Megataxa 019 (1): 114–175
https://www.mapress.com/mt

Article

ISSN 2703-3082 (print edition)
MEGATAXA
ISSN 2703-3090 (online edition)

https://doi.org/10.11646/megataxa.19.1.2
http://zoobank.org/urn:lsid:zoobank.org:pub:A02A8C6B-B566-4735-81A4-A6E8734EA6A7

New taxa of Mesophotic Asteroidea from Ashmore Reef, Western Australia

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Abstract

We report on 27 asteroid specimens collected by the RV *Falkor*, using the ROV *SuBastian*, from mesophotic depths on Ashmore Reef in Western Australia, 2021. Of the total, 10 new species were collected, 9 of which are described here. Sixteen species were new occurrences for Western Australia. One additional shallow water species was observed at mesophotic depths but not collected. Each collected specimen was identified as a different species. In the Valvatida, this included Goniasteridae (n=9), Mithrodiidae (n=1), Ophidiasteridae (n=4), Asterinidae (n=3), Asterodiscididae (n=2), Oreasteridae (n=2), Podosphaerasteridae (n=1), and the Echinasteridae (n=3). Also present were two non-valvatidan groups, a brisingid from the Forcipulatacea and a new species of pterasterid in the genus *Euretaster* from the Velatida. Consistent with other accounts of mesophotic asteroid distribution, some of the species observed here, such as the goniasterid *Churaumiastra hoshi* Mah *et al*. 2024 have been found to be widely distributed across the Indo-Pacific.

Keywords. Mesophotic Ecosystems, MCE, Goniasteridae, Pterasteridae, Podosphaerasteridae, Ophidiasteridae, Asterinidae, *Brisingaster,* Western Australia, Indian Ocean, associates, Polynoidae, Eulimidae

Introduction

Mesophotic ecosystems (MCEs), occurring at depths of 30–150 meters are stratified into upper (30–60m) and lower (below 60m) mesophotic zones, with biodiversity and compositional shifts across these zones driven by diminishing light availability (Loya *et al*. 2019, Baker *et al.*, 2016). For some taxa, mesophotic habitats are hypothesized to act as refugia for fauna that are threatened on shallow reefs (Riegl & Piller 2003; Bongaerts & Smith 2019; Holstein *et al.*, 2015). In some marine invertebrate taxa, such as reef-building corals, a growing body of evidence suggests that conspecific individuals inhabiting shallow and mesophotic environments are genetically distinct (Bongaerts *et al*. 2021; Hernández-Agreda *et al*. 2024), potentially indicating niche-based speciation at depth. Further research on the diversity of marine invertebrates in MCEs is essential to elucidate the conservation significance of these comparatively understudied habitats.

In Australia, mesophotic coral reef ecosystems are found in regions such as the Great Barrier Reef, Coral Sea, Ningaloo Reef, and the Kimberley coast. Although these ecosystems are acknowledged as critical biodiversity hotspots, research on mesophotic reefs remains limited compared to shallow-water reefs. Recent studies have advanced understanding of corals in these habitats, particularly in functional (Bridge *et al.* 2011) and trophic ecology (Carmignani *et al*. 2022). However, information on other marine invertebrates, such as sea stars, remains sparse. Expanding research in mesophotic zones is essential for biodiversity conservation and effective conservation planning, as it supports the protection of these understudied yet crucial environments and their unique biodiversity (Pyle *et al*., 2016).

One such MCE that has up until now remained unexplored is the Ashmore Reef system in northwest Western Australia. In 2021, the Schmidt Ocean Institute supported a marine survey of mesophotic depths (50–150m) in the Ashmore Reef Marine Park using the research vessel R/V *Falkor* and the ROV *SuBastian*. While the voyage primarily focussed on coral, the entire mesophotic zone of Ashmore Reef was mapped in high resolution. This mapping revealed a diverse array of habitat types, including *Halimeda* beds, coral-dominated areas, sponge gardens and mixed filter feeder communities. The deployed ROV allowed for targeted sampling of mesophotic faunal diversity when taxa of interest were observed (Miller *et al*. 2022). The primary objectives of this research are to conduct a taxonomic investigation of asteroid diversity, focusing on the description of new species, and to provide biogeographic insights into the distribution of known species.

 Accepted by T. Saucède: 7 Dec. 2025; published: 6 Jan. 2026

Mesophotic Asteroidea

Ecologically, asteroids have been documented affecting community structure in a wide range of marine ecosystems. Intertidal species in temperate settings were shown to impact nearshore mussel beds (Paine, 1966, 1969), whereas in shallow-water tropical settings, species such as the Crown of Thorns (*Acanthaster* spp.) have substantive impacts on community structure in coral reefs (e.g Birkland & Lucas, 1990). Further exploration of the deep sea and the use of Remotely Operated Vehicles (ROVs) has provided further insight into the ecological impact of deep-sea asteroids on their communities. Multiple observations of the Goniasteridae at depth (200–3000 m) have shown that as predators, they have potentially substantial effects (e.g. Mah 2020, 2022) on "ecosystem engineer" species, such as colonial octocorals and sponges, which form extensive habitats in the deep-sea for a diversity of other species (Meadows *et a*l., 2012).

Mesophotic depths, 30–150 m are a narrow and surprisingly inaccessible depth range. Collections are more difficult as they are considered too deep for SCUBA but too shallow for conventional deep-sea sampling, such as from trawl nets (Mah, 2005). As such, accounts of taxa from these regions have not historically been a primary subject of investigation. Recent discoveries of numerous new seastar species in mesophotic zones (MCEs) (Arai & Fujita, 2021; Mah, 2023) lend support to the hypothesis that MCEs harbor unique biodiversity, distinct from that of shallow-water reefs (Mecho *et al*., 2019). However, most MCEs globally remain unexplored, and further investigation is expected to reveal a wealth of additional seastar species. These discoveries are also likely to provide new ecological insights, including feeding preferences (e.g., corallivory, as noted by Keesing *et al*. 2023), species associations, adaptations, and reproductive behaviors, all of which will advance our understanding of the resilience and ecological functions of mesophotic reef ecosystems.

Many accounts of mesophotic asteroid taxa are present in historical literature. However, specific taxonomic reports for asteroids from this region are uncommon, especially for the Indo-Pacific. Shallow-water species (<50 m) have been summarized in detail from multiple accounts (e.g. Marsh & Fromont 2020; Clark & Rowe 1971; H.L. Clark 1921, 1941 and others). Deeper water accounts (>200 m) include but are not limited to monographs for the Philippines (Fisher 1906, 1913, 1919; Jangoux 1981b) and New Zealand, (H.E.S. Clark & McKnight, 2000; 2001; McKnight 2006).

Mah (1999) re-described and reported on further occurrence of the shallow-water brisingid, *Brisingaster robillardi*, which has since been found to occur in mesophotic depths.

Mah (2003) described a distinctive mesophotic oreasterid, *Astrosarkus idipi* known from Palau and across the tropical Indian and Pacific oceans with further occurrence from Okinawa and Guam (Kogure *et al*. 2009). A second species of *Astrosarkus* along with an account of mesophotic Oreasteridae has since been reported (Mah, 2023). Mah (2005) described new species of *Iconaster* and *Glyphodiscus* (Goniasteridae) from mesophotic and deeper depths. Many species within the Ferdininae, a recently described subfamily within the Goniasteridae (Mah 2017) are described from within the mesophotic zone (30–150 m) and in many cases are not known from shallower depths. Numerous accounts of mesophotic species have been described from Japan, including those of Kogure & Fujita (2012) who described a new species of the goniasterid *Neoferdina* in addition to multiple new occurrences from Kumejima Island, Arai & Fujita (2021) who documented two new goniasterid species from the Ogasawara Islands and Mah & Fujita (2020) who described multiple new species of the mesophotic hyalinothricine *Hyalinothrix* from Japan and the Philippines. Recent accounts have found that some mesophotic species display widespread occurrence, such as *Linckia profunda* from New Caledonia to Rapa Nui (Easter Island) (Mah 2019) or *Astrosarkus idipi* which has been described from mesophotic settings throughout the Indian and Pacific Ocean (Mah, 2023).

Exploration of MCEs in Australia with respect to asteroids is present only indirectly from taxonomic accounts. Australia's asteroid fauna was fully inventoried by Rowe & Gates (1995) which largely treated taxa from the continental shelf (to 200 m), and primarily shallow-water species from 0 to 50 m depths. In most instances where there were deeper-water faunas global distributions were used.

Herein we describe a total of nine new species from mesophotic depths in Ashmore Reef. A further tenth new genus and species is in preparation.

Materials & Methods

Museum abbreviations include Marine Invertebrate Zoology collections of the Western Australian Museum (WAM) in Perth, Australia and the collections of the Invertebrate Zoology Department of the National Museum of Natural History (USNM). Taxonomy and systematics follow phylogenetic results from Mah & Foltz (2011) and Linchangco *et al*. (2017).

The majority of asteroids described here were collected by the RV *Falkor* survey of Ashmore Reef (cruise FK210409), supplemented by previously unidentified specimens from the WAM Marine Invertebrate Zoology collection. "Mesophotic" is defined herein as falling within the broadest definition, 30–150 m, as widely accepted (Baker *et al.* 2016) by depth rather than by other more globally variable environmental criteria. An accounting of the Ashmore mesophotic reef survey including collection methods, survey areas, and details regarding collected materials is presented by Miller *et al.* (2022). A map of the collected Asteroidea is presented in Figure 1. Taxa of interest are listed herein alphabetically by family and subfamily where appropriate.

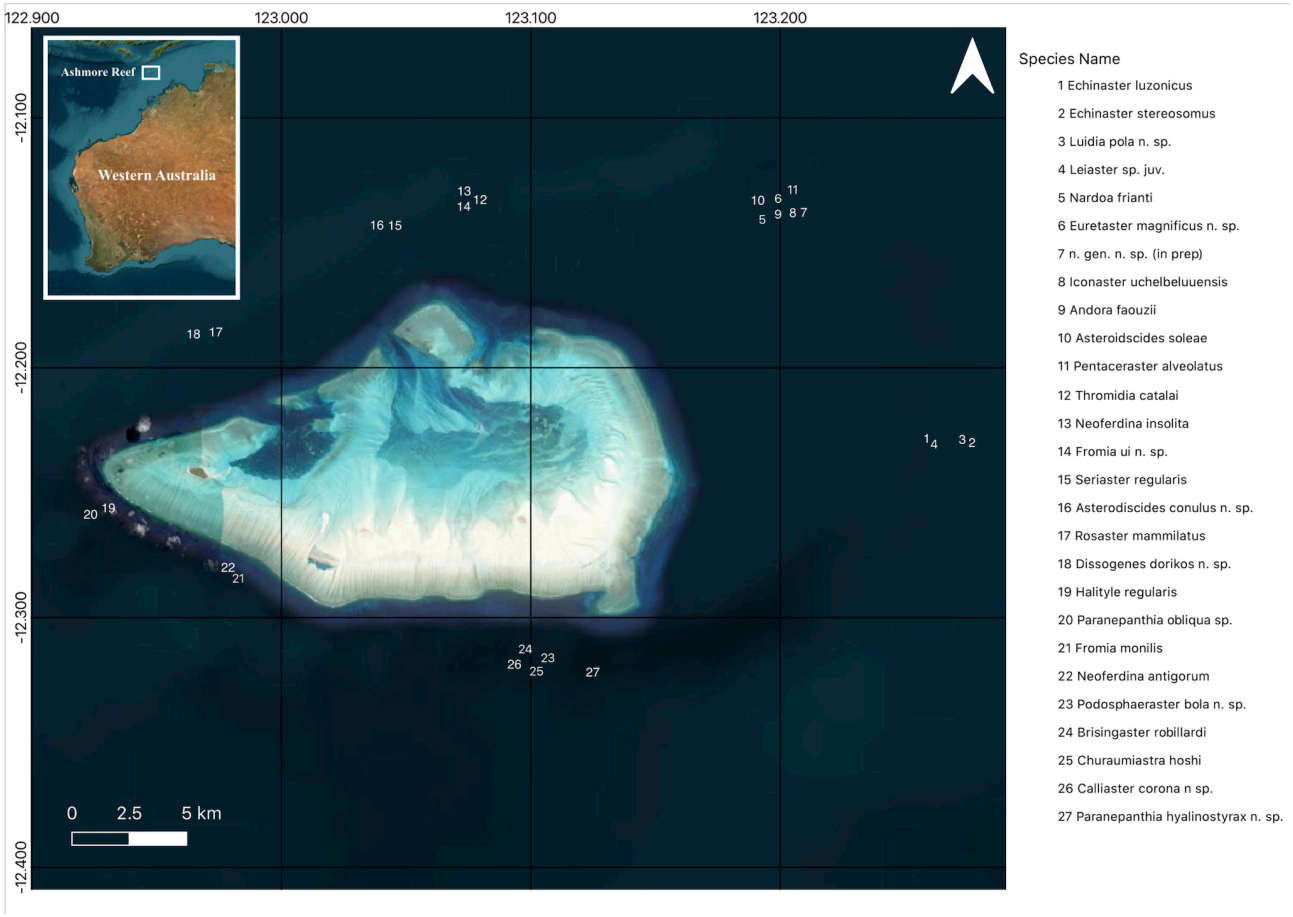

FIGURE 1. Map of the region with specimen collections.

Systematics

ASTERINIDAE Gray, 1840

The Asterinidae is one of the most diverse groups within the Asteroidea, containing over 150 species in at least 25 genera (Mah & Blake 2012) with significant additions resulting from the addition of the Ganeriidae (Mah & Fujita, 2022) as a subfamily based on recent phylogenetic revision (Mah & Foltz, 2011). Within the morphological range of the Asterinidae (O'Loughlin & Waters, 2004) there have historically been two broad trends, those which demonstrate a more "*Asterina*" like body form with a more pentagonal to weakly stellate shape, dorsoventrally flattened especially interradially versus those with a more "*Nepanthia*" like body form which are more stellate with distinct arms and a smaller disk. Although a full phylogenetic survey of the Asterinidae remains an ongoing area of research, there is some indication that the "*Nepanthia*" form reflects a single lineage (Mah & Foltz 2011) whereas the "*Asterina*" form is more phylogenetically widespread.

The "*Nepanthia*" like members include *Nepanthia, Pseudonepanthia, Pseudopatiria* and *Callopatiria* and variably possess superambulacral and/or superactinal plates (O'Loughlin & Waters 2004).

Based on results from Mah & Foltz (2011), Mah & Fujita (2020) further refined classification within the Asterinidae to reflect groups within this diverse lineage. This included establishment of the Ganeriinae as a subfamily within the Asterinidae, including *Ganeria* and other members of the "Ganeriidae" as well as designation of the Hyalinothricinae within the Asterinidae, including *Hyalinothrix* and its relatives.

Asterinids are a diverse group in Australia, for shallow-water species, Marsh & Fromont (2020) have recognized 42 species in 13 genera from depths of <30 m. Rowe & Gates (1995) accounted for a further 13 species in 11 genera from deeper waters, not including those from further taxonomic revision, such as the Hyalinothricinae. The Australian asterinid fauna is sadly noteworthy as it includes *Patiriella littoralis* (Dartnall, 1970), one of the first known 20th Century echinoderm extinctions (O'Hara *et al*. 2018).

Pseudonepanthia A.H. Clark, 1916

Pseudonepanthia A.H. Clark, 1916: 118, A.M. Clark, 1993: 227; O'Loughlin & Waters, 2004: 32; Marsh & Fromont, 2020: 189.

Comments

Pseudonepanthia was described to accommodate

the monotypic *Pseudonepanthia gotoi* by A.H. Clark (1916), which was characterized by the presence of superambulacral plates and bearing crescentic, spine-bearing plates. O'Loughlin & Waters (2004) revised the Asterinidae adding six species which had previously been assigned to *Nepanthia* to *Pseudonepanthia*. Of these six, *Pseudonepanthia grangei* has since been re-assigned to *Hyalinothrix* (Mah & Fujita 2022). At present, six species of *Pseudoenpanthia* are recognized, two species-*P. nigrobrunnea* Rowe & Marsh, 1982 and *P. troughtoni* (Livingstone, 1934), are shallow-water species known only from Australia; one species, *P. reinga* McKnight, 2001 was described from 205 m in New Zealand waters; *P. gracilis* was described from 100–124 m in the Sulu Sea; *P. gotoi* is known primarily from Japan; and *P. briareus* is known from mesophotic depths (27–83 m) in the central Pacific.

***Pseudonepanthia hyalinostyrax* Mah sp. nov.**
Figures 2A, 3A–E

Etymology
The species epithet *hyalinostyrax* is derived from the Greek *hyalinos* for "glass" and *styrax* for "spike" alluding to the glassine inferomarginal spinelets.

Diagnosis
Five rays. Body strongly stellate (R/r=5.85), five arms, tapering, elongate, cylindrical, round in cross-section. Interradial arcs acute. Actinal surface not flat, actinolateral margin rounded. Abactinal plates crescentic to mound-like, each variably round and quadrate to more lobate in shape, each bearing tuft of fine spinelets, 10–40 fine spinelets on plate surface. Marginal plates forming rhomboid shaped plates, with superomarginal plates approximately twice as large as inferomarginal plates. Each superomarginal plate with tufts of short spinelets, 20–40, similar to those on abactinal plates. Inferomarginals approximately 50% of superomarginal size, quadrate in shape **bearing 10–30 short spinelets with pointed glassine tips.** Furrow spines 4–5, short and blunt in straight series, webbed at base, weakly palmate. Subambulacral spine array, 4–6.

This species is distinguished by the presence of three series of furrow spine arrays, two in parallel and a third in oblique to transverse arrangement.

Comments
This species was identified based primarily on the presence of superambulacral plates and the absence of superactinal plates. Given the relatively recent transfer of these species from *Nepanthia* to *Pseudonepanthia* (O'Loughlin & Waters, 2004) there is relatively little in the way of comprehensive comparisons and review and so, additional testing is desirable.

Pseudonepanthia hyalinostyrax **sp. nov.** differs from the shallow-water Australian *P. troughtoni* (Livingstone 1934) in having much smaller and more irregularly shaped abactinal plates, although there are similarities in the lateral abactinal plate arrangement. *Pseudonepanthia nigrobrunnea* (Rowe & Marsh, 1982), differs in having 3–4 furrow spines and 6–7 subambulacral spines as well as more lobate abactinal plates (as outlined in Rowe & Marsh 1982) versus 4–5 furrow and 4–6 subambulacral spines and more polygonal plates in *Pseudonepanthia hyalinosyrax* **sp. nov.** *Pseudonepanthia gracilis* was reported as having flat abactinal plates, differing from the convex plates present in *Pseudonepanthia hyalinostyrax* **sp. nov.** Spination in *P. gracilis* appears similar to *P. hyalinostyrax* **sp. nov.** suggesting close affinities. *Pseudonepanthia briareus* differs in having more triangular plates versus the more irregular and round abactinal plates versus more triangular plates in *Pseudonepanthia hyalinostyrax* **sp. nov.**, which also has a greater number of abactinal spinelets and shows no indication of fissiparity.

This species displayed fewer furrow spines, 4–5 and subambulacral spines, 4–6, versus 6–7 and 7–12 in *Paranepanthia obliqua* **sp. nov.** Adambulacral spination of *Paranepanthia hyalinostyrax* **sp. nov.** shows a furrow spine array parallel to the ambulacral groove with two subambulacrals at oblique to perpendicular orientation to the ambulacral groove, versus *Paranepanthia obliqua* **sp. nov.** 2 which shows the furrow, the subambulacral spine array and an adjacent actinal fan all in a similar transverse orientation to the ambulacral groove.

Ecological Comments
The holotype was observed on a hard substratum composed of coarse, shelly debris and loose pebbles (Fig. 2A) upon which it was likely feeding.

Occurrence/Distribution
Ashmore Reef, Western Australia (Indian Ocean). 124 m.

Description
Body strongly stellate (R/r= 5.85), five arms, tapering, elongate, cylindrical, round in cross-section. Interradial arcs acute. Actinal surface not flat, actinolateral margin rounded.

Abactinal plates crescentic to mound-like, each variably round and quadrate to more lobate in shape, each bearing tuft of fine spinelets, 10–40 fine spinelets on plate surface. Papulae single, one or two pores present between plates. Abactinal plates in three series along radial series, in weakly regular series, in contrast to those on lateral sides, which are flanked by more ordered series from the proximal arm region extending down the length of the arm. Madreporite and anus not observed.

Marginal plates forming rhomboid shaped plates, with superomarginal plates approximately twice as large as inferomarginal plates. Adjacent serially arranged lateral abactinal plates at oblique angle to superomarginals, each plate with tufts of short spinelets, 20–40, similar to those on abactinal plates. Inferomarginals approximately 50% of superomarginal size, quadrate in shape bearing 10–30 short spinelets with pointed glassine tips. Terminal plate broadly triangular, smooth surface.

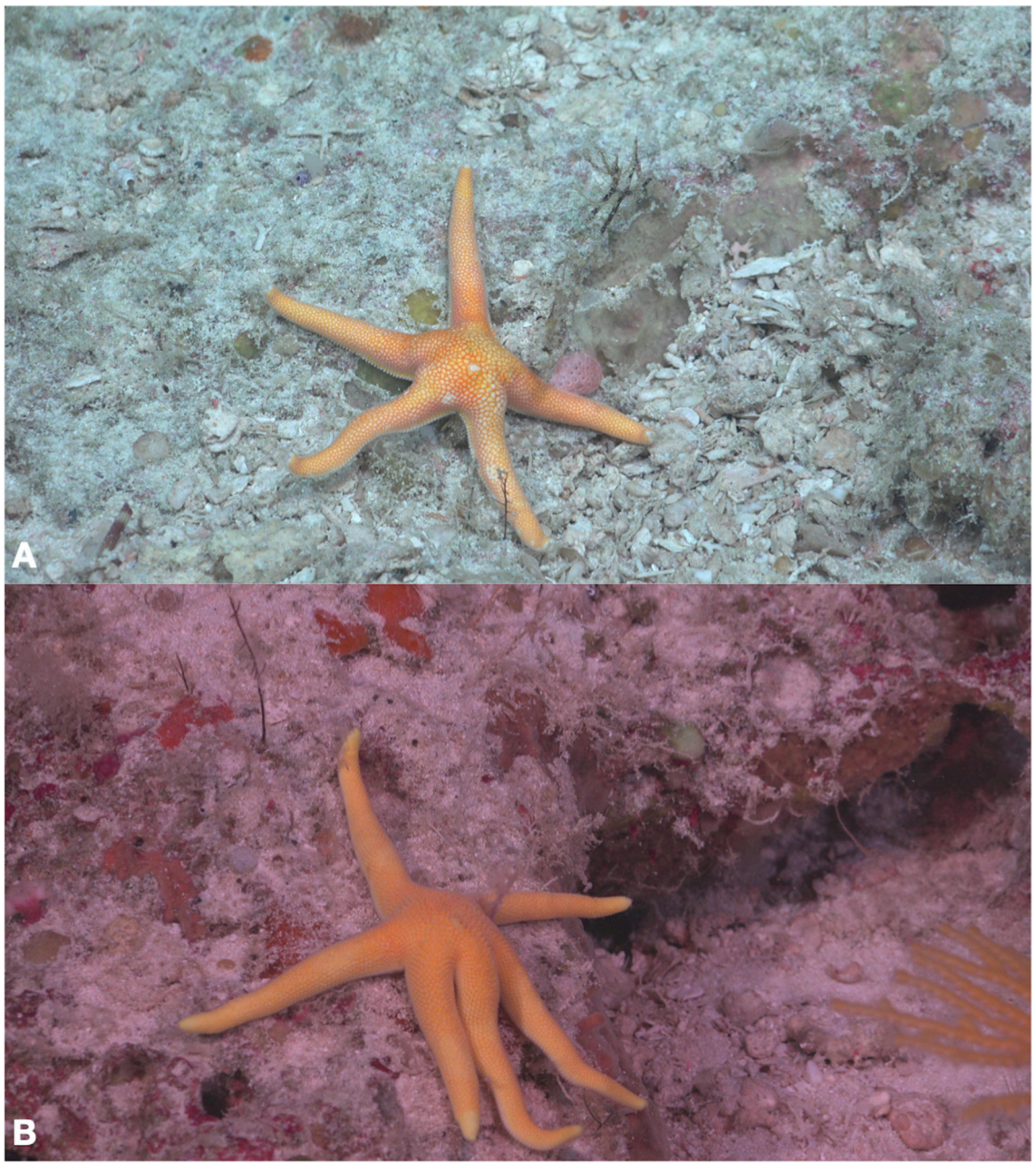

FIGURE 2. *Pseudonepanthia* in situ. A *P. hyalinostyrax* **sp. nov.** WAM Z97546 B. *P. obliqua*, **sp. nov.** WAM Z97579. No scale.

