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Hexactinellida from the Perth Canyon, Eastern Indian Ocean, with descriptions of five new species

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Abstract

Glass sponges (Class Hexactinellida) are described from the Perth Canyon in the eastern Indian Ocean, resulting in 10 genera being recorded, including 11 species, five of which are new to science. In addition, the study resulted in two new records for Australia, *Pheronema raphanus* and *Monorhaphis chuni*, and one new record for the Indian Ocean, *Walteria flemmingi.* A second species of *Calyptorete* is described over 90 years after the genus was first established with a single species. A significant difference was noted between the condition of sponges collected on the RV *Falkor*, which used an ROV, and the earlier RV *Southern Surveyor* expedition, which used sleds and trawls. The ROV collected specimens were in excellent condition, while those from the sleds and trawls tended to be damaged or fragmented.

Keywords: Porifera, Indian Ocean, Western Australia, glass sponges

Introduction

The Hexactinellida (glass sponges) are predominantly deep sea inhabitants with unusual morphology and biology (Leys *et al.* 2007, Dohrmann *et al.* 2008). They are exclusively marine animals that occur in all the world's oceans (Dohrmann *et al.* 2008). Currently it is estimated that approximately 600 species exist (Van Soest *et al.* 2012), but due to many deep sea regions being largely unexplored, this number is certain to increase (Janussen *et al.* 2004).

Glass sponges are important deep sea habitat for other organisms as they provide refuges, hard surfaces for attachment, and moderate water movements. They create complex physical structures, are long lived and slow growing, and may act as nursery areas for motile organisms (Hogg *et al.* 2010). They are of interest to material scientists because of optical and structural properties of their skeletons (Wang *et al.* 2011, Ehrlich *et al.* 2016), and are model organisms for the study of conduction systems in early Metazoan evolution, as they lack a nervous system but are capable of impulse conduction (Leys *et al.* 2007).

A summary of hexactinellid species reported from the Indian Ocean as far north as the Red Sea and south to Antarctica was provided by Schulze & Lendenfeld (1902). Four species were known prior to the Challenger Expedition and an additional 15 species were reported after that voyage. The *Investigator* Expedition (1885-1898) documented an additional 30 species (Schulze & Lendenfeld, 1902), Dendy (1916) another three, two of which were new, collected on the *Sealark* (1905), and Dendy & Burton (1926) two additional species from the *Investigator* collection, one of which was new. Lévi (1964), reporting on the *Galathea* Expedition, documented 10 new species and two known species from the Indian Ocean and provided an updated checklist. Since that time Tabachnick (1994) and Duplessis & Reiswig (2004) both described a new species each from the Indian Ocean, and numerous studies have examined fresh collected Antarctic glass sponges, of which some species are from the southern Indian Ocean (e.g. Janussen *et al.* 2004). For all the above publications, the research was predominantly outside Australian waters.

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The publications that have addressed the glass sponge fauna of Australia are Schulze (1893), Schulze & Lendenfeld (1902), Ijima (1927), Reiswig (1992), Tabachnick & Lévi (1999), Tabachnick *et al.* (2008), Reiswig & Kelly (2018) and MacIntosh *et al.* (2018). Only three have reported on species occurring in Western Australia, Schulze & Lendenfeld (1902), Tabachnick & Lévi (1999) and Tabachnick *et al.* (2008).

Schulze & Lendenfeld (1902) reported four species (and one dubious record) in Australia, and Reiswig (1992) doubled that number when he published on an additional four species from South Australia, one of which was new (Table 1). Tabachnick & Lévi (1999) recorded *Lophophysema inflatum* from Western Australia and a new species, *L. australicum* from Queensland. Tabachnick *et al.* (2008) substantially increased the known Australian hexactinellid fauna by reporting an additional 23 species, consisting of eight new species and one new subspecies. Reiswig & Kelly (2011) added five new and five known species, and later (Reiswig & Kelly 2018) another three known species, bringing the total number of glass sponge species reported from Australian waters to 39, along with three subspecies, one variety and one doubtful record (Table 1). In the Australian Antarctic and Subantarctic Territories a further 22 species and three varieties have been reported (Table 2).

Most of the reported species occur off Western Australia, South Australia, New South Wales and the Antarctic shelf. This is largely due to the work of Tabachnick and colleagues for Western Australia, early expeditions e.g. *Challenger*, *Valdivia*, *Albatross*, *Galathea*, and more recent work (Reiswig (1992), Reiswig & Kelly (2011)) to the other regions. Much work remains to be undertaken, with additional collections from the Western Australian shelf (Fromont *et al.* 2012), and more recently from the Great Australian Bight (MacIntosh *et al.* 2018), still to be fully identified.

The continental margin of Australia is very large, with more than 70% of the Australian Territory, totaling 13.5 million km^2, in the marine realm (OPSAG 2009). The western shelf margin of Australia (the eastern edge of the Indian Ocean) is influenced by a unique southward flowing, warm water, low productivity and salinity current to 300 m depth, and a northward flowing cold and more oxygenated counter current, the Leeuwin Undercurrent, below those depths (Althaus *et al.* 2011). A north to south flowing current system does not occur on any other western continental margin.

The continental shelf of Australia has many canyons (Huang *et al.* 2014). A few have been studied for biodiversity such as some on the south eastern margin and were found to have a rich sponge fauna (Schlacher *et al.* 2007). Directly off Perth is the Perth Canyon, contained within the Perth Canyon Marine Park (Figure 1). Perth Canyon is the second largest canyon on the Australian margin and is topographically complex (Huang *et al.* 2014). It is more than 80 km long and approximately 10 km wide, the canyon head is at 200 m depth and the canyon reaches a maximum depth of 1200 m (Althaus *et al.* 2011). It is the only canyon in Western Australia to have been biologically explored.

Perth Canyon has been identified as having a significant influence on the local ecosystem, with high productivity supporting aggregations of Pygmy Blue whales (Rennie *et al.* 2009). In 2005 the benthic invertebrate fauna of the canyon was examined for the first time as part of a comprehensive study to document the western shelf fauna (Williams *et al.* 2010). In 2015 a second expedition visited the canyon to further explore and document the fauna (Trotter *et al.* 2019). The glass sponges described in this paper were collected on these two expeditions.

Materials and Methods

Glass sponges identified in this study were collected during two unrelated expeditions to the Perth Canyon. The first was on the research vessel, RV *Southern Surveyor*, in 2005 using an epibenthic sled, and the second was on the RV *Falkor* in 2015 using an ROV (remotely operated vehicle). Specimens were photographed after collection where possible, and preserved in 75% ethanol on the vessel. In the laboratory, spicules were isolated using a method devised by Tabachnick that used potassium dichromate, distilled water and sulphuric acid, see Janussen *et. al* (2004) for full methodology. The preparations were examined with a ZEISS Axiolab microscope. For scanning electron microscopy (SEM), sponge samples were first dissolved in bleach, rinsed in distilled water and ethanol, then mounted on SEM stubs, dried, sputter coated, and examined with a Hitachi TM3030Plus SEM. Spicules were measured with a computer digitizer, by eyepiece graticule, or camera lucida. Specimens from Western Australia are deposited in the Western Australian Museum, Perth. Additional material was examined from the Natural History Museum, London, Museum für Naturkunde an der Universität Humboldt zu Berlin, Shirshov Institute of Oceanology of the Russian Academy of Sciences, Moscow, and the Muséum national d'Histoire naturelle, Paris.
Abbreviations used in this study:
av: average

min: minimum
max: maximum
n: number of spicules
sd: standard deviation
CSIRO: Commonwealth Scientific and Industrial Research Organization
NHMUK: Natural History Museum, London, United Kingdom
MNHB: Museum für Naturkunde an der Universität Humboldt zu Berlin, Berlin, Germany
IORAS: Shirshov Institute of Oceanology of the Russian Academy of Sciences, Moscow, Russian Federation
MNHN: Muséum national d'Histoire naturelle, Paris, France
WAM: Western Australian Museum, Perth, Australia

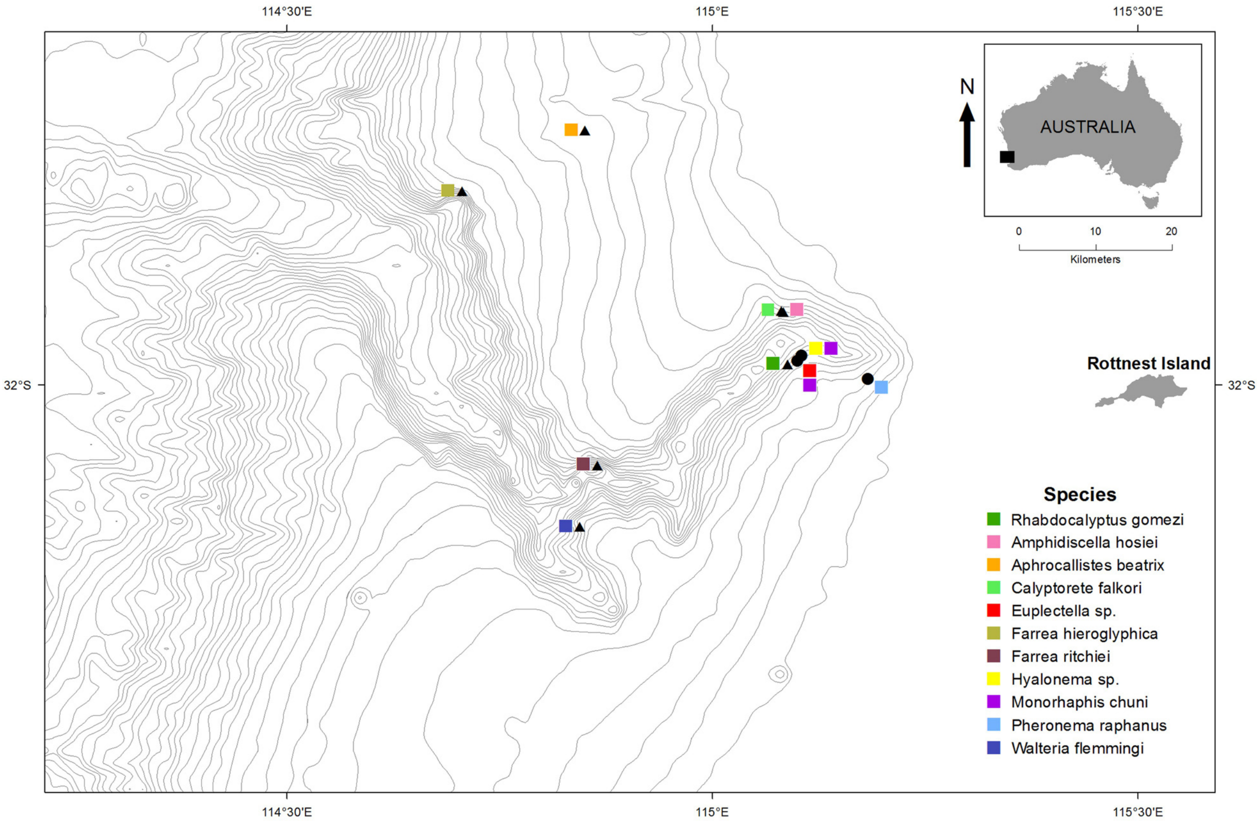

FIGURE 1. Map of Perth Canyon. Triangles are RV Falkor stations and circles are RV Southern Surveyor stations.

Results

Taxonomic descriptions and systematic account

Class Hexactinellida Schmidt, 1870

Order Amphidiscosida Schrammen, 1924

Family Pheronematidae Gray, 1870

Pheronema Leidy, 1868

Pheronema raphanus Schulze, 1895

Material examined. Australia: Western Australia: WAM Z35337, Z98331, Z98330, respectively – 2 specimens and

1 lot (4 fragments), Perth Canyon (31°59'33"S, 115°10'59"E to 31°00'07"S 115°10'41"E, Figure 1), 508–478 m, J. Fromont and C. Whisson, sled, 29/11/2005, RV *Southern Surveyor* station SS1005/068.

Type material: off Andaman Islands: (12° 37'N, 92° 19'E), 530 m, RV *Investigator*, station 210, (NMHUK 1896.09.12.002; HM 5861).

Other material: Western Indian Ocean: 4 specimens (6° 53.1'N, 93° 35.5'E), 752 m, RV *Valdivia*, station 210, (HM 5675, HM 5676, HM 5677, HM 5678, HM 5680). Western Indian Ocean: 4 specimens (7° 48.8'N, 93° 7.6' E), 752 m, RV *Valdivia*, station 211, (NHMUK 1908.09.24.044, HM 3703, HM 4351, HM 5674). Off Philippines: 3 specimens (13° 2.8–2.9'N, 122° 37.1 to 122° 35.5'E), 805 m, *Musorstom* 2, station 39, (MNHN 4243, MNHN 4244, MNHN 4245). East China Sea, off southern Japan: 3 specimens (30° 45.8'N, 128° 04.8'E) 499–492 m, 1/11/1955, RV *Vitiaz* 22, station 3540, (IORAS 5/2/1329; IORAS 5/2/sp4112; ZINRAS sp2218). Off Philippines: 2 specimens (8° 40'N, 119° 48'E), 850 m, 3/1/1975, RV *Vitiaz* 57, station 7242 (IORAS 5/2/sp3320).

Description. Body, Figure 2. The specimens are conical and taper to a narrow base; the atrial cavity (osculum) is shallow or nearly absent (≤10 mm deep). The WA specimens are from 35–80 mm high and 12–45 mm maximum diameter. The osculum is ≤20 mm diameter. Prostalia lateralia appear as several tufts around the sponge maximum circumference (Figure 2), they extend outwards to 20 mm from the surface. Prostalia basalia are presented by tufts at the lower part of the body up to 40 mm long (Figure 2).

FIGURE 2. *Pheronema raphanus* WAMZ98331 external morphology (scale 60 mm).

Spicules. Megascleres Figure 3, Table 3. Choanosomal spicules are pentactins with rays often of different lengths and outer ends conically pointed or rarely rounded; the rays are 0.08–1.90/0.009–0.144 mm (Figure 3 B–C). Uncinates are of two types: normal form which have identical conically pointed outer ends 0.6–2.3/0.004–0.007 mm, and those with one outer end conically pointed and the other rounded 0.5–0.8/0.005 mm (Figure 3 G–H). One specimen has a potential precursor of uncinates – hexactinic spicules with rays covered by harpoon–like spines, in these spicules some of the rays are short and rudimentary, rays are 0.045–0.30/0.005 mm (Figure 3 I). Basalia (about 70/0.015mm) are two-toothed anchorate spicules, they rarely have one tooth, their shafts are spiny (Figure 3 D–F).

