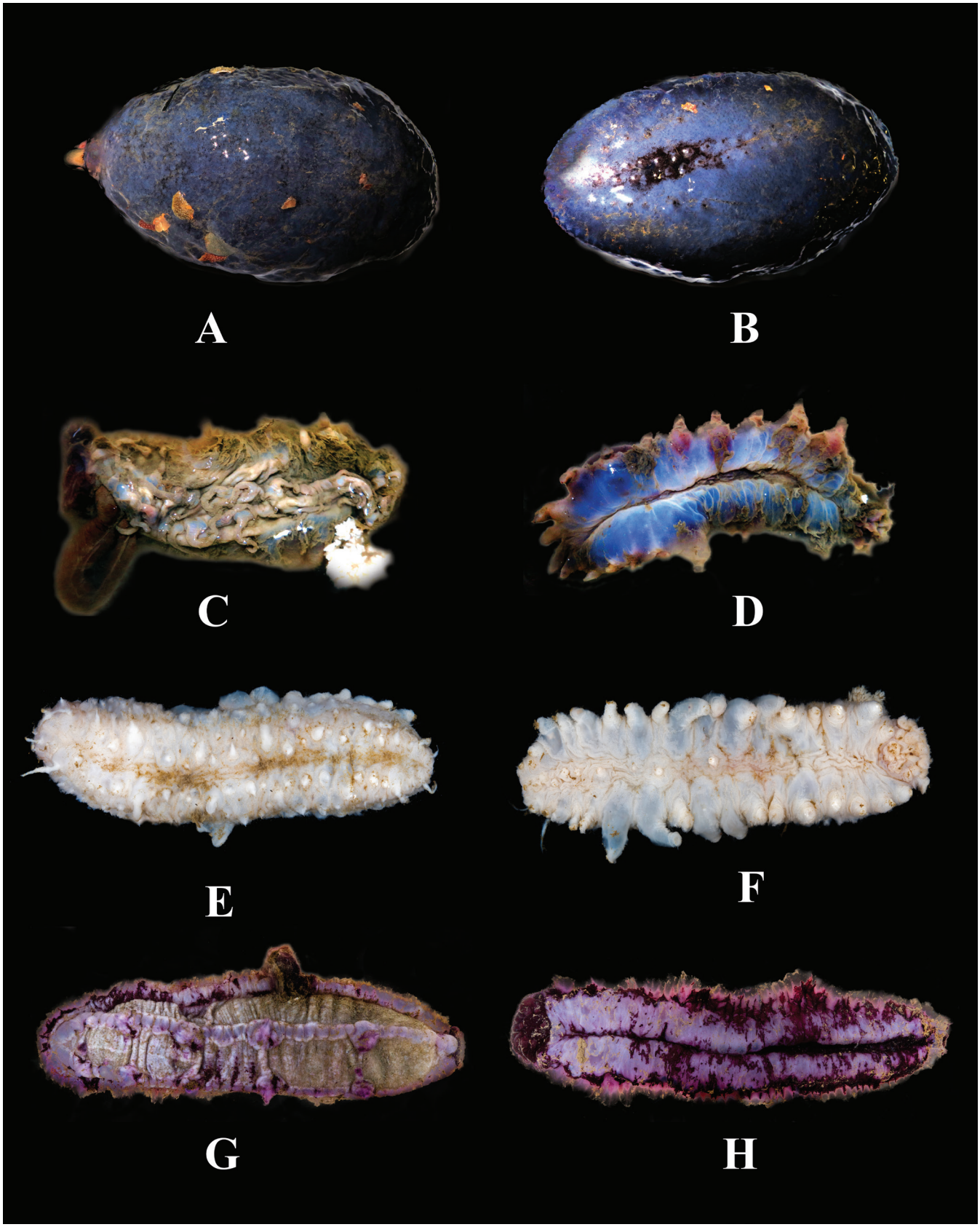

Fig. 4. Deep-sea holothuroids from SJADES, photographed immediately after sorting on the vessel deck. A, C, E, G, dorsal views; B, D, F, H, ventral views. A, B, *Benthothuria funebris* Perrier, 1898, RCO.ECH.2364; C, D, *Laetmogone violacea* Théel, 1879, RCO.ECH.2342; E, F, *Pannychia* cf. *moseleyi* Théel, 1882, RCO.ECH.2368; G, H, *Benthodytes sibogae* Sluiter, 1901, RCO.ECH.2400.