Actinal surface intermediate surface composed of four full actinal plate series, individual plates quadrate in shape, each bearing short spinelets, 10–40.

Furrow spines 4–5, short and blunt, webbed at base, weakly palmate (Fig. 3E). Proximalmost spine extending across discrete space to the subambulacral spine. Subambulacral spine array, 4–6, also in a webbed palmate array present in parallel close adjacent position to furrow spines forming an almost double array of adambulacral webbed spine arrays. A third comb present behind the second, arranged obliquely to transversely bearing 4–8 basally webbed spinelets in palmate arrangement. This latter spine array is widely spaced.

Oral plates each with 10 elongate furrow spines with blunt, rounded tips, a further 11th spine separate and projecting into the mouth (thus a total of 2 projecting into mouth. Approximately four to six spines, blunt, present on the oral plate surface.

Color in life, plates yellow with a darker orange present between plates. Madreporite was white. Irregular patches of white present on disk and along lateral surface of arms. Actinolateral fringe was yellow to white in color. Actinal surface was white.

Material Examined

Holotype. WAM Z97546 Ashmore Reef, Western Australia, 12.32324579°S 123.12174057°E, 124 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/S0408, Coll. 11 April 2021. 1 wet spec. R=4.1 r=0.7.

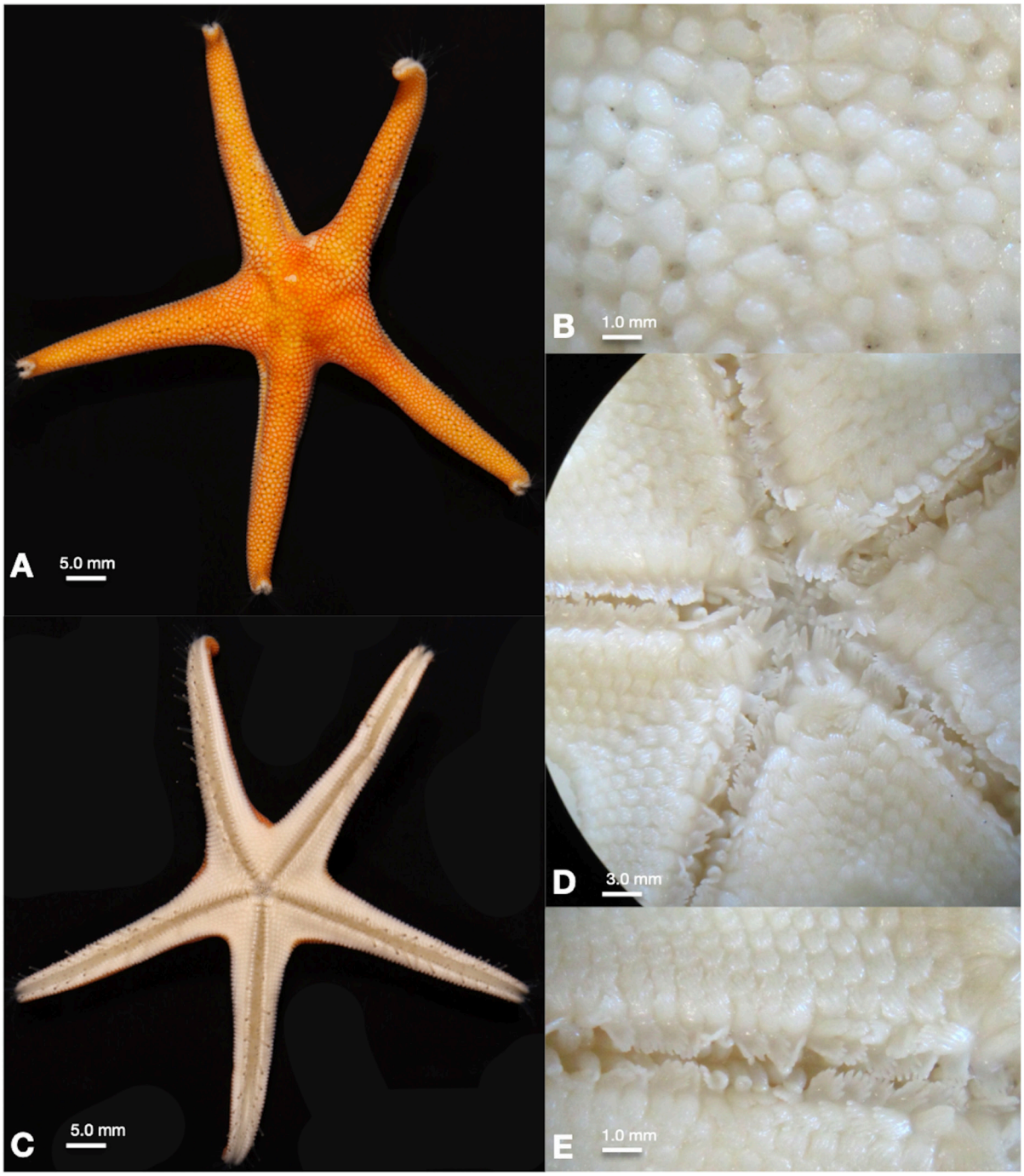

FIGURE 3. *Pseudonepanthia hyalinostryax* **sp. nov.** Holotype. WAM Z97546. A Abactinal. B Abactinal surface. C. Actinal surface. D. Closeup actinal surface, oral region. E. Adambulacral region and furrow spination.

***Pseudonepanthia obliqua* Mah sp. nov.**
Figure 4A–F

Etymology
The species epithet *obliqua* is Latin for "slanting" alluding to the subambulacral spines orientation relative to the ambulacral grooves.

Diagnosis
Six rays. Body strongly stellate R/r= 4.75. Arms five, cylindrical in cross-section. Actinal surface not flat, actinolateral margin rounded. Interradial arcs curved. Disk thickened. Abactinal plates mound-like to lobate, weakly crescentic in shape. Individual plates with short spinelets, 7–30, mostly 10–20, short and weakly expressed such that plates appear bald at first inspection. Papulae single. Marginal plates approximately 60 per arm side. Superomarginal and inferomarginal plates differ in shape. Superomarginals round, evenly spaced. Inferomarginal plates quadrate covered by 20–40 fine spinelets. **Furrow spines 6–7, increasing distally in strongly convex arrangement, separated from subambulacral spine**

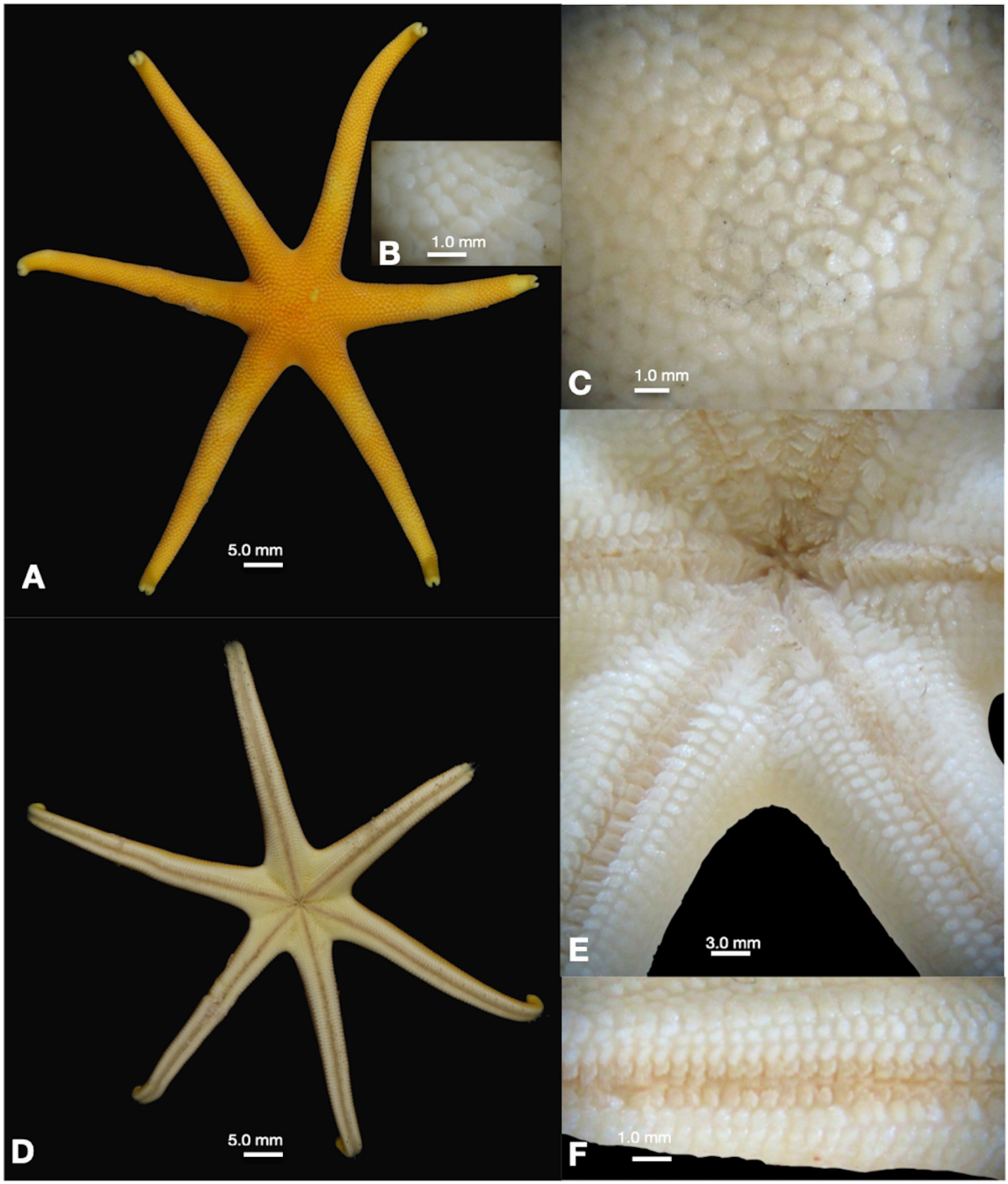

FIGURE 4. *Pseudonepanthia obliqua* n. Holotype. WAM Z97579. A. Abactinal. B. Detail of plates. C. Closeup abactinal surface. D. Actinal surface. E. Closeup oral region. F. Furrow/adambulacral region.

bearing 7–12 spinelets, similar in appearance to actinal plates. **Furrow spine arrays which are parallel to the furrow and have subambulacral spine arrays at oblique to perpendicular angles, oriented transversely to the ambulacral grooves.** Surface covered by dermis.

Comments

Although six-armed, other species with morphological affinity to *Nepanthia*, such as *Pseudonepanthia* are known to demonstrate variation in arm number for various reasons (e.g. *Pseudonepanthia briareus* and fissiparity). Thus, variation in arm number was unclear, but it is plausible that this species' shows greater or fewer arms relative to the six observed on the holotype.

Pseudonepanthia obliqua **sp. nov.** shares the same ordered lateral plate arrangement as *Pseudonepanthia hyalinostyrax* **sp. nov.** and other species, such as *Pseudonepanthia troughtoni*, but abactinal plates are smaller and more irregular in *Pseudonepanthia obliqua* **sp. nov.** Abactinal plate patterns also appear dissimilar

to those *Pseudonepanthia* species summarized by Marsh & Rowe (1982), including *P. briareus, P. gracilis,* and *P. nigrobrunnea*.

This species is distinguished based on the furrow spines and two adjacent subambulacral and actinal fans oriented transversely to the ambulacral furrow. *Paranepanthia* **sp. nov.** 1 possesses furrow spine arrays which parallel to the furrow and have subambulacral spine arrays at oblique to perpendicular angles to the ambulacral grooves.

Ecological Comments
In situ observation of this species shows it on a hard substratum covered by coarse, loose sediment. A colonial stalked metazoan of uncertain affinity, perhaps a hydroid or bryozoan was present between two of its arms implying that this was a potential prey species.

Occurrence/Distribution
Ashmore Reef, Western Australia (Indian Ocean). 145 m.

Description
Six rays. Body strongly stellate R/r= 4.75. Arms five, cylindrical in cross-section. Actinal surface not flat, actinolateral margin rounded. Interradial arcs curved. Disk thickened.

Abactinal plates mound-like to lobate, weakly crescentic in shape. Central plate series, 6 or 7 in irregular arrangement, flanked by ordered lateral series proximally on arm, approximately six per side decreasing further along arm to midpoint. Irregular plates continue from disk eventually occupying full abactinal arm surface distally on arm. Where plates appear most strongly expressed proximally, on disk and arms, these become weakly expressed and more homogeneous near arm tip. Individual plates with short spinelets, 7–30, mostly 10–20, short and weakly expressed such that plates appear bald at first inspection. Papulae single pores present on arm base, approximately 15 located around proximal arm region with 1 to 4 papulae extending on disk from arm region. Papulae absent distally on arm. Madreporite present in recessed plate on surface, flanked by 4 plates, two enlarged to twice the size of the madreporite and covered by short fine spinelets, 30–40. Pedicellariae not observed.

Marginal plates approximately 60 per arm side. Superomarginal and inferomarginal plates differ in shape. Superomarginals round, evenly spaced. Inferomarginal plates more quadrate covered by 20–40 fine spinelets. All marginal plates widely spaced from one another.

Actinal surface distinct but with weakly curved lateral boundary. Three full actinal series in chevron arrangement. Actinal plates mound like, each with fine, sharp spinelets, 8–15 per plate, widely separated from one another.

Furrow spines 6–7, increasing distally in strongly convex arrangement, separated from subambulacral spine bearing 7 to 12 spinelets, similar in appearance to actinal plates. surface covered by dermis.

Oral plates with 7 furrow spines, with an 8th projecting into mouth. These furrow spines interlacing on specimen. Oral plate surface with 3 spinelets on either side of the diastema (6 total per interradius) and further spinelets present elsewhere on oral plate surface.

Abactinal surface was a homogeneous yellow. Disk was a slightly darker orange with lighter yellow on arms. Actinal surface was white.

Material Examined
Holotype. WAM Z97579 Ashmore Reef, Western Australia, 12.26007813°S 122.92652428°E, 145.17 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO408, Coll. 14 April 2021. 1 wet spec. R=3.8 r=0.8.

HYALINOTHRICINAE Fisher, 1911

Fisher 1911: 660; Mah & Fujita 2020: 81.

Diagnosis
Abactinal, marginal and actinal plates, irregular to polylobate, imbricating and spinelet-bearing with short to elongate, blunt, needle-like tips. Plates alternatively paxillae-like and bearing short or glassine spinelets. Plates arranged serially, in straight or transverse rows around single papular pores. Marginal plates follow Blake's (1976) basis for identification, with plates tracking from interradius to arm terminus, but plates are indistinct, being similar to or identical with abactinal and actinal plates.

Seriaster Jangoux 1984

Seriaster Jangoux, 1984: 281,284; A. M. Clark 1996: 191

Diagnosis & Comments. as for species.

Seriaster regularis Jangoux 1984
Figure 5A–D

Seriaster regularis Jangoux, 1984: 284; A. M. Clark 1993: 191; Kogure & Kaneko 2010: 97; Mah & Fujita 2020: 93

Diagnosis
Body strongly stellate R/r= 4–15.0, arms 4–9, deciduous, differing lengths with many specimens showing arms regenerating, interradial arcs acute. Disk and arms relatively flat. **Abactinal skeleton fenestrate, individual plates cruciform with a central paxillae bearing delicate elongate spinelets, 4–9.** Marginal plates present [as per Blake's (1976) criterion for marginal plates] but paxillate and indistinguishable from other abactinal/actinal plates. Actinal plate series incomplete, present only on disk, proximally on arm. Adambulacral plates, immediately adjacent to inferomarginal plates along arm, arranged transversely separated by tissue between them.

Furrow spines 4–8 in palmate fan, mostly 7 individual spines pointed, widely spread with subambulacral spines 4 to 8, elongate, 3 to 4 times the length of the furrow spines. Colors range from solid

FIGURE 5. *Seriaster regularis* WAM Z97599. A. Abactinal. B. Abactinal closeup. C. Actinal. D. Closeup oral region.

red or orange to orange with yellow mottling in Japanese specimens to the mesophotic Australian specimen showing straw to yellow coloration with dark mottled orange patterns on the arms.

Comments

The monotypic *Seriaster regularis* was initially described by Jangoux (1984) from New Caledonia as a member of the Solasteridae. Subsequent work (Mah & Fujita 2020) argued for closer affinity to *Hyalinothrix* and the subfamily Hyalinothricinae, placed within the Asterinidae, as represented by *Tarachaster i*n a three gene overview of the Valvatacea (Mah & Foltz 2011).

Distribution data for *Seriaster regularis* increasingly indicates that it is widespread, extending from Southern Japan, New Caledonia, Vanuatu, the Philippines, the

New Hebrides, and Madagascar, between 25 to 313 m. This occurrence is the second for the Indian Ocean, but is the first record of this species from Australian waters.

Ecological Comments
In situ observations from Ashmore reef (not figured). This species was moving over a coarse, pebbly loosely consolidated sedimented bottom covered by flocculent organic debris.

Occurrence/Distribution
Australia: Ashmore Reef, Western Australia. 141.0 m.
Outside Australia. Japan (Ogasawara & Ryukyu Islands), New Caledonia, Vanuatu, New Hebrides, Philippines, Madagascar, 25–313 m.

Material Examined
WAM Z97599 Ashmore Reef, North side, outer reef slope. Western Australia, 12.14439852°S 123.04234911°E, 141.0 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/S0411, 17 April 2021, 1 wet spec R=4.7 r=0.6. 8 arms.

ASTERODISCIDIDAE Rowe, 1977

Rowe 1977: 190; 1985: 532; Rowe & Gates 1995: 42; Marsh & Fromont 2020: 189; Mah 2021: 405

Diagnosis
Abactinal surface with conical spines with broad bases or tubercles. Superomarginal spines strongly convex to strongly arched, demonstrating a spine-like process in some genera. Intermarginal plates in all save *Kionaster*. Intermarginal papulae present in all but *Goniaster* and *Kionaster*.

Comments
The Asterodiscididae was established by Rowe (1977) in order to more precisely recognize affinities between *Asterodiscides, Amphiaster, Paulia,* and *Pauliella*. Mah (2021) has summarized and refined taxa assigned to this grouping, including *Kionaster*, from the Miocene of Florida (Blake & Portell, 2011), *Uokeaster* from Rapa Nui (Easter Island) and arguing that *Goniaster,* the type genus of the Goniasteridae, including the largest number of asteroid genera, is also an asterodiscidid. Thus, further understanding of asterodiscidid monophyly possesses broader implications.

Rowe and Clark (1995) have summarized all Australian *Asterodiscides*, the only asterodiscidid genus known from Australia. A summary of shallow-water Australian *Asterodiscides* species has been provided by Marsh & Fromont (2020).

Asterodiscides A.M. Clark 1974

A.M. Clark 1974: 435; Rowe 1977: 192; 1985: 532; H.E.S. Clark & McKnight 2001: 141; Mah 2021: 408.

Diagnosis
Mostly from Marsh & Fromont (2020). Body form pentagonal to stellate with R/r ranging from 1.1–2.0. **Superomarginal plates 3–4, of which the distalmost are larger than 2–3 proximal plates. These plates bare and prominent, except for *A. culcitulus* which has plates similar in size to the three proximal plates.** Abactinal tubercles variably shaped, highest at 4.0 mm. Actinal granulation and tuberculation varied with inter marginal papulae present. Furrow spines 3–7, subambulacral spines in one to three series (mostly one or two).

Comments
Asterodiscides is known from 18 species known throughout the Indo-Pacific, which occur in shallow to deep-water settings, ranging from 7 to 804 m (Rowe & Gates 1995) with seven species recorded from Australian waters. Marsh & Fromont (2020) listed six species from shallow-water habitats (<30 m depth). The new species described herein is the eighth Australian species and the second from deeper-water (156 m). *Asterodiscides grayi* Rowe, 1977 is the other deep-water species from 71–108 m.

Rowe (1977, 1986) and Lane & Rowe (2009) have provided extensive monographs for the species in this genus. Although known to be diverse, relatively little information has been documented regarding species biology and ecology. Marsh & Fromont (2020) have shown *A. truncatus* (Coleman, 1911) feeding on sponges.

Asterodiscides conulus Mah sp. nov.
Figures 6A, 7A–F

Etymology
The species epithet *conulus* is derived from the Latin for cone, alluding to the abactinal spine shape.

Diagnosis
Species distinguished by weakly stellate body (R/r=1.8), **cone-like pointed spines, 5–6 large, bald superomarginal plates per interradius, 5–6 furrow spines and 2 series of thickened, enlarged subambulacral spines followed by a single thickened enlarged spine.**

Comments
Asterodiscides conulus **sp. nov.** invited immediate comparison with other species displaying bare superomarginal plates with comparable numbers of furrow spines (5–7) and 2 subambulacral spines, including *A. lacrimulus* Rowe, *A. tuberculosus* (Fisher, 1906), *A. grayi* Rowe, and *A. culcitulus* Rowe. Of these four, the latter, *A. culcitulus* displays a body form that is strongly pentagonal and cushion-shaped as opposed to the more stellate *A. conulus* **sp. nov.** *Asterodiscides conulus* **sp. nov.** is distinctly set apart from these other species based on the strongly convex distalmost pre-terminal superomarginal plates and more numerous round, bare interradial superomarginal plates. *Asterodiscides conulus* **sp. nov.** is further distinctive in that the abactinal and lateral

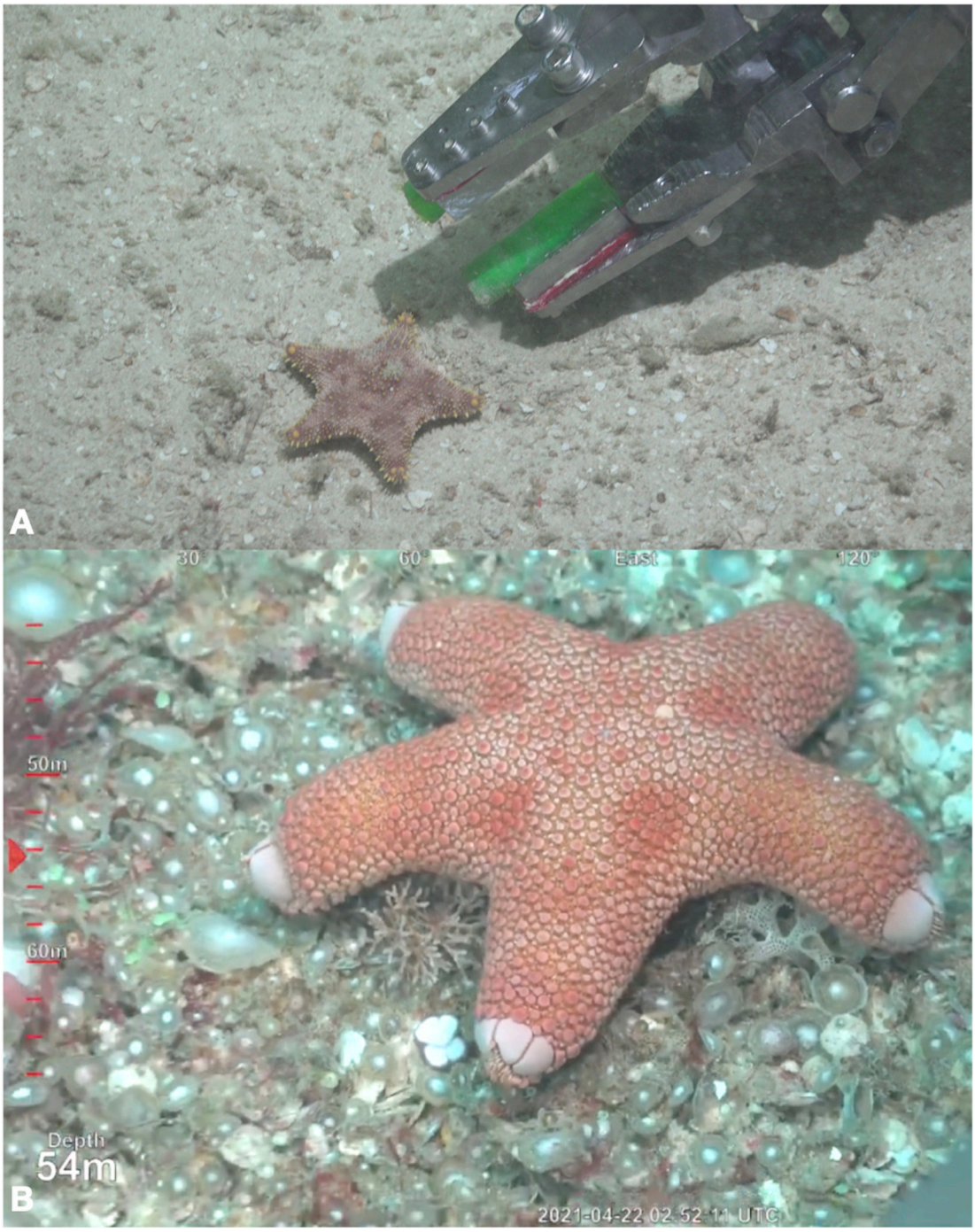

FIGURE 6. *Asterodiscides in situ*. a. *A. conulus* **sp. nov.** WAM Z97603 B. *A. soleae.* WAM Z97660 No scale.

surfaces are covered with distinctly conical spines which are absent in similar species such as *A. tuberculosus*.

