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## New sea cucumber species from the seamounts on the Southwest Indian Ocean Ridge (Echinodermata: Holothuroidea: Aspidochirotida, Elasipodida, Dendrochirotida)

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### Abstract

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Marine research program JC066 (JC067) in the southwest Indian Ocean on the RRS *James Cook* in November and December 2011 collected sea cucumbers with an ROV from the *Atlantis* Bank and *Coral* Seamount. Three new species are described: *Amphigymnas staplesi* O'Loughlin sp. nov.; *Pannychia taylorae* O'Loughlin sp. nov.; *Psolus atlantis* O'Loughlin sp. nov. Genera *Amphigymnas* Walsh and *Pannychia* Théel are reviewed. A lectotype for *Pannychia moseleyi* Théel is designated.

### Keywords

JC066, *Atlantis* Bank, *Coral* Seamount, *Amphigymnas*, *Pannychia*, *Psolus*, lectotype

### Introduction

The Natural Environment Research Council marine program JC066 (JC067) in the southwest Indian Ocean, embracing oceanography, biology and fisheries, and geology and geophysics, was conducted from the RRS *James Cook* in November and December 2011. Sampling was undertaken on the seamounts on the Southwest Indian Ocean Ridge: *Coral* Seamount, *Melville* Bank, *Middle of What* Seamount, *Sapmer* Bank and *Atlantis* Bank (fig. 1). Three specimens of sea cucumbers were collected by a submersible remotely operated underwater vehicle (ROV, 'Kiel 6000') and were sent to Museum Victoria for identification. The specimens represent new species of the synallactid genus *Amphigymnas* Walsh, 1891, the elasipodid genus *Pannychia* Théel, 1882, and the psolid genus *Psolus* Oken, 1815. We use Oken, 1815 as author of *Psolus* provisionally as we await the outcome of an application by Paulay and O'Loughlin to the ICZN (case 3598) for validation of Oken, 1815 as author of this genus. The three new species are described in this work, and the type specimens are lodged in the British Museum of Natural History.

### Methods

Scanning electron microscope (SEM) images were taken by Didier VandenSpiegel after clearing the ossicles of associated soft tissue in commercial bleach, air-drying, mounting on aluminium stubs, and coating with gold. Observations were made using a JEOL JSM-6480LV SEM. Measurements were made with Smile view software.

Photos of specimens were taken in Museum Victoria by Melanie Mackenzie, in collaboration with Mark O'Loughlin, using an SLR Nikon D300S digital camera with a 60 mm Nikkor lens for large specimens, and a Leica DFC500 camera and microscope M205 high-resolution digital camera system with Auto Montage software for small specimens. Photos of live specimens were taken by photographer David Shale and used with permission.

### Abbreviations

ICZN The International Commission on Zoological Nomenclature, or the International Code of Zoological Nomenclature, as appropriate.  
NERC Natural Environment Research Council

- NHMUK British Museum of Natural History (registration number prefix NHMUK).  
 NIWA New Zealand National Institute of Water and Atmospheric Research Ltd (est. 1992).  
 NMV Museum Victoria (registration number prefix F).

Order **Aspidochirotida** Grube, 1840

Family **Synallactidae** Ludwig, 1894

***Amphigymnas*** Walsh, 1891

*Amphigymnas* Walsh, 1891: 199.—Deichmann, 1930: 106–107.

*Diagnosis* (this work). Genus of large synallactid species, up to at least 140 mm long; body wall calcareous, brittle, similar to that of the elasipodid family Deimatidae; mouth ventral, about 20 peltate tentacles; dorsal and lateral body with long conical calcareous papillae, including a ventrolateral series; body flat ventrally, tube feet in ambulacral series or scattered; anus subdorsal posterior; ossicles in body wall large table discs with many perforations, discs variably with or lacking spires comprising 3 or 4 pillars, sometimes cross-bars, pillars lacking distal spines or teeth, spires sometimes reduced to short unconnected pillars.

*Type species.* *Amphigymnas multipes* Walsh, 1891, by monotypy (= *Pannychia woodmasoni* Walsh, 1891, by priority according to the synonymy by Koehler and Vaney 1905) (Indian Ocean, Andaman Sea, 344–896 m). *Synallactes reticulatus* Sluiter, 1901 is a junior synonym (according to the synonymy by Koehler and Vaney, 1905).

*Other included species.* *Amphigymnas bahamensis* Deichmann, 1930 (Atlantic Ocean, Bahamas, 480 m); *A. staplesi* O'Loughlin sp. nov. (Southwest Indian Ocean Ridge, Atlantis Bank, 740 m).

*Remarks.* Koehler and Vaney (1905) examined numerous relevant specimens and judged that *A. multipes* Walsh, 1891 and *S. reticulatus* Sluiter, 1901 were junior synonyms of *P. woodmasoni* Walsh, 1891, the senior synonym based on the name sequence priority in Walsh (1891). They referred *P. woodmasoni* to *Synallactes* Ludwig, 1894. Deichmann (1930) examined the holotype of *A. multipes* and considered *Amphigymnas* Walsh, 1891 to be a good monotypic genus with *A. multipes* Walsh, 1891 the type species based on the single type specimen. She did not examine any *P. woodmasoni* specimens and acknowledged that she was not able to judge whether *A. multipes* and *P. woodmasoni* were conspecific. She rejected the referral of the species to *Synallactes* by Koehler and Vaney (1905) and wrote: '*Amphigymnas* is as good a genus as *Synallactes* and *Bathyploetes* with neither the solid rod-like spire of the typical *Synallactes* nor the long spire with the numerous cross beams of *Bathyploetes*. The deposits remind one so much of those found in certain Deimatidae that at first one would be inclined to place it in that group. It is only when one notes the presence of respiratory trees as well as smaller tables with more or less complete spire and the long synallactid-like supporting rods that one realizes that the genus belongs in

the Synallactidae'. She added the species *A. bahamensis* Deichmann, 1930. Solís-Marín and Laguarda-Figueras (2004) listed *Pannychia woodmasoni* Walsh, 1891 (incorrectly as *Synallactes woodmasoni* Koehler and Vaney, 1905) and *Synallactes reticulatus* as junior synonyms of *A. multipes*. We uphold the work of Deichmann (1930) by recognizing the genus *Amphigymnas* Walsh, 1891, and the work of Koehler and Vaney (1905) by confirming *Pannychia woodmasoni* Walsh, 1891 as the type species.

