

First Record of *Holothuria (Cystipus) dura* (Echinodermata: Holothuroidea) from Japan, with Notes on Locomotion

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The sea cucumber, *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981, previously known only from the Philippines and New Caledonia, is newly recorded from Japanese waters; this is also the first record of the subgenus *Cystipus* from Japan. The two specimens described here were collected from the sublittoral bottoms near Hahajima island (126–261 m depth) and Okinoshima island (100–120 m depth). The morphology of the Japanese specimens is briefly described. *In-situ* photographs of the living individuals and scanning electron micrographs (SEM) of ossicles are provided for the first time for this species. The table ossicles in the dorsal body and in the papillae are highly modified fenestrated spheroids that have not been depicted previously. Some of the ventrolateral conical papillae, especially those in the middle part of the body, were bifurcated, perhaps indicative of increased surface area against the bottom for powerful propulsion while ‘walking’. Some notes on locomotion are given, inferred from the *in-situ* photographs and the morphology of the ventrolateral conical papillae.

Key Words: Aspidochirotida, deep sea, Holothuriidae, marine invertebrates, new record, Pacific.

Introduction

Holothuriidae is one of the most diverse families of sea cucumbers, comprising about 200 species distributed around the world (Paulay 2013). Currently, the family consists of five genera: *Actinopyga* Bronn, 1860, *Bohadschia* Jaeger, 1833, *Holothuria* Linnaeus, 1767, *Labidodemas* Selenka, 1867, and *Pearsonothuria* Levin, Kalinin, and Stonil, 1984 (Rowe 1969). The most speciose genus, *Holothuria* (170 spp.), comprises twenty subgenera (Paulay 2013), of which *Cystipus* (13 spp.) is characterized by having distinctive table ossicles with a knobbed disk and a low spire, the latter bearing many short spines (Rowe 1969).

Holothuria (Cystipus) dura Cherbonnier and Féral, 1981 was originally described from the coastal waters of the Philippines (Cherbonnier and Féral 1981). The description was based on fixed, preserved material, and thus lacked information about the actual shape and colour in the living state. Apart from the type locality, this species has been reported only from New Caledonia (Améziane 2007) in a faunal list, not accompanied by morphological accounts. Therefore, the precise morphology and biogeographic distribution of *H. (C.) dura* are still poorly understood. In this study, *H. (C.) dura* is recorded for the first time from Japanese waters.

Materials and Methods

Specimens were collected from the coastal waters of southern Japan. One specimen was collected during a survey conducted in an area southwest of Hahajima island, the Ogasawara Islands, Japan. A remotely operated vehicle (ROV *Hakuyo*) was used to collect the specimen. Photographs were taken *in-situ* using a camera attached to the ROV. The specimen was fixed in 10% buffered formalin then transferred to 99% ethanol for preservation. The second specimen was collected from Okinoshima island, Sukumo, Kochi, Japan. It was frozen and later transferred to 99% ethanol for preservation. Both specimens are deposited in the National Museum of Nature and Science (NSMT), Tsukuba, Japan.

Ossicles were extracted from the middle part of the dorsal body, the tip of papillae, and the tentacle, by dissolving tissue samples in commercial bleach. Ossicles were washed several times with deionized water and absolute ethanol. They were then air dried and mounted on scanning electron microscope (SEM) stubs. The ossicles were coated with gold-palladium alloy and observed under a JEOL JSM-6380LV SEM at 20 kV acceleration voltage.