Relative to other stellate (R/r=1.8) Australian *Asterodiscides* as summarized by Marsh & Fromont (2020), *A. conulus* **sp. nov.** possesses conical spinelets rather than blunt tubercles, as present in *Asterodiscides truncatus* and *A. pinguiculus* and the distalmost superomarginals are strongly convex rather than flat, as in *Asterodiscides soleae*. *Asterodiscides conulus* **sp. nov.** most closely resembles *Asterodiscides japonicus* Imaoka *et al.* (1991) with which it shares the presence of conical spines on the abactinal surface but differs in the number of furrow spines. In *A. conulus* **sp. nov.**, at R=4.2 has 5–6 furrow spines versus A. *japonicus* which displays 6–8 at R=6.4 to 7.8. Actinal tubercles on A. *conulus* **sp. nov.** are also much fewer and not as closely distributed as they are in *A. japonicus*. The more weakly stellate to pentagonal *A. macroplax* shares the presence of conical, pointed tubercles as seen in *Asterodiscides conulus* **sp. nov.** but is further distinguished in that the distalmost subterminal superomarginals are flat rather and elongate rather than strongly convex.

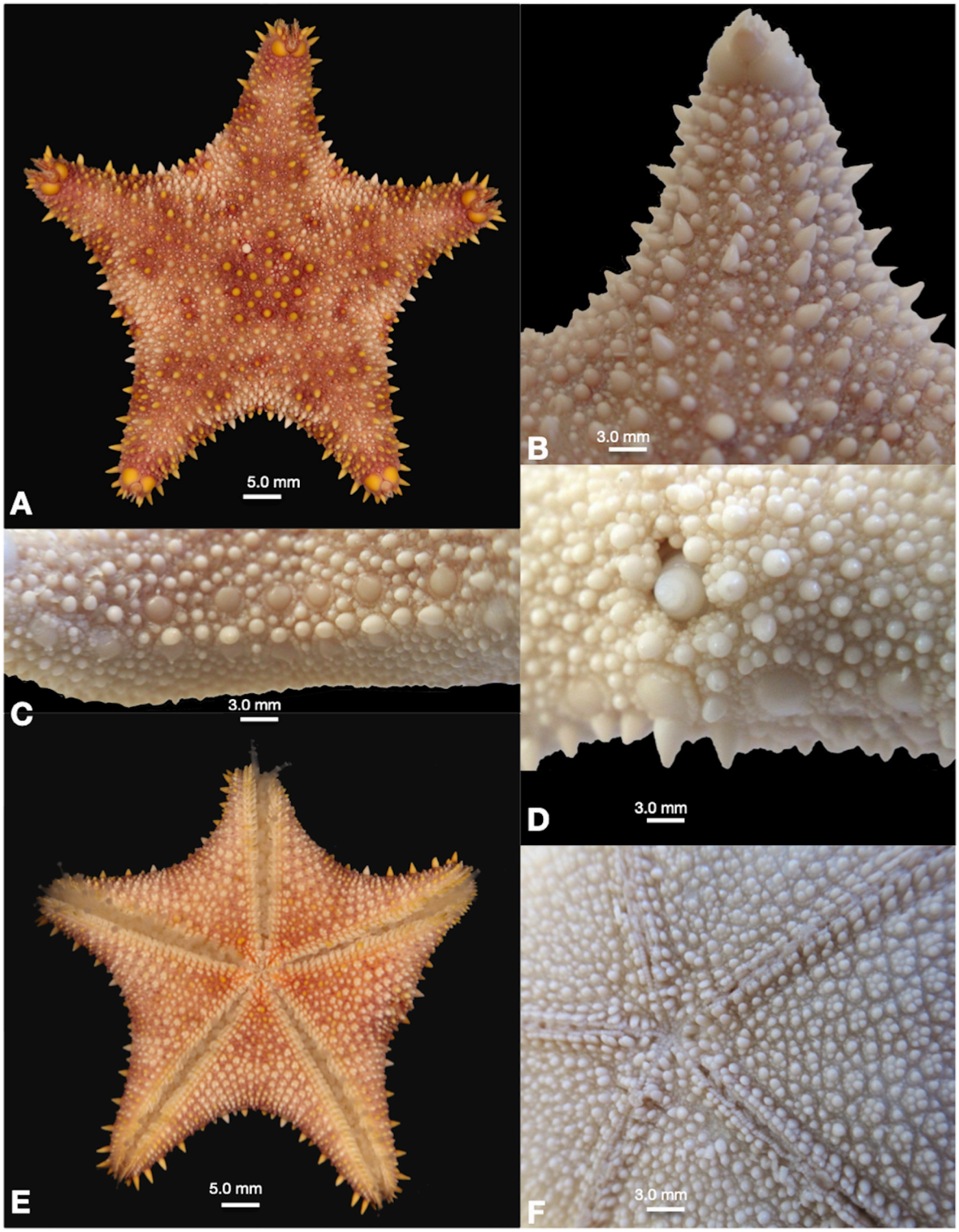

FIGURE 7. *Asterodiscides conulus* **sp. nov.** Holotype. WAM Z97603. A. Abactinal. B. Arm tip. C. Lateral showing marginal plates. D. Parasitic eulimid on actinal interradial region. E. Actinal surface. F. Closeup oral region, adambulacral spines.

Ecological Comments

The holotype was collected from a surface composed of mixed sediment, including light-colored sand and coarse cobbles, shelly fragments and rocks.

A eulimid snail parasite resides within the actinal surface of the holotype. No other accounts of eulimids parasitizing asterodiscidids could be located suggesting that this is a novel occurrence.

Occurrence/Distribution

Ashmore reef, Western Australia. 156 m.

Description

Body, thick, weakly stellate (R/r=1.82) in shape, Arms triangular, interradial arcs weakly curved to straight.

Abactinal plates round to polygonal in shape, surface covered by thick, cone-shaped spines, variably blunt to more

pointed depending on size bearing smooth surfaces. Largest, conical spines present on central disk and along carinal and approximately three adradial series along arm on either side of the central plate series. Adradial series form irregularly curved series along each plate with an alternating series of large round, smooth tubercles with interstitial plate series bearing smaller, spherical tubercles, approximately 50% of the size of the larger adradial series. Larger tubercles surrounded by numerous papulae, 9–30 surrounding each. Papulae present on abactinal surfaces primarily on arms with fewer papulae on disk and interradial areas. Interradii with convergence of adradial series leading to abundant tubercles and smaller, more irregular plates. Pedicellariae, straight valves, forceps-like present alongside tubercles on a minority of adradial series. Madreporite not observed. Anus with spines, five, flattened, pointed. Tubercles, 5–6 present around anal spines.

Marginal plates identical with abactinal plates, occurring between larger more prominent marginal plates. Superomarginals, large, round smooth and hemispherical in shape, 5–6 visible in each interradius. Each plate with peripheral granules, quadrate to polygonal in shape, 20–30 per side. Smaller plates, identical to abactinal plates present in between larger plates. Inferomarginal plates, 12–15, each with prominent, cone-shaped spine similar to those on the abactinal plates, surrounded by peripheral granules, approximately 15–28 per side. Marginal plates that are not oversized, resemble abactinal plates and as such, not conspicuous part of superomarginal or inferomarginal series. Distalmost inferomarginals covered with coarse, quadrate granules and smaller distinct spines. Pre-terminal superomarginal oversized, round and strongly convex , round in shape, flanked by inferomarginals, three to four. Terminal plate triangular, surface smooth.

Actinal surface large, composed of 5–6 full series in chevron formation. Individual plates round to irregularly polygonal in shape. Each plate has one or two cone-shaped or round tubercles with a smooth surface. Secondary granules, 3–15 present on each plate, approximately 50–70% of these granules are half the size or smaller than the primary tubercle.

Furrow spines with blunt tips, 5–6, exceptionally 4, with numbers decreasing distally. Quadrate in cross-section with curved sides. Two subambulacral series, first series adjacent to furrow spines, two spines, each twice as thick as a single furrow spine, blunt-tipped and sitting approximately 40% above the height of the furrow spine. Second subambulacral series with a single, large tubercular spine per plate. This spine with a cone-shaped tip, approximately 2–3 times the thickness of a single furrow spine. Remainder of adambulacral plate with smaller sized granules similar in shape to those on actinal plates. Oral plates with furrow spines, 10, blunt, quadrate in cross-section, close-set. Oral plates with large, cylindrical spines, blunt, easily 2 to 3x the thickness and height of the adjacent furrow spines. Remainder of oral plate surface with 6–8 quadrate granules present.

Color *in situ* was mottled with darker purple blotches on disk center with lighter white to lavender present interradially with white to yellow spination. Distalmost superomarginal plates were a dark yellow.

Material Examined

Holotype. WAM Z97603 Ashmore Reef, Western Australia, 12.14428905°S 123.04127446°E, 156.14 m, Coll. N.G. Wilson, C.S. Whisson, FK210409/SO411, Coll. 17 April 2021. 1 wet spec. R=4.2 r=2.3.

Asterodiscides soleae Rowe 1985

FIGURE 6B, 8A–E

Rowe 1985: 547; A.M. Clark 1993: 292; Rowe & Gates 1995: 43; Marsh & Fromont 2020: 206

Diagnosis

Species identified by the large pre-terminal superomarginal plate, flat-topped abactinal tubercles, furrow spines 3–4, stellate body shape, and a single subambulacral spine.

Comments

This species is largely consistent with this species as outlined in Marsh & Fromont (2020) and Rowe (1985), with flattened distalmost superomarginal plates, three furrow spines, a single subambulacral spine and consistent stellate body shape (R/r=2.0). Its occurrence herein falls within prior depth and distribution records.

Ecological Comments

The collected specimen was observed on a substratum composed of bryozoans and large foraminifera.

Occurrence/Distribution

Ashmore Reef and Houtman Abrolhos, Western Australia. 20–80 m. Outside Australia. New Caledonia.

Material Examined

WAM Z97660 Ashmore Reef, northeast side, outer reef slope, Western Australia, 12.13434682°S 123.18785844°E, 56.23 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO416, 22 April 2021. 1 wet spec. R=6.2 r=3.1

BRISINGASTERIDAE Mah 1998

Diagnosis

Arms 12–13, elongate. Abactinal (disk and proximal arm) skeleton open reticulate, papulae present between abactinal meshes.

Comments

A monotypic family established by Mah (1998, 1999) that includes the stemward *Brisingaster* as determined by phylogenetic analysis of morphology by Mah (1996, 1998). Subsequent molecular phylogenetic data has supported this result (Zhang *et al*., 2019).

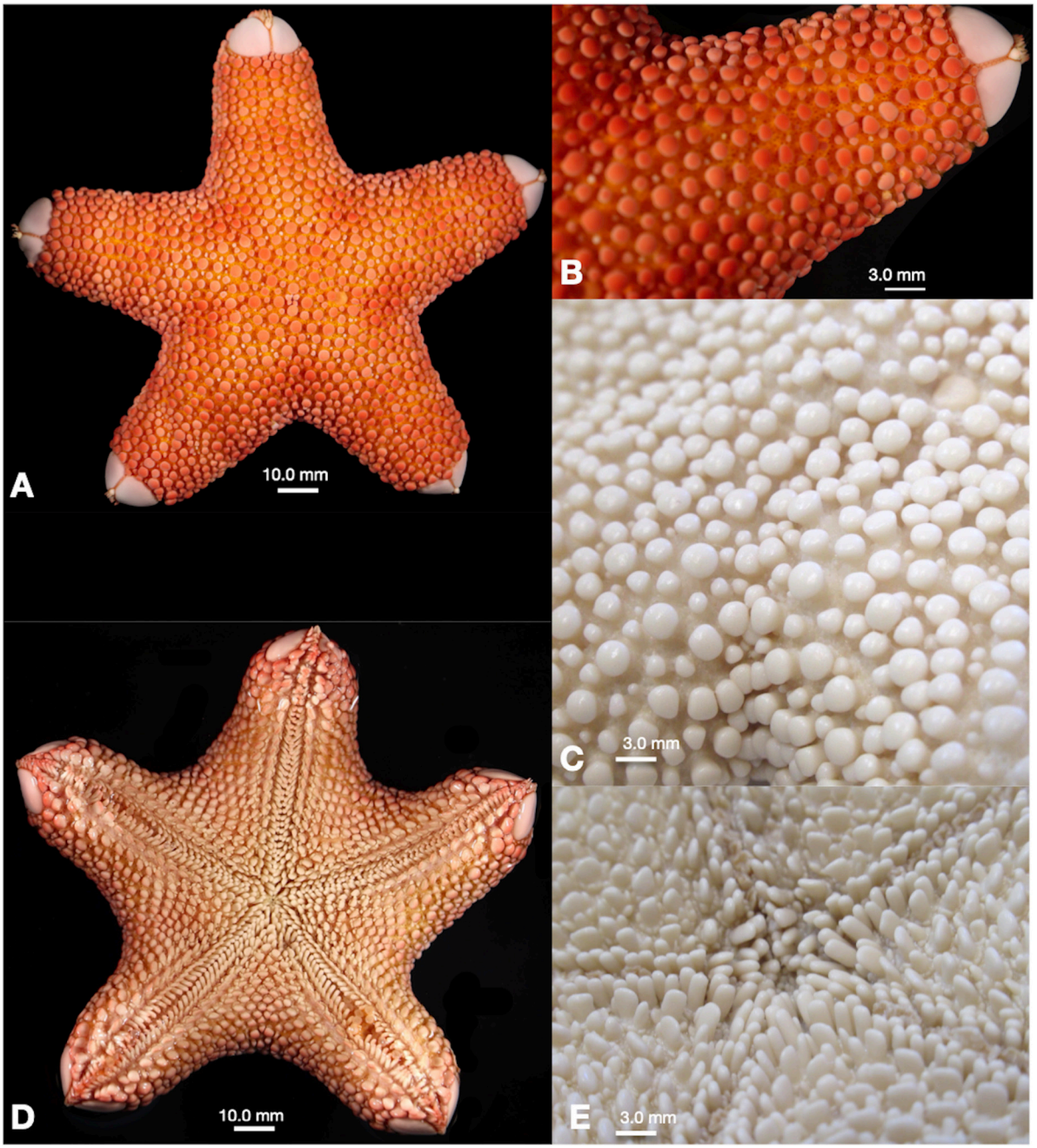

FIGURE 8. *Asterodiscides soleae* WAM Z97660. A. Abactinal. B. Arm tip. C. Abactinal close. D. Actinal region. E. Closeup oral region.

Brisingaster de Loriol, 1883

Brisingaster de Loriol 1883: 55; Mah, 1999: 535

Diagnosis & Comments

As for species below.

Brisingaster robillardi de Loriol, 1883

Figure 9A–D

Brisingaster robillardi de Loriol 1883: 55; Fisher 1917: 419;1919: 502; 1928: 5, 1940: 205, Spencer & Wright 1966: U78; Clark & Downey, 1992: 464, Mah, 1999: 535; McKnight 2006: 77. Mah, 2022: 9; Zhang *et al*. 2024: 17 (for explanation of *B. helenae*)

Diagnosis

Arms 12–13 (on specimens herein but up to 11 in others). Disk inflated, round. Reticulation irregular, not concentric. Disk spines wide, bifid spination. Skeleton on disk and arms reticulate. Papulae present between reticulate skeletal regions on disk and arm areas. Adambulacral plates vertebrae-shaped but squat with distinct tissue-filled space between plates. Each plate with single adambulacral spine, with variable tips. **Adambulacral spines adjacent to mouth and those from midpoint onwards with pointed tip, but those**

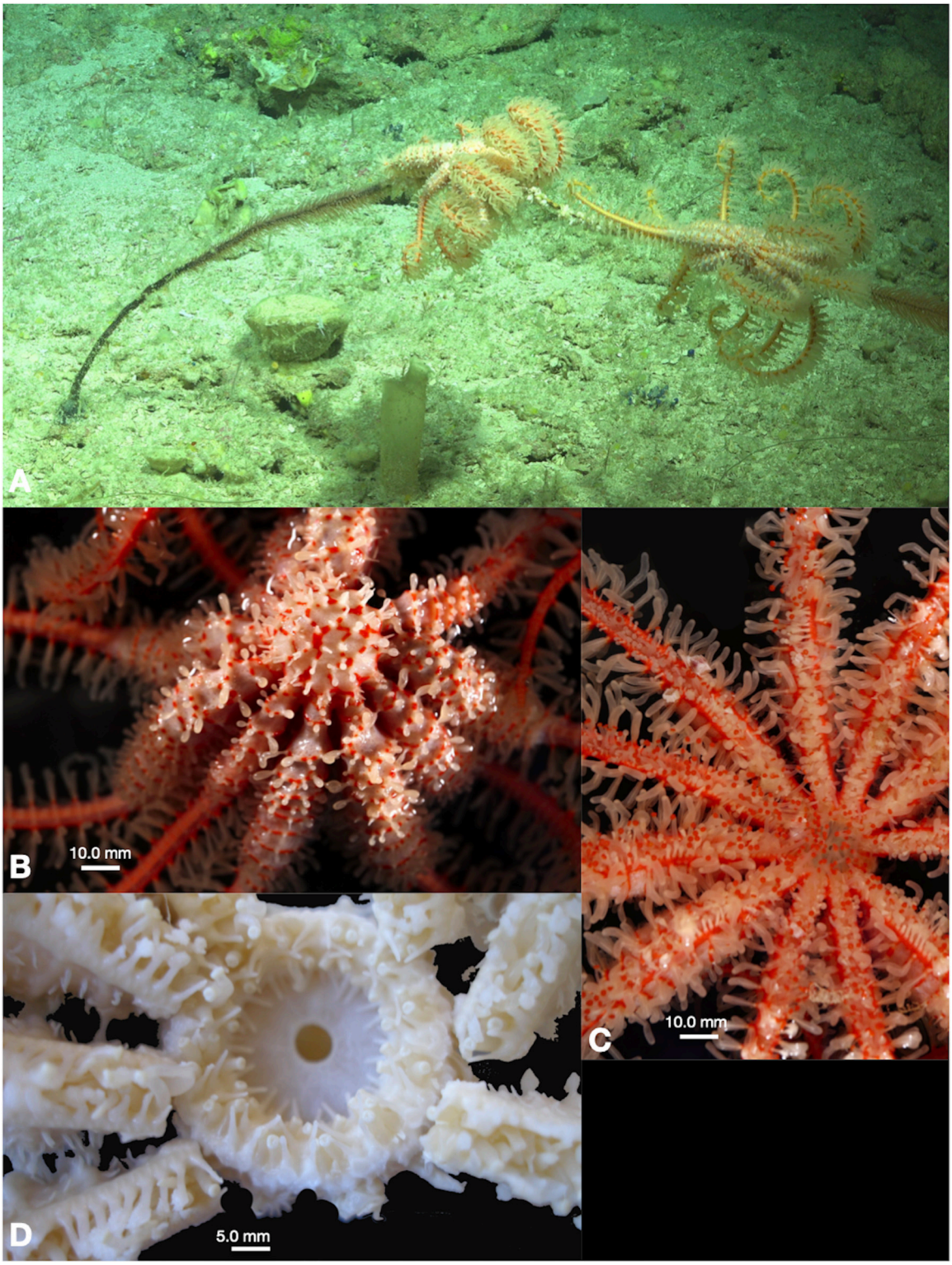

FIGURE 9. *Brisingaster robillardi* A. *in situ* WAM Z97549 and Z97550. No scale. WAMZ97549. B. Abactinal. C. Actinal. D. Closeup oral region.

adambulacrals located proximally with wide, club-shaped tips

In situ color was a light orange with dark orange-red highlights on the skeletal ribs and reticulations on the proximal arm region. Actinal surface and distal arm tips were deep-orange. Lateral spines were white with an orange base.

Comments

An account of this genus (Mah 2020) showed that it was present widely throughout the tropical Pacific and Indian Oceans, extending as far north as Okinawa and into the eastern coast of Africa and the western Indian Ocean. This species was first documented from the Tasman Sea (Rowe 1989) but was misidentified as *Novodinia*. This specimen

is the first from Australia's Indian Ocean coast and the first account of this species from this region.

Zhang *et al*. (2019) showed a separation between the Indian Ocean *B. robillardi* and the Pacific *Brisingaster helenae* based on molecular data, but found no morphological differences between the two species. Further studies of these species throughout its range are desirable. An isopod (WAM C76509) and a barnacle (WAM C76510) were associated with specimen WAM Z97549.

Ecological Comments
Specimens documented here were perched on the stalk of an antipatharian (black coral) (Fig. 9A). The distal ends of both arms were folded or bent and appeared to be turned into the water current.

Occurrence/Distribution
Australia. Off Norfolk Island, Trygon Seamount, Tasman Sea and Clerke and Ashmore Reef, Western Australia. 167–200 m.

Outside of Australia. **Pacific.** Japan (Okinawa region), American Samoa (Tutuila seamount), Central Pacific (Anuu'u seamount), Vanuatu, Fiji Islands, New Caledonia. **Indian.** Mauritius, Madagascar, Sodwana Bay, South Africa, Walters Shoal (southern Indian Ocean). 100–1220m.

Material Examined
WAM Z2737 Clerke Reef, Western Australia, 17º54'12"S 119º17'30"E, 200 m. Coll. L.M. Marsh, 18 Aug 1995. 1 dry spec. R=~14.0 r=0.6.

WAM Z97550 Ashmore Reef, Western Australia, 12.31993468°S 123.09036509°E, 167.31 m, Coll. N.G. Wilson, C.S. Whisson. Station FK210409/SO406, 11 April 2021, 1 wet spec. R=~15.0 r=1.4.

WAM Z97549 Ashmore Reef, Western Australia, 12.31993468°S 123.09036509°E, 167.31 m, Coll. N.G. Wilson, C.S. Whisson. Station FK210409/SO406, 11 April 2021, 1 wet spec. R=17.3 r=0.8.

ECHINASTERIDAE Verrill, 1867

Diagnosis
Body stellate to strongly stellate, small disk, elongate arms, round, cylindrical in cross-section. Skeleton reticulate or loosely tessellate, covered by distinct dermis of variable thickness with spines single or in groups. Marginal plates variable. Pedicellariae absent. Adambulacral spines covered in dermis, many in vertical series. (after Marsh & Fromont 2020).

Comments
The Echinasteridae includes eight genera, including two of the most species-rich and problematic of known genera, *Henricia* and *Echinaster* both known to be difficult owing to a high level of variation, overlapping species definitions, and relatively few, apparent characters, among other difficulties. Molecular data has further complicated understanding by revealing cryptic species distinguished by different characters than those which had previously been used to diagnose taxa (e.g. Eernisse & Strathmann, 2010, Lopez *et al*., 2016).

Rowe & Gates (1995) list 14 species in five genera from Australian waters. Marsh & Fromont list 10 species in three genera from shallow (<30 m) depths.

Echinaster Müller & Troschel, 1840

Diagnosis
Body stellate, to strongly stellate, disk small, arms elongate, cylindrical. Abactinal skeleton reticulate with pronounced spines present individually or in clusters. Adambulacral spines in vertical series. Papulae abactinal and in some, inter marginal.

Comments
Echinaster is a genus including approximately 20 species distributed throughout shallow, tropical-water settings in the Indian, Pacific and Atlantic oceans. Lopes *et al.* (2016) evaluated Atlantic and Indo-Pacific *Echinaster* species with two mitochondrial and a single nuclear gene (COI, 16S and 28S) and concluded that there was support for *Othilia* as the sister clade to a clade containing *Henricia+Echinaster.* Species included within *Othilia* were primarily tropical western Atlantic species from Brazil, Florida and Mexico whereas most of *Echinaster* species were from Indo-Pacific localities with two representatives of *E. sepositus* from the Mediterranean and the East Atlantic.

Rowe & Gates (1995) list eight species of *Echinaster* from Australian waters, most of which appear to be supported as members of *Echinaster* as per Lopes *et al.* (2016). Marsh & Fromont identified all eight species of *Echinaster* from shallow water (<30 m).

