

Two new species of holothurians of the genus *Echinopsolus* Gutt, 1990 (Echinodermata: Dendrochirotida: Cucumariidae) from the North-Western Pacific

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Abstract

Two new species of the genus *Echinopsolus*—*E. sanamyanorum* and *E. onekotanensis* are described. This genus is new for North-Western Pacific marine fauna. *Echinopsolus sanamyanorum* was collected in the Avacha Gulf (south-east coast of Kamchatka), *E. onekotanensis*—near the Onkotan Island (The Kuril Islands).

Key words: North-Western Pacific, Avacha Gulf, Onkotan Island, holothurians, new species, Holothuroidea, Dendrochirotida, Cucumariidae, *Echinopsolus sanamyanorum*, *Echinopsolus onekotanensis*

Introduction

While identifying holothurians in the collection of the Kamchatka Branch of Pacific Geographical Institute from the Avacha Gulf (south-east coast of Kamchatka) and studying a collection from Onkotan Island (The Kuril Islands) in the Zoological Institute of the Russian Academy of Sciences in Saint Petersburg two new species of the genus *Echinopsolus sanamyanorum* and *E. onekotanensis* were discovered. Previously, this genus was not known from Russian seas. *Echinopsolus* was previously placed in family Psolidae, but is included in family Cucumariidae currently (Bohn & Heß 2014). Before adding the present two new species, the genus *Echinopsolus* contained eight species (WoRMS 2020): *E. acanthocola* Gutt, 1990, *E. acutus* (Massin, 1992), *E. charcoti* (Vaney, 1906), *E. excretiospinosus* Massin, 2010, *E. koehleri* (Vaney, 1914), *E. mollis* (Ludwig & Heding, 1935), *E. parvipes* Massin, 1992, *E. splendidus* (Gutt, 1990).

The genus *Echinopsolus* (type species: *E. acanthocola* Gutt, 1990) has the following diagnosis: ten tentacles, ventral pair smaller than others; mouth and anus terminal; numerous cone-shaped processes on dorsal surface, no feet; dorsal body wall, processes included, invested by perforated, one- to multilayered plates; ventral, a narrow sole with feet in the radii present (Gutt 1990).

Echinopsolus splendidus (Gutt, 1990) [= *Microchoerus splendidus* Gutt, 1990] is characterized by 10 tentacles, ventral pair smaller than others; feet only in the radii, dorsally very few and small, ventrally forming a sole; body wall with perforated plates, reducing in number and size with increasing body size; simple ossicles present in tentacles and feet; calcareous ring simple, without posterior processes (Gutt 1990). Vaney (1906) in the description of *Echinopsolus charcoti* (Vaney, 1906) [as *Psolus charcoti*] indicates the presence of a well-defined sole and the absence of scales on the dorsal side such as that of the family Psolidae. These characteristics coincide with *Echinopsolus koehleri* (Vaney, 1914) [= *Psolus koehleri* Vaney, 1914]. *Echinopsolus mollis* (Ludwig & Heding, 1935) [= *Pseudocolochirus mollis* Ludwig & Heding, 1935] has well-defined sole and 10 tentacles (ventral pair smaller than the others). *Echinopsolus parvipes* Massin, 1992 is characterized by distinct ventral sole; tube feet on ventrolateral radii, mid-ventral radius naked except anteriorly and sometimes posteriorly; dorsal side smooth with few papillae; dorsal ossicles numerous multilayered perforated plates; ventral ossicles reduced to small perforated plates and

baskets; ten tentacles, the two ventral reduced; tentacular ossicles very small rods and perforated plates (Massin 1992).

Echinopsolus excretiospinosus Massin, 2010 has the following characters: mouth and anus terminal, ventral sole with large tube feet restricted to the radii, dorsally no tube feet but a few papillae (Massin 2010). Common features of the genus of *Echinopsolus* are 10 tentacles (the ventral pair of which are smaller than the others), a well-developed sole, a dorsal body wall with one- to multilayered perforated plates, and the lack of scales on the dorsal side.

Bohn & Heß (2014) indicated, as a diagnostic character, the difference in the form of papillae of male and female specimens, the presence of anterior brood pouches, and the shape of the spermatozoa. The difference in the form of papillae of male and female are not diagnostic characters (see Edwards 1910: fig. 1; Levin & Stepanov 2005: figs 1–3). The presence of anterior brood pouches in females is not a taxonomic feature (for example in the genus *Ocnus* there is ovoviviparous species *Ocnus glacialis* (Ljungman, 1879) with brood pouches, likewise in the genus *Cucumaria* (*Cucumaria diligens* Djakonov & Baranova, in Djakonov, Baranova & Saveljeva, 1958). The shape of the spermatozoa is not a diagnostic character, because there are round and conic [*Cucumaria conicospermium* Levin & Stepanov, 2002 (Tyurin & Drozdov 2002, 2005)] heads in the genus *Cucumaria*.

Material and methods

Echinopsolus sanamyanorum **sp. nov.** was collected in the Avacha Gulf (southeast coast of Kamchatka) by divers. *Echinopsolus onekotanensis* **sp. nov.** was collected near Onekotan Island (The Kuril Islands) using a trawl. The holothurians were preserved in 70% ethanol. Sclerites obtained from specimens were firstly cleared from associated soft tissue by sodium hypochlorite (NaClO). Then they were washed using distilled water and 70% ethanol, air-dried, and mounted on a microscope slide in Canada balsam. The type specimens of the new species are stored at the Zoological Institute of Russian Academy of Sciences (RAS) in Saint Petersburg (Russia).

Systematics

Phylum Echinodermata Bruguière, 1791 [ex Klein, 1734]

Class Holothuroidea Selenka, 1867

Subclass Holothuriacea Smirnov, 2012

Order Dendrochirotida Grube, 1840

[nom. transl. Pawson & Fell, 1965 (ex. Dendrochiroten Grube, 1840)]

Family Cucumariidae Ludwig, 1894

Subfamily Cucumariinae Ludwig, 1894, *sensu* Panning, 1949

Genus *Echinopsolus* Gutt, 1990

Echinopsolus Gutt, 1990: 112. Type species: *E. acanthocola* Gutt, 1990, by original designation.

Microchoerus Gutt, 1990: 105 [non Wood, 1844]. Type species: *M. splendidus* Gutt, 1990, by original designation.

Diagnosis [emended]. Tentacles 10, ventral pair smaller than others. Mouth and anus terminal. On the dorsal surface of the body present a few tube feet or papillae scatter about whole body. All species of genus *Echinopsolus* have a well-developed sole. Dorsal body wall contains one- to multilayered perforated plates. Scales are absent on the dorsal side.

***Echinopsolus sanamyanorum* Panina, Stepanov, Smirnov & Martynov sp. nov.**
(Figs 1–5)

Psolidae gen. sp.—Stepanov *et al.* 2012: 19–20, figs. 12–15; Smirnov 2013: 199.

Psolidae gen. sp. 1—Stepanov & Panina 2015: 46–47.

Holotype. RAS, Cat. No. 144-143, male, specimen 11 mm long, 12 September 2008, Avacha Gulf (Listvenichnaya Bay, Cape Piramidalny), 158°34.315' N, 52°22.765' E, 19 m depth, stone, boulder, 8°C water temperature, collected by SCUBA diving, collector N.P. Sanamyan (Kamchatka Branch of Pacific Geographical Institute of the Far-Eastern Branch of the Russian Academy of Sciences). No further specimens known.