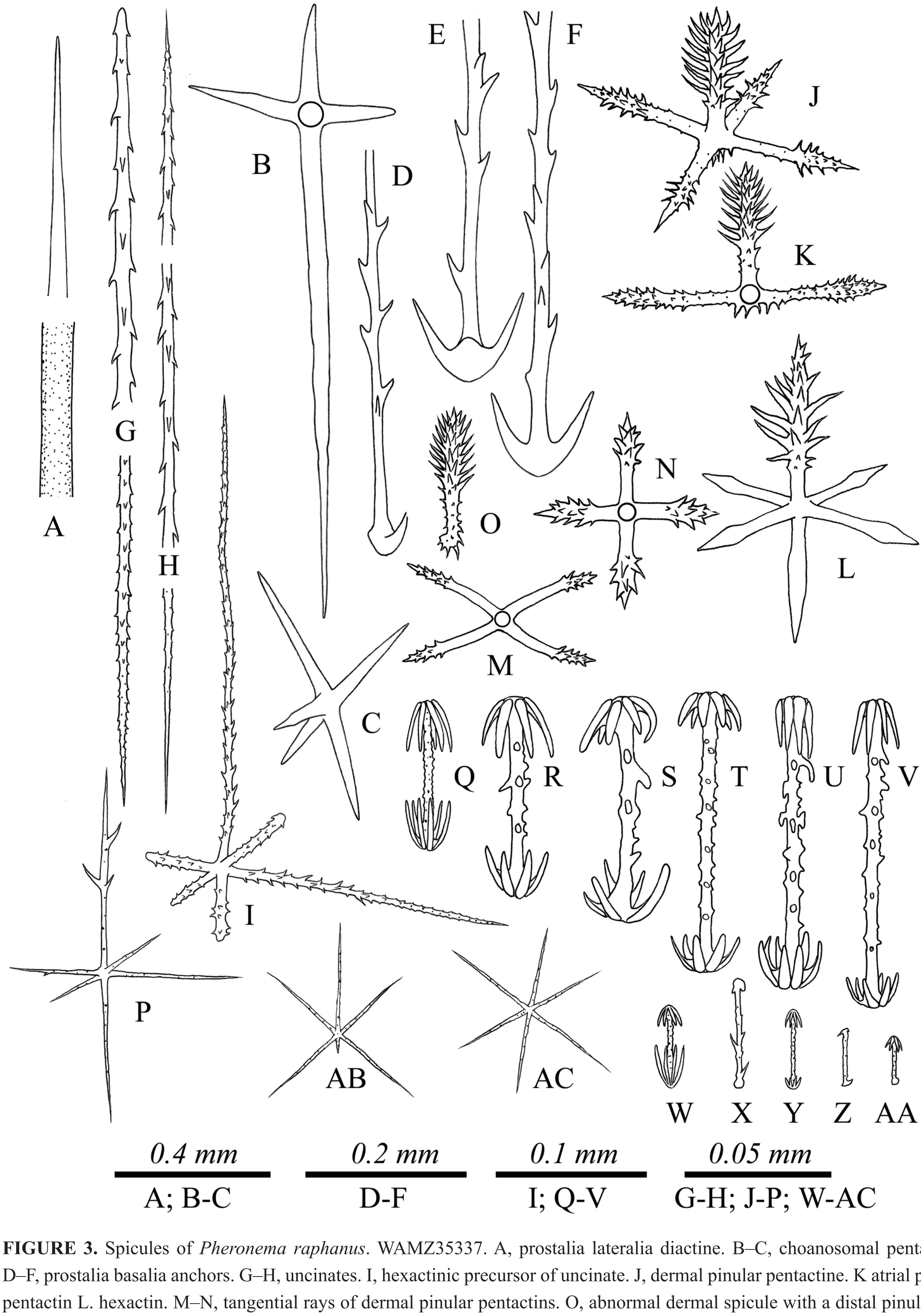

FIGURE 3. Spicules of *Pheronema raphanus*. WAMZ35337. A, prostalia lateralia diactine. B–C, choanosomal pentactins. D–F, prostalia basalia anchors. G–H, uncinates. I, hexactinic precursor of uncinate. J, dermal pinular pentactine. K atrial pinular pentactin L. hexactin. M–N, tangential rays of dermal pinular pentactins. O, abnormal dermal spicule with a distal pinular ray. P, canalaria hexactin. Q–V, macramphidiscs. W–AA, micramphidiscs: W, hemidisc; X, tylodiactine; Y, normal micramphidisc; Z, paradisc; AA, tylodisc. AB–AC, microxyhexactins.

Prostalia lateralia (about 40/0.04 mm) are diactins with conically pointed outer ends, their shafts are partly smooth and partly rough (Figure 3 A). Dermal and atrial spicules are pinular pentactins and some hexactins, occasionally it is possible to find their derivatives only by the tangential rays or the pinular ray (Figure 3 J–O). The pinular ray is ovoid in shape, tangential rays are conically pointed, stout or lanceolate, often spiny or rarely smooth. In tangential plane the rays have the shape of a regular cross or sometimes an x-shape (Figure 3 M–N). A peculiar feature of the dermal and atrial pinular pentactins is the presence of spines situated at the site of the reduced ray (Figure 3 J–K). The pinular ray of the dermal pentactin is 0.015–0.111 mm long, tangential rays are 0.019–0.063 mm long, the diameter of these rays is 0.002–0.005 mm. The pinular ray of the atrial pentactin is 0.030–0.100 mm long, tangential rays are 0.030–0.059 mm long, the diameter of these rays is 0.002–0.005 mm.

Microscleres, Figure 3, Table 3. Amphidiscs are of two types: macramphidiscs and micramphidiscs. The macramphidiscs are 0.070–0.215 mm long, the umbel length is 0.019–0.076 mm long, the umbel diameter is 0.019–0.078 mm (Figure 3 Q–V). The shafts of the macramphidiscs are tuberculated, the teeth of the umbels are often of different size so sometimes the spicules can be referred to as paradiscs. The micramphidiscs are 0.013–0.062 mm long, the umbel length is 0.003–0.018 mm long, the umbel diameter is 0.004–0.014 mm (Figure 3 W–AA). The shafts of the micramphidiscs are tuberculated or rough, the umbels of these spicules are often of different sizes so the spicule can be called a hemidisc. One or two umbels may have spherical widening or no tooth, termed a tylodisc or paraclavule for the former case and tylodiactin for the latter type of spicule. Some micramphidiscs are paradiscs. Oxyoidal microscleres are hexactins and pentactins, the latter often with a rudimentary ray (Figure 3 AB–AC). Sometimes one ray of these microscleres has several long spines, usually this ray is longer, and it may be that such spicules should be considered as canalaria hexactins. The ray of the oxyoidal microscleres is 0.018–0.067 mm.

Remarks. This species was previously known to be distributed in the central and western Indian Ocean (Schulze, 1894; 1904) and the Philippines (Lévi and Lévi, 1989). This new record from the eastern Indian Ocean fills a gap in a previously disjunct species distribution. The newly found representatives are attributed to *Pheronema raphanus* due to the body shape with a shallow atrial cavity and tapering body, and general similarity of the spicules, specifically the shape and size of the pinular pentactins and two types of amphidiscs. There are also a number of differences in the spiculation of the eastern Indian Ocean specimens compared to previous descriptions. These differences are: two types of uncinates, irregular size of the tooth of macramphidiscs with tuberculated shafts, different sizes of umbels in some micramphidiscs, sizes of the pinular spicules and both types of amphidiscs. Pinular pentactins in these specimens of *P. raphanus* have spines situated at the site of the reduced ray.

The reinvestigation of previously described specimens of *P. raphanus* showed that those collected off the Philippines and described by Lévi & Lévi (1989) and those from the East China Sea also have some differences from the type specimens (off Andaman Island) and the specimens from the eastern Indian Ocean (Table 4). The East China Sea specimens have larger dermal and atrial pentactins and larger macramphidiscs. Some of the largest dermal and atrial pentactins have a pinular ray with spines situated approximately two thirds along the ray in the basal part (similar to *P. weberi* Ijima, 1927). The specimens off the Philippines have stout macramphidiscs with a central whorl of tubercles, the specimens from the East China Sea have similar tuberculated macramphidiscs to those in the specimens from off Western Australia. A specimen IORAS 5/2/sp3320 has an additional unique feature with the atrial pentactins notably larger than the dermal ones. It is likely that subspecies status for these geographically and morphologically different specimens of *P. rhaphanus* may be appropriate in future.

Distribution. This species was first recorded from off the Andaman and Nicobar Islands and has also been reported from the Eastern Philippines. This record from the Perth Canyon extends the distribution southward in the Indian Ocean.

Family Monorhaphididae Ijima, 1927

Monorhaphis Schulze, 1904

Monorhaphis chuni Schulze, 1904

Material examined. Australia: Western Australia: WAM Z88465, small fragments, Perth Canyon (31° 57’54”S, 115°06'18''E to 31°56'59''S, 115°07'05''E, Figure 1), 928–1170 m, J. Fromont and C. Whisson, sled, 30/11/2005, RV *Southern Surveyor* station SS1005/073; WAM Z88496, small fragments, Perth Canyon (31° 58'17''S, 115°06'00''E to 31°57'19''S, 115°06'50''E, Figure 1), 848–1050 m, J. Fromont and C. Whisson, sled, 29/11/2005, RV *Southern Surveyor* station SS1005/071.

Description. The material is represented by small fragments of sponge bodies mixed with *Euplectella* and *Hyalonema* fragments.

Remarks. The spicule set is typical for the genus and species (Tabachnick & Lévi, 2000; Tabachnick, 2002a). Rare barrel-shaped amphidiscs found in some representatives of the genus were seen in the slide preparations.

Distribution. Previously reported from the Western Pacific and Western Indian Ocean with northern Zanzibar being the type locality. These records from the Perth Canyon reduce the disjunct distribution between the two oceans, and also extend the distribution further south.

Family Hyalonematidae Gray, 1857

Hyalonema Gray, 1832

Hyalonema sp.

Material examined. Australia: Western Australia: WAM Z35339, 3 fragments, Perth Canyon (31° 57'54''S, 115°06'18''E to 31°56'59''S, 115°07'05''E, Figure 1), 928–1170 m, J. Fromont and C. Whisson, sled, 30/11/2005, RV *Southern Surveyor* station SS1005/073.

Remarks. This material also had fragments contaminated with the spicules of *Monorhaphis chuni* which has been separated and given the registration number WAM Z88465. A few spicule types can be attributed to Hyalonematidae, and to the genus *Hyalonema*. The fragments do not possess specific features to attribute them to any known species.

Distribution. The genus is cosmopolitan and was reported in the eastern Indian Ocean by Tabachnick *et al.* (2008).

Order Sceptrulophora Mehl, 1992

Family Euretidae Zittel, 1877

Euretinae Zittel, 1877

Calyptorete Okada, 1925

Revised generic diagnosis (emended from Reiswig & Wheeler, 2002): The body is cup-shaped and composed of branching and radiating tubes supported on a tubular stalk. The tubes originate from the basal stalk and are arranged radially around a central atrial or pseudoatrial cavity. They have lateral oscula opening on the external surfaces of the cup. These oscula are covered by sieve plates from a layer of fused hexactins similar to those in the dermis. The skeletal framework is euretoid, not channelized. Dermalia are hexactins with a rudimentary distal ray, atrialia likely absent. The uncinate complement varies within species, strongyloscopules always present, tyloscopules may be absent, microscleres with discoidal outer ends are discohexasters and sometimes discohexactins.

Calyptorete falkorae Tabachnick & Fromont sp. nov.

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Material examined. Holotype (WAM Z92540). Australia: Western Australia: 1 specimen, Perth Canyon, Site A, (31°54'45.252''S, 115°4'51.270''E, Figure 1), 695 m, A. Hosie, ROV, 10/03/2015, RV *Falkor* station FPC15_D08_S004.

Description. Body, Figure 4. The body is cup-shaped and comprises branching and radiating tubes supported on a basal stalk. The tubes are arranged radially around a central atrial or pseudoatrial cavity. They have lateral oscula opening on the external surfaces of the cup. These oscula are covered by sieve plates. The internal wall of the cup has longitudinal skeletal struts with fine mesh between, identical in size to the external mesh overlying the sieve plates. Overall height is 110 mm, width of the cup 85 mm, height of stalk 40 mm, width of stalk 25 mm. Wall thickness apically at widest point is 10 mm. The texture is rigid and the colour is creamy white.

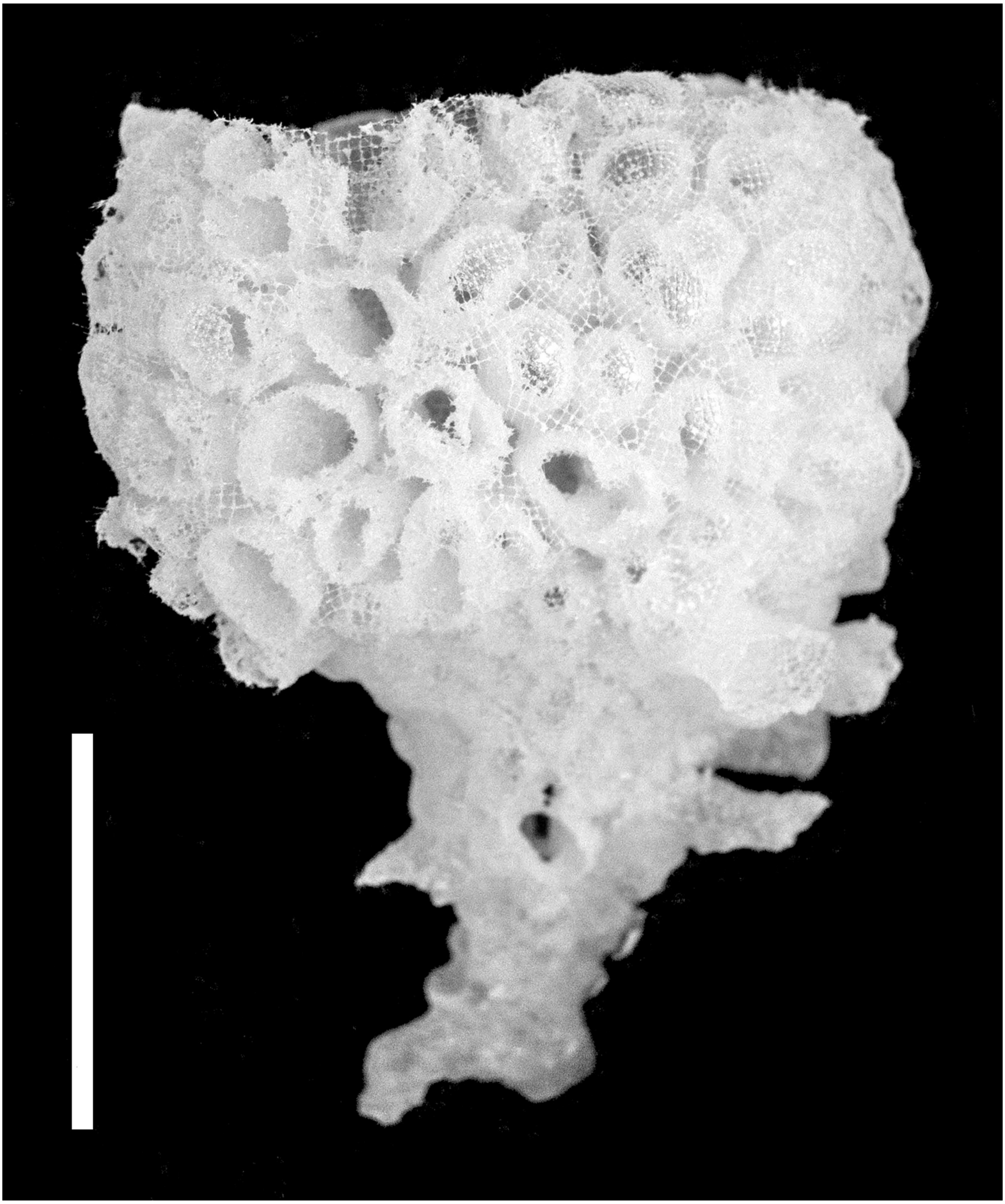

FIGURE 4. *Calyptorete falkorae* **sp. nov.**, holotype, WAM Z92540, external morphology (scale 50 mm).

