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A report of sea cucumbers collected on the first dedicated deep-sea biological survey of Australia's Indian Ocean Territories around Christmas and Cocos (Keeling) Islands (Echinodermata: Holothuroidea)

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Abstract

Mackenzie M., Davey N., Burghardt I., Haines M. L., 2024. A report of sea cucumbers collected on the first dedicated deep sea benthic survey of Australia's Indian Ocean Territories around Christmas and Cocos (Keeling) Islands (Echinodermata: Holothuroidea). *Memoirs of Museum Victoria* 83: 207–316.

The marine benthic biodiversity survey *Investigating the IOT* took place in the waters of Christmas and Cocos (Keeling) Islands in Australia's Indian Ocean Territories (IOT) on two voyages over 2021 and 2022. Both voyages on the RV *Investigator* collected sea cucumbers using a beam trawl from the seamounts and seafloor of the area. A report of sea cucumbers collected is included below, including taxonomic treatments, shipboard and ossicle images, range extensions, and genetic data for species where available. One new species, *Deima oloughlini* Mackenzie and Davey sp. nov., is described. Sea cucumbers collected are now housed in the collections at the Museums Victoria Research Institute in Melbourne, Australia. Range extensions and new species records for Australia will be supplied to compliers, including the Australian Faunal Directory and Atlas of Living Australia, and genetic data will be lodged with GenBank. This report was initiated through funding by an Australian Biological Resources Study Bush Blitz grant, and subsequently supported through funding by Ocean Census. *Investigating the IOT* voyages were supported by Parks Australia, Bush Blitz, Museums Victoria, and other Australian institutions. Voyage time on the RV *Investigator* was supported by the Marine National Facility (CSIRO), and additional travel for holothuroid taxonomic work was supported by a Council of the Heads of Australian Faunal Collections grant.

Keywords

RV *Investigator*, IN2021 V04, IN2022 V08, seamount, abyss, benthic, species, biodiversity, taxonomy, Australian Marine Parks, Christmas Island Marine Park, Cocos (Keeling) Islands Marine Park, Bush Blitz, Ocean Census, Parks Australia

Introduction

Deepwater sea cucumbers (Echinodermata: Holothuroidea) of Australia's Indian Ocean Territories (IOT) are reported here from two voyages on the RV *Investigator*. The *Investigating the IOT* expedition, led by Museums Victoria and supported by CSIRO's Marine National Facility (MNF), Parks Australia, Bush Blitz, and many other Australian museums and institutions, is the first dedicated and extensive survey to assess the deep-sea benthic biodiversity of Australia's IOT. The survey took place over two voyages, the first from 30 June to 29 July 2021 (Voyage IN2021 V04), and the second from 30 September to 3 November 2022 (Voyage IN2022 V08). Each voyage was supported by an international team of scientists, technicians, and crew on board the RV *Investigator*, and conducted seafloor mapping and biological sampling from the numerous seamounts to abyssal plain (100–5400 m) in the waters around Christmas Island and Cocos (Keeling) Islands to the north-west of Australia. Based on converging water flows and significant variations in depths and habitats, it was predicted that the Australian IOT would be a hotspot for species diversity (O'Hara, 2023). Sampling sites now also fall within the recently established Christmas Island and Cocos (Keeling) Islands Australian Marine Parks (fig. 1). Full collection details for Material Examined are provided by species in Appendix 1, with a distribution summary table provided in Table S1, and voyage highlights and summaries provided at the CSIRO MNF data portal (CSIRO et al., 2022a and 2022b).

Prior to the first *Investigating the IOT* voyage (IN2021 V04), the deep-sea holothuroid (sea cucumber) fauna of this region was virtually unknown. Of the ~6170 holothuroid records on the Atlas of Living Australia (ALA) at the time of the first voyage (excluding poorly georeferenced/identified records and human observations), only 259 (~4%) were from bathyal-abyssal depths of 2000 m or greater, and nearly all were from coastal regions or continental shelves. This report adds 10 (plus many Operational Taxonomic Units [OTUs]) to the previous 295 known species of Holothuroidea from Australia (Australian Faunal Directory [AFD], last updated September 15, 2023), significantly extending the geographic and bathymetric range of many of these species.

Of the 295 Australian holothuroid species noted above, only 87 were listed on the GenBank sequence database, with most of these from two shallow-water families. A grant from Bush Blitz allowed for initial identification and genetic sequencing of some of the material collected here, adding significantly to the library of holothuroid sequences for future reference. Additional genetic sequencing was funded by Ocean Census, and tissue from some specimens has subsequently also been submitted to the National Biodiversity DNA Library as part of a larger biodiversity project.

Holothuroids from six of the seven extant orders were recorded from the deep sea of the Australian IOT, with only Apodida (subclass Paractinopoda) not seen in this material. This report documents the full complement of sea cucumbers collected by beam trawl, including 224 specimen lots, with 21 known species from 12 families, additional OTUs recorded as sp. MoV. or cf species, plus those that could only be identified to higher taxonomy. Fifteen of the OTU or known species are recorded from only a single IOT specimen. Over half of all species are suspected to be undescribed, ten known species are recorded for the first time from Australia, and all are new records for the Australian IOT.

The 93 sequenced holothuroids comprise 45 distinct lineages (26 species and 19 molecular OTUs) across 21 genera. Prior to our study, 36 of these lineages did not have any published genetic data for the mitochondrial barcoding gene cytochrome oxidase I (COI). Globally, deep water holothuroids are still very poorly known, and this small collection from Australia's IOT adds significantly to both our morphological and phylogenetic knowledge of the group.

Methods

Specimen collection and identification. Specimens were collected on the RV *Investigator* by beam trawl, stored on ice during sorting and photography, then preserved in 95% ethanol refreshed as required. Melanie Mackenzie and Niki Davey identified specimens through lab-based work at the Museums Victoria Research Institute.

Photography and imaging. Field photos of specimens were taken on board the RV *Investigator* using a Canon 5D Mark 2 camera, with a Canon 100 mm lens (50 mm for larger specimens) and 65 mm MP-E lens. Two flashes were used. The camera was tethered to a Mac running Capture One software. Scanning electron microscope (SEM) images were taken by Nish Nizar at the Museums Victoria Research Institute. Ossicles were cleared of associated soft tissue using commercial bleach and a sonicator, rinsed with water and ethanol to remove bleach crystals, air-dried, and mounted on carbon tape on aluminium stubs. Observations and measurements were made using a Hitachi TM 4000, Benchtop Electron microscope on general SEM settings, 15 kv and low vacuum (charge reduction) mode. Integrated Hitachi software was used for processing and

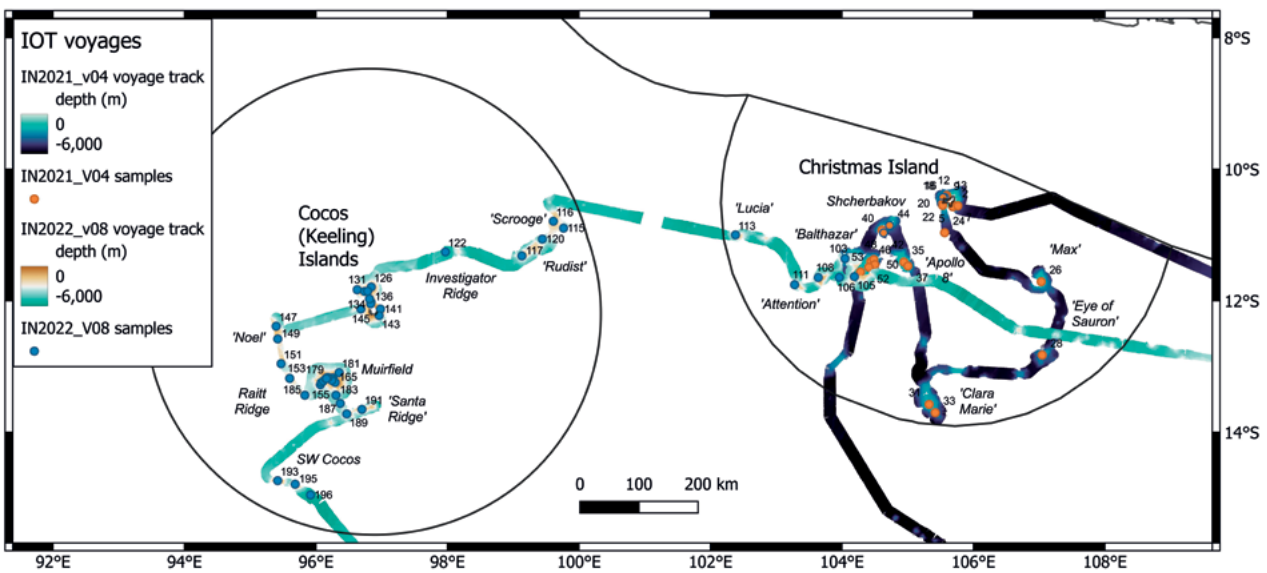

Figure 1. Map of voyage tracks and sampling sites for *Investigating the IOT* voyages IN2021 V04 and IN2022 V08, with Cocos (Keeling) Islands Marine Park and Christmas Island Marine Park outlined and seamounts and features noted. Map prepared by Dr Tim O'Hara.

measurements. Supplementary microscope slide images were taken on an Olympus BH2 compound microscope using an iPhone 12 with Xenevo Clarius 15x Macro adaptor. Nish Nizar prepared plates using Adobe Photoshop 2024.

DNA extraction, amplification, and sequencing. Tissues were taken from the tentacles, tube feet, or body walls of specimens (n=91) after they had been preserved in 95% ethanol. Tube feet were preferred because these samples had higher sequencing success. Extractions were performed using Bioline Isolate II genomic DNA kit (Meridian Bioscience, Memphis, Tennessee USA) or Omega Bio-tek Tissue kit (Omega Bio-tek, Norcross, Georgia USA), following the manufacturer's protocol. We amplified and sequenced the mitochondrial gene regions COI (n=75) and ribosomal subunit 16S (n=54). The COI region was ~658 bp and amplified using the primers COIef 5' ATAATGATAGGAGGRTTTGG 3' and COIer 5' GCTCGTGTRTCTACRTCCAT 3' (Arndt et al., 1996) or, for *Mesothuria*, COIecf 5' ACTGCCCACGCCCTAGTAATGA TATTTTTTATGGTNATGCC 3' and COIecr 5' TCGTGTGTCTACGTCCATTCCTACTGTRAACATRTG 3'. The 16S region was ~530 bp and amplified using the primers 16SarL 5' CGCCGTTTATCAAAAACAT 3' and 16SbrH 5' CCGGTCTGAACTCAGATCACG 3' (Palumbi, 1996). Polymerase chain reactions (PCRs) were performed in 20 µl reactions containing 0.5 µl of each primer (10 *µM*), 10 µl GoTaq Hot Start Master Mix (Promega, Madison, Wisconsin USA), and 2 µl of genomic DNA (diluted 1:10) under the following conditions: initial denaturation step at 95°C for 3 min, 40 cycles at 95°C for 40 s, 45°C for 40 s, 72°C for 50 s, with a final extension at 72°C for 5 min. PCR success was confirmed using gel electrophoresis. PCR products were purified using ExoSAP-IT (USB Corporation, Cleveland, Ohio USA) and sequenced by Macrogen, Inc. (Seoul, South Korea). DNA sequences were edited in Geneious Prime (Biomatters, Auckland, New Zealand, available at: http:// www.geneious.com/) and aligned using Multiple Alignment using Fast Fourier Transform (MAFFT). Protein-coding regions were translated to amino acids and no premature stop codons were observed. Sequences were deposited in GenBank (Table S3).

Phylogenetic analyses. Our sequence data was combined with GenBank sequences from related Holothuroidea to provide greater phylogenetic context. COI and 16S were analysed separately for each taxonomic order (Elasipodida, Holothuriida, Molpadida, Persiculida, and Synallactida) in IQ-TREE (Minh et al., 2020) using a Tamura-Nei 93 model with 1000 bootstraps (figs S1–5). Pairwise uncorrected genetic distances between sequences were calculated using the Kimura 2-parameter model in MEGA-X (Kumar et al., 2018).

Abbreviations

ABRS	Australian Biological Resources Study
AFD	Australian Faunal Directory
ALA	Atlas of Living Australia
CCZ	Clarion-Clipperton Zone
CHAFC	Council of the Heads of Australian Faunal Collections
COI	cytochrome oxidase I
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNA	Deoxyribonucleic acid
EOL	Encyclopedia of Life
IOT	Indian Ocean Territories (used here to refer to the deep-sea survey of Australia's Indian Ocean Territories of Christmas and Cocos (Keeling) Islands)
MNF	Marine National Facility (CSIRO)
NMV	Museums Victoria Catalogue (registration number prefix F)
OBIS	Ocean Biogeographic Information System
OTU	Operational Taxonomic Units
PCR	Polymerase chain reaction
SEM	Scanning electron microscope
sp Mov.	Prefix for unique numbers assigned to Museums Victoria OTU lots (likely new species with more review or material required)
USA	United States of America
WoRMS	World Register of Marine Species

Frequently accessed databases are noted by acronym and year/date accessed in the Taxonomic Treatment and can be found in the references as follows:

- AFD 2023: see Rowe, F.W.E., Gates, J., and O'Hara, T.D. (2012)
- ALA 2024: Atlas of Living Australia (2024)
- WoRMS 2024: WoRMS Editorial Board (2024). Holothuroidea.

Numbers in brackets after registrations refer to numbers of specimens in lots.

Taxonomic treatment

Brief remarks are given at higher taxonomic level, followed by species-level images, diagnosis, and comments on phylogenetic placement and distributions. Taxonomy follows WoRMS (WoRMS Editorial Board, 2024). Specific references for species identification and geographic and bathymetric distributions are noted under each section. Material examined was collected from the Christmas Island and Cocos (Keeling) Islands vicinity in the Australian IOT by O'Hara et al. Marine Invertebrates Team on the RV *Investigator* during voyages IN2021 V04 and IN2022 V08. Full collection details are provided in Appendix 1. Specimens with new genetic data are recorded with an asterisk (*), and where relevant to diagnostic remarks, phylogenetic trees with comparative data in GenBank are included in figures S1–5. Suggested updates to the AFD and ALA based on distribution information from this Australian IOT material and additional specimens in the Museums Victoria Catalogue (NMV) collection database are noted.

Order **Dendrochirotida** Grube, 1840

Diagnosis. (see Grube, 1840)

Remarks. Dendrochirotida are suspension-feeding sea cucumbers found worldwide, more common in shallower waters though extending to abyssal depths. Some species burrow in

soft sediments; others attach to hard surfaces and extend their branched tentacles into the water column to feed. This order comprises 11 currently accepted families, five of which are represented in Australia: Cucumariidae, Phyllophoridae, Psolidae, Sclerodactylidae and Ypsilothuriidae, with others found in Australian Antarctic waters. While it was anticipated that the shallower depths of Muirfield Seamount would provide more suitable bathymetric range for this order, surprisingly only one deep-sea species from one family was represented in the IOT material.

Family **Ypsilothuriidae** Heding, 1942

Diagnosis. (see Heding, 1942)

Remarks. Previously found in the deep sea off the south and northeastern and northwest coasts of Australia, this family comprises U-shaped burrowing species with a covering of spired ossicles. Of the three currently accepted genera, two *(Echinocucumis* and *Ypsilothuria*) were previously recorded for Australia.

Genus ***Echinocucumis*** M. Sars, 1859

Diagnosis (amended from O'Loughlin et al., 2015). Mid-body sub-spherical, tapered non-retractile oral and anal ends, usually upturned; calcareous ring cucumariid-like, lacking posterior prolongations; tentacles ten, digitiform, unequal in size; tube feet slender, restricted to ambulacra, can be discrete, sparse, or absent; body invested with large imbricating scales that are single-layered perforated plates, each scale with predominantly one tall spine typically arising near plate margin.

Remarks. *Echinocucumis* has previously been recorded from the Atlantic, Pacific, Indian, and Southern Oceans including Antarctica with eight currently accepted species. Only one species – *E. ampla* – was found in the IOT, previously recorded from the Southern Ocean and off the eastern coast of Australia. Diagnosis from O'Loughlin et al. (2015) amended to include discrete tube feet and to allow for variation in spine placement on ossicles as not all are marginal.

Echinocucumis ampla O'Loughlin and Skarbnik-López in O'Loughlin et al., 2015

Figure 2a–f, Appendix 1, Table S1.

Echinocucumis ampla O'Loughlin and Skarbnik-López, 2015: 77–80, tables 1, 2, 5, 6; figs 1, 7, 8.—O'Hara et al., 2020: 10, fig. 5, table S1.

Dactylochirotida sp. nov. (HOL 10).—Hibberd and Moore, 2009: 119, 146.

Material examined. NMV F296861 (1) [IN2021 V04 031]; NMV F 308161 (1) [IN2022 V08 105].

Diagnosis of IOT material. Small, white, u-shaped species with prominent belly mid-body. Anterior variably upturned and slightly tapered to a rounded oral end, posterior tapered to upturned tail. Skin thin, brittle, parchment like and often "prickly", particularly on ventral surface, due to the complete cover of imbricating spined scales. Tentacles retracted here but typically ten digitiform of irregular length and supported by curved rod ossicles. Ventrolateral tube feet in sparse, paired rows (fig. 2c). Body wall ossicles were broken in these specimens but show single-layered perforated plates with a single large composite spire greater than 200 μm high and typically marginal sometimes central on plates (fig. 2d, e). Broken solid plates (fig. 2f) were also observed in perianal ossicle samples. Preserved specimens from IOT up to ~25 mm long (lateral width, tentacles withdrawn) and 10 mm high mid-body (NMV F308161).

Remarks. Presence perianally of solid plates was considered a diagnostic character for this species (Mark O'Loughlin, pers comm., 2018). They were seen in this material (fig. 2f) but without the occasional small, spaced perforations expected. The original species description does not include tube feet for the larger (65 mm long) specimen, but the possibility of their presence was raised in "Remarks" (O'Loughlin et al. 2015). In specimens from the eastern Australian abyss subsequently identified as *E. ampla* by O'Loughlin, tube feet were evident in smaller specimens, but rarely in larger specimens (Mark O'Loughlin, pers comm., 2018). Here we report the presence of ventrolateral tube feet, clearly observed in these small IOT specimens when viewed under a microscope (fig. 2c). Only 16S sequence data is available for this species (Table S3). It was recovered in a clade representing the family Ypsilothuriidae.

Distribution. Southern Ocean (O'Loughlin et al., 2015), South Pacific (eastern coast of Australia, see below), and Indian Ocean (Australian IOT, this work).

Full bathymetric range. 557–4139 m (IOT 2189–2435 m).

Type locality. Southern Ocean, southern Kerguelen Plateau northeast of Heard Island, 708 m.

This species was not recorded from Australia in AFD prior to January 2024, but was recorded from off the eastern coast in ALA (January 2024) from Freycinet in Tasmania to the Coral Sea in Queensland at 1006–4139 m. This IOT material represents a geographic range extension for the species.

References. AFD (2023), ALA (2024), O'Loughlin et al. (2015), O'Loughlin (notes and personal correspondence, 2018), Rowe et al. (2017).

Order **Elasipodida** Théel, 1882

Diagnosis. (see Théel, 1882)

Remarks. The Elasipodida are a deep-sea order of sea cucumbers lacking respiratory trees. They are typically gelatinous, have peltate feeding tentacles, and have tube feet adapted for walking along the seafloor or fused for swimming. Unfortunately, the often-soft outer skin is easily damaged during collection, and their watery bodies also make preservation difficult. The order comprises four currently accepted families: Elpidiidae, Laetmogonidae, Pelagothuriidae and Psychropotidae, all of which are represented in Australian waters. As expected for this dominant deep-sea order, all four families were also represented in the IOT material. Hansen (1975) reviewed the Elasipodida comprehensively in the *Galathea Report*, and despite subsequent revisions for specific groups, this remains one of the best overall sources for descriptions and keys for the order.

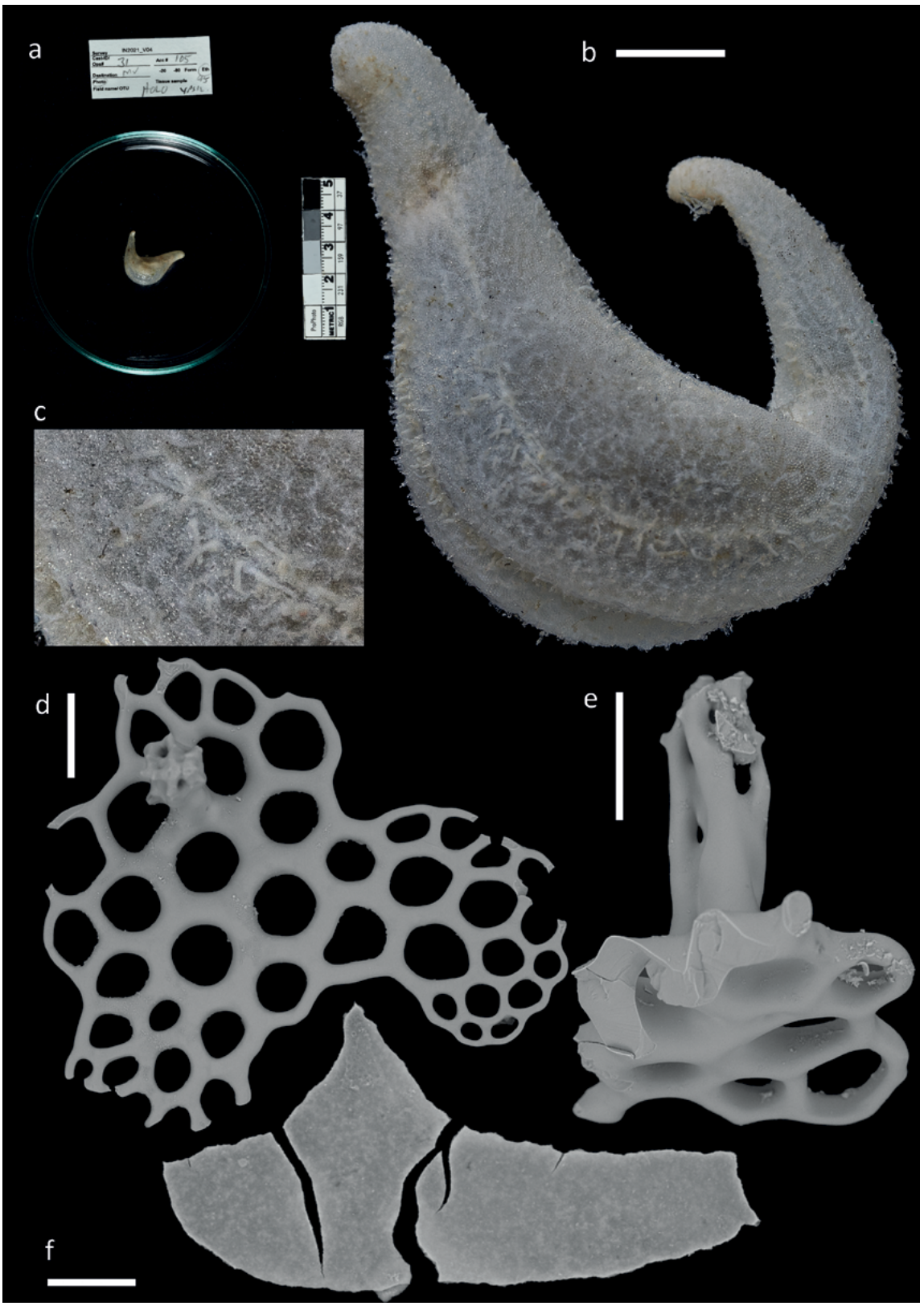

Figure 2. *Echinocucumis ampla*. a, shipboard image in petri dish; b, whole animal image; c, detail of tube feet and plates, NMV F296861; ossicles: d, body wall plate with spire; e, spire, NMV F296861; f, peri-anal solid plate, NMV F308161; scale bars: b=0.25 cm, d–f=100 *μm*.

Family **Elpidiidae** Théel, 1882

Diagnosis (following Hansen, 1975). Tentacles 10–12. Ventrolateral tube feet large, well-spaced, and usually few. Midventral tube feet absent. Calcareous ring consisting of five star-shaped pieces. See Hansen (1975) for further comments.

Remarks. The Elpidiidae are a cosmopolitan deep-sea family, with some species known to form dense benthic aggregations (Gutt and Piepenburg, 1991). Recorded in Australia from off the east and west coasts and in the Great Australian Bight. Of the 13 currently accepted genera, seven are known from Australia: *Achlyonice, Amperima, Elpidia, Kolga, Peniagone, Psychroplanes* and *Scotoplanes*, with additional genera found in Australian Antarctic waters (ALA, 2024; WoRMS, 2024). IOT material includes examples from *Peniagone*, *Psychroplanes* and *Scotoplanes*.

Genus ***Peniagone*** Théel, 1882

Diagnosis. (amended from Hansen, 1975). Dorsal papillae anteriorly placed, usually forming a velum. Ossicles primary crosses or cross-shaped bodies with variable arms and apophyses arising from a central stem. Calcareous ring consisting of five isolated pieces, each having a varying number of arms.

Remarks. Benthic and swimming genus, worldwide except for the Arctic with high species diversity in the Pacific and Antarctic (Gebruk et al., 2014). *Peniagone* ossicles are of an adapted cross shape, with arms always arising from a central beam or stem. Of the 35 currently accepted species of *Peniagone*, five have been previously recorded for Australia: *P. affinis, P. azorica, P. challengeri, P. vignoni,* and *P. vitrea* (ALA, 2024; WoRMS, 2024). Two new records for Australia of known species are recorded here: *P. coccinea* and *P. purpurea*. Eighteen lots of *Peniagone* were recorded from the IOT voyages at depths of 2156–5414 m, with 12 lots further identified to OTU species level as follows: *Peniagone* cf *azorica* (1 lot), *Peniagone* cf *challengeri* (1 lot), *P. coccinea* (4 lots), *P. purpurea* (1 lot), *P. vitrea* (3 lots), *Peniagone* sp. MoV. 7320 (1 lot), *Peniagone* sp. MoV. 7321 (1 lot). Genus diagnosis was amended from Hansen (1975) to note apophyses and central stem. *Peniagone* is a well-supported, monophyletic genus in both the COI and 16S phylogenies (fig. S1). However, more molecular data is needed to resolve species-level relationships.

Peniagone* cf *azorica Marenzeller von, 1892

Figure 3: a–i, Appendix 1, Table S1, Figure S1

Material examined. NMV F308267* (7) [IN2022 V08 145].

Other material. *Peniagone azorica* Marenzeller von, 1892 – off eastern Australia, NMV F241035 [IN2017 V03 090 110]; NMV F240855 [IN2017 V03 032 143] (identified by Mark O'Loughlin, 2018).

Diagnosis of IOT material. Damaged, fragile specimens. Elongate, dorsally raised and convex but ventrally slightly rounded to flattened. Anterior end downturned with ventral mouth on neck tube (not visible in photo) and only four flaccid tentacles remaining. Anus dorsal and terminal. Pink to orange before preservation, with a fragile, translucent brim (<10 mm wide) around the entire animal, extending to form a wider anterior velum of five fused papillae. Central two anterior papillae are longer, with all fused for most of their length. Tube feet where visible appear restricted to posterior third of the body, and almost fully embedded in the brim. Preserved specimens (ethanol) are grey and spongey with chalky skin, brim and fused velum either lost or reduced to stringy pieces and approximately six previously embedded larger tube feet appearing free, with only the series of minute posterior tube feet remaining fused. Ossicles in body wall include larger irregular spinous crosses (fig. 3b–d), with four or more flat to slightly curved arms (up to 455 *μm* long), and *Peniagone*-type crosses with arms and apophyses, both with smooth central beams. *Peniagone*-type crosses mostly two types, some with four arms and 2–4 (typically 4) high apophyses curved inwards (fig. 3g–h), others (more common in ventral wall) with irregular arms curved out and shorter thick, spinous apophyses (fig. 3f, i). Both types have spines (serrations) on both arms and apophyses. Tentacles with same and spinous supporting rods. Most complete preserved specimen from IOT ~105 mm long, 15 mm wide and 15 mm high. Likely same specimen as shipboard image which was ~145 mm long and 45 mm wide before preservation (fig. 3a).

Remarks. Ossicles combined with body shape and tentacles closest to original type description of *P. azorica* Marenzeller von, 1892 from the North Atlantic, and subsequently descriptions by Hansen (1975). Identified as *Peniagone* cf *azorica* here as whole-body brim including completely fused anterior velum and tube feet embedded in a posterior brim (as seen in IOT specimens) does not match the bipartite velum and free tube feet bordering entire ventral sole of the original description, Hansen's (1975) descriptions, or those described more recently from the mid-Atlantic (Rogacheva et al., 2013). Ossicles, colour and morphology of IOT specimens match at least two of the six specimens Mark O'Loughlin identified as *P. azorica* Marenzeller von, 1892 from Australian eastern abyssal stations, which had a brim and fused velum in shipboard images but lost these after preservation (NMV Catalogue, 2018).

Distribution. These specimen lots: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Cocos (Keeling) Stn., 3002–3078 m; Two comparative specimens noted above: off eastern Australia in East Gippsland Marine Park and off Byron Bay, 2562–3853 m.

Full bathymetric range. 2562–3853 m.

References. Gebruk et al. (2014), Hansen (1975), Hansson et al. (2001), Marenzeller von (1892), Rogacheva et al. (2013), Kremenetskaia née Rogacheva (pers comm., 2023), Théel (1882)

Peniagone* cf *challengeri Théel, 1882

Figure 4a, b, Appendix 1, Table S1

Material examined. NMV F308151 (1) [IN2022 V08 105].

Diagnosis of IOT material. Single small, elongate specimen, 32 mm long, 10 mm wide and 5 mm high (preserved). Light pink and soft before preservation, light grey to white and firm once preserved (ethanol). Quite damaged, outer skin looks

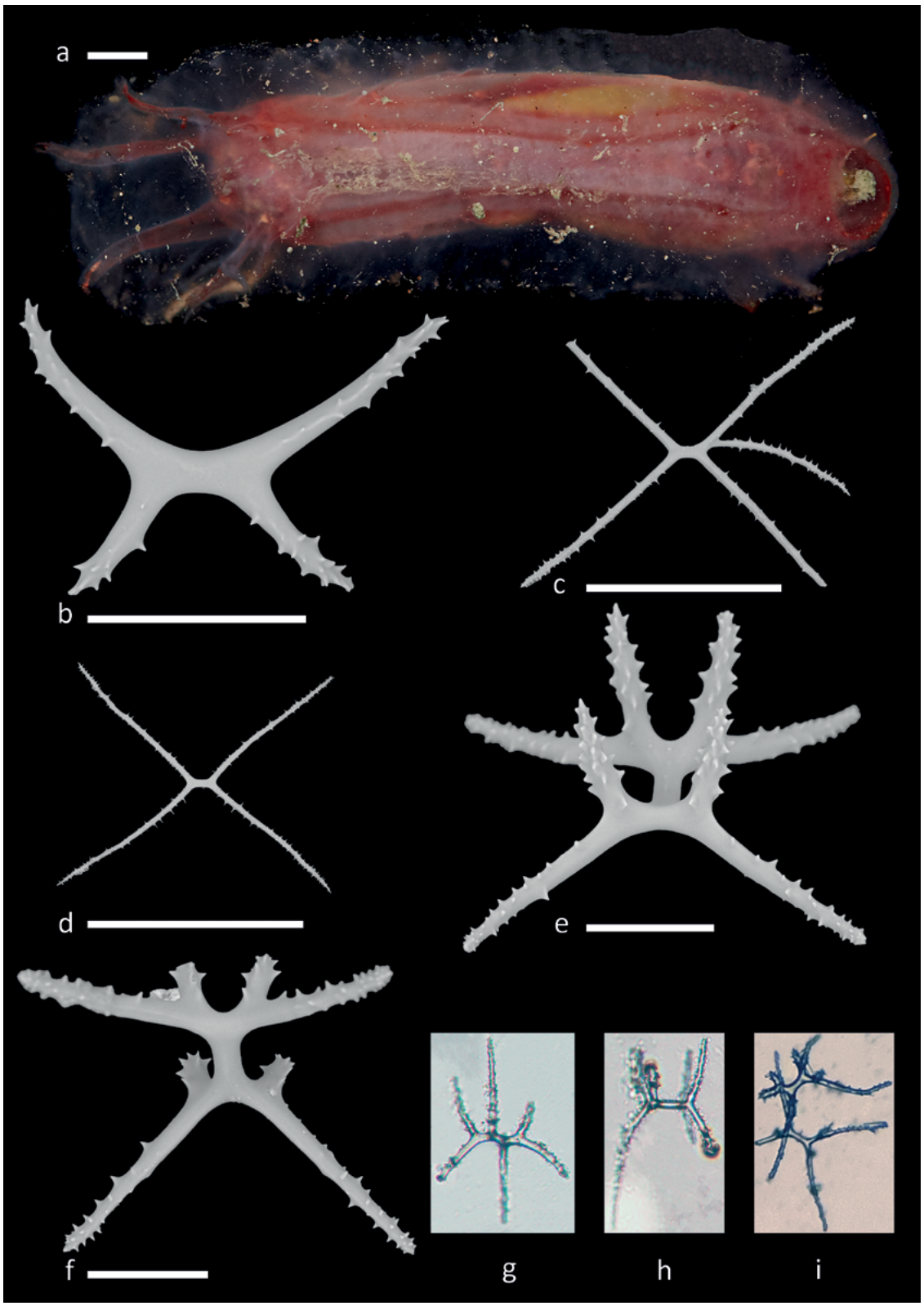

Figure 3. *Peniagone* cf *azorica*. a, shipboard image showing full body brim; ossicles: b–d, ventral body wall crosses, e–f, low *Peniagone*-type crosses from tentacles (similar seen in body wall); g–i, high (g–h) and low (i) *Peniagone*-type crosses from dorsal body wall, NMV F308267; scale bars: a=1 cm, b=100 *μm*, c=300 *μm*, d=500 *μm;* e–f=50 *μm*.

Figure 4. *Peniagone* cf *challengeri*. a, shipboard image; b, body wall ossicle, NMV F308151; scale bar: a=0.5 cm.

stripped and "fluffy" and preserved specimen was stripped of most appendages. Anterior end downturned with ventral tentacle crown. Two long tapered dorsal anterior lobes visible on damaged velum. Tube feet where visible on preserved specimen were free and restricted to posterior section, though live photo shows a potential brim of partly fused appendages. Posterior mid-terminal incision in preserved specimen, but not obvious in shipboard photo so may be an artifact. Minimal ossicles but all *Peniagone*-type crosses with four long spinous arms, long bare central stem, and four short and spinous apophyses.

Remarks. Identified here as closest to *Peniagone challengeri* Théel, 1882 based on the morphology described, particularly the ossicles (which match the illustration for the type specimen of *P. challengeri* in Théel, 1882), bifid velum, posterior tube feet and elongate form, but too damaged to identify further than *Peniagone* cf *challengeri*.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Christmas Island Territory, Balthazar Seamount Stn., 2298–2435 m.

Full bathymetric range. 2298–2435 m.

References. AFD (2024), ALA (2024), Cross et al. (2009), Hansen (1975), O'Loughlin (1998), Rowe et al. (2017), Théel (1882).

Peniagone coccinea Rogacheva and Gebruk in Rogacheva et al., 2013

Figure 5a–o, Appendix 1, Table S1, Figure S1

Peniagone coccinea Rogacheva and Gebruk in Rogacheva et al., 2013: 608–610, figs 13, 14, 18h, i, o, 19e (online supplement 1).—Gebruk et al., 2014: 162.—Kremenetskaia et al., 2021: 14, fig. 9.

Material examined. NMV F296857* (1) [IN2021 V04 028]; NMV F308183 (1), NMV F308188* (1) and NMV F308189 (2) [IN2022 V08 115].

Diagnosis of IOT material. Bright pink to red and gelatinous with semitransparent skin (live), cream to grey with pink tinge (preserved, ethanol). Body form elongate, raised dorsally and broadening towards the posterior end. Most complete preserved specimen up to ~70 mm long, 20 mm high and 20 mm wide (NMV F308183, fig. 5a). Anterior dorsal velum with two pairs of long papillae fused at the base on each side (central ones longer). Mouth downturned on short neck tube with flaccid tentacles extended, only six remaining on the most complete specimen. Posterior with a brim of small, fused tube feet and dorsal anus. Skin is soft and easily damaged. Ossicles of body wall are flat, irregular, variably spinous crosses (fig. 5b–f), and two kinds of *Peniagone*-type crosses, all with smooth (or minutely spinous) central beams, some with irregular extra branches. One version of *Peniagone*-type cross with mostly wide but inward-curving spinous arms and four (3–4) shorter straight, almost vertical spinous apophyses (fig. 5i–k). Other type with mostly four outward-curving arms, quite irregular in length and shape and often strongly spinous at ends, with mostly four short, thick spinous apophyses (fig. 5l–o). Tentacles, tube feet, velum (and occasionally body wall) with additional irregular spinous rods, straight to curved (fig. 5g, h).

Remarks. Colour and brim like *Peniagone* cf *azorica* above, but ossicles are distinctive and have the more "irregular" form of *P. coccinea* Rogacheva and Gebruk in Rogacheva et al., 2013.

Distribution. North Atlantic, Indian Ocean (Australian IOT).

Full bathymetric range. 2600–2974 m (IOT 2760–2974 m).

Type locality. North Atlantic, Mid-Atlantic Ridge south of the Charlie Gibbs Fracture Zone, 2600–2750 m.

This species not previously recorded from Australia in AFD or ALA (January 2024).

This IOT material represents a geographic range extension for the species and a small increase in depth range.

References. AFD (2024), ALA (2024), Gebruk et al. (2014), Rogacheva et al. (2013).

Figure 5. *Peniagone coccinea*. a, shipboard image showing live colour NMV F308183; ossicles: b–h, simple body wall crosses and rods from NMV F308189 (b–d, g, h) and NMV F296857 (e, f); i–o, high and low irregular *Peniagone*-type crosses from body wall of NMV F308189; scale bars: a=1 cm; b, e, f=200 *μm*; c, d, k–n=100 *μm*; g, h=300 *μm*; i, j, o=50 *μm*.

Peniagone purpurea (Théel, 1882)

Figure 6a–i, Appendix 1, Table S1, Figure S1

Elpidia purpurea Théel, 1882: 21–23, pls. 7: 4–6, 33: 13–14, 44: 6.
Peniagone purpurea.—Hansen, 1975: 151–152.—Gebruk, 1990: 111–113, fig. 46.—Gebruk et al., 2014: 162.—Kremenetskaia et al., 2021: 14, fig. 9.
Elpidia ambigua.—Théel, 1882: 27–28, pl. 33: 6.
Peniagone lacinora.—Agatep, 1967: 53–55, pl. 3: 1–9.
Peniagone vexillum.—Perrier, 1902: 429, pls. 12: 6, 19: 24–25.
?*Peniagone ferruginea*.—Grieg, 1921: 7–8, fig. 3, pl. 1: 4–6.

Material examined. NMV F296841* (1) [IN2021 V04 007].

Diagnosis of IOT material. Single partial specimen, light pink to mauve, soft, gelatinous, and partially transparent with thin skin. Purple to grey once preserved and in two pieces, each ~20 mm long. Severely damaged, single podia but no other external features remaining, skin wall not rough. Body wall ossicles typically *Peniagone*-type crosses with smooth (or minutely spinous) central beam, four widely spread long spinous arms and four shorter spinous apophyses directed vertically or outwards (fig. 6b–e). Some with longer and more curved arms (fig. 6f, g). Other crosses lower with arms slightly curved to almost horizontal and short, thick apophyses (fig. 6h, i). Arms up to 320 *μm* long in these samples. Tentacles with crosses and supporting rods.

Remarks. Identification as *P. purpurea* rather than other *Peniagone* species based on limited specimen morphology and colour, combined with ossicles being closest to the type description and illustrations in Théel (1882) (excluding the rough skin from crowded ossicles). Note that Hansen (1975) describes only primary crosses with a well-developed stem and four long apophyses for *P. purpurea*, but IOT material is a closer match to the original illustrations in Théel, with mix of ossicles with shorter or longer apophyses. Differs specifically from *Peniagone vitrea* by mauve colour, more gelatinous skin, and different combination of ossicles as shown in fig. 6 cf. fig. 7.

Distribution. Antarctic, Atlantic, West Pacific, Indian Ocean: southern Indian Ocean (near Crozet), and Australian IOT.

Full bathymetric range. 2800–5610 m (IOT 3200–3345 m).

Type locality. southern Indian Ocean, west of Alfred Faure (Crozet Archipelago), 3560 m.

This species not previously recorded from Australia in AFD or ALA (January 2024).

This IOT material represents a geographic range extension for the species.

References. AFD (2024), ALA (2024), Cross et al. (2009), Gebruk et al. (2014), Théel (1882).

Peniagone vitrea Théel, 1882

Figure 7a–i, Appendix 1, Table S1, Figure S1

Peniagone vitrea Théel, 1882: 50–52, pl. 7: 7–9, 34: 17–18, 44: 10.—Hansen, 1975: 148–150, fig. 70.—Gebruk, 1990 (in Russian): 93–94, fig. 34: 4–9.—O'Loughlin, 1998: 504.—Bribiesca-Contreras et al, 2022: 74–75, fig. 47.—Kremenetskaia et al. 2021: 13, fig. 8a–c.
Peniagone vitrea var. *setosa* Ludwig, 1893: 109; 1894: 105–108.
Peniagone setosa Ludwig.—Clark, 1920: 136.

Material examined. NMV F308222* (1) [IN2022 V08 120]; NMV F308226 (1) [IN2022 V08 122]; NMV F308268 (1) [IN2022 V08 145].

Diagnosis of IOT material. Large glassy-white to cream specimens up to 95 mm long, 20 mm wide and 20 mm high (NMV F308222 preserved). Typical *Peniagone* shape, strongly raised anterior to mid-dorsally then flattening posteriorly, slightly convex to flattened ventrally. Broad and short anterior velum of four papillae, fused for most of their length, with two central papillae a little longer and freer. Mouth on distinct neck tube curved at an acute angle ventrally and with extended flaccid tentacles, only five remaining in the most complete specimen (NMV F308222, fig. 7a). Tube feet also mostly stripped from these specimens but all free and restricted to posterior third. Skin feels very rough due to crowded ossicles that are visible to the eye. Typically, *Peniagone*-type crosses with short, smooth central beam, four straight to slightly curved spinous arms, and 2–4 straight, spinous apophyses (fig. 7g–i). Arms wide, apophyses more vertical and nearly as long as arms where complete. Velum ossicles similar. Tube feet ossicles variably similar tall crosses, to lower versions with wider arms and shorter apophyses. Tentacle ossicles mostly irregular smooth crosses without (or with very reduced) apophyses and straight to slightly or strongly curved rods, variably smooth, spinous, or branching (fig. 7d–f).

Remarks. Despite extensive damage the external morphology available is congruent with the type description for *P. vitrea* Théel, 1882. Body wall ossicles also fit description, but some IOT ossicle arms were up to 417 *μm* long, much longer than the type ossicle arms noted as 160 *μm*. Tentacle ossicles for IOT included curved rods in addition to the straight rods and basic crosses mentioned for types.

Distribution. Widespread in Pacific Ocean, including Clarion-Clipperton Zone (CCZ), Kuril–Kamchatka Trench, off southern Chile, Gulf of Panama; off southern and eastern Australia; Antarctic; Indian Ocean (Australian IOT).

Full bathymetric range. ~1300–4990 m (IOT 3002–4990 m).

Type locality. off southern Chile, 2652 m.

This species previously recorded from Nowra to Point Hicks in AFD (January 2024), and from eastern coast of Australia (off southern Tasmania to northern NSW and Great Australian Bight off South Australia at depths of 1360–4750 m) in ALA (January 2024). This IOT material represents a geographic range extension as the first record of the species from the Indian Ocean, and a potential bathymetric range extension with this previously reported as ~1300–4500 m in Kremenetskaia et al. (2021).

References. AFD (2024), ALA (2024), Bribiesca-Contreras et al. (2022), Clark (1920), Hansen (1975), Kremenetskaia et al. (2021), Ludwig (1894), Théel (1882).

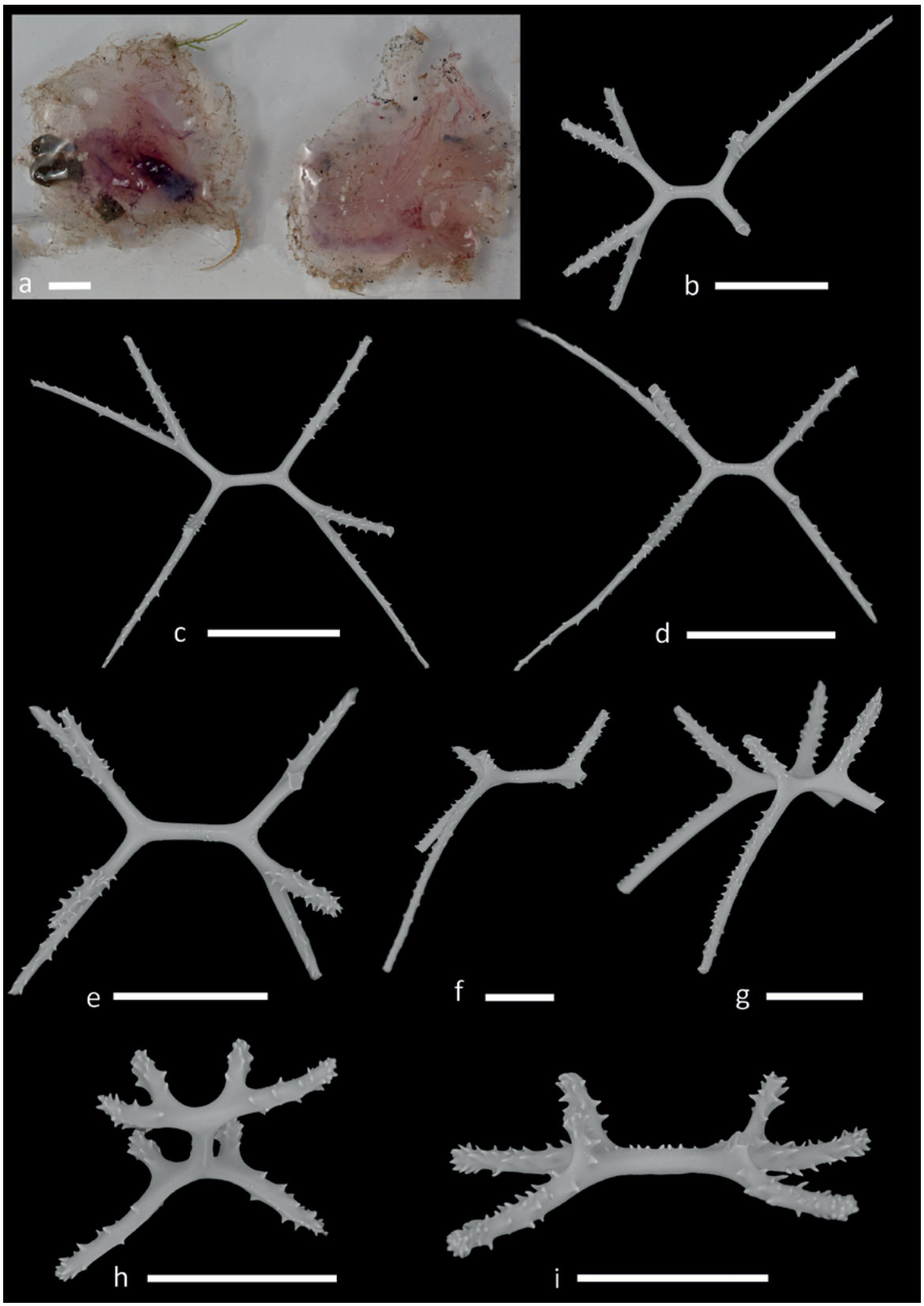

Figure 6. *Peniagone purpurea*. a, shipboard image showing live colour; b–i, body wall ossicles, NMV F296841; scale bars: a=1 cm; b–i =100 *μm*.

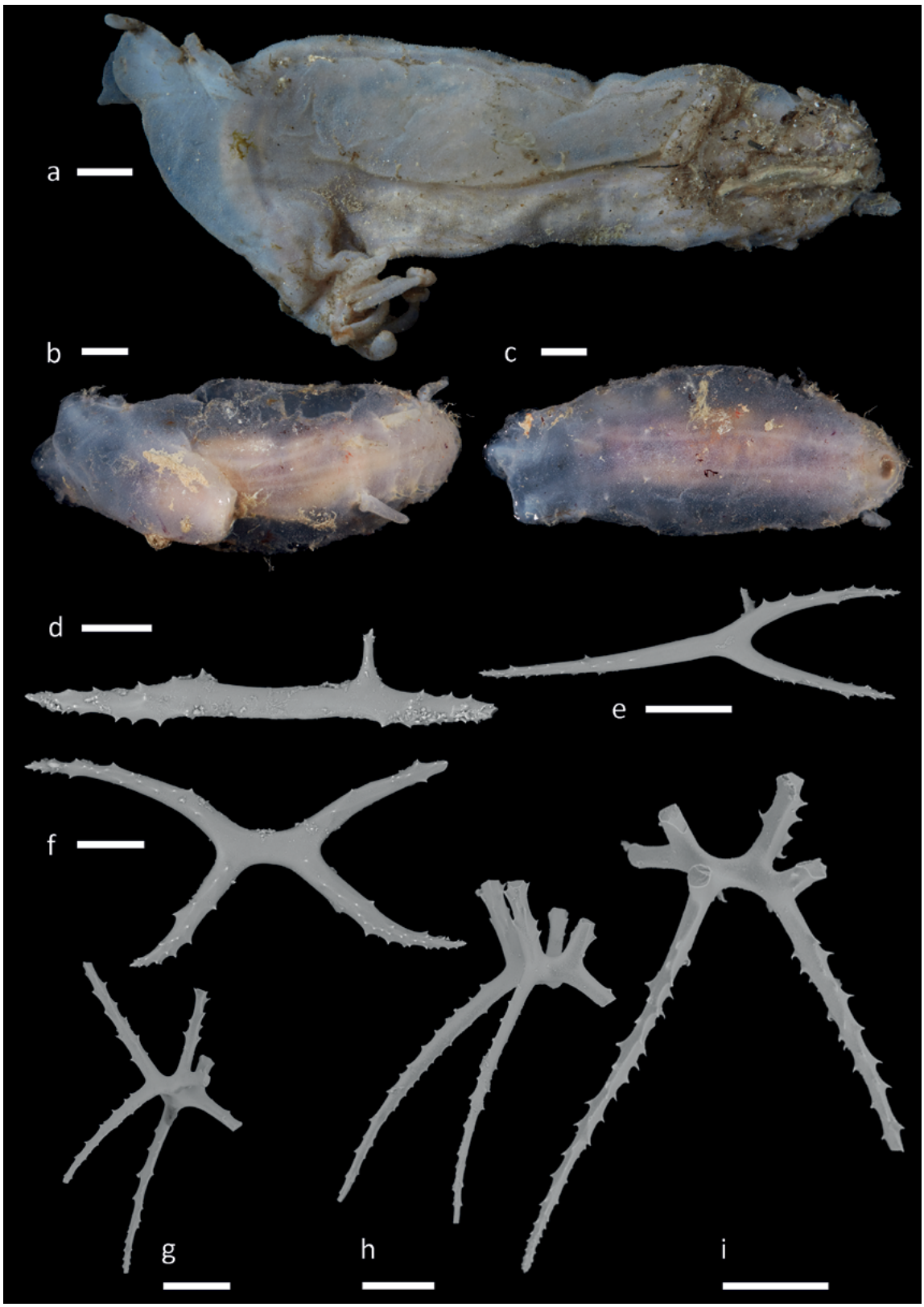

Figure 7. *Peniagone vitrea*. a, shipboard image NMV F308222; b, c, shipboard image NMV F308268; ossicles: d–f, tentacle rods and crosses, NMV F308226; g–i, body wall high *Peniagone*-type crosses, NMV F308266; scale bars: a–c=1 cm, d, f=50 *μm*, e, g–i=100 *μm*.

***Peniagone* sp. MoV. 7320**

Figure 8a–h, Appendix 1, Table S1, Figure S1

Material examined. NMV F308335* (2) [IN2022 V08 196].

Diagnosis of IOT material. Elongate specimens up to 85 mm long and 15 mm wide, only slightly raised dorsally. Grey-cream with black speckled coating on flakey outer skin (preserved, ethanol). Skin semitranslucent revealing central gut with pink to orange tint. Anterior velum severely damaged but appears short or reduced. No obvious neck tube but mouth curved ventrally with darker maroon to brown semi-retracted tentacles. No tube feet remaining. Images look soft, but after preservation hard and crunchy dorsally, softer ventrally. Ossicles *Peniagone*-style crosses with smooth central beam, four (4–5) arms, and four (2–4) apophyses. Arms and apophyses spinous distally and for most of their length. One variety of *Peniagone*-style cross with longer arms and apophyses. Arms variably curve directly down (fig. 8d, e) or horizontally for a short distance before they curve down (fig. 8f, g). Apophyses typically straight and vertical. Second kind of *Peniagone*-style cross with much shorter arms and apophyses (fig. 8h).

Remarks. Damaged specimens with few external characters. Specimens not the typical *Peniagone* shape, colour or texture, but this may be an artifact of being collected from a station with manganese nodules. Many specimens from this site were coated with dark residue and were atypical in colouration. Elongate body with no neck-tube closer to *P. challengeri,* though ossicles show similarities to *P. azorica, P. purpurea* and *P. islandica*. Ossicles not a match for original illustrations for *P. mus* (Djakanov, 1952) which were from the deeper skin layer, though closer to the redescription of *P. mus* by Kremenetskaia et al. (2021). Dorsal ossicles with only one pair of apophyses (fig. 8e) are also a feature of *P. dubia* as redescribed in the same paper, though not as obviously dominant here. Combination of external and ossicle morphology make this distinctly different from other *Peniagone* examined. Here we identify specimen to OTU level as *Peniagone* sp MoV. 7320; additional review of literature and more complete material required to confirm this as a new species.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Cocos Abyssal Stn., 3431–5414 m.

References (for genus *Peniagone*). Djakanov (1952), Hansen (1975), Kremenetskaia et al. (2021), Théel (1882).

***Peniagone* sp. MoV. 7321**

Figure 9a–q, Appendix 1, Table S1, Figure S1

Material examined. NMV F308228* (1) [IN2022 V08 122].

Diagnosis of IOT material. Single, elongated grey-cream specimen, up to 110 mm long (120 mm including tentacles), 30 mm wide and 15 mm high (preserved). Thin, semitranslucent skin with longitudinal muscles and mud gut content clearly visible (fig. 9a). White when preserved. Typical *Peniagone* shape, raised dorsally and with a slight convex curve to the ventral surface. Anus dorsal, terminal. Mouth ventral on short neck with approximately ten flaccid, extended tentacles. Anterior velum present but too damaged to assess. Tube feet all removed. Body wall with a mixture of cross and rod ossicles. Dorsal and lateral body wall with irregular spinous branched rods and low, flattened *Peniagone*-style crosses. Crosses ~200 μm in diameter with a smooth central beam, four arms flat to slightly curved and often irregular in shape and length, and with or without four short thick spinous vertical apophyses. Ventral wall also had smaller spinous primary cross ossicles, with smooth central beams, four (2–4) short apophyses, and irregular, "wiggly" arms of uneven length (fig. 9g, h). Irregular spinous rods also present (fig. 9k–m). Tentacle ossicles with smooth to spinous irregular crosses, variably with four short apophyses, or apophyses-free, and rods (fig. 9n–q). Crosses with apophyses in both smaller and larger forms, and apophyses-free crosses in smaller and larger forms. Rods straight, curved to strongly curved variably smooth to spinous.

Remarks. A combination of external and ossicle morphology, particularly the low crosses and unique small spinous primary crosses with uneven arms, make this specimen distinctly different from other IOT *Peniagone* examined. Ossicles not like *Peniagone* sp. MoV. 7320 above, and not a match for original illustrations for *P. mus* (Djakanov, 1952) or redescription by Kremenetskaia et al. (2021). Here we identify specimen to OTU level as *Peniagone* sp. MoV. 7321; additional review of literature is required before this specimen can be confirmed as a new species.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Investigator Ridge Abyssal Stn., 4980–4990 m.

References (for genus *Peniagone*). Djakanov (1952), Hansen (1975), Kremenetskaia et al. (2021), Théel (1882).

***Peniagone* sp.**

Appendix 1, Table S1.

Material examined. NMV F308146 (5), NMV F308152 (1), NMV F308155 (1) and NMV F308156 (2) [IN2022 V08 105]; NMV F308229 (1) [IN2022 V08 122]; NMV F308321 (1) [IN2022 V08 187].

Remarks. Six additional lots from three different stations are identified to *Peniagone* based on external morphology and ossicles but without sufficient characteristics or genetics to take further at this stage.

Genus ***Psychroplanes*** Gebruk, 1988

Diagnosis. (translated from Gebruk, 1988). Body ovoid, length to width ratio ~2:1. Dorsally convex, body height equal to or exceeding body width. Dorsal ambulacral appendages include a velum and 1–2 pairs of small papillae behind this. Tube feet 5–10 pairs. Calcareous ring pieces with seven pairs of arms. Dorsal ossicles are crosses with well-developed apophyses. Number of apophyses varying: one central apophysis arising from centrum of the cross, and one apophysis on each of the arms can be present. Ventral ossicles also cross-shaped with varying number of apophyses.

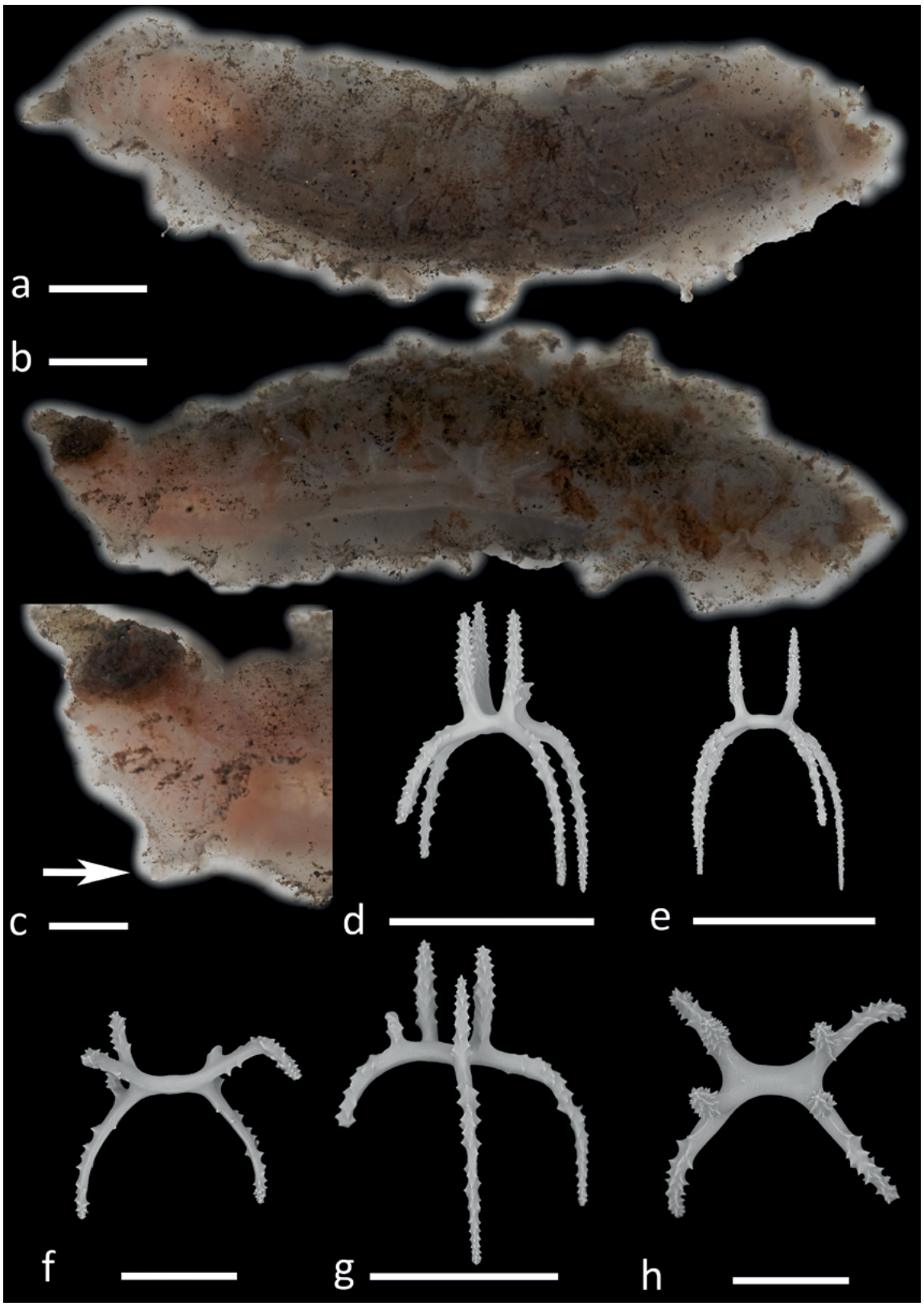

Figure 8. *Peniagone* sp. MoV. 7320. a, b, shipboard images; c, arrow to damaged velum; ossicles: d–h, dorsal body wall *Peniagone*-type crosses, high (d, e), wide (f, g), and low (h), NMV F308335; scale bars: a, b=1 cm, c=0.5 cm, d= 300 μm, e=400 μm, f, h= 100 μm, g=200 μm.