Echinaster luzonicus (Gray, 1840)
Figure 10C–D

Othilia luzonicus Gray 1840: 282; A.H. Clark 1952 290
Echinaster luzonicus Müller & Troschel 1842: 23; H.L. Clark 1921: 98; Hayashi 1938b: 66; Domantay & Roxas: 1938: 230; Clark & Rowe 1971: 40, 42, 72; Hayashi 1973: 75; Marsh 1977: 278; Soota & Sastry 1979: 345; Liao 1980: 166; Marsh & Fromont 2020: 456
Echinaster eridanella Müller & Troschel 1842

Diagnosis
(Modified from Marsh & Fromont 2020). Disk small, arms 5 to 6 (up to 7), slender and cylindrical in cross-section. **Fissiparous with single arms regenerating to produce comet forms. Skeleton reticulate, close-set with numerous short, blunt spines (approximately 1.0 mm) and small papular regions bearing 3–10 papulae.** Two or more madreporites present. **Distinct dermis covers body.**

Collected specimen with six arms, a solid red-orange color with dark papular highlights and dark coloration on each arm tip.

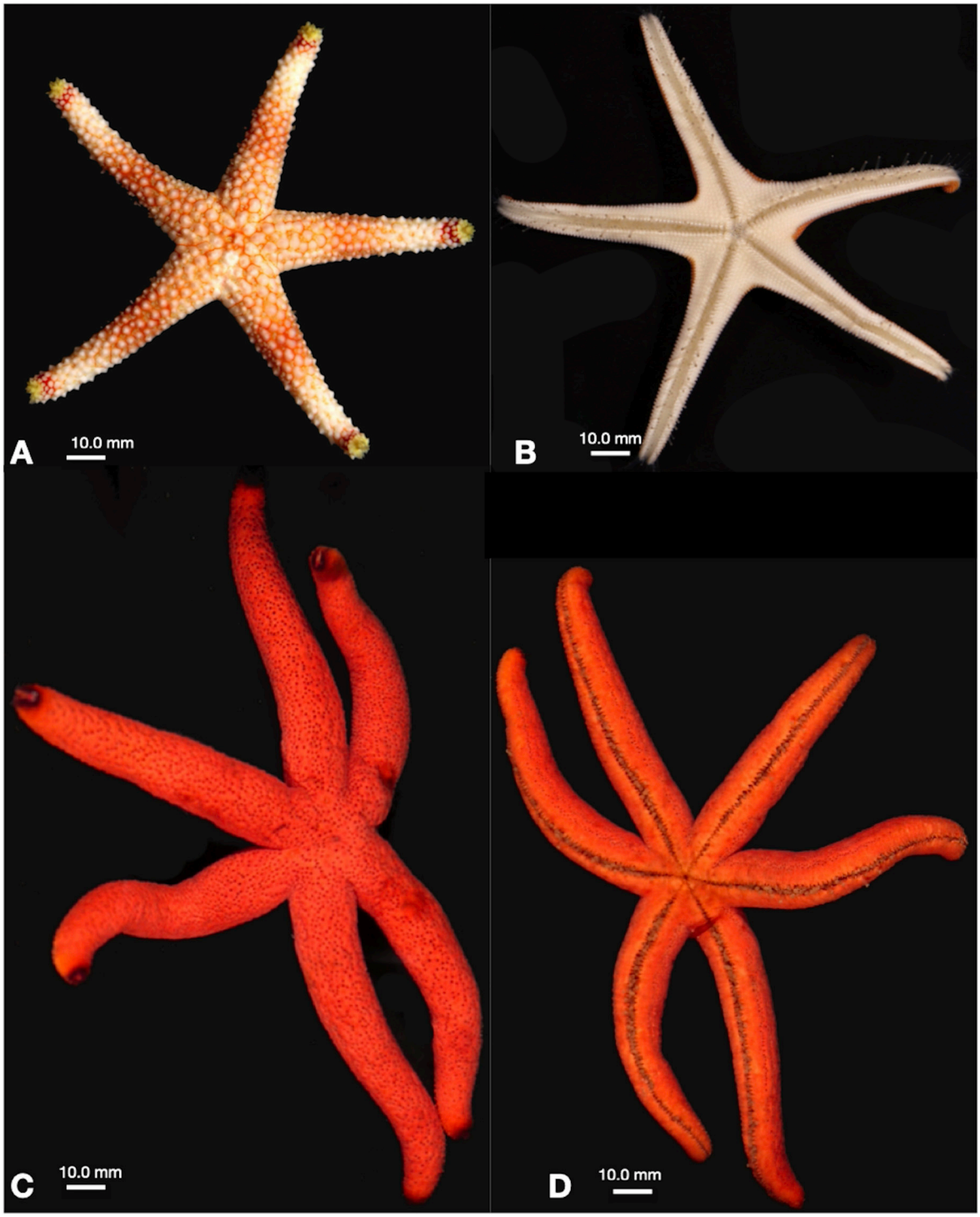

FIGURE 10. *Echinaster* spp. *Echinaster stereosomus* WAM Z97667. A. Abactinal. B. Actinal. *Echinaster luzonicus* WAM Z97677. C. Abactinal. D. Actinal.

Comments

A species that is commonly encountered throughout the tropical Pacific and from the northern coast of Australia (Marsh & Fromont, 2020). This is one of the few observed mesophotic species known from within previously established depth distribution, 0 to 60 m (as outlined by Marsh & Fromont 2020). Color and body morphology, including arm number are highly variable within this species but WAM Z97677 falls largely within the known range of variation.

Ecological Comments

Marsh & Fromont (2020) state that this species feeds on substrate biofilm and encrusting sponges. This specimen was observed on an unconsolidated bottom composed of foraminifera, hydroids, bryozoans, and other coarse rubble and miscellaneous encrusting organisms.

Occurrence/Distribution

Australia. From Ningaloo Reef, inshore and offshore islands of north-western Australia, Western Australia and

the Great Barrier Reef, Queensland, south to the Solitary Islands, New South Wales.

Outside Australia. Maldives, Bay of Bengal throughout the eastern Indian Ocean (Cocos (Keeling) Islands) through, Indonesia, the Philippines, Palau, New Caledonia north to Japan and east to Palmyra Island. 0–60 m.

Material Examined
WAM Z97677 Ashmore Reef, Western Australia, 12.22968711°S, 123.25706623°E, 46.153 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO418, 24 April 2021, 1 wet spec R=6.2 r=1.0, 6 arms.

Echinaster stereosomus Fisher, 1913
Figure 10A–B

Fisher 1913: 195; 1919: 430; H.L. Clark 1926: 3: Marsh 1976: 220; Jangoux 1978: 298; 1981b: 475.

Diagnosis
Modified from Marsh & Fromont (2020). Disk large, arms broad based, tapering and elongate. Spines short, conical, irregular series along arms. **Reticulations close-set with small papular regions bearing 1–6 papulae.** Surface covered by strongly developed dermis with spines exposed. Single madreporite. Non-fissiparous.

Color of the living, *in situ* specimen included dark red bands and highlights on proximal arm regions and on the disk with white coloring distal arm regions. Arm tips with a distinct red band. Colors consistent with those outlined in Marsh & Fromont (2020).

Comments
Occurrence of this species from Ashmore Reef at 150 m is consistent with prior accounts indicating an Indo-Pacifc distribution between 5–146 m (Marsh & Fromont, 2020). Morphology of the specimen was consistent with those of other Australian specimens.

Ecological Comments
The specimen was collected from a light, sandy bottom, coarse with some stones and rocks. Flocculent material present.

Food and ecology of this species are unknown,

Occurrence/Distribution
In Australia. Shark Bay and the inner continental shelf off Western Australia, from Kalbarri (27º40'S) around northwestern and northern Australia and on the Queensland Shelf to Dangar Point, New South Wales.

Outside Australia. Indonesia, the Philippines, Hainan Island (Southern China)

5–146 m (now 149 m) (all based on Marsh & Fromont, 2020)

Material Examined
WAM Z97667 Ashmore Reef, Western Australia, 12.23137041°S 123.27525646°E, 149.85 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO417, 23 April 2021, 1 wet spec R=2.9 r=0.7.

New Genus, New Species (in prep)
FIGURE 11A–C

Comments
This species is a further occurrence of an undescribed echinasterid which has been observed from throughout the Indo-Pacific at shallow to mesophotic depths and is in process of description by Fau *et al.* (in prep.)

Ecological Comments
No ecological data was available for this specimen during collection.

Occurrence/Distribution
Ashmore reef, 97.0 m. Widely occurring throughout the Indo-Pacific in shallow-settings. Description in preparation.

Material Examined
WAM Z97638 Ashmore Reef, outer reef slope, SE side, Western Australia, 12.13922643°S 123.20777125°E, 96.7 m, Coll. N.G. Wilson & C.S. Whisson aboard RV *Falkor*, Station FK210409/SO415, 21 April 2021. 1 wet spec. R=~2.75 mm r=1.0 mm.

GONIASTERIDAE

Diagnosis
Body shape pentagonal to strongly stellate, variably thick and strongly arched to flat, variably soft to stout. Body surface ranges from bare and smooth to covered, completely or partially by thick granule-covered dermis. Abactinal surface highly variable displaying a wide range of granules, tubercles, spines, pedicellariae and other accessories. Marginal plates blocky forming well-defined periphery with either lateral or abactinal-facing surface, each plate variably bare, or covered with granules, spines or pedicellariae. Several genera with superomarginal plates abutted over midline, variably along whole length or partially near the arm tip. Actinal plates quadrate to polygonal in shape, arranged in distinct chevron series with full series adjacent to adambulacral plates. Actinal plates with variable cover of granules, spinelets or pedicellariae as well as larger spines or larger plate-size pedicellariae. Adambulacral plates with furrow spines projecting into tube foot grooves as well as adjacent subambulacral spines. Adambulacral spines variably granular, tubercular or spinose.

Comments
The Goniasteridae is the most diverse family within the Asteroidea (Mah & Blake, 2012) including over 70 extant genera and >260 species. At present, at least three subfamilies, the Ferdininae Mah 2017 (6 genera), the Hippasterinae Verrill, 1899 (4 genera), and the Pentagonasterinae Perrier, 1884 (8 genera) are recognized.

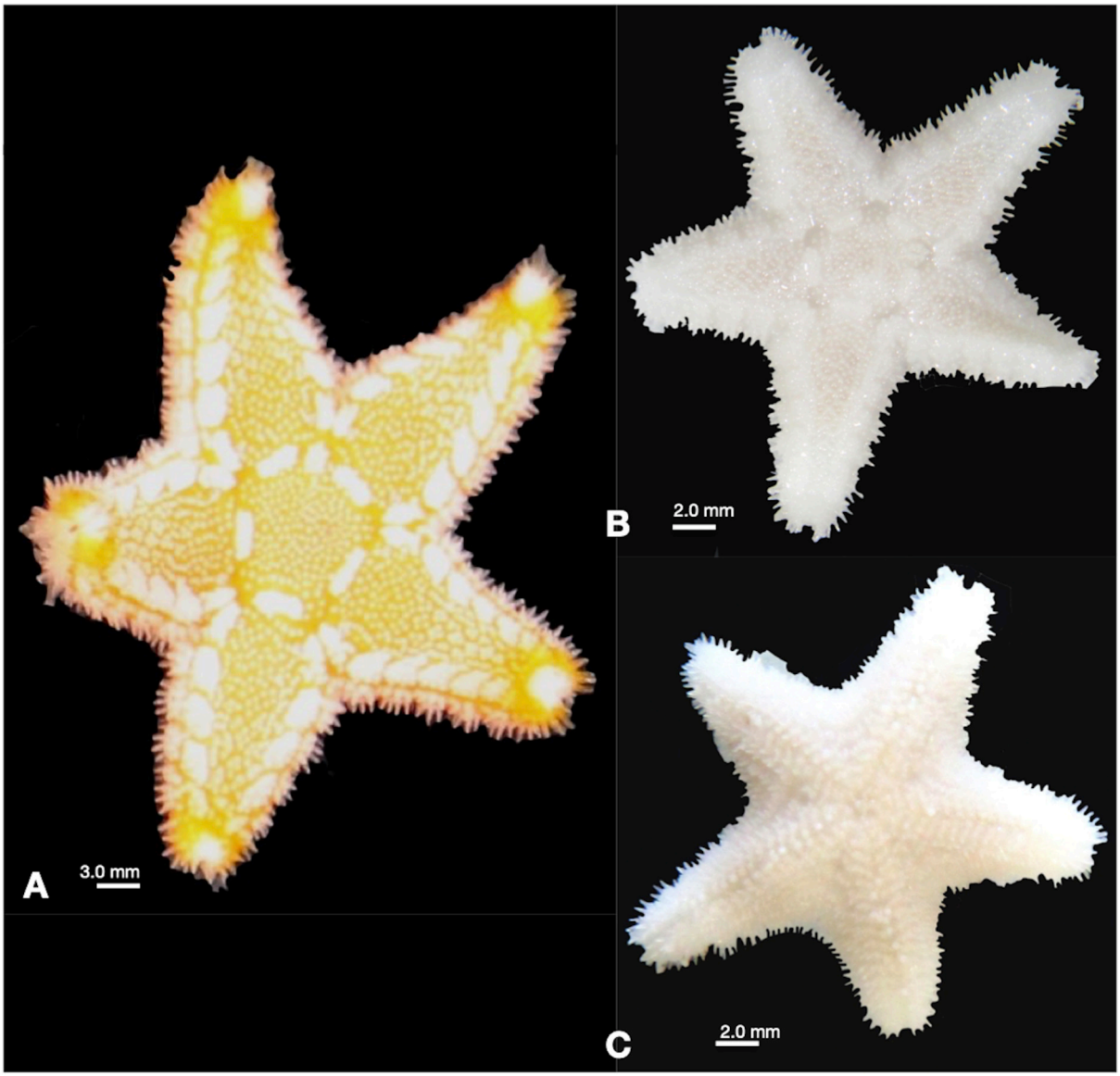

FIGURE 11. Echinasteridae n. gen. **sp. nov.** WAM Z97638, description in preparation. A. Abactinal–living. B. Abactinal–preserved specimen. C. Actinal view.

Identification of subgroupings within the Goniasteridae remains ongoing. The Goniasteridae are present widely in the Pacific, Atlantic, and Indian Oceans from 0 to 4000 m. Description of undiscovered biodiversity is an active area of research (Mah 2015, 2016, 2017, 2020, 2022).

Molecular phylogenetic work has provided clarification to the boundary between the Goniasteridae and other families within the Valvatida, showing, for example, that two historically ophidiasterid genera, *Fromia* and *Neoferdina*, were members of the Goniasteridae (Mah & Foltz 2011), leading to the possibility that other genera within the Ophidiasteridae with goniasterid affinities, such as *Dissogenes*, are members of the Goniasteridae. It should be noted that the Goniasteridae shows morphological overlap with other families, such as the Oreasteridae, and some genera, such as *Anthenea* or *Goniodiscaster*, have occupied historically contentious positions (e.g. Döderlein,1935, 1936 versus Clark & Rowe 1971).

Shallow-water Goniasteridae, including 30 species in 12 genera (depth <30 m) have been documented by Marsh & Fromont (2022). Below 30 m, Rowe & Gates (1995) list an additional 15 species in 9 genera. A majority of Australia's deep-sea (>200m), including its mesophotic asteroid fauna remains undocumented and poorly understood.

Calliaster Gray, 1840

Calliaster Gray 1840: 280; Döderlein 1922: 47; A.M. Clark & Courtman-Stock 1976: 60; A.M. ; Aziz & Jangoux 1985:585; A.M. Clark 1993: 246; Rowe & Gates 1995: 64.

Astrothauma Fisher 1913: 645; 1919: 320; A.M. Clark 1993: 246; Liao & Clark 1995: 91; Kogure *et al*. 2011: 83.

Mabahissaster Macan 1938: 391; A.M. Clark 1993: 261; Rowe & Gates 1995: 64

Milteliphaster(in part) H.E.S. Clark 1982: 35, figs 1–7; Rowe 1989: 289; A.M. Clark 1993: 264; Rowe & Gates 1995: 66; H.E.S. Clark & McKnight 2001: 82.

Diagnosis
Body strongly stellate. A highly variable goniasterid group whose **primary characters include the presence of one to several enlarged subambulacral spines present in transverse series, enlarged conical pointed spines present on abactinal, marginal and actinal plates. Abactinal, marginal and actinal plate surfaces bare and smooth.** Marginal plates form a prominent abactinal border in most genera but this varies among species. Superomarginals in most taxa abutted over midline.

Comments
Calliaster is known throughout the tropical and subtropical Indian and Pacific oceans from mesophotic and upper to middle deep-sea settings (approximately 80–850 m). Eighteen species of *Calliaster* are known, following synonymy and revision of other "*Calliaster*" group members such as *Astrothauma* and *Mabahissaster (*Mah, 2018, 2022). Aziz & Jangoux (1985) were the first to recognize morphological affiliation between *Calliaster* and affiliated genera. Two of these taxa were argued as synonyms pending further work (Mah 2018). Examination of specimen collections (Mah pers. observation) suggests that *Calliaster* is more diverse than has been described, an issue that is further complicated by what appears to be a high level of character variation within species.

At least five species of *Calliaster* are known from Australia (Rowe & Gates, 1995). This includes *Calliaster childreni* Gray 1840, *Calliaster erucaradiatus* Livingstone 1936, *Calliaster regenerator* Doderlein, 1922, *Calliaster spinosus* H. L. Clark, 1916, and *Calliaster wanganellensis* H.E.S. Clark, 1982.

Calliaster corona Mah sp. nov.
Figure 12A, 13A–D

Calliaster elegans A.H. Clark 1952: 284, Kogure & Fujita 2012: 254.

Etymology
The species epithet *corona* is Latin for crown or royal circlet, alluding to the spine pattern on the abactinal surface.

Diagnosis
Distinguished by the presence of **large prominent conical spines proximally, especially on the primary circlet of the disk and 1 to 4 plates along the proximal carinal series, but absent interradially.** Superomarginal plates abutted for approximately 4 pairs along the arm tip. Each superomarginal with two pairs of sharp conical spines on each interradial plate becoming more irregular along the arm. Pedicellariae paddle-shaped.

Comments
Specimens from Ashmore Reef, the Philippines and the Marshall Islands were identified as *Calliaster corona* **sp. nov.** A specimen identified by A. H. Clark (1952) from the Marshall Islands (USNM E7365) as well as a further specimen from the Philippines is argued as conspecific with *Calliaster corona* **sp. nov.** as described herein. These specimens share a prominent series of conical spines present on the primary circlet and along the carinal plate series. The Marshall Island specimen varies in lacking the distinctly elongate, conical spines on the marginal plates, having instead short blunt spines and tubercles. Many of the interradial abactinal plates on USNM E7365 display tubercles rather than being bare as they are on the holotype from Ashmore Reef.

This species shares several characters with *Calliaster elegans* and *Calliaster erucaradiatus*, suggesting a wide-ranging complex across the Indo-Pacific. These characters include the paddle-shaped pedicellariae, the strongly tumid superomarginal plates, the numerous abutted distalmost superomarginal plates and the prominent spines along the primary circlet and carinal plate series. *Calliaster corona* **sp. nov.** differs from *Calliaster elegans* in showing only single spines on each marginal plate series versus the latter species that displays 3 spines per inferomarginal as well as more interradial spination on the disk. *Calliaster erucaradius* lacks pedicellariae where *C. elegan*s and *C. corona* have paddle-like pedicellariae and has additional spination interradially on the disk surface. Other similar species include the Indian Ocean *Calliaster mammilifer* Alcock 1893 that has similar spination patterns to *C. corona* **sp. nov.** but with round tubercular spines without points and multiple inferomarginal spines rather than single spines in *C. corona.*

Ecological Comments
The holotype was collected from a rocky substratum, which was covered with encrusting metazoans, possibly sponges or cnidarians.

Occurrence/Distribution
Australia. Ashmore Reef. 177.0 m.

Outside Australia. Kumejima Island, Southwest Japan, Philippines and Marshall Islands. 122–200 m.

Description
Body stout, shape stellate (R/r=2.24), arms elongate, with rounded tips. Arms quadrate in cross-section, interradial arcs weakly curved to straight.

Abactinal plates round to polygonal in shape, flat with smooth surface. No surficial accessories. Plates present only on disk, absent from arms. Largest centrally on disk becoming smaller distally adjacent to superomarginal plates. Individual plates with small hemispherical granules, 4–30 evenly distributed around plate periphery. Prominent, conical pointed spines present on primary circlet and along basal carinal series on disk. A single spine present on central disk plate, 2–4 spines present on proximal carinal plates. Remainder of plates spineless, smooth with no other accessories. Papulae

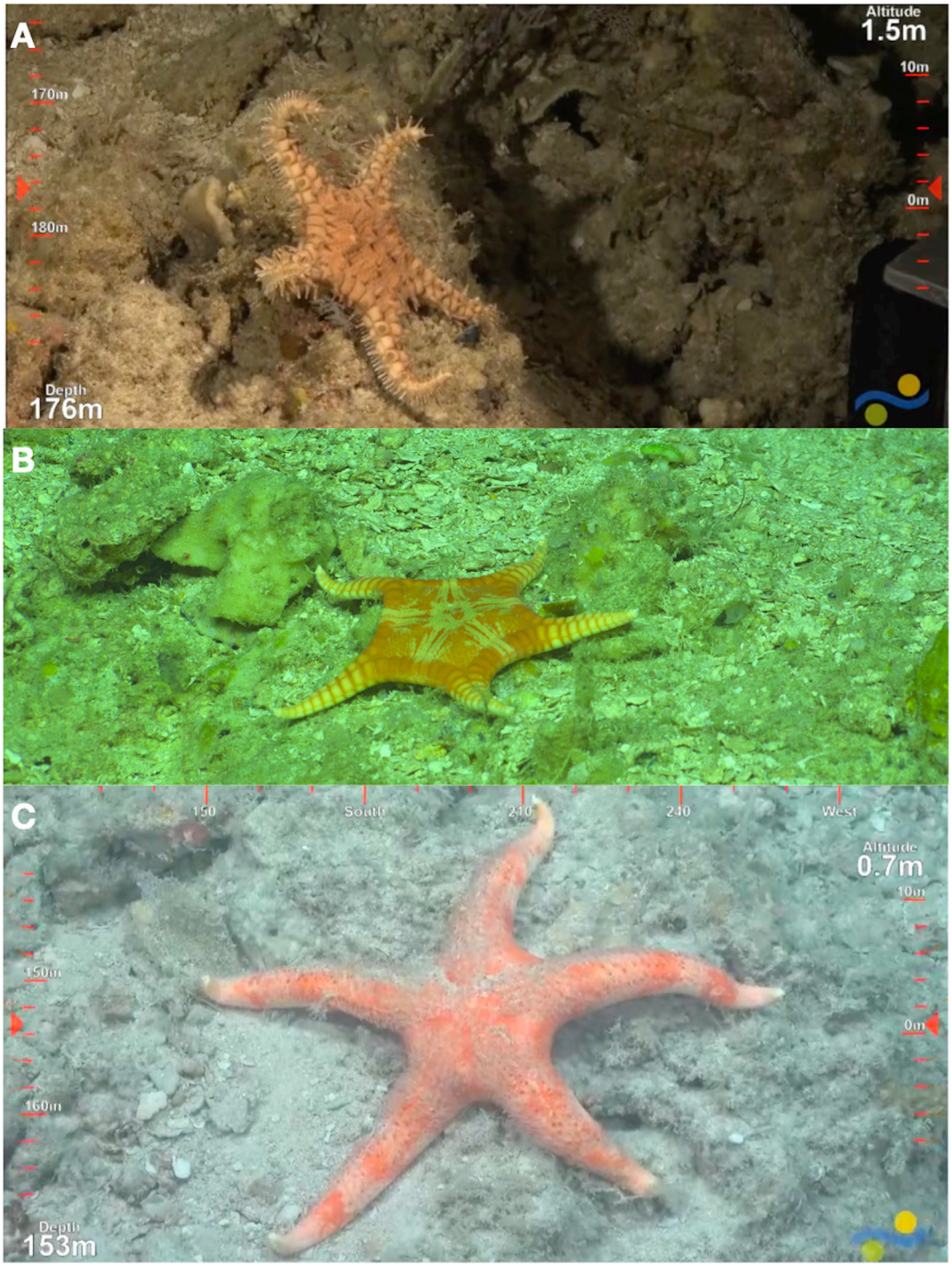

FIGURE 12. Goniasteridae *in situ* A. *Calliaster corona* **sp. nov.** WAM Z97556 B. *Churaumiastra hoshi* Mah *et al*. 2024. WAM Z97558 C. *Dissogenes dorikos* **sp. nov.** WAM Z97587 No scale.

present around proximal arm regions, with pores located around each plate. Madreporite round, flat, with weakly defined sulci, flanked by five adjacent plates

Marginal plates 13 per arm side, 26 per interradius with superomarginals forming a distinct periphery occupying 28% (0.7/2.5) of the disk radius ("r"). Superomarginal and inferomarginal series offset forming zigzag contact. Superomarginals abutted over midline, 9 pairs occupying arm surface. Superomarginal plates tumid, wide, quadrate in shape with rounded abactinal-lateral edge, most with pronounced conical pointed spine present. Spines presenting a distinct fringe around periphery. Marginal plate surface otherwise smooth and bare. Spines present in series interradially on upper side of superomarginal plate adjacent to abactinal plate contact, becoming more irregular along arm series, occupying upper, central and lower locations on plate surface, in offset, alternating series in some individuals. Inferomarginal plates with spine in regular series along the arm and along upper plate edge and central surface on interradial plates.