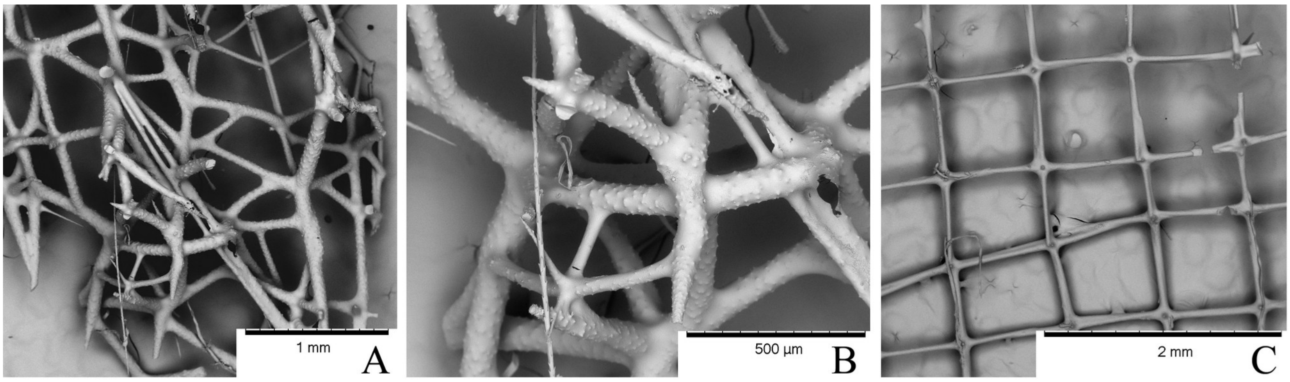

FIGURE 5. *Calyptorete falkorae* **sp. nov.**, holotype, WAM Z92540, SEM images. A, B, euretoid framework of the wall. C, sieve plate constructed from a layer of dermal hexactins.

Framework, Figure 4, 5. The tubes which form the wall of the cup have a typical euretoid skeleton constructed from two layers of framework with rectangular 0.7–0.8 x 0.4–0.5 mm meshes, and some irregular (triangular) constructions common in the euretoid skeleton. The beams are slightly roughened. Dictyonal strands are 0.03–0.06 mm in diameter, the beams between dictyonal layers have the same diameter. The free rays which protrude distally and proximally are 0.3–0.04/0.017–0.023 mm, they have conically pointed or rough and clavate outer ends.

The lateral oscula are rounded, oval or slit-like (some may not have completely divided during the dichotomous branching). They are covered by sieve plates constructed of a layer of dermal hexactins or similar spicules which are connected to adjacent spicules by secondary silica deposition between the tangential rays, and form mostly square meshes 0.08–1.2 mm with beams 0.05–0.08 mm in diameter. The short free ray (distal) is 0.06–0.15/0.03 mm, the proximal ray is 0.5–0.6/0.07 mm.

Spicules. Megascleres, Figure 6. Uncinates of a single type are about 3.6/0.015 mm (Figure 6 J). Discoscopules with short spines over the surface are 0.395–0.730 mm long (n=21, avg: 0.643 mm, std: 0.080 mm), they have 2–5 tines 0.091–0.122 mm long (n=21, avg: 0.106 mm, std: 0.008 mm) (Figure 6 D–E). Some young scopules have a smooth surface, and are 0.426–0.532 mm long (n=2, avg: 0.472 mm, std: 0.075 mm), they have 3–4 tines 0.084–0.091 mm long (n=2, avg: 0.087 mm, std: 0.005 mm) (Figure 6 F). Dermal hexactines have distal ray reduced to short rudiment (Figure 6 A–C). These spicules have a rough surface and rays with conically pointed outer ends. The distal ray of the dermal hexactin is 0.038–0.114 mm long (n=13, avg: 0.071 mm, std: 0.023 mm), tangential rays are 0.517–0.927 mm long (n=24, avg: 0.734 mm, std: 0.117 mm), the proximal ray is 0.258–1.140 mm long (n=10, avg: 0.578 mm, std: 0.274 mm), usually they are shorter than the tangential rays, the diameter of these rays is 0.01–0.05 mm.

Microscleres, Figure 6. Only a few discohexasters and hemidiscohexasters with 1–3 rough or short, spiny, curved secondary rays, were found in the remnants of the dermal membrane(Figure 6 K). They are 0.058–0.096 mm in diameter (n=8, avg: 0.078 mm, std: 0.013 mm), their primary rosette is 0.005–0.013 mm in diameter (n=8, avg: 0.010 mm, std: 0.003 mm).

Remarks. This genus was previously only known from Sagami Bay, off Japan, the locality of the type specimen of *Calyptorete ijimai* Okada, 1925. Until now it was a monospecific genus.

There has been some confusion about the morphology of the genus, and with fresh material this has been reviewed and a revised generic diagnosis provided. The sponge is cup-shaped, "composed from branching and radiating tubes supported on a tubular stalk" and "opened to exterior and to interior" (Reiswig & Wheeler, 2002). One issue was the atrial cavity of the sponge. The true atrial cavity should be considered to be the branching cavity inside the "branching and radiating tubes", while the central cavity inside the cup could have a secondary origin and be regarded as pseudoatrial. In addition, the spicules were described as atrial (gastral) in the original description by Okada (1925) (that is, those situated on the inner atrial surface of the tubes), or dermal from the "pseudoatrial" surface. One problem was the interpretation of the single layer of sieve-like structures found both on the inner (mostly dermal) and pseudoatrial surfaces. If the body shape interpretation of branching tubular construction (Okada,1925; Reiswig & Wheeler, 2002) is followed these structures (which cover the numerous lateral oscula) should be termed sieve plates. If this interpretation is not followed then the branching cavity, which would be considered atrial, should be regarded as a canal. However, this would change the systematic position of the genus to the family Tretodictyidae as such canals should be considered as schizorhyses. This is not followed here. In summary, we provide an amended generic diagnosis due to the new specimen allowing both a revision of the interpretation of the body shape, and to update details on the spicule complement of the genus.

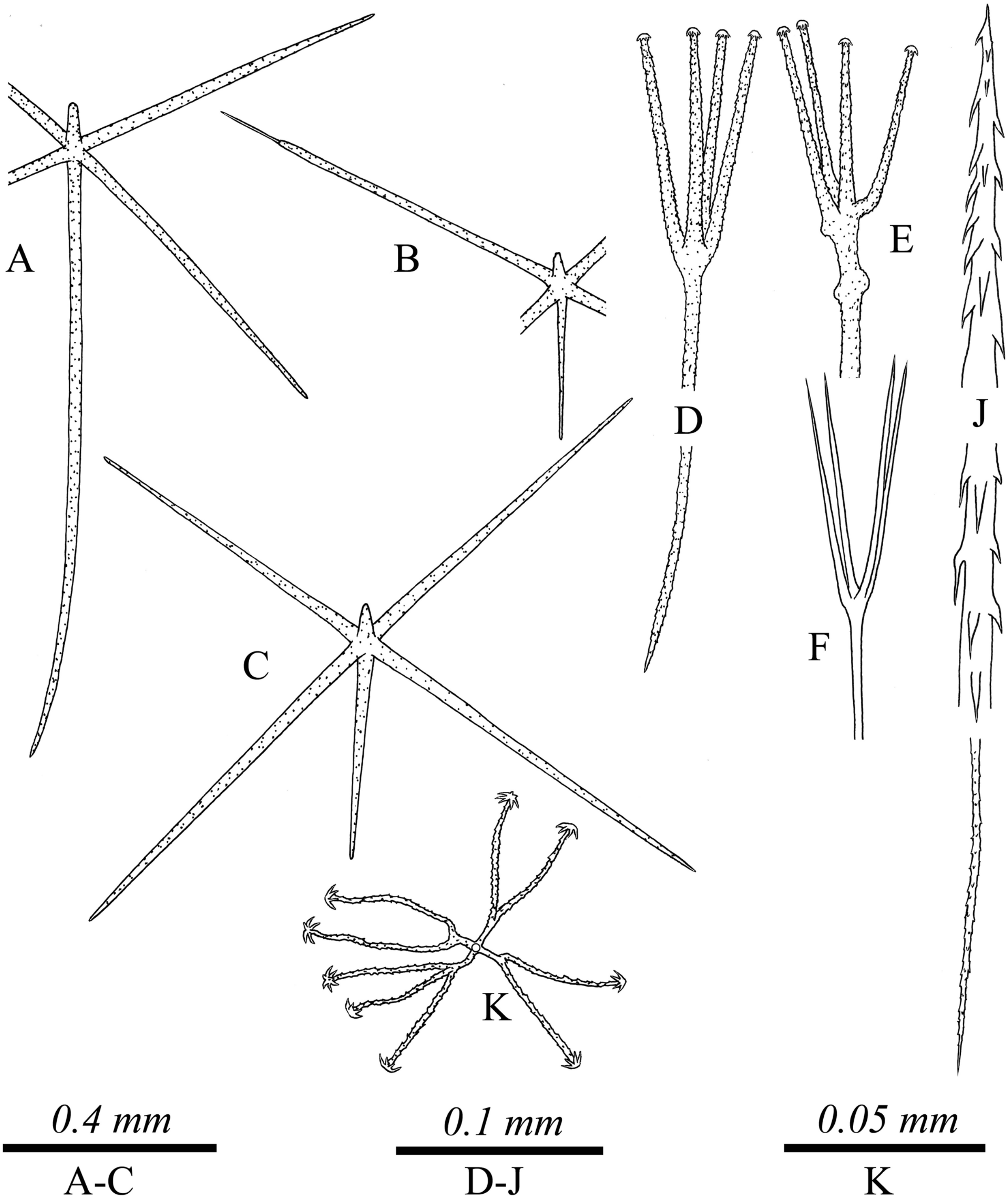

FIGURE 6. Spicules of *Calyptorete falkorae* **sp. nov.,** holotype, WAM Z92540. A–C, dermal hexactins. D–E, strongyloscopules. F, oxyscopule. J, uncinate. K, microdiscohexaster.

The new species is identical in external morphology to *Calyptorete ijimai* but differs in the size of the scopules (the largest scopules in the latter are 0.37 mm in length while in *C. falkorae* sp.nov. they are much larger (0.395–0.730 mm long) and the lack of small uncinates in the new species, with those present being a single size category of 3.6/0.015 mm, while in *C. ijimai* there are four classes. The new species also lacks tyloscopules and discohexactins.

Etymology. The species is named for the RV *Falkor* owned and operated by the Schmidt Ocean Institute in appreciation of providing the ship time and equipment that enabled this specimen to be collected.

Distribution. Currently found only in the Perth Canyon at 695 meters depth.

Family Aphrocallistidae Gray, 1867

Aphrocallistes Gray, 1858

Aphrocallistes beatrix beatrix Gray, 1858

Material examined. Australia: Western Australia: WAM Z92549, Z92553, 2 specimens, Perth Canyon, Site F (31º 42' 2.742''S, 114º51'0.180''E, Figure 1), 691 m, A. Hosie, ROV, 11/03/2015, RV *Falkor* station FPC15_D09_S005; WAM Z92558, 1 specimen, Perth Canyon, Site F (31º 42' 2.202''S, 114º51'0.090''E), 684 m, A. Hosie, ROV, 11/03/2015, RV *Falkor* station FPC15_D09_S007.

Remarks and Distribution. These are specimens (Figure 7) of a widely distributed species in the Indo-West Pacific which has been previously described from the eastern Indian Ocean and off the coastline of Western Australia by Tabachnick et al. (2008).

Family Farreidae Gray, 1872

Farrea Bowerbank, 1862

Farrea ritchieae Tabachnick & Fromont sp. nov.

urn:lsid:zoobank.org:act:8658A1A8-A07F-4D89-A18C-8B70D47B6150

Material examined. Holotype (WAM Z92530). Australia: Western Australia: 1 specimen, Perth Canyon, Site C (32º5'39.450''S, 114º51'53.310''E, Figure 1), 1558 m, A. Hosie, ROV, 08/03/2015, RV *Falkor* station FPC15_D06_S007.

Body, Figure 8. Small stock of branching tubes in two large fragments and two smaller ones. Branches are dichotomous, not anastomosing, flaring at upper ends. Basal plate of sponge not apparent. Overall length 98 and 100 mm (2 large fragments), tube diameter variable 4 to 21 mm apically, wall thickness <1 mm. Texture rigid, softer at apices of branches, surface smooth, colour creamy white. Fine longitudinal lines from reticulate skeleton visible at upper edges of branches, otherwise covered with tissue.

Framework, Figure 8, 9. The wall is constructed of a single layer of farreoid skeleton with rectangular meshes 0.27–0.61x0.52–0.76 mm, with beams from 0.05–0.06 mm in diameter. Rare small hexactins are connected with the dictyonal framework by the distal part of a ray, with rays 0.11/0.5 mm.

Spicules. Megascleres, Figure 10. Rare uncinates are about 1/0.006 mm (Figure 10 B). Dermalia and atrialia are pentactins, their tangential rays have spines directed outside the body, usually the spine situated in front of the ray directed inside the body is largest and may have rare spines, the outer ends of these spicules are rounded (Figure 8 A). The tangential rays of dermal and atrial pentactins are 0.177–0.266 mm long (n= 25, avg: 0.223 mm, std: 0.030 mm), the ray directed inside the body is 0.159–0.342 mm long (n=25, avg: 0.260 mm, std: 0.055 mm), the diameter of these rays is 0.007–0.011 mm. Clavules are pileate forms and are very rare in this species (Figure 10 C–D). Pileate clavules are 0.224–0.342 mm long (n=9, avg: 0.260 mm, std: 0.040 mm), the disc is 0.005–0.015 mm long (n=9, avg: 0.008 mm, std: 0.003 mm) and 0.013–0.032 mm in diameter (n=9, avg: 0.032 mm, std: 0.005 mm).

Microscleres, Figure 10. Microscleres are oxyoidal with 2, rarely 1–3 secondary rays: oxyhexasters and rare oxyhemihexasters (Figure 10 E–F). The oxyhexasters are 0.095–0.134 mm in diameter (n=25, avg: 0.114 mm, std: 0.011 mm), the primary rosette is 0.035–0.067 mm long (n=25, avg: 0.052 mm, std: 0.010 mm).

Remarks. The genus *Farrea* has a large number of species widely distributed in the world's oceans (Reiswig, 2002) with additional species described in more recent publications, for example Reiswig & Kelly (2011). *Farrea* *ritchieae* sp. nov. differs from other species by having a very simple complement of loose spicules consisting of uncinates and dermal and atrial pentactins. It also has a single type of clavule (always pileate), a rare feature among species of this genus. There are only five other *Farrea* species and one subspecies that have pileate clavules as the only clavule type: *F. laminaris* Topsent, 1928, *F. microclavula*, Tabachnick, 1988, *F. anoxyhexastera* Reiswig & Kelly, 2011, *F. ananchorata* Reiswig & Kelly, 2011, *F. aleutiana* Reiswig & Stone, 2013 and *F. occa ouwensi* Ijima, 1927. Although a single type of microsclere is not a rare feature in *Farrea*, oxyoidal outer ends are only reported in a restricted number of species: *F. occa erecta* Ijima, 1927, *F. subclavigera* Ijima, 1927, *F. mammilata* Ijima, 1927, *F. nodulosa* Ijima, 1927, *F. spirifera* Ijima, 1927 and *F. medusiforma* Reiswig & Kelly, 2011. In summary, the simple spicule set, with a single type of clavule and only oxyoidal microscleres found in *F. ritchieae* sp. nov. are unique features which distinguish it from all other described species of *Farrea*.