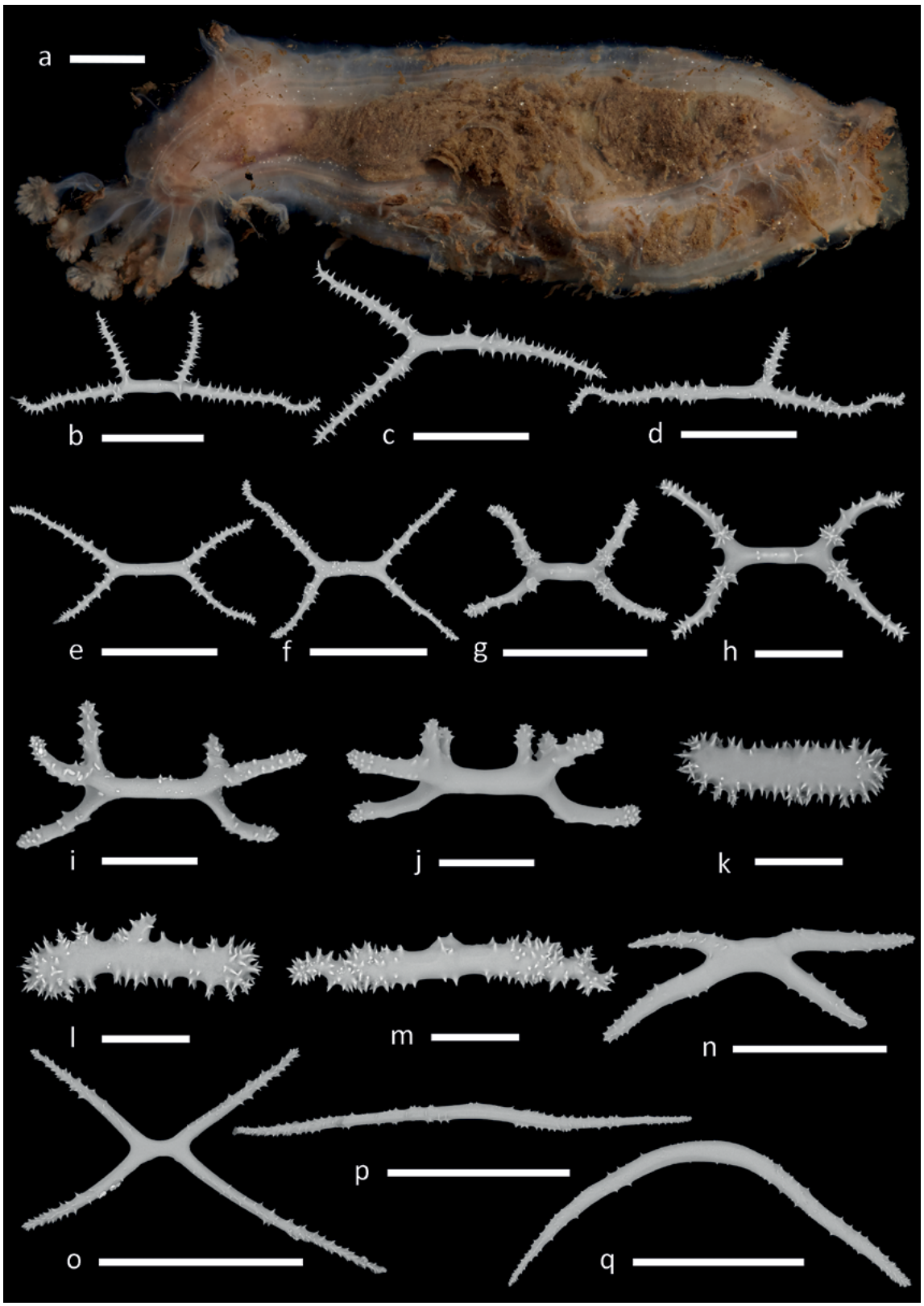

Figure 9. *Peniagone* sp. MoV. 7321. a, shipboard image; ossicles: b–f, dorsal body wall, g–m, ventral body wall, n–q, tentacles, NMV F308228; scale bars: a=1 cm, b–g=100 *μm*, h–m= 50 *μm*, n=200 *μm*, o, q= 300 *μm*, p= 400 *μm*.

Remarks. A rarely seen deep-sea genus known from mostly circumtropical and moderate latitudes. There are currently four accepted species of *Psychroplanes* worldwide, which had all been previously assigned to *Peniagone* (Hansen, 1975; WoRMS, 2024). This genus was erected to account for ossicles unique within Elpidiidae, robust crosses with arms arising from a single central point rather than a central beam (Gebruk, 1988). While the genus is not currently reported from Australia in ALA, *Psychroplanes rigida* (as *Peniagone rigida*) was collected from the eastern Australian abyss off New South Wales in 2017 (NMV Catalogue, 2024). Four lots of *Psychroplanes convexa* are recorded here from the IOT voyages at depths of 2973–4990 m. Diagnosis from translation of the original Russian (Antonina Kremenetskaia, pers comm., 2024).

Psychroplanes convexa (Hansen, 1975)

Figure 10a–j, Appendix 1, Table S1, Figure S1

Peniagone convexa Hansen, 1975: 135–136, figs 57–58, 95: 1, pl. 10: 4–5.

Psychroplanes convexa.—Gebruk, 1988 (in Russian): 917.

Material examined. NMV F308185 (1) [IN2022 V08 115]; NMV F308230 (1) [IN2022 V08 122]; NMV F308284* (1) and NMV F308285 (1) [IN2022 V08 151].

Diagnosis of IOT material. Preserved specimens soft, ovoid, opaque to cream or light purple to grey. Dorsally high and curved, ventrally flattened with sole. All specimens damaged but similar "pig shape" to *Amperima*. Length: width ratio ~2:1, up to 10 cm long and 5 cm wide (NMV F308284, preserved). Anterior velum damaged but broad and thick. Mouth ventral, up to ten tentacles with soft often folded discs, lobed at edges, on short/thick stalks. Large discrete tube feet bordering ventral sole (>5 each side). Skin a little rough/prickly due to cross-shaped ossicles. Cross-ossicles of variable size and predominantly two types. Slender type with four horizontal base arms originating from the centre, and four shorter horizontally directed apophyses, giving the appearance of a small cross on top of a large one when viewed from above (fig. 10e). Arms are smooth with typically bluntly spinous ends (fig. 10f). More robust cross-ossicles, less regular than the slender type, with four outwardly projecting arms, slightly curved up at end and variably spinous (fig. 10g–j). Arms and four shorter vertical, straight to outward-curving apophyses originate from a square-like centre. Tentacles and tube feet similar, with some rods also seen.

Remarks. Presence of true cross ossicles with arms arising directly from centre place these specimens in *Psychroplanes* rather than *Peniagone*. Morphologically also like *Psychroplanes obsoleta* (Hérouard, 1899), which has not been recorded for the Indian Ocean, but more than five pairs of tube feet places this in *Psychroplanes convexa* (Hansen, 1975). Minute dorsal pair of papillae behind anterior velum not seen in these damaged specimens. All specimens have ossicles matching the original *P. convexa* description and illustrations (Hansen, 1975), though NMVF308284 (fig. 10e–g) and NMVF308285 (fig. 10h–j) are the most typical, with some *Peniagone*-style ossicles seen in tentacles for NMVF308230 and some more irregular and spinous versions of robust crosses in NMVF308185. There is insufficient resolution in the COI data to confidently determine its phylogenetic placement within Elpidiidae (fig. S1).

Distribution. Indian Ocean: off east Africa to Sri Lanka, Australian IOT.

Full bathymetric range. 2973–4990 m (IOT 2973–4990 m).

Type locality. Indian Ocean, between Madagascar and Mombasa, and off Sri Lanka, 4040–4820 m.

This species and genus not previously recorded from Australia in AFD or ALA (accessed January 2024). This IOT material represents a geographic and bathymetric range extension for the species and the first record for Australia.

References. AFD (2024), ALA (2024), Gebruk (1988), Hansen (1975)

Genus ***Scotoplanes*** Théel, 1882

Diagnosis (following Hansen, 1975). Dorsal papillae separated into one pair of large anterior papillae, and one large and one small pair placed close together on the middle or posterior part of the body. Tentacle discs with a few, large papillae on the surface and a knobbed margin divided into a pair of large, aboral, retractile lobes. Ossicles consisting of rods and Cs. Calcareous ring consisting of five isolated pieces, each with four pairs of arms.

Remarks. *Scotoplanes* are a charismatic genera of sea cucumber and one of the groups often referred to as sea pigs. They have been observed to aggregate in large densities, particularly around food sources such as whale fall (Gutt and Piepenburg, 1991) and have also been known to host parasitic or hitchhiking invertebrates (Barry et al., 2017). Of the five currently accepted species of *Scotoplanes* worldwide, only *S. globosa* has been previously recorded for Australia (WoRMS and ALA January 2024). A single lot of *S. globosa* was recorded from the IOT voyages at 1019–1023 m.

Scotoplanes globosa (Théel, 1879)

Figure 11a–f, Appendix 1, Table S1

Elpidia globosa Théel, 1879: 14–15, figs 17–19.

Elpidia murrayi Théel, 1879: 16, figs 23–25.

Scotoplanes globosa.—Théel 1882: 29–31, pls. 4, 5: 3, 34: 8–9, 36: 5–6, 44: 12.—Vaney 1908: 409–410, pl. 3: 25–28.—Hansen 1956: 40–41.—D'yakonov et al., 1958: 360.—Agatep 1967: 55–57, pl. 4: 1–13.—Hansen, 1975: 167–169, fig. 83: 9–12, 95: 4, pl. 9: 9.—Gebruk, 1983 (in Russian): 1362–1364, fig. 1: 1–11.—Thandar 1999: 391–392, figs 10, 15f.—O'Loughlin et al., 2020: 21, add. file 1: sup. table S1.

Scotoplanes murrayi (Théel).—Théel 1882: 34, pls. 3: 3–4: 34: 2, 44: 4; Savel'eva 1966, p. 295, pl. 64: 7.

Scotoplanes theeli.—Ohshima, 1915, pp. 242–243.—Ohshima 1916–1919, 3 figs.

Material examined. NMV F308303 (4) [IN2022 V08 157].

Diagnosis of IOT material. Specimens small and damaged with minimal features; soft, round to oval "pigs" up to 40 mm long and 24 mm wide (preserved). Light pink with smooth, thin, and partially transparent skin. Mouth terminal to ventral with ring of mostly removed orange/red tentacles. Specimens grey when

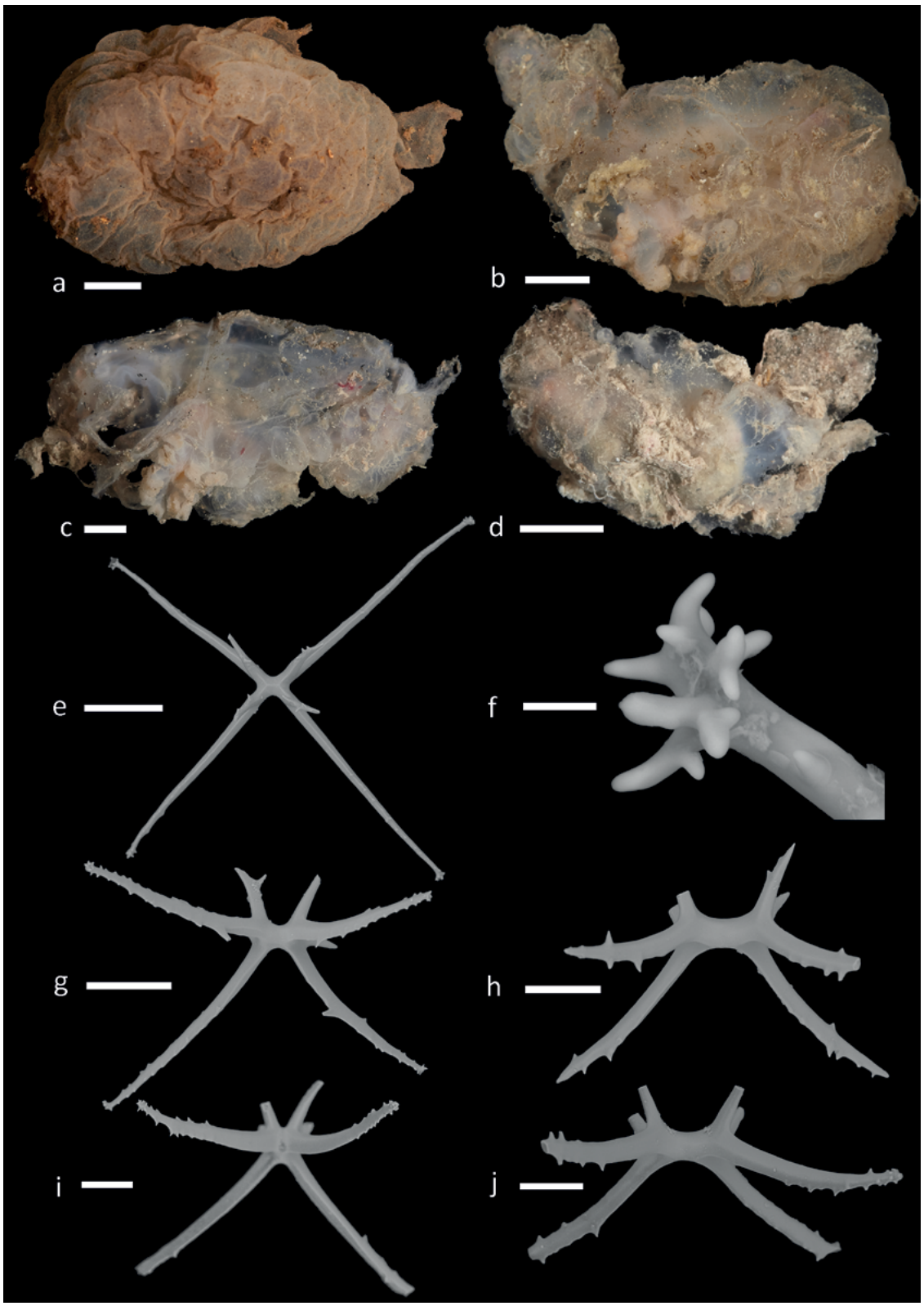

Figure 10. *Psychroplanes convexa*. a–d, shipboard images, a, NMV F308230, b, NMV F 308185, c, NMV F308284, d, NMV F308285; ossicles: slender (e) and robust (g–j) cross ossicles from body wall of NMV F308284 (e–g) and NMV F30825 (h–j); bluntly spinous end of slender cross arm (f); scale bars: a–d=1 cm, e, g=100 *µm*, f=5 *µm*, h–j=50 *µm*.

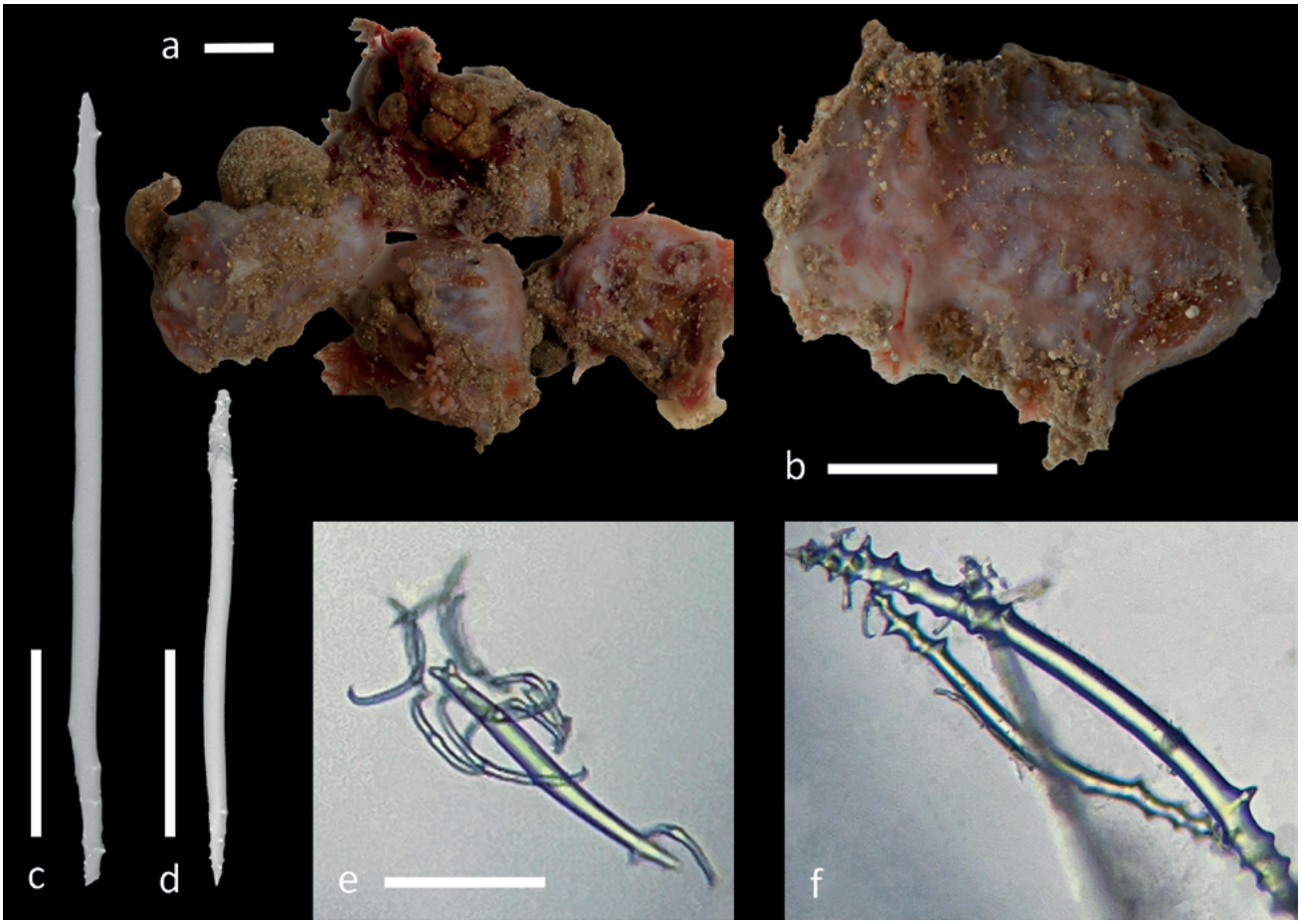

Figure 11. *Scotoplanes globosa*. a, b, shipboard images; ossicles: c, d, body wall; e,f, tentacles, NMV F308303; scale bars: a,b=1 cm, c,d=100 *μm*, e=50 *μm*.

preserved. Anus subdorsal to terminal. Discrete tube feet along outer sides of ventrally flattened sole and some evidence of dorsal papillae. Ossicles only *S. globosa* type rods (104–376 *μm*) and small Cs (32–56 *μm*). Rods variably spinous, particularly distally, and Cs variably individual or clumped (fig. 11e).

Remarks. These specimens are small compared to one type specimen recorded at 18 cm long (Théel, 1879), and the single ~5 cm specimen collected previously from Australian waters (O'Loughlin et al., 2020), however specimens have been recorded from off Cape Point, South Africa, at a maximum size of 15 mm (Thandar, 1999).

Distribution. Largely cosmopolitan (excluding North Atlantic) and typically at depths of over 1000 m.

Full bathymetric range. 545–6770 m (Hansen, 1975 in reference to Ohshima, 1915 and Thandar, 1999) (IOT 1019–1023 m).

Type locality (as *Elpidia globosa*). Southern Indian Ocean south of Australia, 3566 m, and South Pacific Ocean off Chile, 3950 m.

This species not previously recorded from Australia in AFD but recorded from a single station in Freycinet Marine Park off north-east Tasmania at 2751–2820 m in ALA (January 2024). This IOT material represents a geographic range extension for the species in Australia.

References. AFD (2024), ALA (2024), Gebruk (1983), Hansen (1956), Hansen (1975), O'Loughlin, Mackenzie and O'Hara in O'Hara et al. (2020), Thandar (1999), Théel (1879), Théel (1882), Takano et al. (2019).

Elpidiidae sp. Danielssen and Koren, 1879

Appendix 1, Table S1, Figure S1

Material examined. NMV F296840* (1) [IN2021 V04 007].

Diagnosis of IOT material. A single additional specimen lot identified to Elpidiidae. Specimen was severely damaged (in two pieces), opaque pink/orange gelatinous specimen. No real shape retained but with approximately seven darker red tentacles remaining. One specimen piece >50 mm long and ~25 mm wide from shipboard photograph. Irregular branched ossicles, not

crosses, large and flat, ~650 *µm* in diameter, with a short smooth central beam branching into up to eight long (up to ~460 *µm*) spinous arms, but no apophyses or other vertical structures. Rare additional smoother irregular branched crosses up to 136 *µm* long, plus *Peniagone*-style crosses with short apophyses and out-turned arms.

Remarks. No likely species were found in Hansen's (1975) Elpidiidae key and descriptions, and no similar ossicles are observable in more recent publications. Based on COI and 16S, this specimen is basal to *Peniagone*. For 16S, it forms a clade with *Protelpidia murrayi*, *Amperima robusta*, and *Scotoplanes hanseni*, but there is no support for this grouping in COI (fig. S1). Without additional material, this specimen is kept at family level for now.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Christmas Island Territory, Christmas Island SE Stn., 3200–3345 m.

References. Danielssen and Koren (1879), Hansen, (1975), Kremenetskaia et al. (2021).

Family **Laetmogonidae** Ekman, 1926

Diagnosis (amended from Rogacheva et al., 2009). Ossicles wheel-shaped, scattered rods or (in *Laetmogone violacea*) spinous crosses or (in *Gebrukothuria*) rods only. Tube feet conspicuous, evenly distributed along entire ventrolateral radii, never fused into a brim. Midventral tube feet present or absent. Papillae numerous, placed along dorsal radii or dorsal and ventrolateral radii; papillae on dorsal radii free, on ventrolateral radii (if present) free or fused; in rare cases fused to form an anterior brim. Circumoral papillae present or absent. Calcareous ring reduced or not calcified. Gonad composed of numerous branched ducts and tubules.

Remarks. The Laetmogonidae are a cosmopolitan family with seven currently accepted genera, three of which were previously recorded for Australia: *Benthogone, Laetmogone* and *Pannychia*. Found most commonly on the continental slope, these sea cucumbers have an elongated body with dorsal papillae and ventral-oriented feeding tentacles. IOT material includes examples from *Benthogone* and *Psychronaetes*. Diagnosis of family amended here to include rare case of fused anterior brim.

Genus ***Benthogone*** Koehler, 1895

Diagnosis (following Hansen, 1975). Circumoral papillae present. Midventral tube feet absent. Dorsal papillae small, in single rows, double rows, or bands. Ventrolateral papillae absent. Ossicle wheels lack marginal teeth.

Remarks. Of the three currently accepted species of *Benthogone* worldwide, two have been previously recorded for Australia: *B. abstusa* and *B. fragilis,* both off northwestern Australia (WoRMS and ALA January 2024*). Five lots of *Benthogone* were recorded from the IOT voyages at depths of 2156–2435 m, with four of those identified as *B. rosea* – a new species record for Australia.

*ALA records one specimen of *B. rosea* collected from the Mediterranean and lodged at the Australian Museum.

Benthogone rosea Koehler, 1895

Figure 12a–f, Appendix 1, Table S1, Figure S1

Benthogone rosea Koehler, 1896: 114–117, figs 2, 3, 36, 46.—Perrier, 1902: 399–405, pls. 14: 1–2, 19: 8–14.—Grieg, 1921: 5–6.—Hérouard, 1923: 38–39.—Heding, 1940: 369.—Madsen, 1947: 15–16.—Pawson, 1965: 219–221, pl. 5.—Gebruk et al. 2014: 159.
Benthogone rosea var. *cylindrica* Perrier, 1896: 900.
Benthogone rosea var. 4-*lineata* Perrier, 1896: 900.
Benthogone quadrilineata.—Heding, 1940: 369.—Heding, 1942: 15.
Non *Benthogone quatrolineata*.—Augustin, 1908.

Material examined. NMV F296864* (12) [IN2021 V04 031]; NMV F308147 (1) and NMV F310371 (1) [IN2022 V08 105]; NMV F308320 (1) [IN2022 V08 187].

Diagnosis of IOT material. Specimens typically gelatinous, light red, pink, or mauve colour before preservation, with ventral colour often darker, particularly along the midventral, which was occasionally furrowed. Firmer and purple to mauve when preserved. Elongate body slightly raised and curved dorsally, rounded anteriorly and posteriorly and with thin lateral edges. Anus terminal, subdorsal. Ventral mouth often with a darker colouration than body, 15–20 retractable peltate purple tentacles surrounded by circumoral ring of small papillae (fig. 12c). Dorsal radial rows of slender papillae (often retracted and/or hard to detect), and ventral retractable tube feet on lateral margins, with end-disks often visible. IOT specimens up to 110 mm long, 17 mm wide and 7 mm high (NMV F308320 preserved), but average specimen less flattened (e.g. 65 mm long, 12 mm wide and 12 mm high; NMV F296864.1 – preserved). Body wall ossicles large to small *Laetmogone*-like wheels, slightly curved, with central four-rayed raised primary cross. Wheels symmetrical but perimeter is undulating and size graduates from small to large. Larger wheels more typically with eight spokes ~104–218 *µm* dorsally but smaller ventrally. Smaller wheels nine (typically 10 or more) spokes and ~70–118 *µm*. No teeth on rims. The wheel centre is almost filled, with only a narrow slit or hole in the calcareous membrane (presumably the nave as noted in Hansen, 1975), typically below the primary cross. Tentacles with clumps of irregular, curved spinous rods plus wheels. Wheels also observed in papillae and tube feet.

Remarks. There are many similarities with *Laetmogone*, but for intact specimens the presence of circumoral papillae distinguishes *Benthogone* from other genera in Laetmogonidae. The IOT material was a good match to the type description for *B. rosea*, though the midventral was more rust-red than "striking purple" and some of the wheel sizes differed as noted below. Distinguished from *B. fragilis*, which has greater number and different distribution of papillae, and from *B. abstrusa*, which has unretractile larger tube feet and conical dorsal papillae. Spinous rods were only observed in tentacles, some of the larger wheel ossicles were up to 218 *µm* – much larger than the type specimens for the species in Koehler (1895) (100 *µm*) and those observed in Hansen (1975) (160 *µm*). Hansen also saw no correlation in wheel size and spoke number, whilst we observed (like Koehler in the type specimens) typically eight spokes in the larger wheels for IOT specimens, and typically ten or more spokes for smaller wheels. Some specimens had lost some or all their 15–20 tentacles

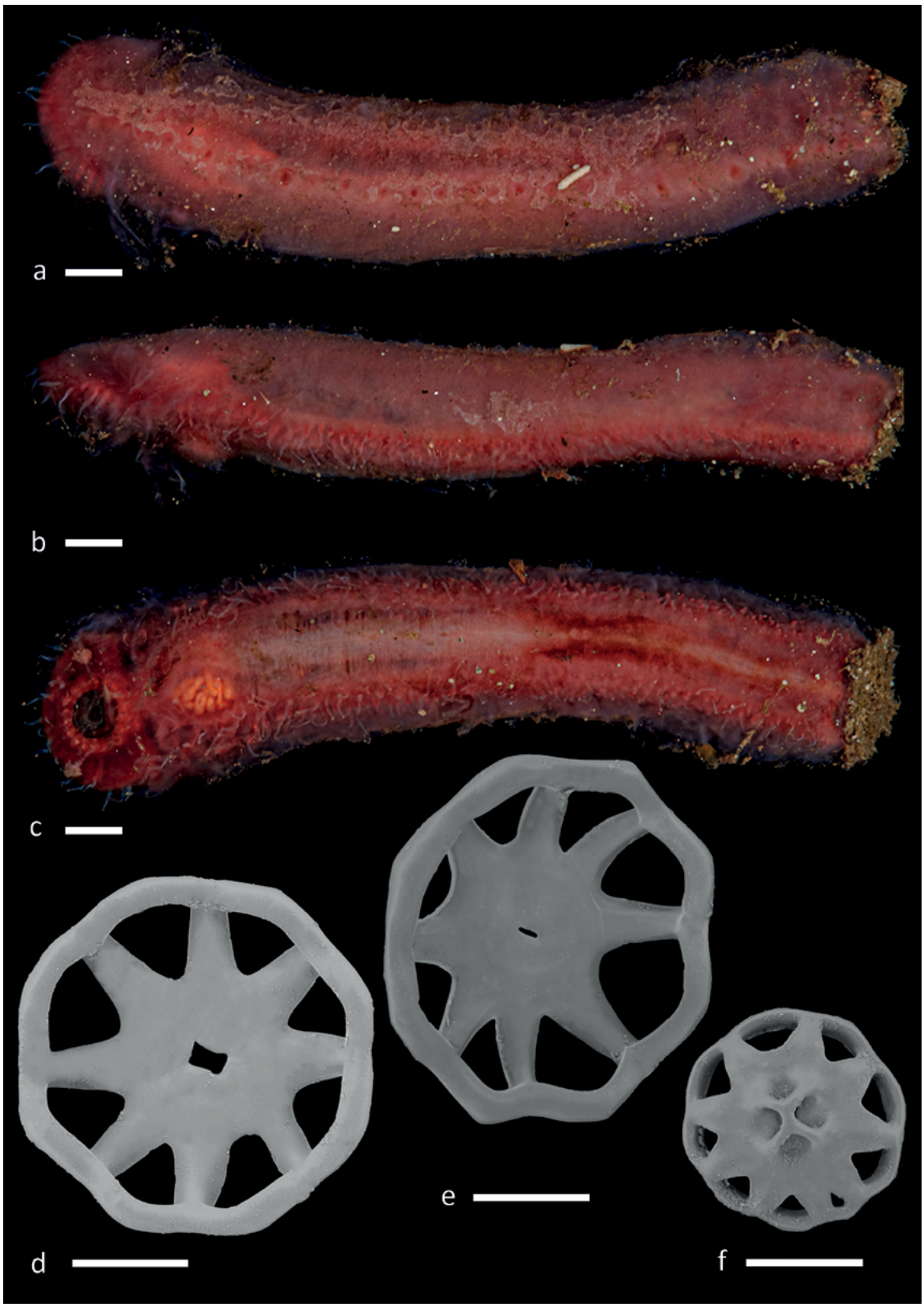

Figure 12. *Benthogone rosea*. a–c, shipboard images showing live colour and circum-oral papillae, NMV F308147; ossicles: d–f body wall wheels, NMV F296864; scale bars: a–c=1 cm, d–f=50 μm.

though trawl damage. Note that the outer skin was susceptible to damage or stripping during collection, and specimens clumped together during preservation, making it harder to see external characters later. Good shipboard photography in and out of water pre-preservation assisted with the observation of external characters. In addition to the original description (and illustration) in Koehler (1895), Hansen (1975) provides some good descriptions and keys and can be used in conjunction with the *Laetmogone* character table from Thander (1998) to rule out *Laetmogone* and other *Benthogone* species. The specimen sequenced for COI and 16S (NMV F296864) does not group with *Benthogone abstrusa* in either gene tree; genetic placement within Elasipodida is unclear (fig. S1). Based on morphological features, we maintain its identification here as *B. rosea*.

Distribution. Eastern North Atlantic from Ireland to Cape Verde (off Mauritania), north of New Zealand (South Pacific), and Indian Ocean (off east Africa and Australian IOT) (Hansen, 1975; Gebruk et al., 2014; this work).

Full bathymetric range. 1103–2480 m (Hansen, 1975; Gebruk et al., 2014) (IOT 2189–2435 m).

Type locality. North Atlantic, Bay of Biscay, 1300 m.

This species not previously recorded from Australia in AFD or ALA (January 2024).

This IOT material represents a geographic range extension for the Indian Ocean and first record for Australia.

References. AFD (2024), ALA (2024), Gebruk et al. (2014), Hansen (1975), Koehler (1895), Massin (1993), Thandar (1998).

Benthogone sp.

Appendix 1, Table S1.

Material examined. NMV F308318 (2) [IN2022 V08 187].

One additional *Benthogone* lot recovered from 2418–2156 m, with one whole damaged specimen and second completely stripped specimen with only central cylindrical gut remaining. Whole specimen dorsoventrally flattened with clear circumoral papillae, translucent light pink to white skin, and rows of small, retracted papillae on each dorsal radii. Unable to identify past genus level at this stage due to absence of tube feet and enough diagnostic ossicles.

Genus: ***Psychronaetes*** Pawson, 1983

Diagnosis (amended from Pawson, 1983). Body typically fusiform, maximum length approximately 30 cm. Ventrolateral radii each with approximately 15 tube feet, bare along midventral line. Dorsal papillae on each radii, and additionally forming an irregular anterior brim. Fifteen tentacles, no circumoral papillae. Ossicles in body wall are wheels, one type but variable size, typically 50 *μm* or more in diameter, usually with 9–12 spokes.

Remarks. *Psychronaetes* is a monotypic genus represented by *P. hanseni*, which was described from two type specimens in the eastern central Pacific CCZ and not previously recorded for Australia (WoRMS and ALA January 2024). Similar in morphology to *Laetmogone*, it can sometimes be split in underwater images thanks to a distinct "head" region and fused anterior fringe of dorsal papillae. A potential new species of *Psychronaetes* (sp. CCZ_101) was recently reported from the abyssal seafloor of the central CCZ at 3132–3562 m (Bribiesca et al., 2022). A single damaged specimen, *Psychronaetes* sp. MoV. 7326**,** was collected from these IOT voyages at a depth of 3053–3144 m and is recorded below. Diagnosis of genus amended to be less restrictive with tube foot shape and papillae number and to clarify ossicle wheel description.

Psychronaetes sp. MoV. 7326

Figure 13a–v, Table 1, Appendix 1, Table S1, Figure S1

Material examined. NMV F308286* (1) [IN2022 V08 151].

Diagnosis of IOT material. Preserved specimen light violet to dark purple, medium-sized, elongated and dorsoventrally flattened ~130 mm long, 25 mm wide and 8 mm high. Very damaged specimen with a covering of mud and bryozoans (fig. 13a). Pronounced anterior constriction forming "neck" and ventral mouth with 15 tentacles on long stems terminating in dark purple elongate oval discs (fig. 13b). Anus appears dorsal and terminal. Body wall soft but suspect outer skin has been stripped. Evidence of dorsal papillae (row numbers not clear), and papillae modified to form a fused anterior brim. Bare midventral radii, but series of tube feet with dark purple discs at tips along each ventrolateral radii, appearing to fuse into a brim in some areas and torn off in others. Ossicles are wheels, all one type though varying in size, concave with smooth curved rim and partially or fully closed central nave with slightly raised central cross. Wheels with typically 12 (11–17) short outer spokes and four (3–4) inner struts as central cross (occasionally branching). Graduating in size but not always related to spoke number, though more common that large ones have 12 spokes and smaller ones ~15. Tube feet have some wheels slightly smaller again than in body wall. In this specimen, body wall wheels 64–240 *μm* (typically 120–240 *μm*), tentacle wheels 104–208 *μm*, and tube foot wheels 56–152 *μm*. The tentacle sample also had irregular rods of variable size (152–676 *μm*), often curved and with slightly spinous ends.

Remarks. The calcareous membrane closing the central nave of the ossicle wheels can be difficult to detect under some microscopes but is clear in SEM images. Many morphological features are not available for full comparison, but this IOT specimen is placed in *Psychronaetes* rather than *Laetmogone* morphologically through the presence of an anterior neck, fused brim of dorsal papillae, and larger ossicle wheels. The typical leathery body and fusiform shape for *Psychronaetes* genus is not obvious in this specimen, presumably due to damage and twisting mid-body. The neck is more obvious in the preserved specimen. It is distinguished from the only accepted species in *Psychronaetes*, *P. hanseni* – by typical ossicle size and spoke number, which, along with tentacle number (15 vs. 18) also distinguish it from *Psychronaetes* sp. CCZ_101 (see Table 1). While the IOT material is likely to represent a new species, it has not been formally erected here due to the damaged nature of

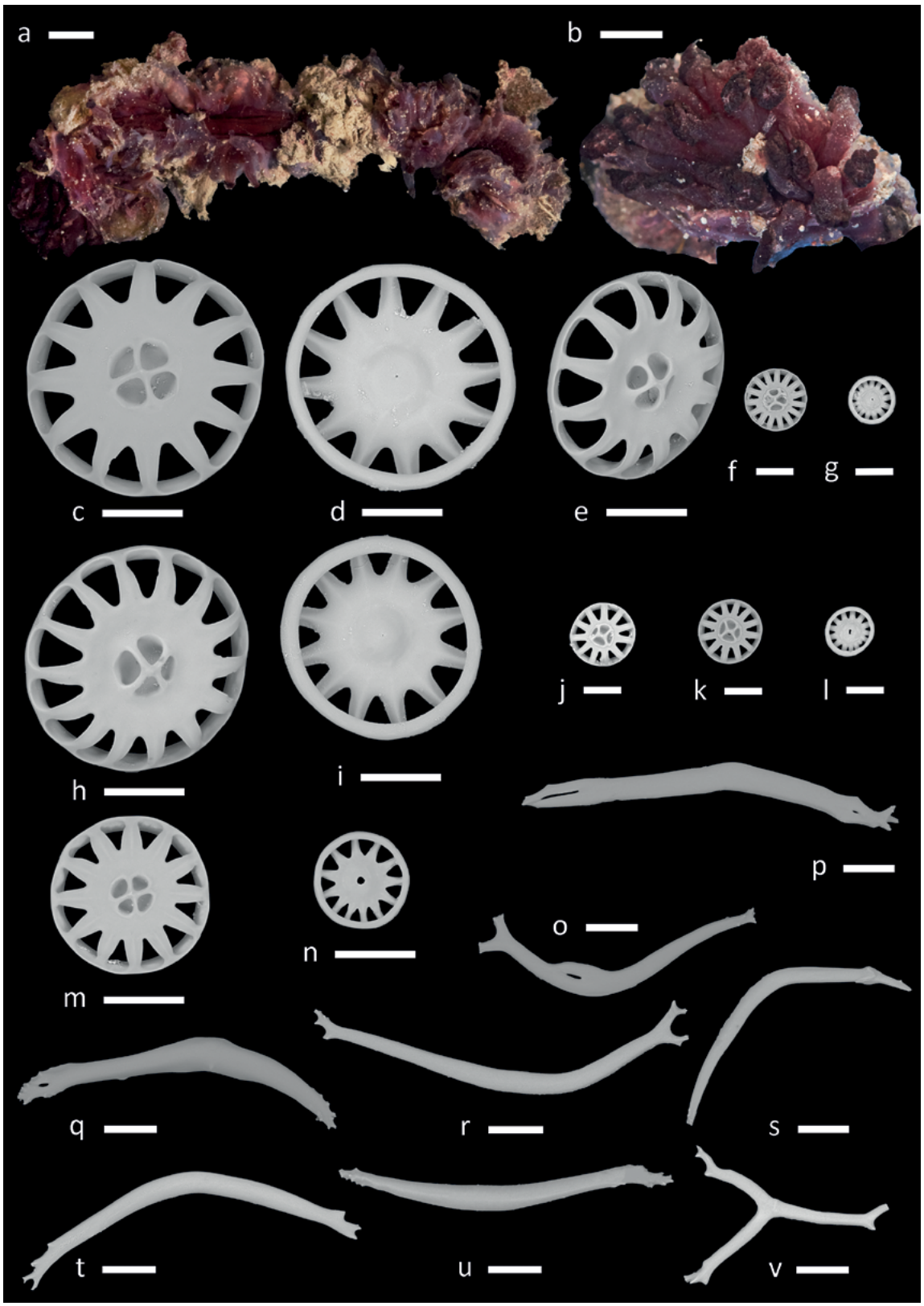

Figure 13. *Psychronaetes* sp Mov 7326. a, shipboard image whole body, b, tentacles; ossicles: c–i, body wall wheels, j–a, tube feet wheels, m–v, tentacle wheels and rods, NMV F308286; scale bars: a=1 cm, b=0.5 cm, c–e, h, i, m–v, =100 μm, f, g, j–l=50 μm.

Table 1. *Psychronaetes* comparison table.

Species & Distribution	Ossicles
Psychronaetes hanseni Pawson, 1983 (2 type lots only): Pacific Ocean, Clarion-Clipperton Zone (CCZ), 4800–5200 m	Body Wall: Wheels. One type, variable in size, smooth rim, short spokes, large central region, raised hub with 4 struts, dorsal larger than ventral, concave, 50–60 *μm* with 9–12 spokes. Tentacle ossicles: Wheels & rods
Psychronaetes sp CCZ 101 Bribiesca et al 2022 (4 specimens), Pacific Ocean, Clarion-Clipperton Zone (CCZ), 3132–3562 m	Body Wall: Wheels. One type, variable in size, smooth rim, short spokes, strongly concave, central primary cross with 4–6 struts, mostly four. Dorsal ossicles numerous, variable in size (77–340 *μm*) but mostly large with 10–16, mostly 12 spokes Tentacle ossicles: not noted
Psychronaetes sp Mov 7326 (this specimen): Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Raitt Ridge North Stn., 3053–3144 m	Body Wall: Wheels. One type, variable in size, smooth curved rim, concave, partially or fully closed central nave (visible under SEM), slightly raised central cross with mostly 4 struts. Wheel diameter typically 120–240 *μm* (64–240 *μm*) with 11–17 spokes. Larger wheels more commonly 12 spokes and smaller ones ~15. Tube foot ossicles: wheels slightly smaller again than in body wall (56–152 *μm*) Tentacle ossicles: Wheels (104–208 *μm*) & rods (up to 676 *μm*)
Distribution (for genus): Pacific and Indian Oceans. *Full bathymetric range* (for genus): 3053–5200 m This genus not previously recorded from Australia (AFD & ALA January 2024). This IOT material represents a major geographic and slight bathymetric range extension for the genus, and a potential new species.	

the single specimen found. Further material and more morphological features would be optimal before describing past *Psychronaetes* sp. MoV. 7326. There is insufficient genetic resolution to determine how this species is related to those within the order Elasipodida (fig. S1).

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Raitt Ridge North Stn., 3053–3144 m.

References. AFD (2024), ALA (2024), Bribiesca et al. (2022), Hansen (1975), Pawson (1983).

Family **Pelagothuriidae** Ludwig, 1893

Diagnosis. (see Ludwig, 1893)

Remarks. Widespread at bathyal to hadal depths, the Pelagothuriidae are a small family of swimming sea cucumbers with only two currently accepted genera and species: *Enypniastes eximia* and *Pelagothuria natatrix*. Both employ a brim of fused tube feet for swimming, though only *P. natatrix* is thought to be truly pelagic. Only *Enypniastes* has been reported for Australia, and again only this genus was found in the IOT material.

Genus: ***Enypniastes*** Théel, 1882

Diagnosis. (see Théel, 1882)

Remarks. Monotypic and cosmopolitan genus with *E. eximia* previously recorded in Australian waters (WoRMS and ALA January 2024). Unfortunately, this species does not have diagnostic ossicles and is often damaged during trawls. Remotely operated vehicle footage in more recent years has allowed much better observation of features including the shape that earned it the moniker "headless chicken monster" and the swimming behaviour that has given it names like "Spanish dancer" or "dreamer" (Wikipedia, 2024). It is also known to shed bioluminescent skin (Robison, 2009). It is recorded here from five stations in the IOT at 643–1991 m.

Enypniastes eximia Théel, 1882

Figure 14a–c, Appendix 1, Table S1, Figure S1

Enypniastes eximia Théel, 1882: 56–57, pl. 8: 6–7.—Sluiter, 1901b: 77–79, pls. 2: 8–9, 5: 5.—Mitsukuri 1912: 215–218, pl. 7: 59–60.—Heding, 1950: 118.—Pawson, 1976: 289, pl. 1a.—Pawson, 1982: 132, fig. 3a, c.—Ohta, 1985: 127–128.—Gebruk, 1989: 61–63, fig. 2: 6–7.—Miller and Pawson, 1990: 10–13, figs 1c, d, 4.—Bluhm and Gebruk, 1999: 181, fig. 6d.—Rogacheva et al., 2013: 611.—Gebruk et al., 2014: 165. —Wirawati and Setyastuti 2021: 464, fig. 5a, b.—Sigwart et al., 2023: 1–2, fig. 1.

Enypniastes decipiens Koehler and Vaney, 1910: 95–96, pl. 3: 1.

Enypniastes globosa Hansen and Madsen, 1956: 58–59, pl. 1: 4–5.

Peniagone ecalcarea Sluiter, 1901a: 74–75, pl. 10: 2.

Enypniastes ecalcarea.—Heding 1950: 118, figs 1–4.

Euryplastes obscura Koehler and Vaney, 1905: 71–72, pl. 4: 7–9.

Pelagothuria bouvieri Hérouard, 1906: 1–6, fig. 2.—Hérouard, 1923: 94–99, pl. 6: 1.

Planktothuria diaphana Gilchrist, 1920: 373–381, figs 1–4.

Enypniastes diaphana.—Billett et al. 1985: 400–403, fig. 2.

Material examined. NMV F296837* (1) [IN2021 V04 005]; NMV F296847* (1) [IN2021 V04 013]; NMV F308201 (1) [IN2022 V08 116]; NMV F308208 (1) and NMV F308209 (1) [IN2022 V08 117]; NMV F308331 (1) [IN2022 V08 195].

Diagnosis of IOT material. Specimens fragile, gelatinous, and bulbous with a convex dorsal surface, flattened ventrally, wider anteriorly, and often translucent, with visible gut. IOT specimens reddish-brown to dark purple with a whiteish, translucent cover and up to 100 mm long and 35 mm wide (NMV F308201 pre-

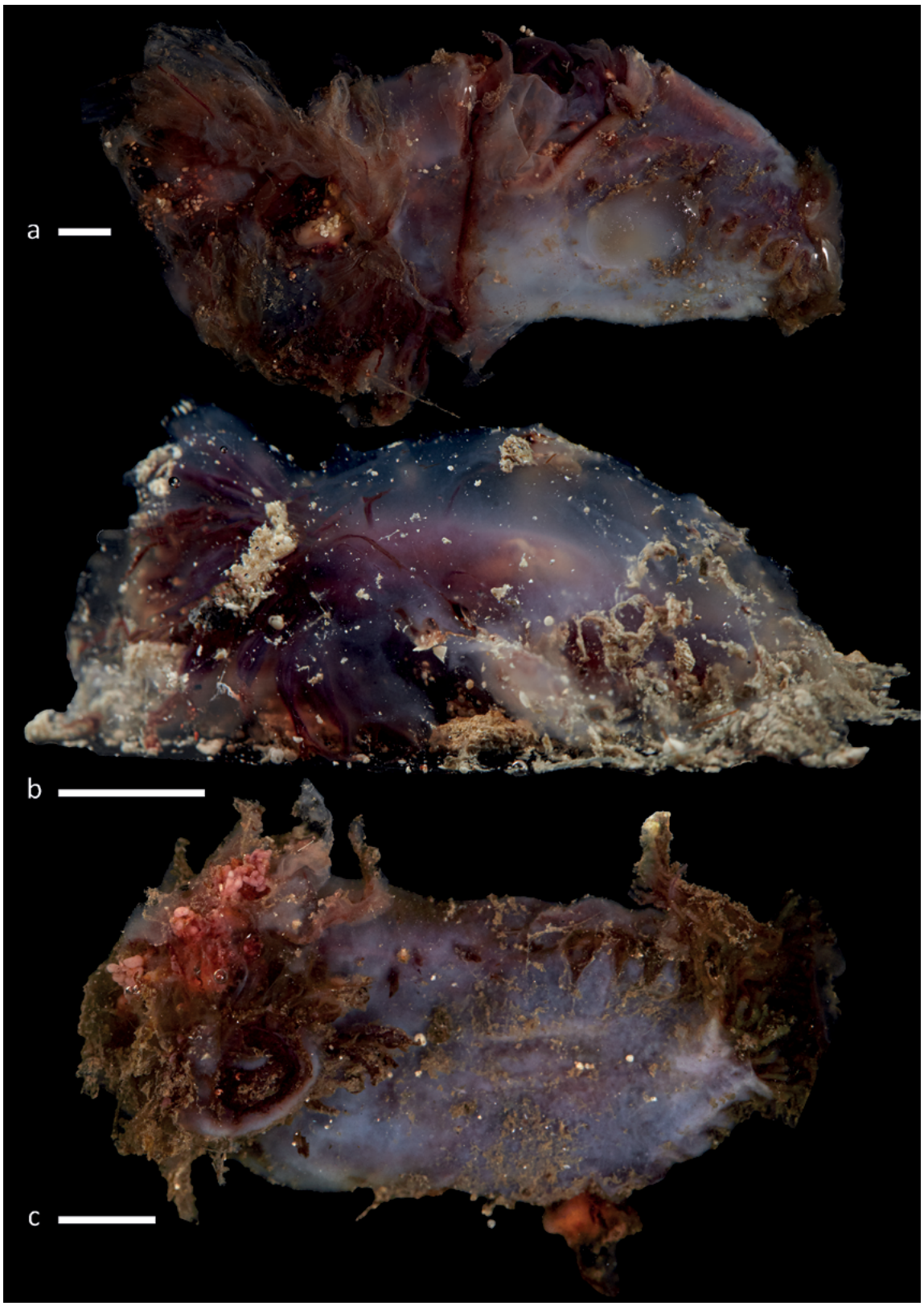

Figure 14. *Enypniastes eximia*. a–c, shipboard images showing live colour, anterior cowl, dorsal papillae, and posterior lateral brim, a, NMV F308201, b, NMV F296847, c, NMV F308209; scale bars: a–c=1 cm

preservation). Mostly light grey with some purple after preservation. Anus dorsal. Mouth ventral behind distinctive broad anterior cowl, up to 65 mm wide, made from a brim of fused tube feet, presenting as canal-like projections with processes at ends, often damaged, torn, and stringy in preserved specimens. Tentacles and canals in anterior cowl typically a darker maroon purple. IOT specimens are all damaged with few additional features, but when visible these include large leaf-like bifurcated tentacles, irregular dorsal papillae (fig. 14b), and two fin-like posterior lateral brims made from fused tube feet (fig. 14c). Ossicles, internal respiratory trees, and calcareous ring are all absent in this species.

Remarks. The previous six species of *Enypniastes* were all synonymised (Gebruk, 1989) making *E. eximia* the only likely identification here. Descriptions of the type specimens (Théel, 1882) and more complete collected specimens (e.g. Sluiter, 1901a; Wirawati and Setyastuti, 2021) include a typical body ratio of 1:2 (twice as long as wide), 12–14 canals in the anterior cowl, up to 20 leaf-like bifurcated tentacles, long dorsal papillae of varying number, and 8–15 fused podia creating the two fin-like posterior lateral brims. Some additional free lateral tube feet are noted in Sluiter, but Wirawati and Setyastuti note that tube feet are absent. Type specimens are 72 mm long and 32 mm wide, but species has been observed up to 250 mm in length (Rowe et al., 2017). Despite damage, available morphology in IOT specimens matches previous reports, including ~1:2 body ratio, though occasionally more elongate. Based on 16S sequences, p-distances between samples here range from 2.3% to 6.6% (fig. S1). For Holothurians, this falls within the range of within-species divergence, so we are comfortable with identifying all specimens here as *E. eximia*.

Distribution. Cosmopolitan with global distribution including reports from as far north as the Aleutian Trench off Alaska, south to Antarctica, and from surface to hadal depths (6900 m Java Trench). Very common in north-east Atlantic.

Full bathymetric range. 0–6900 m (IOT 643–1991 m).

Type locality. South Pacific Ocean (off north-east New Zealand), 2030 m.

This species reported as widespread in Australia in AFD (January 2024) and recorded from surface to 2259 m in ALA (January 2024) including off Western Australia, New South Wales, Tasmania, and South Australia (Great Australian Bight). This IOT material agrees with worldwide distribution of the species.

References. AFD (2024), ALA (2024), Billett et al. (1985), Gebruk (1989), Gebruk et al., (2014), Miller and Pawson (1990), Rogacheva et al. (2013), Rowe, O'Hara and Bardsley in Byrne and O'Hara (2017), Sigwart et al. (2023), Théel (1882), Wirawati and Setyastuti (2021).

Family **Psychropotidae** Théel, 1882

Diagnosis (following Hansen, 1975). Tentacles 10–18. Brim of tube feet surrounding the body and midventral tube feet present. Ossicles cross-shaped or rod-shaped. Calcareous ring absent or consisting of a diffuse network.

Remarks. Psychropotidae are a widespread deep-sea family, typically found from abyssal depths to the continental slope. The group includes the often photographed "Gummy Squirrel" *Psychropotes* with its sail-like dorsal appendage (Heffernan, 2019). Of the three currently accepted genera, two – *Benthodytes* and *Psychropotes* – are found in Australian waters. At least three species of *Benthodytes* and three of *Psychropotes* were observed for the IOT here.

Genus: ***Benthodytes*** Théel, 1882

Diagnosis (following Hansen, 1975). Anus dorsal. Unpaired dorsal appendage absent. Circumoral (or post-oral) papillae present. Tentacles soft, pliable and retractile.

Remarks. *Benthodytes* species are typically elongate, purple to violet-red in colour and have a brim but no unpaired dorsal appendage. Some species have been observed to swim using s-shaped undulations when required (Miller and Pawson, 1990). The genus is found worldwide at depths of 768–7250 m. Of the ten species currently accepted, four have been previously recorded from Australia: *B. lingua, B. sanguinolenta, B. sibogae and B. typica* (AFD and WoRMs, 2024). Fourteen lots of *Benthodytes* were recorded from the IOT at depths of 1304–4990 m, with nine lots further identified to OTU species level as follows: *Benthodytes* cf *incerta* (7 lots), *Benthodytes* cf *sanguinolenta* (1 lot), *Benthodytes* sp. MoV. 7319 (3 lots), and *Benthodytes* sp. MoV. 7388 (2 lots). *Benthodytes* is paraphyletic based on COI, and there is insufficient 16S data to infer the true topology. For COI, within the clade containing *Benthodytes*, the IOT sequences form four well-supported clades: 1) *Benthodytes* cf *incerta*, which is sister to *B. manusensis*; 2) *Benthodytes* sp. MoV. 7319 which is basal to clade 1, *B. manusensis*, *B. palauta*, and *B. marianensis*; 3) *Benthodytes* cf. *sanguinolenta*, which groups with *B. sanguinolenta* from the southern Pacific Ocean and *B.* cf *sanguinolenta* from the CCZ in the eastern Pacific Ocean; 4) *Benthodytes* sp. MoV. 7338. The first two clades group together and are sister to *Psychropotes*. The last two clades are sister to each other and form a distinct lineage from clades 1, 2 and *Psychropotes* (fig. S1).

Benthodytes* cf *incerta Ludwig, 1893

Figure 15a–m, Appendix 1, Table S1, Figure S1

Material examined. NMV F308170*(1), NMV F308171*(1) and NMV F308177 (1) [IN2022 V08 113]; NMV F308197* (2) [IN2022 V08 116]; NMV F308269 (3) [IN2022 V08 145]; NMV F308327 (1) [IN2022 V08 191].

Diagnosis of IOT material. Large light violet specimens with dark-purple tentacles and tube feet, and some darker purple to maroon-red remnant patches. Elongated, semicylindrical body, highly convex dorsally, clear flattened sole ventrally, rounded anteriorly and rounded to slightly tapered posteriorly. Body solid. Skin thin and firm, thicker ventrally, occasionally more gelatinous, particularly dorsally, and appearing to bubble or form warts in places. Anus dorsal, close to terminal. Mouth ventral with circumoral papillae. Up to 15 peltate tentacles (sometimes 10 or 11). Single rows of up to eight (4 pairs) of well-spaced

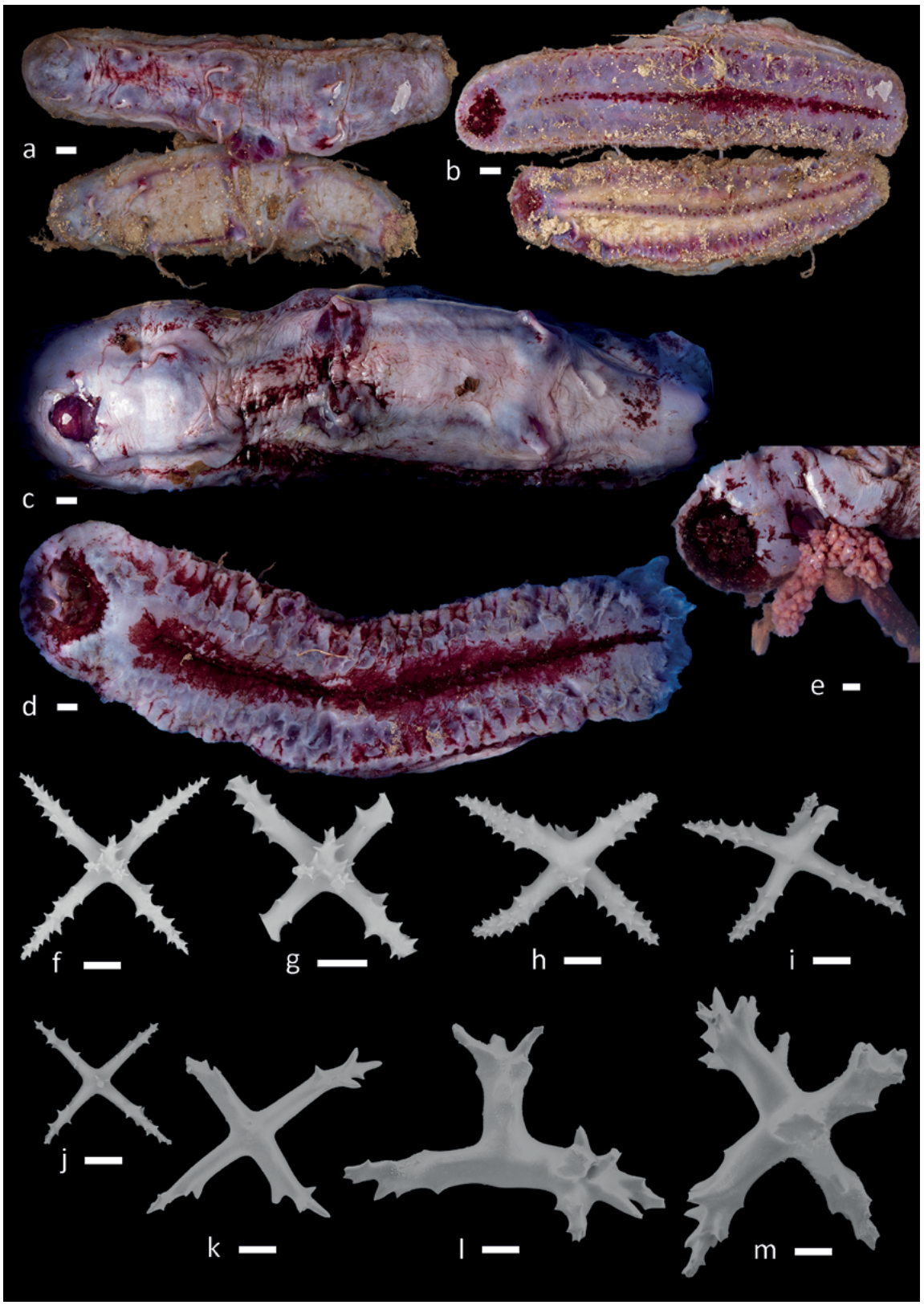

Figure 15. *Benthodytes* cf *incerta*. a–e, shipboard images, a, b, NMV F308197, c, d, NMV F308170, e, NMV F308171; ossicles: f–j, body wall dorsal, NMV F308171, k–m, body wall ventral, NMV F308269; scale bars: a–e=1 cm, f–m=100 *μm*.

papillae along dorsal radii, variable size and tapered at ends. Typically, very narrow lateral brim of short, fused tube feet. Midventral tube feet small, in irregular double row, sometimes bare just below the mouth. IOT specimens large (e.g. 230 mm long, 50 mm wide and 35 mm high: NMV F308327 – preserved). Dorsal body wall ossicles large and small crosses, variably thick and thin, typically with distally spinous arms and central apophyses (broken). Arm length variable (e.g. 176–336 *μm*: NMV F308170), sometimes with corkscrew-like spinous ends. Papillae often same. Smaller crosses typically finer and less spinous, some with no apophyses. Ventral ossicles thick spinous crosses with irregular spinous central apophyses, reduced crosses with and without apophyses, and smooth straight rods with spinous ends. Tentacles straight to curved rods with spinous ends.

Remarks. These specimens vary widely. Specimens match descriptions and illustrations of external morphology for *Benthodytes incerta* using Hansen (1975), but bipartite apophyses were not seen on crosses (though apophyses were typically broken). Ossicles can key to *B. superba*, but other features do not match. One specimen (NMV F308327) has tube feet more "free" than typical when observed in water, and one deeper specimen lot (NMV F308269 from ~3000 m) has a more prominent brim and more "warty" skin than others, but both still fit the general morphology for *B. incerta*. NMV F308177 is partial (skin only), but skin and ossicles match others in group. Specimens differ from *B. marianensis* in ossicles and body form, including narrower brim and fewer dorsal papillae. Specimens have a very similar body form to *B. manusensis*, but with more dorsal papillae, typically a narrower brim, and different ossicles from those shown in Xiao et al. (2018). Most specimens are distinguished also from *B. lingua*, which is thicker and more gelatinous with no clear ventral sole. One specimen (NMV F308171) has a *B. lingua* morphology agreeing with illustrations in Perrier (1902: pl. 12: 1–2), and images of exposed ovaries in Hansen (1975: pl. 12: 2). As discussed under Remarks for the genus, genetics clearly places the specimen with this IOT *B. incerta* group. Without additional specimens including type material for comparison, we do not attempt to assess the validity of *B. lingua* as a species. We acknowledge the variation in specimens here and that material potentially represents a new species but identify all to *Benthodytes* cf. *incerta* for now.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands Territories, Lucia Seamount Stn., Scrooge Seamount Stn., Cocos (Keeling) Stn., and Santa Ridge Stn., 1304–3078 m.