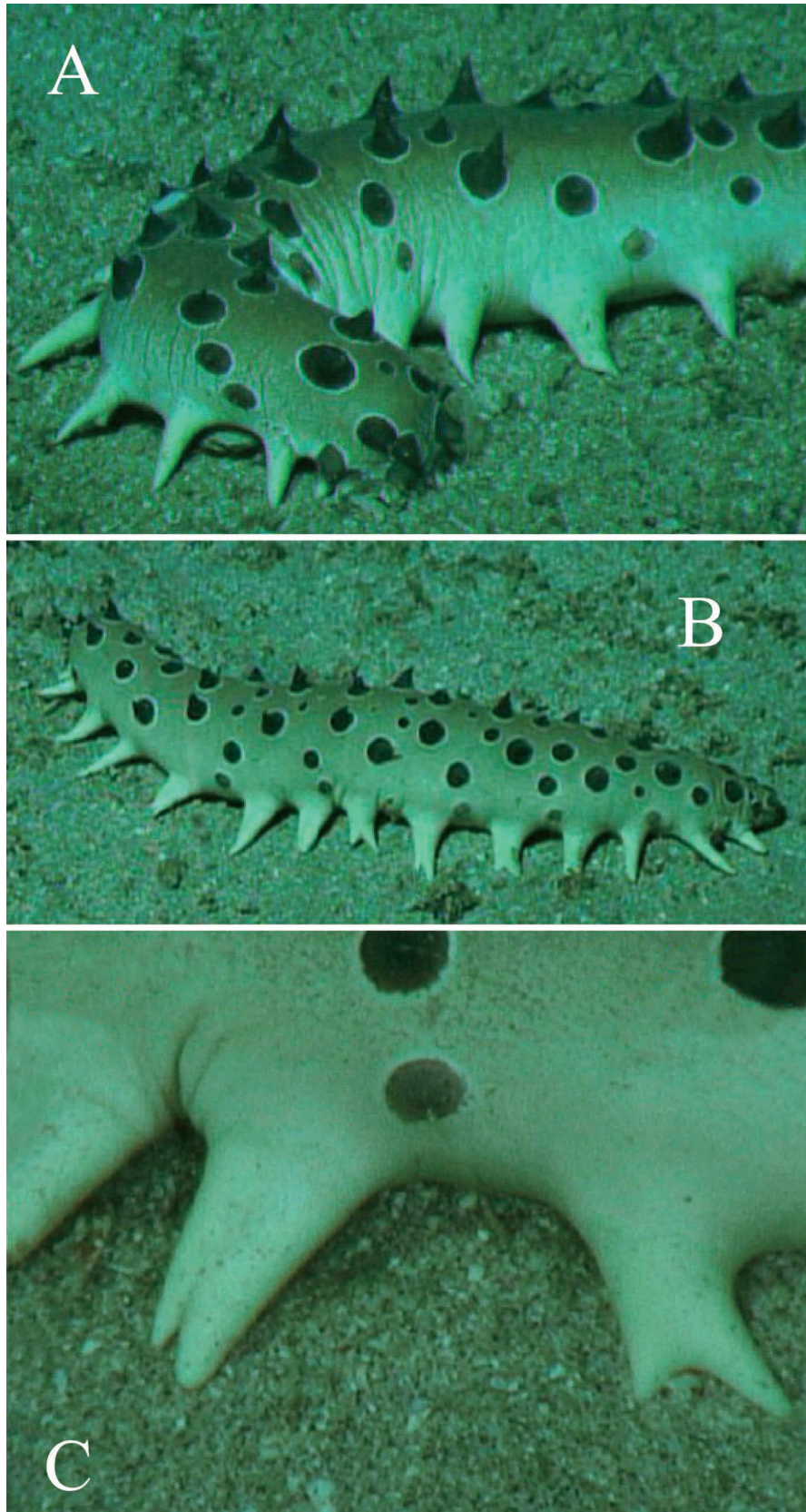


Fig. 1. *In-situ* photography of *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981 (NSMT E-9839). A, Dorsal anterior view; B, dorsal view; C, bifurcated tips of the ventro-lateral papillae. Depth: A, 182.4 m; B–C, 126.3 m.