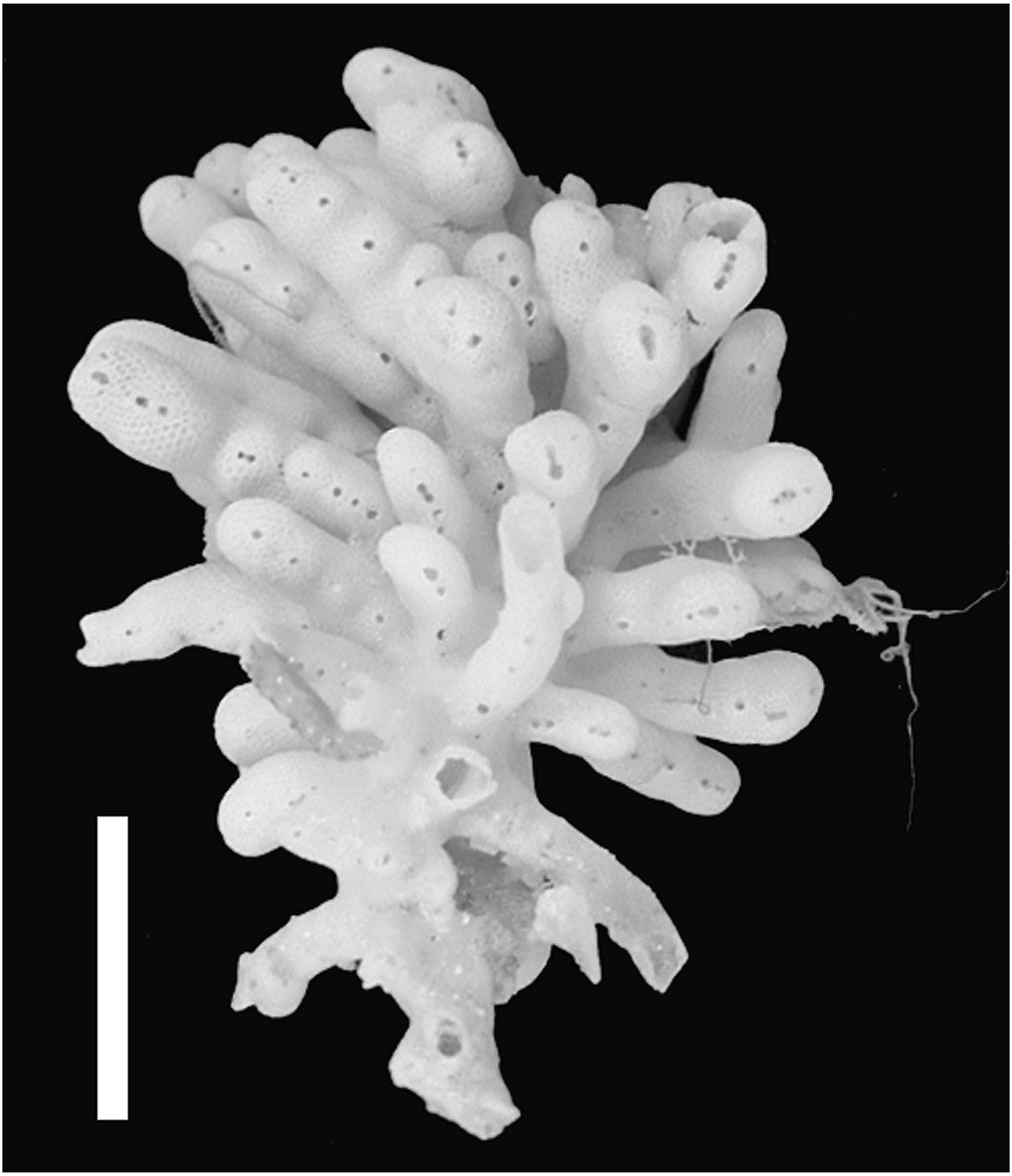

FIGURE 7. *Aphrocallistes beatrix beatrix* WAM Z92553, external morphology (scale 50 mm).

FIGURE 8. *Farrea ritchieae* **sp. nov.**, holotype WAM Z92530, external morphology (scale 60 mm).

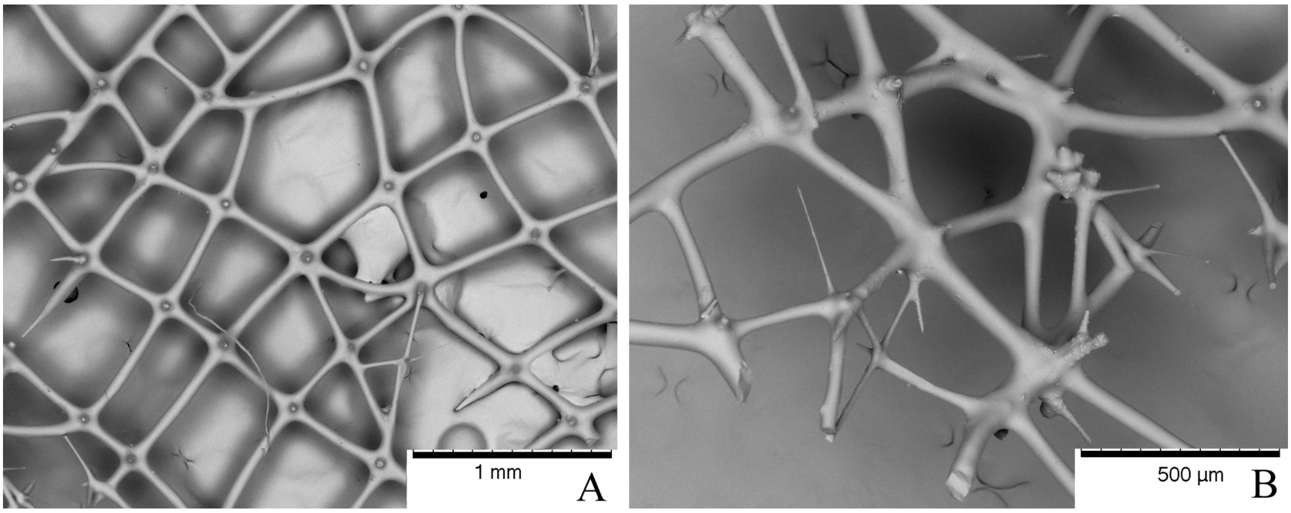

FIGURE 9. *Farrea ritchieae* **sp. nov.,** holotype WAM Z92530, SEM images. A, B, one layer of farreoid skeleton.

Etymology. The species is named for Jenelle Ritchie from the Western Australian Museum, for her diligent work in databasing and organizing the marine invertebrate collections.

Distribution. Currently found only in the Perth Canyon at 1558 meters depth.

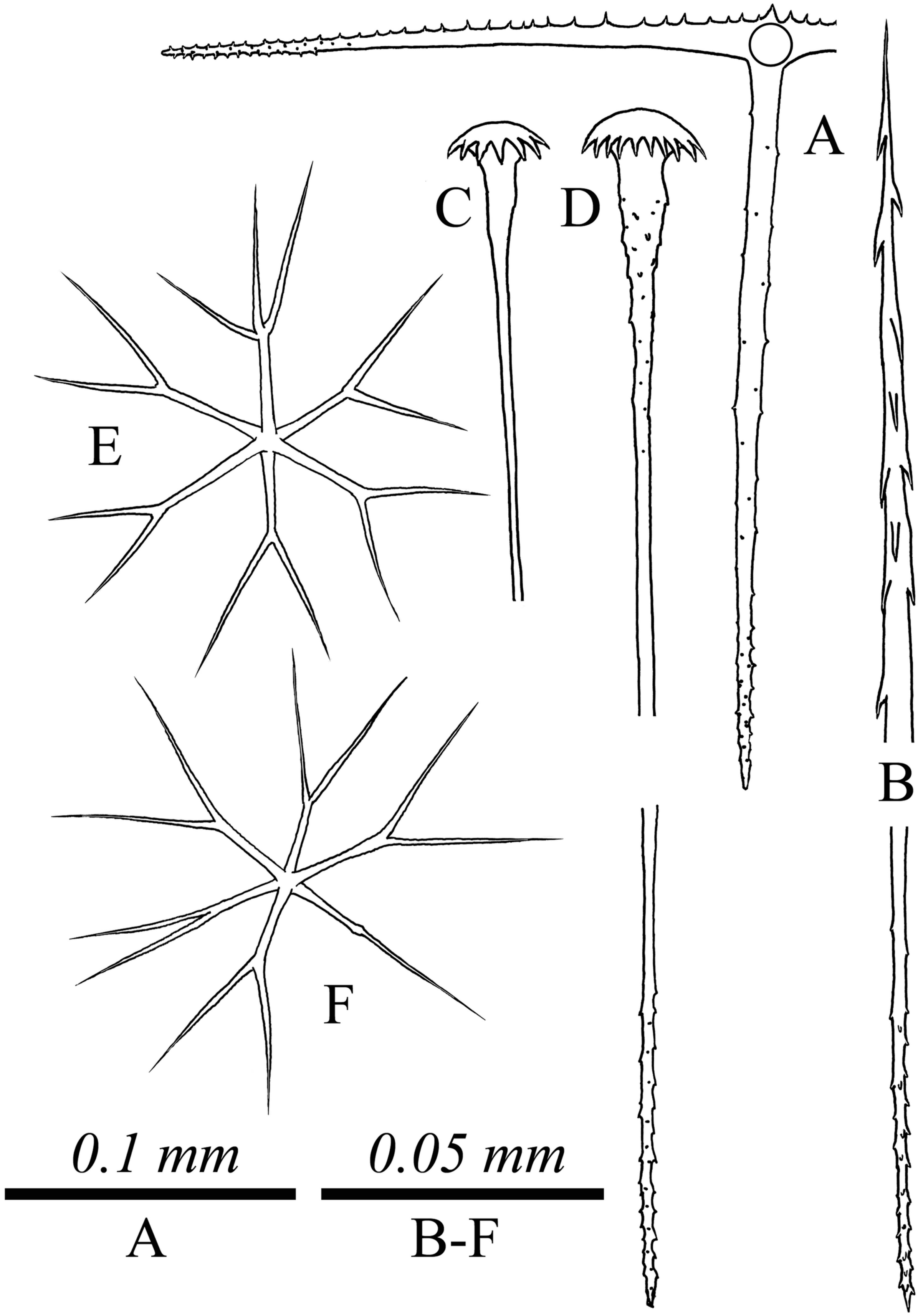

FIGURE 10. Spicules of *Farrea ritchieae* **sp. nov.**, holotype, WAM Z92530. A, dermal pentactin. B, uncinate. C–D, clavules. E, microxyhexaster. F, microxyhemihexaster.

Farrea hieroglyphica **Tabachnick & Fromont sp. nov.**
urn:lsid:zoobank.org:act:7FCB8331-26A8-4852-B8CE-5A3647E171AE

Material examined. Holotype (WAM Z92521). Australia: Western Australia: 1 specimen, Perth Canyon, Site E (31°46'19.884"S, 114°42'21.144"E, Figure 1), 1357 m, A. Hosie, ROV, 07/03/2015, RV *Falkor* station FPC15_D05_S006. Paratype (WAM Z88475). Australia: Western Australia: 1 specimen, Perth Canyon, Site E (31°46'19.884"S, 114°42'21.144"E), 1357 m, A. Hosie, ROV, 07/03/2015, RV *Falkor* station FPC15_D05_S006.

Body, Figure 11. Erect stock of branching tubes with basal plates. Sponge body tapers to basal plate. Two specimens: paratype was attached to a cnidarian fragment. Holotype dimensions: height 60 mm, width at widest point apically 30 mm to base 5 mm, wall thickness 5 mm. Fine reticulate skeleton visible beneath tissue. Texture soft, surface smooth and microhispid, colour creamy white.

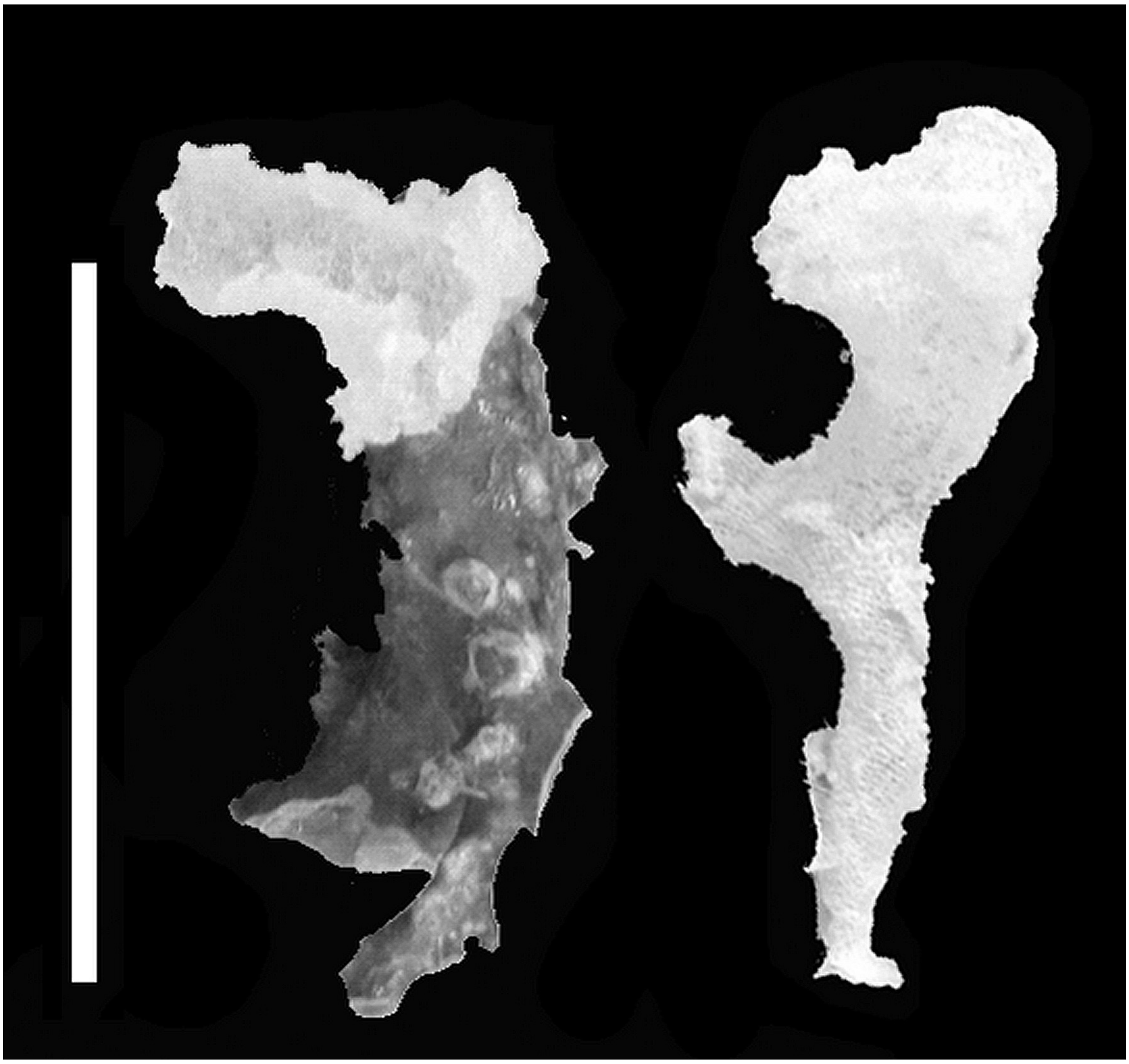

FIGURE 11. *Farrea hieroglyphica,* **sp. nov.**, paratype, WAM Z88475 and holotype, WAM Z92521, external morphology (scale 50 mm).