Full bathymetric range. 1304–3078 m.

References. Hansen (1975), Li et al. (2018), Ludwig (1893, 1894), Xiao et al. (2018).

Benthodytes* cf *sanguinolenta Théel, 1882

Figure 16a–c, Appendix 1, Table S1, Figure S1

Material examined. NMV F308225* (1) [IN2022 V08 122].

Diagnosis. Specimen elongated, slightly raised mid-dorsally but flattened anteriorly, and flattened and tapered posteriorly, 24 cm long, 4.5 cm wide and 1.5 cm high (preserved). Pink to brown and purple (pre-preservation). Heavily damaged and outer skin appears to be stripped, leaving the specimen fluffy. Dorsal radial bands visible, but papillae minute or lost. Midventral line also visible, but tube feet lost. Fused lateral brim of tube feet. Anus dorsal, close to terminal. Mouth ventral, with clear anterior brim of post-oral papillae. At least 16 soft tentacles with marginal processes visible in this specimen, retracted into skin folds. Ossicles rare, only a few irregular smooth rods up to 256 *μm* long.

Remarks. Superficially different from images of *Benthodytes* cf. *sanguinolenta* reported from the CCZ (Bribiesca et al., 2022) and morphologically congruent (where features available) with the diagnosis and whole-body photographs (pl. 3–6) of *B. sanguinolenta* from Hansen (1975). Not identified past *Benthodytes* cf *sanguinolenta* here due to the poor state of the specimen.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Investigator Ridge Abyssal Stn., 4980–4990 m.

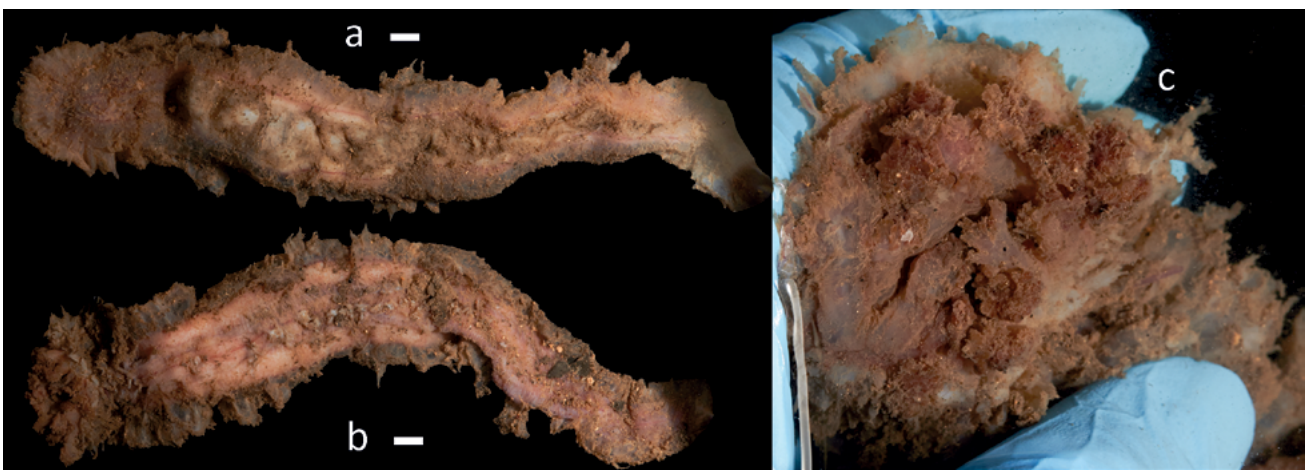

Figure 16. *Benthodytes* cf *sanguinolenta*. a–c, shipboard images showing dorsal, ventral, and oral view of NMV F308225; scale bars: a, b=1 cm.

Full bathymetric range. 4980–4990 m.

References. Bribiesca et al. (2022), Hansen (1975), Li et al. (2018), Ludwig (1894), Théel (1882).

Benthodytes sp. MoV. 7319

Figure 17a–i, Appendix 1, Table S1, Figure S1

Material examined. NMV F308186* (1), NMV F308192 (1) and NMV F308193* (1) [IN2022 V08 115].

Diagnosis of IOT material. Medium-sized flaky, purple *Benthodytes* covered in patches of matted bryozoan. From solid and "chunky" to soft and gelatinous, with specimens damaged and some twisted. Elongate, and dorsally raised, up to 21 cm long, 4 cm wide (NMV F308192, live, excluding brim), and 15.5 cm long, 4.5 cm wide and 2.5 cm high (same specimen preserved, excluding brim). Dark purple remnant "skin" in patches over lighter purple to white colour, more uniformly dark purple ventrally. Wide wispy lateral brim of very filamentous double rows of tube feet, exposed for most of their length. Anus dorsal to subterminal. Mouth ventral and dark purple with up to ~11 retracted tentacles (NMV F308192). Tentacle discs can be large, ~5 mm diameter. Circumoral papillae long, well defined, and filamentous in NMV F308192 (few remaining in others). Dorsal surface "fluffy" and looks stripped of skin. Some evidence of short (~10 mm) horn-like dorsal papillae at anterior end in one specimen, but remaining papillae lost. No obvious ventral tube feet seen. Dorsal body wall ossicles are crosses, thick to thin, variably straight to curved and most with arms distally spinous and central bifurcate apophyses, often broken off, sometimes with additional irregular projections. Rare crosses with horizontal rather than bifurcate top to spire (fig. 17g). Papillae often same. Tentacles straight to curved rods with spinous ends.

Remarks. Not a good match for species key and descriptions in the *Galathea Report* (Hansen, 1975), though absence of dorsal and ventral appendages in these specimens make this hard to judge. Brim of filamentous tube feet exposed for most of their length keys to *B. superba,* but ossicles do not match. Crosses with bifurcate apophyses (often broken off) and ossicles with horizontal top are like those reported for *B. incerta* in Hansen (1975), and for *B. marianensis* in Li et al. (2018), but body forms differ. We identify our specimens here as *Benthodytes* sp. MoV. 7319, noting that additional morphological and genetic samples and more thorough literature review are required before confirming whether this is a new or existing species.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Scrooge Seamount, 2973–2974 m.

References. Hansen (1975), Li et al. (2018).

Benthodytes sp. MoV. 7338

Figure 18a–e, Appendix 1, Table S1, Figure S1

Material examined. NMV F308238* (1) [IN2022 V08 131], NMV F308278* (1) [INV 2022 V08 149] NMV F308288* (10) [IN2022 V08 151].

Diagnosis of IOT material. (NMV F308238). Large light violet specimen with darker purple to maroon-red remnant patches. Elongated, semicylindrical body, dorsally convex, ventrally flattened, rounded anteriorly, and rounded to slightly tapered posteriorly, 20.5 cm long, 6 cm wide, 2 cm high (preserved). Body solid. Skin thin but firm and wrinkled, appearing to bubble near base of dorsal papillae (and through papillae). Ventral surface with light covering of sponge spicules, corals, bryozoans, and grit. Anus dorsal and subterminal. Mouth ventral with brown/maroon tentacles (retracted, ~7 visible) and circumoral papillae. Single rows of well-spaced papillae along dorsal radii. Eight dorsal papillae (4 pairs), with rounded bases and tapered or whip-like ends, some with bubbles or bulges, some very long, up to 85 mm (preserved). Lateral brim up to 1 cm wide, mostly solid with minimal exposed filamentous tips and no free tube feet. Midventral tube feet small, red/maroon, in irregular (paired to alternating) double row, bare at anterior and posterior ends. Multiple tissue samples only with rare cross and rod ossicles. Ventral body wall, single rod (160 *μm*), dorsal and ventral body wall with a few broken crosses with and without evidence of central apophyses (arms 160 *μm*), papillae with slightly larger crosses (arms ~240 *μm*). All three specimen lots collected look superficially quite different, the two below placed here with reservations, based on genetic evidence. Brief descriptions of the two remaining specimen lots follow.

NMV F308278: Very small pink specimen, 2 cm long, 0.5 cm wide (pre-preservation), with evidence of dorsal and potentially lateral papillae and a ventral tentacle crown. Little structure once preserved. Multiple tissue samples had either no ossicles or very rare (2 broken pieces) of *Scotothuria*-like hooked crosses. No *S. herringi* reported from this station (149) but presumed contaminants.

NMV F308288: Elongated, stripped, dorsoventrally flattened samples up to ~17 cm long and 2.5 cm wide (pre-preservation). Gelatinous and dark maroon/red to purple, bright pink when preserved. Lack of any distinct oral/anal end; tentacle crown or appendages indicate that these may be just gut and internal parts of specimens with no complete sample. Multiple tissue samples had either no ossicles or rare (2) *Laetmogone*-like wheels, considered likely contaminants. Note that the only other *Benthodytes* from this station (151) was too damaged to identify past genus level.

Remarks. External morphology of NMV F308238 is like IOT *Benthodytes* cf *incerta*, only with slightly wider, thicker brim, larger papillae and more red than purple colouring dorsally. Ossicles too scarce to demonstrate difference. We identify our specimens here as *Benthodytes* sp. MoV. 7388, noting the difference in external morphology between specimens and that additional morphological and genetic samples and more thorough literature review are required before confirming whether this is a new or existing species.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands Territories, Cocos (Keeling) Stn., Noel Seamount Stn. and Raitt Ridge North Stn., 1589–3144 m.

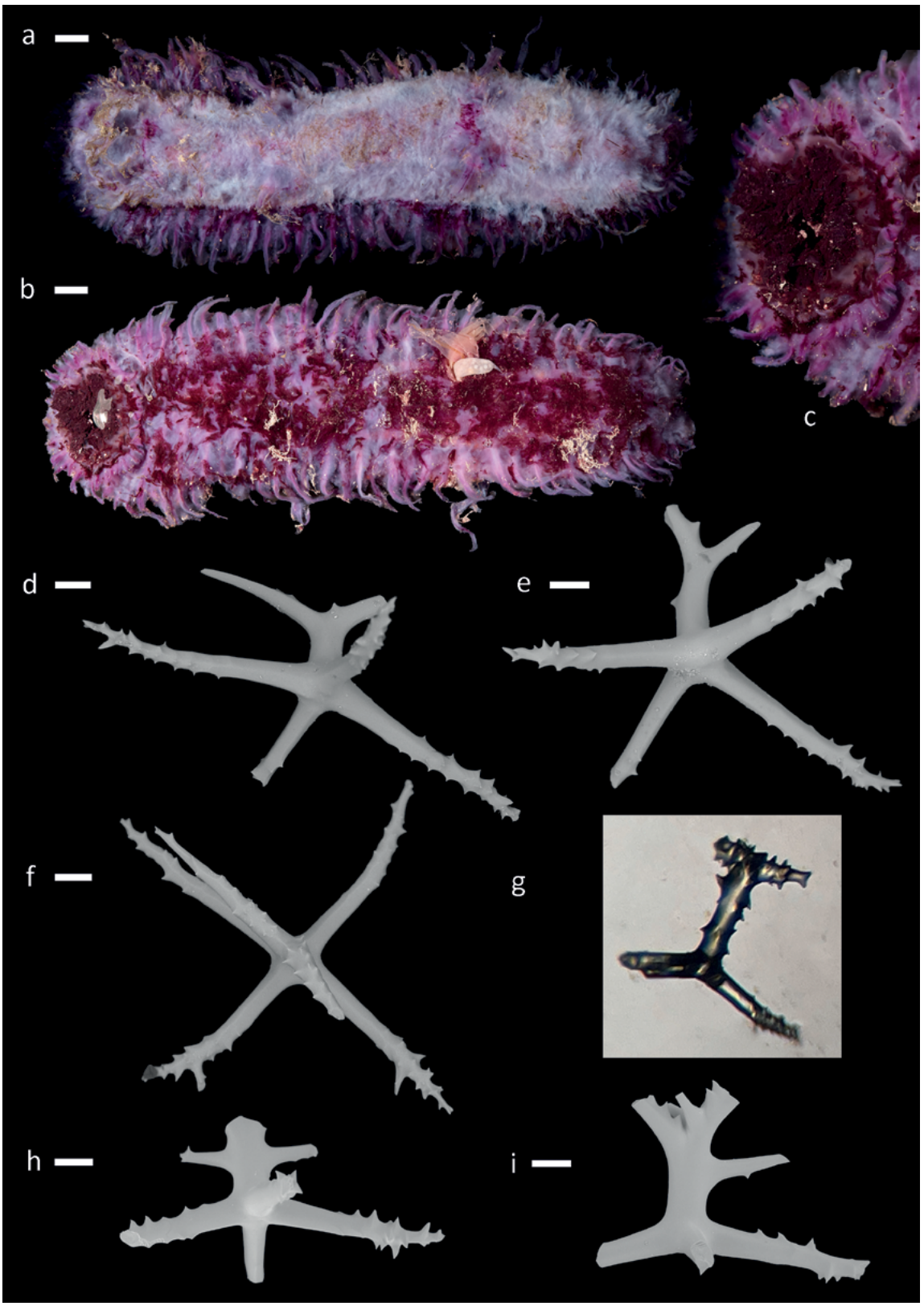

Figure 17. *Benthodytes* sp. MoV. 7319. a–c, shipboard images showing dorsal, ventral, and oral view of NMV F308192; ossicles: d–g, body wall dorsal, NMV F308193, h, i body wall, NMV F308186; scale bars: a–c=1 cm, d–f, h, i=100 *μm*.

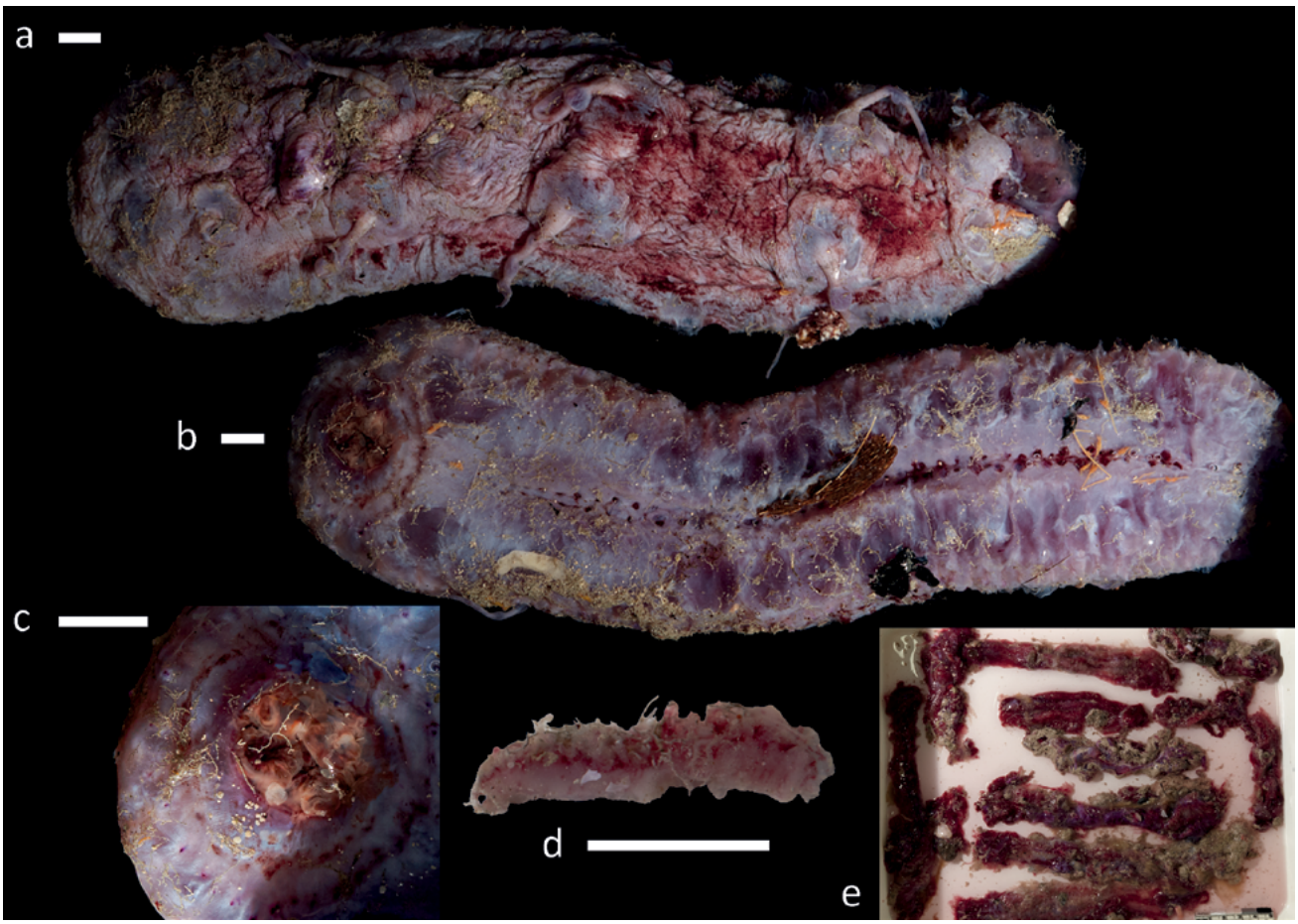

Figure 18. *Benthodytes* sp. MoV. 7338. a–e, shipboard images, a–c, dorsal, ventral, and oral view of NMV F308238, d, NMV F308278, e, NMV F308288; scale bars: a–d=1 cm.

Benthodytes sp.

Appendix 1, Table S1

Material examined. NMV F308281 (1) [IN2022 V08 151].

Remarks. One additional lot identified to *Benthodytes* based on external morphology but too damaged to take further.

Genus: ***Psychropotes*** Théel, 1882

Diagnosis (following Hansen, 1975). Anus ventral. Unpaired dorsal appendage present. Circumoral papillae absent. Tentacle discs of a fixed shape, rounded in outline and with marginal knobs.

Remarks. *Psychropotes* is a deep-sea genus, typically dark purple or yellow, and known for its prominent sail or fin-like dorsal appendage. Of the 19 currently accepted species of *Psychropotes* worldwide, three have been previously recorded for Australia: *Psychropotes depressa*, *P. longicauda* and *P. scotiae* (WoRMS, ALA, and NMV catalogue January 2024). Two of these species are recorded again here: *P. depressa* and *P. longicauda*. Nine lots of *Psychropotes* were recorded from the IOT voyages at depths of 2289–5414 m, with seven lots further identified to OTU species level as follows: *P. depressa* (5 lots), *P. longicauda* (1 lot), and *Psychropotes* sp. MoV. 7327 (1 lot). Both COI and 16S sequence data highly support *Psychropotes* as a monophyletic genus. Within the COI phylogeny, *P. depressa* is basal to the clade containing *P. longicauda*, *P. moskalevi*, and *P. verrucicaudatus*. For 16S, only sequences for *P. depressa* and *P. longicauda* are available; each species forms a well-supported genetic lineage (fig. S1).

Psychropotes depressa (Théel, 1882)

Figures 19a–g, 20h–m, Appendix 1, Table S1, Figure S1

Euphronides depressa—Théel, 1882: 93–96, pls. 26, 35: 5–6, 40: 7, 46: 4.—Ohshima, 1915: 244–245, fig. 1.—Ohshima, 1916–1919, with 3 figs.

Psychropotes depressa.—Hansen, 1975: 106–111, figs 43–44.—Gebruk, 2008: 50, 51; Rogacheva et al., 2013: 599, fig. 17f, g.—Gebruk et al., 2014: 160–161.

Euphronides depressa var. *minor* Théel, 1886b: 2.

Figure 19. *Psychropotes depressa*. a–c, shipboard images showing live colour, dorsal papillae, placement of unpaired dorsal appendage, brim, mouth, and mid-ventral tube feet of a more typical specimen, NMV F308194; ossicles: d–g, dorsal crosses, d–e, mid body, g, posterior, NMV F308194; scale bars: a–c=1 cm, d, g=300 μm, e, f= 200 μm.

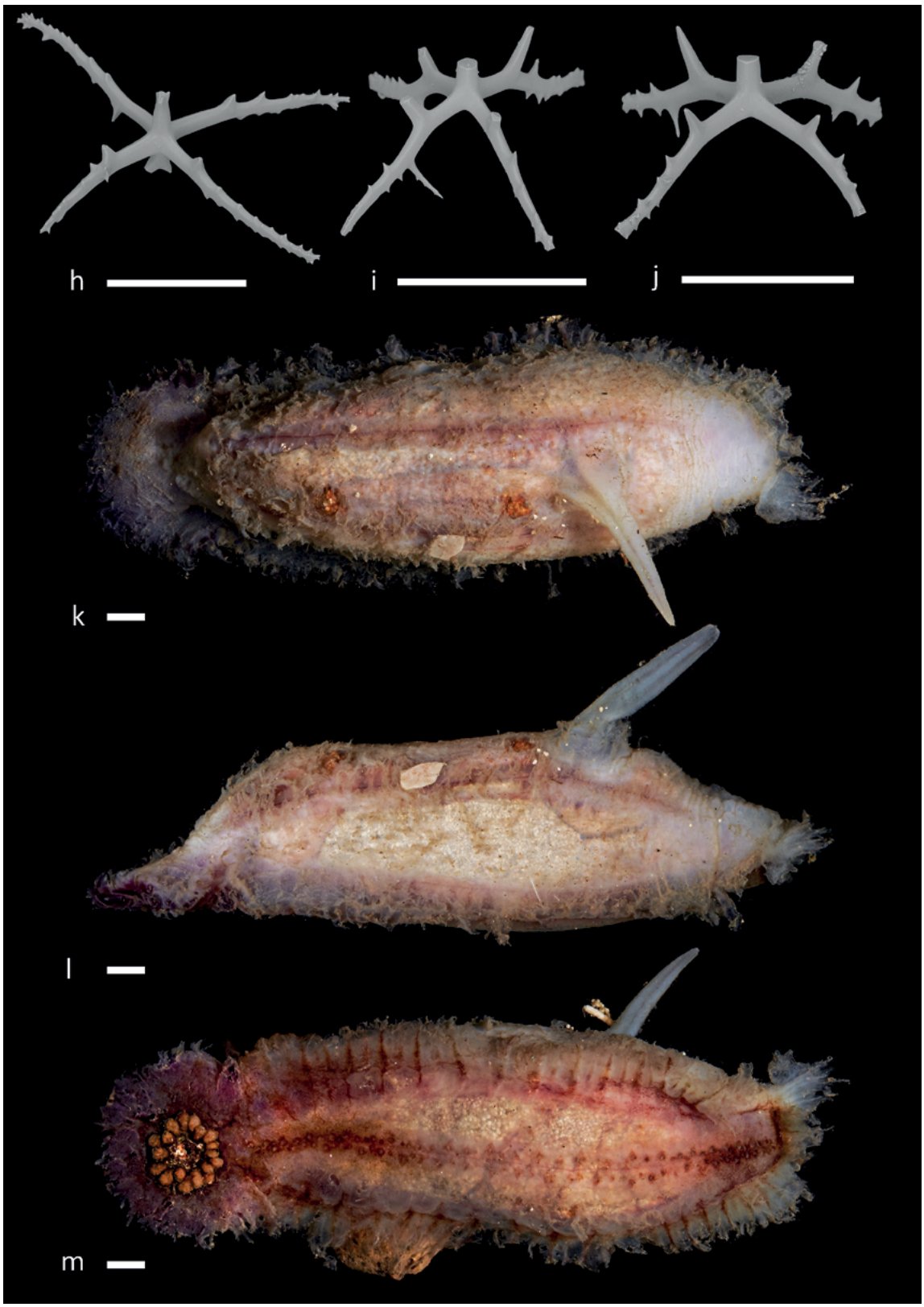

Figure 20. *Psychropotes depressa*. ossicles continued: h–j, dorsal crosses, h, mid body, i–j, posterior, NMV F308194; k–m shipboard images of specimen with less typical morphology, NMV F308148; scale bars: h, j=200 *µm*, i= 300 *µm*, k–m=1 cm.

Euphronides cornuta Verrill, 1884: 217.—Verrill, 1885: 518, 538, figs 32–33.—Deichmann, 1930: 127–128.—Heding, 1940: 368.

Euphronides tanneri—Ludwig, 1894: 39–44, pls. 3: 7, 4, 5: 17–19.

Euphronides auriculata Perrier, 1896: 901–902.—Perrier, 1902: 434–438, pls. 13: 1–2, 20: 12–13.—Grieg, 1921: 8–9.

Euphronides violacea Perrier, 1896: 902.—Perrier, 1902: 438–441, pl. XX: 14.—Deichmann, 1930: 128–129.—Deichmann, 1940: 201–202.—Heding, 1942: 15–16.—Madsen, 1947: 16.—Deichmann, 1954: 384.

Euphronides talismani Perrier, 1896: 902.—Perrier, 1902: 441–444, pl. XX: 15.—Hérouard, 1902: 30–31, pl. II: 19–22.—Deichmann, 1930: 129.—Heding, 1942: 15, fig. 15.

Benthodytes assimilis Théel, 1886b: 2–3.

Material examined. NMV F296865* (2) [IN2021 V04 033]; NMV F296881* (1), [IN2021 V04 050]; NMV F308148* (1) [IN2022 V08 105]; NMV F308194 (2) and NMV F308195 (2) [IN2022 V08 115].

Diagnosis of IOT material. Medium to large violet specimens up to ~255 mm long, 45–75 mm wide and 50 mm high (NMV F308195, preserved, widest at anterior brim). Unpaired, flaccid dorsal appendage, tapering from a wider base to narrow rounded tip, variable in size, approximately one quarter to one seventh of the length of the body in preserved specimens. Dorsal appendage placed at variable distance from the posterior end of the body, but typically one third of a body length from the end. Skin soft and smooth to wrinkled, thin dorsally, usually thicker ventrally. Light purple and pink dorsally, often with darker patches or sometimes semitransparent showing gut contents. Darker purple to rust-red around brim, tentacles, tube feet, and often ventrally. Body form elongate, dorsally raised, ventrally flattened, surrounded by a narrow to very broad brim of enclosed tube feet, sometimes with free filamentous tips, brim often wider anteriorly. Anus ventral, terminal (under brim). Mouth ventral. 18 retractile tentacles, rounded with marginal knobs on discs. Midventral tube feet present throughout nearly entire length of sole, semi-retracted, small to medium and conical, in paired to zigzag row. Up to four pairs of reduced (e.g. <5 mm) dorsal papillae (NMV F308194, NMV F308195), but otherwise inconspicuous or retracted to bumps. Dorsal body wall ossicles are cross-shaped with four arms and one smooth central spine-like apophysis. Arms with gentle to strong curve, length variable (e.g. 136–429 μm), distally spinous but with one or more additional vertical spines and occasionally some extra serrations projecting from the dorsal surface before the arm curves. Rarely a lot more spinous, with spines projecting from both dorsal and ventral surfaces (fig. 19g). Papillae ossicles similar. Ventral ossicles rods (e.g. 320–440 μm) and rare reduced crosses. Tentacles with straight to curved rod ossicles (e.g. 400–528 μm), spinous at ends and occasionally branching.

Remarks. Specimens resembled the original (Théel, 1882) and *Galathea Report* (Hansen, 1975) descriptions for *Psychropotes depressa*, and keyed closest to that species based on external morphology and ossicles, however placement and measurements for the dorsal appendage were more variable in IOT specimens. Two specimens, NMV F296881 and NMV F308148 (fig. 20k–m) were both bulbous and full of mud, with stretched, thin skin, and very tapered and narrow at the anterior once preserved. NMV F296881 was quite damaged and missing its dorsal appendage once preserved. Genetics (fig. S1) confirm these specimens fit with other IOT *P. depressa*, and both morphologies are shown in the accompanying figures.

Distribution. Cosmopolitan. *

Full bathymetric range. 957–4200 m* (IOT 2289–3100 m).

Type locality. North Atlantic Ocean (south of Portugal), 1993–2515 m.

*Reported from Atlantic and Pacific to 4200 m by Rogacheva et al. (2013), but as cosmopolitan to 4060 m by Gebruk et al. (2014). Hansen (1975) is a mix of both.

This species previously recorded for Australia in AFD (Lord How Rise) and from the eastern coast of Australia off Bermagui in NSW to the Coral Sea in Queensland at depths of 1761–2902 m in ALA (January 2024). This IOT material represents a geographic and bathymetric range extension for the species in Australia and new record for the Indian Ocean (no records for this region on the Ocean Biogeographic Information System [OBIS], January 2024).

References. Gebruk et al. (2014), Hansen (1975), OBIS (2024), Rogacheva et al. (2013), Théel (1882).

Psychropotes longicauda Théel, 1882

Figure 21a–k, Appendix 1, Table S1, Figure S1

Psychropotes longicauda Théel, 1882: 96–98, pls. 27: 1, 28, 35: 13–17, 37: 10.—Hansen, 1975 (in part): 115–126, fig. 49: 1–5.—Rogacheva et al., 2009: 473–474, fig. 7.—Gebruk et al., 2014: 161.—Gubili et al., 2017: 288–296.—Gebruk et al., 2020: 1–5, fig. 1.

Non: *Psychropotes longicauda* var. *fusco-purpurea* Théel, 1882: 99, pls. 29: 1, 35: 11.

Non: *Psychropotes longicauda* var. *monstrosa* Théel, 1882: 98–99, pls. 29: 2, 30, 39: 1.

Non: *Psychropotes longicauda* var. *antarctica* Vaney, 1908: 419–420.

Material examined. NMV F308333* (1) [IN2022 V08 196].

Diagnosis of IOT material. Single specimen, elongate and semicylindrical, with a rounded dorsal surface, slightly constricted before additional dorsoanterior bulging, flattened ventrally, and flattened at each end once preserved, ~125 mm long, 37 mm wide and 20 mm high (preserved). Soft but unusually firm for this typically gelatinous species and almost black shipboard (see Remarks). Dark purple to violet/red preserved. Unpaired dorsal appendage of same colour as body, fin-like in appearance, and very close to posterior end; firm rather than flaccid and gelatinous, almost the width of body but shorter than expected (approximately one fifth the size of specimen). Anus ventral. Mouth ventral. Eighteen tentacles with very round firm discs and knobbed margins. Anterior brim of more than ten tube feet, variable in size, fused for most of their length but free and round at ends. Similar for a much smaller posterior brim, with approximately ten tube feet, more regular in length. Ventrolateral tube feet large and free, approximately seven each side. Paired to zigzag series of large to small midventral tube feet. No dorsal papillae observed in this specimen, usually minute. Ossicles irregular spinous crosses and rods. Dorsal body wall ossicles (fig. 21e, f) slender and spinous to thick and serrated crosses, with and

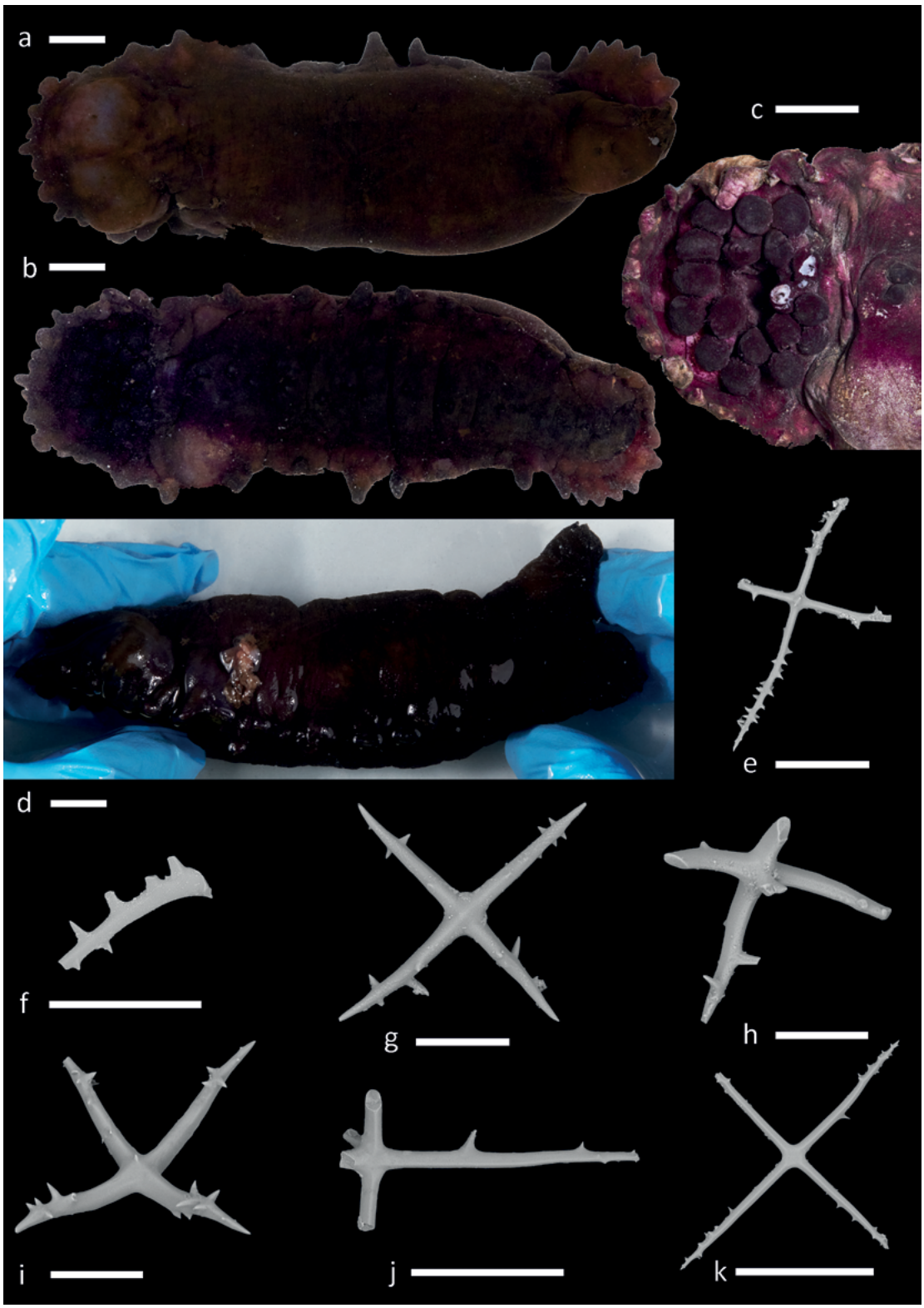

Figure 21. *Psychropotes longicauda*. a, b, d, shipboard images showing very dark live colour with placement of unpaired appendage, a, dorsal, b, ventral, d, lateral views; c, additional oral image after preservation with round tentacles, brim and mid-ventral tube feet; ossicles: e,f, dorsal body wall crosses (broken, with and without apophyses), g–k, ventral crosses, g–i, stout and curved, j, k, slender, all NMV F308333; scale bars: a–d=1 cm, e=100 *µm*, f, j=200 *µm*, g–i=50 *µm*, k= 300 *µm*.

without central apophyses, most broken here. Ventral body wall ossicles (fig.21 g–k) typically stout, slightly curved crosses, with or without broken central apophyses, arms up to ~91 *μm* long with scattered spines mostly distal (fig. 21g–i). Also, slender crosses with longer arms up to 350 *μm* with or without central apophysis (fig. 20j, k), and rare rods. Tentacles with curved to straight, smooth to spinous or branched rods up to 640 *μm* long.

Remarks. We have placed our specimen in *P. longicauda* for now with the usual reservations, and in particular noting that Gubili et al. (2017) assessed *P. longicauda* as a cryptic species complex and Gebruk et al. (2020) redescribed and split the species. The 16S sequence groups with that of *P. longicauda* from California, USA (fig. S1). Our specimen was collected from a station with manganese nodules, so the black colour and firmer texture here may be artifacts rather than typical. Ossicles and external morphology key closest to *P. longicauda* in the *Galathea Report* (Hansen, 1975), with ossicles and features a good match other than the IOT specimen having a slightly reduced dorsal appendage. Ossicles and preserved whole-body dimensions from the original description in the *Challenger* Reports (Théel, 1882) agree with the IOT specimen, but again the dorsal appendage for our specimen is much shorter and more tapered than the "very large" 120 mm one noted in the original description, and those illustrated by Gebruk et al. (2020) or photographed by Ross (2012). The IOT specimen also shows some similarities to the variety now accepted as *P. fuscopurpurea* Théel, 1882 known only from the type locality in the Southern Indian Ocean south of Australia at ~3560 m. The differences between these species were covered well in the redescriptions by Gebruk et al. (2020), with our specimen judged a closer match to the ossicles from *P. longicauda*.

Distribution. Australian IOT (this work), Indian Ocean sector of the Antarctic, Pacific Ocean: Kermadec Trench area. *

Full bathymetric range. 3431–5414 m* (IOT 3431–5414 m).

Type locality (for specimen noted as "best" for species). Southern Indian Ocean, Southern Ocean (northwest of Casey Station Antarctica), ~3614 m.

*Prior to Gebruk et al. (2020), which restricted geographic distribution to the Indian Ocean sector of the Antarctic and the Kermadec Trench area (depth 3560–5414 m), distribution was considered cosmopolitan at 2210–5173 m.

This species was previously recorded in AFD and from western, eastern and southern Australia at depths of 815–4890 m in ALA (January 2024). Note that the NMV Catalogue records one of these specimens (from the Great Australian Bight) at a depth of 4890–5032 m. This IOT material represents a geographic and small bathymetric range extension for the species.

References. AFD (2024), ALA (2024), Gebruk et al. (2014), Gebruk et al. (2020), Gubili et al. (2017), Ross (2012), Théel (1882).

Psychropotes sp. MoV. 7327

Figure 22a–j, Appendix 1, Table S1

Material examined. NMV F308272 (1) [IN2022 V08 147].

Diagnosis of IOT material. Large purple specimen with unpaired dorsal appendage, preserved ~190 mm long, 90 mm wide (including brim) and 20 mm high. Raised and slightly rounded dorsally, flattened ventrally, surrounded by a very broad brim (20–40 mm in live specimen) of enclosed tube feet that gives the animal a wide flattened appearance. Unpaired dorsal appendage opaque pink and positioned approximately one third of the way from posterior end. Flaccid and gelatinous with almost square end, lobed on the tip of each side. Lobes are very small, only ~5 mm in fresh specimen and completely retracted in preserved; darker red lines (presumably canals) leading to them suggest that they are inflatable/extendable. Appendage was approximately one fifth the length of the body before preservation, but closer to quarter the length (~50 mm long) after, presumably due to contraction of the brim reducing the body size. Skin soft and smooth to wrinkled (no warts), thicker ventrally. Light purple to pink or cream dorsally, brim opaque purple with rust-coloured patches. Anus terminal ventral (under brim). Mouth ventral. Approximately 17 retractile peltate tentacles with marginal knobs on discs. Midventral retracted tube feet along a rust-coloured furrow in paired to zigzag row. Up to four pairs of reduced dorsal papillae, longest pair posterior and ~5 mm. Dorsal body wall ossicles (fig. 22d–f) are cross-shaped with four arms and one smooth central spine-like apophysis (e.g. 169 *μm*). Similar in dorsal appendage (fig. 22g–j) and papillae. Arms directed down, but length and shape quite variable. Some crosses with long tapered arms strongly curved from close to central spire, others slightly more robust with arms starting as a horizontal beam before they splay out and down. Arm length variable (e.g. 200–380 *μm* in body wall and up to 486 *μm* in dorsal appendage). Minutely spinous, particularly at ends, but each arm also has (typically one or more) larger vertical spines (e.g. 59 *μm*) at a short distance from the central spire and occasionally some extra serrations projecting from the dorsal surface. Some similar ossicles in lateral brim, along with reduced crosses. Only variable spinous rods seen in ventral samples (e.g. 360 *μm*) and tentacles (e.g. 400 *μm*).

Remarks. External morphology closest to *Psychropotes belyaevi* Hansen, 1975 with the wide brim, bipartite lobe, reduced tentacle number, and longer papillae posteriorly, but appendage is shorter in this specimen than for *P. belyaevi* and only lobed at the tips rather than for most of its length, has 17 rather than 16 tentacles, at least four (rather than three) pairs of papillae, and a wider brim. Ossicles are also closer to *P. depressa* with arched crosses with minimal spines and single central apophyses, compared to the robust crosses lacking apophyses and rings of spines in *P. belyaevi*.

Not a match for other Australian species – *P. longicauda* Théel, 1882 and *P. scotiae* Vaney, 1908 – when compared to Mark O'Loughlin's (2018) notes, original descriptions, or the *Galathea Report* (Hansen, 1975). Kept at OTU level *Psychropotes* sp. MoV. 7327 for now until further literature review and genetic investigation can be conducted.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Noel Seamount Stn., 2617–2721 m.

References. Hansen (1975), O'Loughlin (notes and personal correspondence, 2018), Théel (1882), Vaney (1908).

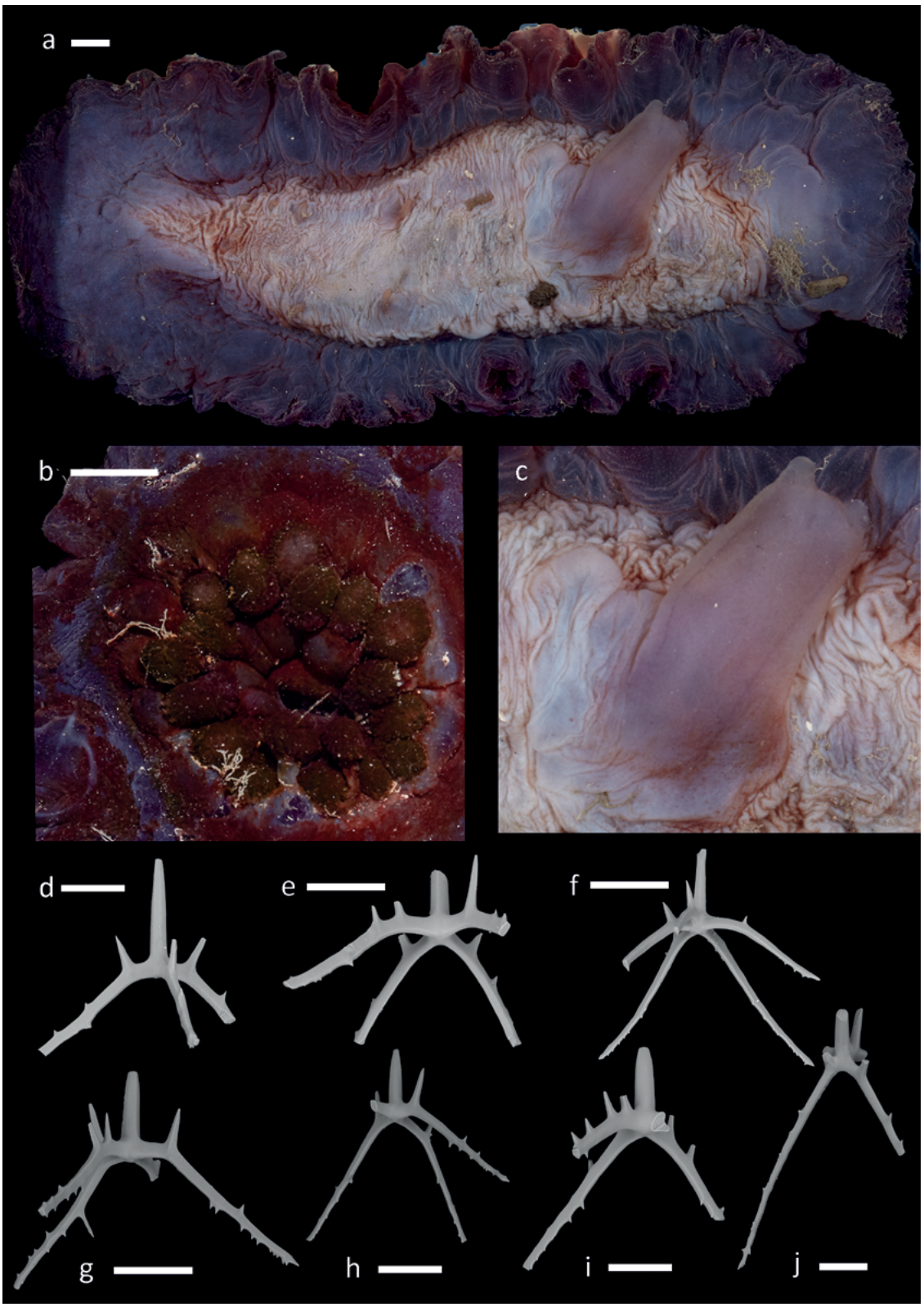

Figure 22. *Psychropotes* sp. MoV. 7327. a–c, shipboard images showing live colour, dorsal papillae, placement of unpaired dorsal appendage, b, close-up of oral end, c, close-up of appendage with lobes; ossicles: d–f, body wall dorsal, g–j, dorsal appendage, NMV F308272; scale bars: a–b=1 cm, d–j =100 μm.

***Psychropotes* sp.**

Appendix 1, Table S1

Material examined. NMV F308162 (1) [IN2022 V08 106]; NMV F308227 (1) [IN2022 V08 122].

Remarks. Two additional lots from two stations were identified to *Psychropotes* based on external morphology and ossicles but without sufficient characteristics or genetics to take further at this stage.

Order **Holothuriida** Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017

Diagnosis. (see Miller et al., 2017)

Remarks. The order Holothuriida was erected in 2017 as a well-supported sister clade to the Neoholothuriida (Miller et al., 2017). The Holothuriida comprises only two currently accepted families, both of which are represented in Australia: Holothuriidae Burmeister, 1837 and Mesothuriidae Smirnov, 2012. The Holothuriidae contain many of the well-known tropical and temperate shallow-water species, but only Mesothuriidae was represented in material from the IOT voyages.

Family **Mesothuriidae** Smirnov, 2012

Diagnosis. (following Smirnov, 2012 and amended for Miller et al., 2017 erection of Holothuriida). Body elongated, rounded, or flattened. Tube feet present along entire ventral side (genus *Mesothuria*) or only along ventral ambulacra (genus *Zygothuria*). Papillae virtually evenly spread on dorsal surface. Twenty (13–22) tentacles with no free-hanging tentacle ampullae present. Stone canal attached to the body wall without penetrating it. Rete mirabile not developed. Radial muscle bands undivided. Gonads in a single tuft of tubules to the left of the mediodorsal mesentery. Calcareous ring well developed. Table ossicles with large, laced disc perforated with large holes, and spire composed of three or four pillars surrounding the central hole.

Remarks. This family exhibits primarily table-shaped ossicles and gonads in a single tuft. The only two accepted genera worldwide, *Mesothuria* and *Zygothuria*, are distinguished in external morphology by tube foot arrangement, body form, structure of calcareous ring and ossicles (Gebruk et al., 2012). Both genera have been reported widely from Australia at depths of 373–4250 m (AFD and ALA, 2024), and are again represented here in IOT material. Miller et al. (2017) maintained the Smirnov (2012) erection of Mesothuriidae, moving it from its former position in Aspidochirotida to their new order Holothuriida. See Smirnov (2012) for further comments on distinguishing traits between families.

Genus ***Mesothuria*** Ludwig, 1894

Diagnosis. (following Gebruk et al., 2012). Body nearly cylindrical, slightly tapered toward both ends, without marginal fringe. Ventral side somewhat flattened; dorsal side uniformly covered with small pedicles of small and equal size, or much smaller dorsally, where they can be hardly visible. Tube feet with sucking disks scattered over entire body. Usually 20 tentacles, very occasionally 18–22. No tentacle ampullae; stone canal attached to body wall without penetrating it. Mouth terminal, anus ventral or subventral. Calcareous ring with rectangular radial segments. Gonads only on left side of dorsal mesentery, in single tuft. Ossicles of body wall quadri-radiate or tri-radiate tables with central primary cross elevated from disk.

Remarks. Cosmopolitan genus with 26 species worldwide, 11 of which have been reported previously for Australia: *Mesothuria abbreviata*, *M. bifurcata*, *M. carnosa, M. lactea, M. marginata, M. murrayi, M. norfolkensis, M. parva, M. regularia, M. sufflava and M. verrrilli* (WoRMS and ALA January 2024). Two new species for Australia are recorded here: *M. cathedralis,* and *M. gargantua*. Twenty-four lots of *Mesothuria* were recorded from the IOT voyages at depths of 754–3345 m, with all further identified to OTU species level as follows: *M. cathedralis* (2 lots), *M. gargantua* (19 lots), and *M. murrayi* (3 lots). Distinguished from *Zygothuria* by semicylindrical body shape, full covering of papillae and typically quadri-radiate compared to tri-radiate table ossicles. In both the COI and 16S datasets (fig. S2), *Mesothuria* is paraphyletic with *M. cathedralis*, *M. gargantua*, and *M. oktaknemus* forming a well-supported monophyly and *M. murrayi* in a separate clade. For COI, *M. murrayi* and *Holothuria hilla* form a single, well-supported lineage but the 16S phylogeny supports *M. murrayi* as monophyletic.

Mesothuria cathedralis Heding, 1940

Figure 23a–n, Appendix 1, Table S1, Figure S2

Mesothuria (*Allantis*) *cathedralis*—Heding, 1940: 336–338, textfig. 5.

Mesothuria (*Penichrothuria*) *cathedralis*.—Heding, 1942: 8–9, textfig. 8, figs 1–5; Non *Mesothuria* (*Allantis*) *candelabri*.—Heding, 1940: 334–335, textfig. 3, figs 1–6.

Mesothuria cathedralis.—Gage et al., 1985: 196.—Gebruk, 2008: 50, 51.—Gebruk et al., 2012: 284, 286–289, fig. 7.—Rogacheva et al., 2013: 592.—Gebruk et al., 2014: 169.

Material examined. NMV F308202* (4) [IN2022 V08 116]; NMV F308237 (1) [IN2022 V08 126].

Diagnosis of IOT material. Small *Mesothuria* species, elongated cylindrical to oval shape, slightly flattened ventrally, with soft, wrinkled, cream-grey to light brown skin, sometimes with a pink tinge. Mouth subventral. Tentacles retracted in IOT specimens and not dissected, but ~20 expected. Anus terminal. Scattered cover of papillae and tube feet all over the body, often longer and more visible as dense lateral or posterior-ventral patches. Elongated (but damaged and distorted) specimen from NMV F308202 is ~110 mm long, 15 mm wide and 15 mm high, while others are closer to an oval or spindle shape once preserved (e.g. 34 mm long, 12 mm wide and 12 mm high: NMV F308237, preserved). Body wall contains many quadri-radiate table ossicles made of a perforated base disc with elevated central primary cross and four tall vertical spires, joined in two places, and angled out to four (rarely three) spinous arms at the tips. Table dimensions up to ~120 μm across by 104 μm high (NMV F308237). Base discs typically irregular with a central ring of approximately eight large irregularly rectangular perforations, often with a secondary outer ring of eight or more smaller round to triangular perforations, though this is variable.

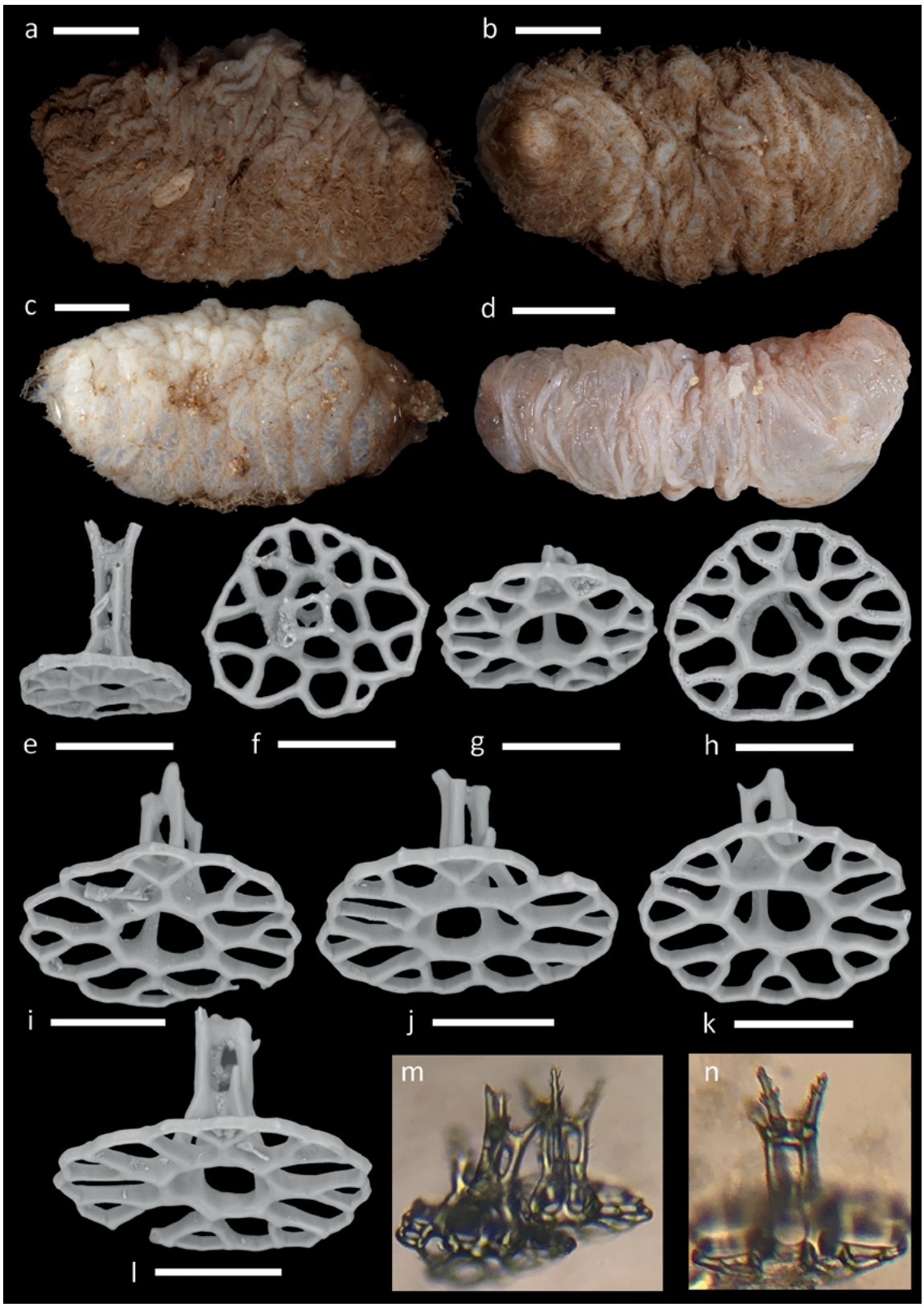

Figure 23. *Mesothuria cathedralis*. a–d, shipboard images, a–c, NMV F308202, d, NMVF308237; ossicles: e–n, body wall tables, e–h, dorsal, i–l, ventral, NMV F308202, m, n, body wall tables with spires intact, NMV F308237; scale bars: a–d=1 cm, e–l =50 *μm*.

Remarks. Within *Mesothuria* the dense covering of tube feet is reminiscent of *Mesothuria murrayi*, but these specimens are distinguished by taller, more elegant ossicle tables, with long slender spires (joined in two places) and spinous ends. Along with the original description in Heding (1940), morphological identifications were made using the additional images and keys from Gebruk et al. (2012) and notes and personal correspondence from O'Loughlin (2018). While these specimens represent a major geographic range extension for the species (see below), O'Loughlin (pers comm., 2018) also placed the species off eastern Australia at abyssal depths, with his specimens displaying table ossicles with 3–5 spires, but similar dimension to IOT specimens at 80–120 *μm* high, with a diameter of up to 128 *μm* across the table disc. The type specimen (Heding, 1940) had uniformly four spires, irregular or crooked at the apex, but our specimens were closer to those described by Gebruk et al. 2012, again with (typically) four spires, but more uniform at their spinous tips.

Distribution. Atlantic Ocean, Indian Ocean (Australian IOT), and off eastern Australia from Tasmania to Queensland.*

Full bathymetric range: 820–4930 m* (IOT 820–1991 m).

Type locality. East Atlantic (Gulf of Guinea area), 2278 m.

*Previous range from Gebruk et al. (2014) was limited to the Atlantic Ocean (various locations) with the depth from Rogacheva et al. (2013) at 1292–4930 m. While this species was not previously recorded from Australia in AFD or ALA (January 2024), the NMV catalogue has records from all eastern states, with specimens identified from off southern Tasmania to the Coral Sea in Queensland at depths of 1013–2650 m. These IOT specimens, along with other NMV catalogue records for Australia, represent a major geographic (and slight bathymetric) range extension for the species.

References. AFD (2024), ALA (2024), Gebruk et al. (2012), Gebruk et al. (2014), Heding (1940), O'Loughlin (notes and personal correspondence, 2018), Rogacheva et al. (2013).

Mesothuria gargantua Deichmann, 1930

Figure 24a–m, Appendix 1, Table S1, Figure S2

Mesothuria gargantua Deichmann, 1930: 95–96, pl. 7, fig. 1.—Deichman, 1940: 191.—Deichman, 1954: 386.—Solís-Marín, 2003: 168, figs 78–82.—Gebruk et al., 2012: 289–290, fig. 8.

Mesothuria (*Allantis*) *gargantua*.—Heding, 1940: 333 (list).

Holothuria verrilli Théel, 1886b: 6 (partim).

Material examined. NMV F296863* (1) [IN2021 V04 031]; NMV F296873* (2), [IN2021 V04 046]; NMV F296880 (1), [IN2021 V04 048]; NMV F308172 (1) and NMV F308173* (5) [IN2022 V08 113]; NMV F308196 (1) [IN2022 V08 116]; NMV F308215 (1), NMV F308217* (1) and NMV F308218 (3) [IN2022 V08 117]; NMV F308234 (1) and NMV F308235 (1) [IN2022 V08 124]; NMV F308236* (1), [IN2022 V08 126]; NMV F308252 (3), [IN2022 V08 136]; NMV F308258 (2), [IN2022 V08 141]; NMV F308260 (6) and NMV F308265 (1), [IN2022 V08 143]; NMV F308296 (2), [IN2022 V08 157]; NMV F308305* (1) [IN2022 V08 161]; NMV F308328 (9), [IN2022 V08 191].

Diagnosis of IOT material. Conspicuous large white robust species, almost cylindrical but slightly flattened ventrally and tapering to rounded ends (e.g. 195 mm long, 55 mm wide and 55 mm high: NMV F308260 largest specimen in lot, preserved). Skin thick and variably smooth to wrinkled. Mouth subventral to ventral with ~20 tentacles (typically retracted). Terminal anus. Midventral line or shallow furrow, sometimes rust-coloured or pink tinged here and between the wrinkles. Almost complete cover of small cylindrical tube feet, though these are inconspicuous at first glance on larger specimens; slightly larger and more obvious on the posterior part of the ventral surface but can be inconspicuous or absent from the anterior of the same. Skin densely packed with ossicles. Ossicles are large, solid, typically quadri-radiate tables made up of a perforated base disc with low spires made of four (rarely five) pillars, e.g. ~80–109 *μm* high, joined in one or two places with short spinous tips. Discs irregular and typically 150–190 *μm* in diameter, but can be larger (up to 280 *μm*, NMV F308260). Many perforations, typically with inner ring of eight or more larger oval perforations, then more irregular, smaller ones towards the edge. Occasional anastomosing or branching on pillars, and edges of discs not always closed. Tube foot ossicles are similar but slightly smaller.

Remarks. Identifications based on description in Deichmann (1930, 1954) with additional information from the clearer figures of type ossicles redrawn in Solís-Marín (2003) and subsequently Gebruk et al. (2012). Typically distinguished from other *Mesothuria* by being large, white and firm, with thick skin and robust, irregular ossicles. Two specimens, NMV F308215 and NMV F308305 (fig. 24e), still grouped genetically with IOT *M. gargantua* but were smaller with softer wrinkled skin, and ossicles often with slimmer pillars with more elongated spines than other IOT *M. gargantua*.

Distribution. Atlantic Ocean and Caribbean Sea, Indian Ocean (Australian IOT).

Full bathymetric range. 720–1968 m (IOT 754–1968 m).

Type locality. Caribbean Sea, off Barbados, 720 m.

This species not previously recorded for Australia in AFD or ALA (January 2024). These IOT specimens extend the geographic and bathymetric range for the species (previously to 1347 m in Gebruk et al., 2012) and are the first records for Australia.

References. AFD (2024), ALA (2024), Deichman (1930, 1954), Gebruk et al. (2012), Heding (1940), O'Loughlin (notes and personal correspondence, 2018), Solís-Marín (2003).

Mesothuria murrayi (Théel, 1886)

Figure 25a–r, Appendix 1, Table S1, Figure S2

Holothuria murrayi Théel, 1886a: 185–186, pl. 10, figs 16–18.

Mesothuria murrayi.—Sluiter, 1901a: 24.—Fisher, 1907: 683–685, pl. 71, figs 1, 1a–h.—Ohshima, 1915: 226.—Hansen, 1956: 45–46, fig. 14b, d, e.—Jangoux et al., 1989: 163 (list), 165–166, fig. 3: a–d.—Solís-Marín, 2003: 180–182.—Gebruk et al., 2012: 303–307, fig. 11.—Wirawati and Setyastuti, 2021: 452, 455, fig. 2a, b.

Mesothuria murrayi var. *parva* Théel, 1886a: 186–187, pl. 9, fig. 2, pl. 16, figs 4–5.