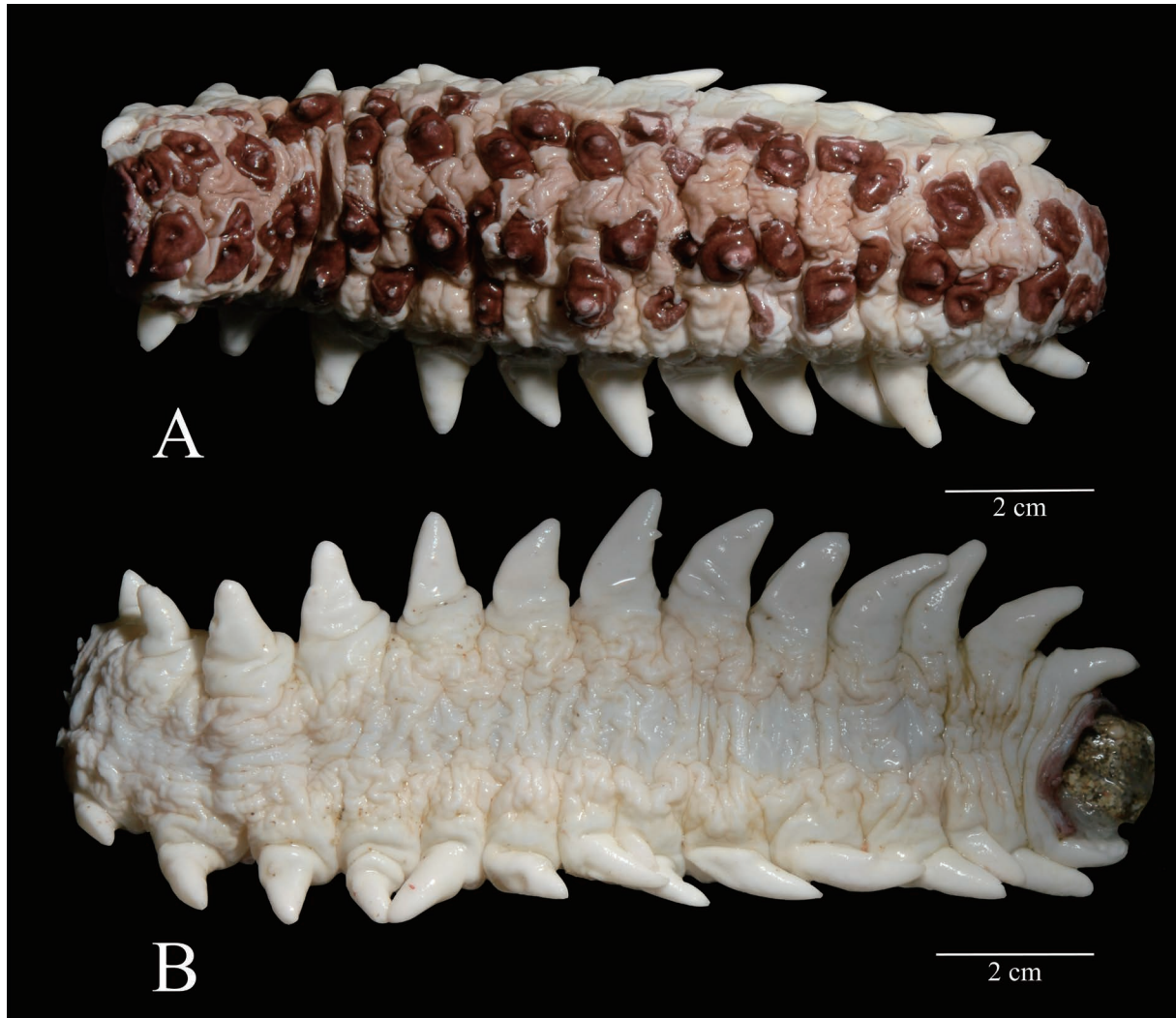


Fig. 2. *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981 (NSMT E-9839). A, Dorsal view; B, ventral view.

Results and Discussion

Holothuria (Cystipus) dura Cherbonnier and Féral, 1981
(Figs 1–6)

Holothuria (Cystipus) dura Cherbonnier and Féral, 1981:
385–387, fig. 17A–M.