Walsh (1891) diagnosed his genus *Amphigymnas* as: 'Body ovoid with narrow tail-like extremities; soft and appears to have been surrounded by a jelly-like material when fresh. Feet very numerous over the whole of the trivium and placed more or less irregularly. Lateral margins with two or three rows of long processes. Back covered with processes except near the mouth and anus where the body tapers and where the dorsal surface is naked; mouth terminal, small; tentacles 15, very small and retracted; anus terminal, small. Calcareous bodies moderate sized, irregularly rounded, many-holed plates somewhat like those of *Pannychia*. Calcareous ring of 5 small pieces loosely connected.' The type specimen of *A. multipes* was 80 mm long, 22 mm wide midbody, the lateral processes about 15 mm long, shorter processes on the back. Koehler and Vaney (1905) examined the type specimen and judged that it was damaged and incomplete. This may explain why Walsh (1891) could describe the type specimen as being 'soft' and the calcareous ring as comprising 'five small pieces loosely connected', neither of which is true for a synallactid.

Deichmann (1930) diagnosed *Amphigymnas* as: 'Closely related to *Synallactes*, but in its texture resembling a Deimatid. Skin thin, glass-like, filled with large deposits, derived from tables; spires 3–4 pillared with 1–2 cross beams and no teeth on top, often reduced or entirely absent, so the large plates resemble the plates found in the Deimatids; dorsally large, conical papillae, ventrally a lateral row of large and conical pedicels, and a midventral row of smaller ones, filled with numerous supporting rods and a rudimentary endplate'.

The distinctive diagnostic characters of *Amphigymnas* are: long, conical, dorsal calcareous papillae, including a ventrolateral series; flat ventrally with small tube feet in ambulacral series or scattered over ventrum; brittle calcareous outer body wall texture resulting from the presence of many large table discs with variably complete spires. We suspect that the three species assigned to *Amphigymnas* are not congeneric. The dorsal table discs with their central cross, four large central perforations, and four-pillared spires, are similar for *A. multipes* Walsh and *A. staplesi* O'Loughlin sp. nov., but quite different from the table discs with numerous small perforations and predominantly three-pillared spires illustrated for *A. bahamensis* Deichmann. And we judge that species with a distinctly ambulacral series of tube feet would not be congeneric with species that have tube feet scattered over the ventrum.

We note that the first description of *S. reticulatus* was in Sluiter (1902). This paper was published after Sluiter (1901) provided an illustrated description of *S. reticulatus* in the *Siboga* report. Sluiter, 1901 is given here as the date of authorship of the species.

*Amphigymnas staplesi* O'Loughlin sp. nov.

Zoobank LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:5CA0C7C6-BF6F-45E5-BE74-C36222E14F92>

Figures 1, 2, 3, 4

*Material examined.* Holotype. Southwest Indian Ocean Ridge, Atlantis Bank, 32.71°S 57.28°E, 707 m, JC066, event 8–3, parent no. 2605, specimen no. JC066–3666, ROV, 9 Dec 2011, NHMUK 2013.4.

*Description.* Body flat ventrally, domed to subrectangular elevation dorsally, 140 mm long, 30 mm wide midbody; mouth ventral, anus subdorsal posterior; body wall firm, thick, outer wall thin, calcareous, brittle; two paired, spaced single series of dorsolateral, conical papillae (four series across dorsally), each papilla up to about 7 mm long; pair of long dorsal posterior papillae up to about 12 mm long; two single series of larger ventrolateral conical papillae each up to about 15 mm long, about 18 papillae in each series; oral disc with ventral marginal continuous series of conical papillae, tapering in size from

largest anteriorly to smallest posteriorly, total of about 30 papillae around oral disc; posterior to the oral disc a ventral transverse series of small conical papillae, irregular lengths; body with median ventral groove with single zigzag series of small tube feet on each side of groove, tube foot diameters about 0.6 mm, about 70 tube feet per series; irregular paired lateroventral series of larger tube feet, diameters about 0.8 mm, about 45 tube feet per lateral paired series; solid synallactid calcareous ring, lacking free-hanging tentacle ampullae; longitudinal muscles undivided; tuft of long thin gonad tubules with some basal branching, male; single polian vesicle; respiratory tree branches about a half body length.

Dorsal body wall ossicles tables, discs with slightly lobed rounded margin, 160–240  $\mu\text{m}$  across, disc with central cross, 4 large central perforations, up to 17 outer perforations, spires with 4 pillars, 2 cross-bars, pillars tapered to a point, lacking distal spines or teeth, spires up to 80  $\mu\text{m}$  long. Dorsal and lateral papillae with irregular thick tables, discs up to 400  $\mu\text{m}$

