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A new *Semperella* (Hexactinellida: Amphidiscosida: Pheronematidae) from Indonesia, Indian Ocean

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Abstract. A new *Semperella* species, *Semperella sjades*, from the Indian Ocean off the south coast of Java (Indonesia) is described. The new sponge species is the largest *Semperella* species described to date, measuring 100 cm in length. Besides its size, it is distinct in having a rounded columnar body exhibiting two different sides: one with mainly atrial areas and the other with mainly dermal areas. It is also distinct in having three types of micropentactins exhibiting: 1) all regular rays; 2) one rudimentary ray; 3) and two rudimentary rays.

Key words. Porifera, Hexactinellida, *Semperella*, SJADES, Indonesia, Indian Ocean

INTRODUCTION

The South Java Deep-Sea (SJADES) Biodiversity Expedition, which was a joint collaboration between National University of Singapore (NUS) and LIPI (Lembaga Ilmu Pengetahuan Indonesia or Indonesian Institute of Sciences), surveyed the relatively unexplored waters off the southern coast of West Java in the eastern region of the Indian Ocean in March–April 2018. It was a 14-day expedition on RV *Baruna Jaya VIII* from Jakarta to Cilacap in southern Java (Indonesia) to survey the deep-sea benthic fauna to depths reaching 2,400 m.

None of major well-known historical expeditions (Challenger, 1872–1875; Investigator, 1885–1898; Valdivia, 1898–1899; Siboga, 1899–1900; Sealark, 1905; Albatross, 1909–1910; Snellius, 1929–1930; Galathea, 1950–1952; and Snellius-II, 1984–1985) had sampled for sponges in this part of the eastern Indian Ocean (see Tabachnick et al., 2019), even though some of the largest Hexactinellida collections were made during the Challenger (Schulze, 1887), Investigator (Schulze, 1895, 1902), Valdivia (Schulze, 1904), and Siboga (Ijima, 1927) expeditions. The Siboga Expedition yielded the most prominent and important sponge collection from Indonesian waters (see Vosmaer & Vernhout, 1902; Vosmaer, 1911; Ijima, 1927; Burton, 1930; Van Soest, 1989). Some 76 hexactinellid species (in 34 genera) were collected, of which 61 species were described as new. Amongst these, only one *Semperella* species, *S. similis*, was collected off Sulawesi (Ijima, 1927), which was probably the first record of this genus in Indonesian waters.

Members of the genus *Semperella* are hexactinellid sponges with a columnar body comprising amphidisc microscleres and mainly pentactines for choanosomal megascleres. Like many hexactinellid sponges, they are deep-water sponges, rarely found in waters less than 200 m depth unlike members of the other three classes of sponges (Demospongiae, Calcarea, and Homoscleromorpha). There are 12 known species of *Semperella* (Van Soest et al., 2019) and all of them are restricted to the Indo-Pacific region at depths ranging between 280 m and 3,036 m. *Semperella schulzei* is the type species of the genus that was discovered off Cebu (Philippines) in the Pacific Ocean (Semper, 1868). It is currently the most recognisable *Semperella* species and is now known to have a wide distribution from Sri Lanka to Indonesia, the Philippines, New Caledonia, and Japan (Van Soest et al., 2019). However, only a few species have been observed to date from the Indian Ocean, apart from *S. schulzei*. *Semperella cucumis* was the first *Semperella* species discovered off the Andaman Islands (Schulze, 1895). It is distinctly different from the type species in having a tapered apical end instead of being club-shaped like *S. schulzei*. It is also distinct from *S. schulzei* in having diactines with spines at both terminal ends pointing outwards. Another *Semperella* species from the Indian Ocean, *S. spicifera*, was discovered some 30 years later, also from waters off Andaman Islands (Schulze, 1904). It also has a tapered apical end, but it is a small-sized species at less than 10 cm in body length. This species has a diverse spicule morphology with seven categories of amphidiscs. A more recent discovery in the Indian Ocean is *S. megaloxea* (see Vinod et al., 2012). This sponge, also collected in the waters off the Andaman Islands, has an unusually short body that is similar in length to its basilia. There have also been very recent descriptions of two other *Semperella* species, *S. jiaolongae* (Gong et al., 2015) and *S. retrospinella* (Wang et al., 2016), both from the Pacific

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Fig. 1. Map of locality (denoted by the pin) in Indian Ocean off Cilacap, Central Java (Indonesia) where *Semperella sjades*, new species, was collected (station CP39).