Holothuria dura: Améziane 2007: 342 [checklist].

Material examined. Two specimens: NSMT E-9839, southwest of Hahajima island, Ogasawara Islands, 26°33'30"N, 142°06'30"E, 126–261 m depth, 7 March 2015, ROV Hakuyo, collected by N. Iwasaki; NSMT E-9840, Okinoshima island, Sukumo, Kochi, 100–120 m depth.

Description. Body vermiform and straight. Approximate body length 14.0–20.9 cm in preserved state. Body surface of preserved specimens wrinkled and folded. Tentacles retracted; number undetermined. Oral opening ventral, surrounded by single ring of minute papillae. Body surface rough and gritty to touch. Two rows of dorsolateral conical papillae on each side; in living state, tapering with sharp

tips and dark coloured with white ring at base; in preserved specimens, blunt in shape and brown in colour. Ventrolateral conical papillae 13 (NSMT E-9839) and 15 (NSMT E-9840) on left side, 15 (NSMT E-9839) and 14 (NSMT E-9840) on right side; some with bifurcate tips, especially those in middle part of body (Fig. 1C); bifurcation not obvious in preserved state (Fig. 2A, B). Ventral body flattened, white (Fig. 2B; NSMT E-9839) or light brown (NSMT E-9840) in colour. Number of tube feet undetermined due to contraction, not crowded and sparsely distributed along radii and interradii; light brown in colour, paler than dorsolateral conical papillae. Fifteen tentacular ampullae. Gonads single tuft. Respiratory tree single. Anus terminal.

Dorsal body wall containing table ossicles, modified table ossicles, and fenestrated ellipsoid ossicles (Fig. 3A–C). Disc of tables 85–99 µm in diameter, very spinous with multiple perforations; four very low pillars with multiple and crowded short spines (Fig. 3C). Modified tables always smaller (diameter 15–20 µm) than tables. Knobs in modified table discs interconnected to spiny pillar forming fenestrated spheroids (Fig. 3B). Fenestrated ellipsoid (57–77 µm height) with smooth, knobbed surface, and irregular per-