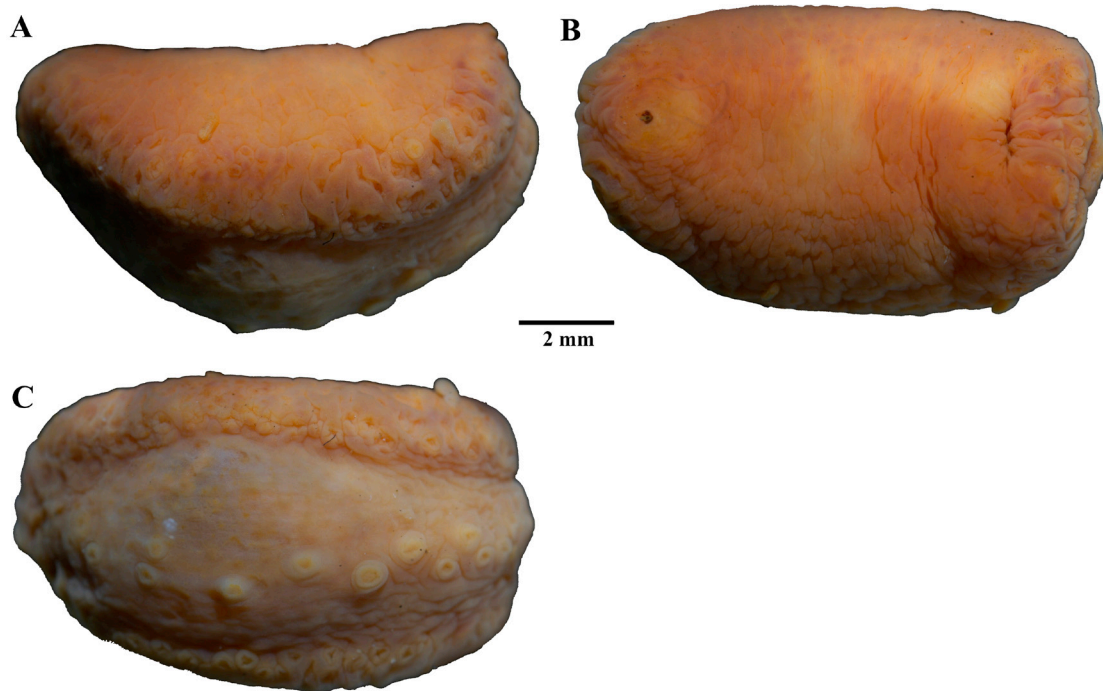


FIGURE 1. *Echinopsolus sanamyanorum*: A—side view, B—top view, C—ventral view (Photo by K.E. Sanamyan).

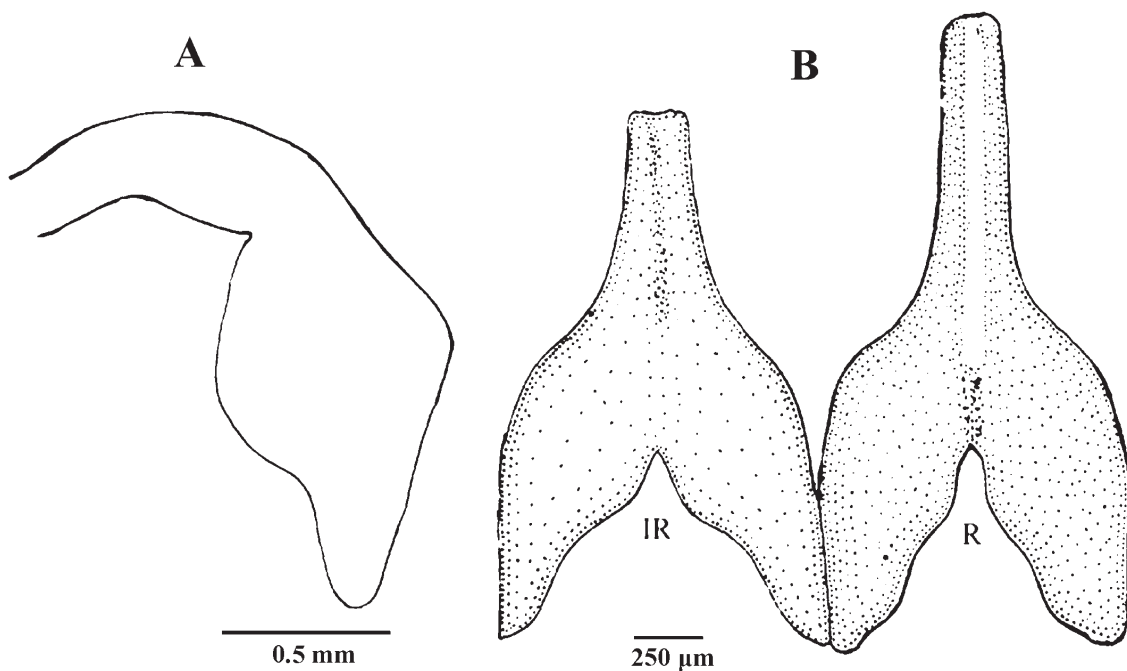


FIGURE 2. *Echinopsolus sanamyanorum*: A—Polian vesicle, B—segments of the calcareous ring (R—radial segment, IR—interradial segment).

Type locality. Avacha Gulf (southeast coast of Kamchatka).

Etymology. The species was named in honor of K.E. Sanamyan and N.P. Sanamyan (Kamchatka Branch of Pacific Geographical Institute of the Far-Eastern Branch of the Russian Academy of Sciences) who collected the holotype and are outstanding scientists in the field of taxonomy of invertebrates.

Diagnosis. Color in life is yellow-pink. The mouth and anus are displaced to the dorsal side. Ventral side is flattened like a sole. The skin is thick and wrinkled on the dorsal side. Tube feet are arranged in three longitudinal rows on the ventral side; on the ventrolateral radius there are 3-4 tube feet in transverse rows, on the mid-ventral radius—one zigzag row. Six tube feet near the mouth on the dorsal side. Tentacles 10, ventral pair smaller than the others. Ossicles are perforated plates and spindle-shaped rods.

Description of the holotype. Length—11 mm, width—7 mm, height 4 mm to the top of mouth cone, 3 mm up to the anus cone. Color in life is yellow-pink. The mouth and anus are displaced to the dorsal side. Ventral side is flat, like a sole. Body is low (ratio of height-length = 1/2), mouth and anus are not raised (Fig. 1). The skin is thick and wrinkled on the dorsal side. Tube feet are arranged in three longitudinal rows on the ventral side; on ventrolateral radii 3-4 tube feet in transverse rows, on mid-ventral radius one zigzag row. Ossicles are perforated plates and spindle-shaped rods. Tentacles 10, ventral pair smaller than the others. Retractors are attached to longitudinal muscles at 1/3 distance from anterior end. One Polian vesicle, broad in the middle and narrow at the distal end (Fig. 2 A). Madreporite and stone canal are absent.

The calcareous ring with 10 segments is low with short posterior processes (Fig. 2 B). Radial segments have a deep posterior notch and a tall anterior projection, which is taller than interradial segments.