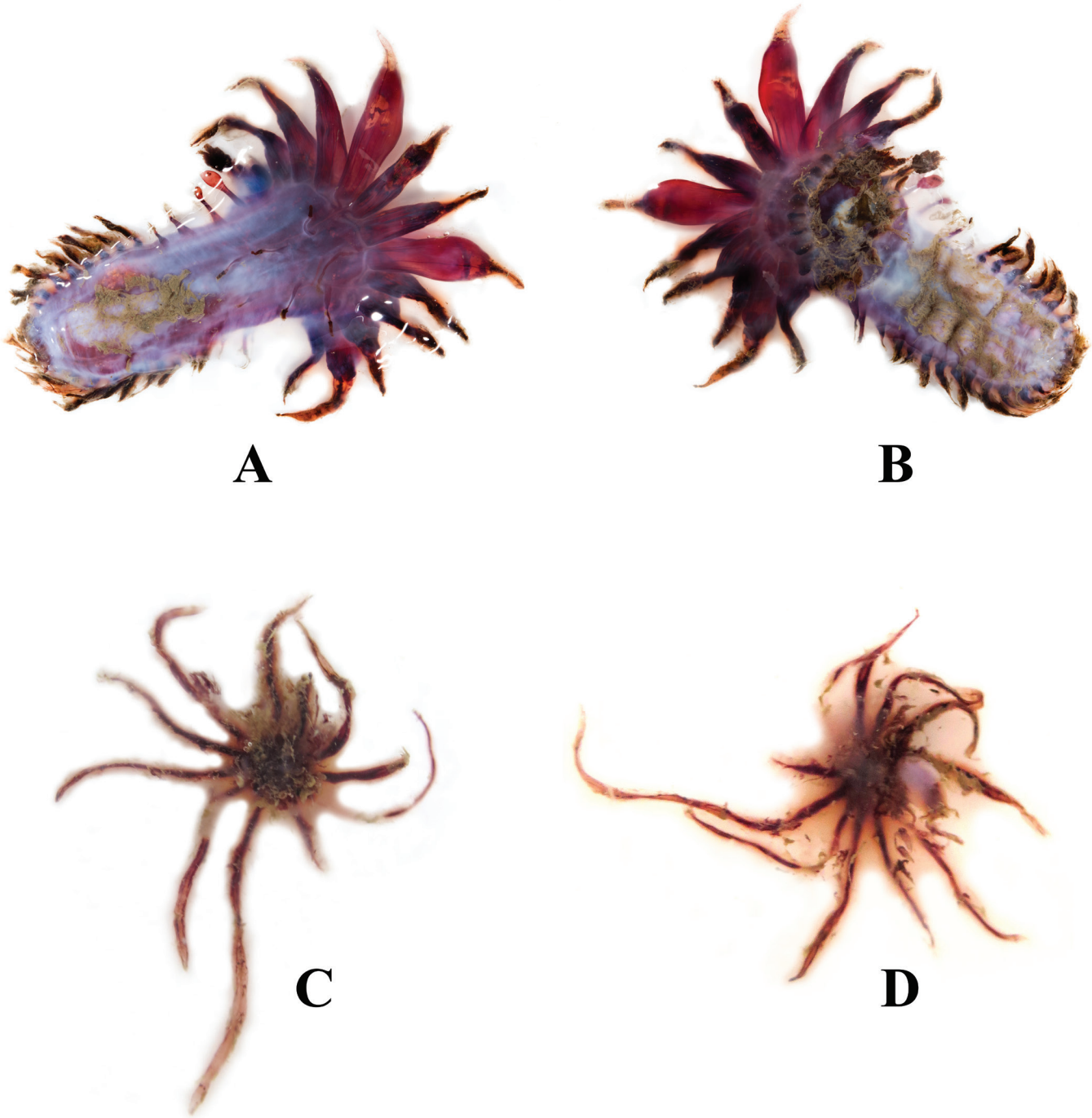

Fig. 5. Deep-sea holothuroids from SJADES, photographed immediately after sorting on the vessel deck. A, dorsal side and B, ventral side of *Enypniastes eximia* Théel, 1882, RCO.ECH.2347; C, anterior side and D, posterior side of *Pelagothuria natatrix* Ludwig, 1893, RCO.ECH.2385.

ECH.1690 (1 ex), stn. CP55, Pelabuhan Ratu Bay (Indian Ocean), 7°01.013′S–7°01.116′S, 106°26.772′E–106°26.421′E, 378–379 m, beam trawl, coll. SJADES Team, 03 April 2018.

Distribution. Andaman Sea, Madagascar, Indian Ocean (South Java).

Remarks. The large tube feet and their arrangement, which are spread densely on the ventral surface in the present material, agree well with the descriptions of *Amphigymnas multipes* Walsh, 1891, and *A. woodmasoni* (Walsh, 1891). The former species *A. multipes* is currently considered a synonym of *A. woodmasoni*.

Bathyplotes Östergren, 1896

Bathyplotes natans (M. Sars, 1868)
(Fig. 3A, B)

Holothuria natans M. Sars, 1868: 20.
Stichopus natans M. Sars, 1877: 58, pl. 7, figs. 18–41; Théel, 1886a: 193.
Bathyplotes natans—Östergren, 1896: 352–353, pl. 18, figs. 27–35; Mortensen, 1927: 384–385, text-figs. 228–2, 229; Deichmann, 1930: 100–102, pl. 9, figs. 1, 2, 9; Heding, 1942: 10–12, text-figs. 10, 11, figs. 1–10, text-fig. 12:1–2; Deichmann, 1954: 386; Gage et al., 1985: 194; Miller & Pawson, 1990: 4; Rowe & Gates, 1995: 328; Liao, 1997: 73–74, fig. 39; Solis-Marin,

2003: 139–141, figs. 23–30; Rogacheva et al., 2013: 590–591; Samyn & Vandenspiegel, 2016: 474, fig. 16A–D.

Material. RCO.ECH.2362 (1 ex), stn. CP25, South of Panaitan Island (Sunda Strait), 6°50.185′S–6°50.923′S, 105°10.353′E–105°10.776′E, 876–937 m, beam trawl, coll. SJADES Team, 27 March 2018.

Distribution. Atlantic Ocean, Pacific Ocean, New Zealand (Rowe & Gates, 1995), Indian Ocean (Mozambique Channel) (Samyn & Vandenspiegel, 2016), and South Java.

Remarks. Notwithstanding that this species is known to have a wide distribution at bathyal depths throughout the world's oceans (Solis-Marin, 2003), it is a first record for Indonesia. Ossicles from the only specimen obtained consisted of C-shaped rods, tables with cruciform disc, one to four holes at each of the disc extremities, spire high formed by four rods connected by several cross beams. These characters closely resemble the ossicles described by Sars (1877), Théel (1886a), Mortensen (1927), and Samyn & Vandenspiegel (2016). However, ossicle C-shaped rods were absent in specimens examined by Heding (1942) and Deichmann (1930).

Bathyplotes cf. *phlegmaticus* Sluiter, 1901a
(Fig. 3C, D)

Bathyplotes phlegmaticus Sluiter, 1901a: 4–5.
Bathyplotes phlegmaticus—Sluiter, 1901b: 36–37, pl. 2, fig. 3, pl. 8, figs. 14–15a, b; Solis-Marin, 2003: 143.

Material. RCO.ECH.2390 (1 ex), stn. CP31, East of Tinjil Island (Indian Ocean), 7°01.755′S–7°01.911′S, 105°57.442′E–105°56.762′E, 1763–1796 m, beam trawl, SJADES Team, 28 March 2018.

Distribution. Indonesia: North Pacific Ocean (Sluiter, 1901a, b) and Indian Ocean (South Java).

Remarks. Body shape and ossicle composition of the present material are in agreement with Sluiter's (1901a) original description of *B. phlegmaticus*.

Paelopatides Théel, 1886

Paelopatides gelatinosus (Walsh, 1891)
(Fig. 3E, F)

Benthodytes gelatinosa Walsh, 1891: 200–202.
Pelopatides gelatinosa—Solis-Marin, 2003: 200–201, figs. 138–139 in CD.
Paelopatides gelatinosus—Koehler & Vaney, 1905: 30–33, pl. V, fig. 5, pl. X, figs. 27–30.

Material. RCO.ECH.2343 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2353 (1 ex), stn. CP10, South of Umbar Bay, Sumatera (Sunda Strait), 5°45.399′S–5°46.183′S, 104°56.098′E–104°56.565′E, 429–446 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2357 (1 ex), stn. CP10, South of Umbar Bay, Sumatera (Sunda Strait), 5°45.399′S–5°46.183′S, 104°56.098′E–104°56.565′E, 429–446 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2394 (1 ex), stn. DW32, South of Tg. Boyong Kareuceng (Indian Ocean), 7°42.583′S–7°42.556′S, 107°34.535′E–107°35.030′E, 977–805 m, dredge, coll. SJADES Team, 29 March 2018.

Distribution. Andaman Sea, Indian Ocean (South Java).

Remarks. This species is recorded for the first time in Indonesia.

Paelopatides sp. 1
(Fig. 3G, H)

Material. RCO.ECH.2345 (1 ex), stn. CP48, South of Tg. Gedeh, Java (Indian Ocean), 7°51.120′S–7°51.718′S, 107°46.245′E–107°46.375′E, 689–637 m, beam trawl, coll. SJADES Team, 01 April 2018; RCO.ECH2349 (1 ex), stn. CP48, South of Tg. Gedeh, Java (Indian Ocean), 7°51.120′S–7°51.718′S, 107°46.245′E–107°46.375′E, 689–637 m, beam trawl, coll. SJADES Team, 01 April 2018.