Ocean. These recent discoveries suggest that there are likely to be other *Semperella* with interesting characters waiting to be discovered from the Indo-Pacific region.

Over 30 hexactinellid specimens comprising more than ten species were collected during the SJADES cruise. This paper describes the largest *Semperella* species collected to date. The new species was compared in detail with three *Semperella* species (*S. schultzei*, *S. similis*, and *S. spicifera*) recorded previously in Indonesian waters (see Van Soest et al., 2019). *Semperella schultzei* was collected during the Challenger Expedition in the Banda Sea, whilst *S. similis* was obtained during the Siboga Expedition from the Sulawesi Sea. *Semperella spicifera* was collected by the Valdivia Expedition from the west coast of Sumatra. *Semperella cucumis* and *S. megaloxea*, the two other *Semperella* species distributed in the Indian Ocean, were examined and discussed in detail as well.

MATERIAL AND METHODS

The single specimen was collected from the Indian Ocean, off south of Java (Indonesia) using a beam trawl during the SJADES expedition from 23 March to 5 April 2018 (Fig. 1). The specimen was photographed immediately after it was brought onto the deck of RV *Baruna Jaya VIII* and preserved in 95% ethanol. For examination of spicules, samples from the dermal surface, atrial surface, and choanosome were digested in nitric acid in glass vials for approximate 10 minutes close to boiling temperature until the organic matter was digested. The nitric acid was then carefully pipetted away, and spicules were rinsed thrice in distilled water before preserving them in 95% ethanol for storage. Spicules were transferred onto aluminium stubs for examination using a JEOL 6010 scanning electron microscope (SEM) to determine the relative abundance of each spicule type while ensuring no spicules were lost or left unexamined. Size measurements of spicules were based on SEM images after suitable calibration. Spicule size data are given as minimum–mean–maximum for 25 spicules unless stated otherwise. The holotype is deposited at the Museum Zoologicum Bogoriense (MZB), Research Center for Biology, Indonesian Institute of Sciences (LIPI) in Cibinong, Java.

TAXONOMY

Phylum Porifera Grant, 1836

Class Hexactinellida Schmidt, 1870

Subclass Amphidiscophora Schulze, 1886

Order Amphidiscosida Schrammen, 1924

Family Pheronematidae Gray, 1870

Semperella Gray, 1868

Definition (from Tabachnick & Menshenina, 2002)**.** Pheronematidae with elongate body (columnar or club-like in shape); deprived of atrial cavity with several everted atrial areas represented by units separated from each other by dermalia.

Diagnosis (from Tabachnick & Menshenina, 2002)**.** The body is elongate (columnar in shape); deprived of atrial cavity, with the everted atrial areas represented by several units separated from each other by dermalia. Basalia are gathered in a compact short tuft. Choanosomal, hypodermal, and hypoatrial spicules are mainly pentactines. Uncinates of one to three kinds: macrouncinates, sometimes mesouncinates, and microuncinates. Prostalia are sceptres and basalia.