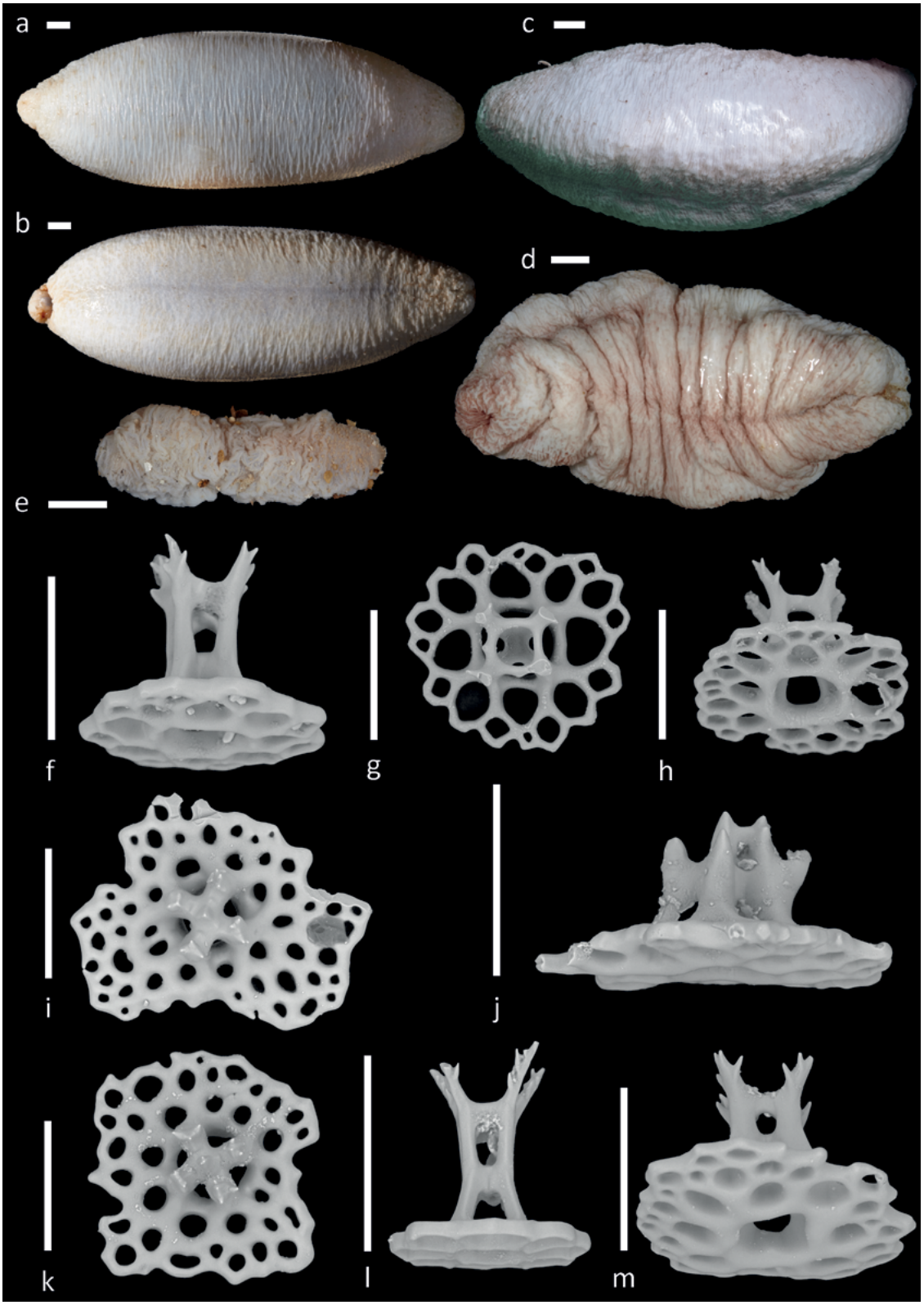

Figure 24. *Mesothuria gargantua*. a–e, shipboard images, a, b, dorsal and ventral, NMV F308234, c, lateral, NMV F296873, d, ventral, thick wrinkled form, NMV F308236, e, small soft form, NMV F308305; ossicles: f–m, body wall tables, f, NMV F308305 (ventral), g, h, NMV F308173, i–k, NMV F308252, l–m, NMV F308215; scale bars: a–e=1 cm, f–m =100 μm.

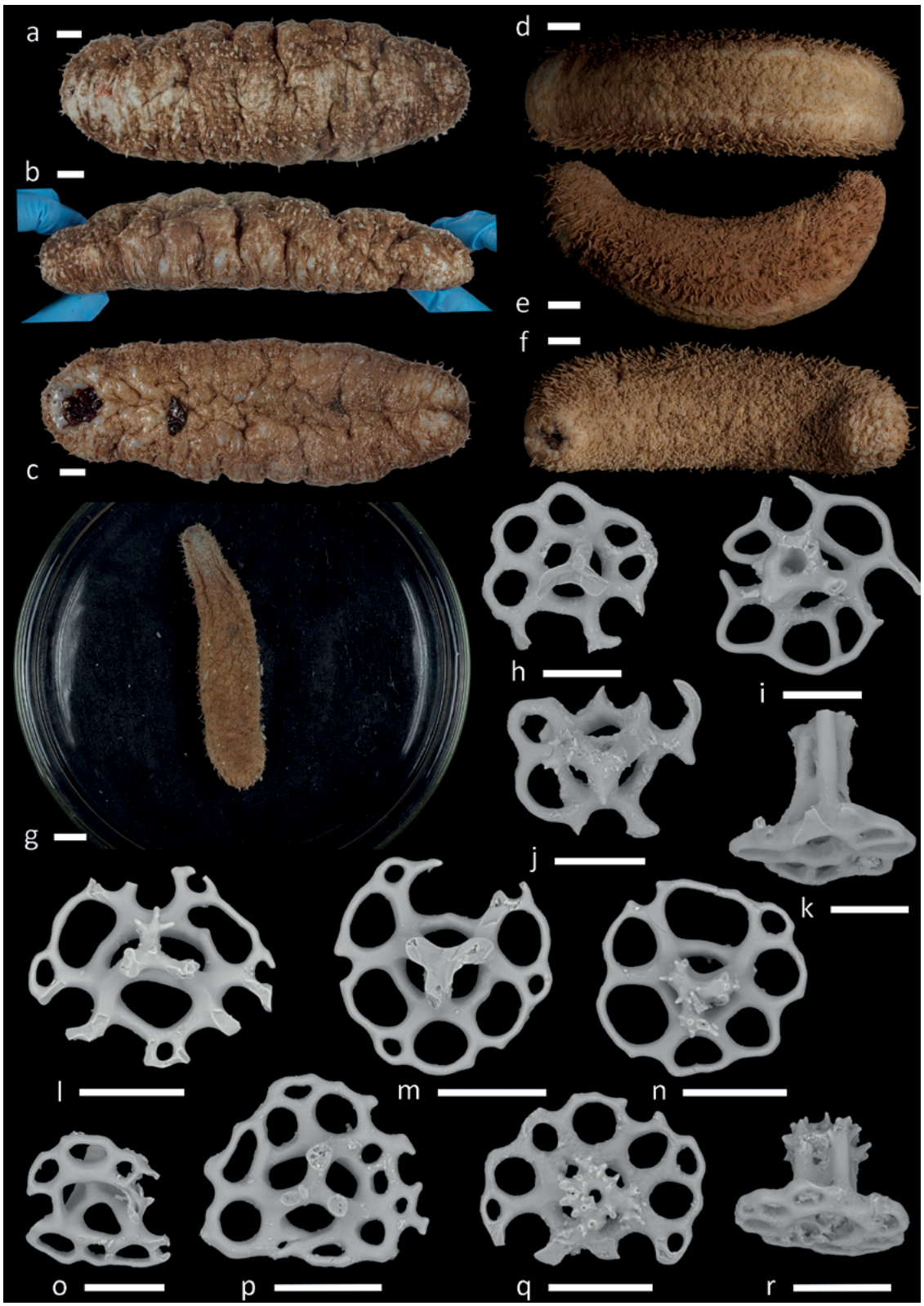

Figure 25. *Mesothuria murrayi*. a–g, shipboard images, a–c, dorsal, lateral, ventral, NMV F296839, d–f, ventral, lateral, dorsal, NMV F308144, g, in petri dish, NMV F296848; ossicles: h–r, body wall tables, h–k, NMV F296839, l–r, anterior dorsal, NMV F296848; scale bars: a–g=1 cm, h–r =50 *μm*.

Mesothuria murrayi var. *parva*.—Augustin, 1908: 18–20, textfig. 14.
Mesothuria murrayi (var.?).—Théel, 1886a: 187, pl. 9, fig. 3.
Mesothuria parva Théel, 1886.—Fisher, 1907: 686–687, pl. 71, figs 2, 2a–c.—Ohshima, 1915: 226.—Thandar, 1984: 341–343, textfig. 63.—Thandar, 1992: 161–163, fig. 1a–h.—Samyn and VandenSpiegel, 2016: 471, fig. 13a, b.
Mesothuria deani Mitsukuri, 1912: 40–42, textfig. 9.

Material examined. NMV F296839* (1) [IN2021 V04 007]; NMV F296848* (1) [IN2021 V04 016]; NMV F308144* (1) [IN2022 V08 105].

Diagnosis of IOT material. Light brown, elongated, cylindrical to semicylindrical specimens, typically medium to large, up to 18.5 cm long, 6 cm wide, 5.5 cm high (NMV F296839 pre-preservation). Terminal to ventral mouth and terminal anus. Tentacles all retracted in IOT specimens (likely 20 but not dissected out). Complete cover of tube feet but very scattered and reduced mid-dorsal and mid-ventral, longer and more conspicuous in lateral bands along the sides of each specimen, with bands moving onto both dorsal and ventral surfaces. Ossicles variable tables, but typically tri-radiate made of a perforated base disc with elevated central primary cross and three pillars, joined by a single cross beam in the middle and again at the top. Topped by three spines/arms angled up or out and spinous at the tips (most broken off in our samples). Bases typically smaller (~110 *μm*) or larger (130 *μm*) discs, with central perforation and six or seven larger perforations. Smaller specimen (NMV F296848) table base most typically ~100 *μm* with six large perforations plus some smaller perforations, and rarely (only one seen) ~90 *μm* table with many perforations and with four-pillared spinous spire lacking typical arms.

Remarks. Specimens key to *M. murrayi* using Gebruk et al. (2012). Specimens agree with the type description (Théel, 1886a) for *M. murrayi* general body form, tube foot distribution, and most ossicles. Ossicles with longer arms/spines not seen here (though most were broken) and remaining ossicles also look like *M. maroccana*, though this species itself may be just an age variation of *M. murrayi* (Gebruk et al., 2012). NMV F308144 (fig. 25d–f) has the body form closest to the type specimens, with body almost cylindrical, anus terminal, and mouth virtually terminal. All three have flexible skin though not obviously thin as recorded for types. NMV F296848 (fig. 25g) is a much smaller, flatter specimen.

Distribution. Cosmopolitan.*

Full bathymetric range. 246–6650 m* (IOT records 781–3345 m).

Type locality. South-east Pacific Ocean (off Chile), 2502 m.

*Many records may be unreliable (see remarks above and Gebruk et al. 2012).

This species previously recorded from outside Cook's Passage Queensland, west-central Pacific Ocean in AFD, and from Western Australia (off Perth), New South Wales, and east of Cape York Queensland in ALA (January 2024). This IOT material represents a geographic and bathymetric range extension for the species in Australia.

References. AFD (2024), ALA (2024), Gebruk et al. (2012), Solís-Marín (2003), Théel (1886a), Wirawati and Setyastuti (2021).

Genus ***Zygothuria*** R. Perrier, 1898

Diagnosis. (following Gebruk et al. 2012). "Body ovoid, flattened, but with well-differentiated sole; integument often wrinkled. Tube feet arranged exclusively in single or double row along ventrolateral ambulacra, placed on sole margin, which often forms fringe. Tube feet widely spread, may be quite big; dorsal papillae minute, not numerous, irregularly distributed or arranged in two simple rows, sometimes totally absent. Twenty tentacles, rarely 13–19; no tentacle ampullae; madreporite placed close to body wall, without penetrating it. Mouth ventral or terminal, anus terminal, without special arrangement. Calcareous ring with triangular radial segments. Ossicles of integument three-pillar (rarely four-pillar) tables; close to middle of their length pillars are linked by transverse beams; pillars merge on top forming spire."

Remarks. Deep-sea genus with six currently accepted species worldwide, two of which have been reported previously for Australia: *Z. lactea* from the south and east and *Z. marginata* from the northwest (WoRMS and ALA January 2024). Three lots of *Zygothuria* are recorded from the IOT voyages at depths of 1426–4766 m, and further identified to species OTU level as *Z. lactea* (1 lot), *Z. thompsoni* (1 lot, new species record for Australia), and *Zygothuria* sp. MoV. 7328 (1 lot). Distinguished from *Mesothuria* by flattened body shape with well-distinguished sole and fringe of ventrolateral tube feet, along with and typically tri-radiate compared to quadri-radiate table ossicles. With limited reviews of genera within Mesothuriidae available, we relied heavily on Solís-Marín (2003) and Gebruk et al. (2012) to identify specimens; both resources highlight the need for further study of the group. Based on both COI and 16S sequence data, *Zygothuria* is monophyletic (fig. S2). In the COI phylogeny, *Z. thompsoni* is sister to *Z. oxysclera*, but no 16S data is available. Without additional samples matching the morphological and/or genetic description of specimen NMV F296850, we are reluctant to identify this specimen past the current OTU level.

Zygothuria lactea (Théel, 1886)

Figure 26a–f, Appendix 1, Table S1

Holothuria lactea Théel, 1886a: 183–184, pl. 9, fig. 15.—Théel, 1886a: 6–7.
Zygothuria lactea.—Perrier, 1898: 1665.—Perrier, 1899: 246.—Perrier, 1902: 322, 327.—Deichmann, 1930: 108–111, pl. 8, figs 8, 9.—Deichmann, 1940: 190–191.—Deichmann, 1954: 386; Solís-Marín 2003: 68–73, figs 3.4, 3.5.—Gebruk et al., 2012: 310–312, 320–321, figs 13, 14.—Gebruk et al., 2014: 170–171.—Wirawati and Setyastuti 2021: 455, fig. 2c, d.
Mesothuria lactea.—Sluiter, 1901a: 25.—Hérouard, 1902: 21–23, pl. 1, figs 17–19; 1923: 13–15, pl. 4, figs 1–3.—Mortensen, 1927: 382–383, fig. 227.
Mesothuria (Zygothuria) lactea.—Heding, 1940: 340–341, fig. 7.
Mesothuria (Zygothuria) lactea lactea.—Heding, 1942: 9–10, fig. 9.

Material examined. NMV F308332 (1) [IN2022 V08 195].

Diagnosis of IOT material. Shipboard notes indicate this specimen was large, flat, very gelatinous, and stuck to the beam trawl net. Little structure and no real features remaining in preserved specimen, soft, wrinkled white tissue in broken

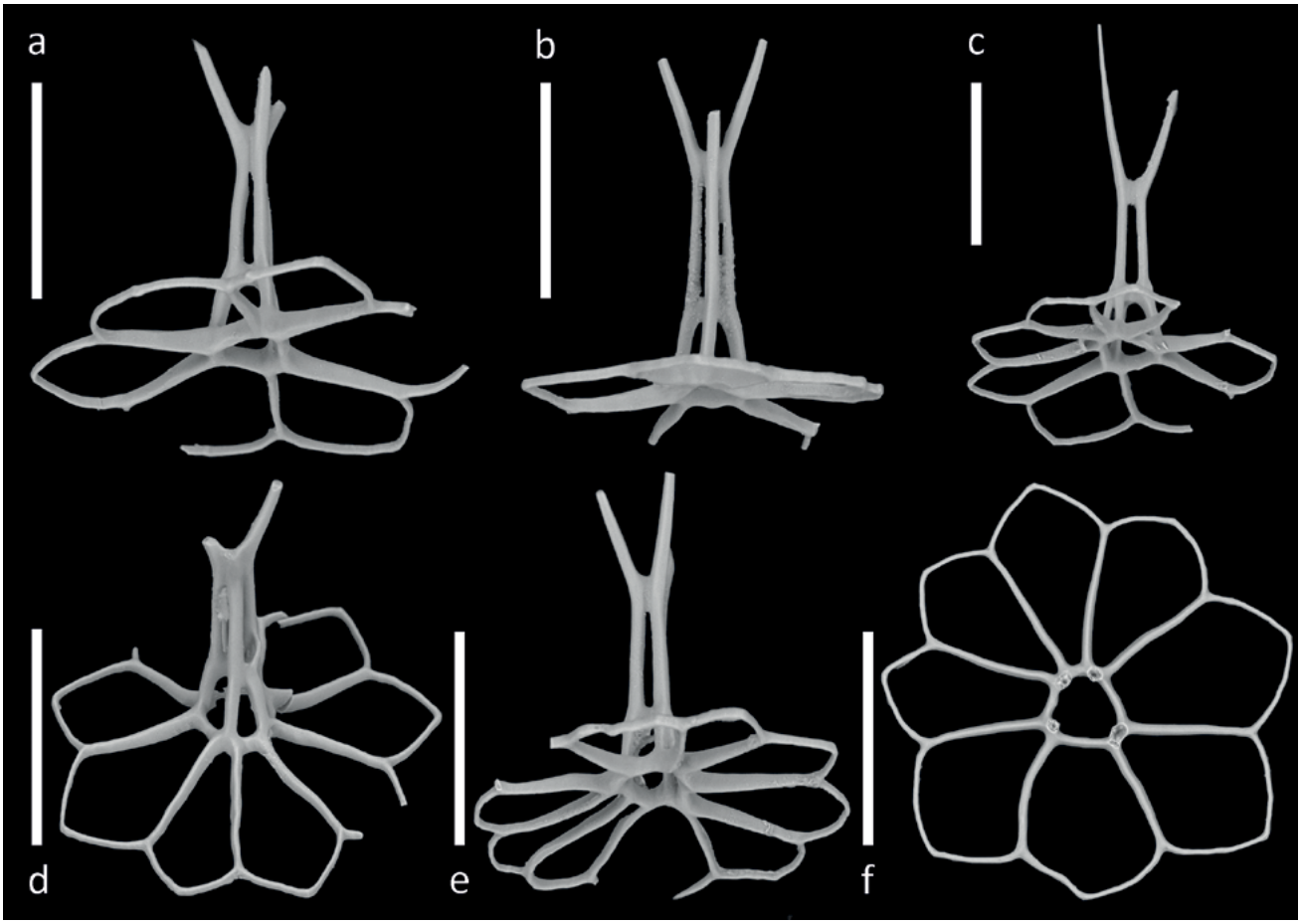

Figure 26. *Zygothuria lactea*. a–f, body wall table ossicles, NMV F308332; scale bars: a–f=100 *μm*.

pieces with some gut and stomach. Skin dense with tri-radiate *Zygothuria* ossicles. Base discs predominantly with six perforations (many also with eight). Three-pillared spires with three long, smooth, slender arms curving up from top, and one transverse beam between base and top. Rare similar tables with four pillars. Rare tables with a single off-centre spire.

Remarks. Extensive damage to the specimen meant that identification was reliant on ossicles only. These keyed closest to *Z. lactea* using Gebruk et al. (2012) and were a good match to the ossicle illustrations and description in the same paper.

Distribution. Cosmopolitan species, though records from the Gulf of Mexico and Caribbean may be unreliable (Gebruk et al., 2012).

Full bathymetric range. 694–5278 m (IOT records 1426–1450 m).

Type locality. Atlantic and Pacific Oceans, off the Azores and New Zealand, 1280–1830 m.

This species not previously recorded for Australia in AFD but recorded at depths of 817–4250 m off the eastern coast of Australia (Queensland to Victoria) and in the Great Australian Bight off South Australia in ALA (January 2024, under previous taxonomy). This IOT material represents a geographic range extension for the species in Australia.

References. AFD (2024), ALA (2024), Gebruk et al. (2012), Gebruk et al. (2014), Hansson et al. (2001), Östergren (1896), Théel (1886a), Solís-Marín (2003).

Zygothuria thompsoni (Théel, 1886)

Figure 27a–f, Appendix 1, Table S1, Figure S2

Holothuria thomsoni Théel, 1886a: 184–185, pl. 10, figs 8, 11.
Holothuria thomsoni var. hyalina Théel, 1886a: 185.
Mesothuria thomsoni (Théel, 1886).—Östergren, 1896: 350–351.
Zygothuria thomsoni (Théel, 1886).—Gebruk et al., 2012: 331–333, fig. 20, table 15.
Zygothuria thompsoni (Théel, 1886).—Solís-Marín, 2003: 277 (incorrect spelling).

Material examined. NMV F308198* (2), [IN2022 V08 116].

Diagnosis of IOT material. Elongate to oval specimens ~12 cm long x 4.2 cm wide, damaged, and atypically flattened or empty. Cream-coloured thin, wrinkled skin, but with some grey flecks

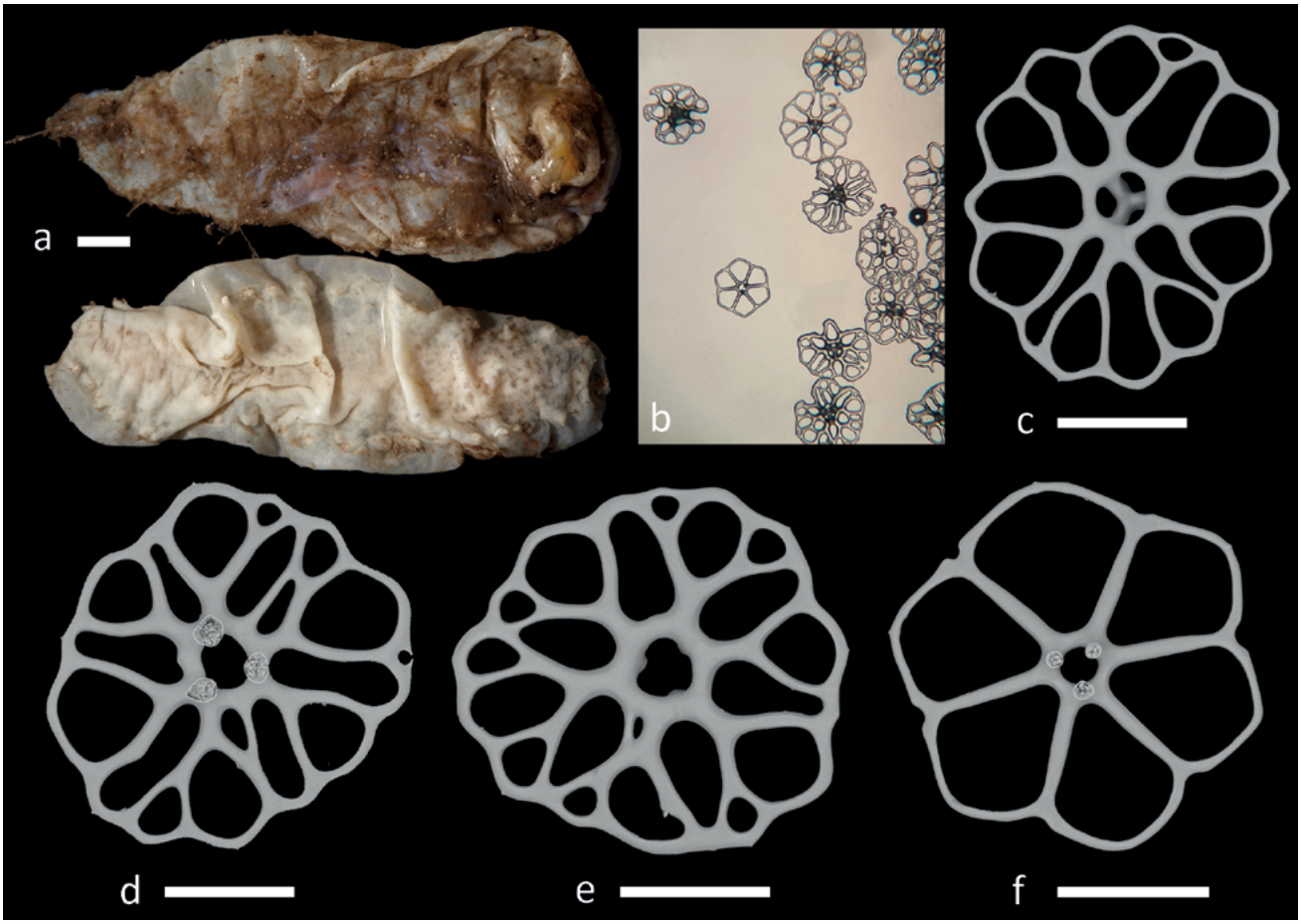

Figure 27. *Zygothuria thomsoni*. a, dorsal and ventral views showing lateral tube feet; ossicles: b, microscope image showing ossicle variety, c–f, body wall table ossicles (broken pillars), NMV F308198; scale bars: a=1 cm, c–f=100 *μm*.

and brown patches in places. Sole clearly defined by well-spaced series of tube feet on each ventrolateral margin, bare midventrally. No sign of dorsal papillae. Anus terminal. Mouth ventral to terminal. Small ossicle tables with predominantly three-armed pillars linked by two transverse beams and topped by three spires. Spires mostly broken but some indication that they are short compared with stem of pillar, and spinous. Bases typically ~240–290 *μm*, thick to thin, irregular with wavy edges and 12 or more elongate to oval or round perforations of varying size. No obvious placement of perforations based on size seen here. Rare thin, symmetrical hexagonal bases ~260 *μm* in diameter with six pentagon-shaped perforations (fig. 27f).

Remarks. Prominent tube feet on ventrolateral radii rather than tube feet scattered over entire body distinguish these specimens as *Zygothuria* not *Mesothuria*. Specimens key closest to *Z. connectens* or *Z. thomsoni* using Gebruk et al. (2012), but with ossicles a closer match to figures of *Z. thomsoni* (Théel, 1886) as redrawn in the same paper.

Distribution. Pacific Ocean, Indian Ocean (Australian IOT), (and as *Z. thomsoni* var. *hyalina* from southern Indian Ocean with limited confidence).

Full bathymetric range. 1991–5307 m (IOT 1957–1991 m).

Type locality. North-west and mid-north Pacific, 3375–5307 m.

This species not previously recorded from Australia in AFD or ALA (January 2024).

This IOT material represents a geographic and bathymetric range extension for the species, previously only known from its type location, though with limited confidence.

References. AFD (2024), ALA (2024), Gebruk et al. (2012), Solís-Marín (2003).

Zygothuria sp. MoV. 7328

Figure 28a–h, Appendix 1, Table S1, Figure S2

Material examined. NMV F296850* (1), [IN2021 V04 024].

Diagnosis of IOT material. One additional small, brown, specimen ~50 mm long and 19 mm wide but severely damaged and not recognisable by external morphology as *Zygothuria*. Turned inside out with five flat longitudinal muscles visible, and evidence of "hairy" skin (potentially flat papillae) but no

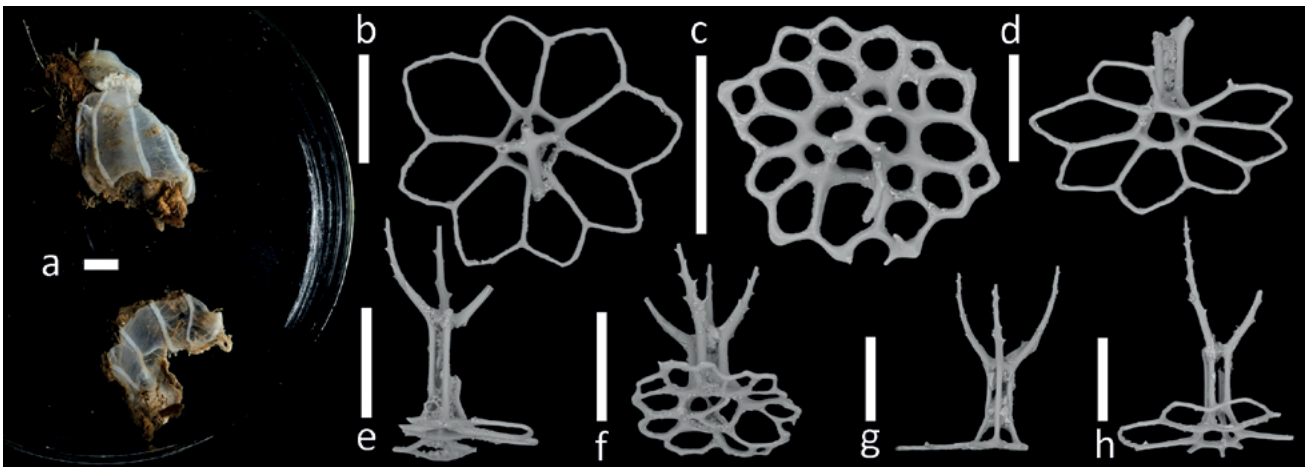

Figure 28. *Zygothuria* sp. MoV. 7328. a, shipboard image of severely damaged specimen in petri dish; b–h, body wall table ossicles, NMV F296850; scale bars: a=1 cm, b–h=100 *μm*.

other visible structures. Numerous failed ossicle samples before tri-radiate and slightly less common quadri-radiate tables were found. Not dense in skin, from tables with thin, well-defined, flower-like base discs with eight uniform perforations (fig. 28b) to tables with less-uniform base discs with multiple irregular perforations (e.g. fig. 28c).

Remarks. Specimen too damaged for accurate account of external morphology, though appears to differ from *Zygothuria* species reviewed by Solís-Marín (2003). Ossicles show individual similarities with several species reviewed by Gebruk et al. (2012), but not in their combination. Without additional specimens for analysis, we would be reluctant to identify this specimen past OTU level *Zygothuria* sp. MoV. 7328.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Christmas Island: Abyss Stn. South of Christmas Island, 4764–4766 m.

References. Gebruk et al. (2012), Solís-Marín (2003).

Order **Molpadida** Haeckel, 1896

Diagnosis. (following O'Loughlin et al., 2015). "Tentacles 15, digitate; body stout, lacking tube feet, usually with an evident tail; anal papillae, tentacle ampullae and respiratory trees present; ossicles may include tables, cups, rods, perforated plates and modified anchors; phosphatic bodies often present."

Remarks. The Molpadida are burrowing holothuroids lacking any tube feet and with a sausage-like body often tapered to a tail. Despite the absence of tube feet, Molpadida do not group with the Apodida, though their position within the Neoholothuriida remains uncertain (Miller et al., 2017). Molpadida often bury themselves in mud or silt and are known from the subtidal zone down to abyssal depths (Pawson et al., 2001). They are represented worldwide by three families, with only Caudinidae and Molpadiidae currently recorded for Australia. Only Molpadiidae was represented in IOT material, with two lots of *Molpadia* from two stations at 3839–4766 m.

Family **Molpadiidae** Müller, 1850

Diagnosis. (following O'Loughlin et al., 2015, after Pawson, 1977). "Tentacles claw shaped or with terminal digits and few small lateral digits. Tentacle ampullae long or reduced. Spicules derived from tri-radiate tables with three-pillared spire. Tail with tables with round to oblong disc or long fusiform rods. Phosphatic deposits often present."

Remarks. Ossicles of some species will gradually transform into light orange or red phosphatic deposits (Pawson et al., 2001). Genera and species within Molpadiidae are differentiated by type or combination of ossicles which include tri-radiate and fusiform tables, fusiform rods, racquets, anchor plates and anchors; and presence or absence of phosphatic deposits (Rowe et al., 2017). Of the three currently accepted genera worldwide, *Heteromolpadia* and *Molpadia* have been previously recorded from Australia, with only *Molpadia* being widespread. We found one *Molpadia* OTU in the IOT material, *Molpadia* cf *blakei* (2 lots).

Genus ***Molpadia*** Cuvier, 1817

Diagnosis. (following O'Loughlin et al., 2015, after Pawson, 1977). "Calcareous deposits include tables, anchors, and rosettes of racquet-shaped plates and large fusiform rods in various combinations. Tail deposits tables or fusiform rods. Phosphatic deposits present or absent."

Remarks. Samyn and VandenSpiegel (2016) commented that there has been no complete revision of *Molpadia* since Pawson put *Trochostoma* and eight other genera into the group between 1965 and 1977. Pawson himself noted the ongoing issues with successfully splitting the loosely defined group into multiple genera, and the acceptance between taxonomists to maintain it for practical purposes, until more is known (Pawson, 1977). There are 60 currently accepted species within *Molpadia* (WoRMS 2024), with eight of these previously known from Australia: *M. adamanensis, M. antarctica, M. dissimilis,*

M. scabrum, M. abyssicola, M. granulata, M. musculus and *M. lenticula* (Rowe et al., 2017), though there are some discrepancies between this list and genera recorded in ALA and in the NMV catalogue. Additional work will be needed to resolve the distribution discrepancies for the genus within Australia. In the IOT we found two lots of *Molpadia*, both from stations over 3700 m, which we have identified here as *Molpadia* cf *blakei*. Tri-radiate tables with a three-pillared spire, along with the presence of phosphatic deposits and lack of plate/cup ossicles, puts specimens into Molpadiidae rather than Caudinidae, while lack of three-armed anchor plates puts them in *Molpadia* rather than *Heteromolpadia* (Pawson, 1977 key). Although we have a reduced dataset, both COI and 16S sequence data indicates that *Molpadia* is paraphyletic, which is concordant with previous findings (Miller et al., 2017). Specific genetic placement of these IOT specimens is noted in Remarks for the species description below.

Molpadia* cf *blakei (Théel, 1886)

Figure 29a–k, Appendix 1, Table S1, Figure S3

Material examined. NMV F296851* (3), [IN2021 V04 024], NMV F308219* (1) [IN2022 V08 120].

Diagnosis of IOT material. Cylindrical, mud-filled specimens with pronounced posterior tail and constricted "neck". Body length up to 77 mm long, 32 mm wide and 35 mm high, semi-retracted tail 6 mm long (NMV F296851, largest specimen, preserved). Brown to light violet or grey. Skin thin and soft, with flat divided longitudinal muscles clearly visible. Tentacles all retracted in these specimens. Body wall ossicles tables with fairly uniform perforated base disc and three-pillared spires, typically over 130 *μm* high and twisted or fused from halfway. Most tables ~100 *μm* in diameter with six holes (3 large, 3 small) though tables with fewer or greater number of holes also present. Where not broken, spires are topped by a crown of five or more hooks (fig. 29c). Some shorter spires ~60 *μm* with less-developed hooks (fig. 29e) also present. Yellow and brown phosphatic deposits seen in tail sample of NMV F308219. Tail crowded with fusiform ossicles with perforated base disc branching into rods at end, and a three-pillared spire typically shorter than in body wall. Base plate ~270 *μm* with typically six (3–8) holes of irregular size. Crown with up to ten hooks but not as curved as in body wall ossicles (e.g. fig. 29j). Tail ossicles only broken discs and pillars in NMV F296851.

Remarks. The IOT specimens were differentiated morphologically using the key from Pawson (1977). Differentiated from *Molpadia musculus* by ossicles not being "almost exclusively" fusiform tables (including in the body wall), and from those fusiform tables (where present in the tail) being much smaller than the 500–1300 *μm* noted for *M. musculus*. Some ossicles, particularly from NMV F296851 are like those in *M. liska* (Pawson, 1977), but distinguished from that species by having divided muscles and more than four hooks on ossicle spires, and NMV F308219 also has additional distinguishing characters of phosphatic bodies, fusiform ossicles in tail, and typically more than three perforations in plates. A close match to the body shape, size, colour and skin thickness for the type specimen for *M. blakei* (68 mm with a 7 mm tail), though while ossicles are visible to the eye, skin in IOT specimens is soft rather than rough. Differs from *M. blakei* sensu stricto in that six perforations are more common than three perforations, and more than "a few" hooks are typical in all pillars including in the tail. Morphologically congruent with *Molpadia* aff *blakei* (Théel, 1886) as described by Rogacheva et al. (2013) from the mid-Atlantic ridge, where body wall ossicles with six holes were more prevalent than the discs with three holes as noted in the original description and descriptions of Deichmann (1930, 1940) and Pawson et al. (2001). For COI, the two IOT *Molpadia* cf. *blakei* samples have identical COI haplotypes and group with *M. musculus* (fig. S3). 16S sequence data was only available for NMV F296851 and it again groups with *M. musculus*. Without additional material for molecular and morphological comparison, we retain our specimens in *Molpadia* cf. *blakei* for now, noting the clear morphological differences from *M. musculus* as diagnosed by Pawson (1977).

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands Territories, Abyss S of Christmas Island Stn. and Rudist Seamount Stn., 3780–4766 m.

Full bathymetric range. 3780–4766 m.

References: AFD (2024), ALA (2024), Gebruk et al. (2014), Miller et al. (2017), O'Loughlin et al. (2013, 2015), Pawson (1965), Pawson (1977), Pawson et al. (2001), Rogacheva et al. (2013), Samyn and VandenSpiegel (2016), Smirnov (2012), Théel (1886).

Order **Persiculida** Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017

Diagnosis (see Miller et al., 2017)

Remarks. Persiculida was erected in 2017 when Miller et al. undertook a major revision of Holothuroidea after molecular evidence showed that three of the five previous orders were non-monophyletic. Persiculida includes many genera formerly assigned to Synallactidae and Gephyrothuriidae; morphological characters include lack of body wall ossicles and presence of a pygal furrow for which the clade is named (Latin *persica* = peach, + *culus* = posterior) (Miller et al., 2017). All three currently accepted families – Gephyrothuriidae, Molpadiodemidae and Pseudostichopodidae – are found in Australia, along with four genera not currently sitting under a family, of which *Benthothuria* is the only one currently reported from Australia (ALA and WoRMS, 2024). Molpadiodemidae, Gephyrothuriidae and Pseudostichopodidae are reported from the IOT voyages.

Family **Gephyrothuriidae** Koehler and Vaney, 1905

Diagnosis (see Koehler and Vaney, 1905)

Remarks. This family was erected to include animals with a cylindrical body, narrower at the oral end, which have papillae or tube feet exclusively on the two dorsal radii but not on the other three. It currently comprises two genera: *Gephyrothuria* and *Paroriza*, previously found off eastern Australia, *Gephyrothuria* from Queensland to Tasmania and *Paroriza* from north and east of Tasmania (WoRMS and ALA, January 2024).

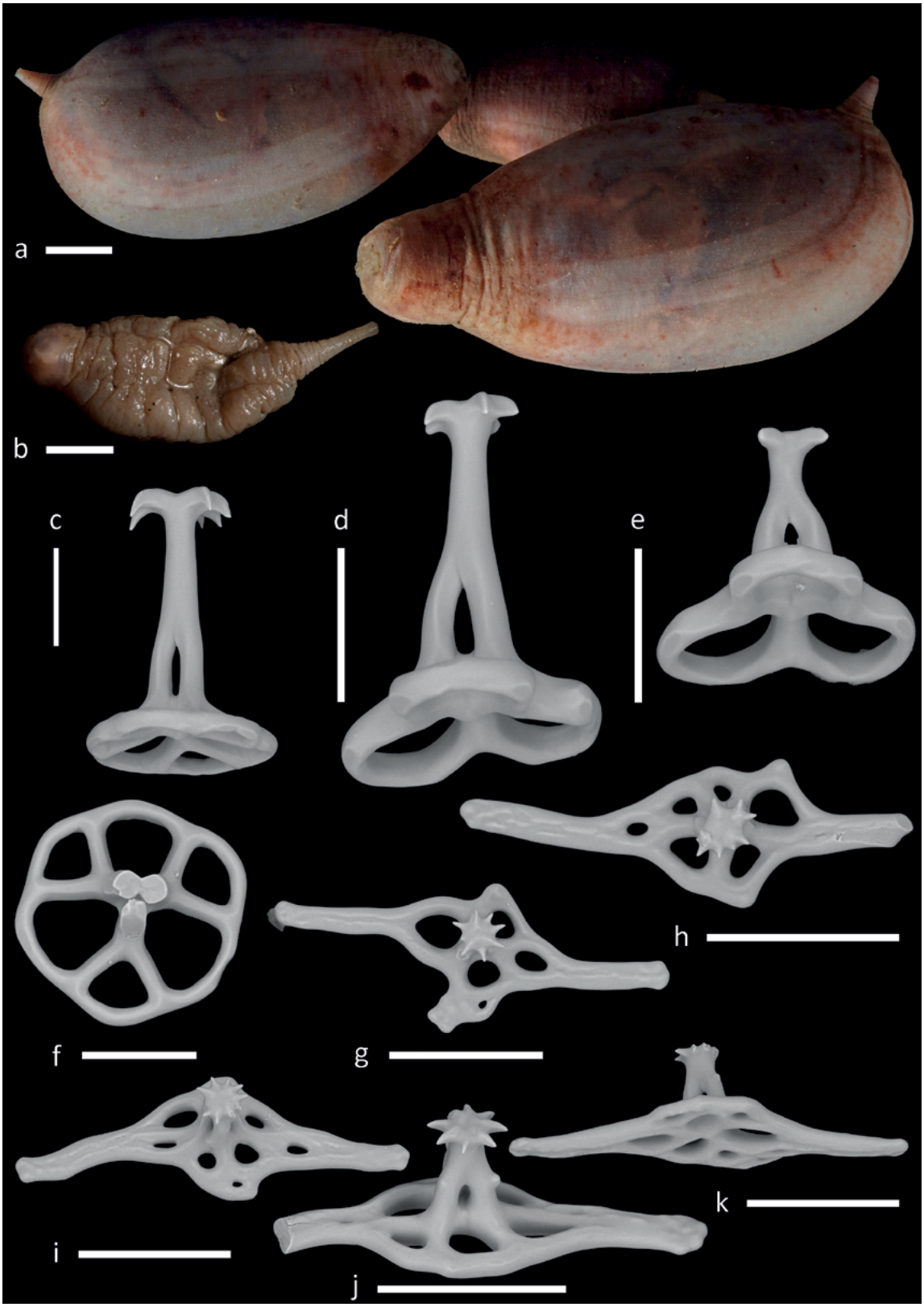

Figure 29. *Molpadia* cf *blakei*. a, b, shipboard images, a, NMV F296851, b, NMV F308219; ossicles, c–f, body wall, g–k, tail, NMV F308219; scale bars: a=1 cm, b=0.5 cm, c–f=50 *μm*, g–k=100 *μm*.

Genus ***Paroriza*** Hérouard, 1902

Diagnosis (see Hérouard, 1902)

Remarks. *Paroriza* was moved to family Gephyrothuriidae by Miller et al. (2017) as a well-supported sister to *Gephyrothuria alcocki*, the type-taxon of Gephyrothuriidae. The morphology of the genus differs from the family diagnosis in that only the midventral is completely bare, not the ventrolateral radii. This description also excludes some smaller specimens that have since been noted to have a complete covering of tube feet (Hansen, 1956). There are four currently accepted species worldwide: *Paroriza grevei* Hansen, 1956, *P. pallens* (Koehler, 1895), *P. prouhoi* Hérouard, 1902 and *P. verrucosa* Massin, 1987. Here we report one lot of *P. prouhoi* from the IOT at a single station, the first species-level record for the genus in Australia (ALA, 2024). *Paroriza* is most easily distinguished from *Gephyrothuria* by being crowded with dorsal appendages rather than having only a few on the dorsal radii, and by being ventrally flattened rather than rounded with a tail (*Gephyrothuria* has a similar shape to Molpadiidae).

Paroriza prouhoi Hérouard, 1902

Figure 30a–e, Appendix 1, Table S1, Figure S4

Paroriza prouhoi Hérouard, 1902: 24–25, pl. 7: 1–2, pl. 8: 30.—Hérouard, 1923: 29–30, pl. 2: 3–4.—Mortensen, 1927: 386.—Deichmann, 1930: 112–113.—Hansson, 2001 (list).—Gebruk et al., 2014: 166–167.

Mesothuria expectans.—Perrier, 1899: 245.—Perrier, 1902: 317–320.—Deichmann, 1930: 92.—Tortonese, 1949: 11 (list).—Madsen, 1953: 168 (list).

Material examined. NMV F308312* (1) [IN2022 V08 183].

Diagnosis of IOT material. Elongate, subcylindrical specimen, slightly raised dorsally and flattened ventrally, rounded at anterior and posterior ends but otherwise a relatively even width throughout body. Body not obviously curved or tapered and small at 57 mm long, 16 mm wide and 10 mm high (preserved). Skin firm and light brown with a complete dorsal cover of tightly packed white-opaque filiform papillae giving the specimen an almost mauve-grey appearance once preserved. Longer and shorter papillae, slightly more condensed on radii, often with a shorter cylindrical tube foot at the base (fig. 30e), these are of variable size and scattered throughout. Papillae up to 8 mm long (dorsal, live) and 6 mm long once preserved, shorter on ventrolateral, wide at base tapering to a rounded tip. Papillae and tube feet extend to ventrolateral and encroach on ventral, with cream to light-brown tube feet continuing across the whole ventral surface, smaller along the midventral line. Anus subventral and dark brown with pygal furrow. Mouth ventral with dark brown to purple tentacles, mostly retracted, two visible on thick stalks and with discs with at least five rounded (not bifid) digit-like processes on edges (fig. 30c). Longitudinal muscles are flat. White and light brown grit caught between papillae and tube feet on surface of the animal. No ossicles present in body wall.

Remarks. This IOT specimen is currently distinguished from *Paroriza prouhoi* Hérouard, 1902 sensu stricto by being noticeably crowded dorsally, and by the presence of midventral tube feet. It also differs from the WoRMS image of a much larger NHMUK specimen of *P. prouhoi* from the Porcupine Abyssal Plain in the Northeast Atlantic, which is bare midventrally and a lot less crowded dorsally (WoRMS, 2024). We have judged that this discrepancy is due to specimen size, because other morphology including presence of large and small "tubes" and dark tentacles and anus match the original description. Hansen (1956), when describing a similar species, *P. grevei,* noted that while larger specimens were bare midventrally, a covering of ventral tube feet was present in smaller specimens. Here we note the same for our small IOT specimen of *P. prouhoi*, which is only 57 mm long compared with the type material recorded at 23 cm (Hérouard, 1902). Noting that the IOT specimen is also a perfect match for a genetic sequence of *P. prouhoi* from the northeast Atlantic, we anticipate a need to revisit species and genus-level descriptions for the group, potentially noting the discrepancies between small and large forms. Distinguished from *P. grevei* Hansen 1956 by tentacle discs having more than the four diagnostic processes Hansen noted, also less cup shaped. Distinguished from *P. pallens* by a mixture of long and short tube feet, scattered throughout, rather than uniform and even distribution. Distinguished from *P. verrucosa* by the presence of a complete dorsal and ventrolateral covering of papillae and scattered tube feet, not just wart-like tube feet, also not smooth or bare ventrally and with different tentacle form.

The single *P. prouhoi* specimen from the IOT was sequenced for COI. The sequence was similar to a previously sequenced *P. prouhoi* from the northeast Atlantic Ocean, with only two base pair differences (fig. S4). No other genetic data for other *Paroriza* species were available at the time of publication.

Distribution. North-East Atlantic, off the Azores, the Bay of Biscay, and the Porcupine Seabight; Mediterranean Sea; Indian Ocean (Australian IOT).

Full bathymetric range: 3948–4880 m (IOT 3948–4047 m).

Type locality. North Atlantic Ocean between Azores and Portugal, 4360 m.

This species not previously recorded from Australia in AFD, and *Paroriza* only recorded at genus level from Australia in ALA (January 2024). This IOT material extends the geographic range for the species and genus as the first record from the Indian Ocean. It also slightly extends the bathymetric range for the species previously recorded from 4080 m (Gebruk et al., 2014) and is a new record for the species in Australia.

References. AFD (2024), ALA (2024), Gebruk et al. (2014), Hansen (1956), Hansson et al. (2001), Hérouard (1902), Massin (1987), WoRMS (2024).

Family **Molpadiodemidae** Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017

Diagnosis. (see Miller et al., 2017)

Remarks. This family was erected in 2017 when molecular evidence combined with morphological characters supported its individual status within Persiculida (Miller et al., 2017). It currently comprises a single cosmopolitan genus: *Molpadiodemas*,

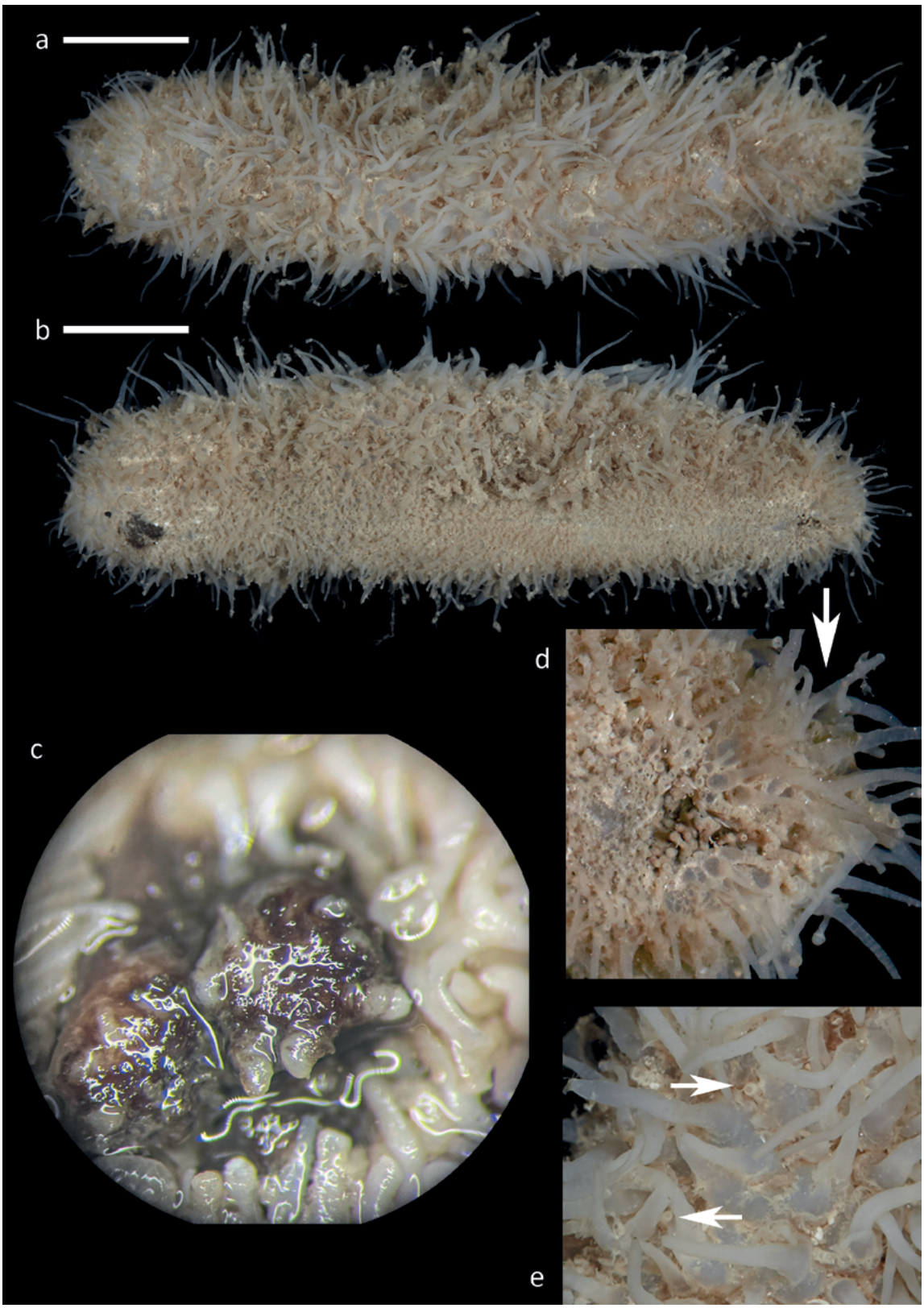

Figure 30. *Paroriza prouhoi*. a, b, shipboard images, dorsal, ventral; c, close-up of tentacle digits, d, close-up of pygal furrow, papillae, ventral tube-feet; e, close-up of dorsal papillae with arrows to smaller tube feet, NMV F308312; scale bars: a, b=1 cm.

previously found off eastern, southern and north-western coasts of Australia at depths of 528–4139 m, and in Australian Antarctic waters (WoRMS and ALA, January 2024).

Genus ***Molpadiodemas*** Heding, 1935

Diagnosis (following O'Loughlin and Ahearn, 2005, amended for Miller et al., 2017 erection of Molpadiodemidae). Cylindrical body with rounded terminal ends; pygal-furrowed; body surface covered in small discrete tube feet; large prominent tube feet and papillae absent from the paired radii; longitudinal muscles undivided and sit flat against the inner body wall, not cylindrical, broadly attached to the inner body wall; gonad tubules branch out from a common gonoduct base, not in series along the gonoduct; ossicles not found in body wall or tube feet; branched rod ossicles can be present in tentacles, frequently with ends intertwining and side branches fused to create mesh.

Remarks. Cosmopolitan genus with a large depth range of 103–7086 m (O'Loughlin and Ahearn, 2005). Sixteen species currently accepted worldwide, with only two previously known from Australia: *Molpadiodemas crinitus* and *M. involutus*. Others are known from Australian Antarctic waters (AFD, ALA and WoRMS, 2024). The group has traditionally been difficult to split from other pygal-furrowed genera such as *Pseudostichopus* due to similar external morphology and the lack of truly diagnostic ossicles, with no ossicles in the body wall or tube feet, and those existing in tentacles and gonads being highly variable. The clearest distinguishing feature is flat, broadly attached longitudinal muscles for *Molpadiodemas*, compared to rounded muscles for *Pseudostichopus*. O'Loughlin and Ahearn's (2005) review remains the most comprehensive resource for morphological features, but we found that our species did not fall cleanly into their key as described. Here we report 30 specimen lots of *Molpadiodemas* from the IOT, with seven lots further diagnosed with genetic support to OTU level as follows: *Molpadiodemas* sp. MoV. 7329 (3 lots), *Molpadiodemas* sp. MoV. 7334 (3 lots), *Molpadiodemas* sp. MoV. 7335 (1 lot). Molecular data confirms the monophyly of *Molpadiodemas*, but at the time of this study molecular data is only publicly available for four of the 16 currently accepted species. Within *Molpadiodemas*, our new sequence data forms three distinct lineages. The first lineage, represented here as *Molpadiodemas* sp. MoV. 7334, contains previously published sequences from *M. crinitus* (only available for COI), *M. morbillus* (only available for COI), *M. involutus* (COI and 16S), *and M. villosus* (only available for 16S). The second lineage, represented here as *Molpadiodemas* sp. MoV. 7335 has only a single individual (NMV F296882) from genetically sampled material, and while differing in some internal characters, is superficially like specimens from the third lineage, represented here as *Molpadiodemas* sp. MoV. 7329 and comprising only IOT samples. While our data increases the available genetic information significantly, more sequencing is needed to assess whether these new lineages correspond to previously described species.

***Molpadiodemas* sp. MoV. 7329**

Figure 31a–g, Appendix 1, Table S1, Figure S4

Material examined. NMV F296854* (1) [IN2021 V04 026]; NMV F308204* (1) [IN2022 V08 117]; NMV F308263* (2) [IN2022 V08 143].

Diagnosis of IOT material. Small, soft, dorsoventrally flattened, up to 35 mm long, 16 mm wide and 4 mm high (NMV F308204, preserved). Gelatinous and translucent to cream-coloured with central cavity visible. Off-white to grey when preserved. Mouth ventral, with orange/brown to yellow tentacles. Anus ventral with pygal furrow. Lateral edges are wavy or bumpy rather than smooth and a darker cream-yellow pre-preservation. Tube feet small and filamentous, not restricted to paired radii, but more matted ventrolaterally. Partial covering of sand and forams. Lateral skin on preserved specimen is flattened completely to look brim-like against the central circular gut tube. Tube feet still visible all over though more concentrated ventrolaterally. Lateral edge is almost ridge-like with concentrated flattened tube feet. Ossicles in tentacles are smooth to irregular, straight to curved rods, many perforated or twisted, some curved rods with plate-like mesh, up to 176 μm, but typically 80–104 μm long.

Remarks. Specimens clearly group together based on pre- and post-preservation morphology. With thread-like tube feet they again key closest to *Molpadiodemas villosus* or *M. porphyrus* using O'Loughlin and Ahearn (2005). Ossicles with simple or mesh rods are like *M. villosus* here but differentiated from that species by being more dorsoventrally flattened, translucent and partially covered in sand, and from *M. porphyrus* by colour and form. Preserved flattened form and rod ossicles rather than true plates distinguish this specimen somewhat from *Molpadiodemas* sp. MoV. 7335, but additional morphological and phylogenetic work is required to further define the group. We identify these specimens here as OTU *Molpadiodemas* sp. MoV. 7329.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas and Cocos (Keeling) Island Territories, Max Seamount Stn., Rudist Seamount Stn., and Cocos (Keeling) Stn., 1113–1990 m.

References. O'Loughlin and Ahearn (2005).

***Molpadiodemas* sp. MoV. 7334**

Figure 32a–h, Appendix 1, Table S1, Figure S4

Material examined. NMV F296842* (1) [IN2021 V04 007]; NMV F296856* (1) and NMV F296859* (3) [IN2021 V04 028].

Diagnosis of IOT material. Variably oval to elongate sub-cylindrical specimens, dorsally low convex and rounded, ventrally flattened. From small at ~3 cm long (NMV F296842) to large at ~15 cm long, 7 cm wide, and 4.6 cm high (NMV F296856, pre-preservation). Soft to firm, gelatinous, opaque to semitranslucent, off-white to cream-brown with some yellow staining ventrally. Mouth ventral, with ~20 peltate cream to orange-brown tentacles. Anus ventral with pygal furrow. Lateral edges are wavy or bumpy rather than completely smooth. Patchy covering with sand and forams, more condensed mid-ventrally, present on all but not as much on NMV F296842. Tube feet can

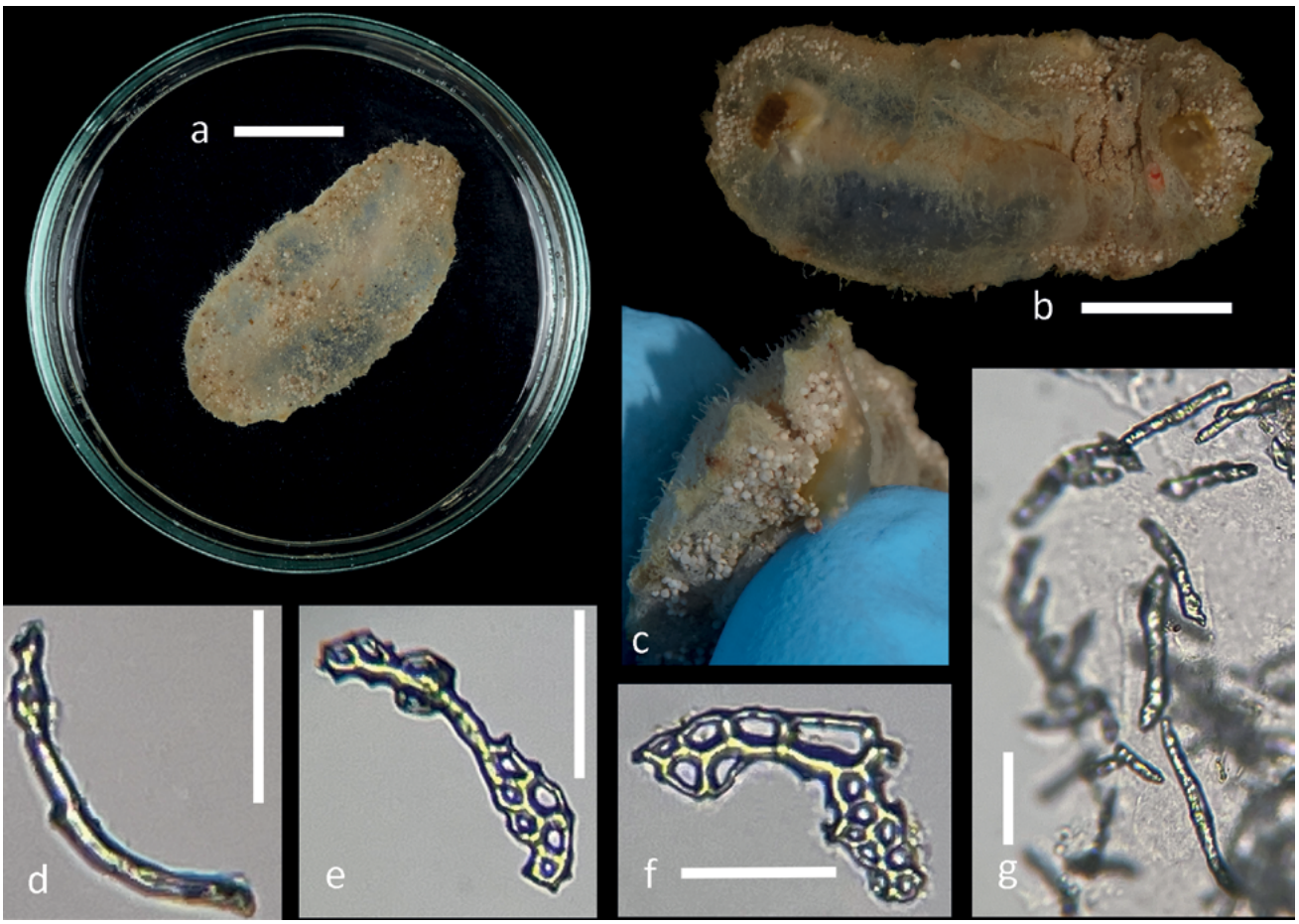

Figure 31. *Molpadiodemas* sp. MoV. 7329. a–c, shipboard images, a, dorsal, in petri dish, NMV F296854, b, ventral, c, close-up of pygal furrow, NMV F308263; tentacle rod ossicles, d, NMV F296854, e, f, NMV F308263, g, NMV F308204; scale bars: a–c=1 cm, d–g=50 *μm*.

be inconspicuous but are small, cream-brown, and filamentous when seen in water, not restricted to radii, but particularly dense and matted ventrolaterally (fig. 32f). More obvious on the other specimens once preserved, condensed ventrolaterally and anteriorly. Specimens look and feel much more like each other once preserved. All off-white to grey and shrink on preservation (e.g. 11 cm long, 5.9 cm wide, 2 cm high, NMV F296856), and skin can form a more defined lateral line, though not a true brim. The orange-yellow staining was retained on the ventral side for NMV F296856, particularly at the oral end. Tube feet of all specimens lay flat rather than projecting out. Tentacle ossicles smooth straight to curved rods with and without central thickening (~120 *μm*), and more typically longer straight to curved rods with some twisting, mesh, or perforations, more typically ~160–240 *μm*, but up to 400 *μm*.