Framework, Figure 12. The wall is constructed from a single layer of farreoid skeleton with rectangular meshes 0.33–0.40x0.52–0.81 mm, constructed from beams 0.020–0.030 mm in diameter.

Spicules. Megascleres, Figure 13. Uncinates, about 2.1/0.006 mm, are very rare (Figure 13 B). Dermalia and atrialia are pentactins (Figure 13 A) with the tangential ray slightly bent toward the ray directed inside the body. These tangential rays have spines directed outside the body, and small spines distributed in all directions at distal parts of the rays. The ray directed inside the body has spines at the base and in the distal part, close to the outer end, with the outer ends of these spicules being rounded. The tangential rays of dermal and atrial pentactins are 0.153–0.378 mm long (n=25, avg: 0.240 mm, std: 0.053 mm), the ray directed inside the body is 0.142–0.443 mm long (n=25, avg: 0.275 mm, std: 0.087 mm), the diameter of these rays is 0.007–0.012 mm. Clavules are represented by two types: pileate and anchorate (Figure 13 C–I). Pileate clavules are 0.336–0.537 mm long (n=25, avg: 0.443 mm, std: 0.054 mm), the disc is 0.007–0.018 mm long (n=25, avg: 0.015 mm, std: 0.003 mm) and 0.030–0.042 mm in diameter (n=25, avg: 0.036 mm, std: 0.004 mm). Anchorate clavules often have irregular spines along the shaft, similar to the tooth of the anchor. At times the number of teeth on the anchor are so reduced that the entire anchor becomes asymmetrical. Anchorate clavules are 0.266–0.885 mm long (n=25, avg: 0.437 mm, std: 0.126 mm), the anchor is 0.024–0.077 mm long (n=25, avg: 0.045 mm, std: 0.013 mm) and 0.041–0.091 mm in diameter (n=25, avg: 0.061 mm, std: 0.015 mm).

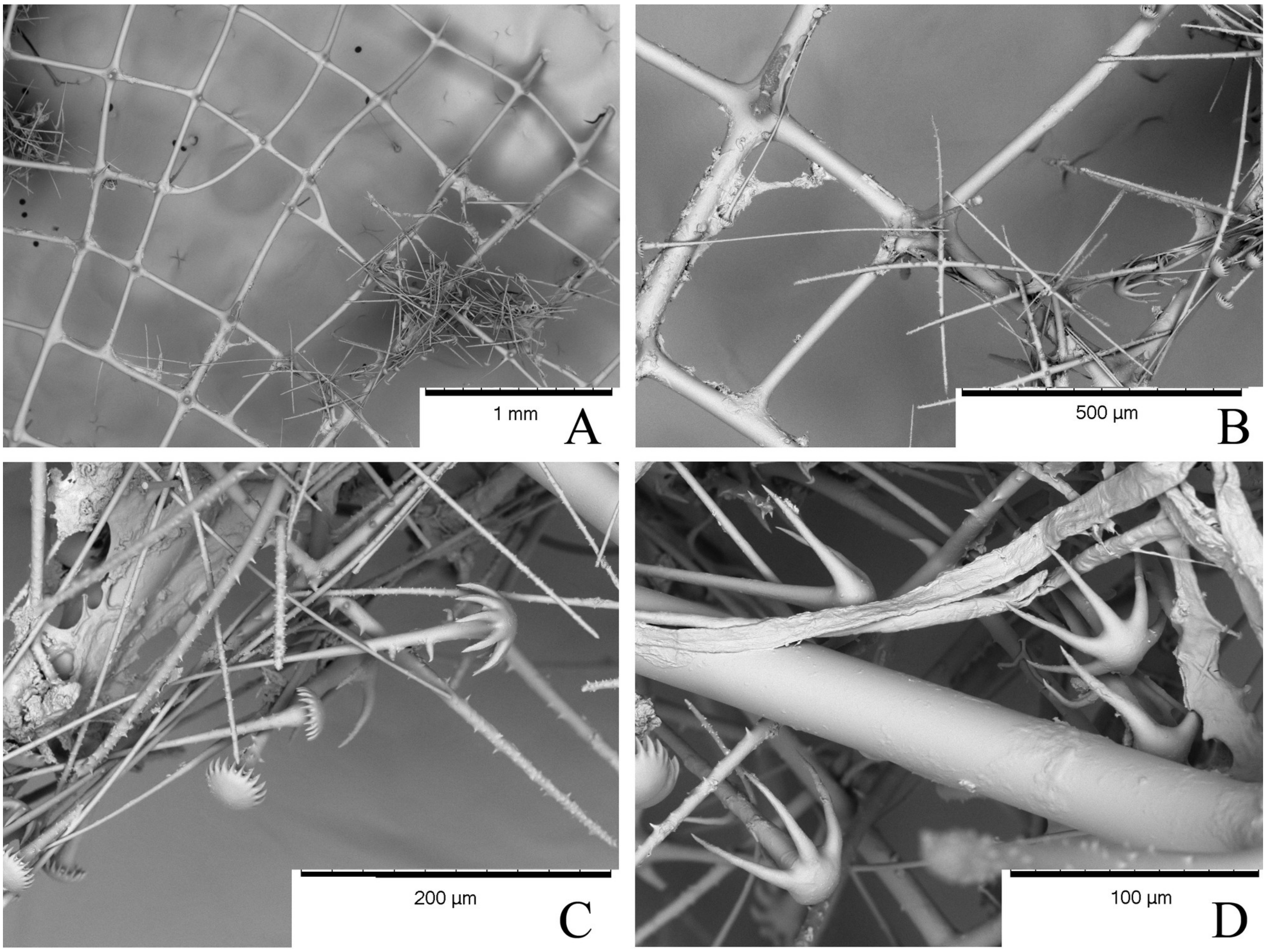

FIGURE 12. *Farrea hieroglyphica,* **sp. nov.**, holotype, WAM Z92521, SEM images. A, B, one layer of farreoid skeleton together with dermal pentactins and clavules. C, loose spicules: pileate and anchorate clavules and rays of dermal pentactins. D, anchorate clavules and some irregular discoidal microscleres.

Microscleres, Figure 13. Microscleres are represented by numerous abnormal hieroglyph-like forms derived from discohexactins and hemidiscohexasters by reduction of the rays. The forms with no secondary rays (descendants from hemidiscohexasters and discohexactins) are very rare. Most common are discoidal stauractins, tauactins and diactins (amphidiscs), sometimes with curved rays (Figure 13 J–W). These discoidal spicules have rays 0.003–0.020 mm long (n=25, avg: 0.012 mm, std: 0.004 mm), the primary ray, when present, is 0.003–0.011 mm long (n=8, avg: 0.007 mm, std: 0.003 mm).

Remarks. The new species has a very specific complement of discoidal microscleres which have a very irregular form (hieroglyph-like), including amphidiscs. These hieroglyph-like spicules are unique for the species. However, the presence of teeth-like spines on the shafts of anchorate clavules is not a specific character as similar spicules have been observed in *F. aculeata* Schulze, 1899, *F. convolvulus* Schulze, 1899, *F. mexicana* Wilson, 1904, *F. beringiana* and *F. beringiana kurilensis* Okada, 1932, *F. lendenfeldi* Ijima, 1927, *F. nodulosa* Ijima, 1927, *F. medusiforma* Reiswig & Kelly, 2011, *F. raoulensis* Reiswig & Kelly, 2011 and rare spines were found on anchorate clavules in *F. nodulosa* Ijima, 1927 and *F. herdendorfi* Duplesis and Reiswig, 2004.

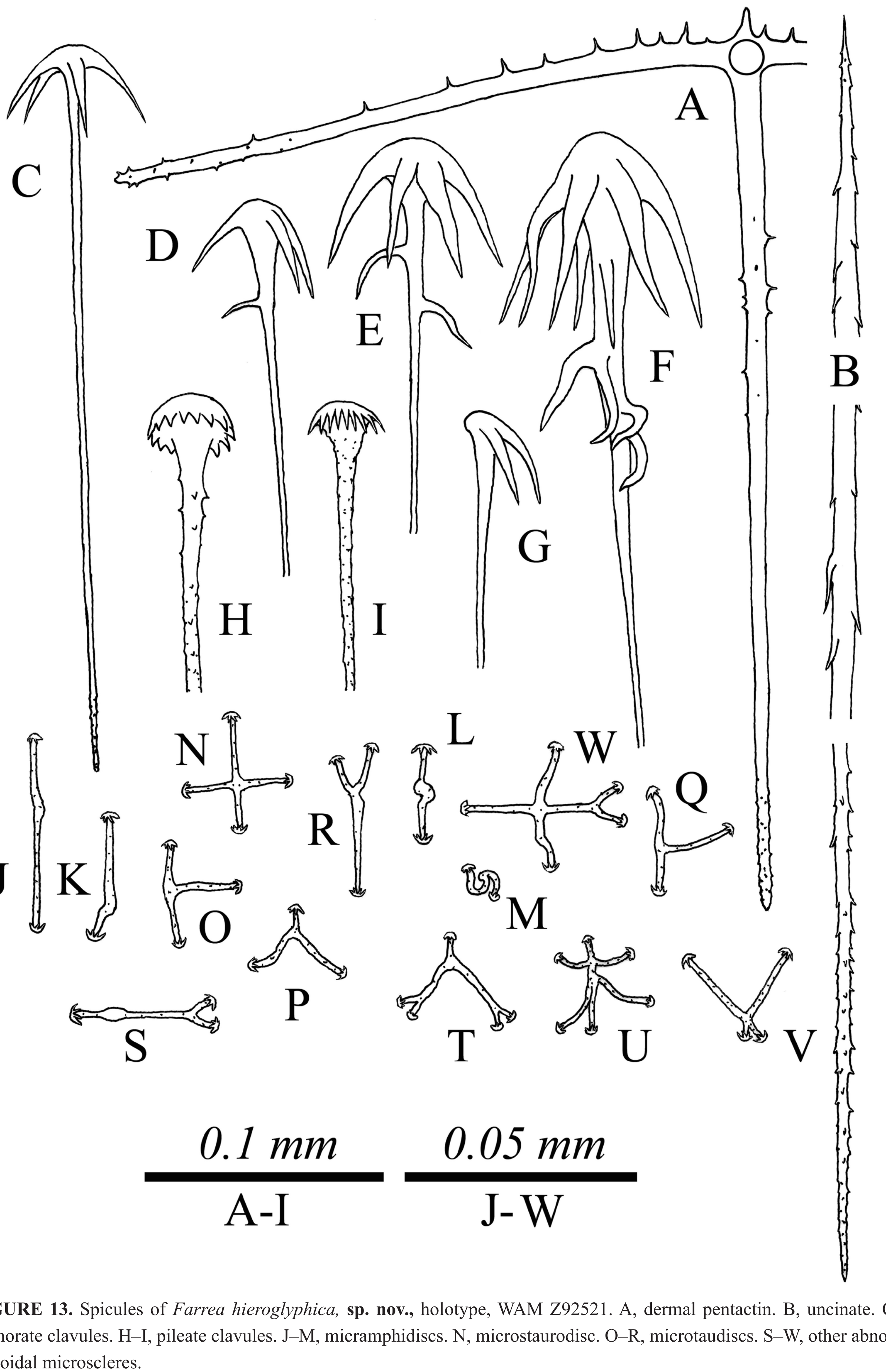

FIGURE 13. Spicules of *Farrea hieroglyphica,* **sp. nov.,** holotype, WAM Z92521. A, dermal pentactin. B, uncinate. C–G, anchorate clavules. H–I, pileate clavules. J–M, micramphidiscs. N, microstaurodisc. O–R, microtaudiscs. S–W, other abnormal discoidal microscleres.

Etymology. The species name refers to the similarity of the discoidal microscleres to oriental hieroglyphs, which are unique to this species.

Distribution. Currently found only in the Perth Canyon at 1357 meters depth.

Order Lyssacinosida Zittel, 1877

Family Euplectellidae Gray, 1867

Euplectellinae Gray, 1867

***Euplectella* Owen, 1841**

***Euplectella* sp.**

Material examined. Australia: Western Australia: WAM Z35338, WAM Z88495, 2 fragments, Perth Canyon (31º 58'17"S, 115º06'00"E to 31º57'19"S, 115º06'50"E, Figure 1), 848–1050 m, J. Fromont and C. Whisson, sled, 29/11/2005, RV *Southern Surveyor* station SS1005/071, .

Body. Specimens are fragments of sponge bodies.

Spicules. Megascleres. Principalia are large stauractins. Common choanosomal spicules are pentactins and hexactins. Some fragments of long spiny spicules are probably basalia. Dermalia are hexactins with rays roughened in distal parts and smooth at the base, conically pointed. The distal ray of the dermal hexactin is 0.089–0.340 mm long (n=20, avg: 0.180 mm, std: 0.071 mm), tangential rays are 0.100–0.266 mm long (n=20, avg: 0.206 mm, std: 0.038 mm), the proximal ray is 0.340–0.666 mm long (n=14, avg: 0.498 mm, std: 0.117 mm), the diameter is 0.011–0.019 mm. Atrialia are pentactins with spiny rays which could not be separated from the choanosomal pentactins.

Microscleres. Microscleres are floricomes, oxyhexasters and rare graphiocomes. The floricomes are 0.133–0.170 mm in diameter (n=25, avg: 0.154 mm, std: 0.009 mm), the primary rosette is 0.015–0.031 mm in diameter (n=25, avg: 0.019 mm, std: 0.004 mm). The oxyhexasters with 2–6 secondary rays are 0.074–0.133 mm in diameter (n=25, avg: 0.090 mm, std: 0.013 mm), the primary rosette is 0.010–0.019 mm in diameter (n=25, avg: 0.013 mm, std: 0.002 mm). Graphiocomes have primary rosettes 0.018–0.023 mm in diameter (n=9, avg: 0.020 mm, std: 0.002 mm) with the secondary rays (rhaphides) largely rare broken fragments.

Remarks. The specimens are fragments potentially of young sponges so it is not possible to identify them to species.

Distribution. The genus is cosmopolitan and has been reported off southern Australia and Indonesia by Ijima (1927), Reiswig (1992), Tabachnick et al. (2008), and New Zealand by Reiswig & Kelly (2018).

Bolosominae Tabachnick, 2002

***Amphidiscella* Tabachnick & Levi, 1997**

***Amphidiscella hosiei* Tabachnick & Fromont sp. nov.**
urn:lsid:zoobank.org:act:9BF862BE-A6BD-469E-8486-75FE9B707EA6

Material examined. Holotype (WAM Z92501). Australia: Western Australia: 1 specimen, Perth Canyon, Site A (31º54'49.620"S, 115º5'1.380"E, Figure 1), 695 m, A. Hosie, ROV, 04/03/2015, RV *Falkor* station FPC15_D02_S001.

Description. Body, Figure 14. The specimen is ovoid, 22 mm long and 10 mm in diameter with osculum 3 mm in diameter, the tubular peduncle about 1 mm in diameter is broken close to the basal part of the body and is represented by a remnant 3 mm long.