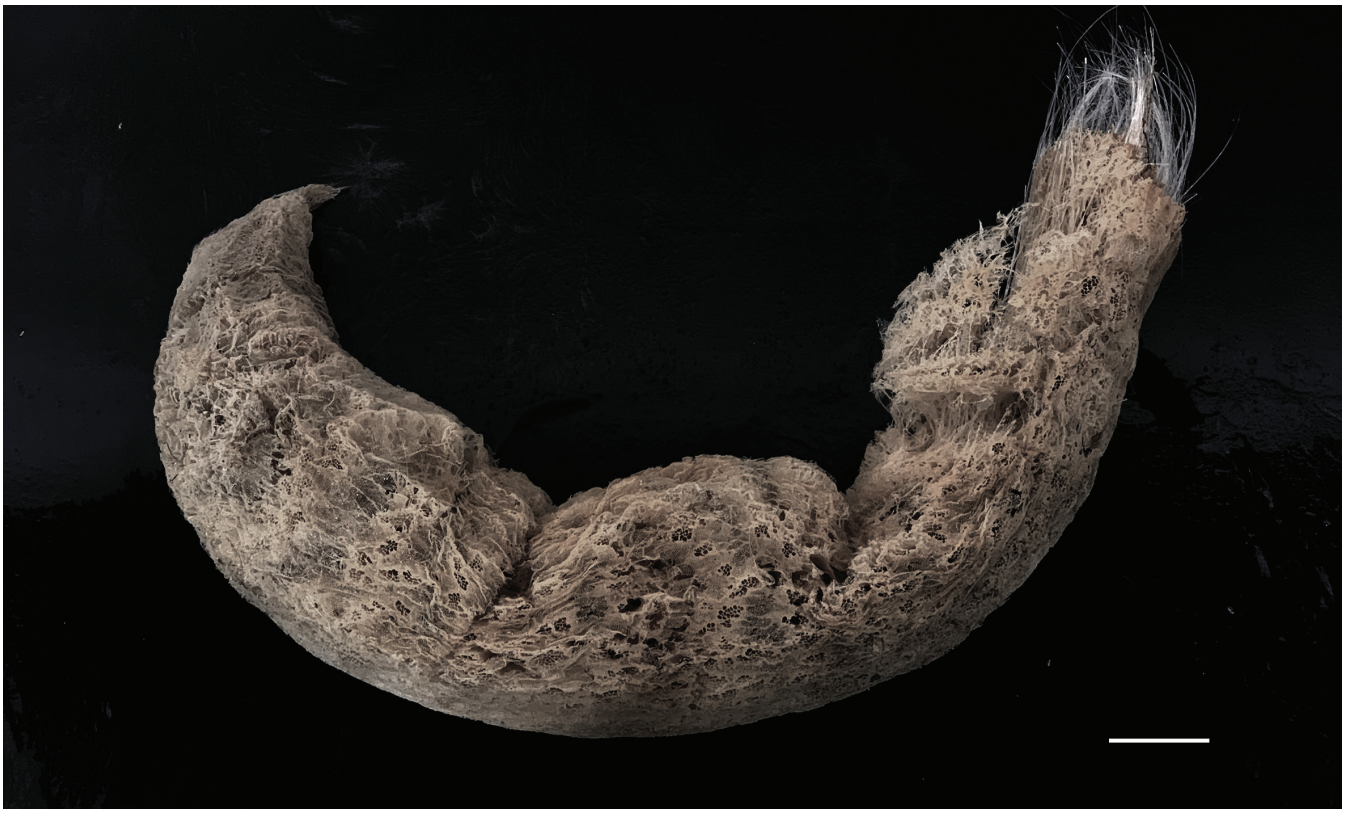

Fig. 2. Photograph of *Semperella sjades*, new species, holotype specimen after preservation in 95% denatured ethanol. Scale bar = 5 cm.

Basalia consist of anchors and oxyoidal monaxones. Dermalia and atrialia are pinular pentactines, rarely hexactines. Microscleres are amphidiscs (from one to three kinds) and combinations of holactinoidal spicules: microhexactines, micropentactines, microstauractines, micromonactines, and rarely microdiactines.

Semperella sjades, new species

(Figs. 2–6)

Type material. Holotype RCO.POR 0450 (in 95% denatured ethanol) SJADES Expedition. Station CP39. 30 March 2018, coll. Lim Swee-Cheng. Beam Trawl. Depth 637 m, muddy substrate. 8°16.060′S, 109°10.944′E, Indian Ocean, south of Cilacap, Central Java, Indonesia (see Fig. 1).