Remarks. Specimens do not clearly group together based on pre-preservation morphology, the large and firm NMV F296856 appearing quite different to the much more gelatinous NMV F296859. However, a lack of brim combined with matted hair-like tube feet take all these specimens to *Molpadiodemas villosus* using the key in O'Loughlin and Ahearn (2005), and tentacle ossicles fall within the types imaged and described. They differ from the species description of *M. villosus* in the same paper (specimens up to 11 cm) by the clear presence here of globigerine and other attachments, and no gonad ossicles were observed from minimal sampling. Specimens also partially fit ossicle images and description of *M. involutus*, though lacked obvious raised protuberances and were not a match to specimen image (fig. 3m–o in O'Loughlin and Ahearn, 2005). These IOT specimens currently group in a lineage with *M. crinitus*, *M. involutus*, and *M. villosus* (as noted in Remarks for the genus), so additional morphological and phylogenetic work is required before firm species distinctions can be made. We identify IOT material here to OTU *Molpadiodemas* sp. MoV. 7334.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island Territory, Christmas Island SE Stn. and Karma Seamount Stn., 2760–3345 m.

References. O'Loughlin and Ahearn (2005).

Figure 32. *Molpadiodemas* sp. MoV. 7334. a–f, shipboard images, a–c, dorsal, lateral, ventral (with pygal furrow), NMV F296856, d, dorsal of small version, NMV F296842, e, f, group shot and close-up of papillae and forams, NMV F296859; g, h, tentacle rod ossicles, NMV F296859; scale bars: a–e=1 cm, g, h=100 *μm*.

***Molpadiodemas* sp. MoV. 7335**

Figure 33a–f, Appendix 1, Table S1, Figure S4

Material examined. NMV F296882* (1) [IN2021 V04 050].

Diagnosis of IOT material. Small, soft, dorsoventrally flattened, approximately 65 mm long and 40 mm wide (live). Gelatinous and translucent to cream-coloured with central cavity visible. Grey colour, wrinkled, and soft once preserved. Mouth ventral, with orange-brown tentacles. Anus ventral with yellow pygal furrow. Lateral edges are folded and wavy or bumpy rather than smooth. Tube feet small and filamentous, not restricted to paired radii, but more condensed and matted ventrolaterally, easier to observe in water. Patchy covering of sand dorsally and laterally, more concentrated midventrally. Specimen remained soft but shrank on preservation to 50 mm long, 32 mm wide and 15 mm high. Tube feet are flaccid and lie flat rather than sticking out, lateral edges flattened and rounded, but presumably not a brim as there is no clear differentiation from sole. Longitudinal muscles are flat and broadly attached to the inner body wall, but appear divided. Ossicles in tentacles distinct mesh plates rather than rods, not uniform in size or shape, sometimes with two or more larger perforations, variable, but up to 192 *μm* long.

Remarks. Longitudinal muscles are flat and attached like *Molpadiodemas*, not rounded like *Pseudostichopus*, but unlike the genus diagnosis appear divided here. Again, based on the key and thin, hair-like tube feet this is identified as *M. villosus*, the only other option being *M. porphyrus*, which is violet in colour and looks distinctly different (O'Loughlin and Ahearn, 2005, fig. 5). However, differs from *M. villosus* in tentacle ossicles and by being more dorsoventrally flattened, translucent and with partial sand cover. Quite different to previous specimens *Molpadiodemas* sp. MoV. 7334, but a closer match (from live image of NMV F296854) to *Molpadiodemas* sp. MoV. 7329. No match to distinguishing characters for any of the species outlined in O'Loughlin and Ahearn (2005). Tentacle ossicles look closest to the description of "lace-mesh" tentacle ossicles of *M. pustulosus*, though those are considered more

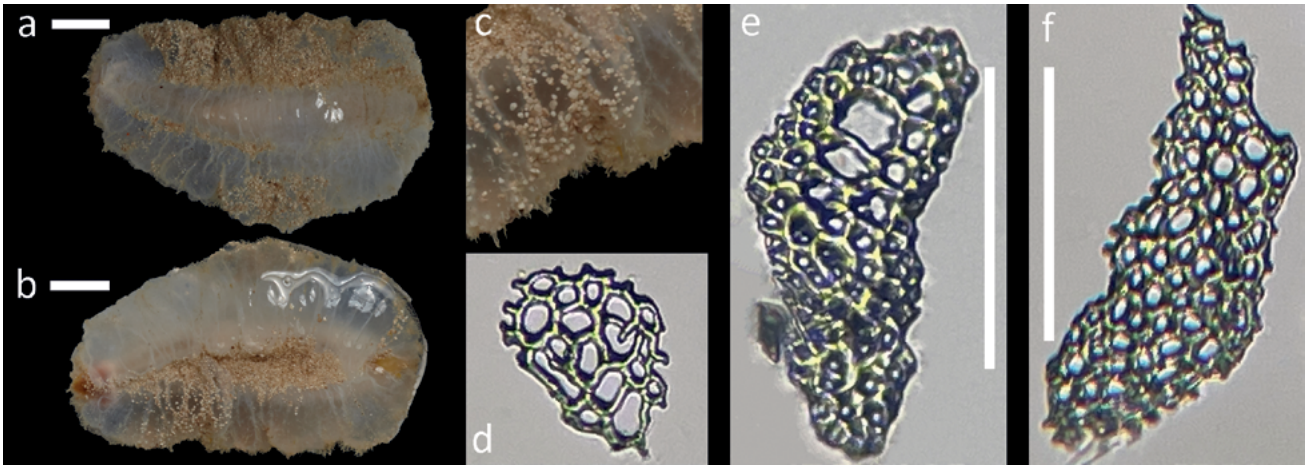

Figure 33. *Molpadiodemas* sp. MoV. 7335. a–c, shipboard images, dorsal, ventral, lateral close-up of tube feet and forams; e–f, tentacle rod ossicles, plates, NMV F296882; scale bars: a, b=1 cm, e–f 100 *μm*.

rod- than plate-like. No obvious nipple-like pustules on the ventrolateral margin also exclude it from this species. While divided flat longitudinal muscles and plate-like tentacle ossicles combined with external morphology indicate this is a new species, the superficial similarity to *Molpadiodemas* sp. MoV. 7329, along with variable characters within the group, means that extensive additional morphological and phylogenetic work is required. We identify the specimen here as OTU *Molpadiodemas* sp. MoV. 7335.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Christmas Island Territory, Balthazar Seamount Stn., 2289–2358 m.

References. O'Loughlin and Ahearn (2005).

***Molpadiodemas* sp.**

Figure 34a–h, Appendix 1, Table S1

Material examined. NMV F308142 (1) [IN2022 V08 103]; NMV F308145 (1) and NMV F308157 (1) [IN2022 V08 105]; NMV F308205 (3), NMV F308210 (1) and NMV F308211 (1) [IN2022 V08 117]; NMV F308221 (1) [IN2022 V08 120]; NMV F308241 (1) and NMV F308251 (6) [IN2022 V08 131]; NMV F308257 (1) [IN2022 V08 141]; NMV F308264 (1) [IN2022 V08 143]; NMV F308271 (1) [IN2022 V08 145]; NMV F308273 (1), NMV F308274 (3) and NMV F308276 (1) [IN2022 V08 147]; NMV F308282 (1), NMV F308283 (1) and NMV F308287 (1) [IN2022 V08 151]; NMV F308293 (2) [IN2022 V08 155]; NMV F308307 (2) and NMV F308308 (1) [IN2022 V08 181]; NMV F308313 (1) [IN2022 V08 183]; NMV F308329 (2) [IN2022 V08 191].

Remarks. Due to the superficial similarity between *Molpadiodemas* sp. MoV. 7329 and *Molpadiodemas* sp. MoV. 7335 and the variation in form for *Molpadiodemas* sp. MoV. 7334, we are reluctant to define the remaining specimens past genus level until species can be more clearly separated based on additional genetics and morphological characters.

Family **Pseudostichopodidae** Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017

Diagnosis (see Miller et al., 2017).

Remarks. As with Molpadiodemidae, this family was erected in 2017 when molecular evidence combined with morphological characters supported its individual status within Persiculida (Miller et al., 2017). Pseudostichopodidae currently comprises a single cosmopolitan genus: *Pseudostichopus*, previously found off eastern, southern, and north-western coasts of Australia at depths of 528–4139 m along with Australian Antarctic waters (WoRMS and ALA, January 2024).

Genus ***Pseudostichopus*** Théel, 1886

Diagnosis (amended from O'Loughlin and Ahearn, 2005, for Miller et al., 2017 erection of Pseudostichopodidae). Characters of Molpadiodemidae (formerly pygal-furrowed Synallactidae): prominent appendages (tube feet, papillae) along the paired radii only; longitudinal muscles cylindrical, not flat, narrowly attached to the body wall; gonad tubules not branched, arising in series along the gonoduct, not from a common base; ossicles sometimes present in tube feet and papillae; tentacle ossicles predominantly unbranched rods, rarely rods with ends intertwining, and side branches fused to create mesh.

Remarks. Cosmopolitan genus with 12 currently accepted species worldwide, four of those previously reported for Australia: *Pseudostichopus hyalegerus, P. mollis, P. peripatus* and *P. spiculiferous*. Four lots of *Pseudostichopus* were recorded for the IOT material, identified here to genus level. *Pseudostichopus* and *Molpadiodemas* can have a very similar body form. Where tube feet or papillae are obvious on the paired radii this indicates *Pseudostichopus*, but if these are inconspicuous the only other simple diagnostic feature to split the genera is cylindrical longitudinal muscles in *Pseudostichopus* (fig. 35d) compared to flattened and broadly attached ones in *Molpadiodemas* (fig. 34a, b). As with *Molpadiodemas*, ossicles

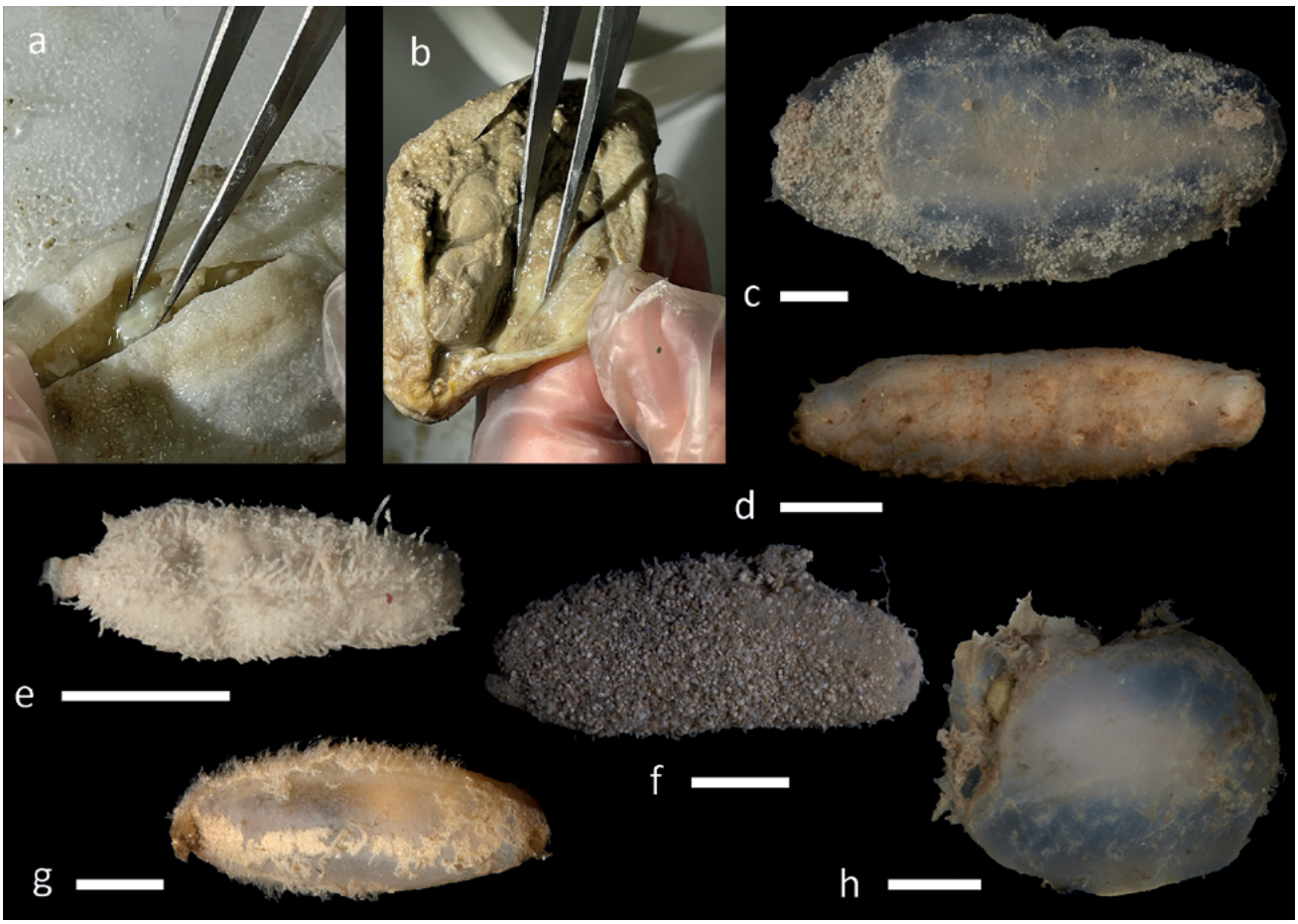

Figure 34. *Molpadiodemas* sp. a, b, characteristic flat longitudinal muscles of *Molpadiodemas,* a, NMV F308282, b, NMV F308142; c–h, shipboard images showing some of the variation in *Molpadiodemas* morphology, c, NMV F308282, d, NMV F308145, e, NMV F308287, f, NMV F308273, g, NMV F308307, h, NMV F308313; scale bars: c–h=1 cm.

being absent from the body wall and variable in other places make them difficult to use diagnostically without further work. Both sequenced *Pseudostichopus* from the IOT are genetically within the well-supported *Pseudostichopus* clade (fig. S4).

***Pseudostichopus* sp.**

Figure 35a–g, Appendix 1, Table S1, Figure S4

Material examined. NMV F296875* (1) [IN2021 V04 046], NMV F308141* (1) [IN2022 V08 103]; NMV F308270 (2) and NMV F312998 (1) [IN2022 V08 145].

Diagnosis IOT material. Four specimens with some variation in size and morphology are identified here to genus level *Pseudostichopus*. One specimen (NMV F312998) with general morphology and longitudinal muscles of *Pseudostichopus* but insufficient characters to describe further. Three remaining specimens with some variation in size and morphology: all with round longitudinal muscles indicating *Pseudostichopus*; opaque rather than truly transparent skin; ventral mouth with retracted pale yellow to brown peltate tentacles (~14 visible); ventral anus in pygal furrow; ossicles absent from body wall but present in tentacles as irregular rods. Rods mostly smooth and tapering at ends, occasionally spinous, straight to curved, many with a central knob; occasionally slightly thicker and more spinous or serrated on top; rare cross-rods with branched and twisted arms. Some specific morphology and sizes noted below.

NMV F308184: Medium, opaque white, elongate, semicylindrical specimen 10.6 cm long, 3 cm wide, and 2.5 cm high when preserved. Dorsally convex, ventrally flattened, tapering to rounded anterior and posterior ends. Body wall firm, thick, semi-gelatinous. Completely smooth with no wrinkles or obvious papillae or tube feet. Very light evidence of some sand, grit and forams, but looks bare to the naked eye. Up to 14.5 cm before preservation, somewhat curled and shrunken in ethanol. Tentacle ossicle rods (as described above) include irregular tapered rods, many with central swelling, up to 200 μm long; smooth and twisted cross-rods up to 80 μm broken (similar size and shape to fig. 11l in O'Loughlin and Ahearn, 2005); and many broken pieces.

NMV F 296875: Small, soft, brown specimen 2.2 cm long, 0.6 cm wide, and 0.4 cm high when preserved. Strongly raised dorsally and flattened ventrally with smooth opaque skin before preservation, slightly wrinkled and dorsoventrally flattened after. Completely covered in sand, grit and forams. Some radial dorsal papillae, but mostly obscured. Tentacle ossicle rods like those described above, up to 232 *µm* long, plus some additional thicker broken serrated/spinous examples.

NMV F308270: Small, soft, white specimen 1.8 cm long, 0.6 cm wide, and 0.2 cm high when preserved. Completely covered in sand, grit and forams. Radial ventrolateral margin wrinkled not smooth (when preserved) with a few well-spaced papillae visible, projecting from rounded mounds. Tentacle ossicle rods like those described above but smaller (e.g. 96 *µm* long) and more broken in this specimen.

Remarks. Variation within species-level characters, along with limitations in our own material, meant further identification based on descriptions or key from O'Loughlin and Ahearn (2005) was not possible. Specimens were possibly closest to *Pseudostichopus aemulatus* but showed many similarities to *P. peripatus*, with these species known to be alike. The key uses dense presence or complete absence of an encrusting cover as a major split for *Pseudostichopus*, including *P. aemulatus* (bare) compared to *P. peripatus* (covered), but both species are known to sometimes be encrusted with sand or fauna, as found here. COI is also inconclusive, showing that NMV F296875 (completely covered in sand and forams) has a 4.2% divergence from NMV F308141 (very light sand and forams). Papillae arrangement is also important, but these can be absent in larger specimens (Solís-Marín et al., 2004) which we observed here for NMV F308141, and unfortunately our other two specimens were also missing most papillae. O'Loughlin and Ahearn (2005) note that *P. aemulatus* is like *P. peripatus* but is opaque and off-white (a closer match to our specimens), rather than grey and semitranslucent; smooth, and lacking ridges (which matches at least two of these three specimens); and with dorsal papillae not widely separated and ventrolateral widely separated, which applies to the rare papillae that were seen. Tentacle ossicles fit *P. aemulatus* but are a closer match in shape to images of *P. peripatus* (O'Loughlin and Ahearn, 2005, fig. 11i–l). At 80–

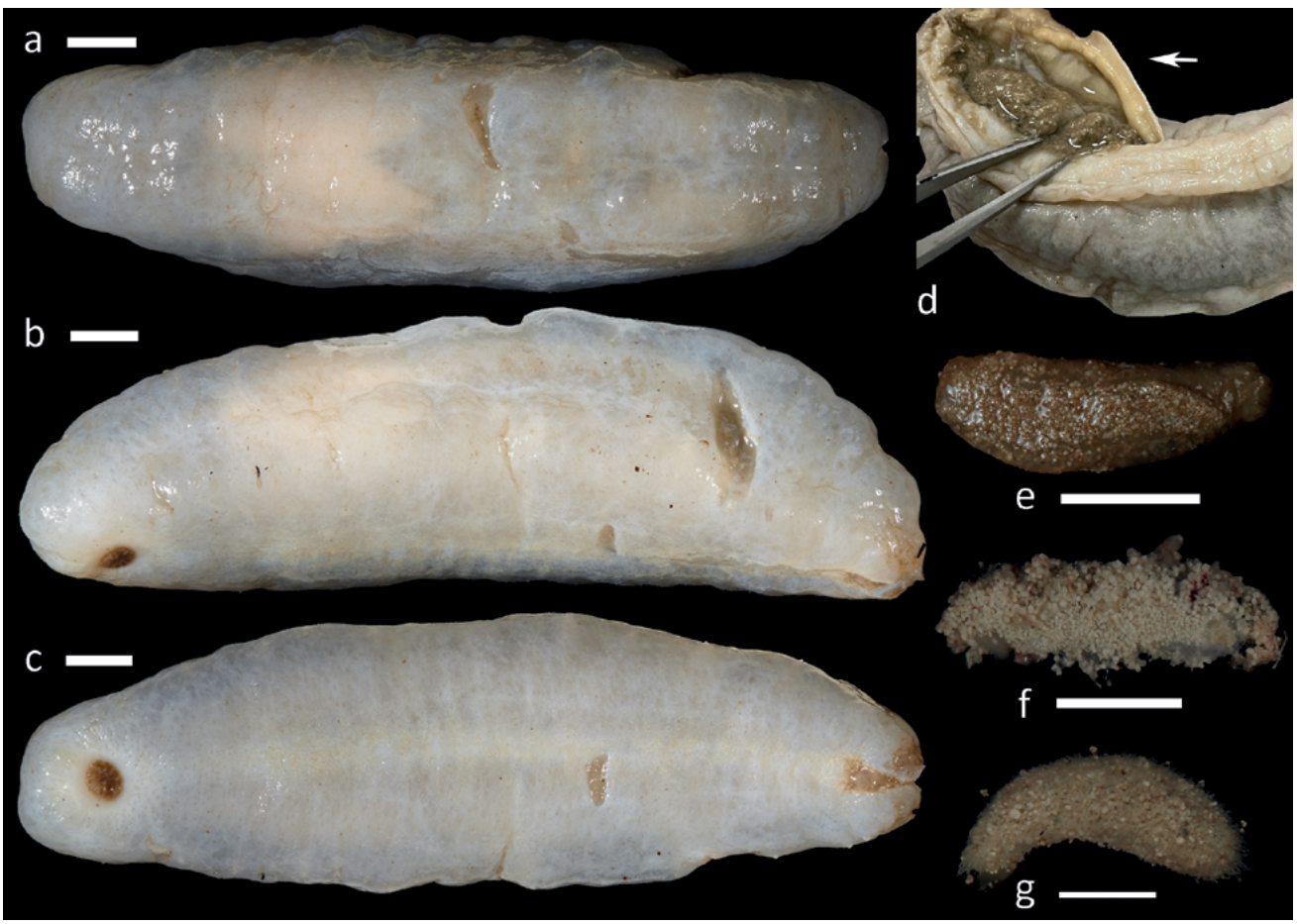

Figure 35. *Pseudostichopus* sp. a–c, e–g, shipboard images showing variation in *Pseudostichopus* morphology, a–c, dorsal, lateral, ventral (with pygal furrow), NMV F308141, e, NMV F296875, f, NMV F308270, g, NMV F312998; d, characteristic rounded longitudinal muscles of *Pseudostichopus*, NMV F308141; scale bars: a–c, e–g=1 cm.

232 *µm* ossicle sizes are a closer match to *P. aemulatus* (up to 260 *µm*) than *P. peripatus* (up to 360 *µm*). There is some wrinkling of skin but no obvious serration like that described for *Pseudostichopus peripatus* and no red-brown tube feet as observed in that species. Without better material for morphological observation, or analysis of additional genes, we identify this IOT material to *Pseudostichopus* sp.

References. O'Loughlin and Ahearn (2005), Solís-Marín et al. (2004).

Order **Synallactida** Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017

Diagnosis. (see Miller et al, 2017)

Remarks. The order Synallactida was newly erected in 2017 with phylogenetics showing it forms a clear individual clade, and a polytomy with Persiculida and Molpadida (Miller et al., 2017). It comprises three families, all with representatives known from Australian waters: Deimatidae Théel, 1882, Stichopodidae Haeckel, 1896, and Synallactidae Ludwig, 1894. As a mostly shallow-water family, Stichopodidae was not seen in the IOT material, but Deimatidae and Synallactidae were both represented.

Family **Deimatidae** Théel, 1882

Diagnosis (following Hansen, 1975 sensu Ekman, 1926). Ossicles varying from perforated plates and spatulated primary crosses to spatulated, or reduced and deformed rods. Wheels absent. Gonads consisting of few, sac-shaped tubules.

Remarks. The Deimatidae are a deep-sea fauna, typically distinctive during surveys due to their clear elliptical to elongated shape, high back with long papillae and flattened base ringed by tube feet. This family comprises three currently accepted genera: *Deima* Théel, 1879, *Oneirophanta* Théel, 1879 and *Orphnurgus* Théel, 1879, all previously known from Australia and represented in the IOT material.

Genus ***Deima*** Théel, 1879

Diagnosis. (following Hansen, 1975). Tentacles 18–20, retractile into the oral cavity; discs with rounded knobs on the margin. Circumoral papillae present. Ossicles perforated plates, consisting of one or several layers of meshwork.

Remarks. The taxonomy for the cosmopolitan genus *Deima* has remained consistent since Hansen's uniting of the previous six species into one (*Deima validum*) represented as two subspecies, *Deima validum validum* Théel, 1879, found worldwide, and *Deima validum pacificum* Ludwig, 1894, known only from the Gulf of Panama in the eastern Pacific (Hansen, 1975). Six lots of *Deima* were recorded from the IOT voyages at depths of 1175–4990 m, and further identified to: *Deima validum validum* (4 lots), and one new species *Deima oloughlini* Mackenzie and Davey sp. nov. (2 lots). The external morphology, clearly retractable tentacles, circumoral papillae and typically a wider oval shape are the easiest features to distinguish *Deima* from similar-looking animals (*Oneirophanta* and *Orphnurgus*) in this family. The *Deima* samples sequenced form two well-supported genetic clades (*D. validum* and *D. oloughlini* Mackenzie and Davey sp. nov.) which are separated by net pairwise distances of 12.7% for COI and 3.8% for 16S (fig. S5).

Deima validum validum Théel, 1879

Figure 36a–h, Appendix 1, Table S1, Table S2, Figure S5

Deima validum Théel, 1879: 5, figs 36–38.—Théel,1882: 68–70, pls. 18, 19, 31: 4–9, 36: 4, 37: 8, 43: 7, 44: 13, 46: 5.—Sluiter, 1901: 60.—Rowe et al., 2017: 480, fig. 11.18b.

Deima validum validum Théel.—Hansen, 1967: 488–490, fig. 5.—Hansen, 1975: 17–23, figs 1: 1–4, 6, 7, 109, pl. 11: 1.—Rogacheva et al., 2013: 595, fig. 18e.—Gebruk et al. 2014: 165.—O'Hara et al., 2020: add. file 1: sup. table S1 (list).

Deima fastosum Théel, 1879: 5–6, figs 1–3.—Théel, 1882: 71–73, pls. 20, 21: 1, 31: 10–13, 35: 7–10, 36:7, 37: 3, 43: 2, 3, 5, 46: 8.

Deima blakei Théel, 1886b: 1–2, figs 1, 2.—Koehler and Vaney, 1905: 55–57, pl. 11: 13–15.—Hérouard, 1923: 40–41, pls. 5: 7, 6: 5.—Deichmann, 1930: 115–116, pls. 10: 7–11, 11: 1–3.—Deichmann, 1940: 198–199.

Deima atlanticum Hérouard, 1898: 88–89, figs 1, 2.—Hérouard, 1902: 32–35, pls. 3: 3, 4: 18, 5: 1–5, 8: 26–29.—Grieg, 1921: 4, pl. 1: 2, 3.

Deima mosaicum Ohshima, 1915: 233–234.—Ohshima, 1916–1919, with 2 figures.

Material examined. NMV F308224* (1) and NMV F308232 (1) [IN2022 V08 122]; NMV F308279 (1) and NMV F308280 (1) [IN2022 V08 151].

Diagnosis of IOT material. Specimens typically pink to white, or white to grey once preserved. Body elliptical to oval, strongly convex dorsally (almost egg-shaped) and flattened ventrally, with a ratio of length to width ~5:3. Specimens up to 90 mm long and 55 mm wide (NMV F308279, fig. 36c, d). Long, non-retractile (but often brittle or broken) papillae, in series along each dorsal radii (~4 pairs visible, others broken) and in ventrolateral series above tube feet (~7 pairs). Anus ventral, almost terminal. Mouth ventral, with retractable tentacles terminating in soft discs, sometimes curled into a cup shape or with rounded or digit-like processes visible. Circumoral papillae present but can be minute or hard to detect. Eleven (9–11) pairs of ventrolateral tube feet in single series along each side, smaller at posterior. Some also include smaller post-anal pair (e.g. NMV F308224, NMV F308280). No midventral tube feet or pre-anal tube feet observed. Ossicles consist of mostly large, often multilayered perforated plates (fig. 36e–h), dorsal up to 4.2 mm, ventral up to 1.5 mm, giving a crunchy texture, plus some smaller variable ossicles including dichotomously branching cross-like rods. Two damaged specimens (NMV F308232 and NMV F308280) had very broken and imbricating plates visible to the eye.

Remarks. Hansen's (1975) redescription for *Deima validum validum* Théel, 1879 noted multilayered plates, 10–13 pairs of ventrolateral tube feet, rare pre-anal tube feet, and 3–7 pairs of lateral papillae, all matching the features of IOT specimens. The description included more dorsal papillae (5–10 pairs) than what was seen for IOT specimens, though he noted that these were more variable (Hansen, 1975). All IOT specimens have many multilayered perforated plates identical to the *Challenger*

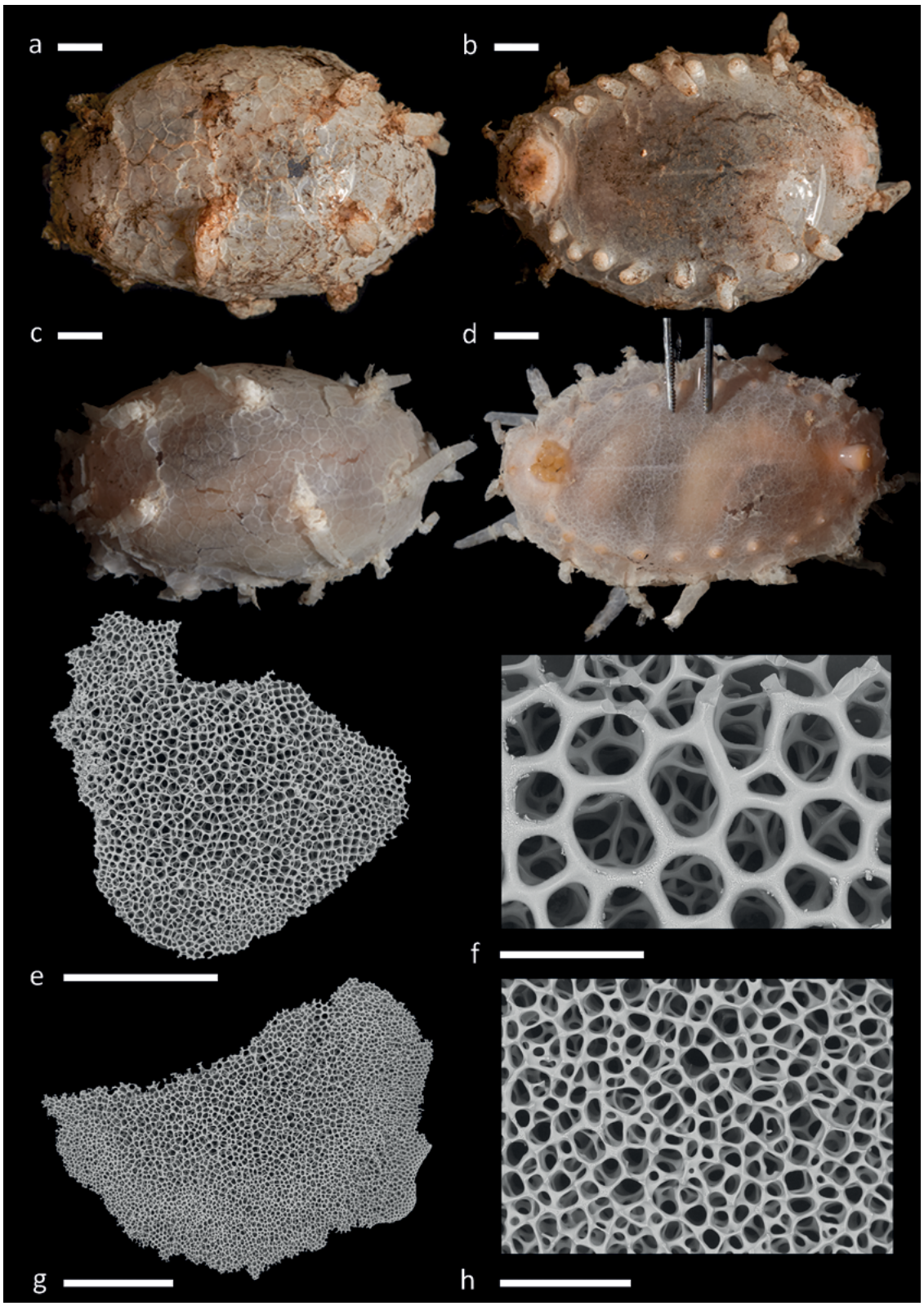

Figure 36. *Deima validum validum*. a–d, shipboard images showing dorsal and ventral appendages and high domed shape, a, b, NMV F308224, c, d, NMV F308279; ossicles: e–h typical multilayered perforated plates of anterior dorsal body wall, NMV F308279; scale bars: a–d=1 cm, e, g=1 mm, f=200 *μm*, h=300 *μm*.

illustrations from the original type specimens of *D. validum* (Théel, 1879, pl. 31, figs 4–9), which, along with fewer dorsal papillae, distinguished them from the only other subspecies in this genus – *D. validum pacificum* Ludwig, 1894. They are also clearly differentiated from the two *Deima* found only at shallower IOT stations less than 2000 m and described below (NMV F308242 and NMV F308216). Presence of fewer papillae dorsally along with post-anal tube feet but no pre-anal tube feet in some IOT specimens indicates that our material differs from *D. validum validum* Théel, 1879 sensu stricto, but we keep it here for now based on the presence of mostly multilayered plates identical to those illustrated in the type material (Théel, 1879).

Distribution. Worldwide (though absent from many areas).

Full bathymetric range. 724–4990 m (IOT 3053–4990 m).

Type locality (as *D. validum*). Mid North Pacific Ocean, 3749 m.

Subspecies not recorded for Australia in AFD or ALA (January 2024), but *D. validum* is recorded in both and many species-level records were further identified to subspecies on the NMV catalogue (O'Loughlin, 1998) and published identification lists (O'Hara et al., 2020), making the current Australian range 1250–4990 m and slightly extending the worldwide depth range, previously 724–4820 m in Gebruk et al. (2014). In Australia this subspecies is now known from Lord Howe Rise, from the eastern abyss off Nowra NSW to just north of Tasmania, from the Great Australian Bight in South Australia and from the Australian IOT.

References. ALA and AFD (2024), Gebruk et al. (2014), Hansen (1975), O'Hara et al. (2020), O'Loughlin in NMV Catalogue (1998), Théel (1879).

Deima oloughlini Mackenzie and Davey sp. nov.

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sp. MoV. 7322

Figure 37a–g, Appendix 1, Table S1, Table S2, Figure S5

Material examined. Holotype: NMV F308216* (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, IOT: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; Paratype: NMV F308242* (1), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, IOT: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022.

Diagnosis. Oval-shaped animal, convex dorsally and flattened ventrally, just over twice as long as wide, white to pink. Ventral mouth with circular field around oral opening, circumoral papillae present, clear marginal knobs on tentacles. Ventral anus. Long tapered papillae, some just short of body width in length, in single rows along dorsal (6 pairs) and ventrolateral (4–6 pairs) radii. Ten pairs of ventrolateral tube feet in single rows below papillae, additional post-anal pair of tube feet present behind/above anus, bare midventral apart from present or absent single pair of pre-anal tube feet. Dominant ossicles are irregular perforated plates, typically single layered though occasionally partially imbricating or developing rudimentary secondary layering. Perforations are not uniform, variable in size, shape, number, and position (fig. 37e–g). Smaller irregular branching structures also present (fig. 37g). Full descriptions for each specimen below.

Holotype. NMV F308216 (larger specimen). Body oval-shaped, convex dorsally, flattened ventrally, ~110 mm long, 52 mm wide and 30 mm high pre-preservation. Dorsoventrally flattened once preserved. Opaque to white, with a pink to orange tinge around tube feet, oral and anal openings. Anus posterior, ventral. Mouth anterior, ventral, and placed in middle of a circular field fringed by obvious circumoral papillae. Tentacles mostly retracted, but ~12 visible. Eight well-developed marginal knobs on each tentacle, curled inwards to give the appearance of digits on a hand (fig. 37d). Ventrolateral tube feet ten pairs, single-rowed, largest mid-body and smallest at posterior. Cylindrical and slightly tapered to rounded end, each capped with a smaller darker end disc. Additional pair of smaller post-anal tube feet present just above/behind the terminal anus, smaller than all ventrolateral tube feet. Two pre-anal tube feet also present on midventral line but lacking any other midventral tube feet. Papillae cylindrical and rigid at base but bending or breaking to flop over and tapering at tip, variable size but largest ~40 mm. Dorsal six pairs, ventrolateral six pairs. Dominant ossicles perforated plates, visible to naked eye, some partially imbricating and giving a crunchy" texture to the dorsal surface. Dorsal ossicle plates are predominantly single layered, variable in size up to 2.1 mm, some with rudimentary branches, knobs, thickening, or anastomosing with a secondary mesh. Thickening and some knobs on plates observed more commonly in perianal samples. Occasionally clustered and imbricating. Perforations are irregular in shape, size, number and placement. Additional ossicles are smaller irregular branching structures up to 0.32 mm that look like individual versions of the initial branches that form multilayers. Ventral with similar single-layered perforated plates to dorsal, but typically smaller (up to 1.5 mm seen here), and often more regular than dorsal plates, with larger perforations clustered towards the centre. Papillae ossicles are elongated and variably curved perforated plates up to 0.8 mm long, some knobbed, thick to thin and branching. Tentacle ossicles thick, straight to curved rods, distally spinous, sometimes centrally bulbous, and up to 0.24 mm long.

Paratype. NMV F308242 (Smaller specimen): Body oval-shaped, convex dorsally, flattened ventrally, ~52 mm long and 25 mm wide pre-preservation. Semitransparent, grey to off-white dorsally and pink to orange ventrally. Anus posterior, ventral, almost terminal. Mouth anterior, ventral, and placed in middle of a slightly raised circular field fringed by retracted circumoral papillae. Tentacles retracted other than single exposed disc ~4 mm wide with six well-developed marginal knobs (4 larger and 2 smaller tapering digits) visible. Ventrolateral tube feet ten pairs, single-rowed. Cylindrical with dark tips, largest mid-body and smallest at posterior. Additional pair of separate smaller post-anal tube feet present just behind/

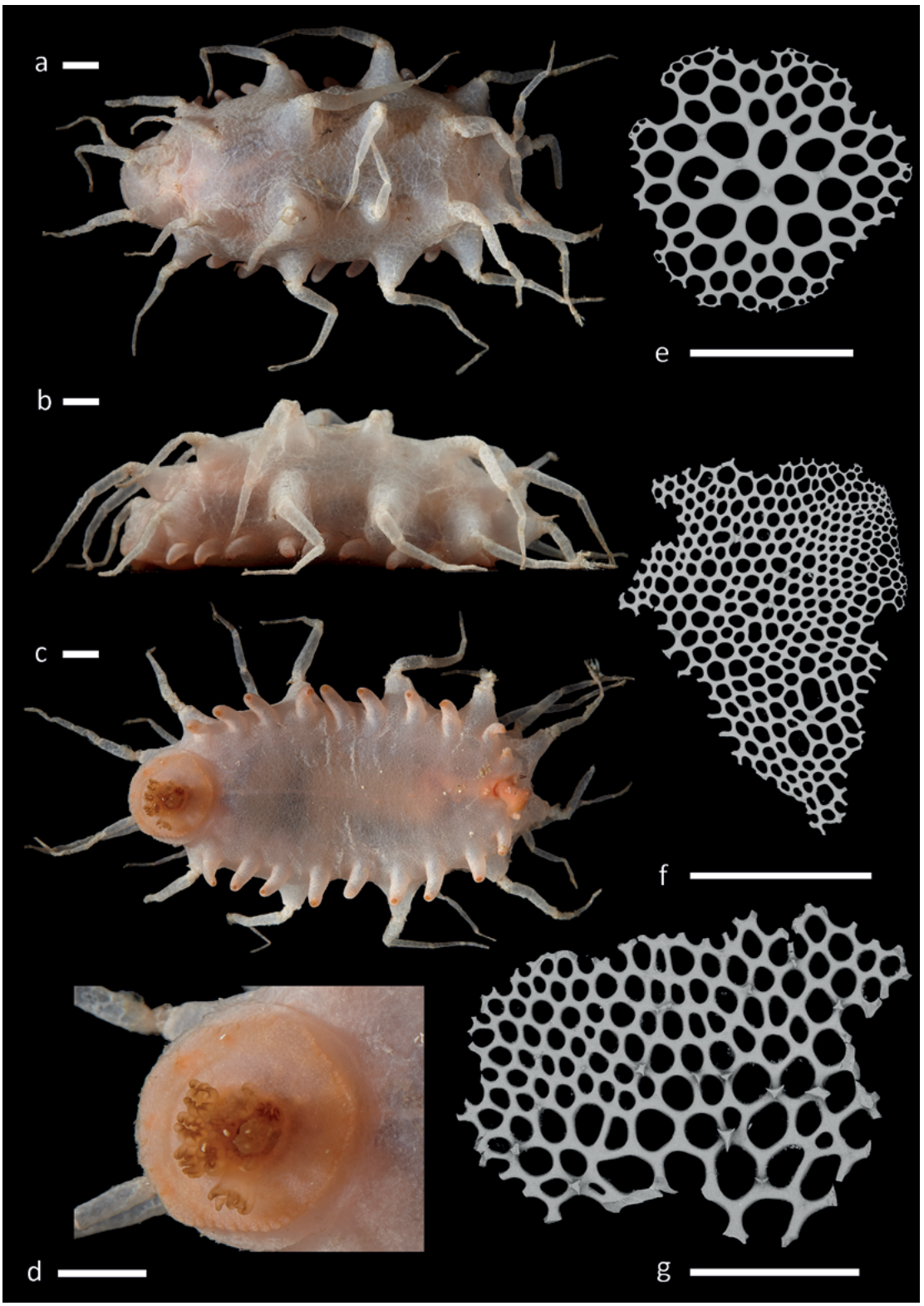

Figure 37. *Deima oloughlini* Mackenzie & Davey sp. nov., a–d, shipboard images showing live colour, oval shape, appendages, and close-up of circum-oral papillae (d) of holotype NMV F308126; ossicles: e–g, typical single-layered plates with irregular perforations, examples from anterior dorsal (f, g) and anterior ventral (e) body wall with rudimentary secondary branching (g), from paratype NMV F308242; scale bars: a–d=1 cm, e, g=500 *μm*, f=1 mm.

above the anus, smaller than all ventrolateral tube feet. Midventral tube feet completely absent. Papillae in single rows, rigid, conical, often broken, cylindrical at base and tapering at tip, variable size but largest ~22 mm (i.e., nearly full width of body). Dorsal six pairs, ventrolateral approximately four pairs. Dominant ossicles are perforated plates. Dorsal plates predominantly single layered, with some starting to develop additional rudimentary branches or mesh for multilayers. Plates often quite large (e.g. 2.1 mm measured for broken plates – fig. 37f). Perforations are irregular in shape and size (e.g. 56–125 *μm* for central perforations, with some larger again towards the plate edge) and number. Additional ossicles are rare smaller irregular branching structures. Ventral ossicles are perforated plates like dorsal, but typically smaller (e.g. up to 857 *μm*, fig. 37e).

Remarks. *Deima oloughlini* Mackenzie and Davey sp. nov. is morphologically very similar to *D. validum validum* Théel, 1879 as redescribed by Hansen (1975), only distinguished by reduced typical number of dorsal papillae, a body ratio of just over 2:1 compared with 5:3, and most noticeably by a smaller ossicle size range and reduced layering of ossicles, with mostly single-layered rather than multilayered plates with less-uniform perforations. IOT specimens of *D. validum validum* also appear more domed dorsally than *Deima oloughlini* Mackenzie and Davey sp. nov. and with thicker, crunchier scales. *Deima oloughlini* Mackenzie and Davey sp. nov. is distinguished morphologically from *D. validum pacificum* Ludwig, 1894 chiefly by the reduced number of dorsal papillae, and the inclusion of rudimentary secondary mesh/branching on plates. *D. validum pacificum* is only known from the eastern Pacific at 1618–2487 m, which also makes it unlikely. Hansen (1975) noted that *D. validum* subspecies have both geographic and bathymetric differences. In Table S2 we also note distinguishing features between *Deima oloughlini* Mackenzie and Davey sp. nov., and the species previously synonymised (synonymy retained here) into *D. validum validum* by Hansen: *D. atlanticum* Hérouard, 1898, *D. blakei* Théel, 1886, *D. fastosum* Théel, 1879, and *D. mosaicum* Ohshima, 1915. Of these, *D. oloughlini* Mackenzie and Davey sp. nov. is closest to the West Indian *D. blakei*, which was noted for typically single-layered perforated plates. The type specimens of *D. blakei* were collected from a similar depth (1048–1115 m) from St Vincent in the Caribbean. The type description is somewhat confused by discussing seven specimens split into two lots of characteristics. Our specimens are both clearly distinguished from four of the type series specimens based on uniform rather than asymmetrical placement of appendages. The remaining three specimens from the type series (which Théel noted as looking more like *D. validum*) are a closer match to our larger specimen for tube feet and papillae, though Hansen noted an additional pair of papillae for some *D. validum* (as *D. blakei*) specimens re-examined from the type location (Hansen, 1975). There is little ossicle detail in the type description for *D. blakei*, just noting they were perforated plates like *Oneirophanta mutabilis*, with minimal secondary layering, but *Deima oloughlini* Mackenzie and Davey sp. nov. differs from the type location material re-examined by Hansen (1975), by typical ossicle size, and perforation shape and placement. *Deima oloughlini* Mackenzie and Davey sp. nov. ossicle plates are up to 2.1 mm dorsally and 1.5 mm ventrally, compared to 1.5 mm and 1.2 mm for *D. validum* (as *D. blakei*), and are also lacking the "remarkably large" central perforations of *D. blakei*, with large and small perforations varying across the plate, particularly in dorsal ossicles. *Deima oloughlini* Mackenzie and Davey sp. nov. also differs from those *D. blakei* specimens subsequently reported from other locations as described in the synonymy by Hansen (1975). The high genetic differentiation between *Deima oloughlini* Mackenzie and Davey sp. nov. and its sister species *D. validum* (COI: 12.7%) is in line with accepted genetic differentiation between other sea cucumber species (e.g. Arndt et al., 1996; O'Loughlin et al., 2011; Gubili et al., 2017). While differences in external morphological features are more cryptic with such variability in the genus, the phylogenetic evidence combined with a clear difference in ossicles gives us the confidence to erect *Deima oloughlini* Mackenzie and Davey sp. nov. here.

Etymology. Named in honour of our late mentor and friend, P. Mark O'Loughlin, for his substantial contribution to holothuroid taxonomy, and his willingness to encourage and mentor so many in the field.

Distribution. These two specimens only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Cocos (Keeling) Stn. and Rudist Seamount Stn.

Full bathymetric range. 1175–1896 m.

References. Arndt et al. (1996), Gubili (2017), Hansen (1975), Hérouard, (1898), O'Loughlin (1998), O'Loughlin et al. (2011), Ohshima (1915), Sluiter (1901a), Théel (1879 and 1886).

Genus ***Oneirophanta*** Théel, 1879

Diagnosis. (amended from Hansen, 1975). Tentacles 15–20, unretractile; discs usually with rounded knobs on the margin but never with ramified processes. Circumoral papillae absent. Ossicles spatulated crosses or perforated, one-layered plates; spatulated rods typically present in the papillae.

Remarks. Bioturbation has been studied in this group, which includes at least one "conveyor belt" species (*Oneirophanta mutabilis*) known to eat and excrete continuously (Moore and Roberts, 1994). It has also been suggested that brood-protection of young occurs in this species (Hansen, 1975). There are three currently accepted species and two subspecies: *Oneirophanta conservata*, *O. mutabilis* (with subspecies *O. mutabilis affinis* and *O. mutabilis mutabilis*), and *O. setigera* (WoRMS, 2024). The geographic subspecies division of *O. mutabilis* has remained since proposed by Hansen (1967), but Rowe et al. (2017) note that the divergence in life history strategies reported by Hansen (1968, 1975) warrant potential treatment at species level. Only *O. mutabilis mutabilis* (as *O. mutabilis*) has been previously reported from off the southern and eastern coasts of Australia (ALA, 2024). Six lots of *Oneirophanta* were recorded from the IOT voyages at depths of 1175–5414 m, all further identified to OTU species level as follows: *O. mutabilis mutabilis* (3 lots), *Oneirophanta* sp. MoV. 7331 (1 lot), and

Oneirophanta sp. MoV. 7333 (2 lots). Morphologically, *Oneirophanta* is distinguished from *Deima* by unretractable tentacles, absence of circumoral papillae, and a typically elongate (rather than oval) body. Easily mistaken for *Orphnurgus glaber*, which can also be elongated and orange/pink with crowded dorsal papillae and large tube feet. As papillae and tube feet arrangement and number are variable across these groups, it is best to separate externally from *Orphnurgus* by tentacle disc margins (which are ramified/branching in *Orphnurgus* but typically knobbed in *Oneirophanta* adult forms) but more accurate to use the dominant ossicle types, which are transformed rods in *Orphnurgus* compared to perforated plates or spatulated crosses in *Oneirophanta*. The genus diagnosis from Hansen above was amended to account for spatulated rods being rare or absent in some specimens, as noted in many of his own observations (Hansen, 1975). While *Oneirophanta* is genetically monophyletic, the relationships between the IOT *Oneirophanta* samples are incongruent between the COI and 16S datasets (fig. S5). In the former, *Oneirophanta* sp. MoV. 7331 is sister to *O. mutabilis mutabilis* and *Oneirophanta* sp. MoV. 7333 is basal to that group. For the latter gene, the relationship between species is unresolved.

Oneirophanta mutabilis mutabilis Théel, 1879

Figure 38a–j, Appendix 1, Table S1, Figure S5

Oneirophanta mutabilis Théel, 1879: 6–7, figs 4–6; Théel, 1882: 62–68, pls. 21: 2, 22, 31: 1–3, 36: 1, 2, 8–11, 37: 4, 13, 38: 11, 12, 40: 1–3, 41: 1, 2, 4, 42: 9, 43: 1, 6, 45, 46: 6, 7.—Perrier, 1902: 374–380, pl. 18: 10–15.—Clark, 1913: 232.—Grieg, 1921: 5, pl. 2: 1, 2.—Hérouard, 1923: 39–40, pls. 4: 10, 5: 3, 4.—Ekman, 1927: 364–366, figs 1, 2.—Agatep, 1967: 63–65, pl. 10: 1–7.—Rowe et al., 2017: 480.

Oneirophanta mutabilis mutabilis—Hansen, 1967: 485–488, figs 3, 4.—Hansen, 1975: 24–32, figs 2–6.—Gebruk et al., 2014: 165.—O'Hara et al., 2020: add. file 1: sup. table S1 (list).

Oneirophanta alternata Perrier, 1900: 117–118.—Perrier, 1902: 380–386, pls. 14: 3, 4, 18: 16–22.

Oneirophanta alternata var. *talismani* Perrier, 1902: 386–388, fig. 6.

Material examined. NMV F296855* (2) and NMV F296858* (1) [IN2021 V04 028]; NMV F308159 (2) [IN2022 V08 105].

Diagnosis of IOT material. Body robust, elongated, roughly cylindrical. Preserved specimens from IOT are large, up to ~24 cm long, 4.5 cm wide and 4.5 cm high (NMV F296855, largest specimen, preserved). Strongly raised dorsally, flattened ventrally, and rounded to almost square at anterior and posterior ends. Colour orange to pink or white with darker brown or orange tips to tentacles and tube feet, but specimens white when preserved. Body wall firm, skin thick. Dorsal surface crowded with long (2.3–11.2 cm long), tapered, non-retractile papillae, making the body wall hard to see. Conspicuous, large (e.g. 3 cm long and 1 cm wide) ventrolateral tube feet in single to paired zigzag series along each side, rare smaller midventral tube feet. Anus terminal, ventral. Mouth terminal, ventral, with 15–20 feeding tentacles that never fully retract. Tentacle disc margins with rounded digit-like knobs but not ramified (branching) processes. Ossicles include perforated plates in various stages of development and variably branching rods and crosses, more concentrated in appendages. Perforated plates single layered with larger perforations at the centre and smaller towards the edge, sometimes with small vertical spines and rudimentary mesh forming, sometimes imbricating but not multilayered. As an ossicle size example for the larger IOT specimen NMVF296855 noted above, plate diameter ~0.45–0.7 mm (dorsal), ~0.48–1.5 mm (ventral), 0.6–1.1 mm (papillae) and branching rods up to ~0.4 mm (tentacle) and ~0.46 mm (tube foot).

Remarks. Specimens here key morphologically to *Oneirophanta mutabilis mutabilis* using Hansen's *Galathea Report* and descriptions, though he mentions ossicle plates with smaller vertical spines but never a secondary layer of meshwork (Hansen, 1975). We note some very rudimentary mesh here, though agree there is no true multilayering. The original type description (Théel, 1879) also noted that plates can be crowded or imbricating. One smaller specimen (NMV F308159) had less typical rods and crosses, though plates were still present. Distinguished from *Oneirophanta conservata* Koehler and Vaney, 1905 by fewer ventrolateral tube feet but more ventrolateral papillae. Distinguished from *O. setigera* by the presence of perforated plate ossicles. Tentacles have clear marginal knobs, distinguishing them from *O. mutabilis affinis*. Both sequenced IOT *O.mutabilis mutabilis* samples form a highly supported clade within the COI phylogeny, with no previous *O. mutabilis mutabilis* available for comparison (fig. S5).

Distribution. Largely cosmopolitan.

Full bathymetric range. 1006–6000 m (IOT 2298–2850 m).

Type locality (as *O. mutabilis*). Southern Indian Ocean (southeast of South Africa), 2515 m.

Subspecies not recorded for Australia in AFD or ALA (January 2024), but many *O. mutabilis* records were further identified to subspecies *O. mutabilis mutabilis* in the NMV catalogue, making the Australian range 1006–3853 m and extending the shallow limits of the previous known depth range (2515–6000 m). In Australia this species is now known from off the eastern coast (north-east Tasmania to the Coral Sea in Queensland), the Great Australian Bight in South Australia, and the Australian IOT.

References. ALA and AFD (2024), Bribiesca et al. (2022), Byrne and O'Hara (2017), Gebruk et al. (2014), Hansen (1975), O'Loughlin (1998).

***Oneirophanta* sp. MoV. 7331**

Figure 39a–g, Appendix 1, Table S1, Figure S5

Material examined. NMV F308334* (1) [IN2022 V08 196].

Diagnosis of IOT material. Body elongated, semicylindrical, equal width for most of its length. Strongly raised dorsally, flattened ventrally, with rounded oral and anal ends. Medium-sized specimen, 130 mm long, 37 mm wide and 22 mm high (preserved). Dirty white with black and brown patches (likely an artifact of the station). Skin thick, firm, and wrinkled once preserved. Anus ventral and terminal. Mouth ventral and terminal with 20 tentacles on short stalks, non-retractable,

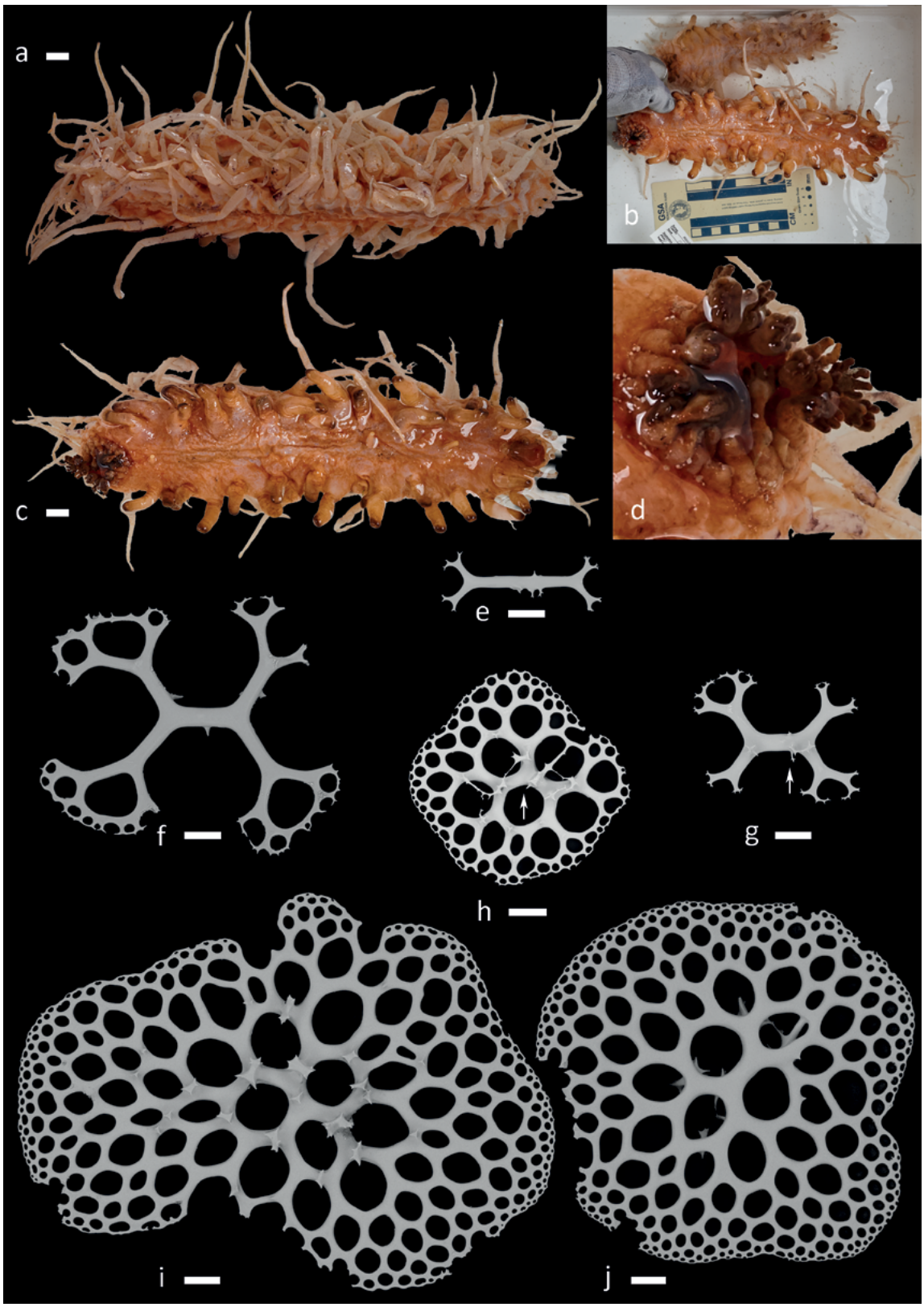

Figure 38. *Oneirophanta mutabilis mutabilis*. a–d, shipboard images showing live colour, appendages, large size, and close-up of tentacles; e–j, body wall ossicles, e, g–j, (h, with arrow to mesh), ventral, f, dorsal, NMV F296855; scale bars: a, c=1 cm, e–j=100 μm.