Actinal surface small with approximately 2.5 plates

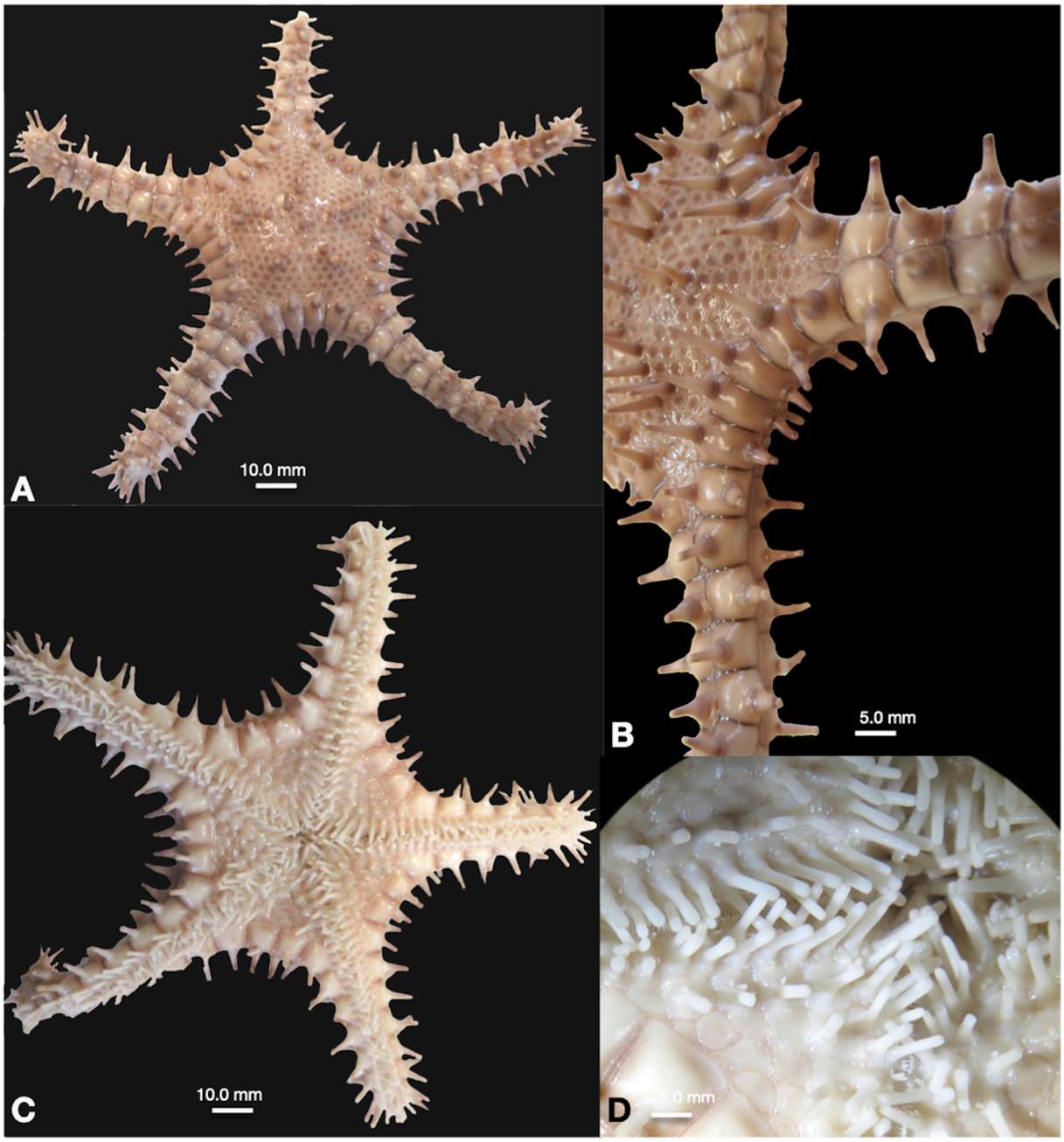

FIGURE 13. *Calliaster corona* **sp. nov.** Holotype. WAM Z97556. A. Abactinal. B. Abactinal–lateral view. C. Actinal. D. Closeup Actinal–oral view.

in series. Each plate is weakly tumid, with granules forming periphery. Shallow fasciolar groove present between plates. Spines, blunt, cylindrical present on plate surface of actinal series adjacent to adambulacral series. Remainder of actinal plates bare and smooth with no accessories. Approximately four inferomarginals in contact with actinal intermediate plates with no other actinal plates beyond those on the disk. Paddle-like pedicellariae, at spine base on actinal plates adjacent to adambulacral plate series.

Furrow spines 10, blunt, decreasing to 7 distally, sharply decreasing in number adjacent to arm tip arranged in straight series. Subambulacral spines two in transverse series. Oral region crowded with spines directed into mouth, approximately 7–10 (difficult to access). Elongate blunt, cylindrical spines, 4, present on oral plate surface with approximately 5–6 granules on edge of each oral plate fissure.

Material Examined

Holotype. WAM Z97556 Ashmore Reef, Western Australia, 12.32008409°S 123.0902967°E, 177.0 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO406, Coll. 11 April 2021, 1 wet spec. R=~5.6 r=2.5.

Paratypes. USNM E7365, Off Bikini Island, Bikini Atoll, Ralik Chain, Marshall Islands, 11.62, -165.55, 122–137 m. Coll. R.D. Russell, 14 Aug, 1947. 1 dry spec. R=4.4 r=1.7.

Mah collection PH-13. Balut Island, Philippines, 200 m. (no other data). 1 dry spec. R=5.8 r=1.7.

Churaumiastra Mah *et al*. 2024

Diagnosis: As for species.

Churaumiastra hoshi Mah *et al.* 2024

FIGURE 12B, 14A–D

Mah *et al.* 2023: 4

Diagnosis

Body planar, strongly stellate (R/r=2.3), arms elongate, interradial arcs weakly curved. **Body covered by a dense cover of granules which forms a pavement like covering over the abactinal, marginal, and actinal surfaces. Abactinal plates hexagonal, disk only with no abactinal plates on arms. Superomarginals directly abutted over mid radius along arm distance. Superomarginal plates form a distinct frame around**

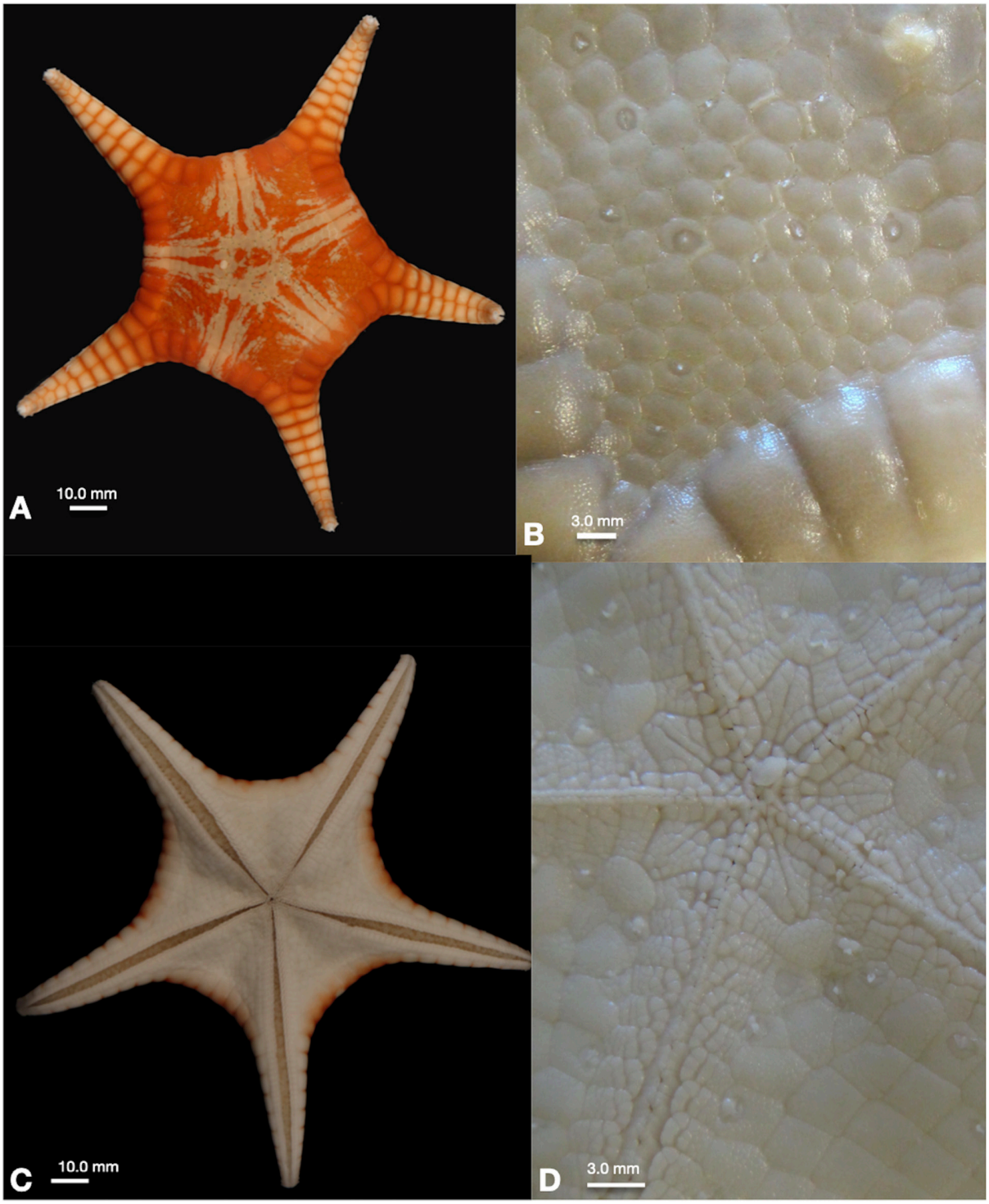

FIGURE 14. *Churaumiastra hoshi* WAM Z97558. A. Abactinal. B. Closeup abactinal surface. C. Actinal. D. Closeup actinal surface.

disk, comprising approximately 20% of the total "r" distance. Actinal regions large with 4–6 distinct series in chevron formation. Individual actinal plates quadrate. Furrow spines four, blunt, quadrate in cross section. Subambulacrals in approximately 3 irregular series with series adjacent to actinal plates, irregularly transitioning in size with actinal granules. **Adambulacral spines, blunt, flattened and nearly flush with actinal surface.** Alveolar pedicellariae with slender valves present or absent.

Comments

Churaumiastra hoshi has been described only recently. Occurrence suggests a widespread distribution from southern Japan and the Philippines to Ashmore Reef in the Indian Ocean. *In situ* observations suggest that it may feed on cnidarians or detritus (Mah *et al*. 2024).

The Ashmore Reef specimen differs from the Okinawan and Philippine specimens in displaying numerous slender alveolar pedicellariae with tong-like valves on both the abactinal and actinal surfaces. Color of WAM Z97558 is also different. The living individual showed dark orange with yellow to orange highlights, in contrast to the Japanese specimen which showed it to be yellow with white highlights (Mah *et al*. 2023).

A polynoid polychaete (WAM V10815) was collected in association with WAM Z97558.

Occurrence/Distribution

Ashmore Reef, Western Australia, 172.2 m.

Outside Australia, the Philippines, Okinawa, southern Japan, 100–200 m.

Material Examined

WAM Z97558 Ashmore Reef, Western Australia. 12.32001331°S 123.09032385°E, 172.28 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO406, Coll. 11 April 2021. 1 wet spec. R=6.7 r=3.2.

Dissogenes Fisher, 1913

Fisher 1913: 212; 1919: 367; Jangoux 1981: 712; H.E.S. Clark & McKnight 2001: 169

Diagnosis

Body stellate to strongly stellate (R/r=3.94–4.0), disk and arms thick, arms elongate, triangular in shape, interradial arcs curved. **Surface covered by granular cover, variably dermis present or absent. Abactinal plates abutted variably with single or more papular pores present, plates extending from disk to arm terminus. Marginal plates quadrate and blocky, forming lateral boundary around periphery.** Actinal surface covered by continuous granular cover, variably covered by dermis or not. Proximal actinal plates with conical spines present or absent, similar in overall gauge with subambulacral spines. Furrow spines 2–7, blunt in known species in straight series. Subambulacral spines similar in size to furrow spines but each twice as thick, approximately 3–6.

Comments

The most recent molecular revision of the Valvatacea (Mah & Foltz, 2011) has revised the traditional placement of genera such as *Fromia a*nd *Neoferdina*, formerly located in the Ophidiasteridae, and instead placed them in the Goniasteridae in alignment with noted morphological affinities. Consequently, the Ophidiasteridae are largely restricted to typological forms with long, tapering cylindrical arms and a small disk (e.g. *Linckia, Ophidiaster*).

Dissogenes is herein, moved from the Ophidiasteridae and placed within the Goniasteridae. *Dissogenes* was described by Fisher (1913, 1919) as demonstrating goniasterid affinities but was placed among the Ophidiasteridae based on its "irregular" abactinal skeleton, small marginal plates, and the close granulation which covers the body surface. All three of these characters, but especially the continuous granulated covering is shared among multiple families, including the Goniasteridae, Oreasteridae, and the Ophidiasteridae among others and does little to support placement within the Ophidiasteridae. The abutted abactinal plate arrangement, the blocky marginal plate morphology and distinct marginal frame arrangement as well as the overall dorsoventrally flattened shape and triangular arms all support placement within the Goniasteridae rather than the Ophidiasteridae following Mah & Foltz (2011) and Mah (2017).

Dissogenes includes two species, *Dissogenes styracia* Fisher, 1913 from the tropical central Pacific and *Dissogenes petersi* Jangoux, 1981 from New Caledonia.

Dissogenes dorikos Mah sp. nov.

Figure 12C, 15A–E

Etymology

The species epithet *dorikos* is derived from the Greek for "skin or hide" alluding to the distinct dermis on this species.

Diagnosis

Body strongly stellate with elongate, triangular arms. Interradial arcs curved. **Abactinal, marginal and actinal surface covered with thick, granule-invested dermis.** Papulae present in clusters of 6 present on distinct abactinal regions. Spines absent on abactinal and marginal surfaces. **Actinal surface with proximal regions covered with single conical spines, comparable in height to subambulacral spines.** Furrow spines, 2–3, tall, standing well above the actinal surface, subambulacral spines single, widely spaced, taller and approximately 10% taller than furrow spines.

Comments

This is the first occurrence of *Dissogenes* from the Indian Ocean and from Australian waters. Although *Dissogenes dorikos* **sp. nov.** differs significantly from known species, it shares the overall body shape with the thick body, elongate arms and granular covering the abactinal, marginal and actinal surface.

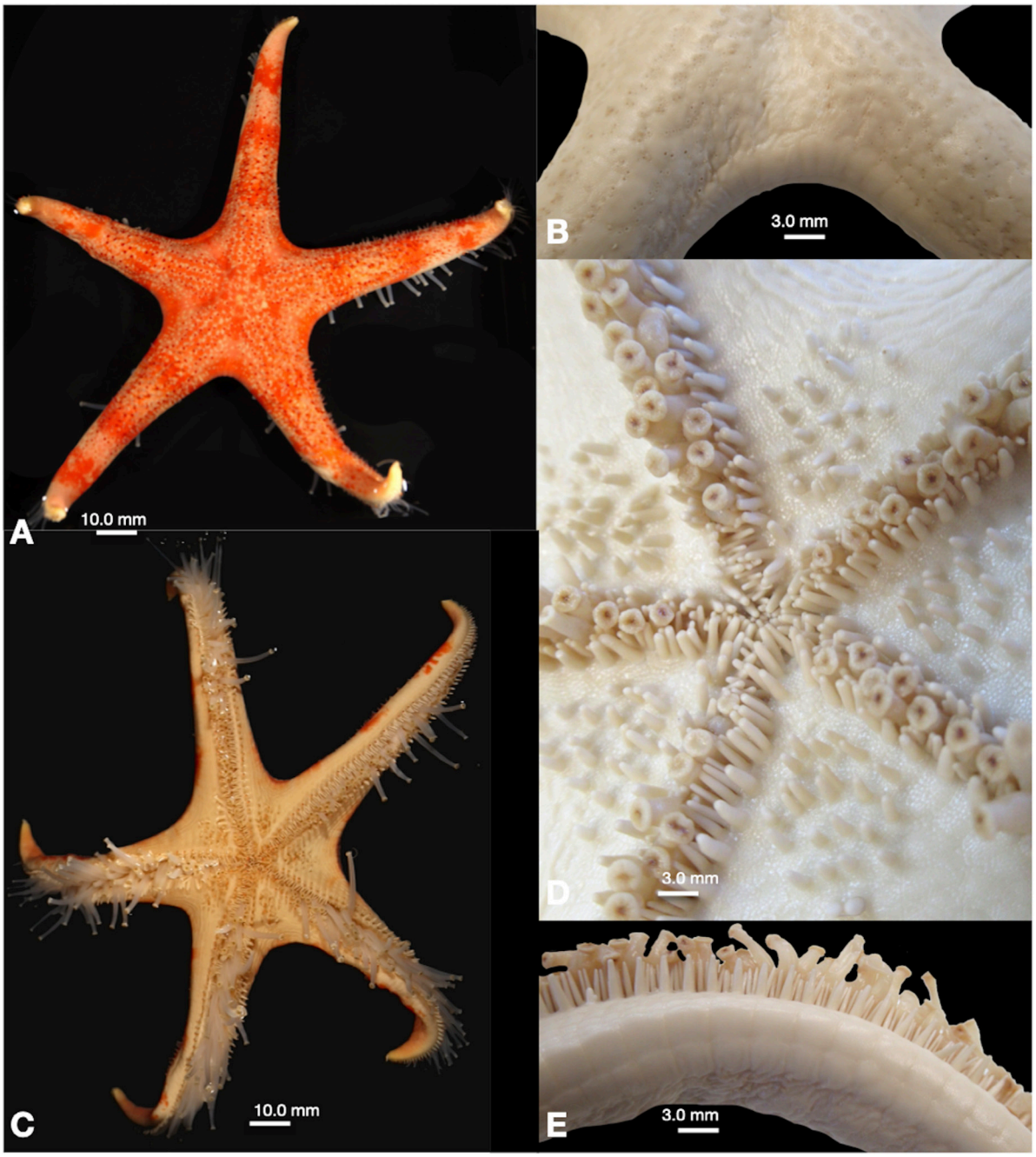

FIGURE 15. *Dissogenes dorikos* **sp. nov.** Holotype. WAM Z97587 A. Abactinal. B. Abactinal–lateral veiw. C. Actinal. D. Closeup oral region with actinal spines. E. Lateral arm view.

Known *Dissogenes* species lack the distinct dermis found in *Dissogenes dorikos* **sp. nov.** This species differs most from the central Pacific *Dissogenes styracia* which is covered by round-tipped, tubercular spines and has 4–5 furrow spines. *Dissogenes dorikos* **sp. nov.** lacks these tubercular spines and has only 2–3 furrow spines. *Dissogenes dorikos* **sp. nov.** differs from *D. petersi*, in having fewer furrow spines (2–3) versus 5–6 in *D. petersi* and displays papular areas with 4–6 papulae per region versus only single papular pores in *D. petersi.* Subambulacral spines are also much larger and distinctly present in series relative to the Pacific *Dissogenes* spp.

Ecological Comments

This is the first observation of this genus and species alive and *in situ*. The holotype was observed on what appeared to be a loosely consolidated, rocky substrate covered by encrusting organisms, possibly sponges or cnidarians. Papulae on *Dissogenes* **sp. nov.** were prominently extended. Sediment was present on the shallow gutters of the abactinal interradial surface, it was also present on one lateral surface of the arm. While likely incidental, its presence was conspicuous and could have been present for a specific purpose, such as feeding. Tube feet on this species were elongate and extended (Fig. 12C, 15E).

A commensal crab - *Lissocarcinus* sp. (WAM C76523) associated with WAM Z97587.

Occurrence/Distribution
Known only from Ashmore Reef, Western Australia, 154 m.

Description
Body strongly stellate, R/r=3.94, arms elongate, gradually tapering with upturned, pointed arm tips. Interradial arcs curved.

Abactinal, marginal, actinal surface overlain with granule-infused dermis. Surface is smooth to the touch. Coarser, polygonal granules more evident around papulae, otherwise granules are homogenous in size, shape, forming continuous cover over plates. Plate boundaries obscured by dermis. Papulae on disk in regular clusters of 6, arranged in serial rows proximally along disk and arms, reduced to single and double pores arranged more irregularly distally along the arm. Interradius on disk either with single pores or no papulae. Many "folds" on skin along the disk and arms. Madreporite triangular, with deep sulci. Anus with short pointed spines, 8–9. Spines absent.

Marginal plates, approximately 40 per arm side (80 interradially) mostly lateral facing, covered by granule-invested dermis. Surface is smooth with no rugosities, dermis appears wrinkled in places. Plates are quadrate in outline with rounded corners, surface weakly convex to fall. Superomarginal and inferomarginal plates widest interradially (triangular to trapezoidal in shape) becoming more squarish distally along the arm. Papulae from abactinal surface in contact along edge of superomarginals where abactinals are in contact but none below marginal plate series. Superomarginal plates more 1:1 proximally becoming more offset with inferomarginal plate forming zig-zag contact. Terminal plate triangular with single spine on tip.

Actinal plates in approximately 2–3 full chevrons, with more irregular plates distally adjacent to inferomarginal plates. Plate surface obscured by granule-invested dermis forming smooth surface. Actinal dermis in direct association with inferomarginal plates. Polygonal granules observed as part of dermis on actinal surface. Proximal plates with large, distinct, conical spines rising well above the actinal surface similar in height to the subambulacral spines. A total of 20–25 spines per interradius, widely spaced from one another, limited largely to proximal region adjacent to the mouth and adambulacral spines.. Multiple "wrinkles" of tissue present distally on actinal surface

Furrow spines 2–3, blunt, conical, standing well above the plate surface. Subambulacral spines single, in pronounced series along adambulacral plate series, evenly spaced along its series. Subambulacral spines with blunt conical point, twice as thick and approximately 10% taller than adjacent furrow spines. Coarse polygonal granules present as part of the dermis around the actinal surface and the adambulacral plate surface, especially around spine base. Oral region crowded, furrow spines 7, blunt and pointed identical to furrow spines on other adambulacral plates with a single plate projecting into the mouth. Oral plate surface with four paired spines on each half of the tissue filled gap. Distinct space between oral and furrow spines from those on the actinal intermediate region.

Tube feet well developed, extended well above furrow and subambulacral spination.

Color in life is yellow to white with dark orange highlights, including alternating orange and yellow bands on the arms. Highly elongate white papulae present. Oral surface is white.

Material Examined
Holotype. WAM Z97587 Ashmore Reef, Western Australia, 12.1878581°S 122.96773299°E, 153.64 m, Coll. N.G. Wilson, C.S. Whisson, FK210409/SO409, Coll. 15 April 2021. 1 wet spec. R=15.0 r=3.8.

Fromia Gray 1840

Fromia Gray 1840: 286; Fisher 1919: 373; H.L. Clark 1921: 38; Rowe & Gates 1995: 81; Mah & Foltz 2011: 771, 779, 782; H.E.S. Clark & McKnight 2001: 170; Marsh & Fromont 2020: 226.

Celerina A.M. Clark 1967: 193; Rowe & Gates 1995: 80

Austrofromia H.L. Clark 1921: 48; Rowe 1989: 291; Rowe & Gates 1995: 81.

Diagnosis
Body strongly stellate (R/r=3.5–5.0), arms elongate, strap-like to triangular in shape. Interradial arcs acute. Arm rectangular in cross-section. **Abactinal plates abutted, ranging ranging from flat to convex, covered with a distinct continuous cover of granules.** Marginal plates broadly quadrate in outline forming discrete frame around abactinal-lateral outline of body. **Marginal plate surface with continuous granular cover. Actinal region small, covered by granules. Papulae present between marginal and actinal plate contact. Furrow spines blunt, relatively few, with variable subambulacral armature.** (following Mah, 2018).