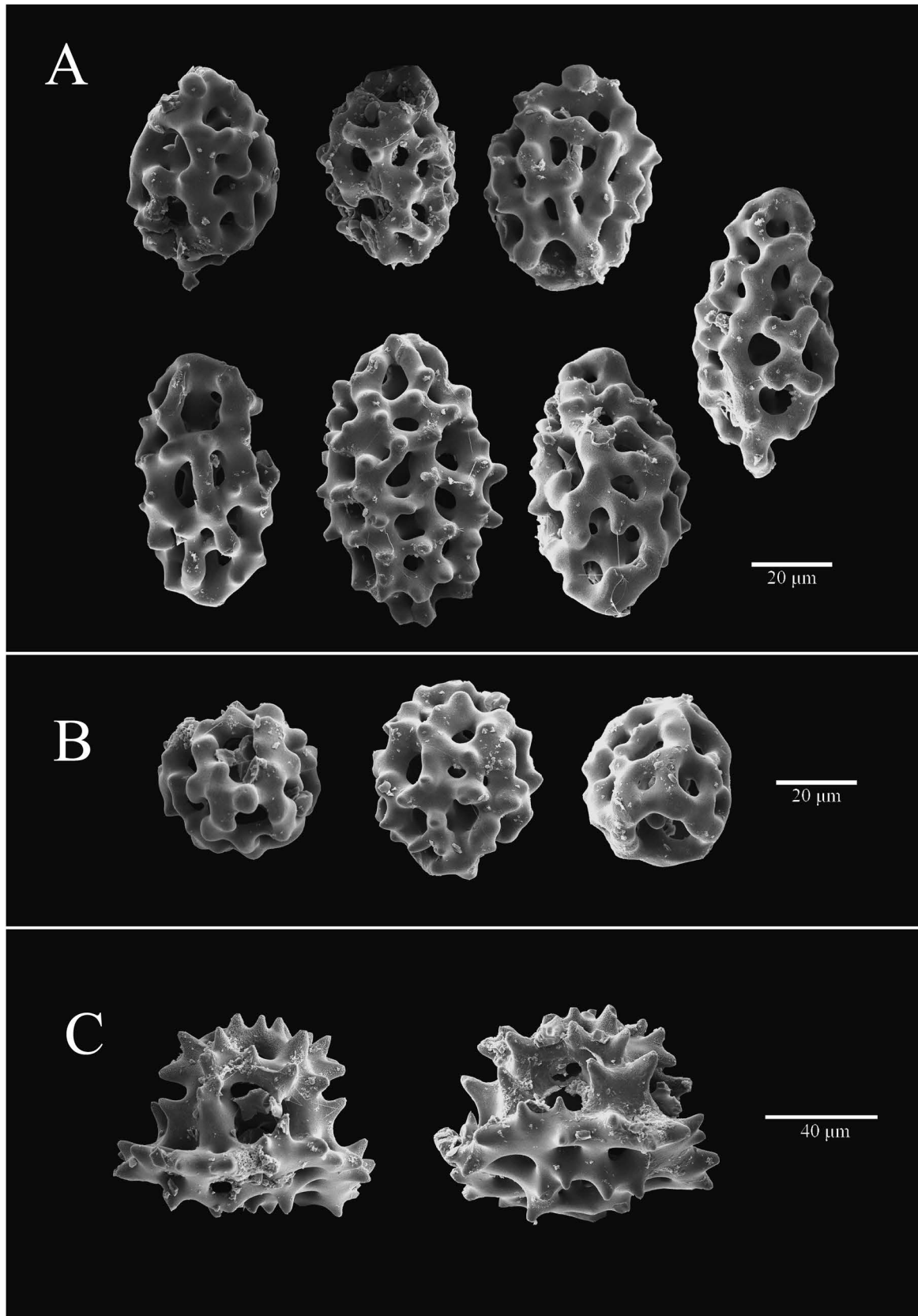


Fig. 3. Ossicles from the dorsal body of *Holothuria (Cystipus) dura* Cherbouner and Féral, 1981 (NSMT E-9839). A, Fenestrated ellipsoids; B, modified table forming fenestrated spheroids; C, tables with low spire and multiple spine tips.