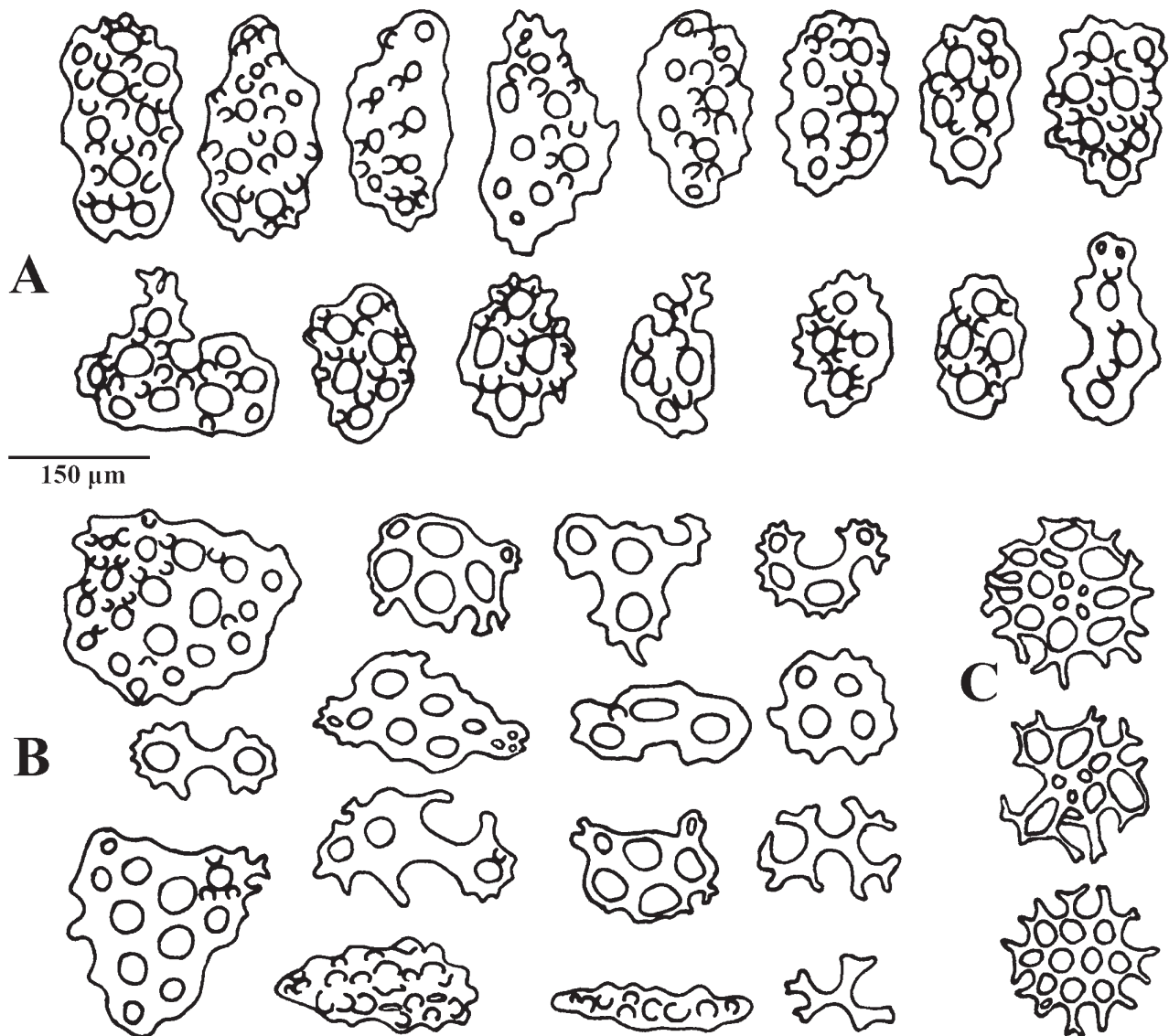


FIGURE 3. *Echinopsolus sanamyanorum*: A, B—ossicles of ventral body wall, C—end plate of the tube feet.

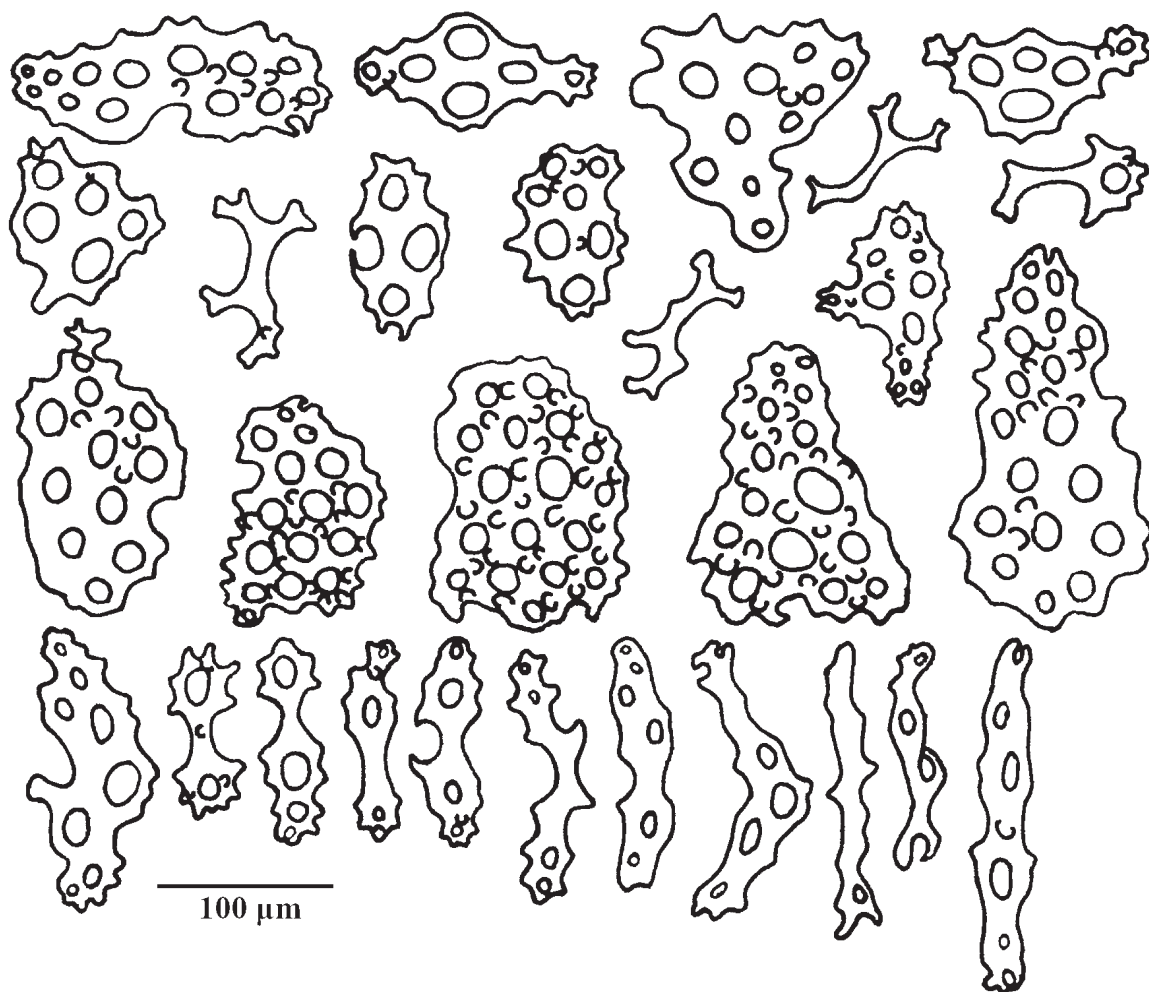


FIGURE 4. *Echinopsolus sanamyanorum*. Ossicles of the dorsal body wall.