Description. The new sponge has a columnar, circular body without angular ridges and a tapered apical terminal end (Fig. 2). It is 1,000 mm in body length (excluding basalia) and 150 mm in maximal diameter (Fig. 2). Surface presents two distinct sides: one comprises mainly of atrial areas (Fig. 3A) and the other mainly of dermal areas (Fig. 3B). The atrial areas are vaguely circular, around 10 mm in diameter, comprising of mostly pentahedral lattices, some triangular and quadrilateral in shape (Fig. 3A). The dermal areas are much larger and irregular compared to the atrial areas, comprising of mostly quadrilateral lattices, some triangular or pentahedral in shape. Protruding prostalia are not observed. Basalia were all broken at the basal end (when it was trawled up) and anchors were not observed.

Spicules. The choanosome spicules comprise pentactines, stauractines (with smooth rays and conical and sometimes bulbous terminal ends) and macrouncinates. Hypodermal/hypoatrial pentactines (Fig. 4A), apical ray, 567–5826.7–6000 µm × 133.7–136.4–140 µm; tangential rays 121.1–132–141.2 µm × 33.3–42–50.5 µm (n = 5). Choanosomal pentactines, 1 or 2 long curvy rays with 4 or 3 short rays respectively (Fig. 4B), 99–1103.6–5678 µm × 24.8–60.5–134.3 µm (n = 7). Choanosomal pentactines, 4 tangential rays and an apical ray (Fig. 4C), 270.8–1006.1–2777.8 µm × 15–25.6–60.6 µm. Choanosomal pentactines with 5 irregular rays (Fig. 4D), 99–1758.8–5658 µm × 20.5–62.9–134.3 µm. Stauractines (Fig. 4E), 223.9–1289.7–3333 µm × 17.6–42.5–69.3 µm (n = 8). Macrouncinates (Fig. 4F), 3333–3946.4–4877 µm × 22.7–24.9–27.1 µm.

The spicules distributed in the atrial and dermal areas comprise pinular pentactines, amphidiscs, micropentactines, and microuncinates. Micropentactines are the most abundant spicules observed. Micropentactines with finely spined tapered tangential rays (Fig. 5A), 70.6–112.7–142.5 µm × 5.9–7.6–8.9 µm. Micropentactines with one rudimentary ray (Fig. 5B) 81.5–115.1–161 µm × 5.6–7.4–9 µm. Micropentactines with two rudimentary rays (Fig. 5C) 78.4–102.5–129.6 µm × 6.7–8.2–9.7 µm. A rare form of micropentactines with two rudimentary rays beside each other was also observed (Fig. 5D).

The atrial and dermal pinular pentactines have similar forms but the atrial pinular pentactines can be twice as large as the dermal pinular pentactines (Fig. 6A, B). The tangential rays are smooth, straight and tapered. Atrial pinular pentactines

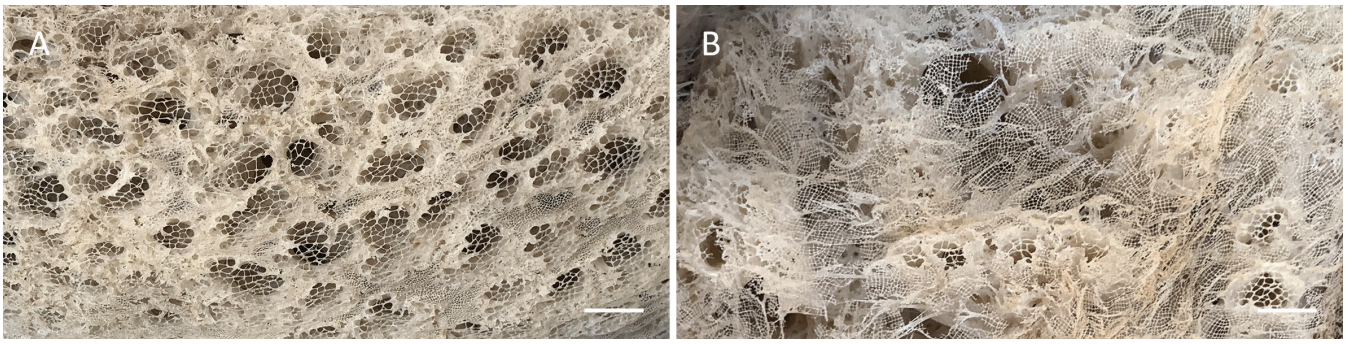

Fig. 3. *Semperella sjades*, new species. A, surface with mainly atrial areas; B, surface with mainly dermal areas. Scale bars: A = 10 mm; B = 10 mm.