Remarks. The material obtained possessed the characters that define the genus *Paelopatides*: body distinctly depressed with slightly larger brim surrounding the body; ventral tube feet arranged in the two rows from posterior up to the middle part of the body; and ossicle with simple triradiate rods (Solis-Marin, 2003). Although both RCO.ECH.2349 and RCO.ECH.2345 were in poor condition, the ossicles of the former specimen could still be observed. It possesses a few types of ossicles including triradiate rods in the body wall, and rods with spinous dichotomous branched in the longitudinal muscle. However, they were still not sufficiently informative to conclusively determine the species.

Paelopatides sp. 2
(Fig. 3I, J)

Material. RCO.ECH.2341 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2354 (1 ex), stn. CP10, South of Umbar Bay, Sumatera (Sunda Strait), 5°45.399′S–5°46.183′S, 104°56.098′E–104°56.565′E, 429–446 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2356 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018; ZRC.ECH.1691 (33 ex), stn. CP10, South of Umbar Bay, Sumatera (Sunda Strait), 5°45.399′S–5°46.183′S, 104°56.098′E–104°56.565′E, 429–446 m, beam trawl, coll. SJADES Team, 25 March 2018.

Remarks. The present material has distinct morphological characters that identify them as belonging to the genus *Paelopatides*: body wall soft and thick with ambulacral area slightly concave and darkened; inter-ambulacral area slightly

convex; mouth ventral, anus dorso-lateral; lateral papillae large and striking; ventral tube feet limited to the ambulacral area and arranged in a single row, from the posterior to the middle region of the body. The anterior region has a large number of small papillae, almost surrounding the mouth. These characters generally agree with the original description of *Paelopatides mollis* by Koehler & Vaney (1905), but they did not provide details of its ambulacral and interambulacral shape. The description provided by Koehler & Vaney (1905) also lacks an illustration of the species. As we were unable to obtain ossicles of the SJADES specimens, identification to the species level was not possible.

Order Persiculida

Benthothuria Perrier, 1898

Benthothuria funebris Perrier, 1898
(Fig. 4A, B)

Benthothuria funebris Perrier, 1898: 1665.
Benthothuria funebris—Perrier, 1899: 248; Perrier, 1902: 365–371; Heding, 1940: 363–364; Heding, 1942: 6; Solis-Marin, 2003: 155–156, fig. 52 in CD; Rogacheva et al., 2013: 591, figs. 17B, 19B.

Material. RCO.ECH.2359 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018; RCO.ECH.2364 (1 ex), stn. CP53, Pelabuhan Ratu Bay (Indian Ocean), 7°09.610′S–7°10.184′S, 106°18.632′E–106°17.714′E, 1521–1714 m, beam trawl, coll. SJADES Team, 02 April 2018; RCO.ECH.2395 (1 ex), stn. CP33, South of Tg. Boyongkareuceng (Indian Ocean), 7°42.912′S–7°43.255′S, 107°36.559′E–107°37.234′E, 525–312 m, beam trawl, coll. SJADES Team, 29 March 2018; RCO.ECH.2399 (1 ex), stn. CP12, Southeast of Tabuan Island (Sunda Strait), 5°52.252′S–5°52.728′S, 104°56.786′E–104°56.422′E, 615–698 m, beam trawl, coll. SJADES Team, 25 March 2018; ZRC.ECH.1692 (1 ex), stn. CP10, South of Umbar Bay, Sumatera (Sunda Strait), 5°45.399′S–5°46.183′S, 104°56.098′E–104°56.565′E, 429–446 m, beam trawl, coll. SJADES Team, 25 March 2018.

Distribution. North Atlantic, South West Greenland, North West Africa, off Moroccan coast, off Sudan (Solis-Marin, 2003), Indian Ocean (South Java; this study).

Remarks. This species is recorded for the first time from Indonesia. The present material was whitish to purple dorsally and purple ventrally when observed fresh immediately after collection. Body oval-elongated with a flat ventral sole. Mouth ventral, anus terminal. Dorsal and ventral sole separated by a continuous row of papillae. Ventral surface with numerous papillae, but at the ambulacral areas, there are an additional two rows of appendices which are large and very sticky to the touch when fresh. Ossicles were not found in any part of the body wall.

Order Elasipodida

Family Laetmogonidae Ekman, 1926

Laetmogone Théel, 1879

Laetmogone violacea Théel, 1879
(Figs. 4C, D, 6A–H)

Laetmogone violacea Théel, 1879: 11, pl. I, fig. 14a–d.
Laetmogone violacea—Théel, 1882: 78–80, pl. XIII, XLII, fig. 2, pl. XXXVI, figs. 20–24; Sluiter, 1901b: 62–63; Perrier, 1902: 390–398, pl. XIX, figs. 1–7; Hansen, 1975: 58–61, figs. 21–22, pl. VIII, fig. 8, pl. XI, figs. 9–10; Rowe & Gates, 1995: 430–431.

Material. RCO.ECH.2342 (1 ex), stn. CP44, South of Cilacap (Indian Ocean), 8°10.065′S–8°09.802′S, 108°37.439′E–108°37.145′E, 1013–970 m, beam trawl, coll. SJADES Team, 31 March 2018.

Morphology. Body elongate, with length 140 mm and width 60 mm. Body colour brownish to pale-grey when fresh, and pale-ivory in ethanol. Tentacles 15, peltate and relatively large. Dorsal body wall very thin, wrinkled, and somewhat damaged. Dorsal papillae very long, slender, and arranged in a single row along each ambulacral groove. Ventral body wall thicker than dorsal with brim on each side. Tube feet large and rather bulky on each side of the brim. Mouth ventral, anus terminal.

Ossicles. Consisting of spiny cross-shaped deposits, wheels, and rods. Cross-shaped deposits with four arms, each arm ending in spinous crown-like, the distance between the ends of the arms is 141–224 μm (Fig. 6A, E). Rarely, three and five-radiate crosses are present in the ventral body wall (Fig. 6D, F). Wheels lacking marginal teeth; large wheels with 8–9 spokes, diameter 215–316 μm (Fig. 6B, G); small wheels with 8–10 spokes, diameter 98–110 μm (Fig. 6C). Rods slender and spiny, 116–238 μm in length (Fig. 6H).

Distribution. Norfolk Island, Australia, Atlantic Ocean, Indo-West Pacific Ocean (Rowe & Gates, 1995).

Remarks. *Laetmogone violacea* is morphologically similar to *L. wyvillethomsoni*. However cross-shaped deposits are absent in *L. wyvillethomsoni* (Hansen, 1975). Since the dorsal part of the single specimen obtained was not in good condition, it was unfortunately not possible to determine the number of papillae, even though it is a key character to differentiate species in this genus based on Heding (1942) and Hansen (1975).