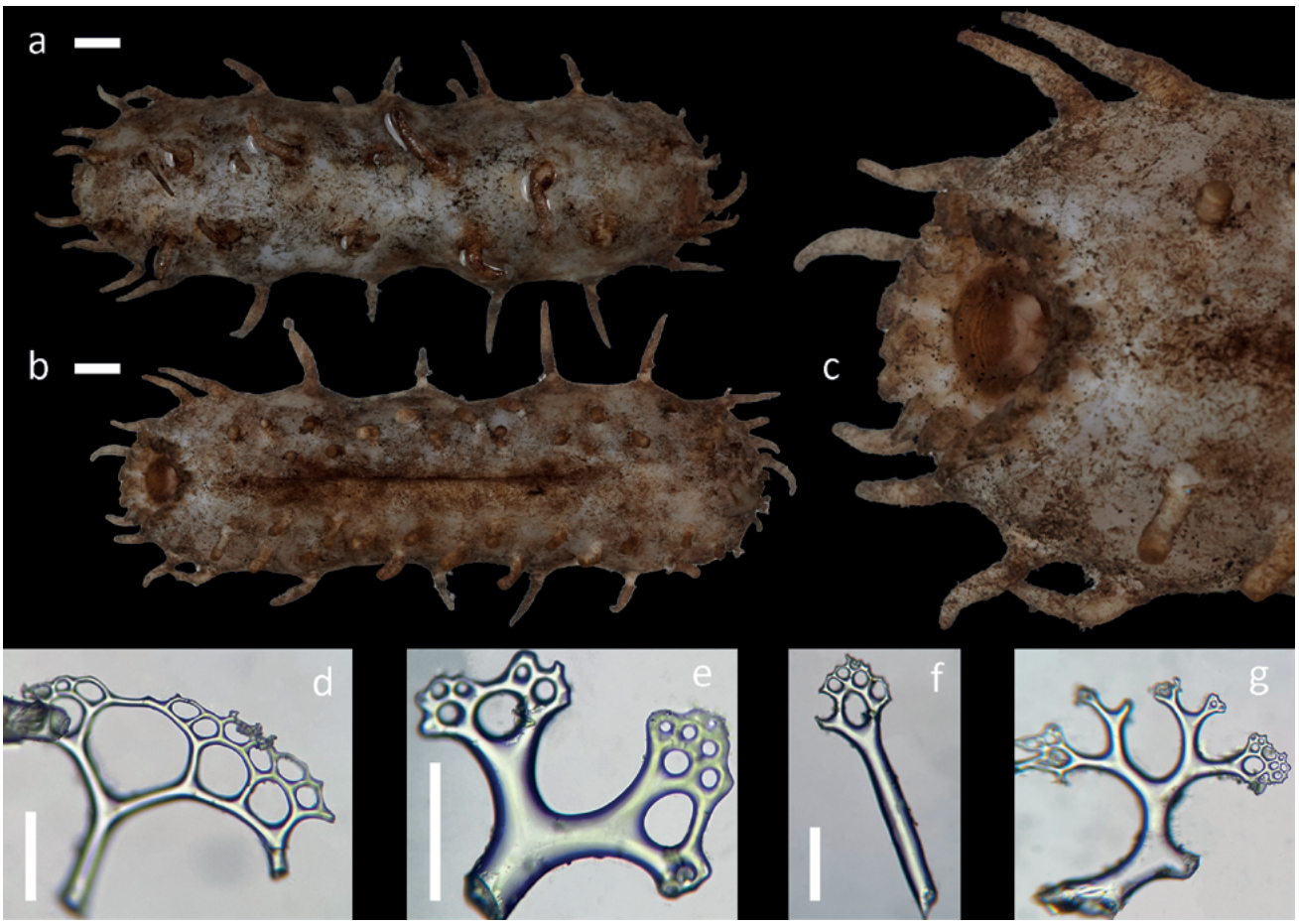

Figure 39. *Oneirophanta* sp. MoV. 7331. a–c, shipboard images showing live colour (with manganese coating from station), dorsal, ventral, and close-up of tentacles; d–g, body wall ossicles, a, dorsal, e–g, ventral, NMV F308334; scale bars: a–c=1 cm, d–f=100 μm.

roughly circular and dark brown at tips, and lacking marginal knobs. Papillae of variable size, with cone shaped base and tapered at tips. Dorsal surface not crowded. Dorsal radii with well-spaced large and small papillae in single rows (10 and 11) on each. Single rows of ventrolateral papillae (6 and 8 per side), plus an additional one anteriorly for both. Ventrally, zigzag rows of extended tube feet on each side. Once preserved outer nine tube feet appear slightly larger than inner 8–9 on each side, all robust with rounded ends. Mostly bare midventrally with just four smaller tube feet in a zigzag pattern towards the anal end. Midventral line darker than the rest of the ventral surface and slightly indented. Body wall ossicles rods and crosses with branching, perforated or spatulated ends, perforations in some ends almost creating thin plates, no complete plates seen. Tube feet and papillae with same and some less branched crosses and rods. No long spatulated rods in papillae. Tentacles smooth to rarely spinous irregular rods with branched ends.

Remarks. This single specimen was from a station with manganese nodules so colouring and texture may be artifacts. While some broken spatulated crosses were seen, it lacks the clustered spatulated papillae rods of *Oneirophanta setigera*. External morphology resembles the subspecies *Oneirophanta mutabilis affinis* Ludwig, 1894, particularly the reduced papillae version represented in Hansen, 1975 (fig 6, p33, bottom picture). Tentacles lacking marginal knobs and the number of dorsal and ventrolateral papillae also fit within the range of *O. mutabilis affinis*, but there are far fewer tube feet in *Oneirophanta* sp. MoV. 7331 (up to 9 each side compared to 15–20). Rod ossicles in these specimens agree with type illustrations for *O. mutabilis affinis* in Ludwig, 1894 (pl. 7, fig. 8–13) of rods with perforated to spatulated ends, but *Oneirophanta* sp. MoV. 7331 also includes some broken spatulated crosses and more importantly lacks the "robust and rather small plates" noted as the dominant ossicle for that subspecies (Hansen, 1975). *O. mutabilis affinis* has previously been restricted to the eastern Pacific, so it is likely that this IOT specimen is a new species, but the authors are reluctant to identify it past OTU level *Oneirophanta* sp. MoV. 7331 without additional study of the literature, and comparative specimen and genetic samples.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Cocos Abyssal Stn., 3431–5414 m.

References (for genus). Hansen (1975), Ludwig (1894).

***Oneirophanta* sp. MoV. 7333**

Figure 40a–k, Appendix 1, Table S1, Figure S5

Material examined. NMV F296845*(1) [IN2021 V04 013]; NMV F308214 (1) [IN2022 V08 117].

Diagnosis of IOT material. Body elongated, semicylindrical and spindle shaped. Strongly raised dorsally, flattened ventrally, and tapered to rounded oral and anal ends. Smaller specimen ~1.5 cm long (NMV F308214 preserved), larger specimen 16 cm long, 5 cm wide and 3 cm high (NMV F296845, preserved). Measurements and specific morphology below based on larger specimen. Colour light pink to white with pink or orange tips to tentacles, papillae, and tube feet. Specimens white when preserved. Body wall firm, but not as thick as previous two species. Papillae are long and slender (up to ~5 cm long, 0.5 cm wide at base), tapered to a point, and non-retractile. In single to zigzag series on two dorsal radii (~16–18 per side), and single lateral rows (~16 per side). Not crowded mid-body with dorsal body wall clearly visible. Medium-sized tube feet (e.g. 0.8 cm long and 0.4 mm wide) in paired to zigzag series along each ventrolateral radii (~35–36 per side), approximately seven smaller rudimentary midventral tube feet mostly restricted to posterior end. Anus terminal, ventral. Mouth terminal, ventral, ~18 non-retractile tentacles with many small indentations on disc margins (not digit-like and not clearly branching). Body wall ossicles spatulated crosses with smooth arms up to 0.4 mm long and central beam, and rods and crosses with additional irregular branching and perforations, some simple, others joining to form plate-like segments. No complete plates seen. Tube feet with similar though less branching, plus curved simple rods, papillae with distinctive densely packed spatulated rods up to 1.95 mm long.

Remarks. Distinguished from *Oneirophanta conservata, O. mutabilis mutabilis* and *O. mutabilis affinis* by spatulated crosses and rods rather than perforated plates as main ossicles. Also distinguished from IOT specimens of *O. mutabilis mutabilis* by being less robust, more spindle-shaped, white to pink rather than orange, having less crowded dorsal papillae, and lacking digit-like marginal knobs to tentacles. *Oneirophanta* sp. MoV. 7333 keys to *O. setigera* (Ludwig, 1893) using Hansen (1975) based on the presence of spatulated crosses in the body wall, and clusters of spatulated rods in the papillae. However, several differences in the IOT material suggest it is a new species. Both Ludwig (1893) and Hansen (1975) describe and illustrate *O. setigera* ossicles as only two main kinds: rods with or without perforations, and spatulated crosses with a central beam and long, smooth arms. Rods of the papillae are particularly noted as being long, spatulated, and in bristle-like clusters (Hansen, 1975). Our specimens have both kinds, but also a third type of more developed rod-plate, in which rods and crosses are developing secondary branching, which in turn is joining to form the beginnings of thick and thin perforated plates. One of our specimens is also much larger (16 cm) than Hansen's (up to 5.3 cm). Other more minor differences between *Oneirophanta* sp. MoV. 7333 and those studied by Ludwig (1893) and Hansen (1975) include: tentacle discs with numerous small indentations on the disc margin compared to the eight rounded knobs clearly noted for *O. setigera*; additional tube feet: at least five extra per side ventrolaterally and one midventrally; ossicle size for spatulated rods in the papillae, with ours at 1.95 mm for a 16 cm specimen, compared to Hansen's at 5–6 mm long for a 5 cm specimen. This ossicle size difference is less conclusive however, because ours are closer to Ludwig's types (specimen size not noted) of *O. setigera*, which had spatulated rods 1.4–1.7 mm long in the papillae. *Oneirophanta* sp. MoV. 7333 is also bathymetrically and geographically removed at 1363–1764 m from the Indian Ocean compared to the known *O. setigera* from the Pacific Ocean: 2104–4064 m Gulf of Panama area, 4540 m Kermadec Trench (Hansen, 1975), 2912 m Galapagos Islands (Salinas-de-León et al., 2020), and French Polynesia (Miller et al., 2017). While likely a new species, the authors are reluctant to identify this IOT material past OTU level *Oneirophanta* sp. MoV. 7333 without additional investigation of *O. setigera* comparative specimens and genetic samples.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island Territory, off McPherson Point, 1363–1501 m; Cocos (Keeling) Islands Territory, Rudist Seamount Stn., 1175–1764 m.

References (for genus). Hansen (1975), Ludwig (1893), Miller et al. (2017), Salinas-de-León et al. (2020).

Genus ***Orphnurgus*** Théel, 1879

Diagnosis. (following Thandar, 1992). "Tentacles 15–20, non-retractile, discs with ramified processes. Circumoral papillae absent. Spicules spatulated crosses and/or rods of greatly varying shape, either spatulate, spindle-shaped, smooth with dichotomous ramifications, or spinous, often a combination of two types."

Remarks. Another charismatic deep-sea megafauna, with IOT samples typically elongated and pink or orange (in life) with prominent papillae and tube feet. The conspicuous dorsal papillae are likely used for respiration (Rowe et al., 2017). Of the nine species known worldwide for this genus, only two have been previously recorded for Australia: *Orphnurgus glaber* from off the north-west coast, and *O. insignis* from off the eastern coast, from New South Wales and the Lord Howe Plateau in the Tasman Sea (WoRMS and ALA, 2024). Thirty-six lots of *Orphnurgus* were recorded from the IOT voyages at depths of 1019–2435 m, with lots further identified to OTU species level as follows: *O. glaber* (13 lots), *O. insignis* (17 lots), *Orphnurgus* sp. MoV. 7318 (5 lots), and *Orphnurgus* sp. MoV. 7332 (1 lot). Distinguished from *Deima* by unretractable tentacles, absence of circumoral papillae, and a typically elongate (rather than oval) body. Distinguished externally from *Oneirophanta* by tentacle disc margins (which are ramified/branching in *Orphnurgus* but only knobbed in *Oneirophanta*) but more easily by ossicles, which are transformed rods in *Orphnurgus* compared to perforated plates in most *Oneirophanta*. *Orphnurgus glaber* is potentially a species complex (Rowe et al., 2017). The sequenced *Orphnurgus* from the IOT form three well-supported lineages (fig. S5). For both the COI and 16S genealogies, *O. glaber* and *Orphnurgus* sp. MoV. 7318 are sister lineages.

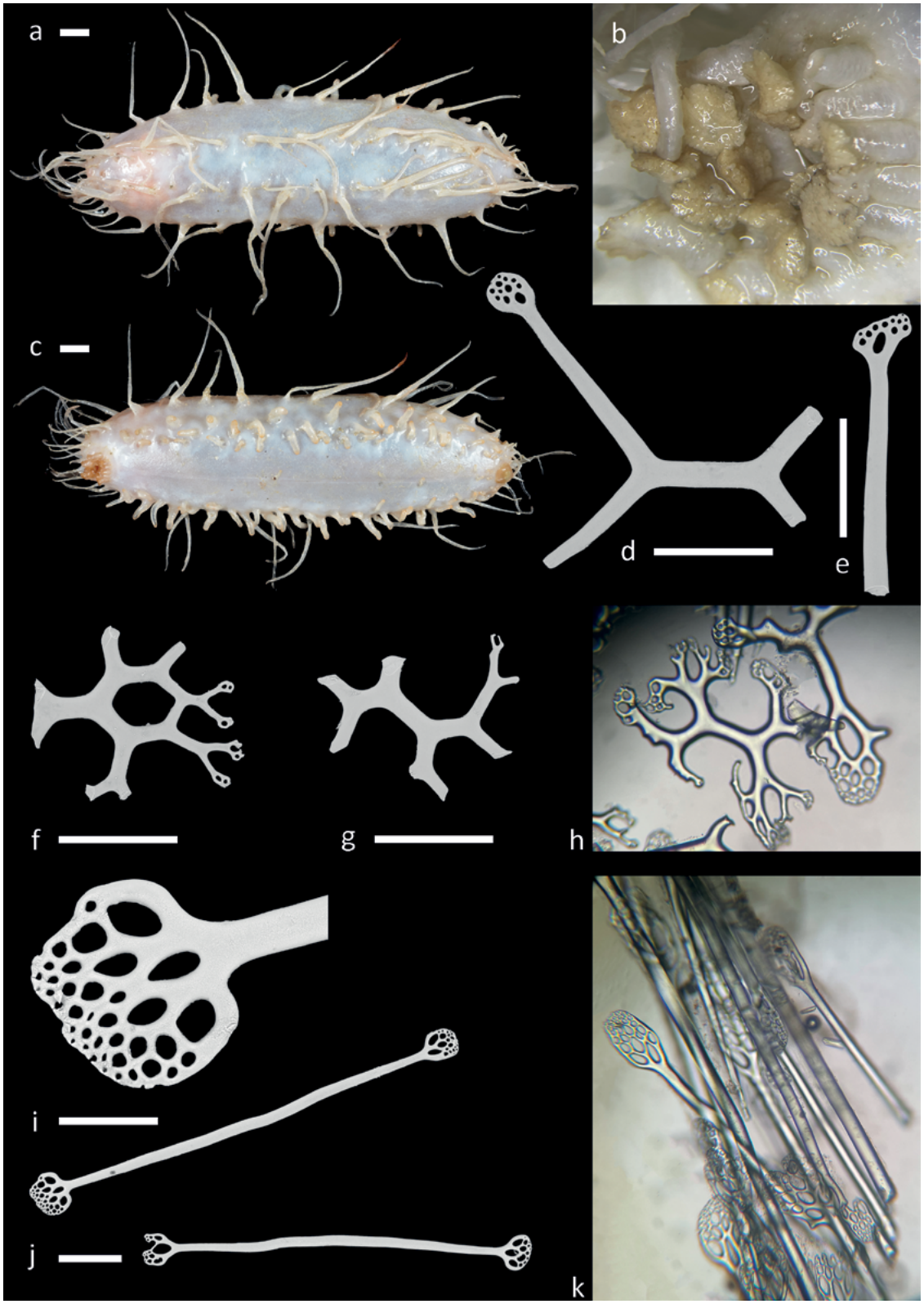

Figure 40. *Oneirophanta* sp. MoV. 7333. a, c, shipboard images showing live colour and appendages, dorsal, ventral; b, close-up of tentacles (preserved); ossicles: d, e, h, body wall ventral, f, g, body wall dorsal, i–k, spatulated rods of papillae, NMV F296845; scale bars: a, c=1 cm, d–g, j=300 *μm*, i=100 *μm*.

Orphnurgus glaber Walsh, 1891 sensu stricto

Figure 41a–o, Appendix 1, Table S1, Figure S5

Orphnurgus asper Théel var. *glaber* Walsh, 1891: 198.

Orphnurgus glaber Walsh, 1891.—Koehler and Vaney 1905: 60–62, pls. 8: 3, 12: 1–3.—Fisher, 1907: 706 (comment).—Hansen 1967: 491–493, figs 9, 10.—Hansen 1975: 39–46 (part, non *O. insignis* synonymy: 43–46), fig. 12, fig. 13 (part): 1–27 and 34–39, pl. 8: 5–7 (non *O. insignis* synonymy: fig. 13: 28–33 and 40–45).—Thandar, 1992: 175 (comment).—Rowe et al., 2017: 479–480, fig. 11.18.

Non *Orphnurgus insignis*.—Hansen 1975: 39–46 (part): fig. 13 (part): 28–33 and 40–45.

Orphnurgus invalidus Koehler and Vaney, 1905: 62-64, pl. 12: 9.

Orphnurgus rigidus Ohshima, 1915: 234–235.—Ohshima 1916–1919, with one figure.

Amphideima investigatoris Koehler and Vaney, 1905: 59–60, pls. 4: 6, 12: 8.

Material examined. NMV F296849* (1) [IN2021 V04 022]; NMV F296869* (7) [IN2021 V04 035]; NMV F296874* (20) [IN2021 V04 046]; NMV F296876* (7) [IN2021 V04 048]; NMV F308163 (7), NMV F308164 (1), NMV F308165 (1) and NMV F308166 (3) [IN2022 V08 108]; NMV F308168 (17) [IN2022 V08 111]; NMV F308254* (1) and NMV F308255 (1) [IN2022 V08 141]; NMV F308299 (1) and NMV F308300 (2) [IN2022 V08 157].

Diagnosis of IOT material. Body elongated, strongly raised dorsally, flattened ventrally, and rounded at ends. Colour salmon-pink to orange or white. White when preserved but often brown or orange at tips of appendages. Body wall smooth, leathery, semitransparent. Papillae variable length, two rows on each dorsal radii plus lateral series above tube feet. Conspicuous, non-retractile ventrolateral tube feet of variable size in single to paired zigzag series along each side (e.g. ~24–25 each side NMV F308164). Extended tube feet can be almost same length as papillae but more cylindrical and less tapered at tip, with an obvious dark end disc (fig 41b). Midventral median line typically visible, mostly bare, sometimes partially scattered to two rows of much smaller tube feet often clearer anteriorly (e.g. ~22 midventral, one tenth size of ventrolateral in NMV F308254). Anus terminal and open. Mouth anterior, ventral, with non-retractile tentacles (~18 visible in NMV F308254). Tentacle disc margins with ramified (branching) processes. Body wall ossicles include smooth rods or spinous rods with solid (rarely flat), thorny ends and/or branched extremities dorsally (fig 41g–k) often the same but shorter and thicker ventrally (fig 41l–o). Lacking large ellipsoids, dumbbell-shaped transformed rods or spatulated rods or crosses. IOT specimens small to medium size (e.g. 36 mm long, 7 mm wide, 10 mm high; NMV 296849, preserved) to 60 mm long, 20 mm wide, 10 mm high (NMV F296869, largest specimen in lot, preserved).

Remarks. Hansen synonymised four species into *Orphnurgus glaber*, made major revisions to the species diagnosis, and applied this to his key for the *Orphnurgus* genus (Hansen, 1975). Cherbonnier and Féral (1981) subsequently raised *O. insignis* back out of synonymy and added new species *O. bacillus* to the genus. Thander (1992) agreed with Cherbonnier and Féral and added two new species, *O. aspersignis* and *O. natalasper*. Pawson (2002) added the most recent new species, *O. dorisae*. These changes make Hansen's 1975 keys and images for *O. glaber* unreliable until further investigation can be undertaken. The more recent key (Pawson, 2002) was based only on ossicles and attempted to clarify some of the changes since Hansen (1975), but suggests that spinous rods are absent and spatulate rods present in *O. glaber*. We note that this is based on Hansen's amended diagnosis, which at the time nominated spatulated rods as the dominant ossicle for *O. glaber*, presumably from one of his synonymies because the original description only notes ossicles as "spinous rods or smooth rods with branched extremities" (Walsh, 1891). Hanson does not mention re-examining type material to amend this diagnosis. Identifications here are based on Walsh's (1891) sensu stricto description of *O. glaber*, with IOT specimens matching the colour, external morphology and ossicles of the type description. Ossicles in IOT specimens are smooth rods with branching or thorny ends but lacking ventral "fat" ellipsoid or dumbbell-shaped transformed rods, which agrees with Thander (1992) (sensu Walsh) and Fisher (1907) (referring to Koehler and Vaney, 1905), and with no spatulated rods. Genetics show sampled IOT *O. glaber* as a new lineage on GenBank, grouping together well but separately from *O. glaber* previously identified (with limited confidence – NMV catalogue) from northwest Australia (fig. S5). We identify the IOT material as *Orphnurgus glaber* Walsh, 1891 sensu stricto, noting that this genus requires further genetic and morphological work to establish clear characters between species. Finally, we report that parasitic Eulimid gastropods (Field number IN2022 V08 141 129) were found attached ventrally to specimen NMV F308254.

Distribution. Widely distributed in Indo-west Pacific, recorded from off southern Africa in the Indian Ocean to Hawaii and Tahiti in the Pacific Ocean.

Full bathymetric range. 397–1553 m (IOT 1019–1533 m).

Type locality. Bay of Bengal, 1025 m.

In Australia this species was not previously recorded in AFD but recorded (identified with limited confidence) from off northwest Australia at depths of 397–990 m in ALA (January 2024). These records and IOT material extend the previously known bathymetric range from 700–1025 m to 397–1553 m, with Australian examples showing the full known depth range of the species, but with the comment that many *O. glaber* as currently known may need revision.

References. AFD (2024), ALA (2024), Cherbonnier and Féral (1981), EOL (2024), Fisher (1907), Hansen (1975), Ohshima (1915), Pawson (2002), Thander (1992), Théel (1879), Walsh (1891).

Orphnurgus insignis Fisher, 1907 sensu stricto

Figure 42a–x, Appendix 1, Table S1, Figure S5

Orphnurgus insignis Fisher, 1907: 702, pl. 73: 1, pl. 77: 1–3.—Ohshima, 1915: 237.—Ohshima,1916–1919: with 3 figures.—Cherbonnier and Féral, 1981: 361, fig. 2a, k.—Thandar, 1992: 173–175 figs 4, 7a.

Orphnurgus glaber Hansen, 1975: 39 (part), textfig. 13 (28–33, 40–45).

Non *Orphnurgus glaber* Walsh, 1891. AM Clark, 1977: 146 (= *O. aspersiginis* Thandar).

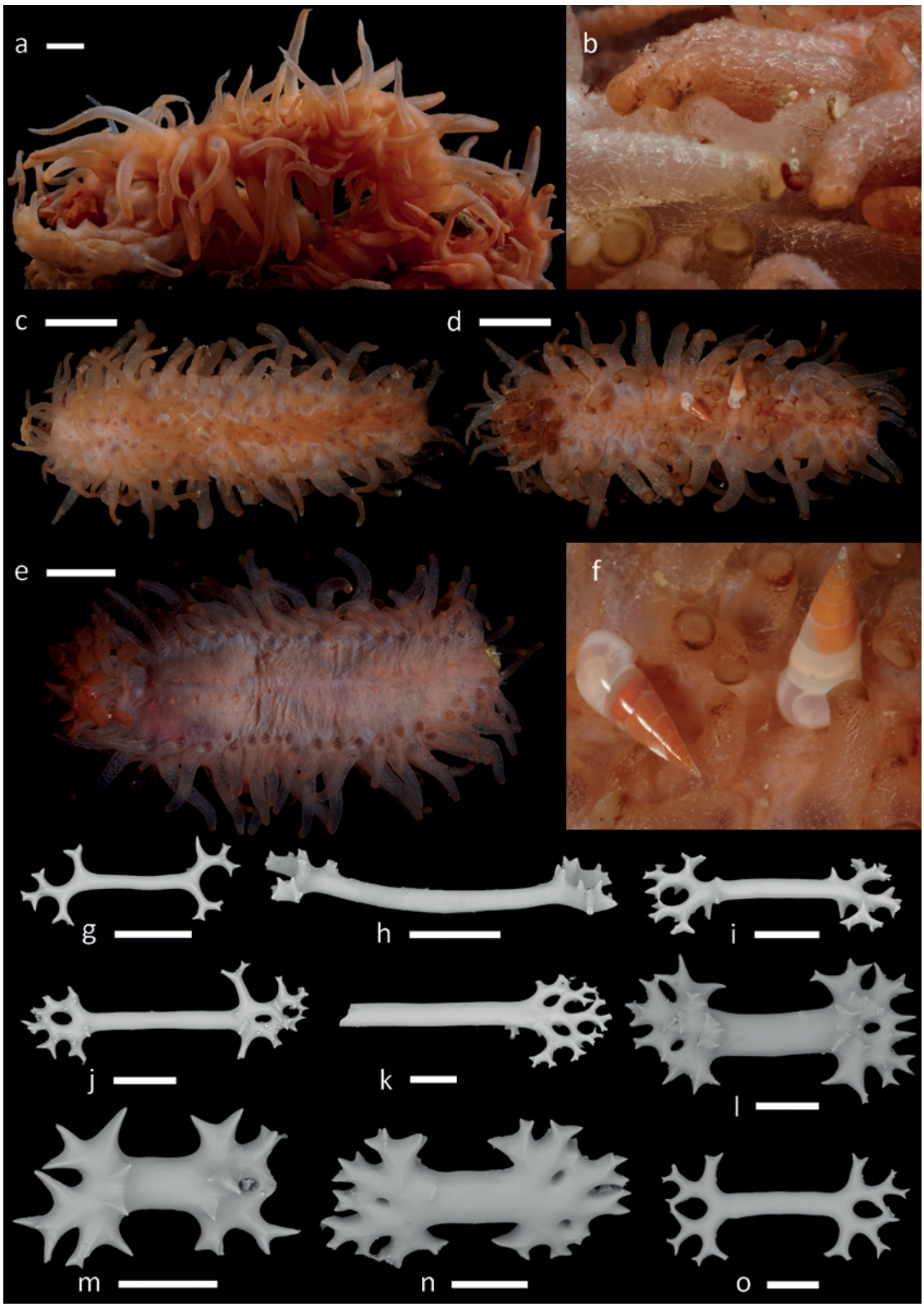

Figure 41. *Orphnurgus glaber*. a–f, shipboard images, a, b, group aquaria image showing live colour and close-up of appendages, NMV F296869, c, d, f , dorsal, ventral, close-up of attached snails, NMV F308254, e, ventral, NMV F308300; ossicles: g–o, body wall thorny rod ossicles, g–k, dorsal, l–o, ventral, NMV F296869; scale bars: a, c, d, f =1 cm, g–o=100 *μm*.

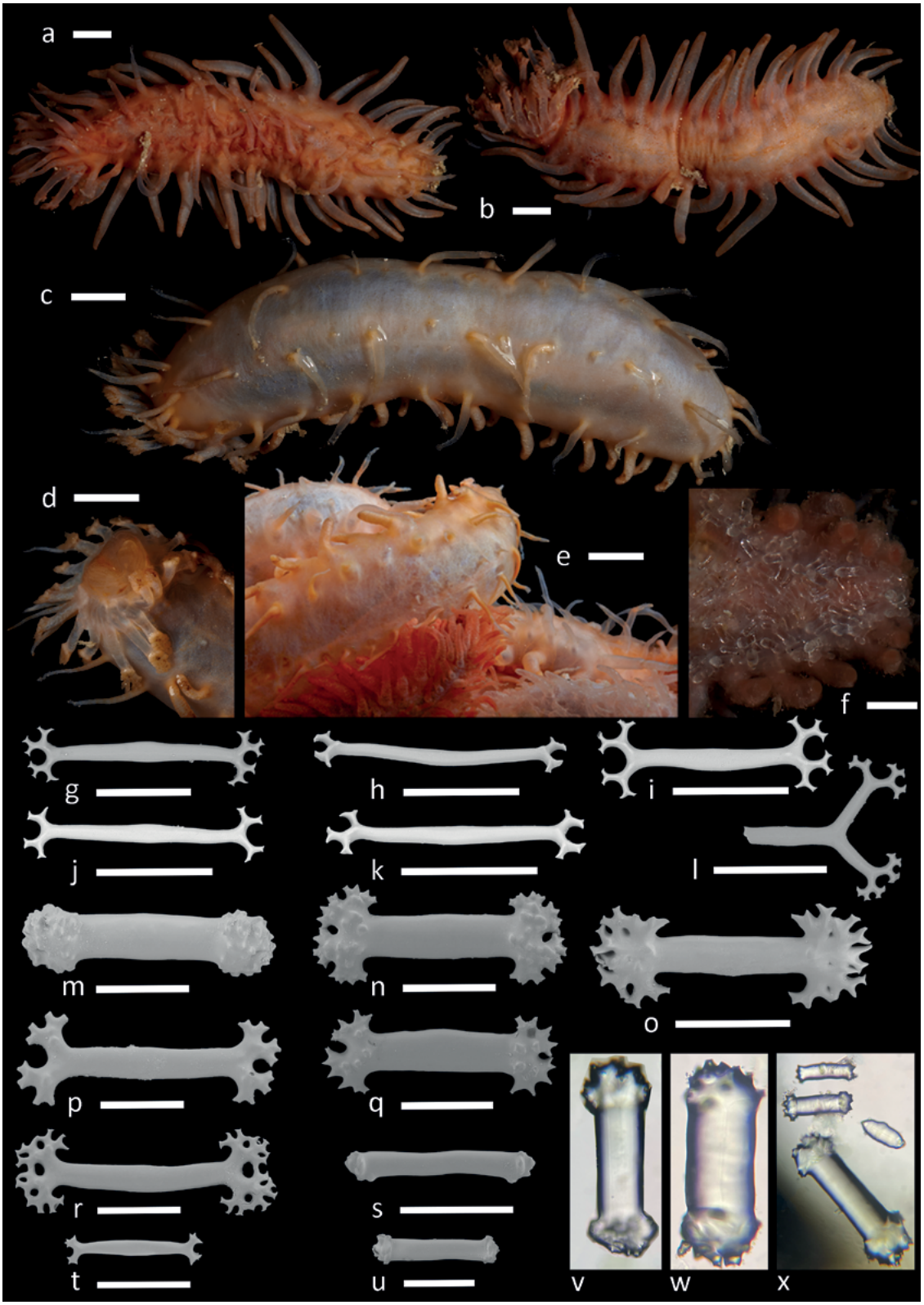

Figure 42. *Orphnurgus insignis*. a–f, shipboard images showing live colour, a, b, dorsal, ventral, NMV F308298, c, dorsal, d, close-up of ventral tentacles, NMV F308301, e, group aquaria image, NMV F296868, f, ossicles visible to eye in body wall, NMV F308176; ossicles: g–x, body wall rod ossicles, g–l, smooth branching dorsal, m–x, thick transformed ventral, NMV F308169; scale bars: a–e=1 cm, f=0.2 cm, g–u=200 *μm*.

Material examined. NMV F296867* (4) and NMV F296868* (6) [IN2021 V04 035]; NMV F296871* (1) [IN2021 V04 040]; NMV F296877* (3) [IN2021 V04 048]; NMV F308149 (1) and NMV F308158 (1) [IN2022 V08 105]; NMV F308167 (1) [IN2022 V08 108]; NMV F308169 (1) [IN2022 V08 111]; NMV F308176 (1) [IN2022 V08 113]; NMV F308212 (1) [IN2022 V08 117]; NMV F308239 (1), NMV F308240 (2), NMV F308246 (1), NMV F308247 (1) and NMV F308248 (1) [IN2022 V08 131]; NMV F308298* (1) and NMV F308301* (2) [IN2022 V08 157].

Diagnosis of IOT material. Body elongated, sub-cylindrical, raised dorsally and flattened ventrally. Small to medium-sized (e.g. 3.6 mm long [NMV F308176] to 11.5 cm long [NMV F308298, tentacles extended]). Salmon-yellow to pink or orange in colour with yellow-brown tips to appendages. White when preserved. Body wall thin, transparent, often rough ventrally. Papillae typically thin, tapered and in single to zigzag series along each dorsal radii, and in lateral series above the ventrolateral tube feet. Of variable length, larger laterally than dorsally. Some specimens with "shaggy" appearance being crowded with papillae, others less so (e.g. 22 or 23 papillae each dorsal radii, and ~13 papillae ventrolateral in NMV F308298, compared to ~13–15 papillae each dorsal radii, and ~9 papillae ventrolateral in NMV F308301, seemingly not size-dependent). Non-retractile ventrolateral tube feet, ~16–18 in single to zigzag series along each side. Extended past lateral papillae length in NMV F308298, but typically shorter, wider, more robust, and less tapered than the papillae. Typically bare of tube feet midventrally, but with median line visible. Anus terminal, slightly dorsal. Mouth terminal but turned to ventral with up to 20 non-retractile tentacles. Tentacles usually quite extended in larger specimens, sometimes with obviously shorter ventral tentacles. Peltate tentacle discs with lobed and ramified (branching) processes on the margins. Dorsal body wall ossicles include smooth, nearly straight rods with branched and sometimes spinous extremities (fig. 42g–l). Dominant ventral ossicles (fig. 42m–x) are thick, transformed rods, variable in shape from ellipsoid to dumbbell or sometimes "lumpy" bodies. Visible to the naked eye in smaller specimens (fig. 42f).

Remarks. Hansen's 1975 synonymy of *Orphnurgus insignis* with *O. glaber* was rejected by Cherbonnier and Féral (1981) and subsequent authors. Our identifications here chiefly follow the original description by Fisher (1907) and subsequent examples by Thandar (1992) with smoother branching rods dorsally and thick transformed rods ventrally, though only rare evidence of dorsal cross ossicles was observed (fig 42l). IOT specimens with less-crowded papillae also match Thander's (1992) South African variety for papillae distribution.

Distribution. Pacific and Indian Oceans including Hawaii, Japan, Philippines, south-east Africa, Australian IOT, off eastern Australia and Tasman Sea.

Full bathymetric range. 222–2435 m (IOT 1019–2435*m).

Type locality. Hawaiian Islands, ~222–387 m.

*Bathymetric range extension. Previously to 1050 m off south-east Africa (Thandar, 1992) or 1147 m in Tasman Sea (ALA, below). This species not previously recorded from Australian IOT in AFD (2024) but recorded from at Lord Howe plateau in the Tasman Sea between Australia and New Zealand (1076–1147 m), and potentially at upper bathyal depths (<1500 m) off the coast of NSW in ALA (January 2024). This IOT material represents a geographic range extension for the species in Australia.

References. AFD (2024), ALA (2024), Cherbonnier and Féral (1981), Fisher (1907), Hansen (1975), Thander (1992).

Orphnurgus sp. MoV. 7318

Figure 43a–o, Appendix 1, Table S1, Figure S5

Material examined. NMV F296870* (2) [IN2021 V04 037]; NMV F296872* (1) [IN2021 V04 040]; NMV F308243 (1) and NMV F312854 (3) [IN2022 V08 131]; NMV F308295 (1) [IN2022 V08 155].

Diagnosis of IOT material. Body elongated, sub-cylindrical, raised dorsally and flattened ventrally. Small specimens, up to 27 mm long, 6 mm wide and 4 mm high here (NMV F312854, preserved). Light pink to orange colour, white when preserved. Skin can be semitranslucent exposing the gut, but typically covered in grit, forams, debris etc., and can look messy or shaggy. Body wall can be crowded with ossicles and have a crunchy texture. Papillae typically thin, tapered and in single to zigzag series (~10) along each dorsal radii, and in lateral series above the ventrolateral tube feet (7+). Non-retractile ventrolateral tube feet, ~19 in single to zigzag series along each side. Typically bare of tube feet midventrally, but with median line visible. Anus terminal, slightly dorsal. Mouth terminal but turned to ventral, with up to 17 tentacles seen in these specimens. Tentacle discs with lobed and ramified (branching) processes on the margins. Ossicles visible to the naked eye. Dorsally include variable rods, long, short, thick or thin. Some simple, smooth with tapered ends, others long and spatulated or with twisted or flattened ends starting to branch or perforate, others forming crosses with branching or perforated ends. Occasional crosses with ends starting to branch. Ventral ossicles with some of the same but typically with thicker rods, almost dumbbell-shaped with the tips of ends starting to spread, flatten and perforate. Tube feet with longer thick rods with at least one perforation and initial branching at ends. Papillae with similar, but often longer and thinner, plus some curved support rods.

Remarks. Genetically, COI and 16S data shows *Orphnurgus* sp. MoV. 7318 as a new lineage with high differentiation from its sister lineage *O. glaber* from the Australian IOT (p-distances: COI = 15.9%, 16S = 6.6%) (fig. S5). The combination of ossicles including long rods with perforated to spatulated ends, very thick rods with flattening, perforating ends, plus crosses, also separates *Orphnurgus* sp. MoV. 7318 from other IOT material, and from the nine currently accepted species in the genus as described. However, given the confusion over morphological features and ossicle form due to synonymies by Hansen (1975) and subsequent revisions of this group (see Remarks under *O. glaber* above), the authors are reluctant to take identification past the OTU level of *Orphnurgus* sp. MoV. 7318 at this stage, with the genus requiring a major review and further phylogenetic and morphological investigation for resolution.

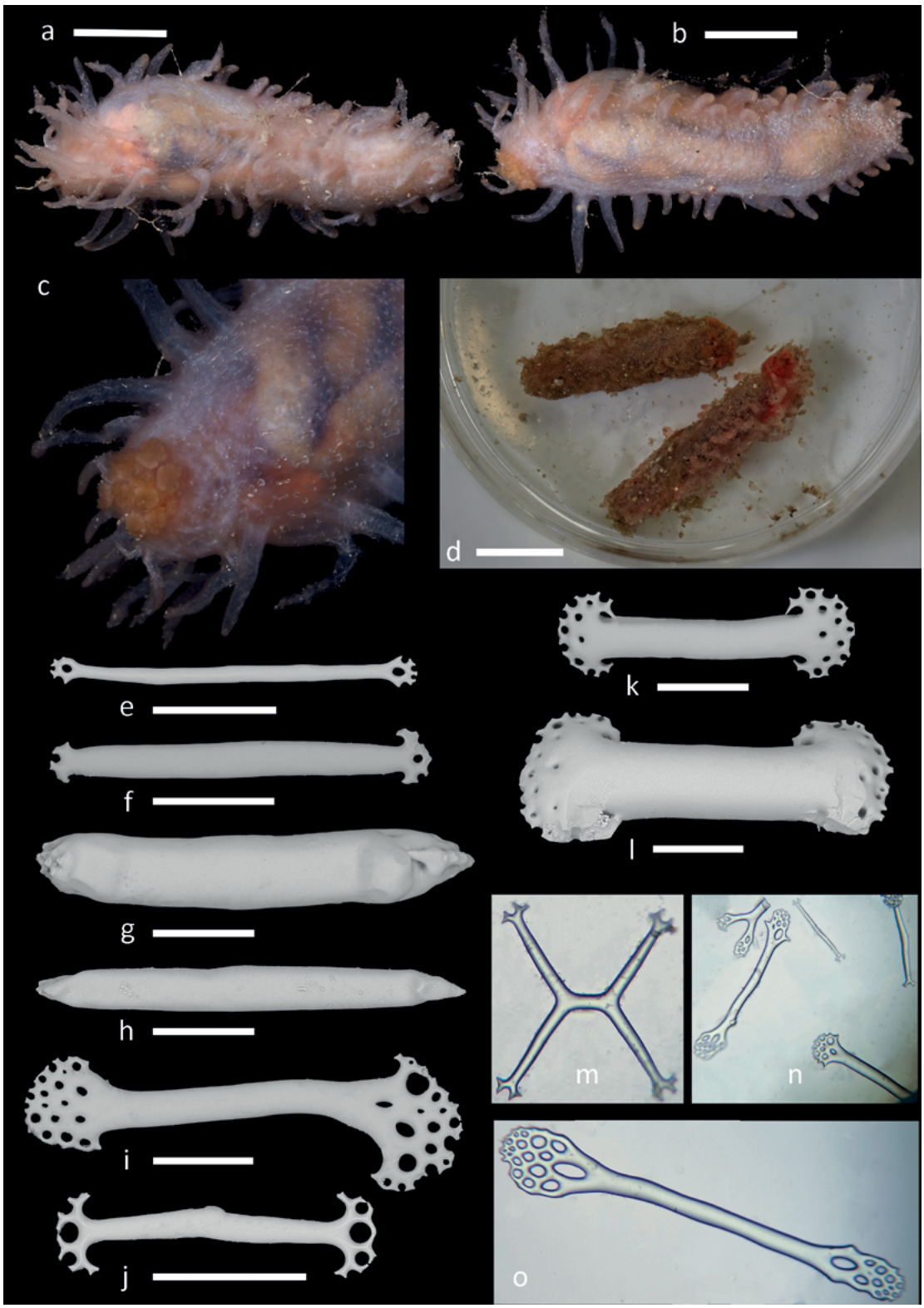

Figure 43. *Orphnurgus* sp. MoV. 7318. a–d, shipboard images showing live colour and appendages, a, dorsal, b, ventral, c, close-up of tentacles, NMV F308243, d, small hard form in petri dish, NMV F296870; ossicles: e–o, body wall rod and cross ossicles, e, dorsal, f, ventral, NMV F296870, g, h, NMV F296872, i, j, n, o, dorsal rods (including spatulated), k, l, ventral thick transformed rods with flat perforated ends, NMV F308243, m, body wall cross, NMV F308295; scale bars: a, b, d =1 cm, e–l=200 *μm*.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands vicinity, 1459–1850 m, including: Apollo Seamount Stn.1640–1850 m, Shcherbakov Seamount Stn.1608–1663 m, Cocos (Keeling) Stn.1589–1896 m, Muirfield Seamount Stn.1459–1595m.

References (for genus). Fisher (1907), Hansen (1975), Pawson (2002), Thander (1992), Théel (1879), Walsh (1891).

Orphnurgus sp. MoV. 7332

Appendix 1, Table S1.

Material examined. NMV F308297 (1) [IN2022 V08 157].

Remarks. One additional lot from a single station at 1019–1023 m was identified to *Orphnurgus* based on external morphology and ossicles. Presence of some "fat" ellipsoid transformed rods, absence of spinous rods with thorny ends, and presence of some spatulated rods means this specimen is excluded from *Orphnurgus glaber* Walsh 1891 sensu stricto and all other genera as currently described. Here we identify this specimen to *Orphnurgus* sp. MoV. 7332 because ossicles still fit Hansen's (1975) synonymised revision of *O. glaber*, which requires morphological examination of type and comparative material, genetic investigation, and significant literature review to sort species-level characters and identify this specimen as either a new species or species to be raised out of synonymy.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Muirfield Seamount Stn., 1019–1023 m.

References (for genus). Fisher (1907), Hansen (1975), Pawson (2002), Thander (1992), Théel (1879), Walsh (1891).

Family **Synallactidae** Ludwig, 1894

Diagnosis. (adapted from Solís-Marín, 2003 and Smirnov, 2012 for Miller et al., 2017 erection of Synallactida). Body usually flattened, with a ventral sole with ambulacral feet, dorsal surface with papillae. Head of the stone canal usually in connection with the body wall, sometimes opening outwards through it. Respiratory trees well developed. Tentacular ampullae absent. No Cuvierian organs. Gonad in two tufts, lying to either side of mediodorsal mesentery. Radial muscle bands typically undivided. Stone canal attached to the body wall and sometimes open externally. Calcareous ring can be well-developed, reduced, or altogether absent. Ossicles: tables, rods, sometimes C-shaped bodies, very rarely buttons.

Remarks. Cosmopolitan, often seen as an important epibenthic group in abyssal footage, but one of the least-studied deep-sea sea cucumbers (Solís-Marín, 2005). At the species level, the differences in morphological characters can be quite subtle, obscuring taxonomic distinctions (Solís-Marín, 2003), and many genera including "pygal-furrowed" groups were removed from this family when they were found to be polyphyletic (Miller et al., 2017). Synallactidae is widespread in Australian waters. Of the ten genera now currently accepted worldwide, three have been previously recorded for Australia: *Bathyplotes, Paelopatides,* and *Synallactes*. All three are reported here for the IOT material, along with the first record for *Scotothuria*. Family diagnosis (above) chiefly follows Solís-Marín (2003) but has been amended to include Smirnov's (2012) summary of ossicle types, and gonad in two tufts only, following the removal of *Mesothuria* (one tuft) during the revision by Miller et al. (2017). Future revision may still be required.

Genus ***Bathyplotes*** Östergren, 1896

Diagnosis. (following Solís-Marín, 2003). "Synallactidae with 15–20 tentacles; mouth ventral, anus dorsal, subdorsal or nearly terminal. Skin rather thick. Body with sole-like ventral side, usually with marginal appendages; midventral ambulacrum naked or provided with a few tube feet; ventrolateral ambulacral with tube feet in a single row or more. Dorsally, papillae more or less distinctly in rows. Tube feet well developed ventrolaterally but are often lacking midventrally. Dorsal side with double row of papillae along each radius. Musculature in most cases undivided; genital organs in two tufts, located on both sides of mesentery. Calcareous ring weakly developed, sometimes completely absent. Ossicles: Tables with cross shaped disc and a spire built up of 4 rods, usually with several cross beams; "C" shaped bodies maybe present. Ossicles in tentacles, simple or branched rods, sometimes smooth, sometimes spiny."

Remarks. Cosmopolitan genus with 25 species accepted worldwide, five of which are currently known for Australia: *Bathyplotes monoculus, B. moseleyi, B. natans, B punctatus,* and *B. sulcatus* (ALA and WoRMS 2024). *Bathyplotes* is closely related to *Synallactes* and can be difficult to distinguish based on external morphology. Distinguished by *Bathyplotes* having predominantly four-pillared tables ossicles, compared to the single-pillared ones seen in *Synallactes*. The *Bathyplotes* sequences included in the COI and 16S phylogenetic analyses indicate that the genus is paraphyletic and IOT samples exclusively comprise four of the main lineages within the clade (fig. S5). Interestingly, *Synallactes* cf. *crucifera* is highly supported as the sister lineage to the *B. moseleyi* and *B. bongraini* group, suggesting an in-depth revision of both genera and likely the family is needed. Specimens here showed similarities to *B. moseleyi*, *B. natans*, and *B. sulcatus*. We have identified tissue-sampled specimens to sp. MoV. OTU level and kept others at genus level due to crossover between characters in our specimens and issues with clearly defined morphological and ossicle characters for the species within the genus. Twenty lots of *Bathyplotes* were recorded from the IOT voyages at depths of 1110–1991 m, with 13 lots further identified to OTU species level as follows: *Bathyplotes* sp. MoV. 7340 (4 lots), *Bathyplotes* sp. MoV. 7341 (6 lots), *Bathyplotes* sp. MoV. 7342 (3 lots). One further lot with both *Bathyplotes* and *Synallactes*-like characters is identified as Synallactidae sp. MoV. 7339 (1 lot).

Bathyplotes sp. MoV. 7340

Figure 44a–q, Appendix 1, Table S1, Figure S5

Material examined. NMV F308259* (2), [IN2022 V08 141], NMV F308261* (1) and NMV F308266 *(4) [IN2022 V08 143], NMV F308304* (1) [IN2022 V08 157].

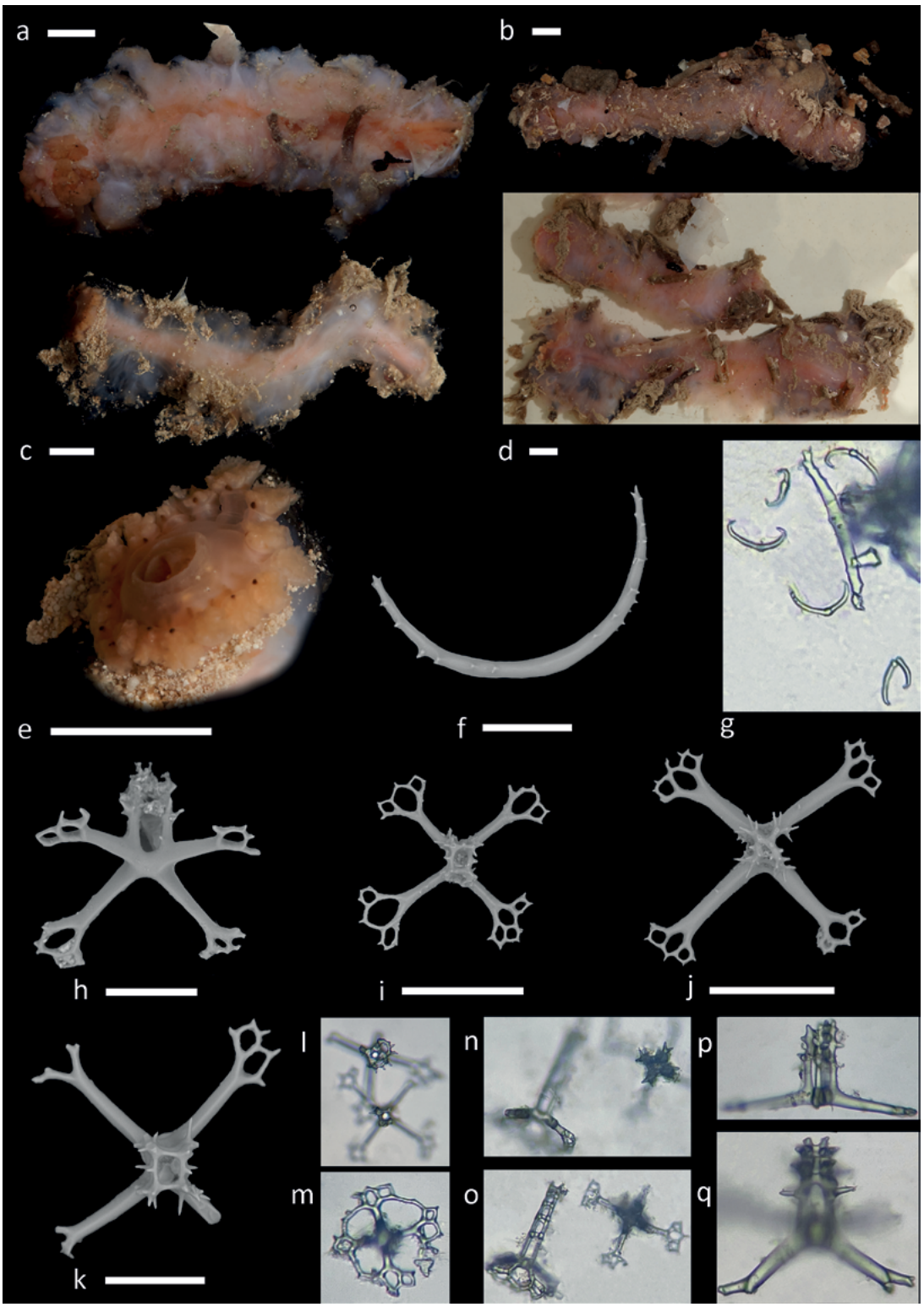

Figure 44. *Bathyplotes* sp. MoV. 7340. a–e, shipboard images showing live colour and form, a, NMV F308259, b, NMV F308261, c, e, body and close-up of tentacles with black spots, NMV F308304, d, NMV F308266; ossicles: f, g, rods and Cs, f, peri-anal body wall, NMV F308266, g, tentacle, NMV F308304, h–q, body wall tables, h–k, type 1 tables, four-pillared towers with square thorny apex, NMV F308266, l, top starting to join, NMV F308261, m, ventral, type 2 tables with bases joining to form button-like discs, n–o, dorsal, type 2, NMV F308259, p, q, type 3 tables shorter, thicker and variably spinous with arms straight to angled, NMV F308266; scale bars: a–e =1 cm, f, h, k=50 *μm*, i, j=100 *μm*.

Diagnosis of IOT material. Specimens all damaged with few external features remaining. Light pink and semitranslucent, gelatinous, elongate, dorsoventrally flattened to cylindrical, and typically covered in grit, up to ~14 cm long, 3.5 cm wide (NMV F308266, pre-preservation). Specimens likely elongate and dorsoventrally flattened when live, but often just central vermiform section remaining here. No tube feet or papillae remaining, although potential canals visible in semitranslucent lateral skin. Anus terminal. Mouth ventral to terminal. Tentacles lost from most specimens, approximately 18 non-retractable light orange tentacles visible in NMV F308304 with prominent black dots (eye spots?) on many. Discs with indented edges look molar-shaped when preserved, black spots remain. Ossicles include spinous rods, occasional Cs, and some or all of the following *Bathyplotes*-type tables,

Type 1) Tables with medium height four-pillared spires viewed from top as highly spinous/thorny central square (occasionally joining) with four long, smooth, slightly curved arms, perforated at ends, often with one or more larger perforations and sharp edges or spines starting to branch.

Type 2) Tables with tall four-pillared spires, distally spinous only (not along spire), with four or five crossbeams on slight angle and base made from four short, perforated arms joined to form a perforated button-disc. Differs from type 1) by shorter, joined arms.

Type 3) Tables with short, thick, four-pillared spires, typically with only one or two crossbeams at top, spires from tapered to almost mace-shaped, irregularly spinous along length of spire.

Remarks. Table type 2) is closest to the type illustration of *Bathyplotes natans* (M. Sars, 1868), only differing in that the original illustrations show no complete discs, but four short arms starting to join, while IOT specimens were often completely joined. Table type 3) matches additional *B. natans* photographs from Solís-Marín (2003) of synonymised *B. bipartitus* type slides. Rods, Cs and Type 3 tables also show some similarities to *B. sulcatus* original type illustrations (Sluiter, 1901) and subsequent (quite different) illustrations by Heding (1940), though Type 2 joined bases are shown. Specimens do not match the photographed form of *B. natans* from type location (Solís-Marín, 2003), and no conspicuous furrow or tube feet are available to check against *B. sulcatus* body form. Given the mixed known characters between species and the distinct square spire tops of Type 1 tables here, here we identify specimens to *Bathyplotes* sp. MoV. 7340.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Cocos (Keeling) Stn. and Muirfield Seamount Stn., 1019–1343 m.

References (for genus). Sars (1868), Solís-Marín (2003), Sluiter (1901a), Théel (1886a).

***Bathyplotes* sp. MoV. 7341**

Figure 45a–p, Appendix 1, Table S1, Figure S5

Material examined. NMV F296878*(1) [IN2021 V04 048]; NMV F308175* (2) [IN2022 V08 113]; NMV F308200* (5) [IN2022 V08 116]; NMV F 308244* (9) and NMV F308245* (2) [IN2022 V08 131]; NMV F308294* (6) [IN2022 V08 155].

Diagnosis of IOT material. Specimens all damaged with few external features remaining. Light pink, elongate, dorsoventrally flattened to cylindrical, often covered in sponge spicules and grit. Up to 16.5 cm long, 3 cm wide, 1 cm high (NMV F308200, largest specimen in lot, preserved). No tube feet or papillae remaining in most specimens, though skin where present was thick and/or covered in warts and papillae. Mouth ventral to terminal. Anus appears terminal. Tentacles lost from most specimens, but where present discs have indented edges. Ossicles include spinous rods, occasional Cs, and some or all the following *Bathyplotes*-type tables.

Type 2) Tables with tall 4-pillared spires, distally spinous only (not along spire), with four or five crossbeams on slight angle and base made from four short, perforated arms joined to form a perforated button-disc (more typical here in papillae and occasionally with fewer spires).

Type 3) Tables with short, thick, four-pillared spires, typically with only one or two crossbeams at top, spires from tapered to almost mace-shaped, irregularly spinous along length of spire.

Type 4) Tables with four arms and a short solid single-pillar spire with spinous crown (more common in papillae or warts).

Type 5) Tables with tall four-pillared spires, with five or six crossbeams, spines along length of spire, with four long, separate, distally perforated arms. Differs from type 1) by additional crossbeams, spines along length of spire and spire square to tapered but not “thorny” at top.

Type 6) Tables with short four-pillared spires, spines mostly distal, one or two crossbeams on slight angle and base made from four short arms joined to form a perforated button disc. This table differs from Type 2) in being much shorter with fewer crossbeams (found in ventral body wall here).

Remarks. Some *B. sulcatus* and *B. natans* ossicle types present here again with some additional variations or omissions. Type 5) tables are distinguished from *B. phlegmaticus* ossicles by lack of spines on table arms. The type 4) tables and skin morphology (papillae and warts) of NMV F296878 was very similar to *B. moseleyi* and Synallactidae sp. MoV. 7339. Most specimens here are from stations deeper than for *Bathyplotes* sp. MoV. 7340. Again the variation in ossicles and morphology within this genetically distinct group leads us to identify specimens here to OTU level *Bathyplotes* sp. MoV. 7341 until this family can be revised with a combination of genetic and morphological analysis.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands Territories, Balthazar Seamount Stn., Scrooge Seamount Stn., Lucia Seamount Stn., and Cocos (Keeling) Stn., 1260–1991 m.

References (for genus). Sars (1868), Solís-Marín (2003), Sluiter (1901a), Théel (1886a).

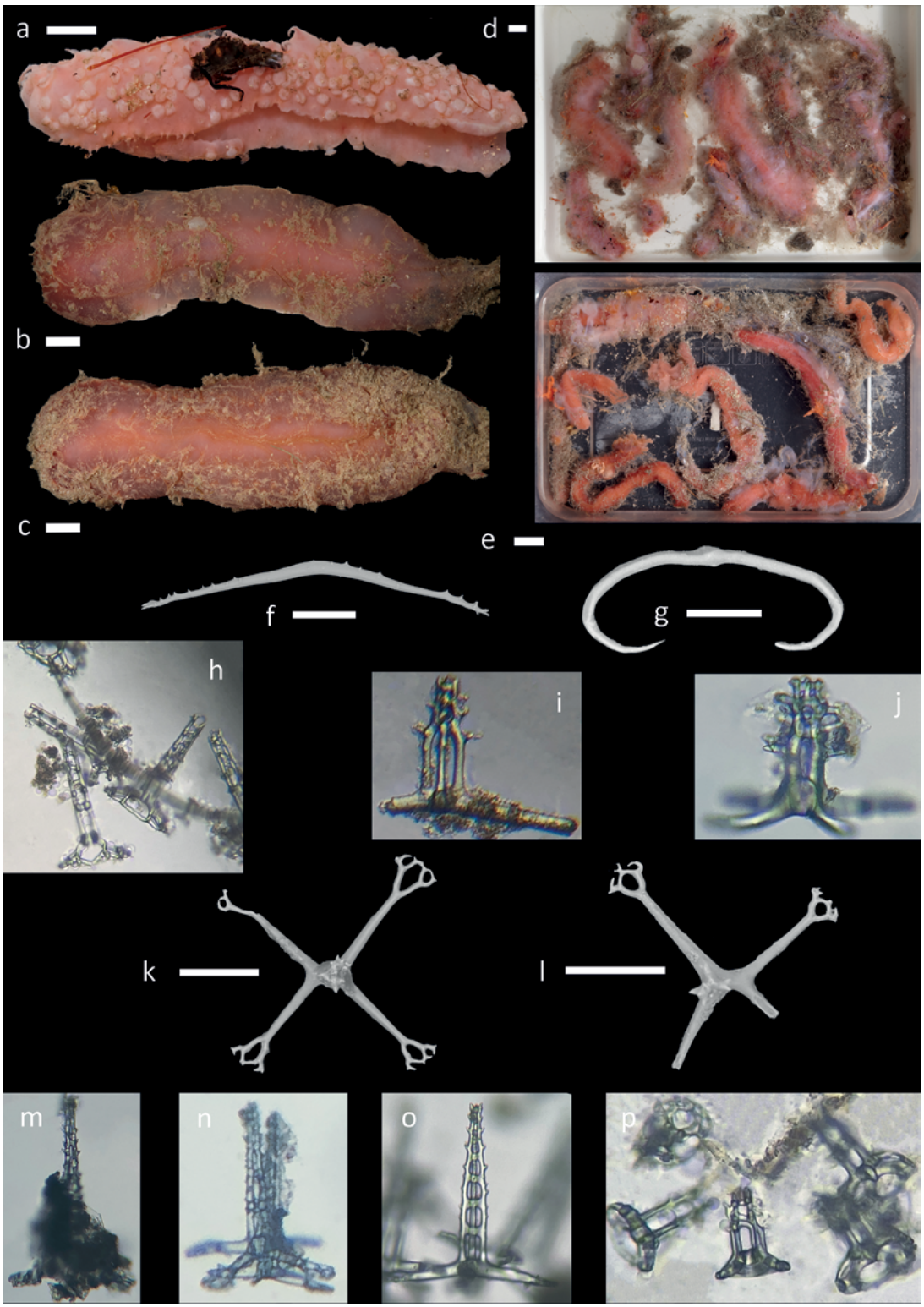

Figure 45. *Bathyplotes* sp. MoV. 7341. a–e, shipboard images showing live colour and variable form, a, skin only, NMV F296878, b, c, NMV F308294, d, NMV F308244, e, NMV F308245; ossicles: f, dorsal rod, g, dorsal Cs, NMV F308175, h, type 2 tables from papillae, NMV F308244, i, type 3 tables, NMV F296878, j, type 3 table, NMV F308175, k, l, type 4 tables, single solid pillar with crown, body wall, NMV F296878, m–o, type 5 tables with spines along tall tapered, spire, m, n, NMV F308175, o, dorsal, NMV F308244, p, ventral, type 6 table, short with button-disc, NMV F308244; scale bars: a–e =1 cm, f, =100 μm, g=20 μm, k, l=50 μm.

***Bathyplotes* sp. MoV. 7342**

Figure 46a–k, Appendix 1, Table S1, Figure S5.

Material examined. NMV F308174* (1) [IN2022 V08 113], NMV F308199* (1) [IN2022 V08 116], NMV F308317* (8) [IN2022 V08 185].

Diagnosis of IOT material. Specimens all damaged with few external features remaining. Light pink to orange, elongate, dorsoventrally flattened to cylindrical, often covered in sponge spicules and grit. Often just central vermiform section remaining here, sometimes with tentacle crown or remnant "fluffy" skin. Often stripped of skin but NMV F308199 (fig. 46b) gives a good example of orange vermiform centre and translucent pink skin with dorsoventrally flattened form when more intact. This specimen up to 5 cm long, 4.3 cm wide, 1.2 cm high, and cream/white with very few characters when preserved. No tube feet or papillae remaining in most specimens, though skin where present had white warts and/or retracted appendages and was slightly rugose from ossicles. Mouth ventral to terminal. Anus appears terminal. Tentacles lost from most specimens, but where present discs have indented edges. Ossicles include occasional Cs and some or all the following *Bathyplotes*-type tables.