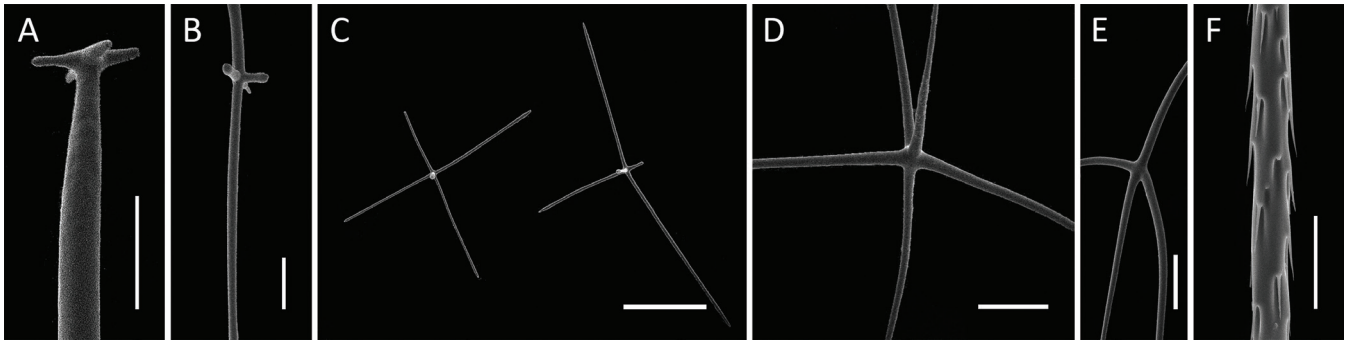

Fig. 4. *Semperella sjades*, new species. A, hypodermal/hypoatrial pentactines; B, choanosomal pentactines with 1 or 2 long curvy ray and 4 or 3 short rays; C, choanosomal pentactines, 4 tangential rays, and an apical ray; D, choanosomal pentactines with 5 irregular rays; E, choanosomal stauractines. Scale bars: A = 500 µm; B = 100 µm; C = 500 µm; D = 250 µm; E = 200 µm; F = 50 µm.

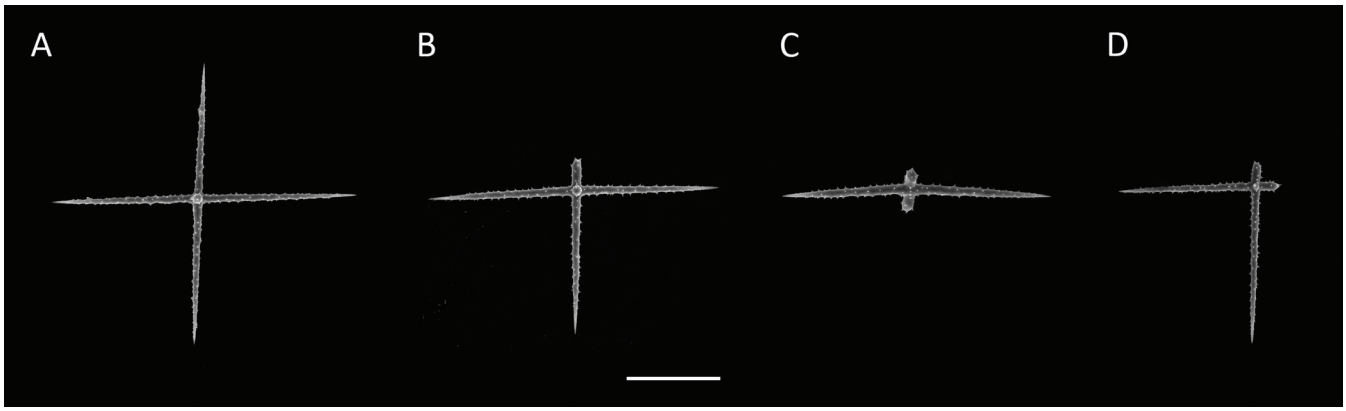

Fig. 5. *Semperella sjades*, new species. A, micropentactines with regular tangential rays; B, micropentactines with one rudimentary ray; C, micropentactines with two rudimentary rays opposite of each other; D, micropentactines with two rudimentary rays side by side. Scale bar = 100 µm.