Pannychia Théel, 1882

Pannychia cf. *moseleyi* Théel, 1882
(Figs. 4E, F, 7A–M, 8A–J)

Pannychia moseleyi Théel, 1882: 88, pl. XVII, pl. XXXII, figs. 1–13
Pannychia moseleyi—Sluiter, 1901b: 71–72; Mitsukuri, 1912: 207–212, fig. 38; Clark, 1913: 232; Ohshima, 1915: 235–236; Hansen, 1975: 72–75, fig. 26; Rowe & Gates, 1995: 431.

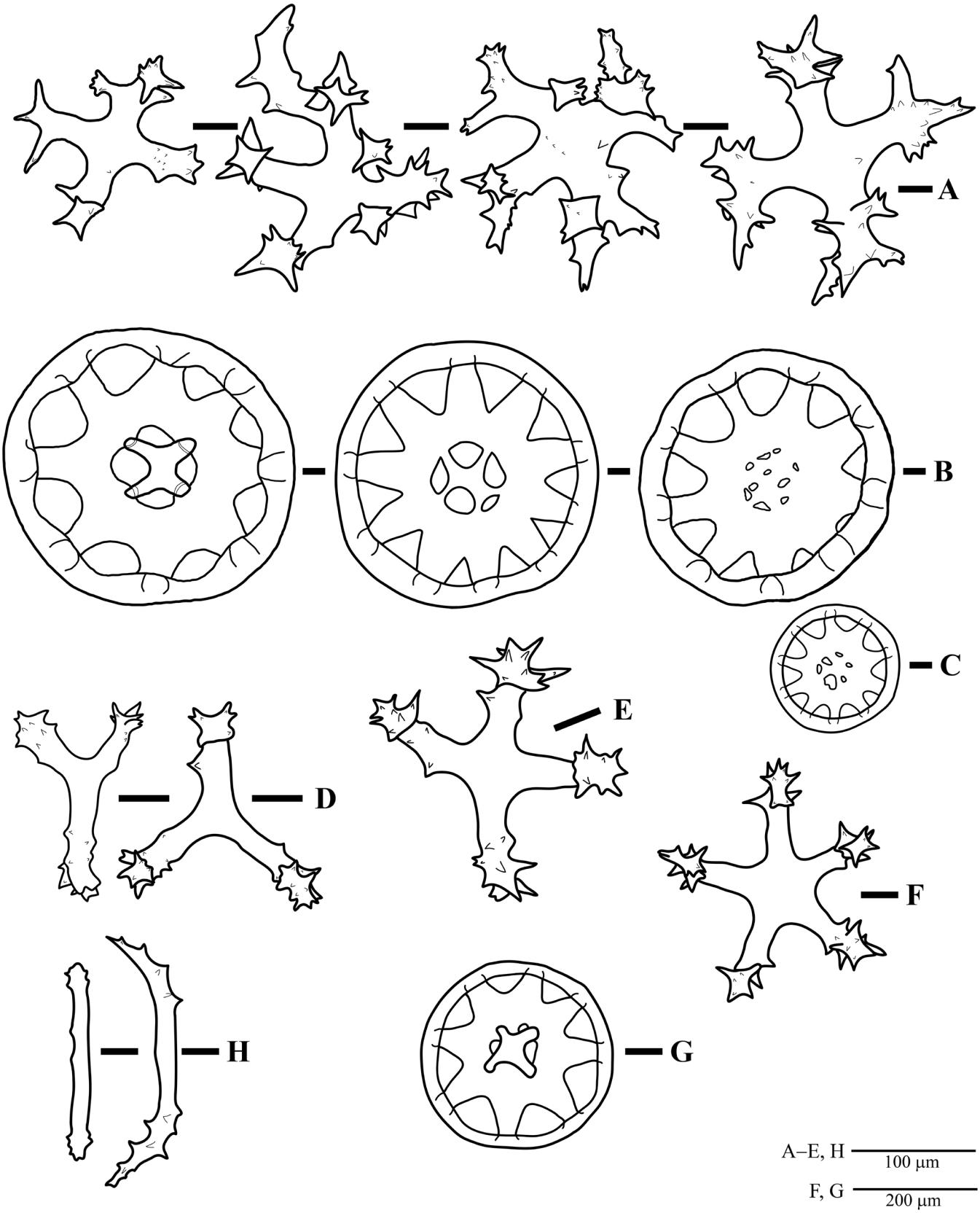

Fig. 6. Ossicles of *Laetmogone violacea* Théel, 1879. Dorsal: A, cross-shaped ossicle; B, large wheel ossicles; C, small wheel ossicle; Ventral: D, tri-radiate cross ossicles; E, cross-shaped ossicles; F, five-radiate cross ossicles; G, large wheel ossicles; H, rods ossicles.