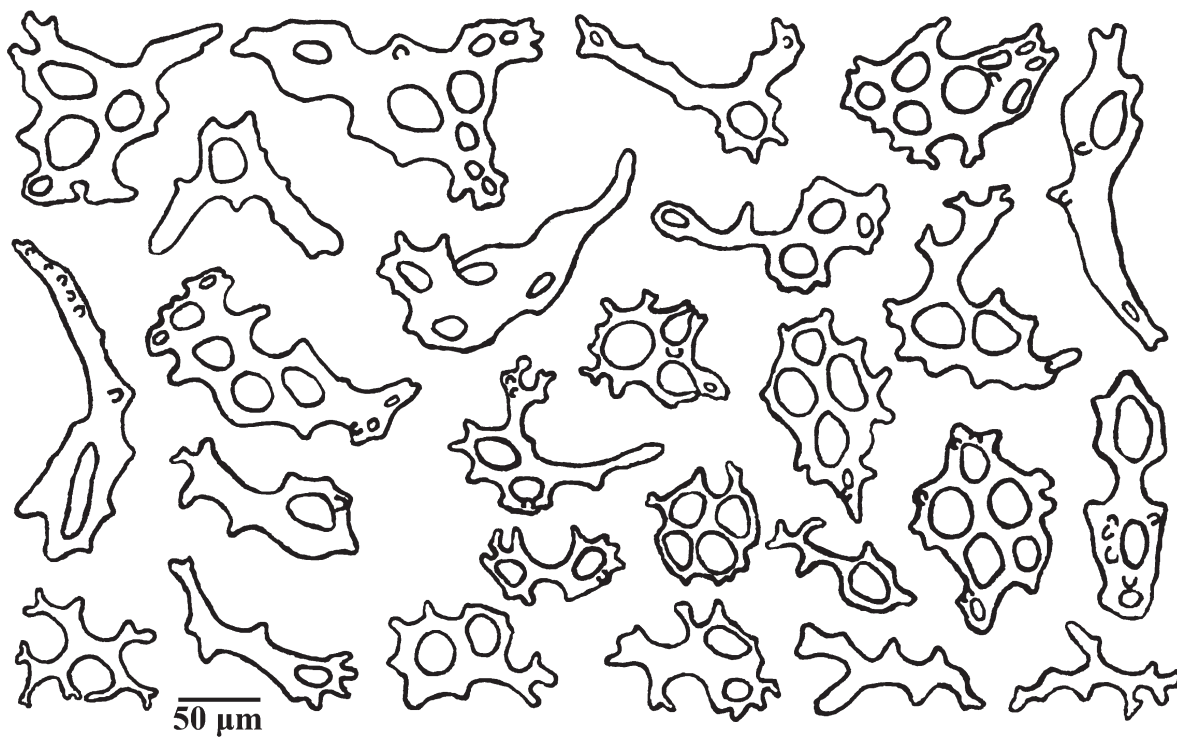


FIGURE 5. *Echinopsolus sanamyanorum*. Ossicles of the tentacles.

Thick oval plates with a wavy edge predominate in the body wall of the ventral side. The plates bear numerous large knobs and round holes scattered over the whole surface (usually 1–2 holes in transverse rows); length 150–244 μm (Fig. 3 A). There are also thick triangular and round ossicles with many holes and a few knobs; thin ossicles of different shapes and without knobs, also crosses and rods; length 150–263 μm (Fig. 3 B). Tube feet have a round end plate of lacey form (length 169–188 μm ; Fig. 3 C) and perforated plates. Ossicles of the dorsal body are perforated plates and branch rods (length 102–214 μm ; Fig. 4). Spindle rods were not found. Ossicles of the tentacles are the plates with few holes, crosses and ramified rods (length 90–200 μm ; Fig. 5).

***Echinopsolus onekotanensis* Panina, Stepanov, Smirnov & Martynov sp. nov.**
(Figs 6–11)

Psolidae gen. sp. 2—Stepanov & Panina 2015: 47.

Holotype. RAS, Cat. No. 477-485, male, specimen 49 mm long, G.B. Elyakov Pacific Institute of Bioorganic Chemistry Institute of the Far Eastern Branch of the Russian Academy of Sciences, 16 August 1982, Onekotan Island (Kuril Islands), 49°28' N, 154°35' E, 100 m depth, trawler-seiner “Dalarik”, trawl. No further specimens known.

Type locality. Onekotan Island (Kuril Islands).

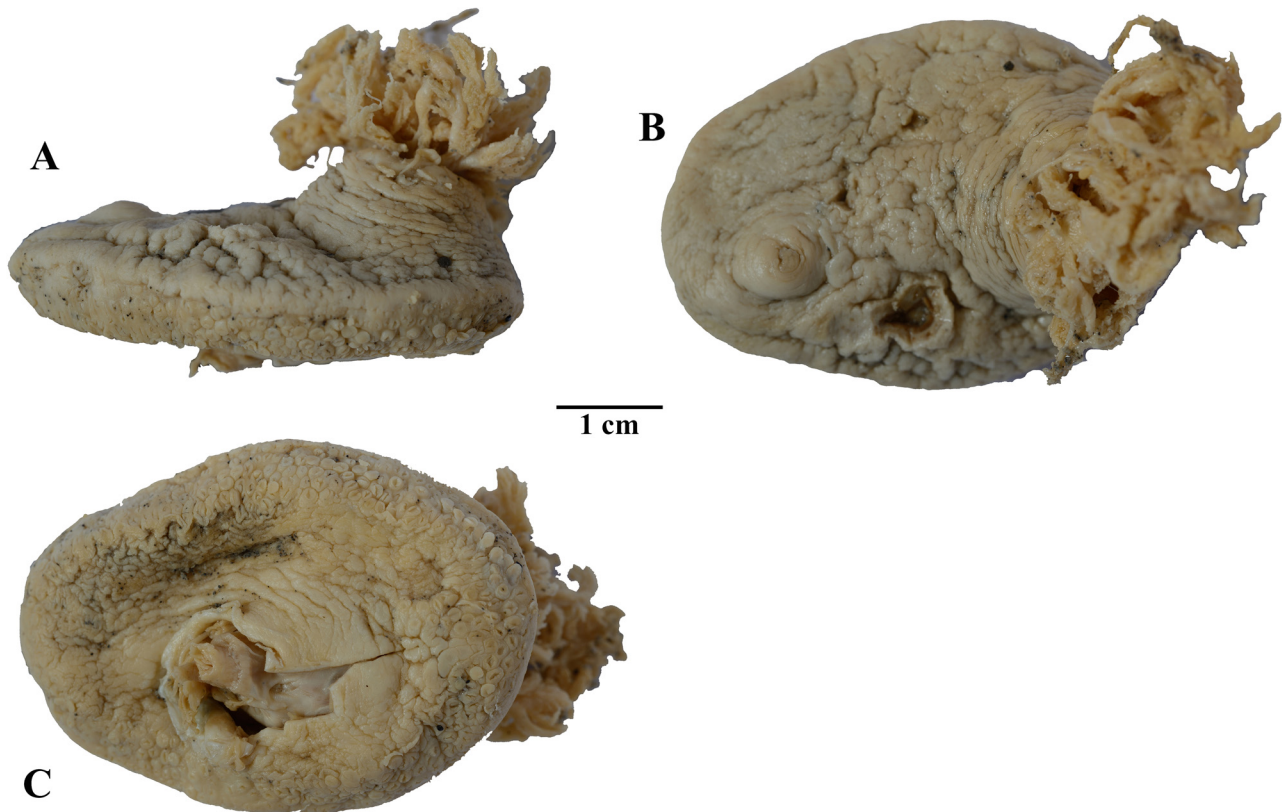


FIGURE 6. *Echinopsolus onekotanensis*: A—side view, B—top view, C—ventral view (Photo of K.E. Sanamyan).