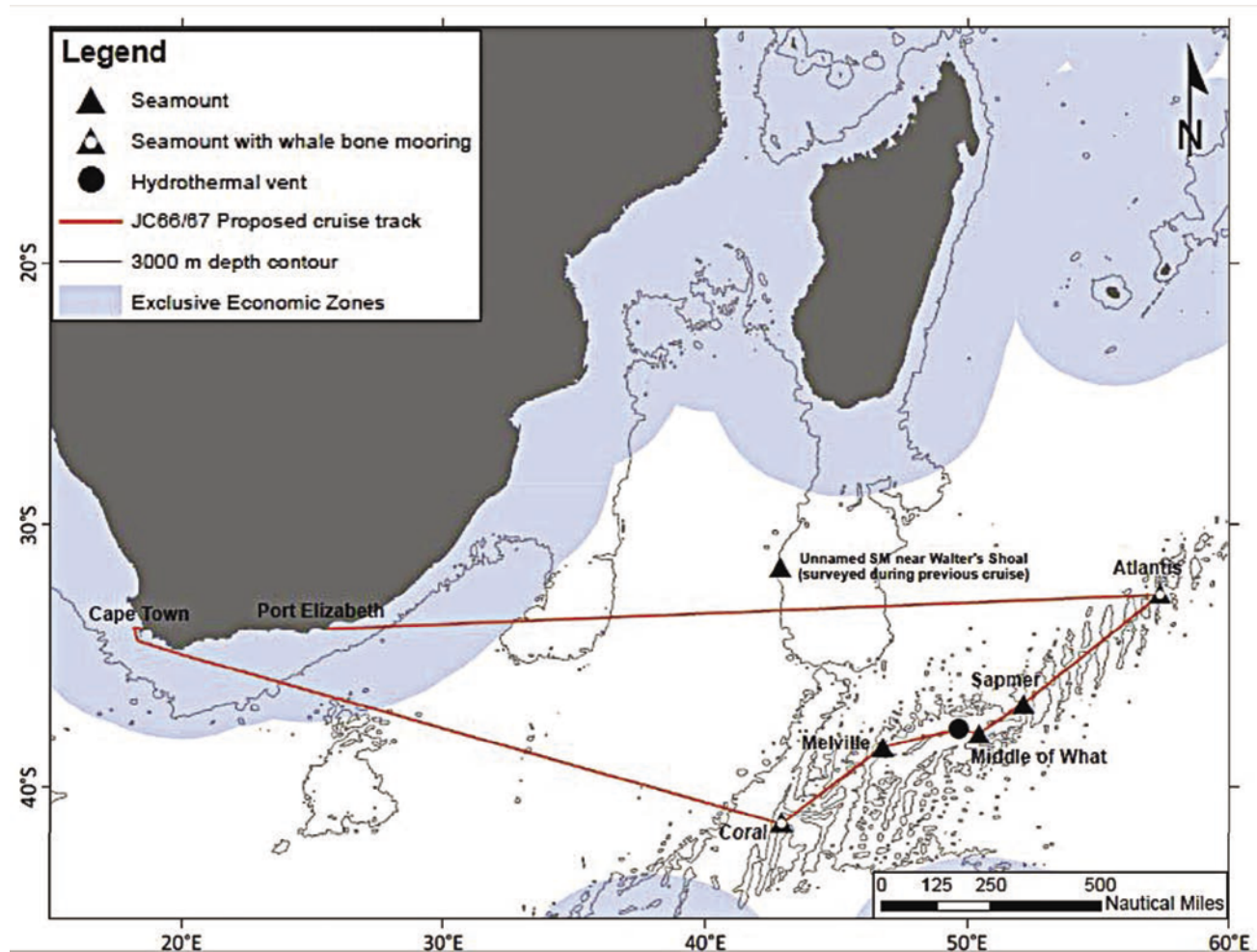


Figure 1. RRS *James Cook* cruise map showing the Southwest Indian Ocean Ridge and the locations of the five seamounts that were visited during NERC JC066. The hydrothermal vent system studied during JC067 is indicated by the filled circle near *Middle of What* seamount. The sea cucumbers described in this study were collected from the *Atlantis* Bank, northeast on the Ridge, and the *Coral* Seamount, southwest on the Ridge.

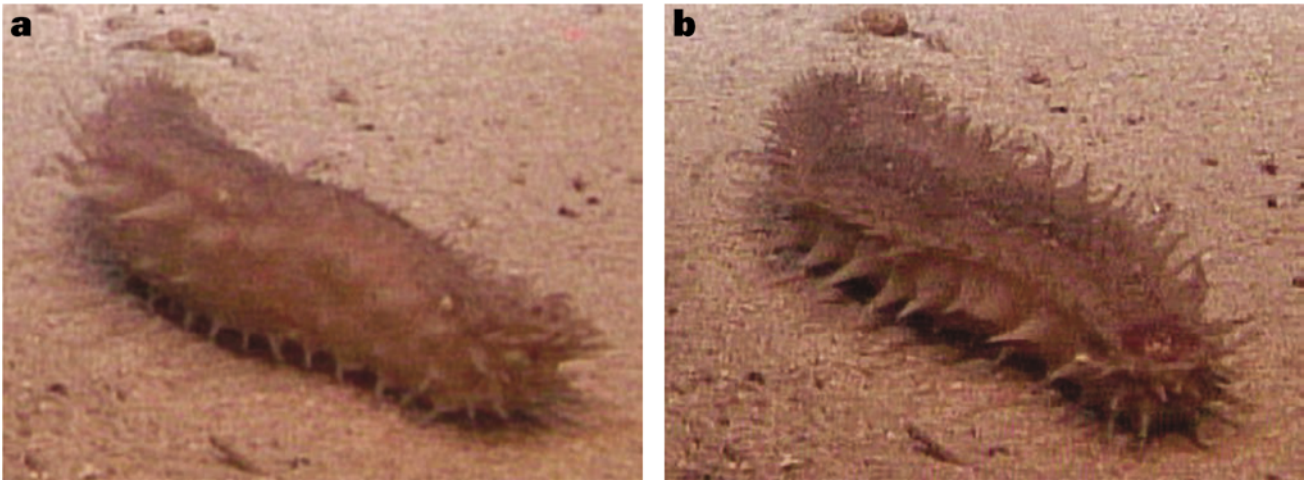


Figure 2. Photos of live holotype specimen of *Amphigygnas staplesi* O'Loughlin sp. nov. (*in situ* on Atlantis Bank; extracted from ROV video footage during cruise JC066; copyright AD Rogers University of Oxford/NERC; specimen NHMUK 2013.4). a, left ventrolateral view of rolling specimen with oral end right and left series of long, conical ventrolateral papillae prominent (up to 15 mm long); b, ventral view of rolling specimen with mouth right, ambulacral series of small tube feet evident, and left ventrolateral series of conical papillae again prominent.

across, many outer perforations, high multiperforate spires, predominantly 4-pillared spires. Ventral body wall with mostly smaller thick 4-pillared tables, spires truncate, pillars lacking cross-bars, discs irregular, typically 160  $\mu\text{m}$  across. Midventral tube feet endplates with very irregular branches creating perforations, diameters up to 520  $\mu\text{m}$ ; tube foot support rods straight to curved, widened midrod, irregular blunt marginal projections, rare perforations midrod and distally, rods up to 480  $\mu\text{m}$  long; tube feet with very irregular tables. Tentacles with slightly curved rods, spinous on outer margin, about 480  $\mu\text{m}$  long.

Colour. Live: body reddish-brown. Preserved: body brown, papillae off-white.

*Distribution.* Southwest Indian Ocean, Atlantis Bank, 740 m.

*Etymology.* Named for David Staples of the Marine Biology Section of Museum Victoria, in appreciation of his contribution during the JC066 voyage and his facilitation of the loan of these specimens to Museum Victoria that has made this work possible.

*Remarks.* We refer our new species to *Amphigygnas* Walsh, 1891 on the bases of: brittle, calcareous outer body wall texture resulting from the presence of many large tables; long, conical, dorsal calcareous papillae, including a ventrolateral series; flat ventrum with small tube feet in ambulacral series. The three species currently assigned to *Amphigygnas* are distinguished by: dorsal tables have rare 3-pillared truncate spires, and ventral tube feet are in median series only (*A. bahamensis* Deichmann, 1930); dorsal tables have rare truncate 4-pillared spires, and ventral tube feet are inconspicuous and scattered (*A. multipes* Walsh, 1891); dorsal tables have predominantly complete 4-pillared spires, and ventral tube feet are in three discrete ambulacral series (*A. staplesi* O'Loughlin sp. nov.).

Order **Elasipodida** Théel, 1882

Family **Laetmogonidae** Ekman, 1926

***Pannychia*** Théel, 1882

*Pannychia* Théel, 1882: 88.—Fisher, 1907: 709.—Mitsukuri, 1912: 207.—Pawson, 1965: 22.—Pawson, 1970: 53.—Hansen, 1975: 72.

*Laetmophasma* Ludwig, 1893: 109.—Ludwig, 1894: 85.

*Diagnosis* (emended from Théel, 1882, and Hansen, 1975). Mouth subventral, lacking circumoral papillae, tentacles about 20, non-retractile; anus dorsoposterior; numerous slender papillae of variable length over the dorsal and lateral body; lateral ventral ambulacra with tube feet in single series, midventral ambulacrum with smaller tube feet; body wall and papillae with numerous wheel ossicles and significantly smaller, slightly concave round to oval plate ossicles; wheels with teeth between larger outer spokes and with fewer small hub spokes, hub covered by a membrane; small plates with about 15 perforations, including 2 large and 2 smaller central ones.