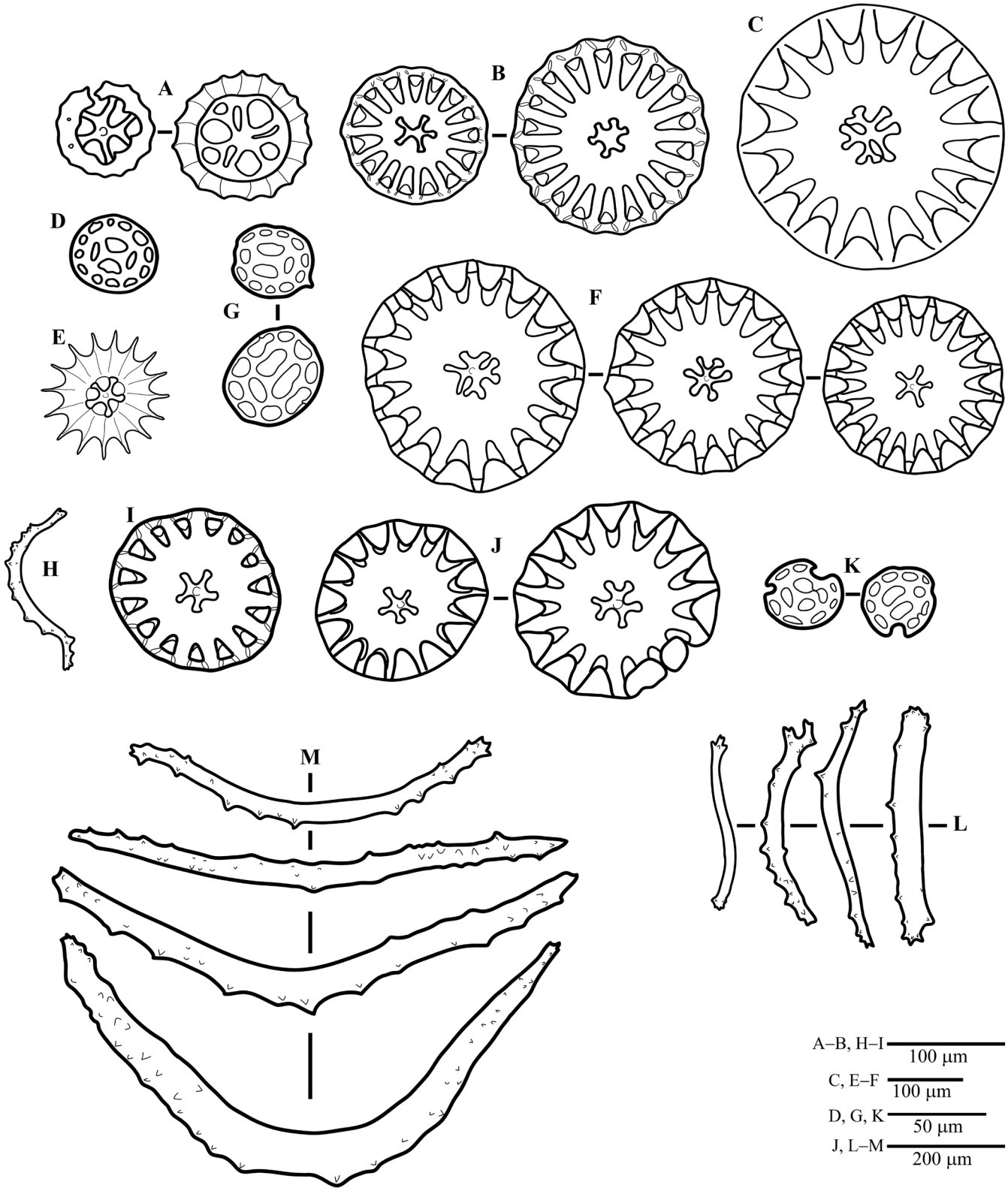

Fig. 7. Ossicles of *Pannychia* cf. *moseleyi* Théel, 1882. Dorsal body wall: A, wheel-like ossicle; B, C, large wheel ossicles; D, small, rounded plate ossicles. Ventral body wall: E, wheel-like ossicles; F, large wheel ossicles; G, small, rounded plate ossicles. Tentacle: H, L, small spinous rod ossicles; I, J, large wheel ossicles; K, irregular small, rounded plate ossicles; M, large spinous rod ossicles.

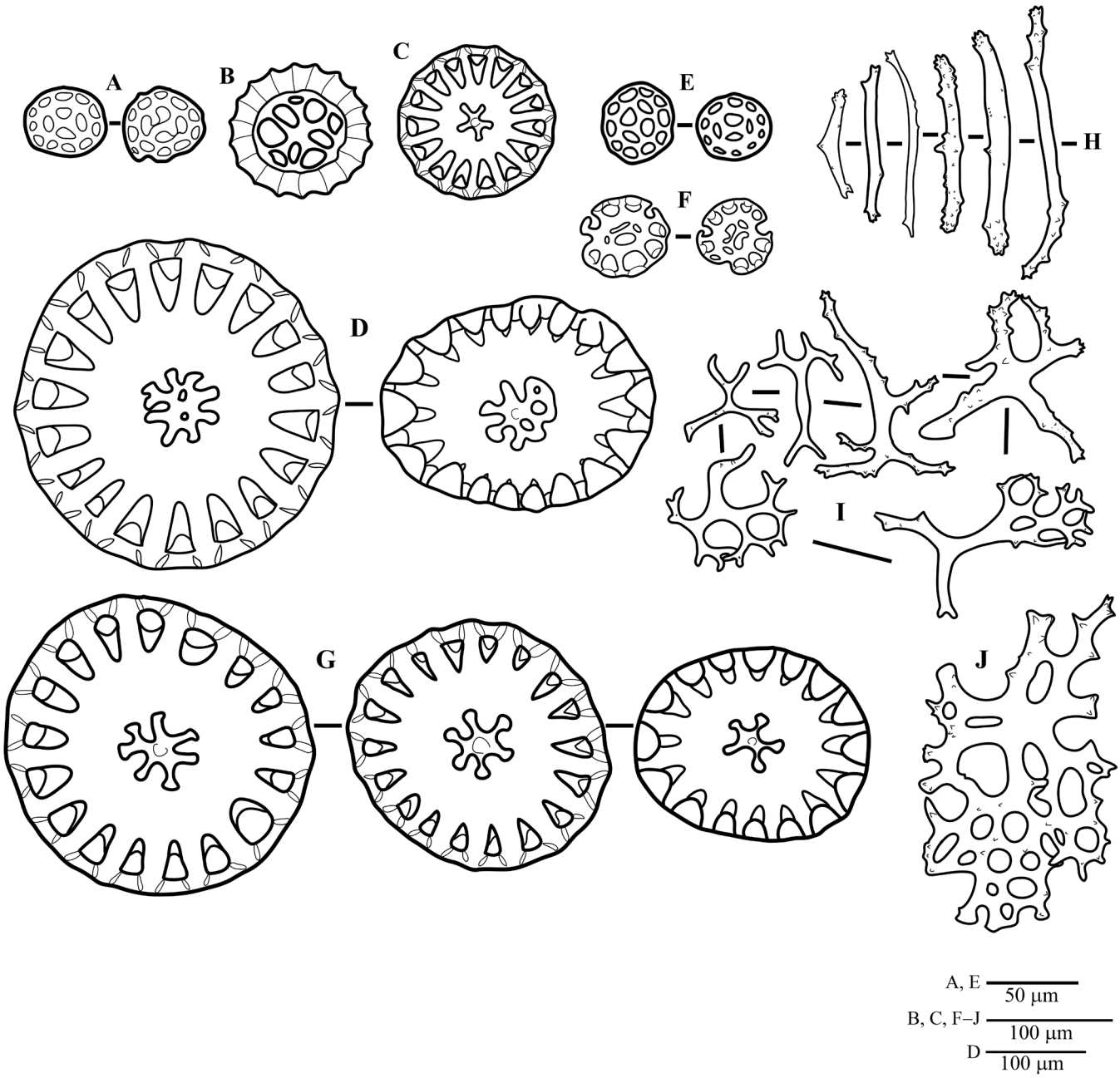

Fig. 8. Ossicles of *Pannychia* cf. *moseleyi* Théel, 1882. Dorsal papillae: A, small, rounded plate ossicles; B, wheel-like ossicle; C, small wheel ossicle; D, large wheel ossicles. Tube feet: E, small, rounded plate ossicles; F, irregular small, rounded plate ossicles; G, large wheel ossicles; H, simple spinous rod ossicles; I, irregular branched rod ossicles; J, large, perforated plate ossicles.

Pannychia moseleyi var. *henrici* Ludwig, 1894: 95–99, pl. X, figs. 1–2.
Pannychia moseleyi virgulifera Ohshima, 1915: 236.
Pannychia multiradiata Sluiter, 1901b: 72–74.
Pannychia pallida Fisher, 1907: 709–711, pl. LXXITIII, fig. 2.
Laetmophasma fecundum Ludwig, 1894: 85–95, pls. X: 3–14, XI: 1–13; Clark, 1913: 231–232; Clark, 1920: 138.