Etymology. The species name is derived from the type locality.

Diagnosis. Color in life is light pink, in alcohol, white. The mouth and anus are displaced to the dorsal side. The ventral side flattened like a sole. The skin is thick and wrinkled on the dorsal side. Ventrolateral tube feet are well developed (4-5 tube feet in transverse rows). In mid-ventral radius tube feet are only found at the oral end. Tube feet near the mouth on the dorsal side are arranged in the following pattern: five small tube feet near the mouth and four larger ones distally. Tentacles 10, ventral pair smaller than others. Ossicles of the body wall are globules and perforated plates. Ossicles of the tube feet are globules, perforated and multi-layered network plates.

Description of the holotype. Length—49 mm, width—33 mm, height 10 mm to the top of mouth cone, 5 mm up to the anus cone (Fig. 6). Color in life light is pink (personal communication of V.I. Kalinin, PIBOC FED RAS) in alcohol, white. The mouth and anus are displaced to the dorsal side. The ventral side is flat like a sole. The skin is thick and wrinkled on the dorsal side. Ventrolateral tube feet are well developed (4-5 tube feet in transverse rows). In mid-ventral radius tube feet are only found at the anteriorly end: three tube feet in four rows. A few tube feet are located near the mouth on the dorsal side: five small tube feet near the mouth and four larger ones distally. Ten tentacles present, the ventral pair of which is smaller than the others. Retractors are attached to longitudinal muscles at a distance 1/3 from anterior end. Gonads are well developed, consisting of the two tufts of the light yellow gonadal tubules.

Polian vesicle, madreporic and stone canal are absent.

The calcareous ring with 10 segments is simple, low with short posterior processes (Fig. 7). Radial segments of calcareous ring have a deep posterior notch and a tall posterior projection which is narrow in the middle. Interradial segments of the calcareous ring are lower than the radials, and have a shallow posterior notch, and a low anterior projection.

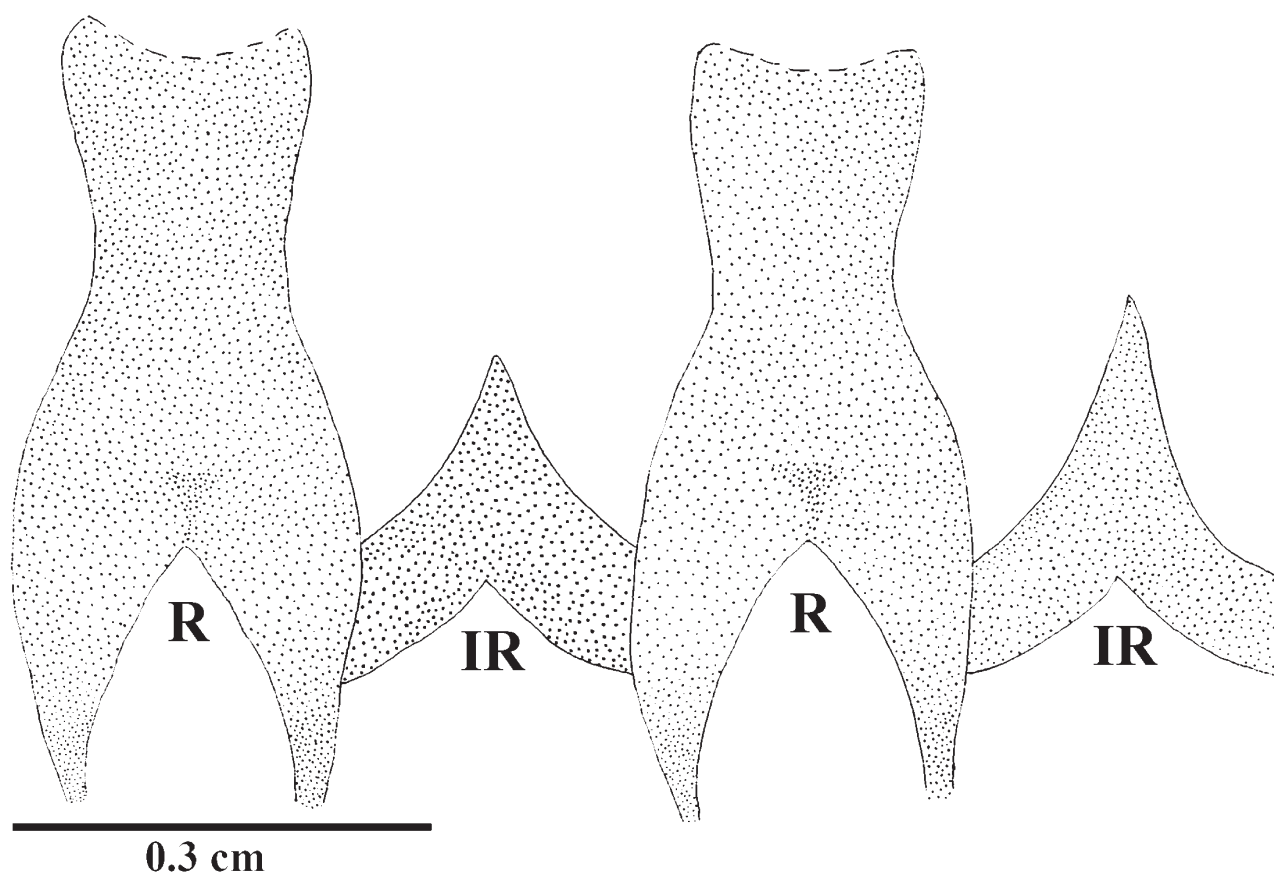


FIGURE 7. *Echinopsolus onekotanensis*. Segments of the calcareous ring (R—radial segment, IR—interradial segment). Dotted line—attachment of retractor.

Ossicles of the dorsal side are compact round globules form with a rough structure (diameter 233–566 μm ; Fig. 8) and three-dimensional crosses (Fig. 9). Ossicles of the ventral side are lacey globules (diameter 96–161 μm ; Fig. 10 A, D, F, C), flat plates with few holes and knobs (length 113–174 μm ; Fig. 10 B), crosses (Fig. 10 E), and multi-layered mesh-like plates. Ossicles of the tentacles are perforated plates with or without knobs: flat (Fig. 11 A, B, C) or curved (Fig. 11 E, F, G, I), multi-layered mesh-like plates (Fig. 11 D) and crosses (Fig. 11 H). Ossicles of the tube feet are lacey globules (Fig. 12 A), flat perforated plates with or without knobs (Fig. 12 B) and multi-layered mesh-like plates (Fig. 12 C).