Spicules. Megascleres, Figure 15. Choanosomal spicules are diactins, rarely tauactins, paratetractins, stauractins and occasionally pentactins (Figure 15 D–E). The diactins widen or have four rudimentary tubercles centrally and they have conically pointed rough outer ends (Figure 15 F–G). The diactins are 1.5–3.1/0.004–0.011mm. Spicules from the peduncle are loose diactins with rounded rough outer ends. Dermal and atrial spicules are hexactins and pentactins (Figure 15 A–C). The hexactins have a conically pointed, or clavate and rounded, smooth or rough ray directed outside the body, while other rays have the outer ends conically pointed and slightly rough. The ray of dermal and atrial hexactins is directed outside the body and is 0.053–0.178 mm long (n=31, avg: 0.103 mm, std: 0.030 mm), tangential rays are 0.118–0.796 mm long (n=25, avg: 0.373 mm, std: 0.134 mm). The ray directed inside the body is 0.304–0.889 mm long (n=20, avg: 0.743 mm, std: 0.127 mm), the diameter is 0.011–0.019 mm. Dermal and atrial pentactins sometimes have a rudimentary ray instead of the ray directed outside the body, the rays of these pentactins have a shape corresponding to those of hexactins. The tangential rays of dermal and atrial pentactins are 0.167–0.471 mm long (n=20, avg: 0.347 mm, std: 0.090 mm), the rays directed inside the body are 0.418–0.973 mm long (n=6, avg: 0.670 mm, std: 0.218 mm), and the diameter 0.007–0.015 mm.

Microscleres, Figure 15. Microscleres are several discoidal types with anchorate discs: discasters, spherical mesodiscohexasters, spherical microdiscohexasters, amphidiscs (rare staurodiscs) and sigmatocomes with long wavy secondary rays (Figure 15 H–P). The discasters are 0.194–0.281 mm in diameter (n=12, avg: 0.236 mm, std: 0.027 mm), diameter of the central spherical part composed from the primary rays is 0.029–0.054 mm (n=12, avg: 0.039 mm, std: 0.007 mm). The mesodiscohexasters are 0.040–0.058 mm in diameter (n=6, avg: 0.050 mm, std: 0.006 mm), the diameter of the primary rosette is 0.011–0.013 mm (n=6, avg: 0.011 mm, std: 0.001 mm). The microdiscohexasters are 0.029–0.034 mm in diameter (n=2, avg: 0.032 mm, std: 0.004 mm), the diameter of the primary rosette is 0.007–0.011 mm (n=2, avg: 0.009 mm, std: 0.003 mm). The amphidiscs always have two short remnant rays in the middle of the primary ray shaft. The amphidiscs are 0.013–0.022 mm long (n=25, avg: 0.017 mm, std: 0.002 mm), the umbel length is 0.002–0.006 mm long (n=25, avg: 0.004 mm, std: 0.001 mm), the umbel diameter 0.003–0.005 mm long (n=25, avg: 0.004 mm, std: 0.001 mm). Rare staurodiscs correspond in size and shape to the umbels of the amphidiscs. The sigmatocomes have secondary rays 0.083–0.110 mm long (n=24, avg: 0.095 mm, std: 0.007 mm), the primary rosette is 0.017–0.022 mm in diameter (n=12, avg: 0.020 mm, std: 0.002 mm). Secondary rays are always broken during spicule preparation and the diameter of the sigmatocomes is extrapolated from fragments about 0.20 mm.

Remarks. A terminology issue has arisen in the literature with the interpretation of the spicule terms sigmatocome and graphiocome. Reiswig and Kelly (2018) used the term 'graphiocome' for spicules that are not true graphiocomes, hence the term has been used incorrectly and is not accepted here. True graphiocomes (for example those in *Euplectella aspergillum*) have numerous secondary rays at each primary one, these secondary rays are very thin and straight and distributed close to each other in compact tufts (unlike pappocomes). In *Amphidiscella monai* Tabachnick and Levi, 1997 the corresponding spicule has a very restricted number of secondary rays that are thick and wavy, an attribute of sigmatocomes as per the original description (Tabachnick and Lévi, 1997). Although the entire shape of these spicules is unknown due to their fragility, they are always observed as having separate primary and secondary rays and it is most likely that the entire spicule is equal to a true sigmatocome or drepanocome (the difference between these two types of microsclere is dubious). Thus graphiocomes are absent in the genus *Amphidiscella* as it was originally described and the transfer of *A. atlantica* Tabachnick & Collins, 2008 to the genus *Vityaziella* (Reiswig and Kelly, 2018) due to the presence or absence of floricomes is not accepted here, and the original genus allocation of the species is formally retained.

The two genera, *Amphidiscella* and *Vityaziella,* are distinguished by the presence or absence of graphiocomes as originally suggested (Tabachnick and Lévi, 1997; Tabachnick, 2002b; Tabachnick and Collins, 2008).

The genus *Amphidiscella* contains six species: *A. caledonica* Tabachnick & Levi, 1997, *A. monai* Tabachnick & Levi, 1997, *A. atlantica* Tabachnick & Collins, 2008, *A. lecus* Reiswig, 2014, *A. abyssalis* Reiswig & Kelly, 2018 and *A. sonnae* Reiswig & Kelly, 2018. There is an additional species off the Falkland Islands not yet fully described (Tabachnick, 2002b). *Amphidiscella hosiei* sp. nov. is most similar to *A. lecus* and the undescribed species off the Falkland Islands. Unlike *A. lecus*, the new species has no floricomes, but does have discasters. The spicule terms used in the description of *A. lecus* (Reiswig, 2014) are reinterpreted here. A spiroxyhexaster is considered to be a sigmatocome, and a codonhexaster is considered to be an anchorate spherical discohexaster. Unlike the undescribed species off the Falkland Islands the new species has several types of discohexasters and choanosomal diactins with conically pointed outer ends (these have clavate outer ends in the Falkland Islands material). Two features of the new species, the presence of dermal and atrial pentactins in addition to hexactins, and loose diactins in the peduncle (diactins in the peduncle of genera of the Bolosominae are fused to each other by numerous synapticular junctions) may be considered a feature of a juvenile, as this specimen is small. In summary, the unique spicule set, lacking floricomes, but with discasters, several types of discohexasters and choanosomal diactins with conically pointed outer ends distinguishes this species from all other species of *Amphidiscella*.

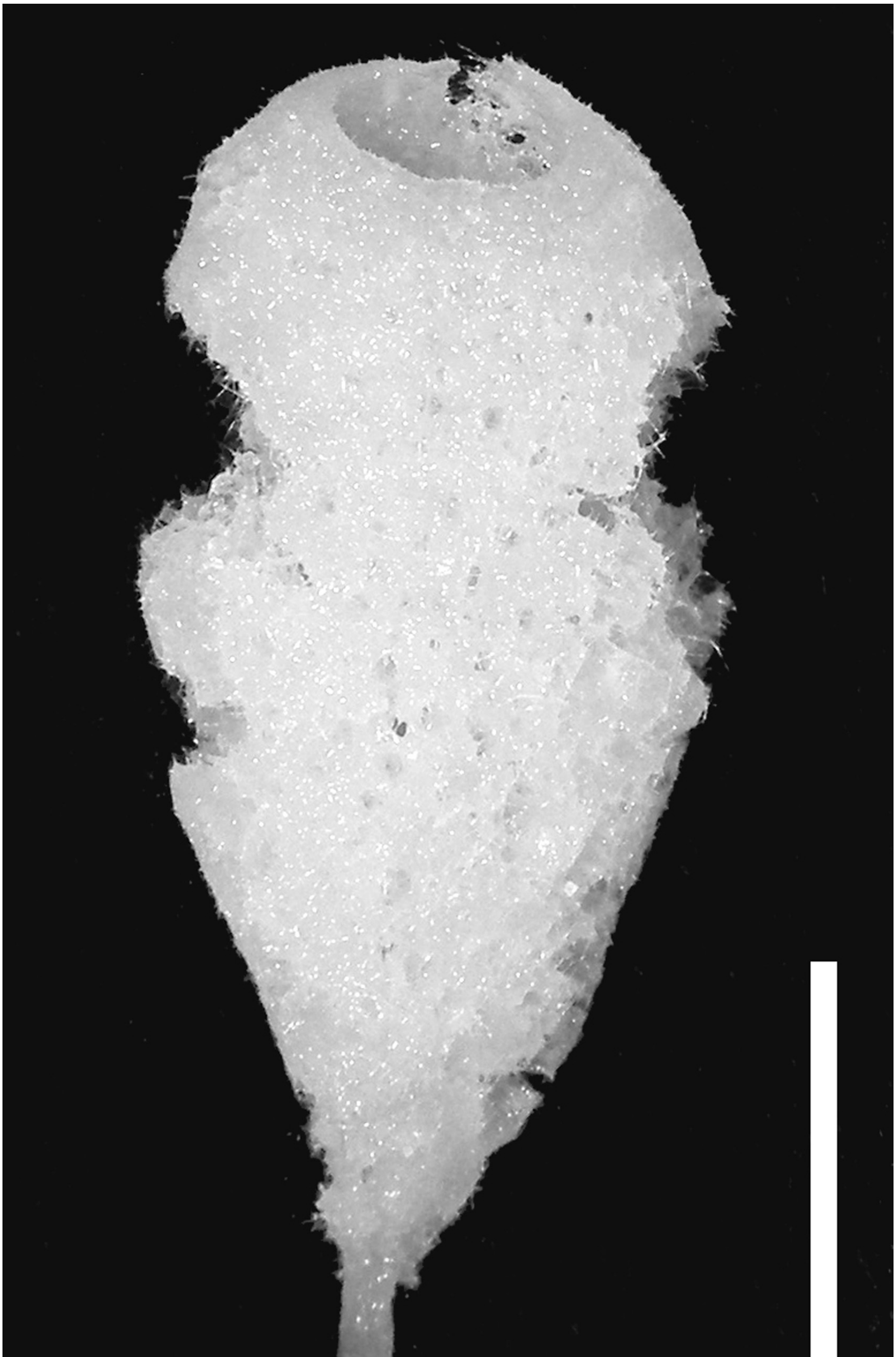

FIGURE 14. *Amphidiscella hosiei* **sp. nov.** holotype, WAM Z92501, external morphology (scale 10 mm).

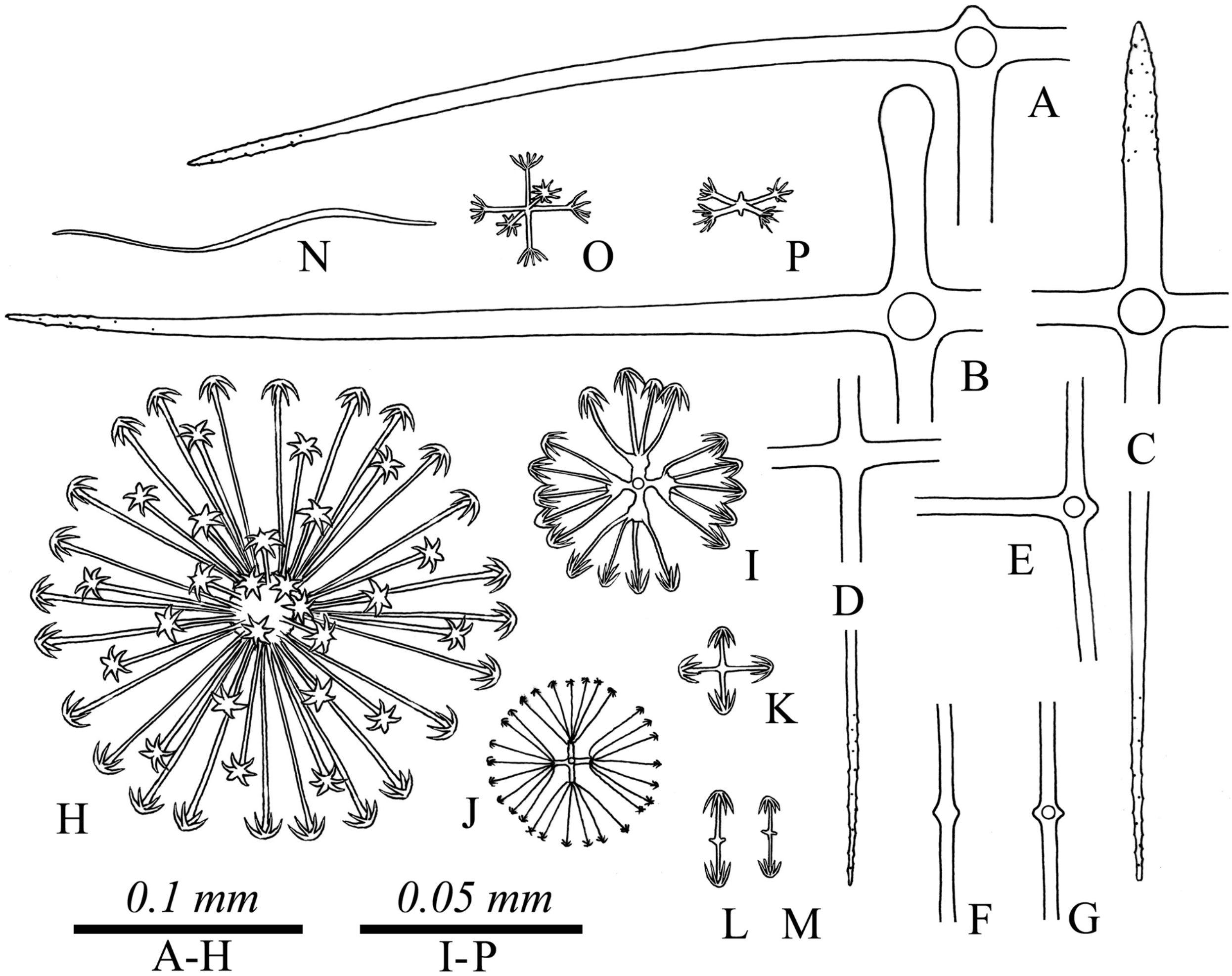

FIGURE 15. *Amphidiscella hosiei* **sp. nov.** holotype, WAM Z92501, spicules. A, dermal pentactin. B–C, dermal hexactins. D, choanosomal stauractin. E, choanosomal tauactin. F–G, choanosomal diactins. H, discaster. I, mesodiscohexaster. J, microdiscohexaster. K, microstauraster. L–M, micramphidiscs. N, secondary ray of sigmatocome. O–P, primary rays of sigmatocomes.

Etymology. The species is named for Andrew Hosie, a Curator at the Western Australian Museum who collected and preserved the glass sponges collected on the RV *Falkor*.

Distribution. Currently found only in the Perth Canyon at 695 meters depth. The genus has six species found in widely disjunct locations: north Atlantic, north east Pacific, the Falkland Islands, New Caledonia and New Zealand. This is the first report of the genus in the Indian Ocean.

Corbitellinae Gray, 1872

***Walteria* Schulze, 1886**

***Walteria flemmingi* Schulze, 1886**

Material examined. Australia: Western Australia: WAM Z92536, 1 specimen, Perth Canyon, Site D (32°9’58.188”S, 114°50’38.754”E, Figure 1), 987 m, A. Hosie, ROV, 09/03/2015, RV *Falkor* station FPC15_D07_S006.

Description. Body, Figure 16, 17. Body is an elongate sac or tube tapering to an attachment point basally and to a terminal oscula apically. Walls are thin and rigid. Overall height 900 mm and diameter 250 mm. Elongate lateral processes extend at right angles from the sponge body. The wall of the sponge is an intricate net-like lattice structure. Texture is rigid and colour is creamy white.