Material. RCO.ECH.2366 (1 ex), stn. CP44, South of Cilacap (Indian Ocean), 8°10.065′S–8°09.802′S, 108°37.439′E–108°37.145′E, 1013–970 m, beam trawl, coll. SJADES Team, 31 March 2018; RCO.ECH.2368 (1 ex), stn. CP13, Between Sumatera and Java (Sunda Strait), 6°00.521′S–6°00.828′S, 104°49.410′E–104°49.428′E, 1259–1268 m, beam trawl, coll. SJADES Team, 26 March 2018; RCO.ECH.2397 (4 exx), stn. CP13, Between Sumatera and Java (Sunda Strait), 6°00.521′S–6°00.828′S, 104°49.410′E–104°49.428′E, 1259–1268 m, beam trawl, coll. SJADES Team, 26 March 2018.

Morphology. Body elongate, between 180–190 mm length and 40–50 mm width. Colour variable, from light grey to sandy brown in fresh specimens; white to pale light brown in ethanol. Tentacles 20, peltate. Body wall thick and soft. Dorsal papillae of two sizes; small and short papillae numerous and spread over the dorsal and lateral regions; larger and longer papillae less numerous and arranged in two rows over the dorsal surface. Ventrolateral tube feet long and large, with sucker, 17 tube feet on each lateral side. Mid-ventral tube feet only 11, scattered in the posterior part, shorter and smaller than ventrolateral. Mouth ventral, anus terminal.

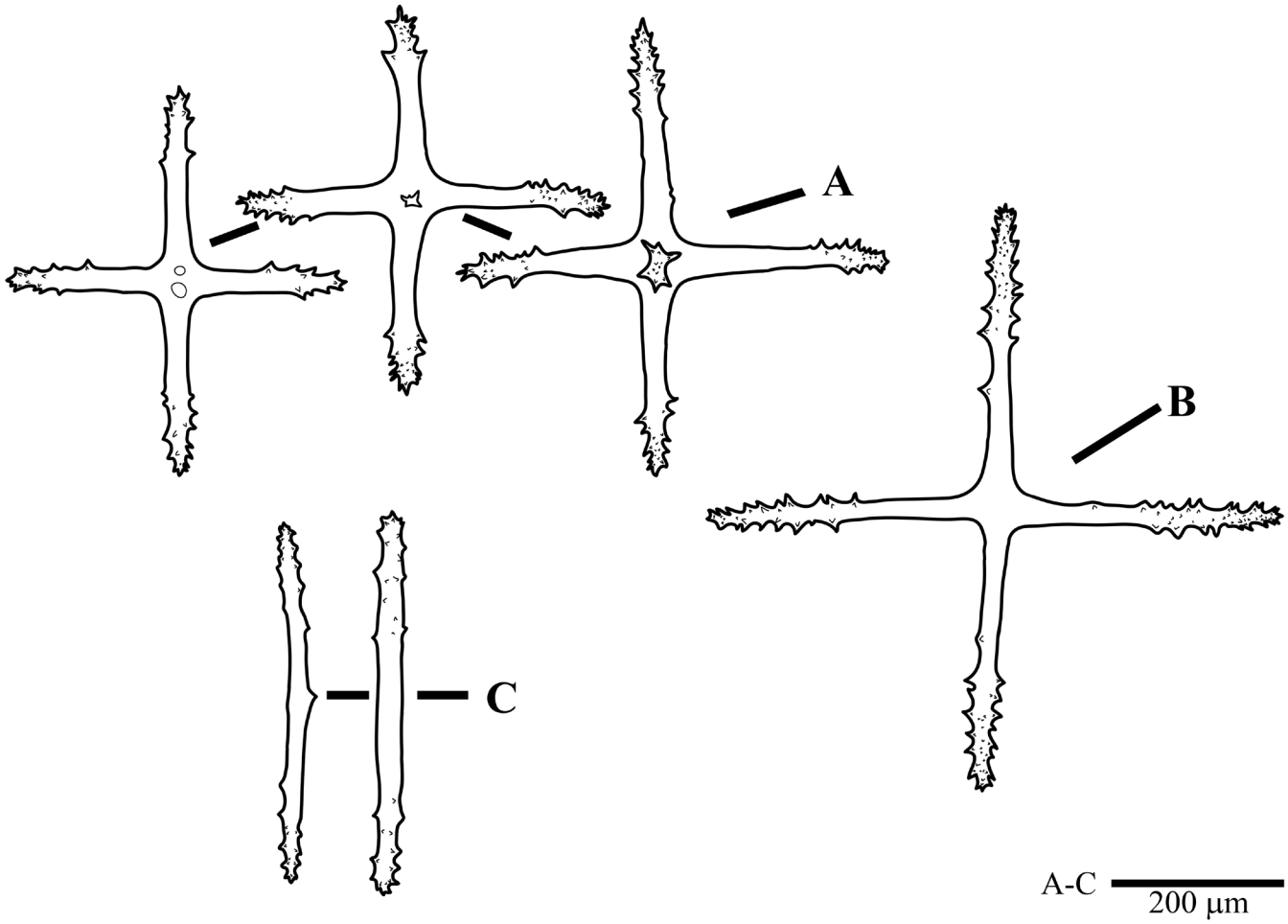

Fig. 9. Ossicles of *Benthodytes sibogae* Sluiter, 1901. Body wall: A, spinous crosses with apophyses; B, spinous crosses without apophyses; C, spinous rods.

Ossicles. Body wall ossicles consist of wheels, wheel-like ossicles, and small rounded plates. Wheels abundant and large with rounded triangular teeth between the outer spokes, diameter 119–380 µm, 15–18 outer spokes and 5–9 central rays (Fig. 7B, C, F). Wheel-like ossicles have similar shape with central part of the wheel, 5–7 central rays, diameter 82–130 µm (Fig. 7A, E). Small, rounded plates rarely with 3–4 central holes and 9–12 peripheral holes, diameter 39–53 µm (Fig. 7D, G). Ossicle composition in dorsal papillae similar with body wall, which comprises large wheels with diameter 106–344 µm (Fig. 8D), wheel-like ossicle with diameter 108 µm (Fig. 8B) and small rounded plates with diameter 40–42 µm (Fig. 8A). Tube feet ossicles consist of several forms: large wheels with diameter 133–282 µm (Fig. 8G); small rounded plates with diameter 36–43 µm (Fig. 8E); irregular small rounded plates with diameter 65–80 µm (Fig. 8F); simple spinous rods 87–224 µm in length (Fig. 8H); irregular branched rods 89–224 µm in length, sometimes branched rod with holes present (Fig. 8I); large perforated plate 253 µm in length present, although very rare (Fig. 8J). Tentacle ossicles consist of large wheels (Fig. 7I, J), irregular, small, rounded plates (Fig. 7K), as well as large (length 254–1,200 µm) and small (length 105–273 µm) spinous rods (Fig. 7H, L, M).

Distribution. South West Pacific Ocean including Indonesia, Australia, New Zealand (Sluiter, 1901b; Rowe & Gates, 1995) and Indian Ocean (South Java; this study).