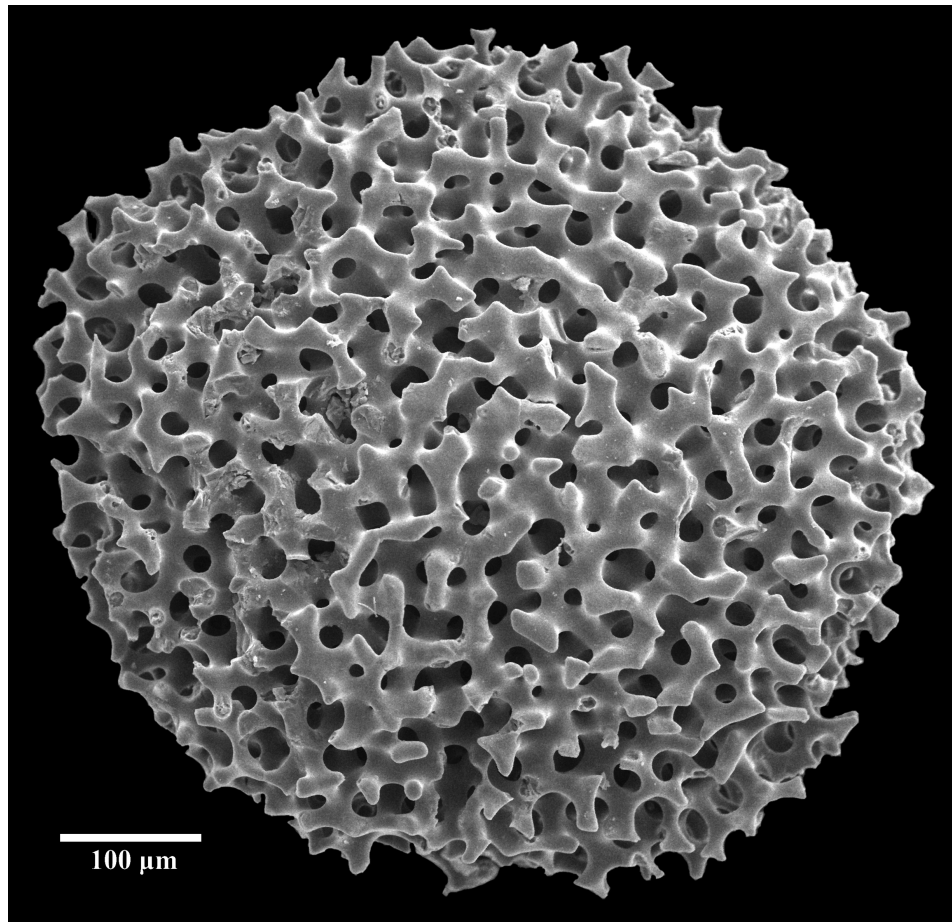


FIGURE 8. *Echinopsolus onekotanensis*. Scanning electron microscope images of a globule of the dorsal body wall.

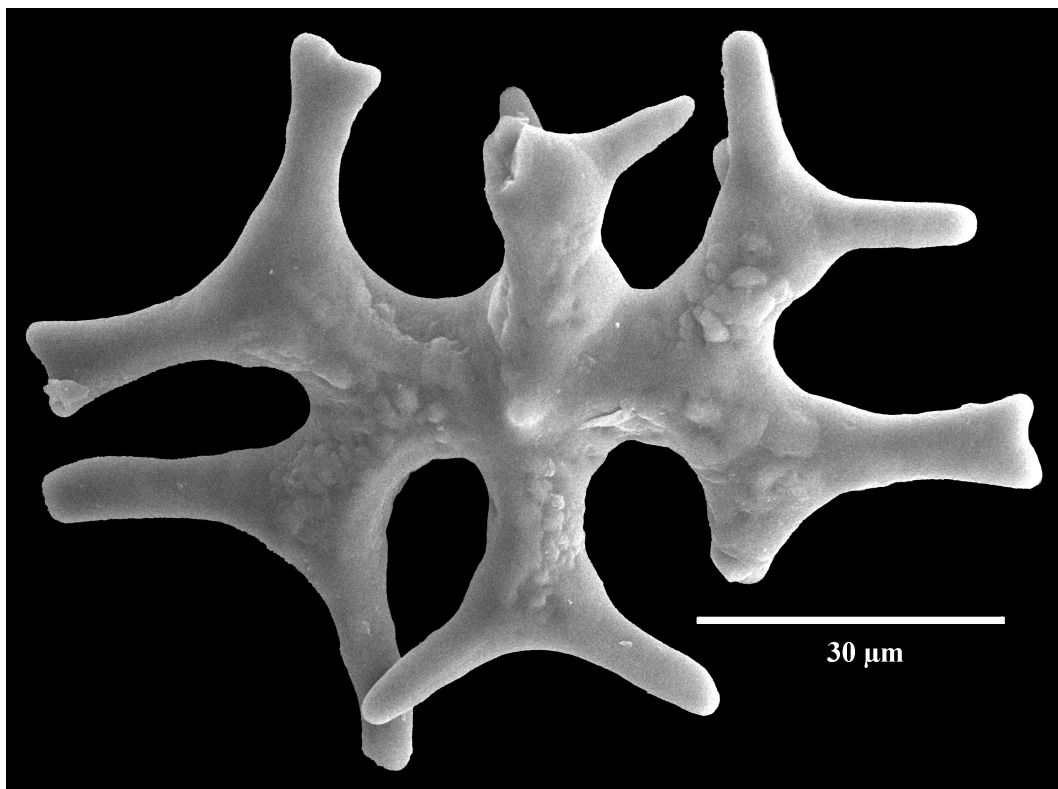


FIGURE 9. *Echinopsolus onekotanensis*. Scanning electron microscope images of a three-dimensional cross of the dorsal body wall.