Comments
Fromia contains 16 species which occur throughout the Indo-Pacific region, in shallow-water reef to deeper mesophotic habitats. *Fromia* and a synonymous genus, *Celerina*, had been historically classified as ophidiasterids until recent molecular data (Mah & Foltz, 2011b) placed it within the Goniasteridae. Rowe and Gates (1995) and Marsh and Fromont (2020) recognized eight species from Australian waters. Several nominal species of *Fromia* are species complexes, and exhibit cryptic speciation over wide distributions, (G. Paulay, unpublished data & pers. comm.). Historically, emphasis has been placed on horizontal distribution but further sampling into mesophotic and deeper settings has resulted in a better understanding of the lower depth limits of many widely occurring *Fromia* species (Mah, 2024).

***Fromia ui* Mah sp. nov.**
Figure 16A, 17A–F

Etymology
The species epithet is derived from "u'i", the Hawaiian word for beautiful alluding to this species lovely appearance. Noun held in apposition.

Diagnosis
Body strongly stellate (R/r=4.4–6.0) with arms showing angular corners, interradial arcs acute. Abactinal plates abutting in irregular arrangement on disk, **a single row of large plates along arm. Superomarginal plates visible on abactinal surface, occupying approximately 70% of total arm width but with abactinal plates extending to arm terminus**. **Marginal plates, overall 28 per interradius from arm tip to arm tip, in gradually decreasing size but overall homogeneous shape.** Furrow spines three with subambulacral spines two. Papulae absent from actinal surface.

Comments
Fromia ui **sp. nov.** is distinguished by the presence of one to few rows of relatively large abactinal plates along the radius of the arm, a character which distinguishes it from *F. pacifica* which shows multiple plates in irregular order along the arm.

Occurrence/Distribution
Ashmore Reef, Ningaloo Reef, Gascoyne Marine Park, 44.5–103 m.

Description
Body stellate (R/r=4.44 to 6.0), disk small, arm shape triangular elongate. Interradial arcs acute. Lateral surfaces strongly developed. Arms angular and quadrate in cross-section

Abactinal plates abutted, mound-like, largely homogeneous in size, irregular in shape on disk, with a series of single large carinal plates extending to arm tip, although some secondary plates are incidentally present near the arm base on the paratype . Abactinal and all plate surfaces covered by continuous granular cover, evenly spread over surface (approximately 6 count along a 1.0 mm line). Granules round to polygonal homogeneous in size, shape with larger plates displaying more coarse central granules relative to those present between plate "valleys. Papulae single, present throughout arm to terminus, approximately 4–10 surrounding each arm plate. Papular pores flanked by 3–6 enlarged granules. Madreporite quadrate, flanked by four plates, sulci well-developed. Anus surrounded by approximately 7 adjacent granules. No pedicellariae.

Marginal plates 14 per arm side, 28 per interradius (arm tip to arm tip), quadrate in shape, angular in

FIGURE 16. *Fromia* spp. *in situ* A. *Fromia ui* **sp. nov.** WA Z97606. B. *Fromia monilis,* WAM Z97570. No scale.

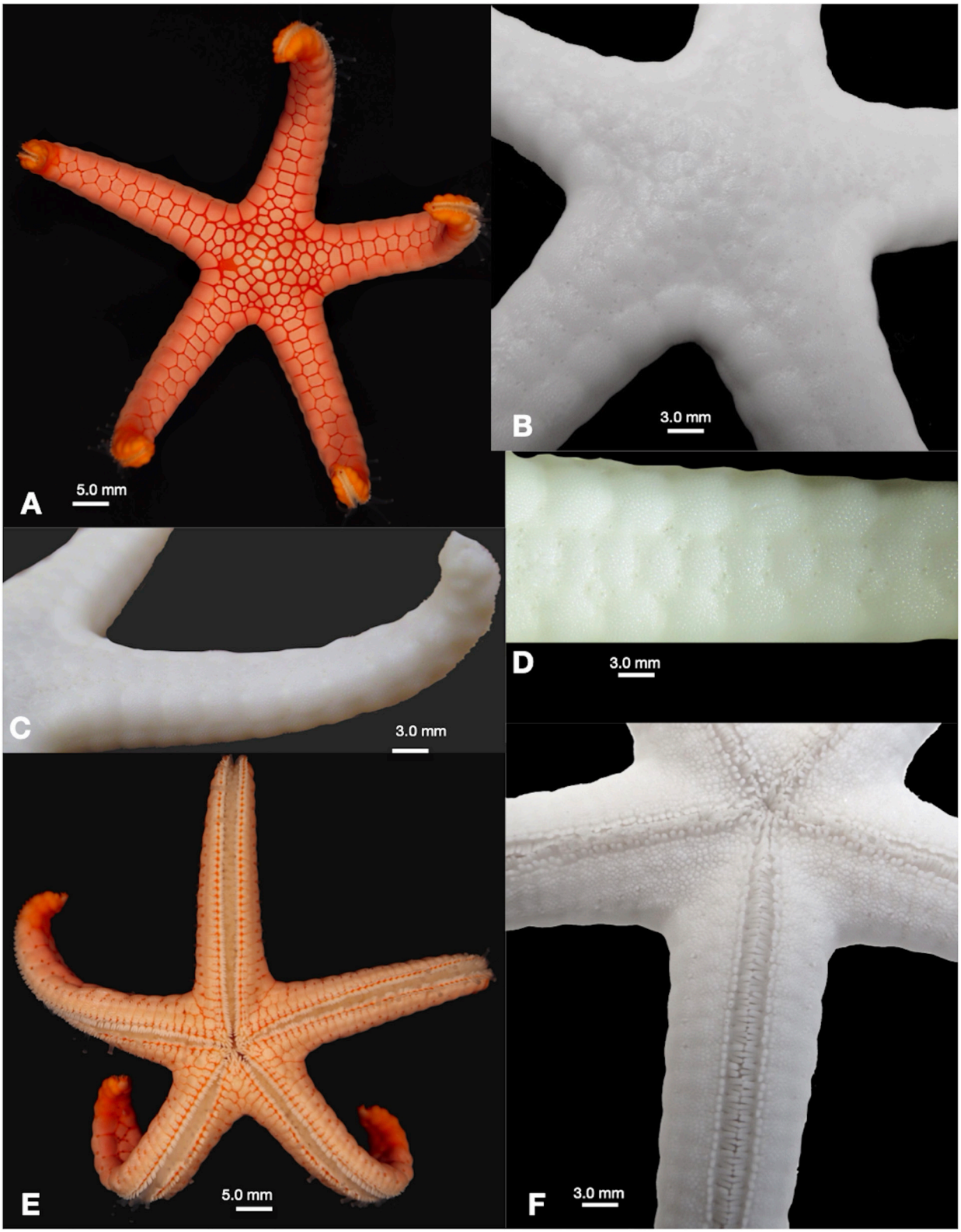

FIGURE 17. *Fromia ui* **sp. nov.** Holotype. WAM Z97606 A. Abactinal. B. Closeup abactinal. C. Abactinal–lateral view. D. Abactinal arm plates. E. Actinal surface. F. Oral and adambulacral closeup, actinal surface.

cross-section forming square abactinal-lateral angle forming well-developed lateral facing. Superomarginal and inferomarginal plates retaining homogeneous shape along most of arm with gradual transition to smaller plates adjacent to arm tip. Marginal plates with continuous granular cover extended from abactinal surface. Superomarginal and inferomarginal granular cover with coarse granules centrally becoming smaller at contacts with other superomarginal and inferomarginal plates. Distalmost superomarginal plates with strongly convex surface. Single papulae present between lower inferomarginal plates, each pore flanked by large granule

equal in size. These papulae extending to arm tip. No pedicellariae. Terminal plate triangular bearing spine with four pointed tips.

Actinal region small, composed of 1–3 plates. Surface covered by irregularly shaped coarse granules, widely spaced, especially adjacent to oral plate contact. Granules 2–3 per 1.0 mm line in this region. Incipient pedicellariae also present, similar in size with granules adjacent to oral plates.

Furrow spines three, quadrate with blunt tips Subambulacral spines two, blunt with round tips, broadly oval in cross-section.

Oral plates with approximately 6 furrow spines, Oral plate surface covered with spines, blunt, pointed, quadrate in cross-section, 4–6 on either side of oral plate suture. Smaller spines, 3–5, blunt, widely spaced from one another on remainder of oral plate.

Material Examined

Holotype. WAM Z97606 Ashmore Reef, Western Australia 12.13390124°S 123.07613337°E, 103.33 m, Coll. N.G. Wilson & C.S. Whisson, Station FK210409/SO413, 19 April 2021, 1 wet spec. R= 4.0 r=0.9.

Paratypes. WAM Z23286 Ningaloo Reef, Osprey, Western Australia 22º12'53"S 113º49'25"E to 22º13'09"S 113º49'17"E, 44.5 to 49.8 m. Coll. M. Salotti, Station CF4010&11/2006/D019, 1 May 2006. 1 wet spec. R=3.4 r=0.8.

WAM Z110250, (CSIRO 10064565) Gascoyne Marine Park, Western Australia, 23º22'11.838"S 113º25'45.2712"E, 110 m. Coll. B. Alvarez, K. MacNaughton, K. Moore, C. Untiedt, Station IN2022V09/136-40, 11 December 2022, 1 wet spec. R=3.6 r=0.6.

Fromia monilis (Perrier, 1869)

Figure 16B

Scytaster Perrier 1869: 62(54)
Fromia japonica Perrier 1881
Fromia major Koehler 1895
Fromia H.L. Clark 1921: 46; Doderlein 1926: 19; Hayashi 1938: 425; 1973: 58; Clark & Rowe 1971: 62; Marsh 1977: 258; 1978: 222; Jangoux 1978: 296; Julka & Sumita Das 1978: 347; A.M. Clark 1993: 332; Rowe & Gates 1995: 82; Marsh & Fromont 2020: 237.

Diagnosis

Body stellate (R/r=3.8–5.0), arms elongate and triangular in shape, disk small, interradial arcs acute. Granular cover continuous over abactinal and marginal plates surfaces, becoming coarser on actinal surface. Abactinal plates weakly convex, especially on disk becoming more so distally. Superomarginal plates convex, homogeneous and contiguous interradially and proximally on arms alternating large and small plates distally, approximately midway along the arm. Furrow spines 2–3, subambulacral spines two with two series of 4–6 granules. Papulae single on corners of abactinal, marginal and actinal surfaces.

Comments

Fromia monilis is a frequently encountered and highly variable goniasterid that occurs in the tropical south and central Pacific as well as adjacent regions in the Indian Ocean. Marsh & Fromont (2020) provided an overview of this species, outlining known biology and reproduction. Variation in this species is poorly understood with other species, such as *Fromia heffernani* (Livingstone, 1931) and *Fromia nodosa* A.M. Clark, 1967, showing similar coloration and plate patterns. Its occurrence at 101 m represents the lower limit of its depth distribution.

Occurrence/Distribution

Australia. Ashmore Reef, Houtman Abrolhos, Western Australia to Great Barrier Reef, Queensland to Elizabeth Reef, Tasman Sea. 0–102 m.

Outside Australia. Red Sea, Maldive Islands, Indonesia, Philippines to New Caledonia, Palau, Samoa and Fiji in the West Pacific. Japan. Okinawa, Ryukyu Islands, Taiwan, 0–100 m (following Marsh & Fromont 2020).

Material Examined

WAM Z97570 Ashmore Reef, Western Australia. 12.28078751°S 122.97542548°E, 102 m. Coll. N. G. Wilson, C.S. Whisson, FK210409/S0407, Coll. 13 April, 2021. 1 wet spec. R= 4.4 r= 1.0.

Iconaster Sladen, 1889

Dorigona Gray 1866: 7 (in part)
Pentagonaster Perrier 1875: 190, 192 (in part)
Iconaster Sladen 1889: 261; Fisher 1911: 172; H.L. Clark 1946: 95; Spencer & Wright 1966: U58, Aziz 1986: 250; Mah 2005: 150.

Diagnosis

Body stellate to strongly stellate in most. Abactinal, marginal, actinal plates plates smooth, devoid of granules. Disk and marginal surfaces flush. Primary circlet, interradial plates enlarged, abactinal plate corners with enlarged granules. Glassy tubercles on most but not all species, superomarginal plates with glassy tubercles on two species, arms elongate with superomarginals abutted across midline. Furrow spines crowded, short and squat, round and polygonal in cross-section. Subambulacral spines round to polygonal in cross-section. Ambulacral plate base with narrow flanges (based on Mah, 2005).

Comments

A genus containing six species present throughout the Indo-Pacific occurring at relatively shallow depths (10–301 m). *Iconaster* was recently reviewed by Mah (2005). Only one species of *Iconaster*, the shallow-water species, *I. longimanus* has been recorded from Australia (summary in Marsh & Fromont, 2020).

***Iconaster uchelbeluuensis* Mah 2005**
Figure 18A–D, 19A

Iconaster Mah 2005: 153.

Diagnosis
Body stellate to strongly stellate R/r= 1.8–2.8. Primary circlet and interradial plates enlarged relative to those proximally on radial regions along arms. Enlarged granules present only on radial regions, absent interradially. Approximately 20 marginal plates per interradius (arm tip to arm tip) with 6–7 distalmost superomarginals abutted over midline. Glassy tubercles absent from abactinal plates, present on superomarginals and inferomarginals. Actinal plates bare and smooth. Furrow spines 2–5, subambulacral spines 2–3, enlarged and twice as thick as furrow spines.

Comments
This is the first occurrence of this species in Australian waters and in the Indian Ocean. This specimen is largely consistent with the description of the type series presented in Mah (2005).

This represents the first time this species has been observed alive and *in situ*. In life, this species displays bright orange plates with lighter yellow to orange highlights on the primary circlet and interradial plates. Superomarginal plates are light orange to yellow with nearly white arm tips. Underside is a light orange with white highlights present at contact between plates.

Ecological Comments
The specimen was collected on a bottom consisting of loosely consolidated, coarse sediment and either sponges or some other kind of organic, epizoic debris.

Occurrence/Distribution
In Australia, known only from Ashmore Reef, Western Australia, 104 m.

Outside Australia. Known from the Philippines, Palau, and New Caledonia. 68–122 m.

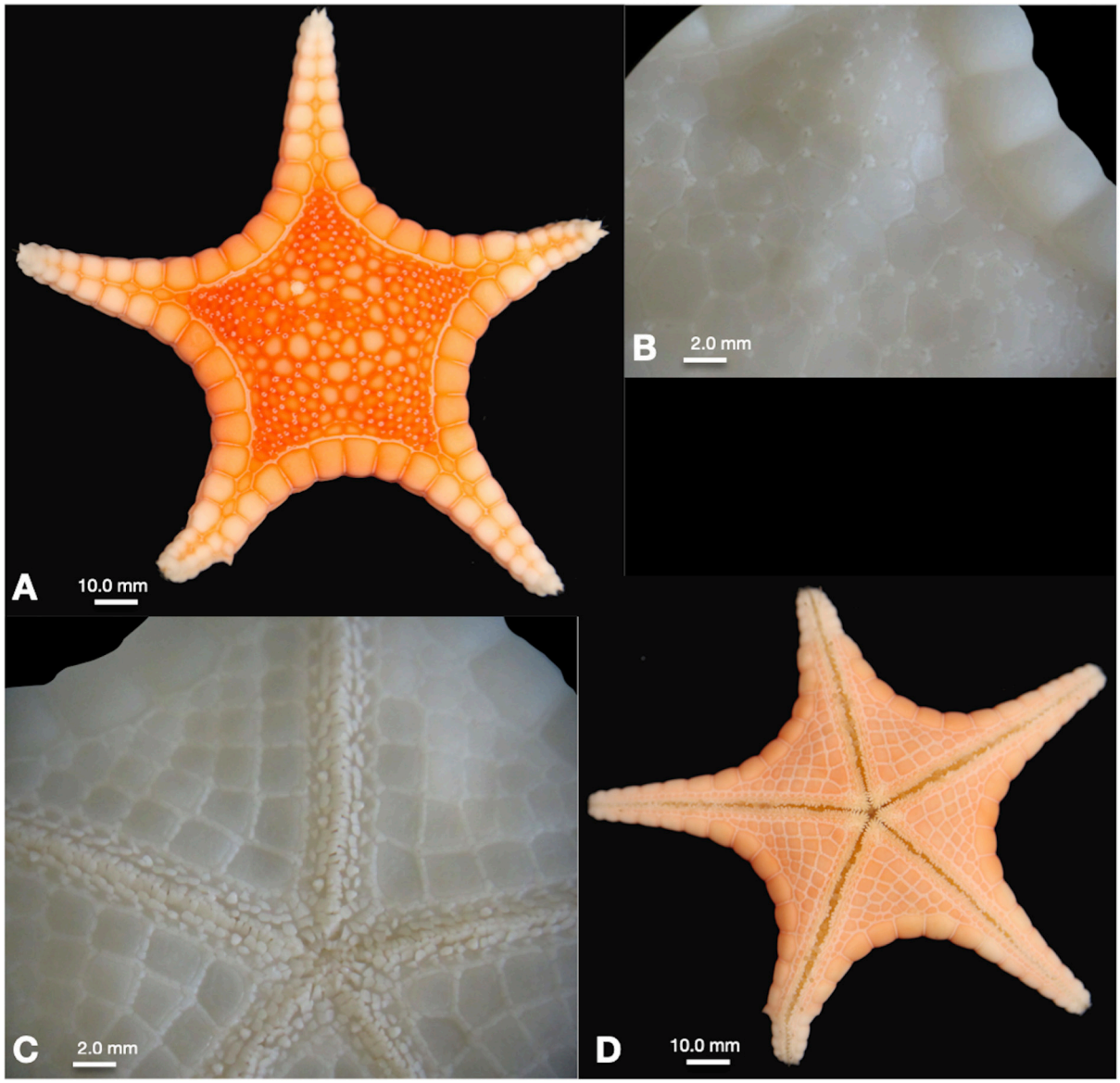

FIGURE 18. *Iconaster uchelbeluuensis*. WAM Z97641. A. Abactinal. B. Closeup abactinal plates. C. Closeup oral and adambulacral region. D. Actinal.

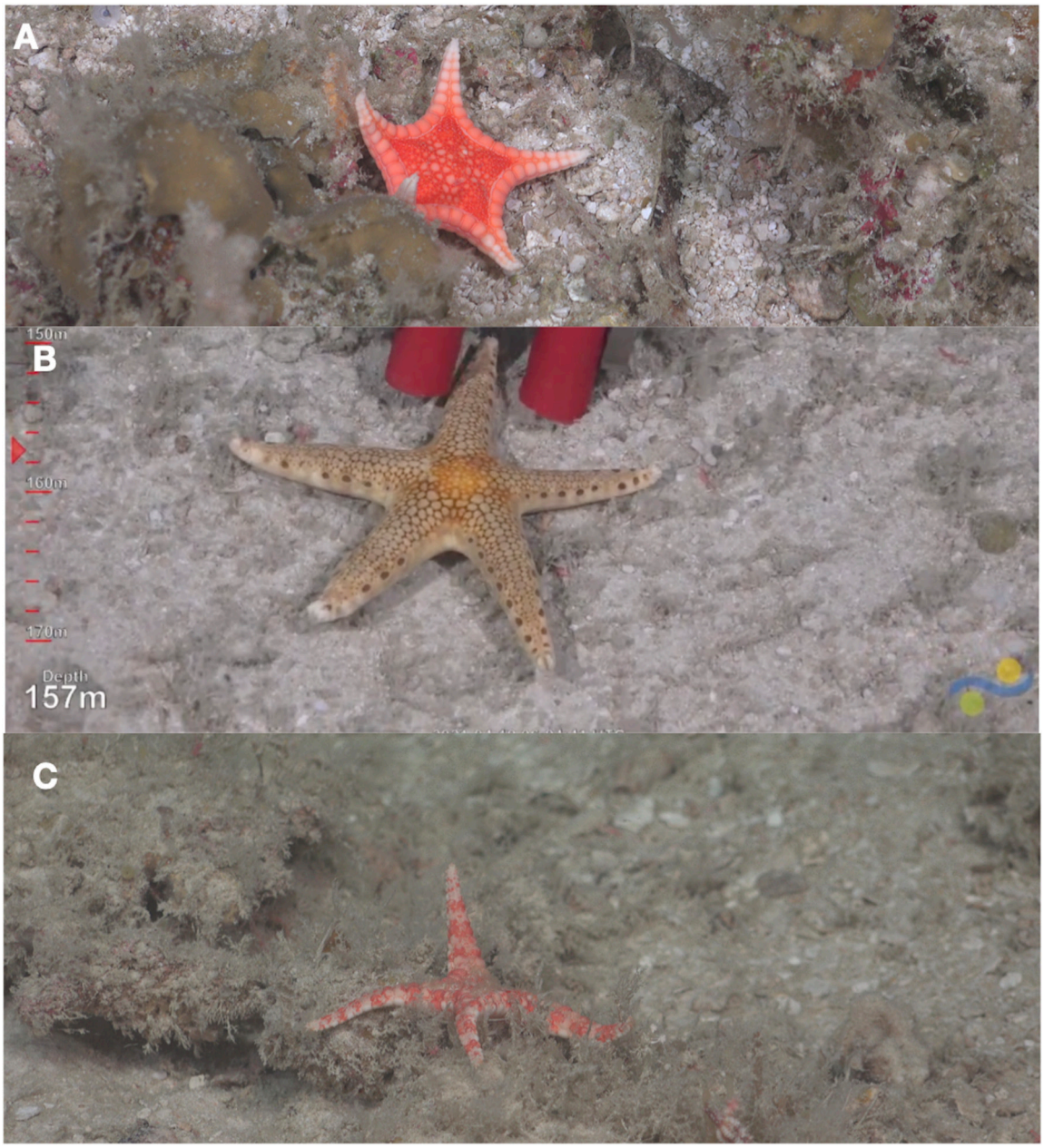

FIGURE 19. Goniasteridae *in situ.* A. *Iconaster uchelbeluuensis*. WAM Z97641 B. *Neoferdina insolita.* WAM Z97616 C. *Rosaster mammilatus*. WAM Z97586. No scale.

Material Examined

WAM Z97641 Ashmore Reef, Western Australia 12.13931737°S 123.20672703°E, 103.8 m, Coll. N.G. Wilson & C.S. Whisson, FK210409/SO415, 21 April 2021, 1 wet spec. R=2.4 r=1.1

Neoferdina Livingstone 1931

Ferdina (in part) Gray 1840: 282; 1866: 12; Perrier 1875: 447; Sladen 1889: 397; Fisher 1911: 241; H.L. Clark 1921: 37.

Scytaster Müller & Troschel, 1842: 34; Grube 1860: 9; Dujardin et Hupé, 1862: 365; Lütken 1865: 163.

Neoferdina Livingstone 1931: 307; H.L. Clark 1946: 112; Clark & Rowe 1971: 64 (in key); Jangoux 1973: 776; A.M. Clark, 1993: 344 (checklist); Rowe & Gates, 1995: 89; Liao & Clark, 1995: 119; H.E.S. Clark & McKnight, 2001: 175.

Diagnosis

Body strongly stellate (R/r=~2.0–5.7, mostly between 3.0–4.0 cm), body flattened (i.e. quadrate in cross-section) in most species but variably pentagonal in larger individuals, body surface almost completely covered by granular tegument, save for bald patches or spots on abactinal and marginal plates. Crystalline nodules absent from abactinal, marginal plates. Abactinal plates variably flat to strongly convex, forming distinctive bumpy surfaces in many species. These plates also present in transverse series across the arm in several but not all species. Marginal plates variably equal dimensions to

elongate to elliptical in shape. Most superomarginals convex, variably weak to strong but all with distinct bald region. *N. annae* **sp. nov.** with bare regions on penultimate superomarginals, but otherwise covered by granular tegument. Inferomarginals variably granule-covered or with bald patch present. Actinal intermediate regions small (with fewer than four full actinal series) with single furrow spine series, subambulacral accessories absent. Most species display a bright to striking color pattern with a wide range, generally with dark colored superomarginal plates and lighter colored disk plates. (from Mah, 2017).

Comments
A genus containing 12 species occurring only in the Indo-Pacific region at shallow to intermediate (mesophotic) depths (0–200 m) which has been reviewed by Mah (2017). Marsh & Fromont (2020) list two species, *Neoferdina cumingi* and *Neoferdina insolita* from Australian waters.

Neoferdina antigorum Mah, 2018
Figures 19B, 20A–B

Mah 2018: 44

Diagnosis
Characterized by the presence of very few to absent strongly convex, bald abactinal plates but with a distinct round, bald patch on each superomarginal plate, which forms a regular, homogeneous series along the arm. A continuous granular tegument covers most of the body surface in this species. Abactinal plates are mostly homogeneous. This species has a minority of convex abactinal plates with bare patches and spinelets on distalmost inferomarginal plates. Bald patches absent from the proximalmost inferomarginal plates

Comments
This is the first occurrence of this species in Australia.