Remarks. All specimens collected in present study possessed 17 ventrolateral tube feet, which are considerably fewer than the 25–45 tube feet in *P. moseleyi* described by Théel (1882), Ohshima (1915), Hansen (1975), and O'Loughlin et al. (2013). In contrast, Ludwig (1894) indicated that the material he examined possessed 15–25 ventrolateral tube feet. In addition, Fisher (1907) observed 20 or less ventrolateral tube feet for *P. pallida*, and Ludwig (1894) described 16–20 ventrolateral tube feet for *Laetmophasma fecundum*. Furthermore, Sluiter (1901b) observed that his species, *P. multiradiata*, possessed 18–20 ventrolateral tube feet.

In terms of ossicle morphology, there are 15–18 spokes and 5–9 central rays in the large wheels (Figs. 7B, C, F, 8D, G) observed from the body wall, dorsal papillae, and ventral tube feet in our present material. The number of spokes in many previous descriptions of *P. moseleyi* number only 11–14 spokes (Théel, 1882; Mitsukuri, 1912; O'Loughlin, 2013), although Hansen (1975) described his *P. moseleyi* specimens as having 13–19 spokes and 5–6 central rays. Wheel-like ossicles that look like undeveloped/reduced wheels (Figs. 7A, E, 8B) were also present in the Java specimens. Such ossicles have neither been observed previously in *P. moseleyi* nor in

P. taylorae. In addition, the consistent absence of mid-ventral tube feet in the anterior region of the animal appears to be a significant departure from the condition in *P. moseleyi* and *P. taylorae*, where mid-ventral tube feet are present along the entire length of the animal. For these reasons, we were unable to identify our material with certainty, although they appear to be allied closely with *P. moseleyi*.

Family Psychropotidae Théel, 1882

Benthodytes Théel, 1882

Benthodytes sibogae Sluiter, 1901
(Figs. 4G, H, 5A–C)

Benthodytes sibogae Sluiter, 1901a: 17, 18.
Benthodytes sibogae—Sluiter, 1901b: 55–58, pl. I, fig. 2, pl. IX, fig. 11, pl. X, fig. 2; Hansen, 1975: 84–87, figs. 31–33.
Benthodytes hystrix Sluiter, 1901a: 19, 20.
Benthodytes hystrix—Sluiter, 1901b: 59–60, pl. IV, fig. 4, pl. X, fig. 10; Heding, 1940: 367.

Material. RCO.ECH.2400 (1 ex), stn. CP13, Between Sumatera and Java (Sunda Strait), 6°00.521′S–6°00.828′S, 104°49.410′E–104°49.428′E, 1259–1268 m, beam trawl, coll. SJADES Team, 26 March 2018.

Morphology. Body elongated; length 200 mm, and width 60 mm, anterior part more rounded than posterior. Ventral region flattened. Fresh specimen uniformly purple. Several irregular spots with darker colours are present in the ventral and lateral body surface. Since previous authors have never mentioned this colour pattern, it is possible that these irregular spots were artefacts caused by friction during the collection process using beam trawl. Body wall wrinkled, and slightly rough to the touch. Mouth ventral surrounded by 14 tentacles, and anus dorsal. Dorsal papillae large, conical with tapered end, five pairs arranged along the longitudinal thickening in the ambulacral area. Brim broad and well developed with dark violet channel in the middle of ambulacral region.

Ossicles. Body wall has cross-shaped ossicles and rods. Spinous crosses abundant, with single or bipartite central apophyses, arm length 427–540 μm (Fig. 9A). Sometimes a very large spinous cross with 678 μm arm length and no apophyses was also observed (Fig. 9B). Rods slender and spinous with 321–420 μm length (Fig. 9C).

Distribution. Indonesia: Bali Sea, Flores Sea, Ceram Sea (Sluiter, 1901b), and South Java Sea.

Remarks. The species is described from a single specimen that was poorly preserved, although pertinent observations were made of the animal immediately after it was brought onto the vessel deck. The morphological characters of the specimen agree well with *Benthodytes manusensis* Xiao, Li & Sha, 2018, from the Manus Basin in the Bismarck Sea, except in the number of large papillae. The specimen we collected clearly bears five large dorsal papillae, while *B. manusensis* has only three. The number of large dorsal papillae is an important taxonomic character used to distinguish species within the genus (Xiao et al., 2018). Sluiter (1901b) identified that his specimen possessed six large dorsal papillae present in the dorsal body wall. On the contrary, Hansen (1975) did not provide the number of dorsal papillae in *B. sibogae* collected from Galathea Expedition, but the ossicles from the ventral region were described to be spinous crosses without apophyses. This is consistent with our specimen, and hence we have identified it as such.

Family Pelagothuriidae Ludwig, 1893

Enypniastes Théel, 1882

Enypniastes eximia Théel, 1882
(Fig. 5A, B)

Enypniastes eximia Théel, 1882: 56, pl. VII, figs. 6–7; Sluiter, 1901b: 77–79, pl. II, figs. 8–9, pl. X, fig. 5; Rogacheva et al., 2013: 611.
Peniagone ecalcarea Sluiter, 1901a: 26, 27.
Euriplastes obscura Koehler & Vaney, 1905: 71–72, pl. IV, figs. 7–9.
Enypniastes decipiens Koehler & Vaney, 1910: 95–96, pl. III, fig. 1.
Planktothuria diaphana Gilchrist, 1920: 373–382, text-figs. 1–4.
Enypniastes globosa Hansen & Madsen, 1956: 58, 59.
Pelagothuria Bouvieri Hérouard, 1906: 1–6, figs. 1–2.

Material. RCO.ECH.2347 (1 ex), stn. CP27, 6°58.624′S–6°58.937′S, 105.53.745′E–105°53.363′E, East of Tinjil Island (Indian Ocean), 481–557 m, beam trawl, coll. SJADES Team, 28 March 2018; RCO.ECH.2355 (1 ex), stn. CP27, 6°58.624′S–6°58.937′S, 105.53.745′E–105°53.363′E, East of Tinjil Island (Indian Ocean), 481–557 m, beam trawl, coll. SJADES Team, 28 March 2018.

Morphology. Body twice as long as broad, length 75–83 mm, width 30–35 mm. Anterior much wider than posterior. Colour uniformly dark purple covered by whitish, translucent gelatinous skin. Mouth ventral, behind a very broad brim, surrounded by 20 large tentacles; anus dorsal. Podia covered by translucent gelatinous skin. Dorsal papillae thin and long, scattered irregularly. Lateral papillae can be divided into two types according to their length: short papillae arranged far apart in anterior half, whilst long papillae are tightly arranged in the posterior half of the animal. Tube feet absent.

Ossicles. Absent.

Distribution. Cosmopolitan species (Rogacheva et al., 2013).

Pelagothuria Ludwig, 1893

Pelagothuria natatrix Ludwig, 1893
(Fig. 5C, D)

Pelagothuria natatrix Ludwig, 1893: 111; Clark, 1920: 132.
Pelagothuria ludwigi Chun, 1900: 546–549 + text-figs.