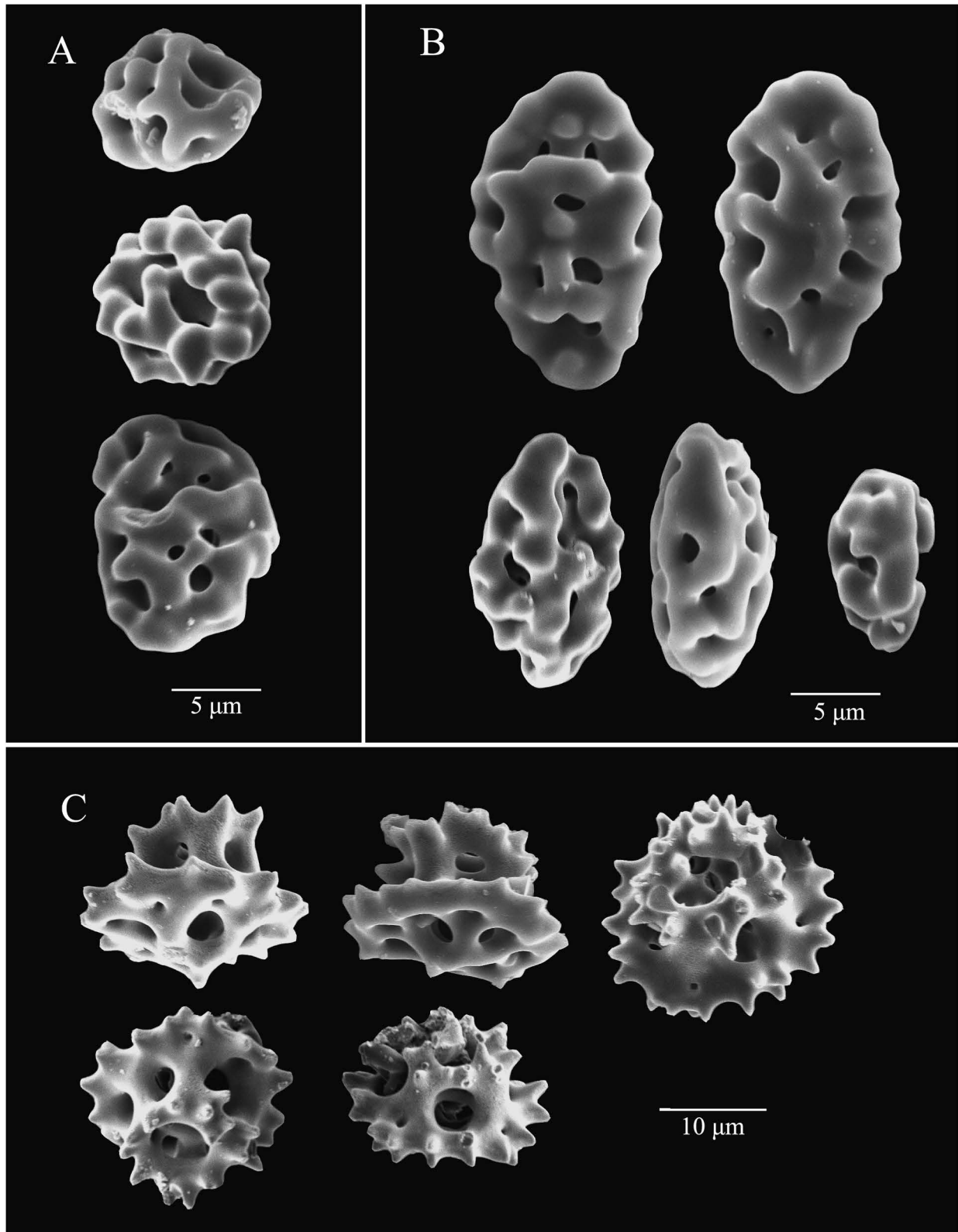


Fig. 4. Ossicles from the ventral body of *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981 (NSMT E-9839). A, Fenestrated ellipsoids; B, modified table forming fenestrated spheroids; C, tables with low spire and multiple spine tips.

forations (Fig. 3A). Ventral body wall with tables, modified tables, and fenestrated ellipsoids (Fig. 4A–C). Disc of tables in ventral body smaller (diameter 73–87 µm) than those in dorsal body (Fig. 4C). Dorsal papillae containing modified tables, fenestrated ellipsoids, and rod ossicles (Fig. 5A–C).

Modified tables in papillae forming very knobby fenestrated spheroids (Fig. 5A). Rods in papillae with central perforations; the latter being 4–20 in number (Fig. 5C). Tentacles bearing rods with smooth surface; some spinelets present on rods, especially numerous at both ends (Fig. 6).