Ecological Comments
This is the first observation of this species *in situ.* Specimen was collected from a coarse bottom of loosely consolidated shelly debris and sediment.

Occurrence/Distribution
Ashmore Reef, Western Australia, 123 m.

Outside Australia, known previously only from the Philippines, 80–200 m.

Material Examined
WAM Z97568 Ashmore Reef, SW side, outer reef slope. Western Australia 12.28131641°S 122.97546605°E, 122.78 m, Coll. N.G. Wilson & C.S. Whisson, FK210409/SO407, 13 April 2021, 1 wet spec. R=2.4 r=0.35.

Neoferdina insolita Livingstone 1936
Figure 20C–D

Neoferdina insolita. Livingstone 1936: 384; Clark & Rowe 1971: 65 (in key); Rowe & Gates 1995: 89; Gosliner *et al*. 1996: 261; Coleman 2007: 41; Humann and deLoach 2010: 438; Antokhina & Britayev 2012: 899, 900 (Pl. 7, fig. 29); Marsh & Fromont 2020: 260.

Diagnosis
R/r <4.0, primarily 3.2–3.6. Superomarginals with dark colored bald region occupying most of superomarginal surface. Marginal plates in regular series. Convex abactinal plates completely absent. Colors of nominal species variable. Some exhibit solid, identical coloration on the disk and arms, with darkened highlights between the plates; others exhibit darker or distinctly colored pattern on the disk relative to the arms

Comments
WAM Z97616 conforms closely with the image and description for this species as outlined by Marsh & Fromont (2020). The Ashmore specimen differs in that the proximalmost interradial superomarginal plates show weakly developed to absent dark colored patches versus the fully developed dark bare circles figured in Marsh & Fromont (2020: 260) from Cliff Head. Based on this species' known depth distribution, the Ashmore specimen is present at the deeper end of its range.

During post-collection photography of WAM Z97616, a polynoid polychaete (WAM V10822) was observed in association. Although its exact relationship was unclear, other polynoids are found in close association with sea stars (e.g. Pettibone, 1969). If this was a commensal or symbiotic relationship, it would be the first known for *Neoferdina*.

Ecological Comments
In situ observation of this specimen showed a loosely consolidated sediment covered bottom with overlay of grey flocculent material. This differs slightly from the shallower habitat described by Marsh & Fromont (2020) which described this species as present on coral reefs, including reef flats, crests and slopes, although they did also include the continental shelf with which this seems more similar.

Occurrence/Distribution
Ashmore Reef, Western Australia, 158 m.

In Western Australia, from off the west coast shelf off Cliff Head at 150 m, off Wedge Island at 188 m and the North West Shelf at 100 m. On the Great Barrier Reef, Queensland from Lodestone Reef to Bushy-Redbill Reef and the Solitary Islands, NSW. 100–188 m. (based on Marsh & Fromont 2020)

Outside Australia. Sagami Sea, central Japan (see below), Papua New Guinea, Taiwan (Gulf of Tonkin), 3–80 m.

Material Examined
WAM Z97616, outer reef slope, Ashmore Reef, Western Australia. 12.13064985°S 123.07628123°E, 158.3 m,

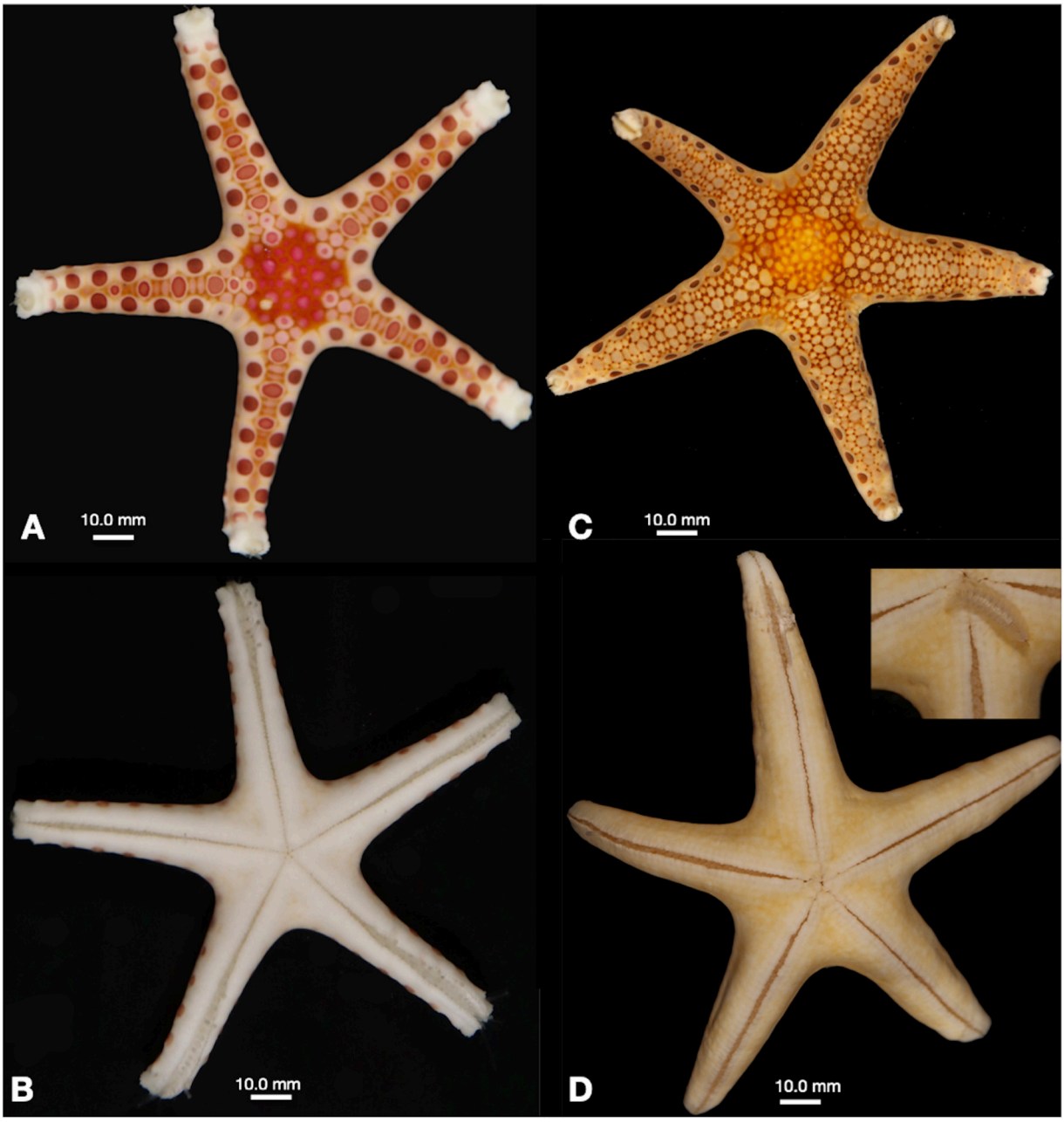

FIGURE 20. *Neoferdina* spp. *N. antigorum* WAM Z97568. A. Abactinal. B. Actinal. *N. insolita* WAM Z97616. C. Abactinal. D. Actinal.

Coll. N.G. Wilson & C.S. Whisson, FK210409/SO413, 19 April 2021, 1 wet spec. R=7.1 r=2.6.

Rosaster Perrier 1894

Perrier, 1894: 386; Fisher, 1911: 164; Verrill, 1915: 110; Fisher 1919: 240; Macan, 1938: 364; Halpern, 1970: 208; 1970b: 57; Clark & Downey, 1992: 265; A.M. Clark, 1993: 282 (checklist);
H.E.S. Clark & McKnight, 2001: 126.

Diagnosis

Body generally stellate to strongly stellate with arms long, tapering. Abactinal plates tabulate, granular accessories present on plate surface. Plate base with bar-shaped, radiating ossicles evident on coelomic side. Fasciolar grooves well developed. Superomarginal plates variably abutted over midline with some species showing abactinal plates extending to arm tip versus other species which show abutted superomarginals at arm base. Pedicellariae, when present, slender and tong-shaped. Marginal plates forming distinct border around periphery in all species (approximately 20–25% of "r").

Comments

Rosaster includes 11 species, which occur primarily in the tropical Indian and Pacific oceans with a single species in the tropical Atlantic. Some species, such as *Rosaster symbolicus* (Sladen 1889) occur widely throughout the

Pacific. Rowe and Gates (1995) record three species, *Rosaster mimica* Fisher, 1913, *Rosaster nannus* Fisher, 1913, and *Rosaster symbolicus* (Sladen, 1889) from Australian waters. Although *Rosaster mammilatus*, as outlined herein is a fourth known Australian occurrence, boundaries between species have shown overlap as greater character variation is discovered (Mah, unpublished data).

Fisher (1919) differentiated *Rosaster* from *Mediaster* based on a single character, the presence/absence of rudimentary superambulacral plates. Based on this single character and the numerous species assigned to both *Rosaster* and *Mediaster*, a review of species is warranted to clarify the intersection of variation and taxonomic concepts between these taxa. Based on the shared

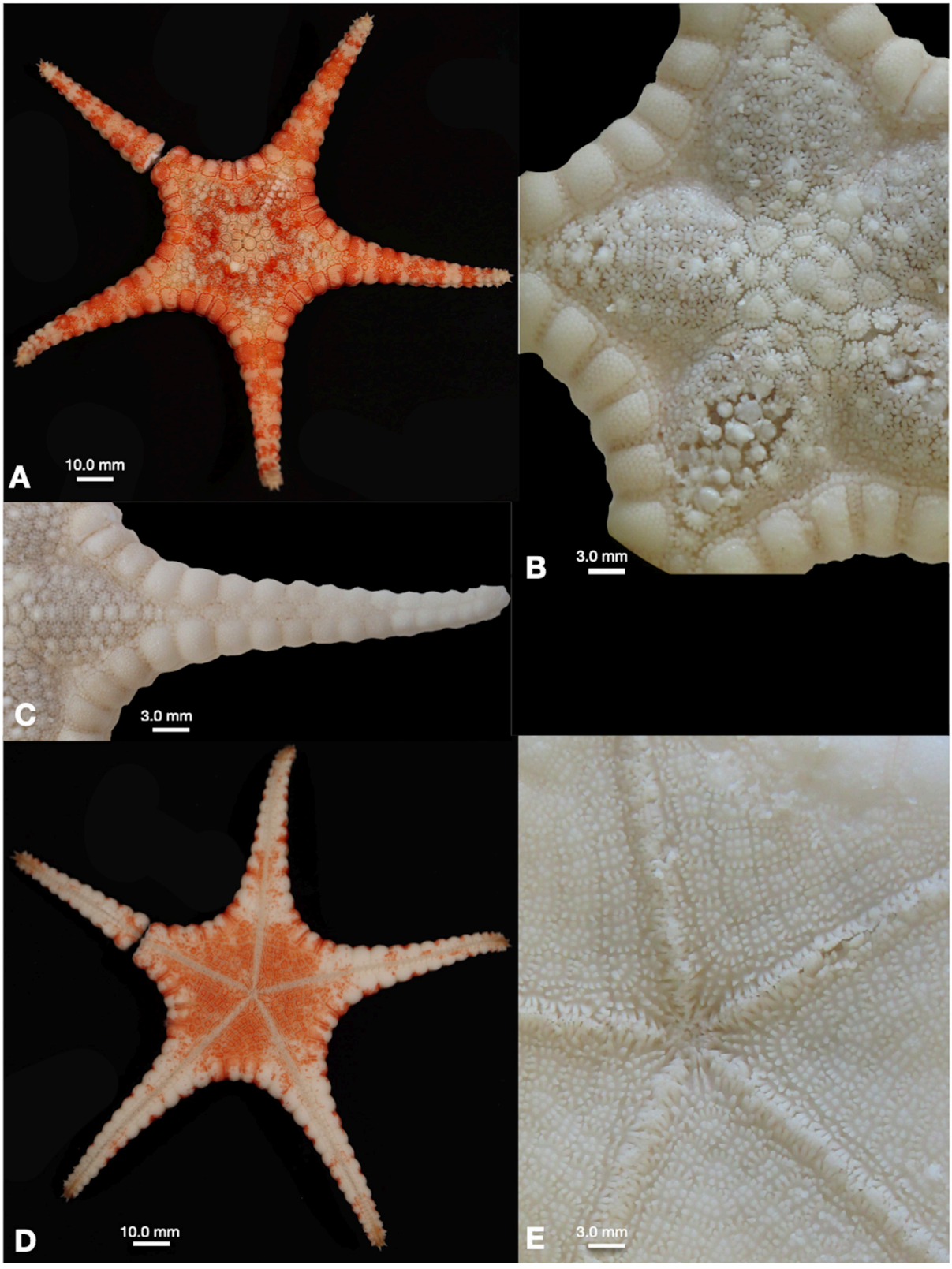

FIGURE 21. *Rosaster mammilatus* WAM Z97586. A. Abactinal. B. Closeup Abactinal. C. Abactinal arm plates. D. Actinal. E. Closeup oral, adambulacal regions.

character of outwardly radiating, bar-shaped ossicles with *Mediaster*, and *Nectria*, Rosaster should be added to the Mediasterinae.

Nothing is known regarding their biology or ecology.

Rosaster mammilatus Fisher, 1913

Figure 19C, 21A–E

Fisher, 1913: 632; 1919: 247; A.M. Clark, 1993: 283 (checklist).

Diagnosis

Body stout, stellate in shape (R/r=3.0–3.4) with arms elongate, strongly tapering, interradial arcs curved. Abactinal plates tabulate with trapezoidal peripheral granules, approximately 8–40 (mostly 8–10, with central round granules, 1–30. When a single granule is present, it is similar in size to peripheral granules. Description does not note pedicellariae, but tong-like abactinal pedicellariae are present on WAM Z97586. Fasciolar groove well developed. Single row of abactinal plates along the arm, but with abutted superomarginal plates distally. Superomarginals massive, tumid, covered by polygonal granules. Widely spaced in type but close set on specimen. Superomarginal plates 26 per interradius (in type) 30–32 herein. Actinal plates broad with widely spaced angular spinelets, approximately 5 to 30, widely spaced with approximately 20 peripherally (5 per side) and the remainder on central surface. Description suggests accessories are more granular, 9–12 per plate. Furrow spines blunt, 3–5 with subambulacral spines, 3–5.

Comments

WAM Z97586 presented some difficulty owing to what appeared to be significant variation from the typological description (type locality in the Philippines) as summarized by Fisher (1913, 1919). Notably, this specimen possesses numerous abactinal pedicellariae, densely spaced polygonal marginal granules, a greater number of marginal plates per interradius (30–32 versus 24–26 in Philippine specimens) and more numerous and finer abactinal and actinal spination. However, the specimen does show several identifying features, such as the tubercles or single blunt spine on distalmost marginal plates, and the limited abactinal plate series extending only halfway along the arm as the superomarginal plates become abutted distally. On this basis, it was decided that this specimen reflected variation but further review of *Rosaster* specimens and species concepts is warranted.

Ecological Comments

Figure 19C shows WAM Z97586 resting on a substratum of white to grey coarse sediment and apparent rocks or hard substratum, which was covered by a fibrous to flocculent

covering, possibly hydroids or sediment overlying algae. The posture of the specimen suggests predation on the white overlying material.

An unidentified polynoid worm (WAM V10818) was collected in association with the exterior of the specimen (WAM Z97586).

Occurrence/Distribution

In Australia: Ashmore Reef, 135 m. Outside Australia. The Philippines, 112 m.

Material Examined

WAM Z97586 Ashmore Reef, Western Australia 12.18706329°S 122.97052776°E, 134.97 m, Coll. N.G. Wilson & C.S. Whisson, Station FK210409/SO409, 15 April 2021, 1 wet spec.R=3.7 r=1.1.

LUIDIIDAE Sladen 1889

Diagnosis

Arms 5 to 10, strap-like, covered by paxillae, round to quadrate in shape. Marginal plates also paxillate, similar in appearance to abactinal plates. Inferomarginal plates massive, lateral or ventrolateral in position but never conspicuous from surficial views. Tube feet with double ampullae, pointed tips. Superambulacral plates present. (based on Marsh & Fromont 2020 and Clark & Downey 1992).

Comments

A monotypic family containing the single genus, *Luidia,* which in turn contains, approximately 50 species (Mah & Blake, 2012) which occur primarily at relatively shallow (0–200 m) shelf settings on unconsolidated sediment bottoms, where they are often observed buried below the subsurface. Gates & Rowe (1995) report eight species of *Luidia* from Australian waters, of which one, *L. varia* Mortensen, 1925 is a synonym of the widespread *L. maculata* Müller & Troschel, 1842. *Luidia* species are known primarily as predators of mollusks, echinoderms, and other infaunal invertebrates (Jangoux, 1982).

Luidia pola Mah sp. nov.

Figure 22A, 23A–F

Etymology

The species epithet, *pola* is derived from the Indonesian name for pattern, alluding to the decorative patterns observed on the abactinal surface.

Diagnosis

Arms seven. Abactinal granules with pointed tips. **Spines absent from abactinal paxillae. Paxillae proximally quadrate becoming round, more distally. Pedicellariae beak-like bivalve or trivalve, present along lateral paxillae.** Enlarged adambulacral spines pointed, two then one present along arm series, forming fringe along edge

Comments

Luidia pola **sp. nov.** invites comparison with similar "*alternata*" group *Luidia* taxa (summarized in Clark

FIGURE 22. *In situ* Luidiidae & Ophidiasteridae. A. *Luidia pola* **sp. nov.** WAM Z97666 B. *Leiaster* sp. WAM Z97674 C. *Leiaster* sp. Uncollected. showing color variation. No scale.

&Rowe, 1971). *Luidia pola* **sp. nov.** differs from *Ludia maculata* Müller & Troschel, 1843 and *Luidia australis* Doderlein, 1920 in possessing numerous pedicellariae on both the superomarginals, inferomarginals and adjacent lateral plates. Paxillae in *Luidia pola* **sp. nov.** are topped with pointed granules versus those in *L. maculata, L. australis* and *L. avicularia* Fisher, 1913, which are rounded. *Luidia pola* **sp. nov.** possesses round, but homogeneous distal abactinal paxillae whereas *L. australis* has enlarged and irregular plates at its distalmost tip. *Luidia pola* **sp. nov.** differs from *Luidia avicularia* in lacking oral pedicellariae, spines, possessing a "bold" color pattern, and having 7 rather than 9 or 10 arms. Note that arm number in other *Luidia* spp. does vary and further specimen collections will likely show further variation in this species.

Two polynoid polychaete associates (WAM V10826 and V10827) were collected in association with this species.

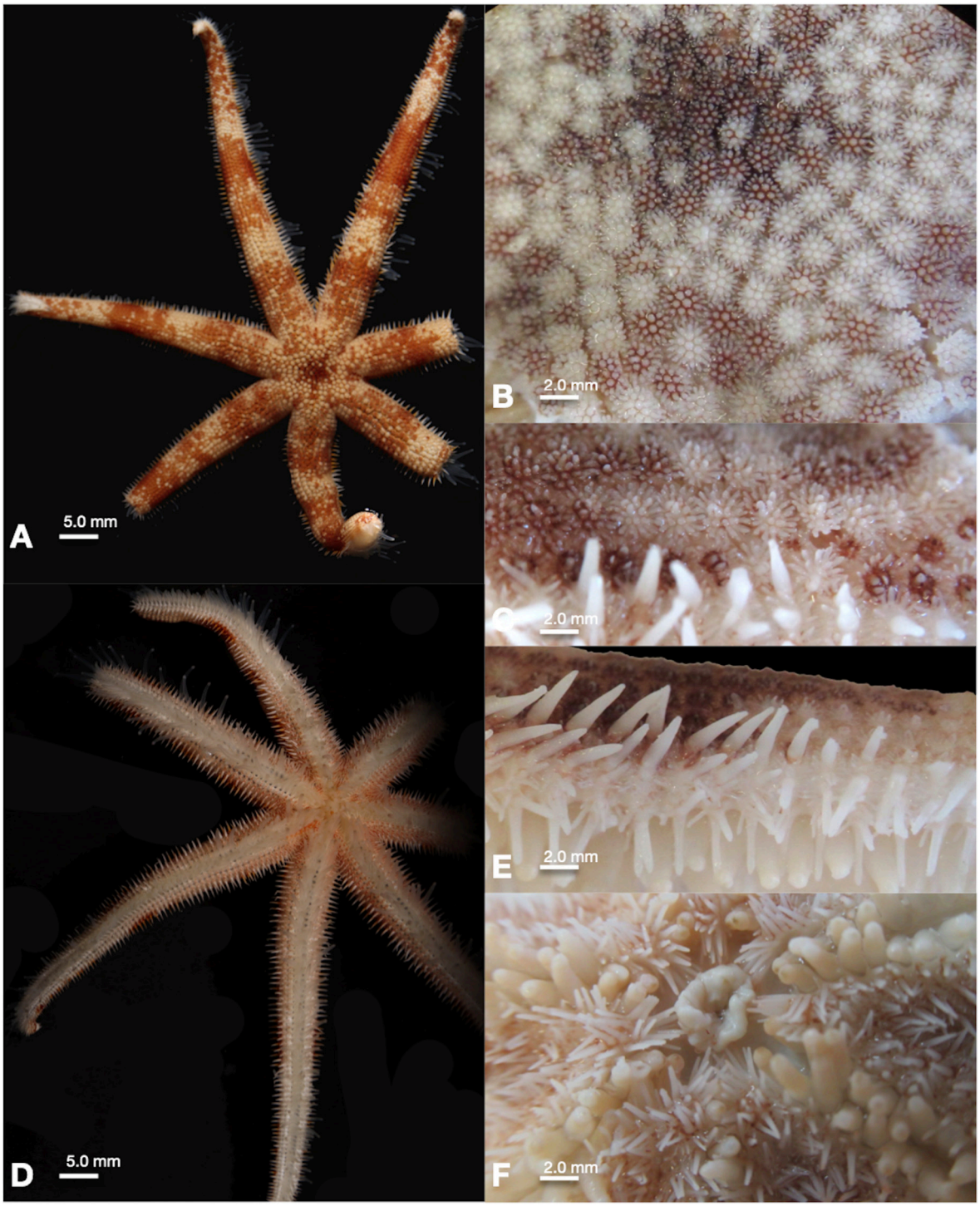

FIGURE 23. *Luidia polo* **sp. nov.** Holotype. WAM Z97666. A. Abactinal B. Closeup abactinal plates. C. Arm plates showing pedicellariae. D. Actinal E. Lateral spination. F. Oral region.

Ecological Comments

Luidia pola **sp. nov.** was observed *in situ* on white to grey colored coarse sediment and pebbles which appeared to be covered by a grey flocculent detritus. The disk of the specimen was elevated above this surface and appeared expanded with paxillae distended owing to strong arching of the disk. No prey items were observed.

Occurrence/Distribution

Known only from Ashmore Reef, Western Australia. 146 m.

Description

Arms seven, Body strongly stellate (R/r=8.6). Disk small, arms elongate, strap like. Interradial arcs acute.

Abactinal plates paxillate, ranging from quadrate to round in shape with proximal paxillae more rectangular and slightly larger proximally. Paxillae with central granules, 4 to 15, conical in shape with pointed tip, surrounded by 10–25 peripheral spinets. All paxillar spinelets and granules spaced, evenly distributed on plate surface. Individual paxillae tall with well-developed fasciolar grooves.

Proximal paxillae in linear rows, with quadrate shaped paxillar surfaces on approximately 33% of the proximal arm distance. More distally, paxillar surface becomes round and more circular shaped with all distalmost plates transitioning to completely circular. Spinelets on these distal plates smaller, more homogeneous. No large primary spines present.

Marginal plates similar to those on abactinal surface. Paxillar surface with short, pointed cone-shaped spinelets, surrounded by short, pointed peripheral spinelets, 10–30. Inferomarginal plate series with a single pedicellariae, beaklike bivalve and trivalve on each plate, present on approximately 50% of the plates along the arm series.

Adambulacral plates arranged transversely to ambulacral groove, elongate in shape. Enlarged adambulacral spines pointed, 4 to 6 present along arm series, forming fringe along edge. Shorter spines, 20–60, forming periphery around adambulacral plate spine base. Straight, two piece, pedicellariae one per plate present approximately halfway along arm.

Oral plates with elongate spines, 6 to 10 in widely splayed series along mouth plates in two to three series. No pedicellariae on oral spines.

Tube feet pointed.

Body with mottled coloration, primarily on arms with central spot on disk. Color endures fixation/preservation in alcohol.