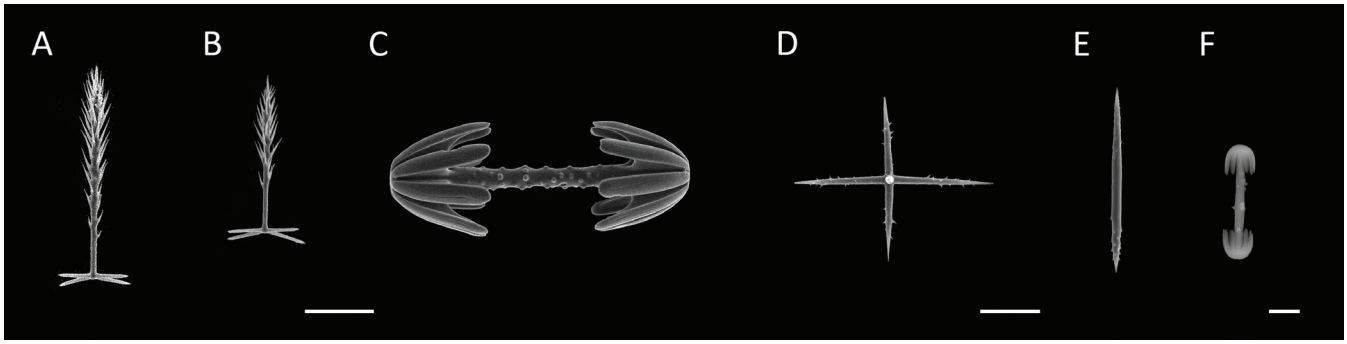

Fig. 6. *Semperella sjades*, new species. A, atrial pinular pentactines; B, dermal pinular pentactines; C, macramphidiscs; D, micropentactines with a few large spines; E, microuncinates; F, micraphidiscs. Scale bars: A, B, C = 100 µm; D, E = 50 µm; F = 5 µm.

(Fig. 6A): pinular ray, 148.5–306–500 µm × 6–9.9–14.8 µm; tangential rays, smooth, 33.3–67.7–173.6 µm × 4.2–7.1–13 µm. Dermal pinular pentactines (Fig. 6B): pinular ray 133.7–209.9–266.7 µm × 6–7.1–7.8 µm; tangential rays smooth, 46–56.6–70.4 µm × 5–5.8–7.1 µm.

There are three types of amphidiscs: macramphidiscs (Fig. 6C), mesamphidiscs, and micraphidiscs (Fig. 6F). Both macramphidiscs and mesamphidiscs are similar in form and possess shafts bearing numerous tubercules whereas micramphidiscs have spines. Both macramphidiscs and micraphidiscs are abundant but mesamphidiscs are uncommon. Macramphidiscs (Fig. 6C) total length 417.9–463.1–495.5 µm; umbel length 141.8–151.5–179.2 µm; umbel diameter 164.2–180.6–194 µm. Mesamphidiscs, total length 302–316.4–336.8 µm, umbel length 118.8–122.1–126.9 µm, umbel diameter 133.7–139.2–147.4 µm. Micramphidiscs (Fig. 6F) total length 20.2–21.7–23.4 µm; umbel length 5.1–5.4–5.7 µm; umbel diameter 5.5–5.8–6.1 µm. Microuncinates (Fig. 6E) are present in large numbers; these measure 124–146.2–178.6 µm × 6.8–8.3–10.3 µm. There are micropentactines with a few spines at the distal end, which are distinct from the micropentactines with finely spined rays, 36.2–67.6–83.8 µm × 5–6.29–8 µm. Hexactines, microhexactines, microdiactines, microstauractines, and micromonactines are all absent.