Material. RCO.ECH.2385 (1 ex), stn. CP48, South of Tg. Gedeh, Java (Indian Ocean), 7°51.120′S–7°51.718′S,

107°46.245′E–107°46.375′E, 689–637 m, beam trawl, coll. SJADES Team, 01 April 2018.

Morphology. Body wall thin, soft, slightly translucent, violet to purpura coloured. Body approximately three times as long as thick, posterior tapering and rounded. Length of the body including the large papillae is 37 mm. Tentacle 13, divided into two parts at the end and surrounded by very large and long anterior papillae. The large anterior papillae covered with thin translucent membrane and merge at the base of the papillae. No other podia were observed in the surface of the body except for the large anterior papillae.

Ossicles. Absent.

Distribution. Central America (Ludwig, 1893); eastern tropical Pacific, Galapagos (Clark, 1920), and Indian Ocean (South Java).

Remarks. *P. natatrix* is perhaps the oddest holothurian species in existence because its shape is more reminiscent of a medusa and bears no resemblance to most sea cucumbers (Miller & Pawson, 1990). It is recorded for the first time in Indonesia.

DISCUSSION

The material of holothuroids collected in this expedition is not only interesting from the taxonomic point of view but also from a zoogeographical perspective. The taxonomic characters and their variation are important in order to estimate the range variation within the species. Individual variation, local variation, and geographical variation might occur during the identification process (Hansen, 1975). Several characters are consistently used as key characters to determine the identity of deep-sea species, i.e., tentacles, calcareous ring, tube feet, papillae, calcareous deposit or ossicles, and internal anatomy (Hansen, 1956, 1964, 1975; Thandar, 1998, 2009; O'Loughlin, 2000; O'Loughlin & Ahearn, 2006; Gebruk, 2008; O'Loughlin et al., 2009, 2013; Deepa & Kumar, 2011; Gebruk et al., 2014a, b; Martinez et al., 2014). Unfortunately, the use of ossicles is not applicable to several species listed here due to their absence, i.e., in *Enypniastes eximia*, *Pelagothuria natatrix*, *Paelopatides* sp. 1, and *Paelopatides* sp. 2. Inherent difficulties in collecting and preserving specimens that retain their original shape also affect the identification process (Solis-Marin, 2003).

Among the orders described here, the Elasipodida comprises exclusively deep-sea holothuroids. Four families are known to belong to this order, i.e., Elpidiidae, Laetmogonidae, Pelagothuriidae, and Psychropotidae. During the cruise, Elpidiidae was the only family that was not found. Species in the Laetmogonidae (*Laetmogone violacea* and *Pannychia* cf. *moseleyi*) and Psychropotidae (*Benthodytes sibogae*) were found at depths of 970–1,300 m, while the Pelagothuriidae (*Enypniastes eximia* and *Pelagothuria natatrix*) were from shallower depths, i.e., 400–650 m. Members of this family have their tentacles connected directly to the water vascular ring canal (Miller & Pawson, 1990). Both pelagothuriid species described here are categorised as swimming species (Hansen & Madsen, 1956; Miller & Pawson, 1990; Bluhm & Gebruk, 1999), with *Pelagothuria natatrix* being pelagic in habit, whilst *Enypniastes eximia* is known to be benthopelagic, hovering just above the seabed (Miller & Pawson, 1990).

Out of a total of 15 species of holothuroids recorded here, five are recorded for the first time in Indonesian waters: *Zygothuria* cf. *oxysclera* (Perrier, 1899), *Bathyplotes natans* (M. Sars, 1868), *Paelopatides gelatinosus* (Walsh, 1891), *Benthothuria funebris* Perrier, 1898, and *Pelagothuria natatrix* Ludwig, 1893. Although these five species are known to have wide geographical distributions, *Bathyplotes natans* (M. Sars, 1868) and *Benthothuria funebris* Perrier, 1898, range beyond the Indo-Pacific region into the Atlantic and Southern Oceans.

Species represented by single specimens include *Benthodytes sibogae* Sluiter, 1901, from station CP13; *Zygothuria lactea* (Théel, 1886) from station CP22; *Zygothuria* cf. *oxysclera* (R. Perrier, 1899) from station CP12; *Bathyplotes natans* (M. Sars, 1868) from station CP25; *Bathyplotes* cf. *phlegmaticus* Sluiter, 1901, from station CP31; *Laetmogone violacea* Théel, 1879, from station CP44; and *Pelagothuria natatrix* Ludwig, 1893, from station CP48. These were all collected from depths of 600–1,800 m, which are within the bathyal zone (400–2,600 m). Ecological conditions in the bathyal zone are known to be more variable than at deeper depths. The lack of uniformity in species composition collected during the cruise may be a reflection of such environmental conditions.

A number of other species were collected from several sampling stations, including *Mesothuria murrayi* (Théel, 1886) collected from stations CP39 and CP40; *Amphigymnas woodmasoni* (Walsh, 1891) collected from stations CP50 and CP55; *Paelopatides* sp. 2 collected from stations CP12 and CP10; *Benthothuria funebris* R. Perrier, 1898, collected from stations CP12, CP53, and CP33; *Pannychia* cf. *moseleyi* Théel, 1882, collected from stations CP44 and CP13. Among them, *Benthothuria funebris* was rather common, with about 20 individuals collected from each sampling station. Furthermore, the depth range of the stations where *B. funebris* collected was wide (500–1,200 m), and the substratum type also varied (mud to coarse sand). This suggests that the species is adapted to a wide range of depths and substrata.

ACKNOWLEDGEMENTS

The South Java Deep-Sea (SJADES) Biodiversity Expedition 2018 was organised by the Research Center for Oceanography, Indonesian Institute of Sciences, and the National University of Singapore. We would like to thank Peter Ng and Dwi Listyo Rahayu as the principal investigators from both institutions involved. Many thanks are also due to our colleagues from the Tropical Marine Science Institute (NUS), Lee Kong Chian Natural History Museum (NUS), Research Center for Deep-Sea (LIPI), Conservation Unit for Bitung Marine Life (LIPI),

as well as the captain and crew of RV *Baruna Jaya VIII* for ensuring a successful cruise. We are grateful to Iffah binte Iesa for curation and cataloguing of specimens at the Lee Kong Chian Natural History Museum (LKCNHM), to Rene Ong for her photographs of fresh material presented in this paper, and to Hesni Nurmaria for curation and cataloguing of specimens at the Reference Collection, Research Center for Oceanography (LIPI). Specimens were collected under the research permit RISTEKDIKTI 80/SIP/FRP/E5/Dit.KI/III/2018. We express our sincere thanks to David Lane and Peter Mark O'Loughlin for their inputs towards species identification, and Gustav Paulay, Fransisco Solis-Marin, and Tan Koh Siang for their reading of the manuscript and providing constructive comments that improved the manuscript.

AUTHORS' CONTRIBUTIONS

Both authors equally contributed to the present research.

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