Type 5) Tables with tall four-pillared spires, with five or six crossbeams, spines along length of spire, with four long, separate, distally perforated arms (fig. 46d–i).

Type 7) Tables, with four-pillared spires, typically with two or three crossbeams in top half of spire, and slightly tapered, irregularly spinous along length of spire but especially at top, four perforated arms variably joining. Like Type 3) but slightly taller, with additional crossbeams and often starting to join between arms. Seen here in papillae around endplates (fig. 46j, k).

Remarks. See previous remarks. Some *B. sulcatus* and *B. natans* ossicle types present here again with some additional variations or omissions. Specimens all damaged with very few external features. Identified here to OTU level *Bathyplotes* sp. MoV. 7342.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Christmas Island and Cocos (Keeling) Islands Territories, Scrooge Seamount Stn., Lucia Seamount Stn., and Raitt Ridge North Stn., 1936–1991 m.

References (for genus). Sars (1868), Solís-Marín (2003), Sluiter (1901a), Théel (1886a).

***Bathyplotes* sp.** Östergren, 1896

Appendix 1, Table S1.

Material examined. NMV F296879 (1) [IN2021 V04 048]; NMV F308178 (1), NMV F308179 (20), and NMV F308180 (1) [IN2022 V08 113]; NMV F308213 (1) [IN2022 V08 117]; NMV F308249 (3) [IN2022 V08 131]; NMV F308262 (1) [IN2022 V08 143]; NMV F308290 (2) [IN2022 V08 153]; NMV F308323 (13) [IN2022 V08 189].

Remarks. Remaining specimens were not placed into species at this time due to lack of clarity in distinguishing characteristics as noted above.

Genus ***Paelopatides*** Théel, 1886

Diagnosis. (following Martinez et al., 2019 after Solís-Marín, 2003) "Body more or less distinctly depressed, with a rather considerable rim surrounding the sides and the extremities. Tentacles 15–20, peltate, or sub digitate on margin of the crown. Mouth ventral. Anus dorsal or subdorsal. The tube feet form a double row along the odd ambulacrum, except on the anterior part where they are absent. The papillae form a simple row around the margin of the rim and are scattered along each of the two dorsal ambulacra as well. Interambulacra naked. Gonads on both sides of the dorsal mesentery. A rete mirabile is sometimes present. One or two Polian vesicles. Stone canals apparently lacking. No calcareous ring. Ossicles: Simple tri-radiate or quadri-radiate rods either smooth or spinous; with slightly branched tips; exceptionally deposits often entirely wanting."

Remarks. Typically large, purple, gelatinous group, with at least one species, *Paelopatides retifer* reported to swim (Miller and Pawson, 1990). Of the 21 currently accepted species of *Paelopatides* worldwide, four have previously been recorded for Australia: *P. appendiculata, P. aspera* (one record only), *P. ovalis* (one record only), and *P. quadridens* (WoRMS, ALA and NMV catalogue, 2024). Five lots of *Paelopatides* are recorded here from the IOT voyages at depths of 2000–3839 m and further identified to OTU species level as follows: *Paelopatides* sp. MoV. 7336 (2 lots), *Paelopatides* sp. MoV. 7337 (3 lots). The COI sequence data indicates two well-supported *Paelopatides* lineages that form a clade with IOT *Scotothuria herringi* (fig. S5). There is 10.9% net genetic divergence between the two *Paelopatides* lineages. Within each *Paelopatides* lineage, the IOT samples are more closely related to each other than the GenBank sequences from specimens collected in the eastern Pacific Ocean. Only one IOT specimen was sequenced for 16S. This individual grouped with the same *Paelopatides* specimen from California, USA as it did in the COI phylogeny. Accurate identification can be difficult in the group due to ossicles often being absent or not diagnostically distinctive, and specimens not maintaining their form when preserved.

***Paelopatides* sp. MoV. 7336**

Figure 47a–k, Appendix 1, Table S1, Figure S5.

Material examined. NMV F308191* (1) [IN2022 V08 115]; NMV F308306* (1), [IN2022 V08 181].

Diagnosis of IOT material. Large oval, light to dark purple, thick, firm, depressed specimens, up to 33 cm long and 16 cm wide (NMV F308191, pre-preservation). Dorsal surface low convex, with delineation between central body and brim not clear, but possibly more visible here in NMV F308306 (fig. 47c, d). Scale pattern sometimes visible dorsally. Central section between the dorsal radii is lighter in colour and thick with central ridges and protuberances, which are absent from the smooth skin of the brim between the dorsal radii and the lateral edge. Up to four single scattered rows of retracted papillae dorsally, visible when off centre, any additional papillae obscured mid-body by

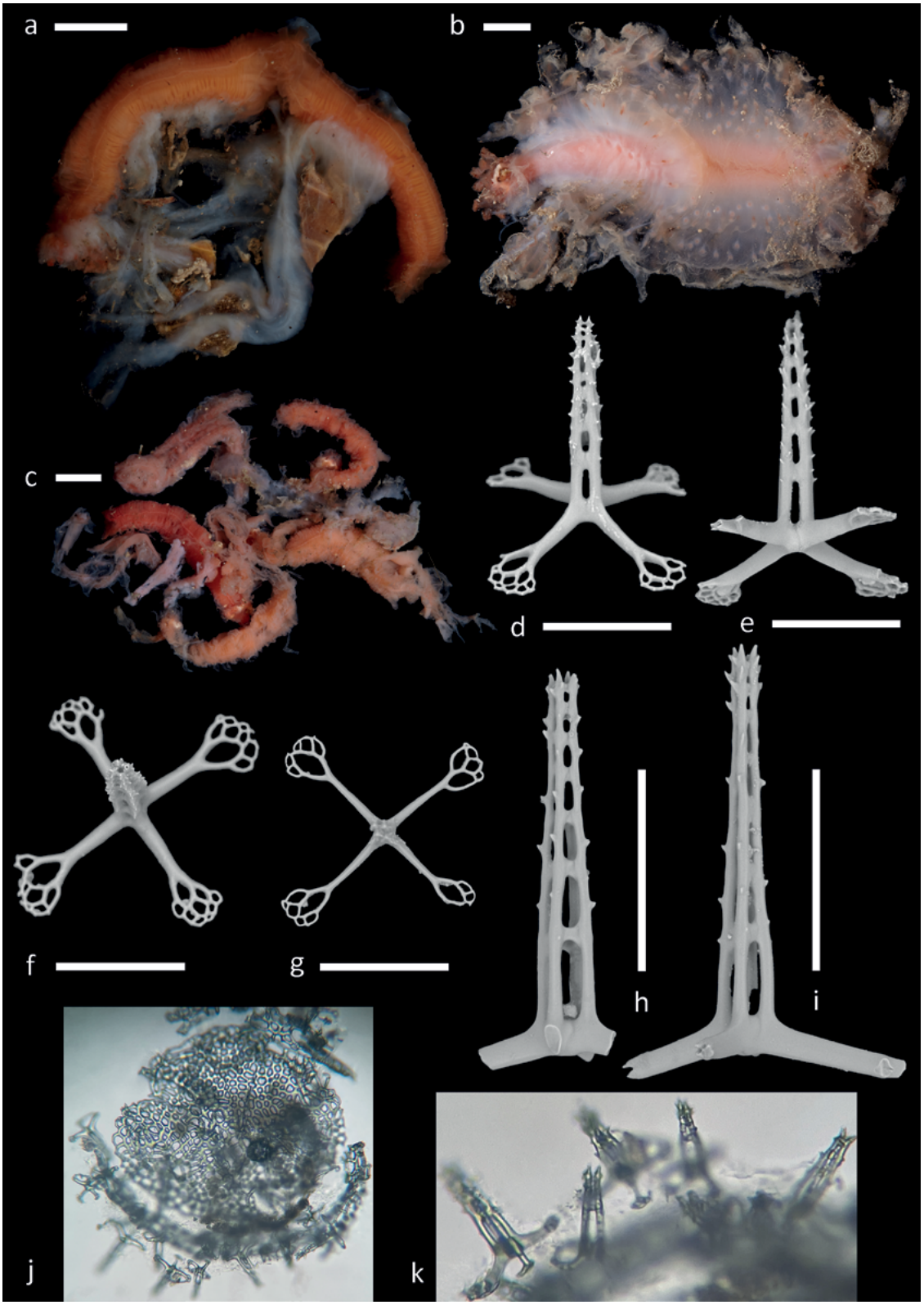

Figure 46. *Bathyplotes* sp. MoV. 7342. a–c, shipboard images showing live colour and variable form, a, NMV F308174, b, NMV F308199, c, NMV F308317; ossicles: d–k, body wall tables, d–f, type 5 tables with tall, spinous pillars, NMV F308174, g–i, type 5 tables, NMV F308199, j, k, type 7 tables in-situ, NMV F308174; scale bars: a–c =1 cm, d–i=100 *μm*.

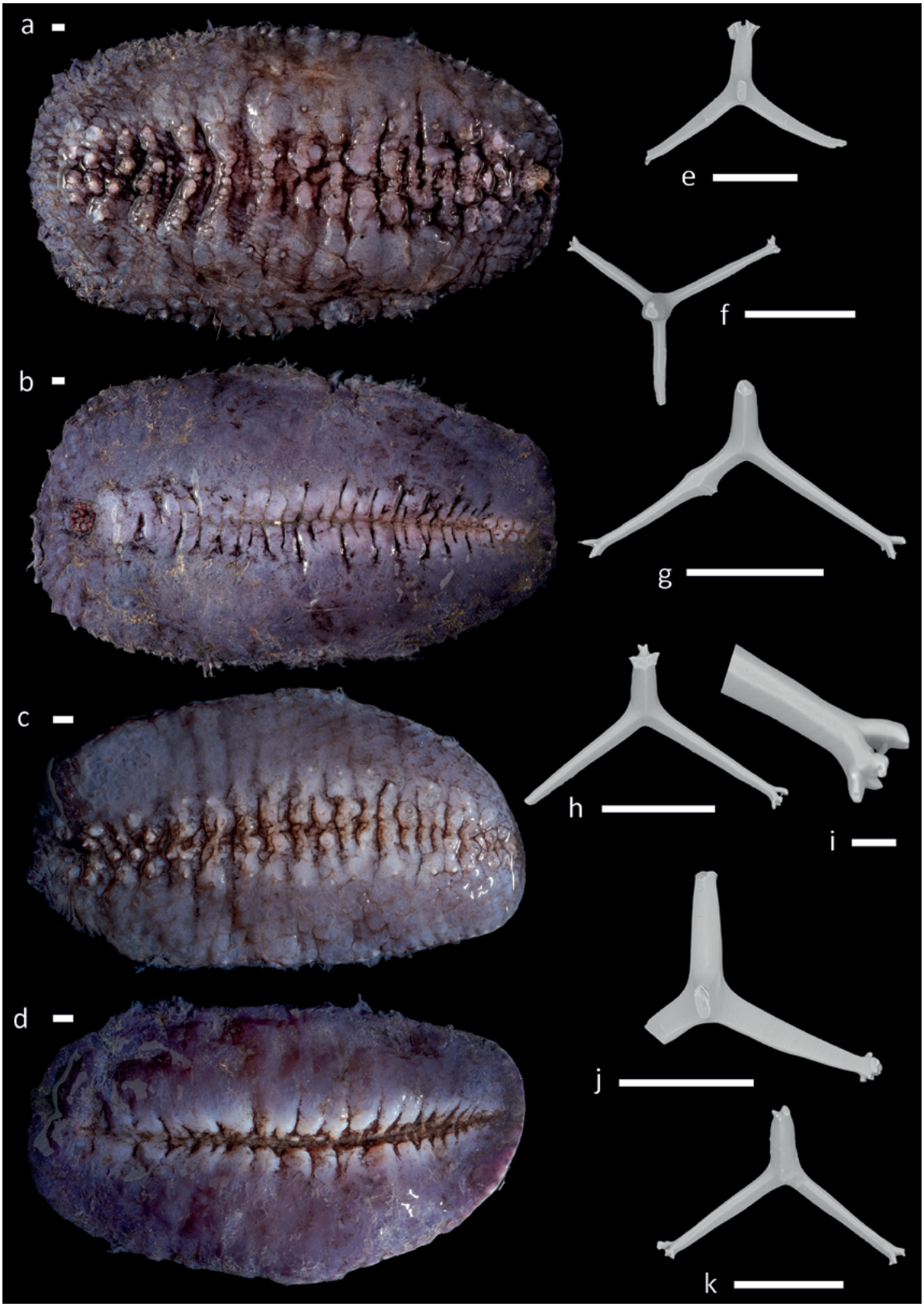

Figure 47. *Paelopatides* sp. MoV. 7336. a–d, shipboard images showing live colour and form, a, dorsal, b, ventral, NMV F308191, c, dorsal, d, ventral, NMV F308306; body wall ossicles from dorsal anterior, NMV F308191; scale bars: a–d =1 cm, e–h, j, k=100 μm, i=10 μm.

the wrinkled ridges and raised knobs with dark purple patches mid-body, though occasional papillae projecting from domed bases here. Lateral edge also with raised protuberances and/or ridges and canals indicating likely retracted papillae, though not seen here. Ventral surface also low convex with no clear delineation between sole and brim, other than the midventral being a clear lighter colour with darker midventral furrow and many horizontal dark purple wrinkles and ridges. Two alternating rows of midventral tube feet evident in posterior section only. Anus dorsal. Mouth ventral. Thick tentacles retracted (~15 visible), each with four or more knobbed orange/brown lateral digits. Specimens are still firm and rigid but shrink on preservation to 23 cm long, 11 cm wide, and 3.5 cm high (NMV F308191), and 20.5 cm long, 11 cm wide, 2 cm high when preserved (NMV F308306, from ~24 cm long, 14 cm wide). A thick main lateral brim and two thinner posterior-lateral brims of fused papillae are also clearer on preserved specimens. Colour is almost black dorsally but purple ventrally. Body wall with triradiate ossicles present, often with long arms and central spire and minimal branching on all.

Remarks. Based on ventral tube feet being restricted to the rear third of the body, these specimens key to *Paelopatides illicitus* Sluiter, 1901 using the available key to southern hemisphere *Paelopatides* (Martinez et al., 2019), but IOT specimens are much smaller, not cylindrical, and ossicles are not a match to type illustrations (Sluiter, 1901). Not a clear match to any species described and illustrated in Koehler and Vaney (1905), for example wider and with more dorsal papillae than *P. insignis*, closer shape to *P. ovalis* but with less defined brim, fewer midventral tube feet, and dorsal papillae restricted to dorsal radii, completely different shape to the elongated *P. gelatinosus* (also imaged in Wirawati and Setyastuti, 2021), has the wart-like dorsal surface of *P. verrucosus*, but again not a match to the body shape. Not a match to the triradiate or rod ossicles of species illustrated in Koehler and Vaney (1905): *P. verrucosus*, *P. ovalis, P. insignis, P. modestus, P. magna*. Ossicles are possibly closest to *P. incerta*, being triradiate with long straight arms and minimal branching at ends, but the specimens lack the clear brim and non-retractile papillae of that species. We identify our specimens here as *Paelopatides* sp. MoV. 7336, noting that additional genetic samples, literature review, and morphological examination of comparative material may be required before confirming whether this is a new or existing species.

References. Koehler and Vaney (1905), Martinez et al. (2019), Solís-Marín (2003), Wirawati and Setyastuti (2021).

Paelopatides sp. MoV. 7337

Figure 48a–c, Appendix 1, Table S1, Figure S5.

Material examined. NMV F296843* (1) and NMV F296844* (1) [IN2021 V04 012]; NMV F308220* (1) [IN2022 V08 120].

Diagnosis of IOT material. (NMV F296844). Large, round, light purple specimen, up to 19.8 cm long and 15.5 cm wide, body very thick but depressed, with an extensive lateral brim visible from the ventral surface only (fig. 48 b). Skin thin but opaque. Mouth ventral, anus appears subdorsal to terminal. Complete cover of scattered dark-purple papillae dorsally and carrying over onto the visible ventral brim. Ventral interambulacra is bare, midventral line is deeply furrowed and wrinkled. Some scattered midventral tube feet observed, but mostly obscured by wrinkles and ridges so could not ascertain pattern. No ossicles found. Specimen after preservation shrinks to 18.5 cm long, 11.5 cm wide, and 2.5 cm high. Looks more like previous species *Paelopatides* sp. MoV. 7336 once preserved as much more reduced, flattened, and oval rather than round, but texture much softer and more gelatinous than *Paelopatides* sp. MoV. 7336 and thin top layer of skin also stripped. Preserved colour closer to light purple and black dorsally, ventral surface retains purple colour. All three specimens collected look superficially quite different, the two below placed here with reservations, based on genetic evidence. Brief descriptions of the two remaining specimens are as follows.

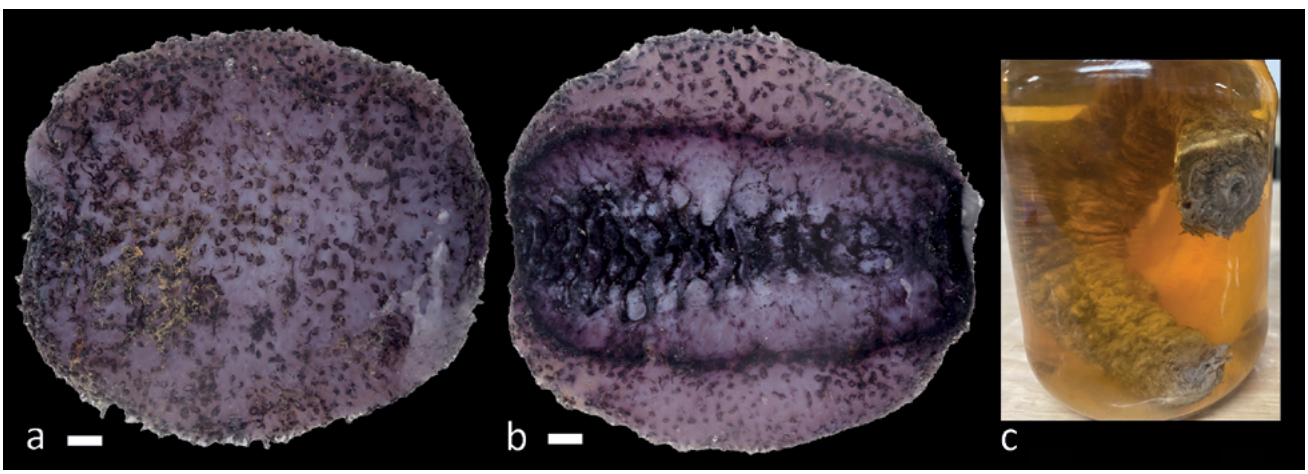

Figure 48. *Paelopatides* sp. MoV. 7337. a, b, shipboard images showing live colour and form of best specimen, a, dorsal, b, ventral, NMV F296844; c, cylindrical morphology (preserved, in jar) of NMV F308220; scale bars: a–d =1 cm

NMV F296843: Small, dark purple, gelatinous, dorsoventrally flattened specimen, ~8.5 cm long and 4.5 cm wide. Skin semitranslucent to opaque. Cylindrical gut visible. This specimen was damaged with no obvious appendages, but multiple dorsal canals visible through skin indicate potential scattered papillae.

NMV F308220: Cylindrical, elongated, purple/brown to cream specimen, severely damaged and stripped of skin and appendages, ~12.5 cm long x 2.8 cm wide x 2 cm high (fig. 48c). Mouth ventral. Anus terminal. No ossicles found. Potentially just the central cavity of a specimen with entire brim stripped, but no skin left to confirm this.

Remarks. Initially identified superficially as *Benthothuria funebris* due to the general colour and form of NMV F296844, but genetics places this firmly within *Paelopatides*, and both genetics and general morphology distinguish it from *Paelopatides* sp. MoV. 7366 above. The complete cover of dorsal papillae does not clearly fit the genus diagnosis for *Paelopatides* (Solís-Marín, 2003), but excluding the presence of ossicles it suits the more general adaptation of Solís-Marín's diagnosis by Wirawati and Setyastuti (2021): "*Paelopatides*: body distinctly depressed with slightly larger brim surrounding the body; ventral tube feet arranged in the two rows from posterior up to the middle part of the body; and ossicle with simple triradiate rods". Unable to ascertain pattern of ventral tube feet to use the key to southern hemisphere *Paelopatides* (Martinez et al., 2019). Round shape and complete dorsal cover of papillae along with absence of ossicles does not clearly fit any of the species described in Koehler and Vaney (1905). Lack of ossicles along with additional papillae and the anus not being clearly dorsal suggests the need for further comparison against *Benthothuria* species for this lineage. We note that morphologically *Paelopatides* can look very similar to *Benthothuria*, both including large purple species with thick, oval form, though *Benthothuria* has no ossicles and anus is terminal. Solís-Marín (2003) noted that phylogenetics showed *Paelopatides* and *Benthothuria* are related, this relationship was not examined by Miller et al. (2017), and *Benthothuria* is currently placed directly under Persiculida rather than with *Paelopatides* in Synallactidae. We identify our specimens here as *Paelopatides* sp. MoV. 7337, noting the difference in external morphology between specimens and that additional morphological and genetic samples and more thorough literature review are required before confirming whether this is a new or existing species.

Distribution. These specimen lots only: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Rudist Seamount Stn., Christmas Island Territory, off McPherson Point, 2000–3839 m.

References. Koehler and Vaney (1905), Martinez et al. (2019), Solís-Marín (2003), Wirawati and Setyastuti (2021).

Genus ***Scotothuria*** Hansen, 1978

Diagnosis. (following Hansen, 1978). "Synallactidae with dendritic tentacles and with body surrounded by a continuous brim of partly fused podia. Calcareous deposits cross-shaped with arms ending in a cluster of spines and with a central apophysis ending in a hood of downward-bent hooks; spines otherwise arranged in regularly spaced rings along the length of the arms and the apophysis."

Remarks. Monotypic genus represented by *Scotothuria herringi,* previously reported from the Atlantic Ocean and from the Indian Ocean off the coast of Kenya. Benthopelagic species typically found swimming above the seafloor by undulating their ventrolateral brim (Gebruk et al., 2014). Some specimens also found to carry parasitic nematodes in their coelom (Billet et al., 1985). Two lots of *S. herringi* were recorded from two stations on the IOT voyages at depths of 3431–5414 m, representing the first records for the genus and species in Australian waters. Prior to these voyages there was only one record of this species being collected by benthic trawl, being most commonly collected in pelagic trawls from 20 to 3900 m above the seafloor (Gebruk et al., 2014).

Scotothuria herringi Hansen, 1978

Figure 49a–l, Appendix 1, Table S1, Figure S5.

Scotothuria herringi Hansen, 1978: 34–37, figs 1–9.—Billett et al., 1985: 406–407, fig. 5.—Miller and Pawson, 1990: 4.—Gebruk et al, 2014: 169.

Material examined. NMV F308231* (1) [IN2022 V08 122]; NMV F308338* (1), [IN2022 V08 196].

Diagnosis of IOT material. Deep violet to almost black specimens, soft and gelatinous with few features remaining other than some partly fused and some free podia giving a shaggy appearance. Spongey when preserved, some lumps at one end of NMV F308338 that may have been a damaged mouth, exposed gut, and flat longitudinal muscles. No additional external features observed in these specimens, but type description includes ~18 retractile dendritic tentacles and body surrounded by lateral brim of partially fused to wholly embedded podia, plus some minute posterior midventral tube feet. IOT specimens small and damaged, ~72 mm long and 26 mm wide (NMV F308338, pre-preservation) to ~95 mm long and 55 mm wide (NMV F308231, pre-preservation). The larger specimen shrank to ~60 mm long on preservation. Dense with distinctive cross-like table ossicles with four arched arms and single tall central spire terminating in palm-tree or umbrella-like hood of downward projecting hooks, some apophyses with pointed tip projecting above this. Umbrella-like hooked structures sometimes also present at further intervals along spire or replaced by rings of reduced spines. Arms also have regularly spaced rings of spines. Apophyses and arms otherwise smooth. Ossicle arm width and spire height are variable (fig. 49c–h). Second type of ossicle very irregular rods, crosses, and Ys (typically ~90–130 μm long), covered by rings of spines and terminating in thickened spinous ends (fig. 49i, k, l). One specimen (NMV F308231) also has perforated plates, a feature not previously reported for this species. Considering the state of the specimens these might be contaminants, but the sample has at least five plates, of variable shape and size (~520–1000 μm wide). Shape, number, and size of perforations were also variable, and there were some weak initial indications of secondary layering (fig. 49j).

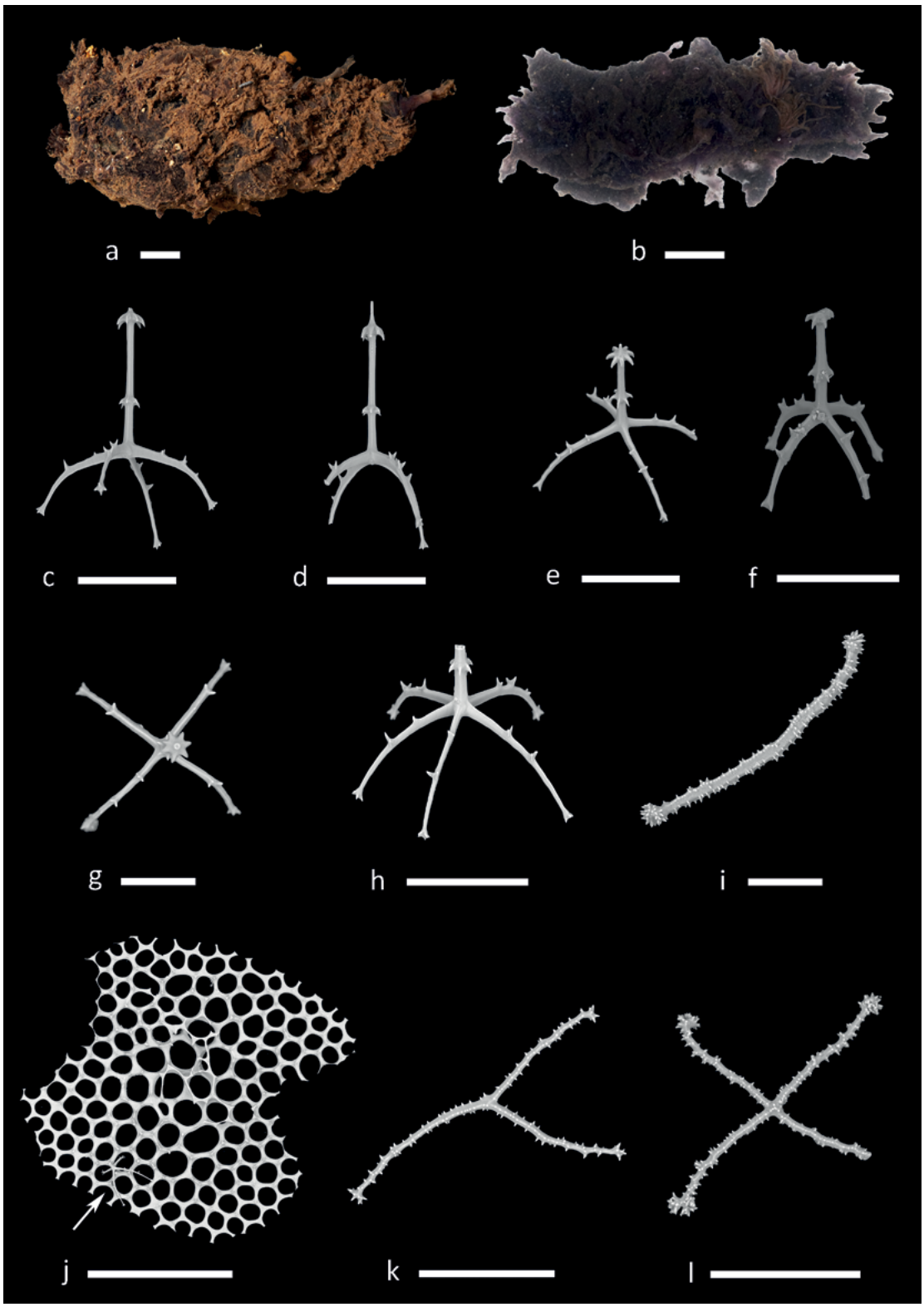

Figure 49. *Scotothuria herringi*. a, b, shipboard images showing live colour and form, a, NMV F308321 (note specimen is purple under the 'shaggy' exterior), b, NMV F308338; ossicles: c–h, body wall cross-like table ossicles with hood of hooks, c–e, g, h, NMV F308231, f, NMV F308338; i, k, l, irregular spinous rods, crosses and Ys from body wall, i, l, NMV F308231, k, NMV F308231; j, perforated plate (contaminant?) with arrow pointing to hooked table ossicle for scale, NMV F308231; scale bars: a, b=1 cm, c–f, h, k, l= 100 *μm*, g, i=50 *μm*, j=500 *μm*.

Remarks. Specimens with few remaining external characters and distinguished almost entirely based on their distinctive ossicle form. While illustrations provided by Hansen (1975) and subsequent images provided by Bohn (2006) of *Psychropotes semperiana* Théel, 1882 have a similar downward hook-shaped cap to their cross-like ossicles, *P. semperiana* ossicles are much more spinous and robust, and lack the curved arms and additional circles of hooks present in *Scotothuria herringi* Hansen, 1978, along with the additional irregular rods, crosses, and Ys noted above.

One specimen (NMV F308338) was from a station with magnesium nodules, which may have led to its slightly darker colour, but both specimens were dark violet to black. Specimens were similar in size to the range given for the types for *Scotothuria herringi* Hansen, 1978, which were 55–85 mm long pre-preservation, shrinking to 48–80 mm after (Hansen, 1978). A larger specimen from a subsequent collection was 150 mm pre-preservation, shrinking to 70 mm after (Billet et al., 1985).

Solís-Marín (2003) suggested that similarities with ossicles from *Galatheathuria aspera* (Théel, 1886a) might indicate *S. herringi* is a juvenile of that species, but more taxonomic work is required. Billet et al. (1985) and Miller and Pawson (1990) note that *Scotothuria herringi* Hansen, 1978 is a possible synonym of *Dendrothuria similis* (Koehler and Vaney, 1905), but more material from the type localities would be required before any decision on synonymy. Because the distinct "umbrella-hook" apophyses were not described in *D. similis*, we have placed our specimens in *S. herring* for now, with ossicles being a perfect match for the type material and subsequent work by Billet et al. (1985). While no comparative genetic sequences for *Scotothuria* were available, the sequences for both *Scotothuria* examined in this study comprise a well-supported monophyly and form a clade with *Paelopatides* (fig. S5).

Distribution. Eastern Atlantic and Indian Oceans.

Full bathymetric range. 1250–5414 m (IOT 1874–5414 m).

Type locality. North Atlantic Ocean (west of Ireland), collected at 1250–1500 m (station depth 5161 m).

This species not previously recorded from Australia in AFD or ALA (January 2024).

This IOT material represents a geographic and bathymetric range extension for the genus and species, previously with multiple records from the East Atlantic but only a single record from the Indian Ocean off Kenya at 1250–4980 m (Gebruk et al., 2014).

References. AFD (2024), ALA (2024), Billet et al. (1985), Bohn (2006), Gebruk et al. (2014), Hansen (1978), Koehler and Vaney (1905), Miller and Pawson (1990), Solís-Marín (2003).

Genus ***Synallactes*** Ludwig, 1894

Diagnosis. (following Solís-Marín, 2003 for *Synallactes* sensu stricto). "Body cylindrical or sub-cylindrical. Tentacles 18–20. Stone canal attached to the body wall. Ventral surface flattened, without any marginal border. Ventral tube feet and dorsal papillae in longitudinal series and confined to ambulacra. On ventral surface, three zones of tube feet. Gonad in two tufts. Body wall ossicles comprise three or quadri-radiate tables, the distal ends of the arms with a larger or smaller number of perforations, and often lateral processes which may unite with similar processes of other arms to produce a complex lattice-like network. Spire of a single pillar, which may be terminally divided or perforated, or both. Tube feet with supporting rods."

Remarks. Of the 26 currently accepted species worldwide (WoRMS, 2024), none are currently recorded for Australia in AFD or ALA (2024), though species are present in Australian (see below) and Australian Antarctic waters (NMV catalogue, 2024). Three lots of *Synallactes* were recorded from IOT voyages at depths of 2156–2418 m, all identified as *Synallactes* cf. *crucifera*. Within the Synallactidae, *Synallactes* and *Bathyplotes* can have very similar external morphology, particularly when damaged or "stripped" during trawls. Solís-Marín (2005) noted that this has led to past confusion between the species (e.g. Koehler and Vaney, 1905; Heding, 1940) and the introduction of variations in ossicle description. Here we followed Solís-Marín's diagnosis above for identification, which specifies single-pillared central spires for *Synallactes*, compared to the multi-pillared spires with crossbeams as currently known for *Bathyplotes*. Where the animal or skin is complete, midventral tube feet are also present for *Synallactes* but not *Bathyplotes*. Specimens sequenced from this taxon have identical COI and 16S haplotypes (fig. S5). For both genes, *Synallactes* cf *crucifera* is monophyletic within the genus *Bathyplotes* and sister to *Bathyplotes* samples collected in the southern Atlantic and Pacific oceans and Antarctica, indicating the need for a future revision of the group.

Synallactes* cf *crucifera Perrier R., 1898 sensu Rogacheva et al., 2013

Figure 50a–j, Appendix 1, Table S1, Figure S5.

Material examined. NMV F296862* (2) [IN2021 V04 031]; NMV F308319* (1) and NMV F312858 (1) [IN2022 V08 187].

Other material. *Synallactes* cf. *crucifer*a Perrier, 1898, sensu Rogacheva et al., 2013. – off eastern Australia, NMV F240992 [IN2017 V03 070 123]; NMV F241034 [IN2017 V03 090 106], identified by Mark O'Loughlin (2018).

Diagnosis of IOT material. Specimens elongated and sub-cylindrical, ventrally flattened to slightly curved, tapered at oral and anal ends. Body typically salmon-yellow to pink or orange (pre preservation). Where present, thick outer layer of bumpy skin with scattered white wart-like processes in some specimens, but can look flaky, fluffy, or vermiform as the thicker body wall tends to strip off. Where visible, single to double rows of retractable papillae along each dorsal radius, and additional row of shorter, thicker dorsolateral papillae. Papillae conical with whip-like tips. Ventrolateral tube feet and smaller midventral tube feet present, but skin often split along midventral and/or completely stripped. Mouth ventral or directed ventrally, with 18–20 tentacles. Anus subdorsal. Example of preserved size: 80 mm long, 25 mm wide, and 8 mm high (NMV F296862, larger specimen). Body wall with cross-shaped ossicles, typically four-armed (rarely 5 or 6) distally spatulated, and with a single solid, spinous, central spire. Spire of two typical types,

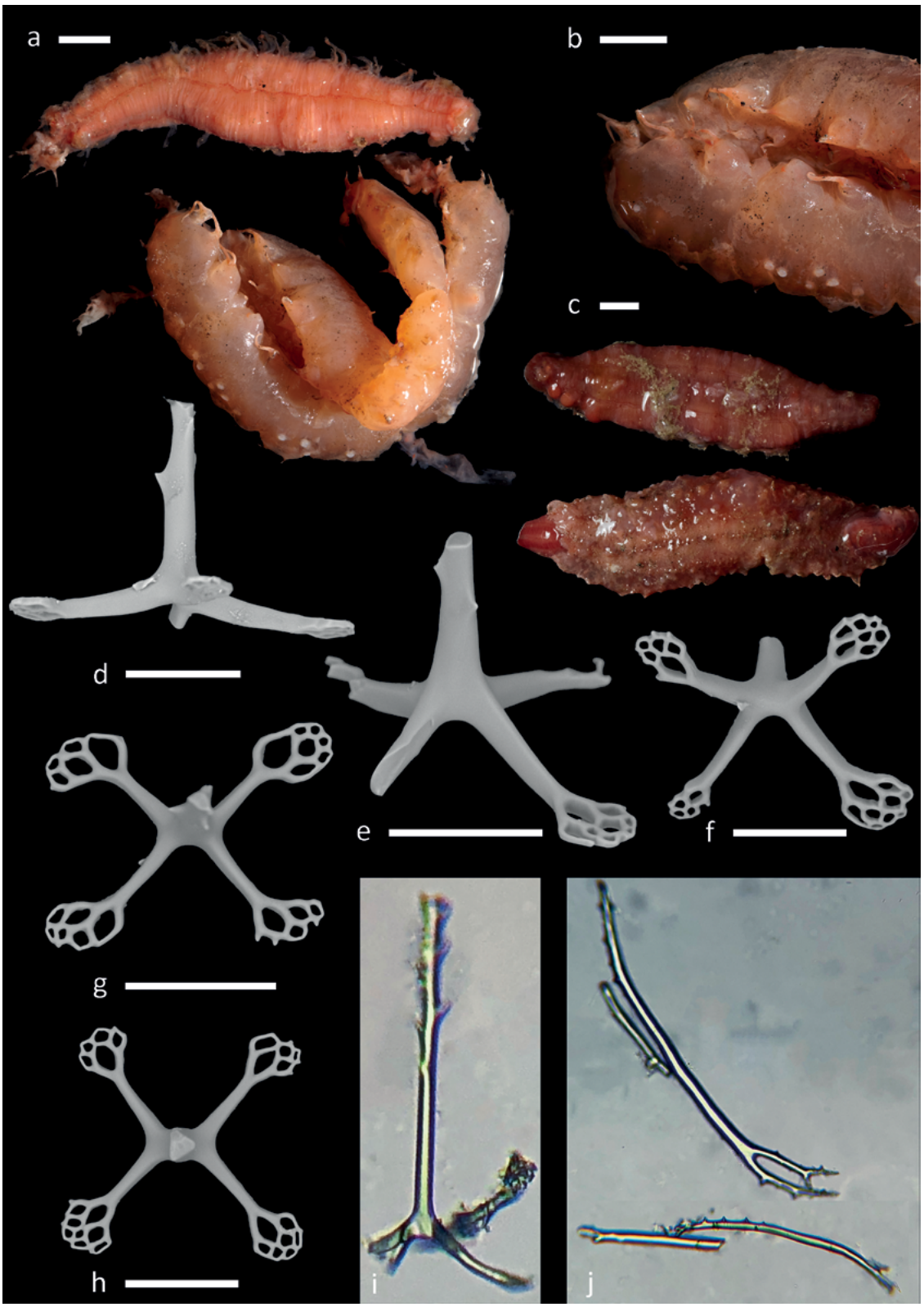

Figure 50. *Synallactes* cf *crucifera*. a–c, shipboard images showing live colour and form, a, b, body with stripped skin, NMV F308319, c, dorsal and ventral, NMV F296862; ossicles: d–h, body wall table ossicles, j, tentacle rods, NMV F296862, i, papillae table ossicle with very tall spire, NMV F308319; scale bars: a–c=1 cm, d–h=50 *μm*.

short and thick cross type with spire height similar to arm length (56–110 *µm* in these specimens, fig. 50 d–h), and tall and thin cross type with spire approximately three times the arm length (up to 184 *µm* in these specimens, fig. 50i). Both types tapered at top, with vertically directed spines running up the spire. Each arm distally flattened and perforated, typically with 1–3 larger perforations and three or more smaller, but quite variable and often broken from taller ones. In these samples, dorsal and ventral body walls have predominantly the shorter cross type, papillae have both tall and short types (though longer papillae often dense with the taller version), tube feet have predominantly the shorter cross type, and one papillae sample also has curved rods and rare end plates. No "tall" cross types were found in NMV F308319, but the short type agrees with other specimens. Tentacle ossicles are irregular curved rods, often bifid at ends, sometimes branching. Some smooth rods also observed in body wall.

Remarks. Ossicles with some similarities to those figured for *Synallactes profundus* (pl. 10: fig 19–20, Koehler and Vaney, 1905) but differs in body form. Closest to two eastern Australian *Synallactes* cf *crucifera* identified by Mark O'Loughlin in 2018 (NMV catalogue; sensu Rogacheva et al., 2013 as per Mark O'Loughlin pers comm.) with mix of tall/thin and short/thick spires and variable numbers of perforations at spatulated ends of arms. Differs from *Synallactes crucifera* Perrier, 1898 and subsequent diagnosis by Deichman (1940) in having typically more perforations at the ends of arms and no perforations at the tip of the central spire. Solís-Marín (2003) noted that much *Synallactes* morphology is similar and more genetic work may be required to refine the species. See genus remarks for current genetic placement of these morphologically congruent *Synallactes* within *Bathyplotes*.

Distribution. These specimen lots: Indian Ocean, Australian IOT, Cocos (Keeling) Islands Territory, Santa Ridge Stn., Clara Marie Seamount Stn., 2156–2418 m.

Two comparative specimens noted above: off eastern Australia, New South Wales, Hunter Marine Park and off Byron Bay, 2474–2595 m.

Full bathymetric range. 2156–2595 m.

References. AFD (2024), ALA (2024), Deichman (1940), Koehler and Vaney (1905), O'Hara et al. (2020), O'Loughlin (notes and personal correspondence, 2018), Perrier R. (1898, 1902), Solís-Marín (2003), Solís-Marín and Laguarda-Figueras (2004), Solís-Marín (2005).

Synallactidae sp. MoV. 7339

Figure 51a–j, Appendix 1, Table S1, Figure S5.

Material examined. NMV F296846* (2) [IN2021 V04 013].

Diagnosis of IOT material. Medium-sized, elongated, almost cylindrical specimens, slightly flattened ventrally (e.g. 14.5 cm long, 3.5 cm wide, 3 high; preserved). Soft, damaged specimens, firm once preserved, with most skin separated from body. Outer skin salmon pink with white warts and bare body light pink to mauve (live). Skin thick and covered dorsally with white warts and some longer radial papillae (not clear rows). All off-white to grey when preserved. Mouth ventral with approximately five tentacles remaining on one specimen, anus terminal. Tube feet (on shed skin) with zigzag double rows of small outer tube feet (presume ventrolateral), single rows of larger tube feet inside that, and four rows of smaller tube feet (two double rows of zigzags) midventral. Body wall ossicles of various types: typical four-armed tables with multiple perforations at the end of arms (arms ~100 *µm*), though spires not clear; dorsal wall dense with robust four-armed tables ~128 *µm* in diameter, typically with single perforations at ends of arms starting to branch, a short solid central spire ~72 *µm* high and topped with a crown of three bifid teeth; very small four-armed tables with completely joined arms forming button-like discs ~33 *µm* in diameter with four

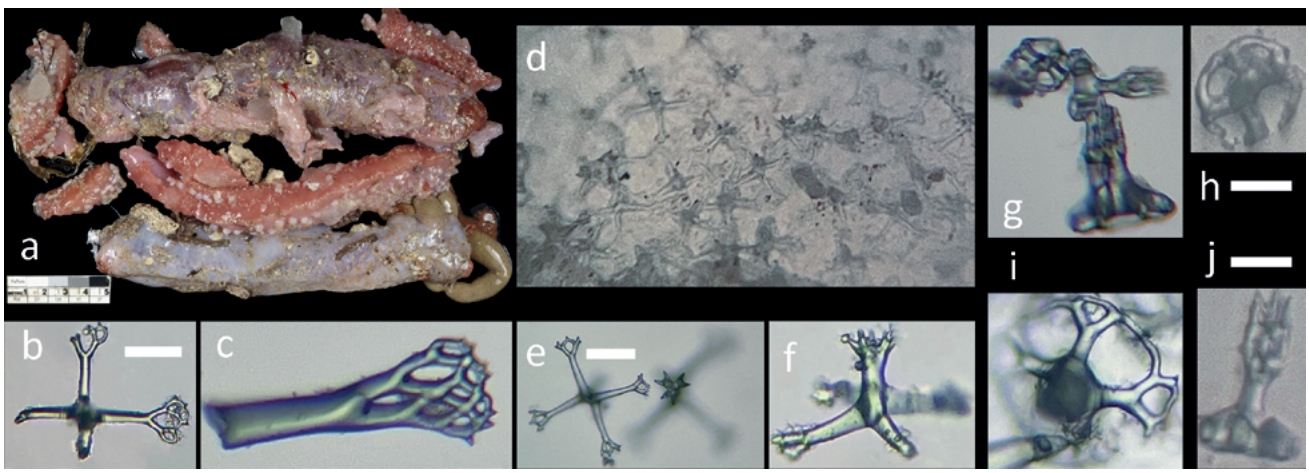

Figure 51. Synallactidae sp. Mov. 7339. a, shipboard image showing live colour and stripped skin; ossicles: b, c, body wall, typical pillared tables with distally perforated arms, d–f, body wall and papillae, robust tables with solid spire and crown, including some in-situ, g–j, very small tables with joined arms forming button-like discs, all NMV F296846; scale bars: b, e=50 *µm*, h, j=20 *µm*.

perforations or up to 80 *μm* with five or more perforations, and spires made of three or more joined pillars ~56 *μm* high and distally spinous. Rare Cs (~96 *μm*), and smooth rods (~200 *μm*). Papillae with four-armed *Bathyplotes*-style tables with four arms perforated at the ends, distally spinous spire of approximately four pillars with one or two crossbeams towards the top. Robust single-spired tables present in warts/papillae and body wall.

Remarks. Damaged specimens but some features available on skin and body. Distinctly different in size and robustness to *Bathyplotes* and *Synallactes* species collected in the IOT, though with some similar external characters to Antarctic species *B. moseleyi* and *B. natans*, particularly with dorsal covering of white warts and papillae and ventral tube feet being more numerous. Differs from both in ventral tube foot arrangement and in ossicles with thick single-pillared spire more common than typical *Bathyplotes* spires with pillars joined by transverse beams. Small tables have closed bases like *B. punctatus* but are very small with fewer than six perforations and irregular spires. While these ossicles and the combination of ossicles and morphology are not known to fit any current species, due to its damaged nature and without more material to identify further, we identify this lot as OTU Synallactidae sp. MoV. 7339. Presence here of numerous robust single-pillared tables (also seen in other IOT *Bathyplotes*) as the dominant ossicle calls into question the single-pillared table vs multi-pillared table division for *Synallactes* and *Bathyplotes*. A revision of the group using morphological and genetic evidence is needed.

Distribution. This specimen lot only: Indian Ocean, Australian IOT, Christmas Island Territory, off McPherson Point, 1363–1501 m.

References. Sars (1868), Solís-Marín (2003), Sluiter (1901a), Théel (1886a).

Holothuroidea de Blainville, 1834 - Indeterminant

Appendix 1, Table S1

Material examined. NMV F296860 (4) [IN2021 V04 028]; NMV F3308143 (5) [IN2022 V08 103]; NMV F308150 (1), NMV F308153 (1) and NMV F308160 (1) [IN2022 V08 105]; NMV F308187 (1) [IN2022 V08 115]; NMV F308233 (1) [IN2022 V08 124]; NMV F308250 (2) [IN2022 V08 131]; NMV F308253 (1) [IN2022 V08 136]; NMV F308256 (3) [IN2022 V08 141]; NMV F308275 (4) [IN2022 V08 147]; NMV F308289 (1) [IN2022 V08 153]; NMV F308302 (1) [IN2022 V08 157]; NMV F308309 (3) and NMV F308311 (1) [IN2022 V08 181]; NMV F308314 (1) and NMV F308315 (1) [IN2022 V08 183]; NMV F308322 (1) [IN2022 V08 187].

Remarks. Seventeen additional lots were too damaged or incomplete to determine confidently past Holothuroidea for this project.

Acknowledgments

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Appendix 1:
Full collection data by species for Material Examined.

Dendrochirotida: Ypsilothuriidae: *Echinocucumis*

Echinocucumis ampla O'Loughlin and Skarbnik-López in O'Loughlin et al., 2015

NMV F296861 (1) [IN2021 V04 031] Indian Ocean, Australia, Indian Ocean Territories: Clara Marie Seamount (13° 34' 35" S – 13° 34' 36" S, 105° 19' 39" E – 105° 22' 03" E), 2189–2264 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Jul 2021; NMV F 308161 (1) [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2435–2298 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022.

Elasipodida: Elpidiidae: *Peniagone*

Peniagone* cf *azorica Marenzeller von, 1892

NMV F308267 (7) [IN2022 V08 145] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 36" S – 12° 07' 49" S, 96° 40' 60" E – 96° 40' 39" E) 3002–3078 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022.

Other material. *Peniagone azorica* Marenzeller von, 1892 – eastern Australian Abyss: NMV F241035 [IN2017 V03 090 110] New South Wales, off Byron Bay (28°40' 35" S – 28°42' 32" S, 154° 12' 12" E – 154° 11' 23" E), 2562–2587 m, Coll: O'Hara et al. Marine Invertebrates Team, RV Investigator, 7 June 2017; NMV F240855 [IN2017 V03 032 143] Victoria, East Gippsland CMR (38° 28' 44" S – 38° 27' 11" S, 150° 11' 04" E – 150° 11' 10" E), 3850–3853 m, Coll: O'Hara et al. Marine Invertebrates Team, RV Investigator, 24 May 2017. (Identified by Mark O'Loughlin, 2018).

Peniagone* cf *challengeri Théel, 1882

NMV F308151 (1) [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E) 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022.

Peniagone coccinea Rogacheva and Gebruk in Rogacheva et al., 2013

NMV F296857 (1) [IN2021 V04 028] Indian Ocean, Australia, Indian Ocean Territories: Karma Seamount (12° 49' 33" S – 12° 50' 02" S, 107° 02' 48" E – 107° 04' E), 2760–2850 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Jul 2021; NMV F308183 (1), NMV F308188 (1), NMV F308189 (2), [IN2022 V08 115] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 53' 45" S – 10° 52' 22" S, 99° 45' 59" E – 99° 46' 38" E), 2973–2974 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Oct 2022.

Peniagone purpurea (Théel, 1882)

NMV F296841 (1), [IN2021 V04 007] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SE (10° 33' 22" S – 10° 32' 34" S, 105° 45' 51" E – 105° 46' 18" E), 3200–3345 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Jul 2021.

Peniagone vitrea Théel, 1882

NMV F308222 (1), [IN2022 V08 120] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 03' 47" S – 11° 03' 51" S, 99° 26' 36" E – 99° 29' 13" E), 3780–3839 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Oct 2022; NMV F308226 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022; NMV F308268 (1), [IN2022 V08 145] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 36" S – 12° 07' 49" S, 96° 40' 60" E – 96° 40' 39" E), 3002–3078 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022.

***Peniagone* sp. Mov. 7320**

NMV F308335 (2), [IN2022 V08 196] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos Abyssal (14° 57' 09" S – 14° 58' 15" S, 95° 55' 01" E – 95° 56' 30" E), 3431–5414 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

***Peniagone* sp. Mov. 7321**

NMV F308228 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Oct 2022.

***Peniagone* sp.**

NMV F308146 (5), NMV F308152 (1), NMV F308155 (1), NMV F308156 (2) [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308229 (1) [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08 "E – 97° 59' 33 "E); 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022; NMV F308321 (1) [IN2022 V08 187] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 33' 42" S – 13° 33' 10" S, 96° 22' 06" E – 96° 22' 56" E), 2156–2418 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 25 Oct 2022.

Elasipodida: Elpidiidae: *Psychroplanes* Gebruk, 1988

Psychroplanes convexa (Hansen, 1975)

NMV F308185 (1), [IN2022 V08 115] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 53' 45" S – 10° 52' 22" S, 99° 45' 5"9 E – 99° 46' 38" E), 2973–2974 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Oct 2022; NMV F308230 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022; NMV F308284 (1) and NMV F308285 (1), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022.

Elasipodida: Elpidiidae: *Scotoplanes* Théel, 1882

Scotoplanes globosa (Théel, 1879)

NMV F308303 (4), [IN2022 V08 157] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 5"6 E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

Elpidiidae sp.

NMV F296840 (1) [IN2021 V04 007] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SE (10° 33' 22" S – 10° 32' 34" S, 105° 45' 51" E – 105° 46' 18" E), 3200–3345 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Jul 2021.

Elasipodida: Laetmogonidae: *Benthogone* Koehler, 1895

Benthogone rosea Koehler, 1895

NMV F296864 (12), [IN2021 V04 031] Indian Ocean, Australia, Indian Ocean Territories: Clara Marie Seamount (13° 34' 35" S – 13° 34' 36" S, 105° 19' 39" E – 105° 22' 03" E), 2189–2264 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 July 2022; NMV F308147 (1) and NMV F310371 (1) [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308320 (1), [IN2022 V08 187] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 33' 42" S – 13° 33' 10" S, 96° 22' 06" E – 96° 22' 56" E), 2156–2418 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 25 Oct 2022.

***Benthogone* sp.**

NMV F308318 (2), [IN2022 V08 187] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 33' 42" S – 13° 33' 10" S, 96° 22' 06" E – 96° 22' 56" E), 2156–2418 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 25 Oct 2022

Elasipodida: Laetmogonidae: *Psychronaetes* Pawson, 1983

***Psychronaetes* sp. Mov. 7326**

NMV F308286 (1), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022.

Elasipodida: Pelagothuriidae: *Enypniastes* Théel, 1882

Enypniastes eximia Théel, 1882

NMV F296837 (1), [IN2021 V04 005] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SE (10° 34' 13" S – 10° 33' 48" S, 105° 41' 23" E – 105° 41' 38" E), 643–997 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 6 July 2021; NMV F296847 (1), [IN2021 V04 013] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island, off McPherson Point (10° 25' 29" S – 10° 25' 27" S, 105° 35' 42" E – 105° 36' 05" E), 1363–1501 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 July 2021; NMV F308201 (1), [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59 S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308208 (1) and NMV F308209 (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308331 (1), [IN2022 V08 195] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: SW Cocos (14° 47' 26" S – 14° 48' 08" S, 95° 40' 59" E – 95° 41' 23" E), 1426–1450 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

Elasipodida: Psychropotidae: *Benthodytes* Théel, 1882

Benthodytes* cf *incerta Ludwig, 1893

NMV F308170 (1), NMV F308171 (1), and NMV F308177 (1), [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102° 22' 56" E – 102° 23' 54" E), 1936–1968 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308197 (2), [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308269 (3), [IN2022 V08 145] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 36" S – 12° 07' 49" S, 96° 40' 60" E – 96° 40' 39" E), 3002–3078 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022; NMV F308327 (1), [IN2022 V08 191] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 39' 07" S – 13° 39' 48" S, 96° 41' 55" E – 96° 42' 41" E), 1304–1325 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 26 Oct 2022.

***Benthodytes* cf sanguinolenta** Théel, 1882

NMV F308225 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022.

***Benthodytes* sp. Mov. 7319**

NMV F308186 (1), F308192 (1), and NMV F308193 (1), [IN2022 V08 115] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 53' 45" S – 10° 52' 22" S, 99° 45' 59" E – 99° 46' 38" E), 2973–2974 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Oct 2022.

***Benthodytes* sp. Mov. 7338**

NMV F308238 (1), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308278 (1), [IN2022 V08 149] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories:

Noel Seamount (12° 34' 53" S – 12° 35' 21" S, 95° 25' 06" E – 95° 25' 52" E), 1904–1874 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 18 Oct 2022; F308288 (10), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022.

***Benthodytes* sp.**

NMV F308281 (1), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022.

Elasipodida: Psychropotidae: *Psychropotes* Théel, 1882

Psychropotes depressa (Théel, 1882)

NMV F296865 (2), [IN2021 V04 033] Indian Ocean, Australia, Indian Ocean Territories: Clara Marie Seamount (13° 42' 07" S – 13° 42' 07" S, 105° 25' 09" E – 105° 26' 48" E), 3007–3100 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Jul 2021; NMV F296881 (1), [IN2021 V04 050] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 27' 03" S – 11° 27' 06" S, 104° 30' 07" E – 104° 30' 60" E), 2289–2358 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308148 (1), [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308194 (2) and NMV F308195 (2), [IN2022 V08 115] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 53' 45" S – 10° 52' 22" S, 99° 45' 59" E – 99° 46' 38" E), 2973–2974 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Oct 2022.

Psychropotes longicauda Théel, 1882

NMV F308333 (1), [IN2022 V08 196] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos Abyssal (14° 57' 09" S – 14° 58' 15" S, 95° 55' 01" E – 95° 56' 30" E), 3431–5414 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

***Psychropotes* sp. Mov. 7327**

NMV F308272 (1), [IN2022 V08 147] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Noel Seamount (12° 23' 16" S – 12° 23' 43" S, 95° 23' 40" E – 95° 24' 36" E), 2617–2721 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 18 Oct 2022.

***Psychropotes* sp.**

NMV F308162 (1), [IN2022 V08 106] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Christmas Abyssal (11° 38' 45" S – 11° 39' 29" S, 103° 57' 41" E – 103° 59' 55" E), 4908–4944 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308227 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022.

Holothuriida: Mesothuriidae: *Mesothuria* Ludwig, 1894

Mesothuria cathedralis Heding, 1940

NMV F308202 (4), [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308237 (1), [IN2022 V08 126] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 47' 30" S – 11° 47' 30" S, 96° 50' 26" E – 96° 51' 33" E), 820–822 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14 Oct 2022.

Mesothuria gargantua Deichmann, 1930

NMV F296863 (1), [IN2021 V04 031] Indian Ocean, Australia, Indian Ocean Territories: Clara Marie Seamount (13° 34' 35" S – 13° 34' 36" S, 105° 19' 39" E – 105° 22' 03" E), 2189–2264 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Jul 2021; NMV F296873 (2), [IN2021 V04 046] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 24' 16" S – 11° 24' 19" S, 104° 26' 25" E – 104° 27' 49" E), 1237–1290 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F296880 (1), [IN2021 V04 048] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 22' 27" S – 11° 22' 14" S, 104° 29' 07" E – 104° 30' 14" E), 1260–1347 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308172 (1) and NMV F308173 (5) [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102 22' 56" E – 102 23' 54" E), 1936–1968 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct; NMV F308196 (1) [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308215 (1), NMV F308217 (1) and NMV F308218 (3), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct; NMV F308234 (1) and NMV F308235 (1) [IN2022 V08 124] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 51' 30" S – 11° 51' 30" S, 96° 44' 25" E – 96° 45' 05" E), 967–1020 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 13 Oct 2022; NMV F308236 (1), [IN2022 V08 126] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 47' 30" S – 11° 47' 30" S, 96° 50' 26" E – 96° 51' 33" E), 820–822 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14 Oct 2022; NMV F308252 (3), [IN2022 V08 136] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 01' 10" S – 12° 01' 34" S, 96° 50' 11" E – 96° 51' 12" E), 754–890 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Oct 2022; NMV F308258 (2), [IN2022 V08 141] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 41" S – 12° 07' 59" S, 96° 58' 48" E – 96° 59' 21" E), 1110–1139 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Oct 2022; NMV F308260 (6) and NMV F308265 (1), [IN2022 V08 143] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 13' 32" S – 12° 14' 21" S, 96° 57' 36" E – 96° 58' 16" E), 1113–1343 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022; NMV F308296 (2), [IN2022 V08 157] Indian Ocean, Australia, Cocos

(Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' 38" S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 56" E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022; NMV F308305 (1), [IN2022 V08 161] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 13' 15" S – 13° 13' 40" S, 96° 06' 41" E – 96° 07' 33" E), 808–811 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 21 Oct 2022; NMV F308328 (9), [IN2022 V08 191] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 39' 07" S – 13° 39' 48" S, 96° 41' 55" E – 96° 42' 41" E), 1304–1325 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 26 Oct 2022.

Mesothuria murrayi (Théel, 1886)

NMV F296839 (1), [IN2021 V04 007] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SE (10° 33' 22" S – 10° 32' 34" S, 105° 45' 51" E – 105° 46' 18" E), 3200–3345 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Jul 2021; NMV F296848 (1), [IN2021 V04 016] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island NW (10° 25' 47" S – 10° 25' 40" S, 105° 33' 53" E – 105° 34' 28" E), 781–1114 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Jul 2021; NMV F308144 (1), [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Jul 2021.

Holothuriida: Mesothuriidae: *Zygothuria* R. Perrier, 1898

Zygothuria lactea (Théel, 1886)

NMV F308332 (1), [IN2022 V08 195] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: SW Cocos (14 47' 26" S – 14 48' 08" S, 95° 40' 59" E – 95° 41' 23" E), 1426–1450 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

Zygothuria thompsoni (Théel, 1886)

NMV F308198 (2), [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022.

Zygothuria sp Mov. 7328

NMV F296850 (1), [IN2021 V04 024] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Abyss South of Christmas Island (10° 57' 56" S – 10° 58' 30" S, 105° 33' 49" E – 105° 35' 46" E), 4764–4766 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Jul 2021.

Molpadida: Molpadiidae: *Molpadia* Cuvier, 1817

Molpadia cf *blakei* (Théel, 1886)

NMV F296851(3), [IN2021 V04 024] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Abyss S of Christmas Island (10° 57' 56" S – 10° 58' 30" S, 105° 33' 49" E – 105° 35' 46" E), 4764–4766 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Jul 2021; NMV F308219 (1), [IN2022 V08 120] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 03' 47" S – 11° 03' 51" S, 99° 26' 36" E – 99° 29' 13" E), 3780–3839 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Oct 2022.

Persiculida: Gephyrothuriidae: *Paroriza* Hérouard, 1902

Paroriza prouhoi Hérouard, 1902

NMV F308312 (1), [IN2022 V08 183] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 26' 12" S – 13° 27' 06" S, 96° 18' 17" E – 96° 19' 35" E), 3948–4047 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 24 Oct 2022

Persiculida: Molpadiodemidae: *Molpadiodemas* Heding, 1935

Molpadiodemas sp. MoV. 7329

NMV F296854 (1), [IN2021 V04 026] Indian Ocean, Australia, Indian Ocean Territories: Max Seamount (11° 42' 37" S – 11° 42' 55" S, 107° 01' 55" E – 107° 03' 28" E), 1915–1990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Jul 2021; NMV F308204 (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308263 (2), [IN2022 V08 143] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 13' 32" S – 12° 14' 21" S, 96° 57' 36" E – 96° 58' 16" E), 1113–1343 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022.