*Type species.* *Pannychia moseleyi* Théel, 1882 (monotypy) (Tasman Sea).

*Synonyms* (by Hansen, 1975): *Laetmophasma fecundum* Ludwig, 1893; *P. moseleyi mollis* Savel'eva, 1933; *P. moseleyi* var. *henrici* Ludwig, 1894; *P. moseleyi vigulifera* Ohshima, 1915; *P. multiradiata* Sluiter, 1901; *P. pallida* Fisher, 1907.

*Other included species.* *Pannychia taylorae* O'Loughlin sp. nov. (below).

*Remarks.* Hansen (1975) judged that specimens of *P. moseleyi* Théel, 1882 showed a wide range of variations and as a consequence synonymized six species and varieties with *P. moseleyi*. In collaboration with Niki Davey (NIWA) we





Figure 3. Photos of holotype of *Amphigymanas staplesi* O'Loughlin sp. nov. (preserved, 140 mm long, NHMUK 2013.4). a, dorsal view of holotype with oral end left; b, ventrolateral view of holotype with oral end left; c, ventral view of oral region showing marginal and post-oral transverse papillae; d, midbody ventral view showing discrete ambulacral series of tube feet.

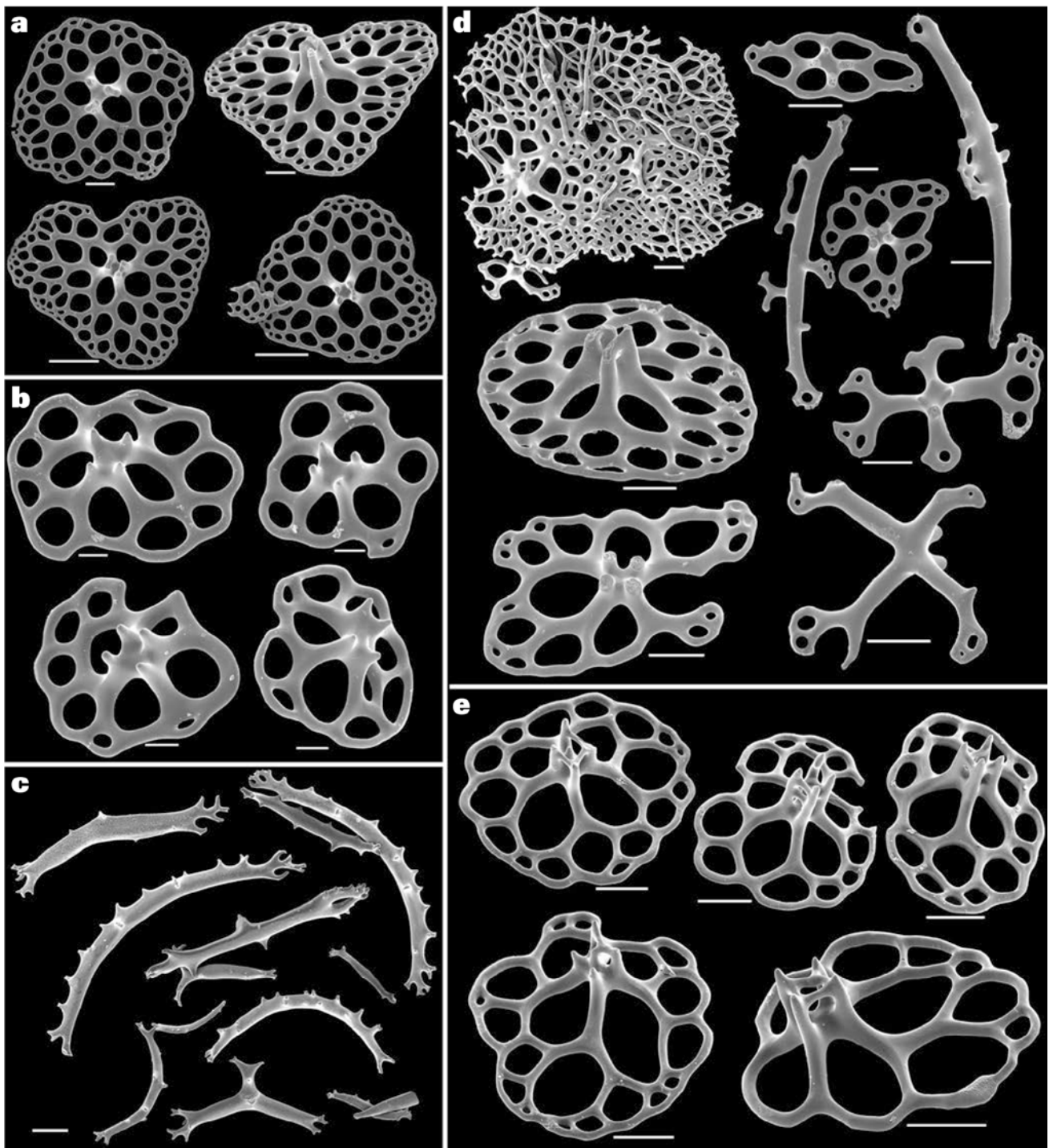


Figure 4. SEM images of ossicles from holotype of *Amphigygnas staplesi* O'Loughlin sp. nov. (NHMUK 2013.4). a, tables from lateral papilla (scale bars 50  $\mu\text{m}$ ); b, tables with truncate spires from ventral body wall (scale bars 20  $\mu\text{m}$ ); c, tentacle rods with outer surface spines (scale bar 50  $\mu\text{m}$ ); d, ventrolateral tube foot endplate (top left, scale bar 100  $\mu\text{m}$ ), tube foot support rods, very irregular and under-developed tables (scale bars 50  $\mu\text{m}$ ); e, tables from dorsal body wall with distal spires lacking teeth (scale bars 50  $\mu\text{m}$ ).

examined numerous specimens from the eastern Australian, New Zealand and Antarctic Admiralty Seamount regions and found some consistent morphological differences that are congruent with molecular phylogenetic data. Some consistent morphological characters for species that we observed are colour, numbers of tube feet, maximum wheel size, and numbers of large outer and small inner spokes in the wheels. Based on morphological and phylogenetic data we distinguish *P. moseleyi* and two additional species of *Pannychia* from these regions (Davey *et al.*, in preparation). We anticipate that molecular data will invite a review of the numerous current synonymies.

Table 1. Morphological characters for the lectotype of *Pannychia moseleyi* Théel, 1882 and holotype of *P. taylorae* O'Loughlin sp. nov.