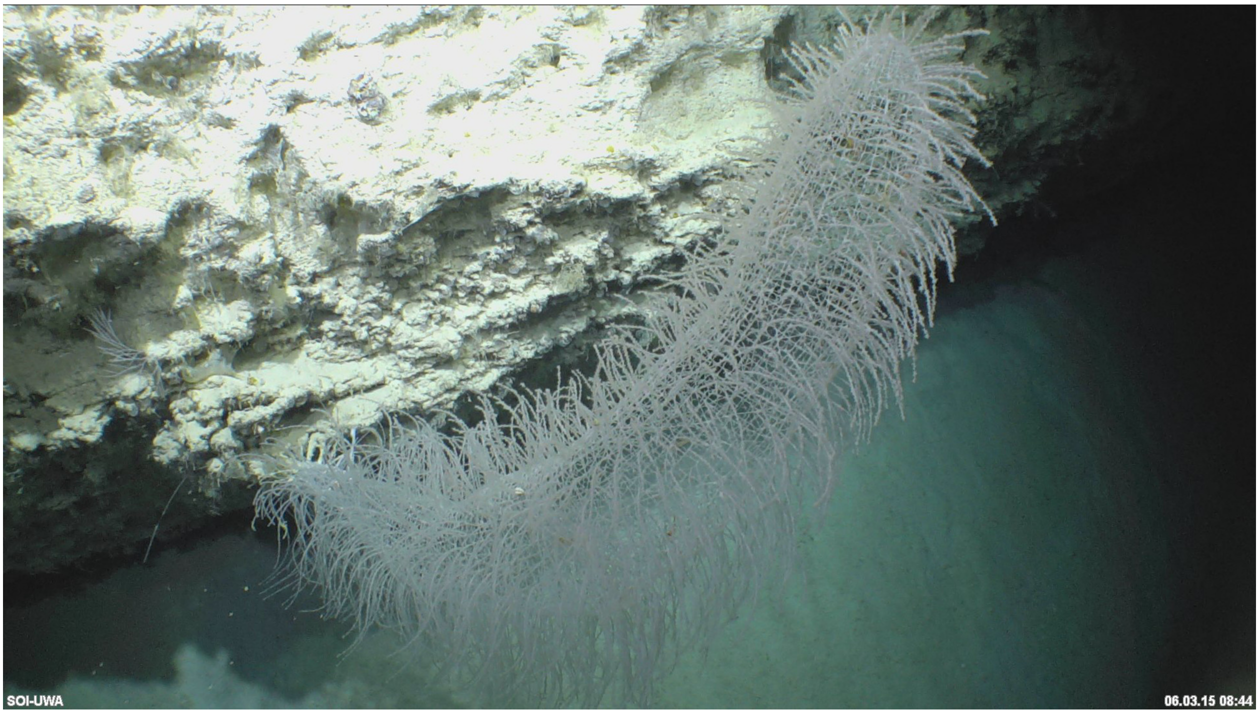

FIGURE 16. *Walteria flemmingi* A, in situ image, Perth Canyon. B, Atrial surface, WAM Z92536.

Spicules. Megascleres. Choanosomal spicules are diactins at least 0.5–15 mm long (some can be longer)/0.007–0.040 mm in diameter and rare tauactins. They have conically pointed rough outer ends. The small choanosomal diactins have a widening in the middle, the large ones have numerous synapticular junctions. Dermalia are hexactins with rough rays, the distal ray is usually clavate, other rays have rounded outer ends. The distal rays of the dermal hexactins are 0.048–0.229 mm long (n=26, avg: 0.138 mm, std: 0.047 mm), the tangential rays are 0.074–0.178 mm long (n=26, avg: 0.122 mm, std: 0.029 mm), the proximal ray is 0.167–0.548 mm long (n=26, avg: 0.322 mm, std: 0.094 mm), the diameter of these rays is 0.007–0.050 mm. Atrialia are most likely represented by minute spots at the intersections of the skeletal beams, seen from the atrial surface (Figure 16b). They are pentactins and stauractins with rounded outer ends and a roughened surface in parts, usually close to the ends. They have tangential rays 0.037–0.189 mm long (n=9, avg: 0.083 mm, std: 0.061 mm) and about 0.010 mm in diameter.

FIGURE 17. *Walteria flemmingi* WAM Z92536, external morphology (scale 50 mm).

Microscleres. Discoidal microscleres are represented by large and small discasters and small discohexasters. The rare large discasters are 0.085–0.104 mm in diameter (n=3, avg: 0.095 mm, std: 0.010 mm), diameter of the central spherical part composed of the primary rays is 0.014–0.022 mm (n=3, avg: 0.018 mm, std: 0.005 mm). Small discasters and discohexasters are 0.058–0.076 mm in diameter (n=27, avg: 0.066 mm, std: 0.005 mm), diameter of the central spherical part composed of the primary rays in the discasters and diameter of the primary rosette is 0.011–0.022 mm (n=27, avg: 0.014 mm, std: 0.003 mm). Diameter of the primary rosette of the graphiocome is 0.022–0.029 mm (n=12, avg: 0.025 mm, std: 0.002 mm), the length of the secondary ray is 0.108–0.185 mm (n=12, avg: 0.152 mm, std: 0.019 mm). Spiny oxyhexactins have rays 0.031-0.149 mm (n=24, avg: 0.087 mm, std: 0.039 mm). Oxyhexasters are 0.068–0.083 mm in diameter (n=11, avg: 0.078 mm, std: 0.005 mm), diameter of the primary rays 0.009–0.016 mm (n=11, avg: 0.012 mm, std: 0.002 mm). Onychohexasters are 0.072–0.079 mm in diameter (n=4, avg: 0.077 mm, std: 0.003 mm), diameter of the primary rays are 0.009–0.014 mm (n=4, avg: 0.011 mm, std: 0.002 mm). Floricomes are 0.065–0.079 mm in diameter (n=2, avg: 0.072 mm, std: 0.010 mm), diameter of the primary rays are 0.011–0.014 mm (n=2, avg: 0.013 mm, std: 0.003 mm).

Remarks. The newly found specimen from Perth Canyon is the first report of a representative of *Walteria* in the Indian Ocean. This genus can be easily divided into two species mostly by external body shape: *W. flemmingi* has an ovoid or clavate body with irregular, usually not rounded or oval lateral oscula; *W. leuckarti* has a thin and long tubular body with lateral rounded or ovoid oscula. The new specimen belongs to *W. flemmingi*. It contains onychohexasters and floricomes previously described in some specimens from the South Pacific (Tabachnick, 2002b; Reiswig & Kelly, 2018). It also contains oxyhexasters and rare large spherical discohexaster microscleres reported for the specimens off New Zealand (Reiswig & Kelly, 2018). It is very difficult to find the atrial spicules, likely the atrial areas are represented by small spots on the intersections of the main skeletal beams composed of fused and unfused diactins from the atrial surface, which contain few pentactins and stauractins. The observed variations in microsclere content and dimensions do not notably differ from previous descriptions of representatives of this species.

Distribution. This is the first record of the genus *Walteria* in the Indian Ocean. Previously it has been recorded in the Western Pacific from Japan to north east of New Zealand and in South Australia at depths of 370–4732 meters (Tabachnick, 2002b; Reiswig & Kelly 2018; MacIntosh *et al.* 2018).

Rossellidae Schulze, 1885

Rhabdocalyptus Schulze, 1886

Rhabdocalyptus gomezi Tabachnick & Fromont sp. nov.

urn:lsid:zoobank.org:act:753E0CF3-DBEF-4A46-8ACC-8480C0B4B1F5

Material examined. Holotype (WAM Z92506). Australia: Western Australia: 1 specimen, Perth Canyon, Site B (31°58'31.488''S, 115°5'18.204''E, Figure 1), 936 m, A. Hosie, ROV, 06/03/2015, RV *Falkor* station FPC15_D04_S001.

Description. Body, Figure 18. The specimen is ovoid about 20 mm long and 13 mm in diameter with osculum 8 mm in diameter. The specimen is attached to a solitary coral. Prostalia lateralia are diactins which protrude up to about 10 mm from the body and hypodermal pentactins with tangential rays situated close to the dermal surface.

Spicules. Megascleres, Figure 19. Prostalia lateralia are diactins and hypodermal pentactins. The diactins have conically pointed outer ends, and rough or smooth stout shafts 7–10/0.03 mm (Figure 19 G–H). Hypodermal pentactins have paratropal tangential rays usually with spines (rarely smooth) and conically pointed outer ends (Figure 19 A–C). The tangential rays of the hypodermal pentactins are 4.2–5 mm long, the proximal ray is about 4.6 mm long, the diameterof these rays is 0.03–0.04 mm. Choanosomal diactins 0.9–5/0.004–0.015 mm have conically pointed or rounded, roughened outer ends, the shafts are stout or with a central widening (Figure 19 D–F). Dermalia are stauractins and some diactins, sometimes tauactins and stauractins with a rudimentary fifth ray. These spicules have rough rays with conically pointed or rounded outer ends (Figure 19 I–J). The rays of dermal stauractins are 0.104–0.196 mm long (n=25, avg: 0.146 mm, std: 0.021 mm), the diameter is 0.004–0.007 mm. The diactins have a central widening, or two rudimentary tubercles, the rays are 0.152–0.237 mm long (n=23, avg: 0.180 mm, std: 0.024 mm), diameter of the rays is 0.007–0.008 (Figure 19 G–H). Atrialia are hexactins with rough rays and conically pointed outer ends (Figure 19 K). The proximal ray of the atrial hexactins is 0.118–0.170 mm long (n=16, avg: 0.148 mm, std: 0.015 mm), tangential rays are 0.130–0.189 mm long (n=23, avg: 0.161 mm, std: 0.015 mm), the distal ray is 0.241–0.437 mm long (n=23, avg: 0.303 mm, std: 0.047 mm), the diameter of these rays is 0.006–0.007 mm

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FIGURE 18. *Rhabdocalyptus gomezi* **sp. nov.,** holotype, WAM Z92506, external shape (scale 10 mm).

Microscleres, Figure 19. Microscleres are represented by discoctasters, oxyoctasters, oxyhexasters and oxyhemihexasters (Figure 19 L–Q). The discoctasters usually have asymmetrical discs at the ends of the secondary rays making these rays of floricoidal shape. The discoctasters are 0.115–0.155 mm in diameter (n=19, avg: 0.141 mm, std: 0.010 mm), diameter of the primary rosette is 0.022–0.040 mm long (n=19, avg: 0.030 mm, std: 0.005 mm). Oxyoctaster is 0.140 mm in diameter with primary rosette 0.036 mm in diameter. Oxyhexasters and oxyhemihexasters have 1–3 secondary rays, usually slightly curved and rough. They are 0.079–0.115 mm in diameter (n=25, avg: 0.101 mm, std: 0.011 mm), diameter of the primary rosette is 0.005–0.011 mm (n=25, avg: 0.008 mm, std: 0.001 mm).

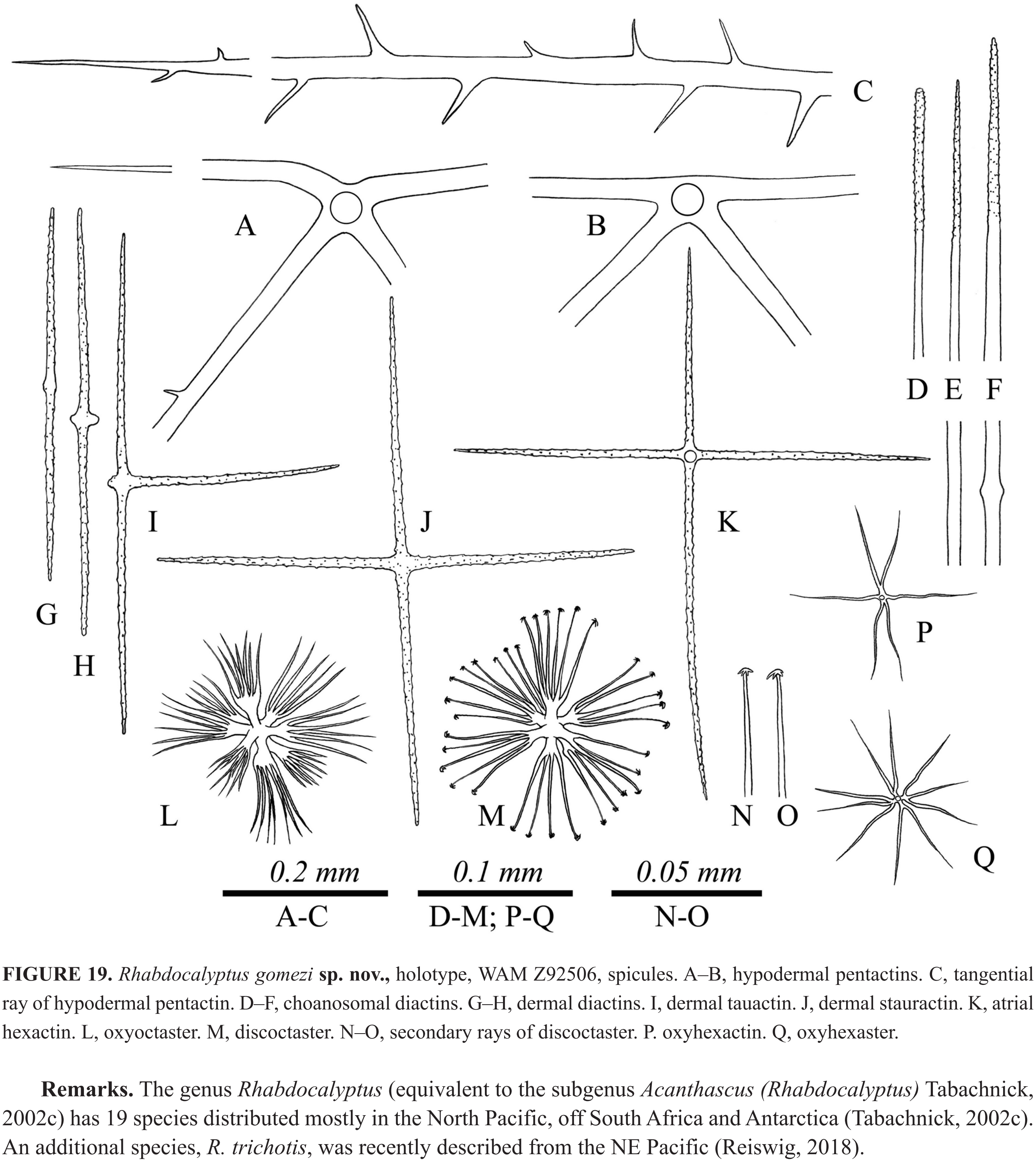

FIGURE 19. *Rhabdocalyptus gomezi* **sp. nov.,** holotype, WAM Z92506, spicules. A–B, hypodermal pentactins. C, tangential ray of hypodermal pentactin. D–F, choanosomal diactins. G–H, dermal diactins. I, dermal tauactin. J, dermal stauractin. K, atrial hexactin. L, oxyoctaster. M, discoctaster. N–O, secondary rays of discoctaster. P. oxyhexactin. Q, oxyhexaster.

Remarks. The genus *Rhabdocalyptus* (equivalent to the subgenus *Acanthascus (Rhabdocalyptus)* Tabachnick, 2002c) has 19 species distributed mostly in the North Pacific, off South Africa and Antarctica (Tabachnick, 2002c). An additional species, *R. trichotis*, was recently described from the NE Pacific (Reiswig, 2018).