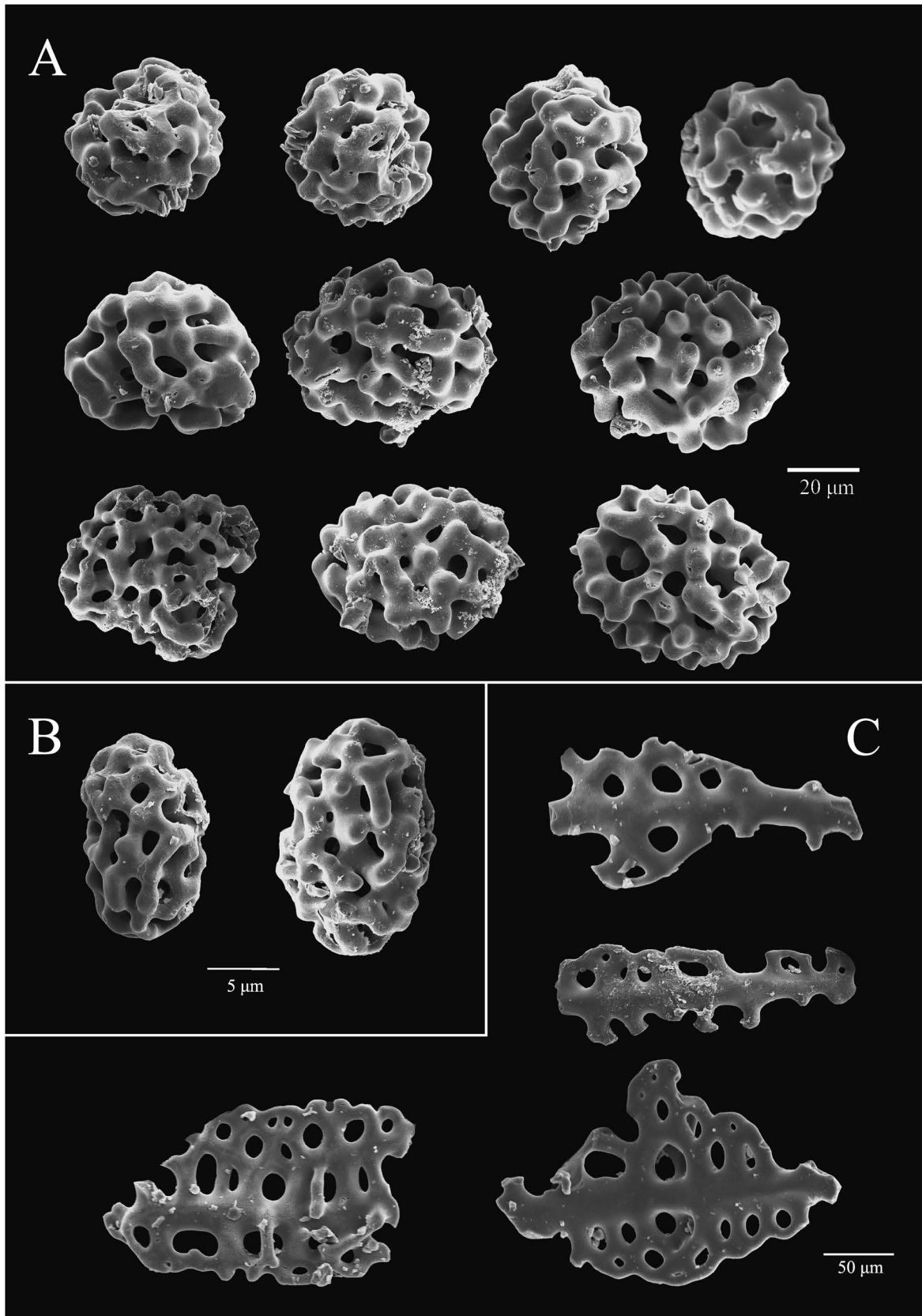


Fig. 5. Ossicles from the papillae of *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981 (NSMT E-9839). A, Modified tables forming fenestrated spheroids; B, modified table forming fenestrated ellipsoid; C, rods with central perforations.



Fig. 6. Rod ossicles from the tentacles of *Holothuria (Cystipus) dura* Cherbonnier and Féral, 1981 (NSMT E-9839).

Distribution. Philippines (South China Sea), 100–210 m (Cherbonnier and Féral 1981); New Caledonia (Améziane 2007); and Japan, 100–261 m (this study).

Remarks. Undoubtedly, our specimens can be identified as *Holothuria (Cystipus) dura* because they are morphologically consistent with the original description by Cherbonnier and Féral (1981). It is especially true in terms of the dorsolateral conical papillae, which are entirely dark-coloured with each base bordered by a white ring against the pale-coloured dorsal surface of the body; this character is unique among the 12 members in the subgenus *Cystipus*. One of the new findings in our *in-situ* observation is that the dorso-lateral conical papillae often taper to form an acutely pointed, often slightly curved, cone in the living state, with each tip directed upward (Fig. 1A, B), although they are mostly deformed in the preserved state (Fig. 2A).