Morphological characters	<i>P. moseleyi</i> Théel, 1882 lectotype	<i>P. taylorae</i> O'Loughlin sp. nov. holotype
Preserved length	200 mm	180 mm
Residual preserved colour	dark violet dorsally	off-white
Ventrolateral tube feet per lateral series	29–30	19
Midventral tube feet total number	55	23
Maximum wheel diameter	240 $\mu\text{m}$	328 $\mu\text{m}$
Outer spoke number	11–13	9–15
Hub spoke number	4, none 6	5–7, none 4

### *Pannychia moseleyi* Théel, 1882

*Synonymy* (excluding Hansen, 1975, synonyms). *Pannychia moseleyi* Théel, 1882: 88–90, pl. 17 figs 1–2, pl. 32 figs 1–13.—Mitsukurin, 1912: 207–212, fig. 38.—Ohshima, 1915: 235–236, pl. 8 figs a, b.—Djakonov, Baranova and Savel'eva, 1958: 360.—Pawson, 1965: 22.—Pawson, 1970: 53.—Hansen, 1975: 72–75, fig. 26.—Cherbonnier and Féral, 1981: 365–366, fig. 5A–I.

*Lectotype* (designated in this work). Syntype, Australian continental slope off Sydney, 34°8'S 152°0'E, 1739 m, at *Challenger* stn 164, NHMUK (18)83.6.18.52.

*Paralectotype* (designated in this work). Syntype, New Zealand, off East Cape on the North Island of New Zealand, 37°34'S 179°22'E, 1281 m, *Challenger* stn 169, NHMUK (18)83.6.18.53.

*Material examined*. Tasman Sea, off New South Wales, Wanganella Bank, 521–1008 m, NMV F94007, NMV F94008, NMV F98046, NMV F98059, NMV F98695, NMV F98469; S. Norfolk Ridge, 469 m, NMV F98477; off Tasmania. Cascade Seamounts, 600–1000 m, NMV F136931, NMV F136933, NMV F136934, NMV F136935, NMV F136937. New Zealand, Challenger plateau, 526–575 m, NIWA 30721, NIWA 30722, NIWA 30685; Chatham Rise, 532 m, NIWA 30636.

*Description of lectotype* (from Théel, 1882; see table 1). Up to about 200 mm long, 40 mm wide, subcylindrical dorsally and laterally, flat ventrally; mouth anterior, ventral, anus posterior, terminal; 20 tentacles; single series of 29–30 tube feet on each lateroventral ambulacrum, irregular double series of 55 smaller tube feet midventrally; irregular series of up to 100

long to very short dorsolateral and lateral papillae, biggest up to 20 mm long, bare middorsally; calcareous ring rudimentary, fragile, spongy; ossicles large and small wheels; large wheels up to 240  $\mu\text{m}$  diameter, 11–13 outer spokes, 4 inner spokes, lobes/teeth between bases of spokes wide; small wheels 52  $\mu\text{m}$  long.

*Colour*. Preserved: white grey; dark violet dorsally; ends of papillae whitish; ends of tentacles and tube feet yellowish.

*Remarks*. Théel (1882) described his new genus and species *P. moseleyi* for two specimens. Based on the inner spoke numbers noted by Théel (1882), in our experience diagnostically reliable, we judge that the larger syntype from off Sydney that is in fairly good condition (*Challenger* stn 164) is probably not conspecific with the smaller very damaged syntype from off New Zealand (*Challenger* stn 169). We designate the *Challenger* stn 164 syntype as the lectotype (NHMUK (18)83.6.18.52).

### *Pannychia taylorae* O'Loughlin sp. nov.

*Zoobank* LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:77705FFB-3331-44AC-9266-BDD53F760E49>

Figures 1, 5, 6, 7, table 1

*Material examined*. Holotype. Southwest Indian Ocean Ridge, Coral Seamount, 41.38°S 42.85°E, 1286 m, JC066, specimen no. JC066–204, ROV, 13 Nov 2011, NHMUK 2013.5.

*Description*. Body wall thick, soft; body with low elevation, rounded anteriorly and posteriorly, slight brim marginally, body 180 mm long, up to 45 mm wide; numerous dorsal and lateral thin papillae evident in photo of live animal, few remaining on preserved holotype, up to about 15 mm long; mouth subventral, anus dorsoposterior; damaged orally, 16 of 20 tentacles remaining; single series of 19 tube feet on each lateroventral ambulacrum, median ventral ambulacrum with 23 smaller tube feet in paired series posteriorly, more scattered anteriorly.

Ossicles in dorsal and ventral body wall and dorsal papillae abundant wheels and small concave oval to round plates; wheels up to 328  $\mu\text{m}$  diameter, 9–15 outer spokes, rounded triangular teeth between the bases of the spokes, central wheel hub with 5–7 spokes, predominantly 6 never 4, hub covered by a membrane; small plates about 56  $\mu\text{m}$  long, up to about 70  $\mu\text{m}$  long, irregularly oval to round, slightly lobed margin, slightly concave, about 15 perforations, typically 11 marginally with 4 centrally, sometimes 2 larger centrally. Tentacle ossicles rarely branched, curved rods with thick spines on outer surface, rods up to 350  $\mu\text{m}$  long.

*Colour*. Live: body pale blue, tentacle and tube foot ends pale brown. Preserved: body off-white, tentacle and tube feet ends pale brown.

*Distribution*. Southwest Indian Ocean, Coral Seamount, 1286 m.

*Etymology*. Named for Michelle Taylor (Department of Zoology, University of Oxford) in appreciation of Michelle's tireless and efficient work in organizing the biological science team and processing the collections for voyage JC066.





Figure 5. Photos of live holotype specimen of *Pannychia taylorae* O'Loughlin sp. nov. (NHMUK 2013.5). a, photo of live holotype specimen (*in situ* on Coral Seamount; taken by ROV during cruise JC066; copyright AD Rogers University of Oxford/NERC); b, ventral view of live holotype (with two commensal polynoid specimens) (photo taken by David Shale and used with permission).



Figure 6. Photos of holotype of *Pannychia taylorae* O'Loughlin sp. nov. (preserved, 180 mm long, NHMUK 2013.5). Ventral view of holotype with oral end below and midventral tube feet more numerous posteriorly. Insert with ventral view of damaged oral region showing non-retractile tentacles.