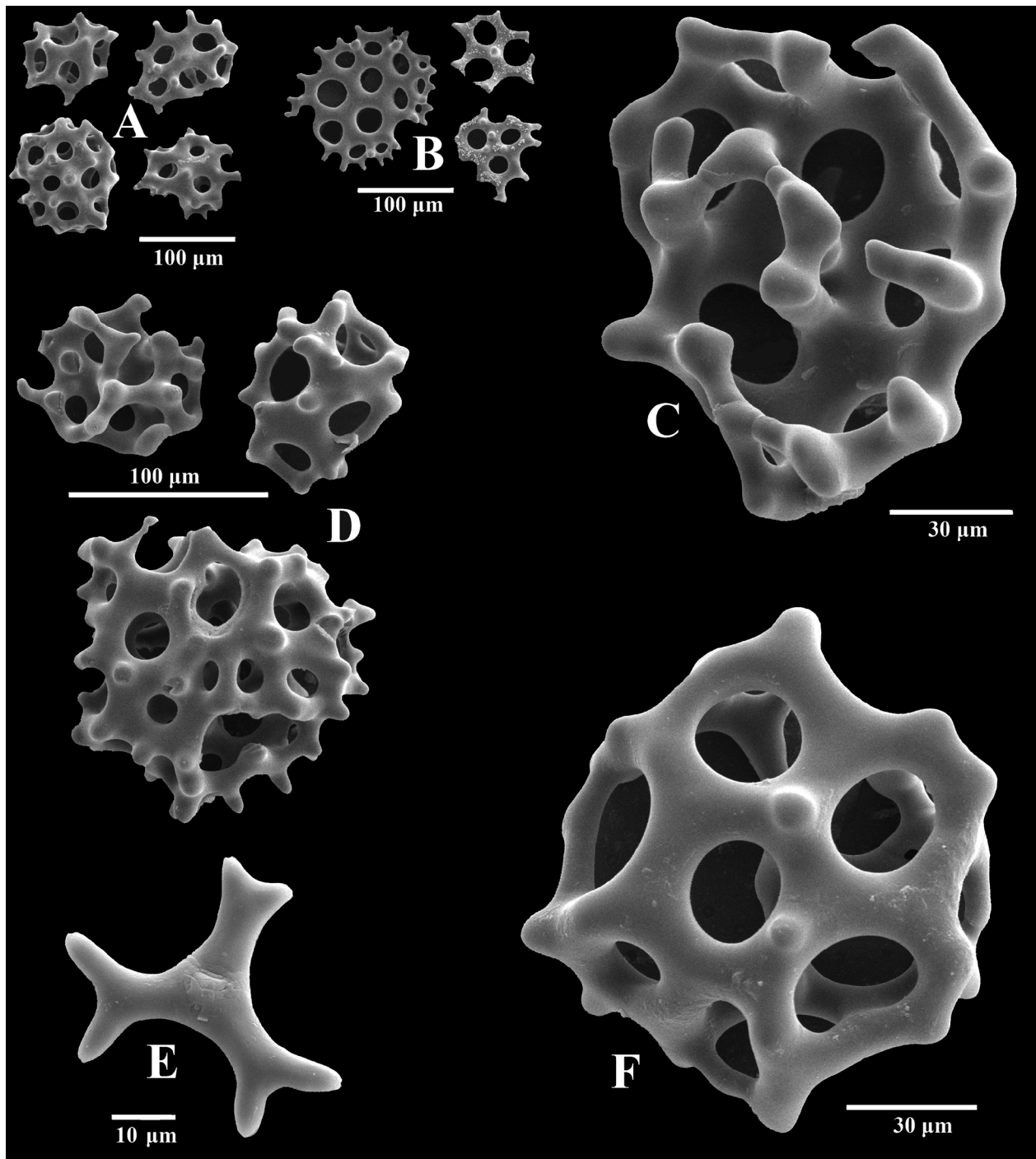


FIGURE 10. *Echinopsolus onekotanensis*. Scanning electron microscope images of ossicles of the ventral body wall: A, D, F—globules, B—perforated plates, C—baskets, E—cross.

Discussion

The main characters of genus *Echinopsolus* are: ten tentacles the ventral pair of which are smaller than the others; the presence of a few feet or papillae on the dorsal surface of the body, mouth and anus terminal; well-developed sole; and the absence of scales on the dorsal side. The new species *E. onekotanensis* and *E. sanamyanorum* show all of these characters and thus are referred to the genus *Echinopsolus* here. Present findings continue the series of the recent reports on the holothuroidean fauna of the North West Pacific (e.g., Stepanov & Panina 2016; Panina *et al.* 2019).

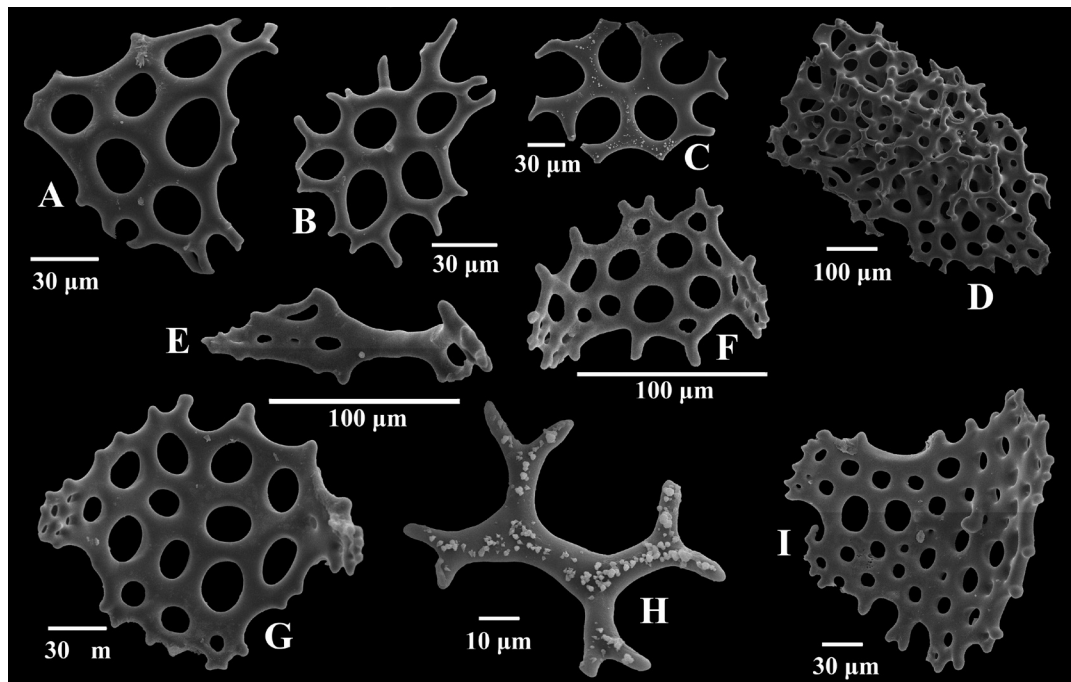


FIGURE 11. *Echinopsolus onekotanensis*. Scanning electron microscope images of ossicles of the tentacles: A, B, C—flat perforated plates, E, F, G, I—curved perforated plates, D—multi-layered mesh-like plates, H—cross.