The new species is the second representative of the genus in the Indian Ocean with the other species, *Rhabdocalyptus monstraster* Tabachnick, 1994, in the western Indian Ocean off Madagascar and South Africa. Among numerous species only three representatives of this genus have stauractins as the dominant dermal spicule: *R. victor* Ijima, 1897; *R. bidentatus* Okada, 1932 and *R. monstraster* Tabachnick, 1994 (the first two species inhabit the

North Pacific and the latter is from the south west Indian Ocean). Unlike these described species *R. gomezi* sp. nov. has smaller microscleres, specifically the discoctasters, oxyhexactins and oxyhemihexasters, which are from 0.079–0.155 mm. In known species they are: 0.130–0.140 mm in diameter in *R. bidentatus* and 0.060–0.120 mm in *R. monstraster*. The oxyoidal microscleres are similar in size for *R. monstraster* and *R. gomezi* sp. nov. but the former species has notable spines on these spicules which are lacking in the new species. The discoctasters of the new species are similar in shape to those of *R. bidentatus* but they are completely floricoidal (floricoidal secondary rays) in the latter species. Microdiscohexasters are not found in the new species but this is not considered important. Finding these spicules in some representatives of the genus *Rhabdocalyptus* is a very delicate operation which sometimes requires use of notable amounts of sponge for the spicule preparation.

Etymology. The species is named for Oliver Gomez from the Western Australian Museum for his dedication to the sponge and marine invertebrate collections.

Distribution. Currently found only in the Perth Canyon at 936 meters depth. The sub genus has numerous species and it has been recorded from the Indian Ocean previously, off South Africa and Madagascar.

Discussion

This work focused on the glass sponge fauna off the west coast of Australia, eastern Indian Ocean, specifically from the Perth Canyon. It increases the glass sponge fauna known from Australia from 39 to 47 species with five new species described, two new records for Australia, *Pheronema raphanus* and *Monorhaphis chuni*, and one new record for the Indian Ocean, *Walteria flemmingi.* It describes a second species of the genus *Calyptorete*, first recorded over 90 years ago from Sagami Bay off Japan, the locality of the type specimen of *Calyptorete ijimai* Okada, 1925. The high incidence of new species as a result of this study (56%, 5 of 9 identified species) is not unusual. Janussen & Reiswig (2009) noted that many of the hexactinellid species collected during recent deep sea expeditions are new to science.

Much remains to be done on the glass sponge fauna of Australia. Recent expeditions (e.g. Schlacher *et al.* 2007, Fromont *et al.* 2012, MacIntosh *et al.* 2018) have collected specimens from southeastern Australia, Western Australia and the Great Australian Bight in South Australia respectively. Future expeditions (in 2020) are planned in canyons off north-western and south-western Australia. Deeper regions of the vast Australian continental margin remain to be explored. Continuing to identify specimens from existing glass sponge collections and to undertake additional fieldwork will begin to address the gap noted by MacIntosh *et al.* (2018), that deep sea studies on regional and global scales are still too scarce to generalize on the relationships between sampling effort, species distributions and diversity. However, at this time the affinities of the Australian glass sponge fauna are largely Indo-West-Pacific.

A notable difference between the two collections undertaken in the Perth Canyon was the condition of the specimens. The first expedition, the Voyage of Discovery on the RV *Southern Surveyor* in 2005, sampled the shelf edge of the west coast of Australia to document patterns of diversity, the influences of physical environmental covariates on species richness and assemblage structure and to link these to spatial scales (Williams *et al.* 2010). This wide ranging expedition used sleds and trawls as collecting equipment. The second expedition on the RV *Falkor* was a targeted ROV exploration of the Perth Canyon. Consequently, specimens from the second expedition were in excellent condition, while those from the first were more damaged or fragmented. Continuing to use ROVs for collection of specimens from the deep sea will greatly enhance museum collections and exhibitions, and allow for detailed comparison of specimens from different regions, thus determining species distributions and biogeographic ranges.

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Table 1. Species reported from Australia in order of publication date. References provided are where the species was recorded as being in Australia. Abbreviations for states and territories of Australia: NT = Northern Territory, QLD = Queensland, NSW = New South Wales, TAS = Tasmania, VIC = Victoria, SA = South Australia, WA = Western Australia. * = dubious record.

Species	Authority	Publications	NT	QLD	NSW	TAS	VIC	SA	WA
Hyalonema (Cyliconemaoida) acuferum	Schulze, 1893	Schulze (1893)	X						
Hyalonema (Coscinonema) conus	Schulze, 1886	Schulze & Lendenfeld (1902)						X	
Holascus fibulatus	Schulze, 1886	Schulze & Lendenfeld (1902)						X	
Holascus polejaevi	Schulze, 1886	Schulze & Lendenfeld (1902)							X
**Caulophacus (Caulophacus) oviformis*	(Schulze, 1886)	Schulze & Lendenfeld (1902)							X
Caulophacus (Caulophacus) pipetta	(Schulze, 1886)	Schulze & Lendenfeld (1902)							X
Neoaulocystis zitteli sibogae	(Ijima, 1927)	Ijima (1927)	X						
Farrea hanitschi	Ijima, 1927	Ijima (1927)	X						
Pheronema amphorae	Reiswig, 1992	Reiswig (1992)						X	
Farrea occa occa	Bowerbank, 1862	Reiswig (1992); MacIntosh *et al.* 2018						X	
Euplectella aspergillum regalis	Schulze, 1900	Reiswig (1992)						X	
Regadrella okinoseana	Ijima, 1896	Reiswig (1992); Tabachnick *et al.* 2008						X	X
Semperella schultzei	(Semper, 1868)	Tabachnick *et al.* 2008							X
Hyalonema (Hyalonema) proximum	Schulze, 1904	Tabachnick *et al.* 2008							X
Hyalonema (Hyalonema) soelae	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X
Hyalonema (Corynonema) intersubgenerica	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008		X					
Hyalonema (Cyliconema) apertum	Schulze, 1886	Tabachnick *et al.* 2008 as *H. (C). apertum maehrenthali*							X
Hyalonema (Cyliconema) lanceolata	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X

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Species	Authority	Publications	NT	QLD	NSW	TAS	VIC	SA	WA
Hyalonema (Cyliconema) clavapinulata	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X
Hyalonema (Cyliconema) timorense	Ijima, 1927	Tabachnick *et al.* 2008							X
Hyalonema (Cyliconema) keiense	Ijima, 1927	Tabachnick *et al.* 2008							X
Hyalonema (Oonema) microstauractina	Tabachnick & Lévi, 2000	Tabachnick *et al.* 2008		X					
Chalaronema sibogae	Ijima, 1927	Tabachnick *et al.* 2008							X
Lophophysema inflatum	Schulze, 1900	Tabachnick & Lévi 1999; Tabachnick *et al.* 2008							X
Lophophysema australicum	Tabachnick & Lévi, 1999	Tabachnick & Lévi 1999; Tabachnick *et al.* 2008		X					
Farrea occa ouwensi	Ijima, 1927	Tabachnick *et al.* 2008		X					
Farrea occa mammillata	Ijima, 1927	Tabachnick *et al.* 2008							X
Eurete schmidtii schmidtii	Schulze, 1886	Tabachnick *et al.* 2008							X
Pararete semperi	(Schulze, 1886)	Tabachnick *et al.* 2008							X
Aphrocallistes beatrix beatrix	Gray, 1858	Tabachnick *et al.* 2008; Reiswig and Kelly 2011			X				X
Neoaulocystis zittelii	(Marshall & Meyer, 1877)	Tabachnick *et al.* 2008 as *N. zitteli zitteli*							X
Euplectella paratetractina	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X
Euplectella aspergillum australicum	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X
Placopegma plumicomum	Tabachnick & Lévi, 2004	Tabachnick *et al.* 2008		X					
Corbitella cf. *elegans*	(Marshall, 1875)	Tabachnick *et al.* 2008							X
Scyphidium australiense	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X
Sympagella multihexastera	Tabachnick, Janussen & Menschenina, 2008	Tabachnick *et al.* 2008							X

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Species	Authority	Publications	NT	QLD	NSW	TAS	VIC	SA	WA
Anomochone furcata	Reiswig and Kelly 2011	Reiswig and Kelly 2011			X				
Anomochone expansa	Ijima, 1927	Reiswig and Kelly 2011			X				
Farrea raoulensis	Reiswig and Kelly 2011	Reiswig and Kelly 2011			X				
Chonelasma hamatum	Schulze, 1886	Reiswig and Kelly 2011			X				
Psilocalyx wilsoni	Ijima, 1927	Reiswig and Kelly 2011			X				
Euplectella imperialis	Ijima, 1894	Reiswig and Kelly 2018			X			X	
Walteria flemmingi	Schulze, 1886	Reiswig and Kelly 2018; MacIntosh *et al.* 2018						X	
Euplectella plumosum	Tabachnick & Lévi, 2004	Reiswig and Kelly 2018						X	
Total species numbers per state			3	5	7			9	24

Table 2. Species reported from the Australian Antarctic and Subantarctic Territories in order of date of species description, all documented in Hooper & Wiedenmayer (1994) except for the last six species.

Species	Authority
Rossella antarctica	Carter, 1872
Aulocalyx irregularis	Schulze, 1886
Bathydorus spinosus	Schulze, 1886
Rossella racovitzae var. racovitzae	Topsent, 1901
Holascus obesus	Schulze, 1904
Holascus tenuis	Schulze, 1904
Caulophacus (Caulodiscus) valdiviae	Schulze, 1904
Anoxycalyx ijimai	Kirkpatrick, 1907
Rossella vanhoeffeni var. vanhoeffeni	(Schulze & Kirkpatrick, 1910)
Rossella vanhoeffeni var. armata	(Schulze & Kirkpatrick, 1910)
Chonelasma choanoides	Schulze & Kirkpatrick, 1910
Caulophacus (Caulophacus) antarcticus	Schulze & Kirkpatrick, 1910
Hyalonema (Cyliconema) drygalskii	Schulze & Kirkpatrick, 1910
Rossella fibulata	Schulze & Kirkpatrick, 1910
Rossella lychnophora	Schulze & Kirkpatrick, 1910
Rossella mixta	Schulze & Kirkpatrick, 1910
Anoxycalyx (Scolymastra) joubini	(Topsent, 1916)
Rossella villosa	Burton, 1929
Rossella vitiosa	Wiedenmayer in Hooper & Wiedenmayer (1994)
Farrea occa occa	Bowerbank, 1862 (reported in Reiswig & Kelly, 2011)
Farrea medusiforma	Reiswig and Kelly 2011
Aphrocallistes beatrix beatrix	Gray, 1858 (reported in Reiswig & Kelly, 2011)
Aulocalyx australis	Reiswig and Kelly 2011
Homoieurete macquariense	Reiswig and Kelly 2011
Regadrella australis	Reiswig & Kelly, 2018

Table 3. Spicule dimensions of *Pheronema raphanus* (mm): L, l – length, d – diameter.

	WAM Z35337					WAM Z98330					WAM Z98330.2					WAM Z98331					WAM Z98330.3				
	n	min	max	av	sd	n	min	max	av	sd	n	min	max	av	sd	n	min	max	av	sd	n	min	max	av	sd
L dermal pentactin pinular ray	26	0.015	0.081	0.05	0.014	25	0.026	0.111	0.062	0.023	25	0.033	0.07	0.05	0.009	26	0.033	0.056	0.046	0.007	26	0.026	0.096	0.049	0.013
L dermal pentactin tangential ray	26	0.026	0.056	0.042	0.008	25	0.019	0.063	0.042	0.009	25	0.033	0.052	0.045	0.005	26	0.033	0.052	0.044	0.005	26	0.03	0.048	0.038	0.005
L atrial pentactin pinular ray	26	0.03	0.074	0.054	0.013	12	0.056	0.1	0.068	0.015	25	0.03	0.078	0.059	0.011	3	0.074	0.078	0.075	0.002					
L atrial pentactin tangential ray	26	0.037	0.052	0.044	0.004	12	0.033	0.046	0.041	0.005	25	0.03	0.059	0.046	0.008	3	0.044	0.052	0.047	0.004					
L macramphidisc	17	0.148	0.192	0.172	0.016	5	0.07	0.215	0.171	0.063	1	0.144	0.144	0.144		20	0.104	0.215	0.163	0.03	15	0.155	0.215	0.185	0.022
l macramphidisc umbell	17	0.019	0.076	0.037	0.012	5	0.019	0.041	0.031	0.008	1	0.033	0.033	0.033		20	0.022	0.063	0.045	0.011	15	0.026	0.048	0.037	0.006
d macramphidisc umbell	17	0.037	0.078	0.058	0.012	5	0.026	0.048	0.039	0.008	1	0.035	0.035	0.035		20	0.019	0.063	0.044	0.01	15	0.03	0.048	0.037	0.006
L micramphidisc	26	0.018	0.047	0.026	0.007	34	0.016	0.047	0.026	0.007	25	0.02	0.034	0.026	0.004	25	0.013	0.031	0.023	0.004	25	0.016	0.052	0.025	0.008
l micramphidisc umbell	26	0.004	0.018	0.007	0.003	34	0.004	0.014	0.007	0.002	25	0.004	0.013	0.006	0.002	25	0.004	0.009	0.006	0.002	25	0.003	0.013	0.006	0.002
d micramphidisc umbell	26	0.005	0.014	0.007	0.002	34	0.004	0.013	0.007	0.002	25	0.005	0.011	0.007	0.001	25	0.004	0.009	0.006	0.001	25	0.004	0.011	0.006	0.002
L oxyhexactin ray	26	0.025	0.05	0.036	0.007	25	0.029	0.047	0.039	0.006	25	0.029	0.049	0.038	0.006	25	0.024	0.067	0.037	0.009	26	0.018	0.059	0.033	0.009

Table 4. Comparative spicule dimensions of *Pheronema raphanus* specimens from different regions (mm): L, l – length, d – diameter.
* = measurements from Lévi and Lévi (1989).

	P. raphanus		*P. raphanus raphanus*													
	WAM specimens		Schulze, 1894; 1905			BMNH 1896.09.12.002					*MNHN (p1244)					
	W Australia		Central & W Indian Ocean			Andaman Islands					Philippines Islands					
	min	max	min	max	av	n	min	max	av	sd	n	min	max	av	sd
L dermal pentactin pinular ray	0.015	0.111	0.07	0.14	0.08	8	0.056	0.085	0.069	0.011	25	0.037	0.174	0.085	0.04
L dermal pentactin tangential ray	0.019	0.063			0.05	8	0.048	0.063	0.054	0.005	25	0.033	0.085	0.06	0.015
L atrial pentactin pinular ray	0.03	0.1	0.07	0.14	0.08	9	0.048	0.074	0.06	0.01	25	0.041	0.196	0.103	0.041
L atrial pentactin tangential ray	0.03	0.059			0.05	9	0.037	0.063	0.046	0.008	25	0.044	0.093	0.066	0.013
L macramphidisc	0.07	0.215	0.3	0.35		16	0.2	0.248	0.221	0.014	3	0.207	0.481	0.31	0.149
l macramphidisc umbel	0.019	0.076			0.07	16	0.048	0.078	0.067	0.008	3	0.07	0.111	0.097	0.023
d macramphidisc umbel	0.019	0.078			0.08	16	0.063	0.089	0.077	0.007	3	0.063	0.148	0.115	0.045
L micramphidisc	0.013	0.052	0.03	0.04							2	0.018	0.027	0.023	0.006
l micramphidisc umbel	0.003	0.018			0.08						2	0.004	0.004	0.004	0
d micramphidisc umbel	0.004	0.014			0.08						2	0.005	0.007	0.006	0.001
L oxyhexactin ray	0.018	0.067			0.075	9	0.027	0.072	0.043	0.014	25	0.035	0.07	0.052	0.01