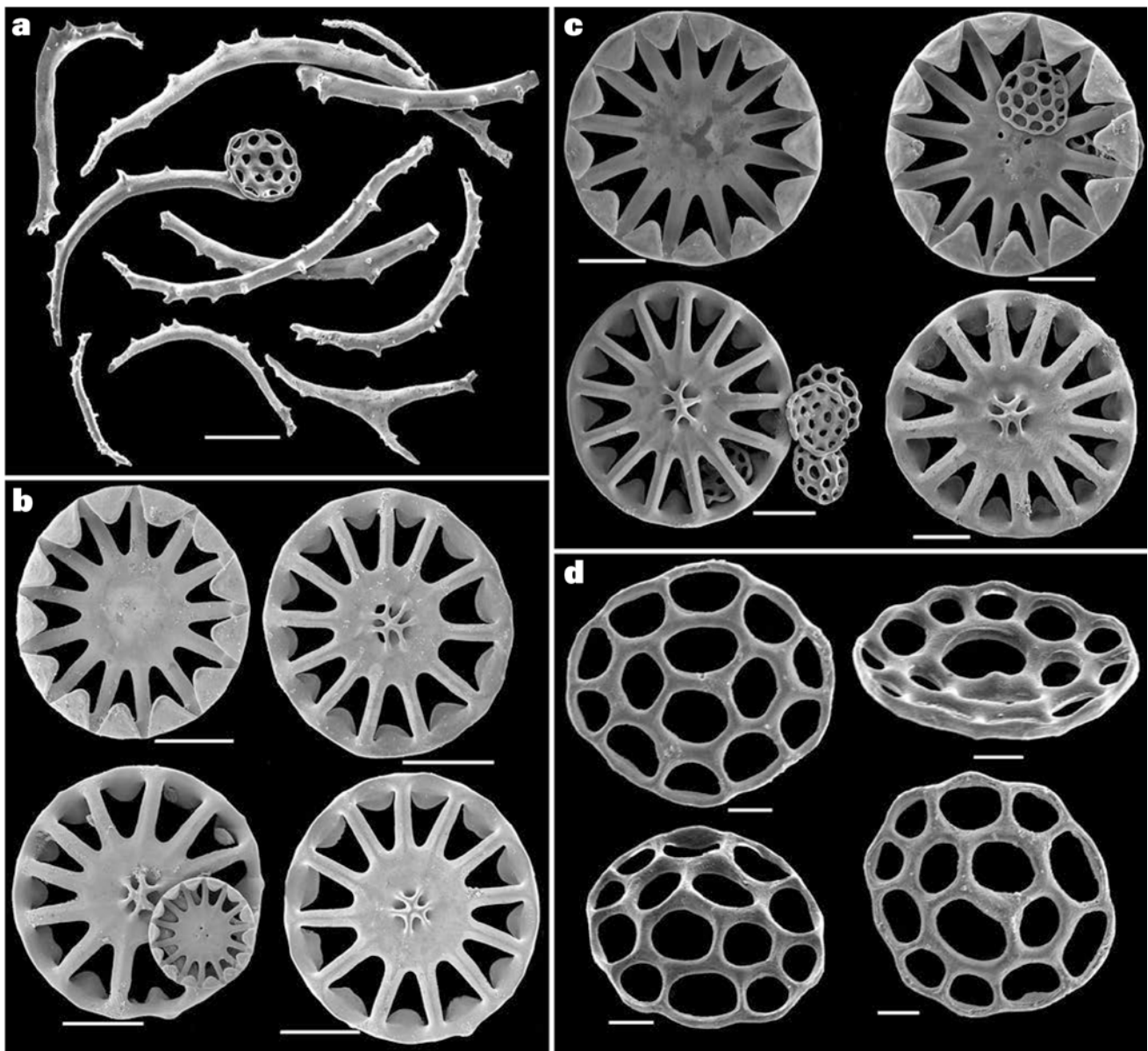


Figure 7. SEM images of ossicles from holotype of *Pannychia taylorae* O'Loughlin sp. nov. (NHMUK 2013.5). a, tentacle rods with outer surface spines (scale bar 50  $\mu\text{m}$ ; small plate ossicle probable contaminant from body wall); b, wheels from dorsal body wall (scale bars 100  $\mu\text{m}$ ); c, wheels and small plates from dorsal papilla (scale bars 50  $\mu\text{m}$ ); d, small concave plates from ventral body wall (scale bars 10  $\mu\text{m}$ ).

**Remarks.** The single type specimen of *P. taylorae* O'Loughlin sp. nov. is closest in its morphological characters to the Antarctic Admiralty Seamount specimens that we have examined, but we judge that they are not conspecific. These specimens represent a species of *Pannychia* that is quite distinct morphologically and genetically from *P. moseleyi* (Davey *et al.*, in preparation). In table 1 we detail the significant morphological diagnostic differences between *P. taylorae* O'Loughlin sp. nov. and *P. moseleyi*.

Order **Dendrochirotida** Grube, 1840

Family **Psolidae** Burmeister, 1837

**Psolus** Oken, 1815

**Diagnosis** (from Mackenzie and Whitfield, 2011). Species of Psolidae with large imbricating or contiguous dorsal and lateral scales; ventrolateral scales at margin clearly demarcated from

thin sole that lacks conspicuous scales; tube feet absent dorsally and laterally, except sometimes present orally and anally; 10 dendritic tentacles, eight large and two small ventrally.

*Remarks.* Oken, 1815 was rejected for systematic validity by ICZN (1956, opinion 417). Paulay and O'Loughlin have submitted an application to ICZN for Oken, 1815 validity as author of *Psolus* (case 3598). We use the authorship here provisionally.

*Psolus atlantis* O'Loughlin sp. nov.

Zoobank LSID. <http://zoobank.org/urn:lsid:zoobank.org:act:DE8353F7-D506-4264-8638-9FF3EA29254A>

Figures 1, 8, 9, 10

*Material examined.* Holotype. Southwest Indian Ocean Ridge, Atlantis Bank, 32.72°S 57.25°E, 1117 m, JC066, event 8–5, parent no. 2547, specimen no. JC066–3686, ROV, 10 Dec 2011, NHMUK 2013.6.

*Description.* Body oval with slight posterior rounded taper, body 28 mm long, up to 17 mm wide, up to 7 mm high at oral cone; dorsal and lateral body covered by imbricating large multilayered scale ossicles of variable sizes, up to 7 mm wide, not perforated for tube feet, lateral marginal scales very small; dorsal and lateral scales sparsely but distinctly granular, granular appearance caused by pyramidal projections on the multilayered scale ossicles, not caused by small surface ossicles; oral cone dorsal with slight pyramidal elevation, 5 triangular interradiol oral valves separated by 5 narrow radial

oral scales, oral cone not discrete with dorsal scales encroaching basally on oral scales; anus dorsal posterior, surrounded by an irregular cluster of small scales.

Distinct thin-walled sole, overhung marginally by small lateral scales; inner marginal, irregular, single to zigzag to double series of tube feet with diameters about 0.6 mm; outer marginal, single series of smaller inconspicuous tube feet with diameters about 0.3 mm; a few tube feet on midventral ambulacrum anteriorly and posteriorly, but lacking midventral series of tube feet.

Ossicles in central sole small, thick, smooth crosses and plates with up to 7 perforations, ossicles up to 200  $\mu\text{m}$  long; inner tube feet endplates with irregular small perforations centrally and irregular larger perforations marginally, margin smooth and not denticulate, endplate diameters up to about 400  $\mu\text{m}$ ; tube foot support ossicles irregular curved plates with more perforations than the ossicles in the sole, up to about 20, lengths up to about 200  $\mu\text{m}$  long.