Our SEM observation of the ossicles revealed that the

tables found in the dorsal body and the ones in the papillae are highly modified, forming fenestrated spheroids. A similar ossicle was termed “pseudo-boutons” (pseudo-buttons) by Cherbonnier and Féral (1981: 385); these were reported to vary in shape [from slightly nodular to elongate], in size, and in fenestration form (Cherbonnier and Féral 1981: fig. 17M), or to be several arrays of trabeculae (Cherbonnier and Féral 1981: fig. 17I). Moreover, table ossicles with 2–3 crossbeams (Cherbonnier and Féral 1981: fig. 17K) were not observed in our specimens, suggesting that these ossicles may vary in shape within the species.

With respect to the ventrolateral conical papillae, our study revealed that *i*) they vary intraspecifically in terms of the number [20 or so on each side in the type material *vs.* 13–15 papillae on each side in our material], and *ii*) at least some of the papillae are bifurcated. The latter condition may be a common feature among some member of the

subgenus *Cystipus* that have prominent ventrolateral conical papillae, viz., *H. (C.) jousseumei* Cherbonnier, 1954 and *H. (C.) casoae* Laguarda-Figueras and Solís-Marín, 2009, in addition to *H. (C.) dura*. Although bifurcation of the ventrolateral conical papillae was not mentioned in the original descriptions of these three species (Cherbonnier 1954; Cherbonnier and Féral 1981; Laguarda-Figueras and Solís-Marín 2009), it holds true at least in two of them, *H. (C.) dura* and *H. (C.) casoae*. As to the latter species, while we were not able to examine the actual specimens, the photograph illustrating the holotype specimen (Laguarda-Figueras and Solís-Marín 2009: fig. 1) clearly depicts the presence of bifurcation at the ventro-lateral conical papillae. Future studies should address commonality of bifurcation of the ventro-lateral conical papillae among the member of the subgenus *Cystipus* and other taxa, especially those occurring on sublittoral soft bottoms like *H. (C.) dura*.

Notes on locomotion. We infer that the ventrolateral conical papillae in *Holothuria (Cystipus) dura* are most likely used for locomotion in a similar manner to those holothurians occurring on deeper bottoms in the bathyal, abyssal, and hadal zones (200–6000 m depth) (Hansen 1972, 1975; Gebruk 1995). Contrary to deep-water species, shallow-water sea cucumbers in the intertidal to sublittoral zones (less than ~200 m depth) generally utilize numerous tube feet to attach to the predominantly hard substratum, move, and undergo a wide range of activities (Hyman 1955; Flammang and Jangoux 1992). The enlarged ventrolateral conical papillae and the sparse density of ventral tube feet in *H. (C.) dura* indicate that the species has adopted the ‘walking’ strategy, in which they use ventrolateral conical papillae to move on the soft bottom (Hansen 1972). Furthermore, the bifurcation at the tips of the ventrolateral conical papillae could possibly be an adaptation to increase the surface of contact area against the substratum in order to maintain the efficiency of locomotion, at the same time compensating the decreased number of ventral tube feet. As the protraction and retraction of the ventrolateral conical papillae are maintained by hydrostatic pressure from the fluid contained in the dermal cavities (Hansen 1972; VandenSpiegel *et al.* 1995), bifurcation of the tips of the ventrolateral conical papillae in preserved specimens are obscured due to the loss of water content within the dermal cavities. However, judging from the *in-situ* photographs, bifurcation of papillae appears to be more obvious in the middle part of body rather than in the posterior and anterior ends (Fig. 1B). We speculate that this would be because papillae in the middle body require increased surface area against the bottom for powerful propulsion, whereas those in both ends of the body would be mainly used to control the direction of locomotion.

Acknowledgments

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