Etymology. The sponge is named after the joint Indonesia–Singapore SJADES (South Java Deep-Sea) biodiversity expedition in 2018.

Remarks. At 100 cm in body length and 15 cm in maximal diameter, *Semperella sjades*, new species, is probably the largest *Semperella* now known to date. The largest known *Semperella* prior to this was *S. schulzei* with a length of 51 cm (see Semper, 1868; Schulze, 1895, 1904; Ijima, 1927; Tabachnick & Lévi, 2000; Tabachnick & Menshenina, 2002). It is also distinct in having three types of micropentactins exhibiting: 1) all regular rays; 2) one rudimentary ray; 3) and two rudimentary rays.

The new species has a tapered apical end instead of the typical club-shaped body form exhibited by most congeners. Only *Semperella cucumis*, *S. stomata*, and S. *spicifera* share this body form (see Schulze, 1895, 1904; Ijima, 1896) but they can be clearly distinguished by a number of characters. *Semperella cucumis* is distinct in having 80–160 µm diactines at both terminal ends pointing outwards (Schulze, 1895). *Semperella stomata* has micramphidiscs that are much larger at 22–88 µm (Ijima, 1896). *Semperella spicifera* is the smallest *Semperella* described at less than 10 cm in length, and it has seven types of amphidiscs with a size range of 16–320 µm; 1) 320 µm; 2) 306 µm tiny umbel; 3) 272 µm; 4) 107 µm; 5) 69 µm; 6) 40 µm; and 7) 16 µm (Schulze, 1904). The other Indian Ocean species, *Semperella megaloxea* seems to have a vaguely tapered apical end but the presence of long diactines (50 mm), spined sauractines, and four types of microdiactines (Vinod et al., 2012) clearly distinguish it from the new species. The majority of *Semperella* species with club-shaped bodies and concave and convex sides with angled edges possess distinctive characters that distinguish them from the new species. *Semperella alba* has only two types of amphidiscs with spined shafts that are less than 200 µm in length (0.184–0.3 mm and 0.048–0.096 mm). *Semperella abyssalis*, *S. crosnieri*, *S. similis*, *S. varioactina*, *S. jiaolongae*, and *S. retrospinella* all have only one type of amphidiscs but they all have additional characters that are distinct from the new species. *Semperella abyssalis* has unique micromonactins with spherical and pointed terminal ends (Tabachnick & Lévi, 2000); *S. crosnieri* has a tongue-like body (Tabachnick & Lévi, 2000); *S. similis* does not have microuncinates (Ijima, 1927); *S. varioactina* has monactins 200 µm in length (Tabachnick & Lévi, 2000); *S. jiaolongae* does not have sauractines (Gong et al., 2015); and lastly *S. retrospinella* has distinct atrial pinular pentactines with recurved spines (Wang et al., 2016). Lastly, the new sponge is quite similar to *S. schulzei* in spicule composition but the three types of finely spined micropentactines are absent in *S. schulzei* specimens (see Semper, 1868; Schulze, 1895, 1904; Ijima, 1927; Tabachnick & Lévi, 2000; Tabachnick & Menshenina, 2002).

It is interesting to note that only *Semperella schultzei* has an Indo-Pacific distribution, as all its congeners have so far only been reported from either the Indian Ocean or Pacific Ocean. The new species, together with *S. cucumis*, *S. megaloxea*, and *S. spicifera* in the Indian Ocean, inhabit relatively shallow waters between 371–530 m. The new species extends the depth range of Indian Ocean congeners to 637 m. In contrast, the most recent *Semperella* species discovered in the Pacific Ocean, *S. retrospinella* was found at 2,741 m depth, and *S. abyssalis* at 3,036 m. All Pacific Ocean *Semperella* species are known from depths exceeding 1,000 m except for *S. schultzei* that has been reported at a relatively shallow depth of 280 m in Philippine waters.

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