Colour. Live: red dorsally. Preserved: white.

*Distribution.* Southwest Indian Ocean, Atlantis Bank, 1117 m.

*Etymology.* Named, in apposition, for the Atlantis Bank on the Southwest Indian Ocean Ridge from which this specimen was collected.

*Remarks.* The morphological characters that distinguish, in combination, *P. atlantis* O'Loughlin sp. nov. from all other *Psolus* Oken, 1815 species are: five discrete triangular oral

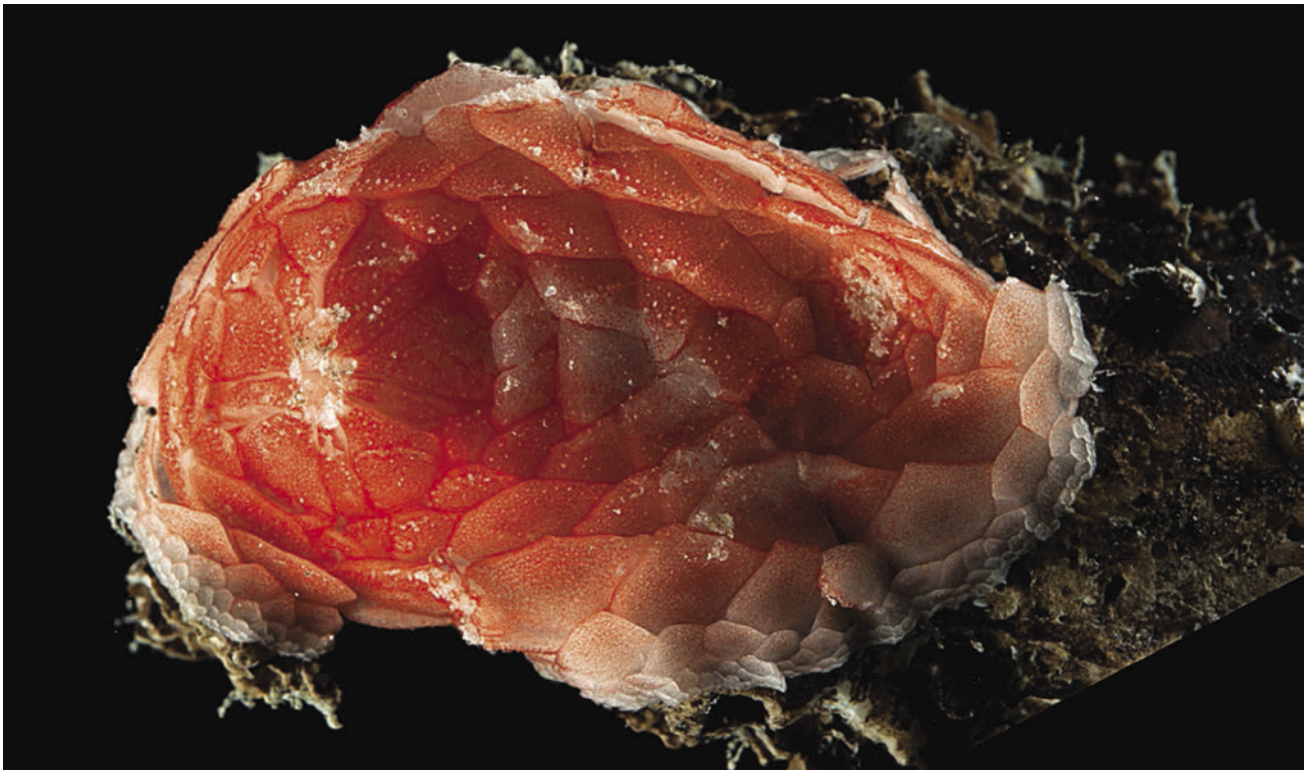


Figure 8. Photo of dorsal view of live holotype specimen of *Psolus atlantis* O'Loughlin sp. nov., attached to a rock fragment from Atlantis Bank collected during cruise JC066 (oral end left; specimen NHMUK 2013.6; photo taken by David Shale and used with permission).