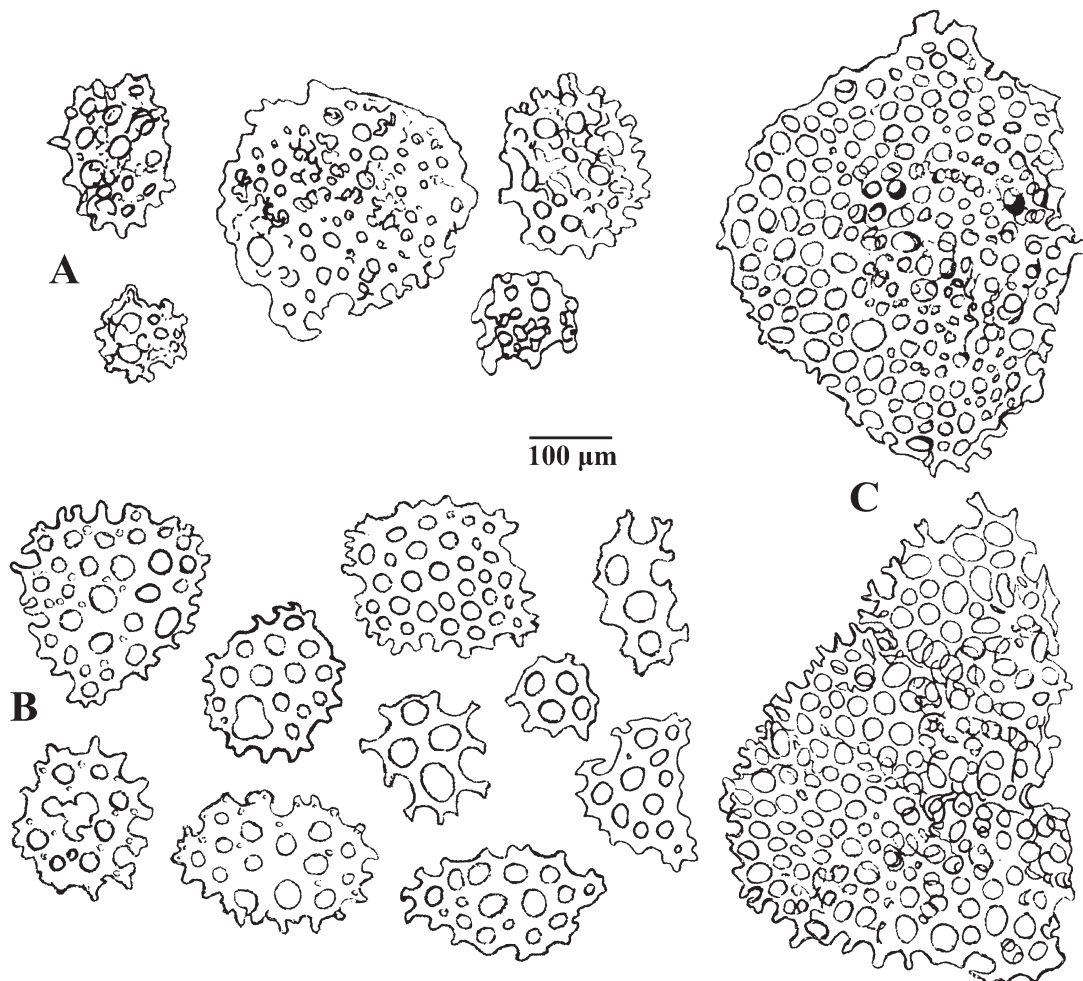


FIGURE 12. *Echinopsolus onekotanensis*. Ossicles of the tube feet: A—globules, B—perforated plates, C—multi-layered mesh-like plates.

TABLE 1. Comparison of ten species of *Echinopsolus*

Species	Characters						Sources
	Maximum body length/width, mm	Colour in life	Dorsal tube feet	Midventral tube feet	Dorsal ossicles	Ventral ossicles	
<i>E. acanthocola</i>	23/11	Rosy to brownish red	Numerous cone-shaped processes on dorsal surface, no feet	Anteriorly and sometimes posteriorly	Multilayered perforated plates	One- to two-layered perforated plates	Gutt 1990
<i>E. acutus</i>	18/6	Unknown	Cylindrical tube feet in single radial rows	Full single row	Monolayered perforated plates	Monolayered perforated plates	Massin 1992
<i>E. charcoti</i>	50/15	Grayish	No dorsal tube feet, except around mouth and anus	Full single row	Mono- multilayered perforated plates, baskets	Monolayered perforated plates	Ekman 1925
<i>E. excretiospinosus</i>	18/?	Unknown	Large conical tube feet scattered at whole body	Anteriorly	Monolayered perforated plates	Monolayered perforated plates	Massin 2010
<i>E. koehleri</i>	65/25	Red	No dorsal tube feet, except around mouth	Full single row	Monolayered perforated plates, baskets	Monolayered perforated plates, baskets	Ekman 1925
<i>E. mollis</i>	30/15	Unknown	Cylindrical to conical tube feet scattered at whole body	Full double row	Monolayered perforated plates	Monolayered perforated plates	Ludwig & Heding 1935
<i>E. onekotanensis</i> sp. nov.	49/33	Light pink	No dorsal tube feet, except around mouth	Anteriorly	Globules	Monolayered perforated plates, baskets, globules	Our data
<i>E. parvipes</i>	30/12	Unknown	Large conical tube feet scattered at whole body	Anteriorly and sometimes posteriorly	Multilayered perforated plates	Monolayered perforated plates, baskets	Massin 1992
<i>E. sanamyranorum</i> sp. nov.	11/7	Yellow-pink	No dorsal tube feet, except around mouth	Full single row	Monolayered perforated plates	Monolayered perforated plates	Our data
<i>E. splendidus</i>	40/28	Light grey to light pink	No dorsal tube feet, except around mouth and anus	Anteriorly	Monolayered perforated plates	Monolayered perforated plates	Gutt 1990

The species described lack rows of tube feet or papillae on the dorsal side and the lateral side (except near the mouth) placing *E. onekotanensis* and *E. sanamyanorum* close to *E. charcoti*, *E. koehleri*, and *E. splendidus*, but different from other species of genus (Table 1). The mouth cone of *E. sanamyanorum* **sp. nov.** does not rise above the body and is similar to *E. acutus*, *E. excretiospinosus*, *E. charcoti*, *E. mollis*, and *E. splendidus*, and differs from other species of genus. In the mid-ventral radius *E. onekotanensis* **sp. nov.** has tube feet only at oral end similar to *E. acanthocola*, *E. excretiospinosus*, *E. parvipes*, and *E. splendidus* and differs from other species of the genus. In the mid-ventral radius of *E. sanamyanorum* **sp. nov.** tube feet are arranged in a single row, resembling the position in *E. acutus*, *E. charcoti*, *E. koehleri*, but differing from other species of genus. Ossicles of dorsal wall *E. sanamyanorum* **sp. nov.** are monolayered perforated plates and close to species like *E. acutus*, *E. excretiospinosus*, *E. mollis*, and *E. splendidus*, but different from other species of the genus. In the dorsal wall *E. onekotanensis* **sp. nov.** possesses only globules, a condition which differs from all species of the genus. Ossicles of the ventral wall in *E. sanamyanorum* **sp. nov.** are monolayered perforated plates (globules, baskets, and multilayered perforated plates are all absent), a pattern which is similar to the species *E. acutus*, *E. charcoti*, *E. excretiospinosus*, *E. mollis*, and *E. splendidus* but different from other species of the genus. *Echinopsolus onekotanensis* **sp. nov.** possesses ventral body wall globules that differ from all species of the genus and, in addition, possesses monolayered perforated plates and baskets that are similar to those in *E. koehleri* and *E. parvipes*. The ossicles of tentacles *E. sanamyanorum* **sp. nov.** are monolayered perforated plates similar to all species of genus except *E. onekotanensis*.

Key to the *Echinopsolus* species

- 1a. Numerous cone-shaped papillae on dorsal surface, dorsal tube feet absent *E. acanthocola* Gutt, 1990
- 1b. Dorsal tube feet present 2
- 2a. No dorsal tube feet, except around mouth and anus 3
- 2b. Dorsal tube feet in single radial rows or scattered over whole body 7
- 3a. Mid-ventral tube feet arranged in single row from anteriorly to posteriorly 4
- 3b. Mid-ventral tube feet anteriorly 6
- 4a. Dorsal ossicles: baskets absent *E. sanamyanorum* **sp. nov.**
- 4b. Dorsal ossicles: baskets present 5
- 5a. Ventral ossicles: baskets present *E. koehleri* (Vaney, 1914)
- 5b. Ventral ossicles: baskets absent *E. charcoti* (Vaney, 1906)
- 6a. Dorsal ossicles: globules *E. onekotanensis* **sp. nov.**
- 6b. Dorsal ossicles: monolayered perforated plates *E. splendidus* (Gutt, 1990)
- 7a. Dorsal tube feet in single radial rows *E. acutus* (Massin, 1992)
- 7b. Dorsal tube scattered across whole body 8
- 8a. Mid-ventral tube feet in full double row *E. mollis* (Ludwig & Heding, 1935)
- 8b. Mid-ventral tube feet anteriorly 9
- 9a. Ventral ossicles: monolayered perforated plates and baskets *E. parvipes* Massin, 1992
- 9b. Ventral ossicles: monolayered perforated plates, baskets absent *E. excretiospinosus* Massin, 2010

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