Molpadiodemas sp. MoV. 7334

NMV F296842 (1), [IN2021 V04 007] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SE (10° 33' 22" S – 10° 32' 34" S, 105° 45' 51" E – 105° 46' 18" E), 3200–3345 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Jul 2021; NMV F296856 (1) and NMV F296859 (3), [IN2021 V04 028] Indian Ocean, Australia, Indian Ocean Territories: Karma Seamount (12° 49' 33" S – 12° 50' 02" S, 107° 02' 48" E – 107' 04" E), 2760–2850 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Jul 2021.

Molpadiodemas sp. MoV. 7335

NMV F296882 (1), [IN2021 V04 050] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 27 03" S – 11° 27 06" S, 104° 30 07" E – 104° 30 60" E), 2289–2358 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021.

Molpadiodemas sp.

NMV F308142 (1), [IN2022 V08 103] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 21' 33" S – 11° 22' 16" S, 104° 02' 53" E – 104° 03' 28" E), 3510–3611 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308145 (1) and NMV F308157 (1), [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022;

NMV F308205 (3), NMV F308210 (1) and NMV F308211 (1) [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308221 (1), [IN2022 V08 120] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 03' 47" S – 11° 03' 51" S, 99° 26' 36" E – 99° 29' 13" E), 3780–3839 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Oct 2022; NMV F308241 (1) and NMV F308251 (6) [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308257 (1), [IN2022 V08 141] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 41" S – 12° 07' 59" S, 96° 58' 48" E – 96° 59' 21" E), 1110–1139 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Oct 2022; NMV F308264 (1), [IN2022 V08 143] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 13' 32" S – 12° 14' 21" S, 96° 57' 36" E – 96° 58' 16" E), 1113–1343 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022; NMV F308271 (1), [IN2022 V08 145] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 36" S – 12° 07' 49" S, 96° 40' 60" E – 96° 40' 39" E), 3002–3078 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022, NMV F308273 (1), NMV F308274 (3) and NMV F308276 (1) [IN2022 V08 147] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Noel Seamount (12° 23' 16" S – 12° 23' 43" S, 95° 23' 40" E – 95° 24' 36" E), 2617–2721 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 18 Oct 2022; NMV F308282 (1), NMV F308283 (1) and NMV F308287 (1), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022; NMV F308293 (2), [IN2022 V08 155] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 16' 41" S – 13° 16' 59" S, 96° 04' 06" E – 96° 05' 09" E), 1459–1595 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022; NMV F308307 (2) and NMV F308308 (1) [IN2022 V08 181] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 05' 33" S – 13° 06' 25" S, 96° 21' 09" E – 96° 21' 46" E), 2889–2923 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 23 Oct 2022; NMV F308313 (1), [IN2022 V08 183] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 26' 12" S – 13° 27' 06" S, 96° 18' 17" E – 96° 19' 35" E), 3948–4047 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 24 Oct 2022; NMV F308329 (2), [IN2022 V08 191] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 39' 07" S – 13° 39' 48" S, 96° 41' 55" E – 96° 42' 41" E), 1304–1325 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 26 Oct 2022.

Persiculida: Pseudostichopodidae: *Pseudostichopus* Théel, 1886

Pseudostichopus sp.

NMV F296875 (1), [IN2021 V04 046] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 24' 16" S – 11° 24' 19" S, 104° 26' 25" E – 104° 27' 49" E), 1237–1290 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308141 (1), [IN2022 V08 103] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 21' 33" S – 11° 22' 16" S, 104° 02' 53" E – 104° 03' 28" E), 3510–3611 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308270 (2) and NMV F312998 (1) [IN2022 V08 145]; Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 36" S – 12° 07' 49" S, 96° 40' 60" E – 96° 40' 39" E), 3002–3078 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022.

Synallactida: Deimatidae: *Deima* Théel, 1879

Deima validum validum Théel, 1879

NMV F308224 (1) and NMV F308232 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022; NMV F308279 (1) and NMV F308280 (1), [IN2022 V08 151] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (12° 57' 27" S – 12° 58' 30" S, 95° 28' 12" E – 95° 29' 15" E), 3053–3144 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022.

Deima oloughlini sp nov. Mackenzie and Davey (sp. Mov. 7322)

NMV F308216 (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308242 (1), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022.

Synallactida: Deimatidae: *Oneirophanta* Théel, 1879

Oneirophanta mutabilis mutabilis Théel, 1879

NMV F296855 (2) and NMV F296858 (1), [IN2021 V04 028] Indian Ocean, Australia, Indian Ocean Territories: Karma Seamount (12° 49' 33" S – 12° 50' 02" S, 107° 02' 48" E – 107° 04' E), 2760–2850 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Jul 2021; NMV F308159 (2), [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022.

Oneirophanta sp. MoV. 7331

NMV F308334 (1), [IN2022 V08 196] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos Abyssal (14 57' 09" S – 14 58' 15" S, 95° 55' 01" E – 95° 56' 30" E), 3431–5414 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

Oneirophanta sp. MoV. 7333

NMV F296845 (1), [IN2021 V04 013] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island, off McPherson Point (10° 25' 29" S – 10° 25' 27" S, 105° 35' 42" E –

105° 36' 05" E), 1363–1501m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Jul 2021; NMV F308214 (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022

Synallactida: Deimatidae: *Orphnurgus* Théel, 1879

Orphnurgus glaber Walsh, 1891

NMV F296849 (1), [IN2021 V04 022] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island SW (10° 32' 59" S – 10° 33' 15" S, 105° 31' 59" E – 105° 32' 09" E), 1388–1533 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Jul 2021; NMV F296869 (7), [IN2021 V04 035] Indian Ocean, Australia, Indian Ocean Territories: Apollo Seamount (11° 24' 45" S – 11° 24' 46" S, 104° 56' 32" E – 104° 57' 55" E), 1285–1350 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 13 Jul 2021; NMV F296874 (20), [IN2021 V04 046] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 24' 16" S – 11° 24' 19" S, 104° 26' 25" E – 104° 27' 49" E), 1237–1290 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F296876 (7), [IN2021 V04 048] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 22' 27" S – 11° 22' 14" S, 104° 29' 07" E – 104° 30' 14" E), 1260–1347 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308163 (7), NMV F308164 (1), NMV F308165 (1), and NMV F308166 (3), [IN2022 V08 108] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Glogg Seamount (11° 38' 52" S – 11° 39' 52" S, 103° 38' 23" E – 103° 39' 20" E), 1355–1451 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Oct 2022; NMV F308168 (17), [IN2022 V08 111] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Attention Seamount (11° 45' 25" S – 11° 46' 20" S, 103° 16' 49" E – 103° 17' 18" E), 1401–1408m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308254 (1) and NMV F308255 (1), [IN2022 V08 141] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 41" S – 12° 07' 59" S, 96° 58' 48" E – 96° 59' 21" E), 1110–1139 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Oct 2022; NMV F308299 (1) and NMV F308300 (2), [IN2022 V08 157] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' 38" S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 56" E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

Orphnurgus insignis Fisher, 1907

NMV F296867 (4) and NMV F296868 (6), [IN2021 V04 035] Indian Ocean, Australia, Indian Ocean Territories: Apollo Seamount (11° 24' 45" S – 11° 24' 46" S, 104° 56' 32" E – 104° 57' 55" E), 1285–1350 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 13 Jul 2021; NMV F296871 (1), [IN2021 V04 040] Indian Ocean, Australia, Indian Ocean Territories: Shcherbakov Seamount (10° 55' 29" S – 10° 55' 27" S, 104° 36' 41" E – 104° 38' 04" E), 1608–1663 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14 Jul 2021; NMV F296877 (3), [IN2021 V04 048] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 22' 27" S – 11° 22' 14" S, 104° 29' 07" E – 104° 30' 14" E), 1260–1347 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308149 (1) and NMV F308158 (1), [IN2022 V08 105] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Balthazar Seamount (11° 38' 04" S – 11° 39' 40" S, 104° 11' 25" E – 104° 13' 33" E), 2298–2435 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 7 Oct 2022; NMV F308167 (1), [IN2022 V08 108] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Glogg Seamount (11° 38' 52" S – 11° 39' 52" S, 103° 38' 23" E – 103° 39' 20" E), 1355–1451 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Oct 2022; NMV F308169 (1), [IN2022 V08 111] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Attention Seamount (11° 45' 25" S – 11° 46' 20" S, 103° 16' 49" E – 103° 17' 18" E), 1401–1408 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308176 (1), [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102 22' 56" E – 102 23' 54" E), 1936–1968 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308212 (1), [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308239 (1), NMV F308240 (2), NMV F308246 (1), NMV F308247 (1) and NMV F308248 (1), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308298 (1) and NMV F308301(2), [IN2022 V08 157] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' 38" S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 56" E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

Orphnurgus sp. Mov. 7318

NMV F296870 (2), [IN2021 V04 037] Indian Ocean, Australia, Indian Ocean Territories: Apollo Seamount (11° 28' 18" S – 11° 28' 21" S, 105° 00' 14" E – 105° 02' 15" E), 1640–1850 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14 Jul 2021; NMV F296872 (1), [IN2021 V04 040] Indian Ocean, Australia, Indian Ocean Territories: Shcherbakov Seamount (10° 55' 29" S – 10° 55' 27" S, 104° 36' 41" E – 104° 38' 04" E), 1608–1663 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14 Jul 2021; NMV F308243 (1) and NMV F312854 (3), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308295 (1), [IN2022 V08 155] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 16' 41" S – 13° 16' 59" S, 96° 04' 06" E – 96° 05' 09" E), 1459–1595 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

Orphnurgus sp. Mov. 7332

NMV F308297 (1), [IN2022 V08 157] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' 38" S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 56" E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

Synallactida: Synallactidae: *Bathyplotes* Östergren, 1896

***Bathyplotes* sp. MoV. 7340**

NMV F308259 (2), [IN2022 V08 141] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 07' 41" S – 12° 07' 59" S, 96° 58' 48" E – 96° 59' 21" E), 1110–1139 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Oct 2022; NMV F308261 (1), and NMV F308266 (4) [IN2022 V08 143] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 13' 32" S – 12° 14' 21" S, 96° 57' 36" E – 96° 58' 16" E), 1113–1343 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022; NMV F308304 (1) [IN2022 V08 157] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 14' 38" S – 13° 15' 39" S, 96° 04' 53" E – 96° 05' 56" E), 1019–1023 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

***Bathyplotes* sp. MoV. 7341**

NMV F296878 (1), [IN2021 V04 048] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 22' 27" S – 11° 22' 14" S, 104° 29' 07" E – 104° 30' 14" E), 1260–1347 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308175 (2) [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102 22' 56" E – 102 23' 54" E), 1936–1968 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308200 (5), [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308244 (9) and NMV F308245 (2) [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308294 (6), [IN2022 V08 155] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 16' 41" S – 13° 16' 59" S, 96° 04' 06" E – 96° 05' 09" E), 1459–1595 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 20 Oct 2022.

***Bathyplotes* sp. MoV. 7342**

NMV F308174 (1), [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102 22' 56" E – 102 23' 54" E), 1936–1968m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308199 (1) [IN2022 V08 116] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 47' 27" S – 10° 47' 59" S, 99° 36' 39" E – 99° 37' 48" E), 1957–1991 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308317 (8), [IN2022 V08 185] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (13° 26' 11" S – 13° 26' 42" S, 95° 49' 52" E – 95° 50' 53" E), 1913–1950 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 24 Oct 2022.

***Bathyplotes* sp. Östergren, 1896**

NMV F296879 (1) [IN2021 V04 048] Indian Ocean, Australia, Indian Ocean Territories: Balthazar Seamount (11° 22' 27" S – 11° 22' 14" S, 104° 29' 07" E – 104° 30' 14" E), 1260–1347 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 16 Jul 2021; NMV F308178 (1), NMV F308179 (20), and NMV F308180 (1) [IN2022 V08 113] Indian Ocean, Australia, Christmas Island Territory, Indian Ocean Territories: Lucia Seamount (10° 59' 56" S – 11° 00' 00" S, 102 22' 56" E – 102 23' 54" E) 1936–1968 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 9 Oct 2022; NMV F308213 (1) [IN2022 V08 117] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 19' 07" S – 11° 18' 28" S, 99° 07' 58" E – 99° 09' 07" E), 1175–1764 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 11 Oct 2022; NMV F308249 (3), [IN2022 V08 131] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (11° 49' 56" S – 11° 50' 37" S, 96° 37' 36" E – 96° 38' 56" E), 1589–1896 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 14–15 Oct 2022; NMV F308262 (1), [IN2022 V08 143] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos (Keeling) (12° 13' 32" S – 12° 14' 21" S, 96° 57' 36" E – 96° 58' 16" E), 1113–1343 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 17 Oct 2022; NMV F308290 (2), [IN2022 V08 153] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Raitt Ridge North (13° 10' 52" S – 13° 11' 19" S, 95° 36' 03" E – 95° 37' 02" E), 1736–1747 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 19 Oct 2022; NMV F308323 (13), [IN2022 V08 189] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 43' 20" S – 13° 43' 24" S, 96° 28' 05" E – 96° 28' 54" E), 1872–1943 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 25 Oct 2022

Synallactida: Synallactidae: *Paelopatides* Théel, 1886

***Paelopatides* sp. MoV. 7336**

NMV F308191 (1), [IN2022 V08 115] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Scrooge Seamount (10° 53' 45" S – 10° 52' 22" S, 99° 45' 59" E – 99° 46' 38" E), 2973–2974 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 10 Oct 2022; NMV F308306 (1), [IN2022 V08 181] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Muirfield Seamount (13° 05' 33" S – 13° 06' 25" S, 96° 21' 09" E – 96° 21' 46" E), 2889–2923 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 23 Oct 2022.

***Paelopatides* sp. MoV. 7337**

NMV F296843 (1) and NMV F296844 (1), [IN2021 V04 012] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island, off McPherson Point (10° 23' 57" S – 10° 23' 51" S, 105° 35' 41" E – 105° 36' 05" E), 2000–2051 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 Jul 2021; NMV F308220 (1) [IN2022 V08 120] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Rudist Seamount (11° 03' 47" S – 11° 03' 51" S, 99° 26' 36" E – 99° 29' 13" E), 3780–3839 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Oct 2022.

Synallactida: Synallactidae: *Scotothuria* Hansen, 1978

Scotothuria herringi Hansen, 1978

NMV F308231 (1), [IN2022 V08 122] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Investigator Ridge Abyssal (11° 15' 26" S – 11° 15' 29" S, 97° 58' 08" E – 97° 59' 33" E), 4980–4990 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12–13 Oct 2022; NMV F308338 (1), [IN2022

V08 196] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Cocos Abyssal (14 57' 09" S – 14 58' 15" S, 95° 55' 01" E – 95° 56' 30" E), 5414–3431 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 27 Oct 2022.

Synallactida: Synallactidae: *Synallactes* Ludwig, 1894

Synallactes cf *crucifera* Perrier R., 1898

NMV F296862 (2), [IN2021 V04 031] Indian Ocean, Australia, Indian Ocean Territories: Clara Marie Seamount (13° 34' 35" S – 13° 34' 36" S, 105° 19' 39" E – 105° 22' 03" E), 2189–2264 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 12 Jul 2021; NMV F308319 (1) and NMV F312858 (1), [IN2022 V08 187] Indian Ocean, Australia, Cocos (Keeling) Islands Territory, Indian Ocean Territories: Santa Ridge (13° 33' 42" S – 13° 33' 10" S, 96° 22' 06" E – 96° 22' 56" E), 2156–2418 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 25 Oct 2022.

Synallactidae sp. MoV. 7339

NMV F296846 (1), [IN2021 V04 013] Indian Ocean, Australia, Christmas Island, Indian Ocean Territories: Christmas Island, off McPherson Point (10° 25' 29" S – 10° 25' 27" S, 105° 35' 42" E – 105° 36' 05" E), 1363–1501 m, Coll: O'Hara et al. Marine Invertebrates Team, RV *Investigator*, 8 July 2021.

Holothuroidea de Blainville, 1834 - Indeterminant [station numbers only]

NMV F296860 (4) [IN2021 V04 028]; NMV F3308143 (5) [IN2022 V08 103]; NMV F308150 (1), NMV F308153 (1) and NMV F308160 (1) [IN2022 V08 105]; NMV F308187 (1) [IN2022 V08 115]; NMV F308233 (1) [IN2022 V08 124]; NMV F308250 (2) [IN2022 V08 131]; NMV F308253 (1) [IN2022 V08 136]; NMV F308256 (3) [IN2022 V08 141]; NMV F308275 (4) [IN2022 V08 147]; NMV F308289 (1), [IN2022 V08 153]; NMV F308302 (1) [IN2022 V08 157]; NMV F308309 (3) and NMV F308311 (1) [IN2022 V08 181]; NMV F308314 (1) and NMV F308315 (1) [IN2022 V08 183]; NMV F308322 (1) [IN2022 V08 187].

Table S1. Distribution Summary table: Species by station and depth.

	No. of spec.	Station No.	Depth From (m)	Depth To (m)
Dendrochirotida: Ypsilothuriidae				
Echinocucumis ampla	1	31	2189	2264
Echinocucumis ampla	1	105	2435	2298
Elasipodida: Elpidiidae				
Peniagone cf azorica	7	145	3078	3002
Peniagone cf challengeri	1	105	2435	2298
Peniagone coccinea	1	28	2760	2850
Peniagone coccinea	4	115	2973	2974
Peniagone purpurea	1	7	3200	3345
Peniagone vitrea	1	120	3839	3780
Peniagone vitrea	1	122	4980	4990
Peniagone vitrea	1	145	3078	3002
Peniagone sp. MoV. 7320	2	196	5414	3431
Peniagone sp. MoV. 7321	1	122	4980	4990
Peniagone sp.	9	105	2435	2298
Peniagone sp.	1	122	4980	4990
Peniagone sp.	1	187	2418	2156
Psychroplanes convexa	1	115	2973	2974
Psychroplanes convexa	1	122	4980	4990
Psychroplanes convexa	2	151	3053	3144
Scotoplanes globosa	4	157	1023	1019
Elpidiidae sp.	1	7	3200	3345
Elasipodida: Laetmogonidae				
Benthogone rosea	12	31	2189	2264
Benthogone rosea	2	105	2435	2298

Table S1. Distribution Summary table: Species by station and depth.

	No. of spec.	Station No.	Depth From (m)	Depth To (m)
Benthogone rosea	1	187	2418	2156
Benthogone sp.	2	187	2418	2156
Psychronaetes sp. MoV. 7326	1	151	3053	3144
Elasipodida: Pelagothuriidae				
Enypniastes eximia	1	5	643	997
Enypniastes eximia	1	13	1363	1501
Enypniastes eximia	1	116	1991	1957
Enypniastes eximia	2	117	1175	1764
Enypniastes eximia	1	195	1450	1426
Elasipodida: Psychropotidae				
Benthodytes cf incerta	3	113	1968	1936
Benthodytes cf incerta	2	116	1991	1957
Benthodytes cf incerta	3	145	3078	3002
Benthodytes cf incerta	1	191	1304	1325
Benthodytes cf sanguinolenta	1	122	4980	4990
Benthodytes sp. MoV. 7319	3	115	2973	2974
Benthodytes sp. MoV. 7338	1	131	1896	1589
Benthodytes sp. MoV. 7338	1	149	1904	1874
Benthodytes sp. MoV. 7338	10	151	3053	3144
Benthodytes sp.	1	151	3053	3144
Psychropotes depressa	2	33	3007	3100
Psychropotes depressa	1	50	2289	2358
Psychropotes depressa	1	105	2435	2298
Psychropotes depressa	4	115	2973	2974
Psychropotes longicauda	1	196	5414	3431
Psychropotes sp. MoV. 7327	1	147	2617	2721
Psychropotes sp.	1	106	4908	4944
Psychropotes sp.	1	122	4980	4990
Holothuriida: Mesothuriidae				
Mesothuria cathedralis	4	116	1991	1957
Mesothuria cathedralis	1	126	820	822
Mesothuria gargantua	1	31	2189	2264
Mesothuria gargantua	2	46	1237	1290
Mesothuria gargantua	1	48	1260	1347
Mesothuria gargantua	6	113	1968	1936
Mesothuria gargantua	1	116	1991	1957
Mesothuria gargantua	5	117	1175	1764
Mesothuria gargantua	2	124	1020	967
Mesothuria gargantua	1	126	820	822

Table S1. Distribution Summary table: Species by station and depth.

	No. of spec.	Station No.	Depth From (m)	Depth To (m)
Mesothuria gargantua	3	136	754	890
Mesothuria gargantua	2	141	1139	1110
Mesothuria gargantua	7	143	1113	1343
Mesothuria gargantua	2	157	1023	1019
Mesothuria gargantua	1	161	811	808
Mesothuria gargantua	9	191	1304	1325
Mesothuria murrayi	1	7	3200	3345
Mesothuria murrayi	1	16	781	1114
Mesothuria murrayi	1	105	2435	2298
Zygothuria lactea	1	195	1450	1426
Zygothuria thomsoni	2	116	1991	1957
Zygothuria sp. MoV. 7328	1	24	4764	4766
Molpadida: Molpadiidae				
Molpadia cf blakei	3	24	4764	4766
Molpadia cf blakei	1	120	3839	3780
Persiculida: Gephyrothuriidae				
Paroriza prouhoi	1	183	3948	4047
Persiculida: Molpadiodemidae				
Molpadiodemas sp. MoV. 7329	1	26	1915	1990
Molpadiodemas sp. MoV. 7329	1	117	1175	1764
Molpadiodemas sp. MoV. 7329	2	143	1113	1343
Molpadiodemas sp. MoV. 7334	1	7	3200	3345
Molpadiodemas sp. MoV. 7334	4	28	2760	2850
Molpadiodemas sp. MoV. 7335	1	50	2289	2358
Molpadiodemas sp.	1	103	3611	3510
Molpadiodemas sp.	2	105	2435	2298
Molpadiodemas sp.	5	117	1175	1764
Molpadiodemas sp.	1	120	3839	3780
Molpadiodemas sp.	7	131	1896	1589
Molpadiodemas sp.	1	141	1139	1110
Molpadiodemas sp.	1	143	1113	1343
Molpadiodemas sp.	1	145	3078	3002
Molpadiodemas sp.	5	147	2617	2721
Molpadiodemas sp.	3	151	3053	3144
Molpadiodemas sp.	2	155	1459	1595
Molpadiodemas sp.	3	181	2923	2889
Molpadiodemas sp.	1	183	3948	4047
Molpadiodemas sp.	2	191	1304	1325

Table S1. Distribution Summary table: Species by station and depth.

	No. of spec.	Station No.	Depth From (m)	Depth To (m)
Persiculida: Pseudostichopodidae				
Pseudostichopus sp.	1	46	1237	1290
Pseudostichopus sp.	1	103	3611	3510
Pseudostichopus sp.	3	145	3078	3002
Synallactida: Deimatidae				
Deima validum validum	2	122	4980	4990
Deima validum validum	2	151	3053	3144
Deima oloughlini sp. nov.	1	117	1175	1764
Deima oloughlini sp. nov.	1	131	1896	1589
Oneirophanta mutabilis mutabilis	3	28	2760	2850
Oneirophanta mutabilis mutabilis	2	105	2435	2298
Oneirophanta sp. MoV. 7331	1	196	5414	3431
Oneirophanta sp. MoV. 7333	1	13	1363	1501
Oneirophanta sp. MoV. 7333	1	117	1175	1764
Orphnurgus glaber	1	22	1388	1533
Orphnurgus glaber	7	35	1285	1350
Orphnurgus glaber	20	46	1237	1290
Orphnurgus glaber	7	48	1260	1347
Orphnurgus glaber	12	108	1451	1355
Orphnurgus glaber	17	111	1408	1401
Orphnurgus glaber	2	141	1139	1110
Orphnurgus glaber	3	157	1023	1019
Orphnurgus insignis	10	35	1285	1350
Orphnurgus insignis	1	40	1608	1663
Orphnurgus insignis	3	48	1260	1347
Orphnurgus insignis	2	105	2435	2298
Orphnurgus insignis	1	108	1451	1355
Orphnurgus insignis	1	111	1408	1401
Orphnurgus insignis	1	113	1968	1936
Orphnurgus insignis	1	117	1175	1764
Orphnurgus insignis	6	131	1896	1589
Orphnurgus insignis	3	157	1023	1019
Orphnurgus sp. MoV. 7318	2	37	1640	1850
Orphnurgus sp. MoV. 7318	1	40	1608	1663
Orphnurgus sp. MoV. 7318	4	131	1896	1589
Orphnurgus sp. MoV. 7318	1	155	1459	1595
Orphnurgus sp. MoV. 7332	1	157	1023	1019
Synallactida: Synallactidae				
Bathyplotes sp. MoV. 7340	2	141	1139	1110
Bathyplotes sp. MoV. 7340	5	143	1113	1343

Table S1. Distribution Summary table: Species by station and depth.

	No. of spec.	Station No.	Depth From (m)	Depth To (m)
Bathyplotes sp. MoV. 7340	1	157	1023	1019
Bathyplotes sp. MoV. 7341	1	48	1260	1347
Bathyplotes sp. MoV. 7341	2	113	1968	1936
Bathyplotes sp. MoV. 7341	5	116	1991	1957
Bathyplotes sp. MoV. 7341	11	131	1896	1589
Bathyplotes sp. MoV. 7341	6	155	1459	1595
Bathyplotes sp. MoV. 7342	1	113	1968	1936
Bathyplotes sp. MoV. 7342	1	116	1991	1957
Bathyplotes sp. MoV. 7342	8	185	1913	1950
Bathyplotes sp.	1	48	1260	1347
Bathyplotes sp.	22	113	1968	1936
Bathyplotes sp.	1	117	1175	1764
Bathyplotes sp.	3	131	1896	1589
Bathyplotes sp.	1	143	1113	1343
Bathyplotes sp.	2	153	1736	1747
Bathyplotes sp.	13	189	1943	1872
Paelopatides sp. MoV. 7336	1	115	2973	2974
Paelopatides sp. MoV. 7336	1	181	2923	2889
Paelopatides sp. MoV. 7337	2	12	2000	2051
Paelopatides sp. MoV. 7337	1	120	3839	3780
Scotothuria herringi	1	122	4980	4990
Scotothuria herringi	1	196	5414	3431
Synallactes cf crucifera	2	31	2189	2264
Synallactes cf crucifera	2	187	2418	2156
Synallactidae sp. MoV. 7339	2	13	1363	1501
Holothuroidea Indet.				
Holothuroidea sp.	4	28	2760	2850
Holothuroidea sp.	5	103	3611	3510
Holothuroidea sp.	3	105	2435	2298
Holothuroidea sp.	1	115	2973	2974
Holothuroidea sp.	1	124	1020	967
Holothuroidea sp.	2	131	1896	1589
Holothuroidea sp.	1	136	754	890
Holothuroidea sp.	3	141	1139	1110
Holothuroidea sp.	4	147	2617	2721
Holothuroidea sp.	1	153	1736	1747
Holothuroidea sp.	1	157	1023	1019
Holothuroidea sp.	4	181	2923	2889
Holothuroidea sp.	2	183	3948	4047
Holothuroidea sp.	1	187	2418	2156

Table S2. *Deima* comparison table.

	Tube feet	**Papillae**	**Ossicles**	**Shape/size/other**
Deima oloughlini Mackenzie and Davey sp nov. sp Mov 7322	Ventral / Lateral Single, spaced rows. Larger (holotype): 11 pairs 10 + 1 smaller pair post anal*. 1 pair pre-anal* (on mid-ventral). Smaller (paratype): 11 pairs 10 + 1 smaller pair post-anal. No pre-anal	Rigid, easily broken. Dorsal – 6 pairs Ventrolateral – 4–6 pairs Larger (holotype): 6 pairs Smaller (paratype): ~4 pairs	Perforated plates Mostly single-layered* Dorsal – Up to 2.1 mm (broken) Ventral – Up to 1.5 mm Some with rudimentary branch/ mesh/anastomosing/knobs and thickening Mix of large and small perforations across plates. Largest not always central* and not 'remarkably large' in these specimens* Less regular perforations than IOT *D. validum validum* *	Oval Ratio just over 2:1*
Deima validum validum Théel, 1879	Théel, 1879: Ventral, Single rows 11 pairs (10 + 1 smaller pair pre-anal) Hansen, 1975 (including all synonyms): Ventral 11 pairs (10–13) Rare pre-anal (absent in west Indian ocean) Bare mid-ventral	Théel, 1879: Inflexible Dorsal – 6 left 8 right Ventrolateral – 7 each side [but reassessed by Ludwig and Hansen – see below] Hansen, 1975 (including all synonyms): Rigid, conical, variable length Dorsal – 5–10 pairs Ventrolateral – 3–7 pairs	Théel, 1879: Perforated plates Covered by mesh, mostly multilayered. Additional small branching spicules Hansen, 1975: As above Dorsal – 1.5–7 mm Ventral – 0.5–4.0 mm	Elliptical, 5:3 ratio for length to breadth Tentacles: Often retracted. 18–20 Cup-shaped with marginal knobs* 4–10 knobs (visible but often contracted)
Deima validum pacificum Ludwig, 1894	Hansen, 1975: 11 pairs Pre-anal x 1 pair	Hansen, 1975 Dorsal – 11–16* pairs Ventrolateral – 4–5 pairs	Hansen, 1975: Perforated plates Single layered only* Dorsal – 1.5–2 mm Ventral – 0.75–1 mm (half)	
Deima atlanticum Hérouard, 1898 [currently accepted as *Deima validum validum*]	Hansen, 1975: 11 pairs	Hansen, 1975: Dorsal – 5 pairs Ventrolateral – 3 pairs	Hansen, 1975: Perforated plates Multilayered	
Deima blakei Théel, 1886 [currently accepted as *Deima validum validum*]	Théel, 1886 3 specimens: 11 pairs 10 + 1 post-anal pair, 1 pair pre-anal pair 4 specimens: distinctly asymmetric/variable Hansen, 1975: ~11 pairs (up to 12 for ones from type location) Pre-anal – 1 pair (type location)	Théel, 1886 3 specimens: Dorsal: 5 to 6 pairs Ventrolateral: 6 pairs (above tube feet) 4 specimens: distinctly asymmetric/variable Hansen, 1975: Dorsal – 5–10 pairs Ventrolateral – 4–5 pairs [rigid and conical to flexible and slender]	Théel, 1886 All like *Oneirophanta mutabilis* (i.e. perforated plates with minimal secondary layering). Thinner skin than *D. validum* (i.e. less multilayered plates) Hansen, 1975: Perforated plates Dorsal – <1.5 mm Ventral – 1.2 mm Secondary layer absent or only feeble 'Remarkably large' central perforations Ventral plates sometimes with elongated primary rod (like *Oneirophanta mutabilis mutabilis*)	Théel, 1886 3 of the type series were like *Deima validum*, remaining 4 all had very asymmetric placement of appendages

Table S2. *Deima* comparison table.

	Tube feet	**Papillae**	**Ossicles**	**Shape/size/other**
Deima fastosum Théel, 1879 [currently accepted as *Deima validum validum*]	Théel, 1879 11 each side Hansen, 1975: 11–13 pairs No pre-anal No midventral	Théel, 1879 Dorsal – 4 each side Ventrolateral – 4 each side Much longer than half width (i.e. >14 mm) Hansen, 1975: Dorsal – 5 pairs Ventrolateral – 3 pairs [more than half width of body]	Théel, 1879 Perforated plates Crowded / Small to large. Irregular rounded / imbricating to multilayered / plate rises to conical knob in centre* Hansen, 1975: Perforated plates Imbricating to multilayered Small to large (up to 5 mm) With large reticulated conical knob*	Hansen, 1975: Elongate and equal (not elliptic) 130 mm x 28 mm
Deima mosaicum Ohshima, 1915. [currently accepted as *Deima validum validum*]	Hansen, 1975: 11–13 pairs Pre-anal x 1 pair	Hansen, 1975: Dorsal – 8–10 pairs Ventrolateral 4–5 pairs [long, up to 8 cm]	Hansen, 1975: Dorsal 3–4 mm Ventral: 0.8–2 mm Dorsal 2-layered (but feebly developed second layer) Ventral single-layered	Hansen, 1975: Up to 11 cm Tentacles: only 18

*Distinguishing feature

Table S3. Voucher information and GenBank accession numbers for specimens sequenced for COI and/or 16S mitochondrial genes. All vouchers are lodged at Museums Victoria (NMV).

Order	**Species**	**Registration number**	**COI**	**16S**
Dendrochirotida	*Echinocucumis ampla*	NMV-F296861	-	PP817865
Elasipodida	*Benthodytes* cf *incerta*	NMV-F308170	PP778419	PP817906
Elasipodida	*Benthodytes* cf *incerta*	NMV-F308171	PP778418	-
Elasipodida	*Benthodytes* cf *incerta*	NMV-F308197	PP778420	-
Elasipodida	*Benthodytes* cf *sanguinolenta*	NMV-F308225	PP778424	
Elasipodida	*Benthodytes* sp. MoV. 7319	NMV-F308186	PP778422	-
Elasipodida	*Benthodytes* sp. MoV. 7319	NMV-F308193	PP778421	-
Elasipodida	*Benthodytes* sp. MoV. 7338	NMV-F308238	PP778428	-
Elasipodida	*Benthodytes* sp. MoV. 7338	NMV-F308278	PP778430	-
Elasipodida	*Benthodytes* sp. MoV. 7338	NMV-F308288	PP778429	-
Elasipodida	*Benthogone rosea*	NMV-F296864	PP778425	PP817917
Elasipodida	Elpidiidae sp.	NMV-F296840	PP778426	PP817916
Elasipodida	*Enypniastes eximia*	NMV-F296837	-	PP817911
Elasipodida	*Enypniastes eximia*	NMV-F296847	-	PP817912
Elasipodida	*Peniagone* cf *azorica*	NMV-F308267	PP778478	-
Elasipodida	*Peniagone coccinea*	NMV-F296857	PP778479	PP817913
Elasipodida	*Peniagone coccinea*	NMV-F308188	PP778480	-
Elasipodida	*Peniagone purpurea*	NMV-F296841	-	PP817914
Elasipodida	*Peniagone* sp. MoV. 7320	NMV-F308335	PP778482	-
Elasipodida	*Peniagone* sp. MoV. 7321	NMV-F308228	PP778481	-
Elasipodida	*Peniagone vitrea*	NMV-F308222	PP778483	PP817915
Elasipodida	*Psychronaetes* sp. MoV. 7326	NMV-F308286	PP778427	PP817918

Table S3. Voucher information and GenBank accession numbers for specimens sequenced for COI and/or 16S mitochondrial genes. All vouchers are lodged at Museums Victoria (NMV).

Order	Species	Registration number	COI	16S
Elasipodida	*Psychroplanes convexa*	NMV-F308284	PP778477	-
Elasipodida	*Psychropotes depressa*	NMV-F296865	-	PP817908
Elasipodida	*Psychropotes depressa*	NMV-F296881	-	PP817907
Elasipodida	*Psychropotes depressa*	NMV-F308148	PP778423	PP817909
Elasipodida	*Psychropotes longicauda*	NMV-F308333	-	PP817910
Holothuriida	*Mesothuria cathedralis*	NMV-F308202	PP778431	-
Holothuriida	*Mesothuria gargantua*	NMV-F296863	PP778435	PP817870
Holothuriida	*Mesothuria gargantua*	NMV-F296873	PP778434	PP817867
Holothuriida	*Mesothuria gargantua*	NMV-F308173	PP778433	-
Holothuriida	*Mesothuria gargantua*	NMV-F308217	PP778432	-
Holothuriida	*Mesothuria gargantua*	NMV-F308236	-	PP817868
Holothuriida	*Mesothuria gargantua*	NMV-F308305	-	PP817869
Holothuriida	*Mesothuria murrayi*	NMV-F296839	PP778493	PP817871
Holothuriida	*Mesothuria murrayi*	NMV-F296848	PP778492	PP817873
Holothuriida	*Mesothuria murrayi*	NMV-F308144	PP778494	PP817872
Holothuriida	*Zygothuria* sp. MoV. 7328	NMV-F296850	PP778436	PP817866
Holothuriida	*Zygothuria thompsoni*	NMV-F308198	PP778437	-
Molpadida	*Molpadia* cf *blakei*	NMV-F296851	PP778498	PP817874
Molpadida	*Molpadia* cf *blakei*	NMV-F308219	PP778497	-
Persiculida	*Molpadiodemas* sp. MoV. 7329	NMV-F296854	PP778484	PP817893
Persiculida	*Molpadiodemas* sp. MoV. 7329	NMV-F308204	PP778485	-
Persiculida	*Molpadiodemas* sp. MoV. 7329	NMV-F308263	PP778486	-
Persiculida	*Molpadiodemas* sp. MoV. 7334	NMV-F296842	PP778489	PP817896
Persiculida	*Molpadiodemas* sp. MoV. 7334	NMV-F296856	PP778487	PP817894
Persiculida	*Molpadiodemas* sp. MoV. 7334	NMV-F296859	PP778488	PP817895
Persiculida	*Molpadiodemas* sp. MoV. 7335	NMV-F296882	PP778490	PP817897
Persiculida	*Paroriza prouhoi*	NMV-F308312	PP778491	-
Persiculida	*Pseudostichopus* sp.	NMV-F296875	PP778496	PP817904
Persiculida	*Pseudostichopus* sp.	NMV-F308141	PP778495	PP817905
Synallactida	*Bathyplotes* sp. MoV. 7340	NMV-F308259	PP778447	-
Synallactida	*Bathyplotes* sp. MoV. 7340	NMV-F308261	PP778449	-
Synallactida	*Bathyplotes* sp. MoV. 7340	NMV-F308266	PP778450	PP817900
Synallactida	*Bathyplotes* sp. MoV. 7340	NMV-F308304	PP778448	-
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F296878	PP778446	PP817898
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F308175	PP778441	-
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F308200	PP778442	-
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F308244	PP778445	-
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F308245	PP778444	-
Synallactida	*Bathyplotes* sp. MoV. 7341	NMV-F308294	PP778443	-

Table S3. Voucher information and GenBank accession numbers for specimens sequenced for COI and/or 16S mitochondrial genes. All vouchers are lodged at Museums Victoria (NMV).

Order	Species	Registration number	COI	16S
Synallactida	*Bathyplotes* sp. MoV. 7342	NMV-F308174	PP778438	-
Synallactida	*Bathyplotes* sp. MoV. 7342	NMV-F308199	PP778439	PP817899
Synallactida	*Bathyplotes* sp. MoV. 7342	NMV-F308317	PP778440	-
Synallactida	*Deima oloughlini* sp. nov.	NMV-F308216	PP778461	PP817875
Synallactida	*Deima oloughlini* sp. nov.	NMV-F308242	PP778462	-
Synallactida	*Deima validum validum*	NMV-F308224	PP778463	PP817876
Synallactida	*Oneirophanta mutabilis mutabilis*	NMV-F296855	PP778464	PP817877
Synallactida	*Oneirophanta mutabilis mutabilis*	NMV-F296858	PP778465	-
Synallactida	*Oneirophanta* sp. MoV. 7331	NMV-F308334	PP778466	PP817878
Synallactida	*Oneirophanta* sp. MoV. 7333	NMV-F296845	PP778467	PP817879
Synallactida	*Orphnurgus glaber*	NMV-F296849	PP778468	PP817880
Synallactida	*Orphnurgus glaber*	NMV-F296869	PP778469	PP817881
Synallactida	*Orphnurgus glaber*	NMV-F296874	PP778470	PP817882
Synallactida	*Orphnurgus glaber*	NMV-F296876	-	PP817883
Synallactida	*Orphnurgus glaber*	NMV-F308254	PP778471	PP817884
Synallactida	*Orphnurgus insignis*	NMV-F296867	PP778474	PP817887
Synallactida	*Orphnurgus insignis*	NMV-F296868	-	PP817888
Synallactida	*Orphnurgus insignis*	NMV-F296871	PP778476	PP817889
Synallactida	*Orphnurgus insignis*	NMV-F296877	-	PP817890
Synallactida	*Orphnurgus insignis*	NMV-F308298	PP778475	PP817891
Synallactida	*Orphnurgus insignis*	NMV-F308301	-	PP817892
Synallactida	*Orphnurgus* sp. MoV. 7318	NMV-F296870	PP778472	PP817885
Synallactida	*Orphnurgus* sp. MoV. 7318	NMV-F296872	PP778473	PP817886
Synallactida	*Paelopatides* sp. MoV. 7336	NMV-F308191	PP778459	-
Synallactida	*Paelopatides* sp. MoV. 7336	NMV-F308306	PP778460	-
Synallactida	*Paelopatides* sp. MoV. 7337	NMV-F296843	PP778454	PP817903
Synallactida	*Paelopatides* sp. MoV. 7337	NMV-F296844	PP778455	-
Synallactida	*Paelopatides* sp. MoV. 7337	NMV-F308220	PP778456	-
Synallactida	*Scotothuria herringi*	NMV-F308231	PP778457	-
Synallactida	*Scotothuria herringi*	NMV-F308338	PP778458	-
Synallactida	*Synallactes* cf *crucifera*	NMV-F296862	PP778451	PP817901
Synallactida	*Synallactes* cf *crucifera*	NMV-F308319	PP778452	PP817902
Synallactida	*Synallactidae* sp. MoV. 7339	NMV-F296846	PP778453	-

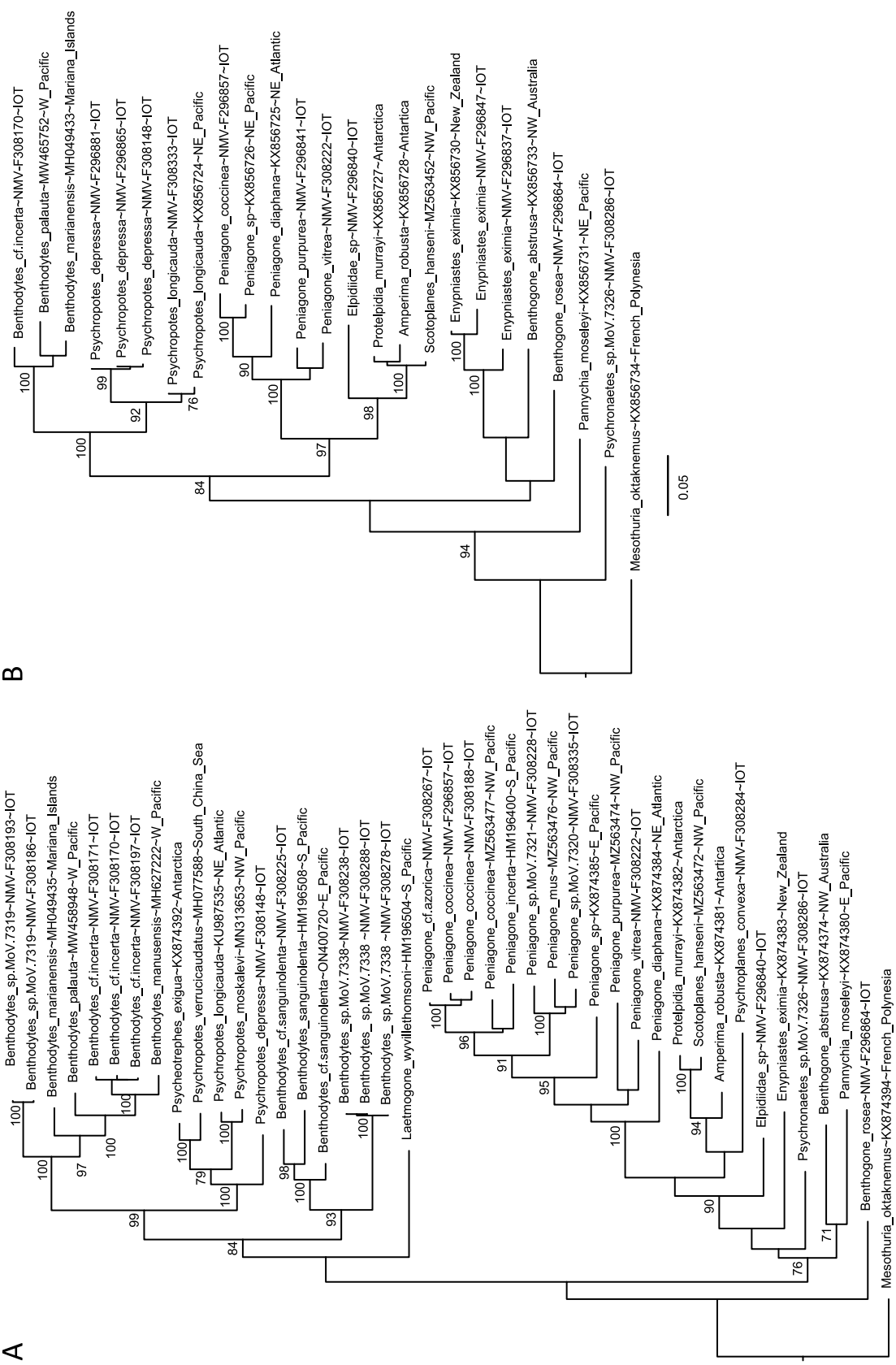

Figure S1. Maximum likelihood phylogeny of Elasipodida inferred from A) COI and B) 16S sequences. Bootstrap values over 70% are shown above major nodes. Sample names include registration numbers for IOT samples sequenced for this paper or GenBank numbers for previously published data and sample collection location. NMV = National Museum of Victoria.

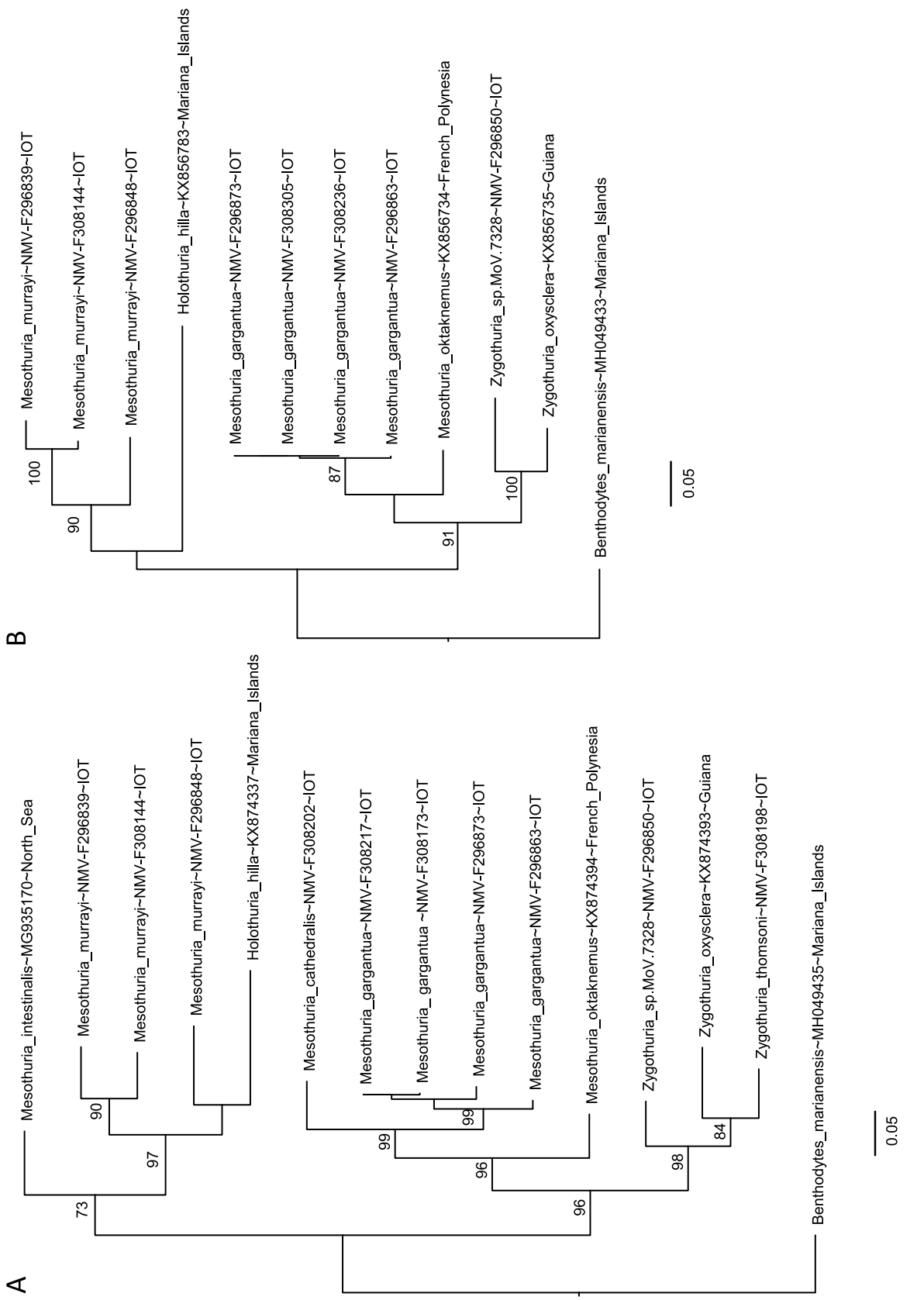

Figure S2. Maximum likelihood phylogeny of Holothuriida inferred from A) COI and B) 16S sequences. Bootstrap values over 70% are shown above major nodes. Sample names include registration numbers for IOT samples sequenced for this paper or GenBank numbers for previously published data and sample collection location. NMV = National Museum of Victoria.

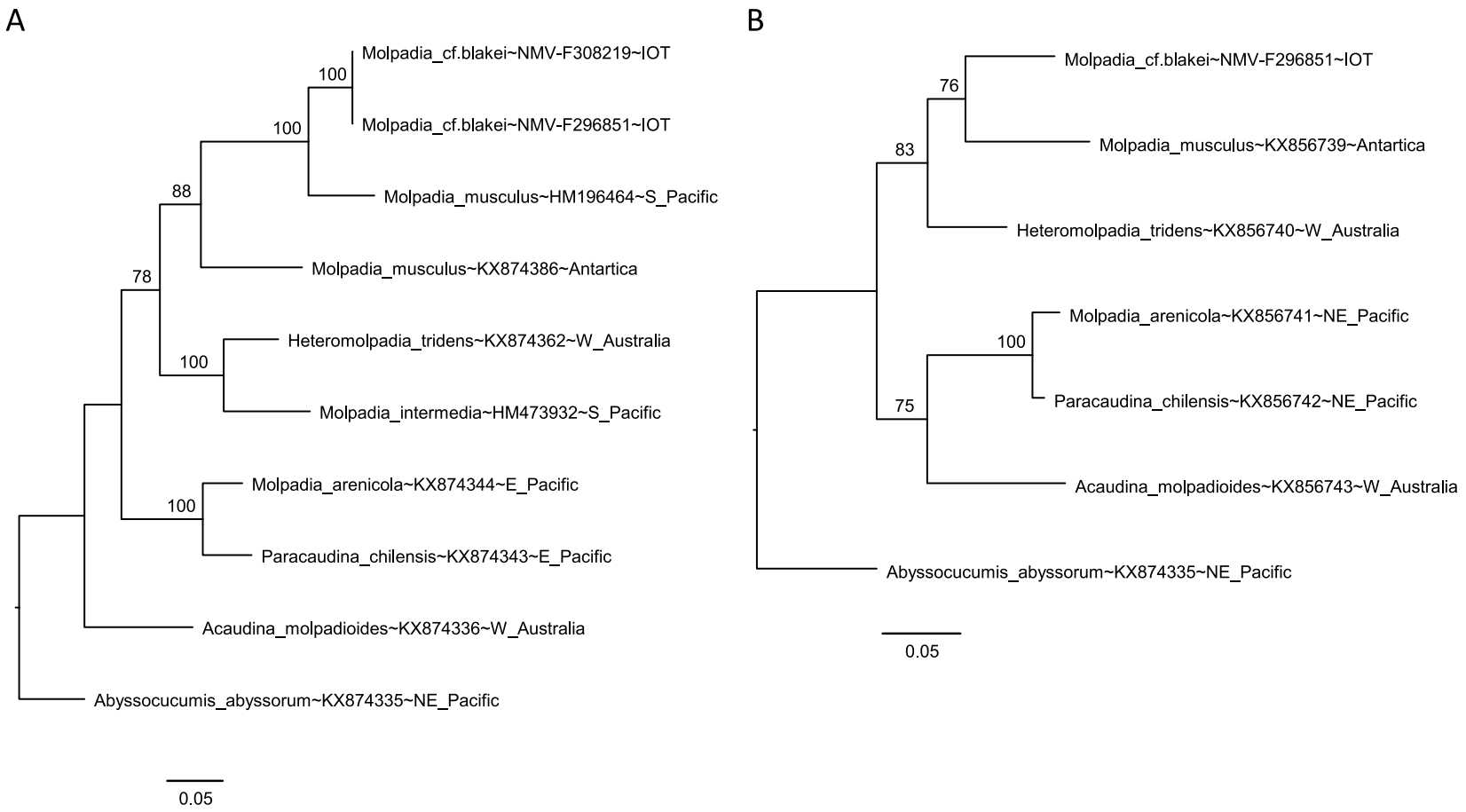

Figure S3. Maximum likelihood phylogeny of Molpadida inferred from A) COI and B) 16S sequences. Bootstrap values over 70% are shown above major nodes. Sample names include registration numbers for IOT samples sequenced for this paper or GenBank numbers for previously published data and sample collection location. NMV = National Museum of Victoria.

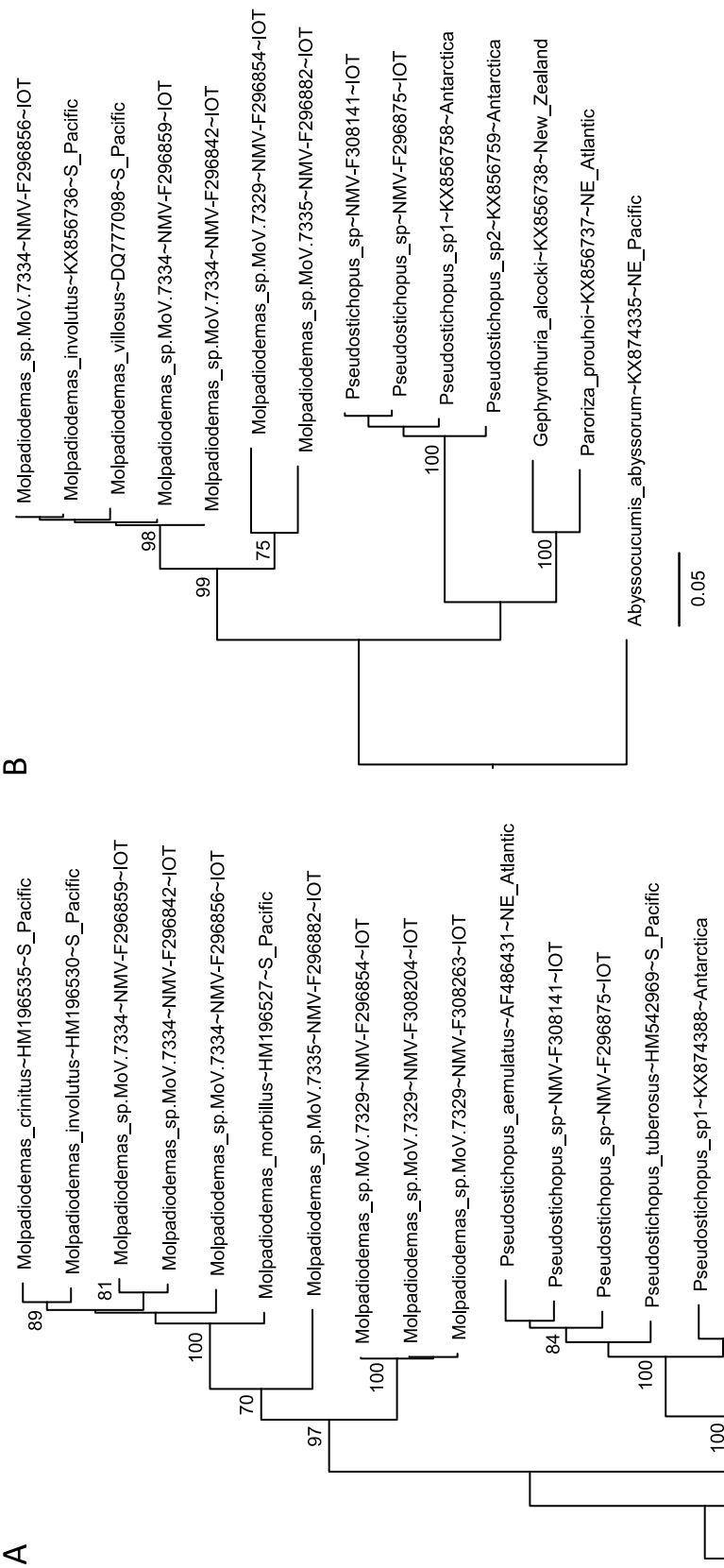

Figure S4. Maximum likelihood phylogeny of Persiculida inferred from A) COI and B) 16S sequences. Bootstrap values over 70% are shown above major nodes. Sample names include registration numbers for IOT samples sequenced for this paper or GenBank numbers for previously published data and sample collection location. NMV = National Museum of Victoria.

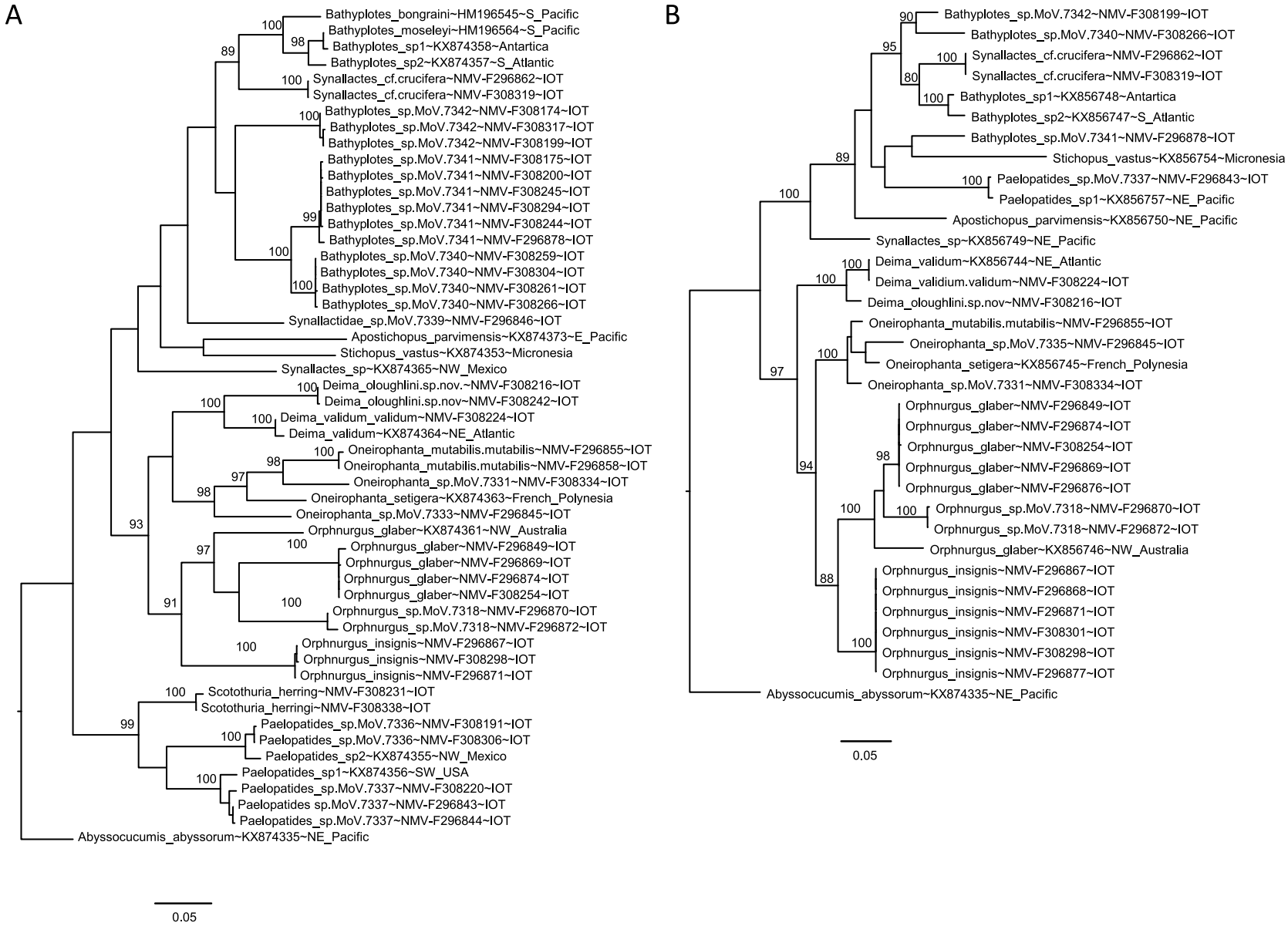

Figure S5. Maximum likelihood phylogeny of Synallactida inferred from A) COI and B) 16S sequences. Bootstrap values over 70% are shown above major nodes. Sample names include registration numbers for IOT samples sequenced for this paper or GenBank numbers for previously published data and sample collection location. NMV = National Museum of Victoria.