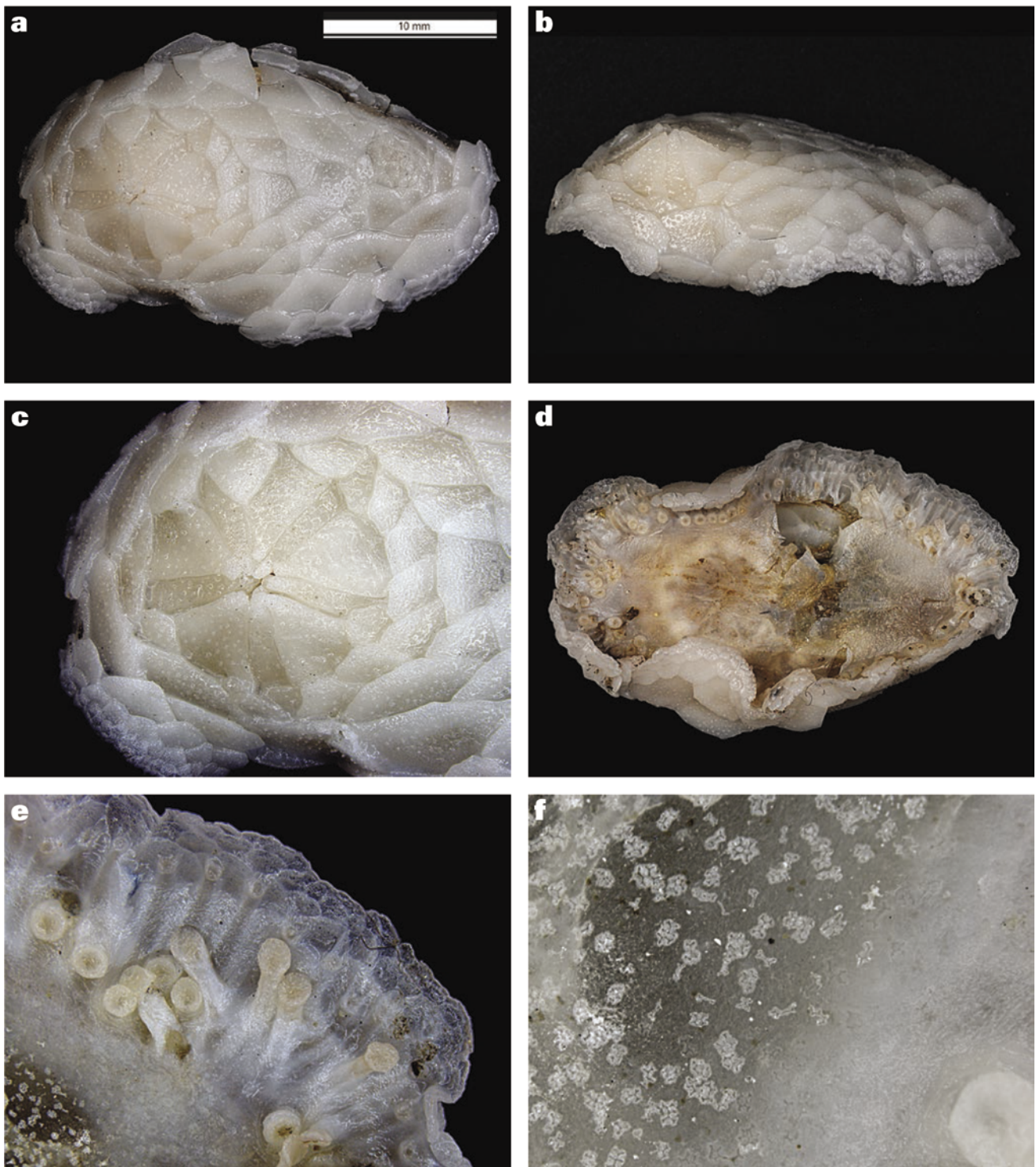


Figure 9. Photos of holotype of *Psolus atlantis* O'Loughlin sp. nov. (preserved, 28 mm long, NHMUK 2013.6). a, dorsal view of holotype with oral valves left; b, dorsolateral view of holotype showing elevated oral valves; c, view of five triangular interradial oral valves and five narrow radial oral valves; d, ventral view of sole; e, ventral view of margin of sole showing inner series of large tube feet and outer series of small inconspicuous tube feet; f, view of sole showing scattered, small perforated plate and cross ossicles.



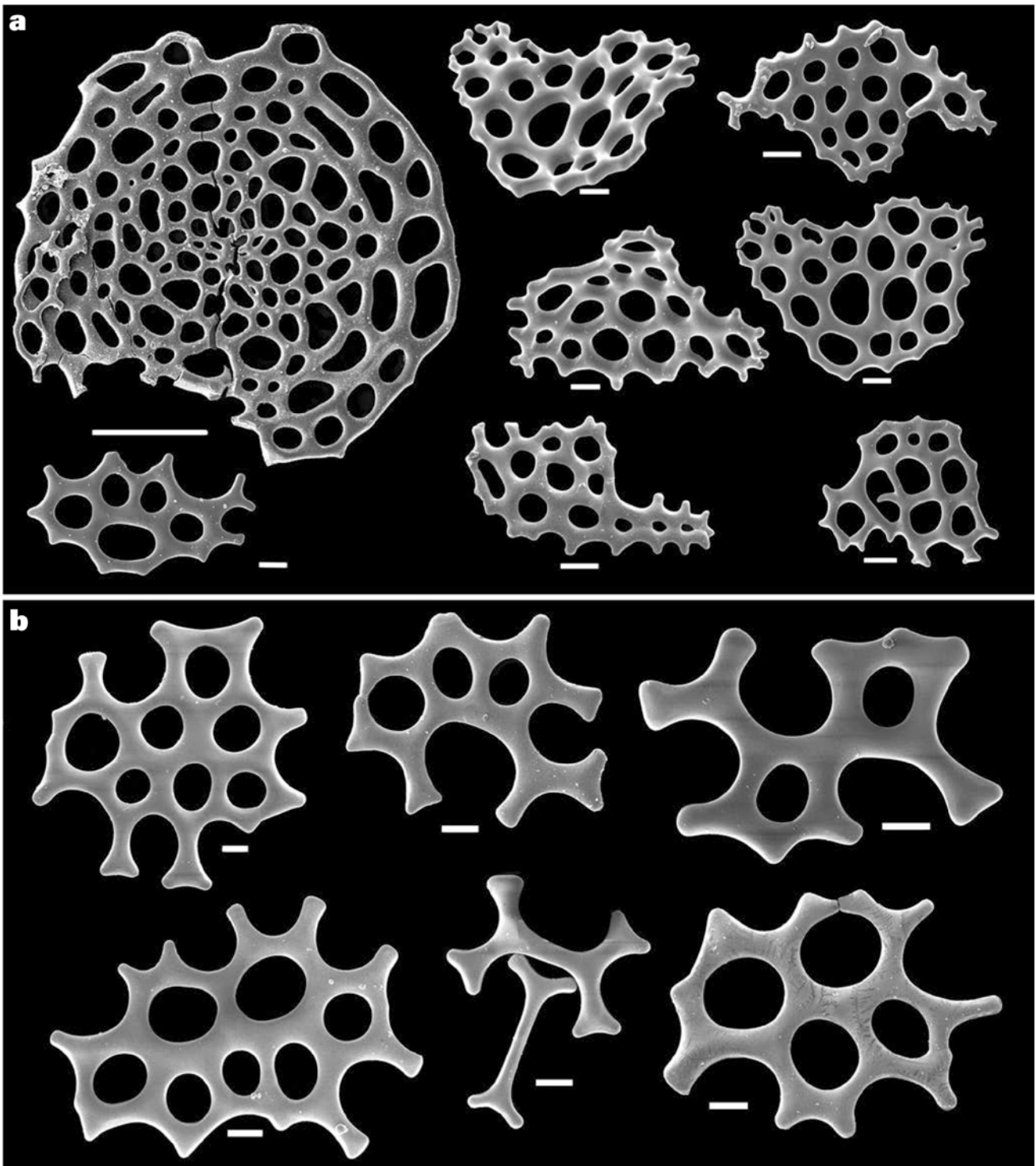


Figure 10. SEM images of ossicles from holotype of *Psolus atlantis* O'Loughlin sp. nov. (NHMUK 2013.6). a, tube foot endplate (top left; scale bar 100  $\mu\text{m}$ ) and tube foot support ossicles (scale bars 20  $\mu\text{m}$ ); b, small plates and crosses from central sole (scale bars 20  $\mu\text{m}$ ).

valves separated by single, thin rectangular oral plates; conspicuously granuliform oral, dorsal and lateral scales; absence of a midventral ambulacral series of tube feet; absence of any dorsal ossicles in addition to the large scales; small thick smooth perforated plate ossicles with fewer than eight perforations in the midsole; absence of cups or concave plate ossicles in the sole. We note the significant depth of occurrence (1117 m) of *P. atlantis*, relative to the occurrence of most *Psolus* species. We have compared *P. atlantis* with other southern *Psolus* species directly or in the works of Carriol and Féral (1985), Cherbonnier (1974), Deichmann (1930), Ekman (1925), Ludwig and Heding (1935), Mackenzie and Whitfield (2011), O'Loughlin and Whitfield (2010), Thandar (2009), Théel (1886a, 1886b) and Vaney (1906, 1914).

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