Material Examined

Holotype. WAM Z97666 Ashmore Reef, east side, outer reef slope, Western Australia, 12.230088642°S 123.27471273°E, 145.86 m, Coll. N.G. Wilson, C.S. Whisson, FK210409/SO417, 23 April 2021, 1 wet spec. R=8.6 r=1.0.

MITHRODIIDAE Viguier, 1878

Mithrodiidae Viguier 1878: 682

Echinasteridae (Mithrodinae) Viguier 1879: 128; Perrier 1884: 164

Echinasteridae (Mithrodiinae) Sladen 1889: xxxviii, 538

Mithrodidae Perrier 1893: 849; 1894: 4, 141

Mithrodiidae Fisher 1906: 1094; 1911: 252; Verrill 1914: 204; Spencer & Wright 1966: U71; A.M. Clark & Courtman-Stock 1976: 87; Caso 1977: 2; Blake 1987: 520; A.M. Clark 1993: 324 (checklist); Marsh & Fromont 2020: 286,

Ophdiasteridae (Mithrodiinae) Blake 1980: 178; 1981: 391.

Comments

The Mithrodiidae is a small family, containing two genera, within the Valvatida present at relatively shallow depths (0–150 m) in the tropical Atlantic, Pacific and Indian oceans. *Thromidia* is known only from the Indo-Pacific, whereas *Mithrodia* is present in the tropical Atlantic, Eastern and Indo-Pacific. Morphological and molecular data suggests a sister-group relationship with the Ophidiasteridae (Blake 1987; Mah & Foltz 2011). Although frequently observed, much of their basic biology, such as feeding, etc. is poorly understood.

Mithrodiids are characterized by a distinct reticulate network enclosing distinct papular regions, but bearing distinct spines or tubercles with a surface completely covered by a dermis bearing granules, scales or spinelets.

Two genera and three species of mithrodiids, *Mithrodia clavigera* (Lamarck, 1816), *Thromidia brycei* Marsh 2008 and *Thromidia catalai* Pope & Rowe 1977, are known from Australian waters (Marsh & Fromont 2020).

Thromidia Pope & Rowe, 1977

Thromidia Pope & Rowe 1977: 202; Marsh & Fromont 2020: 288

Diagnosis

Body strongly stellate, R/r=7.1 to 7.7, arms thick, disk small. Adult body attains large size with R=30.0 cm. Abactinal skeleton reticulate, surface and spines covered with small tubercles and spine-like granules. Marginal plates inconspicuous, without spines. Actinal intermediate areas wide, with multiple rows. (following Marsh & Fromont 2020).

Comments

Thromidia includes four species which occur in shallow-water tropical Pacific and Indian Ocean habitats at moderate depths (10–65 m). Marsh and Fromont (2020) identify two species of *Thromida* from Australia, including the widely occurring *Thromidia catalai* and the endemic *Thromidia brycei* from Western Australia, described by Marsh (2009)

Thromidia catalai Pope & Rowe 1977

Figure 24A

Thromidia catalai Pope & Rowe 1977: 203

Diagnosis

Widely spaced tubercles present on the distalmost region on each arm. Abactinal skeleton forms an open reticulate network, enclosing large papular regions. Three to five furrow spines in a webbed fan adjacent to a single, large subambulacral spine.

Coloration showing pink to white disk and arms with dark red to brown tips. A second uncollected specimen of this species at 104 m displayed identical coloration.

As with all known specimens of *Thromidia*, *T. catalai* with large individuals attaining R=20 to 35.0 cm.

Comments

Although *Thromidia catalai* occurs widely throughout the Indo-Pacific it has previously only been found from Australia from the Capricorn Group, Great Barrier Reef, Queensland.

A specimen identified as *T. catalai* by Marsh (2000) from the Montebello Islands appears to be *Thromidia brycei* as described by Marsh (2009).

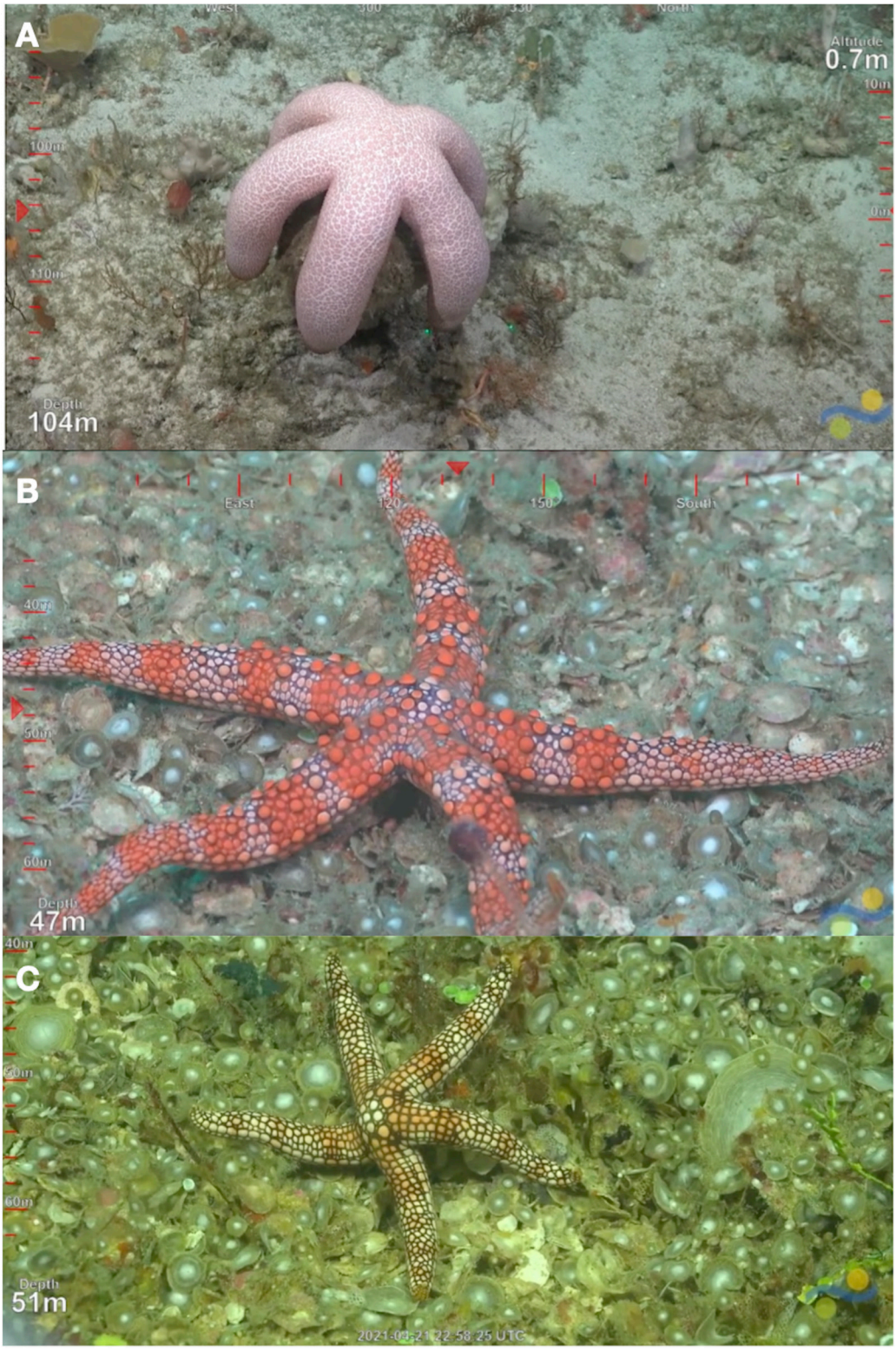

FIGURE 24. *In situ* Mithrodiidae & Ophidiasteridae. A. *Thromidia catalai* feeding (not collected) B. *Nardoa frianti* WAM Z97657 C. *Andora faouzii*. WAM Z97656. No scale.

WAM Z97609 marks the first occurrence of this species from this region of Western Australia.

Ecological Comments

A second observation of this species from *Falkor* Dive 417 at UTC 03: 47:02 showed an individual at 104 m (uncollected) with its disk hunched over what appeared to be a barrel sponge with its arms wrapped around the edge upon which it was apparently feeding (Fig. 24A). Specimen WAM Z97609 was positioned adjacent to what appeared to be a cluster of encrusting organisms, which might also have been sponges or a similar kind of debris.

When collected, tube feet on WAM Z97609 displayed tube feet extended during collection with various types of debris adhered to it during collection suggesting that it was engaged in feeding.

Both individuals of this species observed on the Ashmore Reef slope were present on loosely consolidated, white, coarse sediment and rubble, consistent with Marsh and Fromont (2020).

Occurrence/Distribution

Australia. Ashmore Reef, Western Australia, 99.3 to 104 m.

Outside Australia.Indonesia, Papua New Guinea, Solomon Islands, New Caledonia, Hawaii, Guam, and the Ogasawara Islands, Japan. 10–105 m (summary in Marsh & Fromont 2020).

Material Examined

WAM Z97609 Ashmore Reef, north side, outer reef slope. Western Australia, 12.1341071°S 123.07647971ºE, 99.3 m, Coll. N.G. Wilson, C.S. Whisson, Station FK210409/SO413, 19 April 2021, 1 wet spec. R= 27.5 r= 5.0.

OPHIDIASTERIDAE Verrill, 1870

Verrill, 1870: 344; H.L. Clark 1921: 36; Spencer & Wright 1966: U64; Downey 1973: 61; A.M. Clark & Courtman-Stock 1976: 69; Walenkamp 1976: 17; Miller 1984: 205; Clark & Downey 1992: 268; Rowe & Gates 1995: 79; H.E.S. Clark & McKnight 2001: 167.

Linckiidae Viguier 1879: 144; Sladen 1889: xxxv, 397 (includes *Chaetaster*); Perrier 1894: 327; Fisher 1911: 240.

Linckiinae Sladen, 1889: xxxv, 397; Perrier 1893: 852

Comments

The Ophidiasteridae has historically included 106 species represented by 27 genera (Mah & Blake 2012) which are best known from tropical shallow (0–150 m) habitats in the Atlantic, Indian, and Pacific Oceans (e.g. Clark & Downey 1992; A.M. Clark, 1993, Rowe & Gates 1995). The typological morphology for members of the Ophidiasteridae, follows taxa such as *Linckia* or *Ophidiaster* displaying elongate arms which are thick and cylindrical in cross-section with small disks, narrow ambulacral grooves and a continuous granule-infused dermis covering the body surface.

However, molecular overviews of the Valvatida (Mah & Foltz 2011) have shown multiple genera within the Ophidiasteridae, including *Fromia* and *Neoferdina* to be members of the Goniasteridae (Mah 2017) and a re-evaluation of taxa within the Ophidiasteridae reveals others which are also likely members of the Goniasteridae (e.g. *Dissogenes* reassigned herein). Taxa included herein follow the historical placement, pending further evaluation of their phylogenetic position.

Andora A.M. Clark, 1967

Diagnosis

Similar to *Nardoa*, but distinguished by ordered abactinal plates on the proximal third of the arms arranged in regular longitudinal and transverse rows.

Comments

Andora was described as a subgenus of *Nardoa* (A.M. Clark 1967) to accommodate *Nardoa faouzii* Macan, 1938. Rowe (1977) elevated *Nardoa (Andora)* to a genus, including four species in two subgenera. Based on comparison of specimens displaying these patterns, it is difficult to consistently maintain the basis for the linear versus irregular proximal arm plate patterns as variation in further specimens are compared. Although I retain *Andora* herein, it seems difficult to retain separately from *Nardoa* and further testing is desirable.

Andora (Andora) faouzii (Macan, 1938)

Figure 24C, 25A–B

Nardoa faouzii Macan, 1938: 407

Nardoa (Andora) faouzii A.M. Clark 1967; James 1973: 559.

Andora (Andora) faouzii Rowe 1977: 237

Diagnosis

Strongly stellate (R/r=7.75), large abactinal primary disk plates, round to polygonal in shape, all separated by smaller plates and finer, darker granules. Proximal arm plates more overall homogeneous in size, shape versus those distally on arm which are more heterogeneous in size, shape and irregularly arranged. Superomarginal and inferomarginal plates similar to one another in number (not differing by more than 50%). Furrow spines 4 to 5, truncate with rounded tip. Subambulacral spines, 3, approximately half the length of the furrow spines.

Color *in situ* straw to yellow with dark orange in bands over the arms as well as over proximal third of arm. Interstices between plates dark brown to grey or black in color. Arm tips light. Oral surface straw to yellow in color.

Comments

This represents the first occurrence of this species in Australian waters at a novel depth (52.4 m) compared to that of the type (13.5 m). Nothing is known regarding its biology or ecology.

Ecological Comments

This species was observed on a loose, unconsolidated substratum composed primarily of large foraminifera in the genus *Cycloclypeus* Carpenter 1856 as well as algae, bryozoans and other encrusting organisms.

Occurrence/Distribution

Australia. Ashmore Reef, Western Australia, 52.4 m.

Outside Australia. Southeast Arabia, southern India, Seychelles. <1.0–13.5 m.

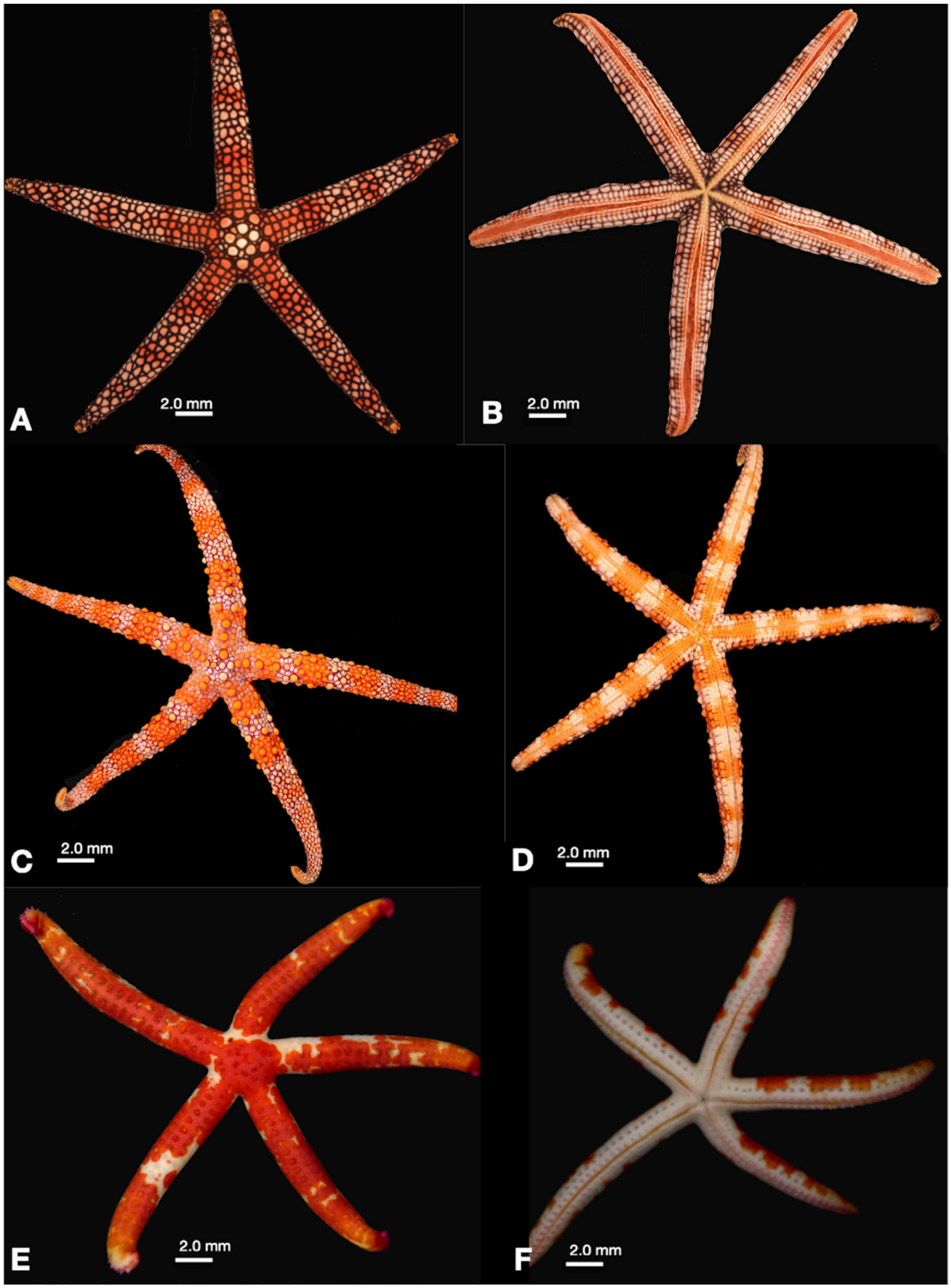

FIGURE 25. Ophidiasteridae. *Andora faouzii* WAM Z97656 A. Abactinal. B. Actinal. *Nardoa frianti* WAM Z97657 C. Abactinal. D. Actinal. *Leiaster sp.* WAM Z97674 E. Abactinal. F. Actinal. Scale bar=2.0 cm, A–F.

Material Examined
WAM Z97656 Ashmore Reef, Northeast side, outer reef slope, Western Australia. 12.13421786°S 123.18751562°E, 52.4 m. Coll. N. G. Wilson, C.S. Whisson, Station FK210409/SO416, 22 April 22 April, 2021. 1 wet spec. R=6.2 r=0.8.

Leiaster Peters, 1852

Peters 1852: 177; Fisher 1919: 396; H.L. Clark 1921: 71; 1946: 119; Jangoux 1980: 88
Type species: *Ophidiaster (Leiaster) coriaceus* Peters 1852

Comments
Consistent with the more "typological" members of the Ophidiasteridae, *Leiaster* possesses a small disk, and elongate cylindrical arms, which are thick and round in cross section but is distinguished by the presence of a conspicuous smooth dermis which covers nearly the complete external surface and eight distinct papular rows (Marsh & Fromont 2020; Jangoux 1980). Species in this genus were reviewed by Jangoux (1980). Five species occur across the tropical Pacific from the tropical coast of Central and South America, to Hawaii and southern Japan to the east coast of Africa and throughout the Indian Ocean. No Atlantic species are known, although the genus *Copidaster* also displays a conspicuous smooth dermis and eight papular rows.

Leiaster species (WAM Z97674)
Figure 25E–F

Specimen Description
For WAM Z97674, body strongly stellate (R/r=10.75). R=4.3. Plates appear cruciform. Papular pores 4–15 in regular papular regions in well-defined, regular series along disk and arms. Soft dermis present over surface plates. Abactinal and marginal plates largely indistinguishable due to dermal cover. Furrow spines, short blunt, quadrate in cross-section, in linear series along edge of tube foot groove. Subambulacral spines, blunt, larger than furrow spines, twice as thick and approximately 20% taller. Subambulacral spines present approximately every eight furrow spines.

Color in life, orange-red with mottled white in irregular blotches along arms with two showing large white patches. Arm tips with light orange highlights. Papular pores darker than surrounding orange. Oral surface white with dark papular pores.

Comments
Based on its well-defined papular pores, this specimen could have been either *Leiaster glaber* (Peters 1852) or *Leiaster leachii* (Gray, 1840). Full species identification was not attempted for this specimen. WAM Z97674 was relatively small (R=4.3 cm) compared to many of the specimens upon which taxonomic characters were derived for other species (R=10 to 20) with adults of some species showing R up to 40.0 cm (e.g. *Leiaster leachii*, Marsh & Fromont 2020). It was unclear if diagnostic characters would be evident on individuals at this size. Diagnostic characters for species in *Leiaster* requires examination of crystal bodies on the abactinal and marginal plates, which requires destructive sampling from the specimen, namely the removal of the dermis via bleach or physically destructive means.

Owing to the specimen's status as a unique specimen from mesophotic Ashmore Reef settings, its conservation was a significant consideration and so, destructive sampling was avoided in lieu of a less invasive identification methodology to be determined.

Leiaster sp. (uncollected)
FIGURE 22B–C

Specimen Description
A second, larger specimen (R=~8.0 cm) of *Leiaster* was observed but not collected on dive 422 at time UTC04:58:46 at 47.0 m. This specimen was white with orange and dark (purple?) mottled patches on its arms. Actinal surface was white with dark papular pores and purple subambulacral spines. Papular pores were numerous and widespread over the abactinal surface. Papular areas were not well-defined. This specimen likely represented a separate species from WAM Z97674. Based on its poorly defined papular pores and colors, this specimen appeared to be consistent with *Leiaster coriaceus* as figured by Marsh & Fromont (2020: 316).

Ecological Comments
Both species of *Leiaster* were observed on unconsolidated, rocky substrates adjacent to algae, bryozoans and rocks bearing numerous encrusting organisms.

Occurrence/Distribution
Ashmore Reef, Western Australia, 47.0 and 48.2 m.

Material Examined
WAM Z97674 Ashmore Reef, east side, outer reef slope, Western Australia, 12.22970773°S 123.25685726°E, 48.2 m Coll. N.G. Wilson & C.S. Whisson, Station FK210409/SO418, 24 April 2021 1 wet spec. R=4.3 r=0.4.

Linckia Nardo 1834

Linkia Nardo 1834: 717.
Linckia (name corrected) Gray 1840: 284 (Name corrected); Verrill 1870: 285; Perrier 1875: 135 (399); Fisher 1906: 990; 1919: 400; H.L. Clark 1921: 62; Downey 1968: 144; 1973: 66; Clark & Downey 1992: 274. Mah 2021: 426.

Diagnosis
Identified by the irregular pattern of abactinal plates and occurrence of papular pores present along the lateral sides of each arm. Arms thick, elongate, disk small.

Linckia guildingi Gray, 1840
Figure 26

Diagnosis
Disk small, arms elongate, body strongly stellate. Arms 5 in most but variably 6, cylindrical in cross-section, tapering distally to a blunt tip. Two madreporites, autotomous when small. Abactinal plates and papular areas irregularly arranged. Marginal and actinal plates in series. Papulae absent from actinal surface. Furrow spines round tipped in unequal pairs, no granules present between spines. Few to no granules between furrow and subambulacral spines, which are round and larger than, but projecting above the granules of the actinal plates. A second series of slightly smaller subambulacral spines adjacent to the first. Pedicellariae absent (modified from Marsh & Fromont, 2020).

Comments
Although only imagery was recorded, this species showed the more elongate arm morphology and madreporite consistent with *Linckia guildingi* from Marsh & Fromont (2020).

The specimen was pink with darker papular areas.

This species has been collected previously from shallow-water habitats on Ashmore Reef. *Linckia guildingi* is widely occurring in the Atlantic and Pacific.

Ecological Comments
Observed on unconsolidated, coarse substrate composed of large foraminifera in the genus *Cycloclypeus* as well as algae, bryozoans and other encrusting organisms.

Occurrence/Distribution
Australia. Intertidal reef flat to northeast side, outer reef slope, Ashmore Reef. 0–52.0 m. Houtman Abrolhos, around northern Australia and the Great Barrier Reef south to the Bunker Group, Queensland (Marsh & Fromont, 2020). 0–114 m.

Outside Australia. Circumtropical distribution in the Indo-Pacific from east Africa to Hawaii, West Indies, and Brazil in the Atlantic (Marsh & Fromont 2020; Clark & Downey 1992).

Material Examined
None (Image only). Dive 416, location 6, 52 m dive 2 at UTC 04:39:56.

Nardoa Gray, 1840

Diagnosis
Body stellate to strongly stellate, disk small, arms elongate. Abactinal plates with weak to round surface. Abactinal, marginal, actinal surface covered with continuous granular cover. Individually, granules polygonal to flat. Marginal plates decrease regularly in size with no alternation in size. Intermarginal plates absent. Papulae present abactinally, intermarginally, actinally. (following Marsh & Fromont, 2020).

Comments
Nardoa is a genus which currently includes nine species which are present only in the tropical Indo-Pacific, predominantly in shallow (0–100 m) water habitats. *Nardoa* previously included many more species summarized by Clark & Rowe (1971) and A.M. Clark (1993). Several of these species, such as *Nardoa rosea* H.L. Clark, 1921, among others, were re-allocated to the genus *Gomophia* based on the presence of large, hemispherical tubercles on the abactinal and marginal plates (see Rowe & Gates, 1995, Marsh & Fromont 1995). These taxonomic changes were made in a checklist and without character argumentation. Thus, characterization of this change for

FIGURE 26. *Linckia guildingi in situ*. Uncollected. No scale.

many of these species is uncertain. Complete resolution of this taxonomic arrangement awaits confirmation from further molecular phylogenetic evaluation.

Nardoa frianti Koehler, 1910

Figure 24B, 25C–D

Koehler, 1910: 158; Fisher 1919: 385; Hayashi 1938: 280; A.M. Clark 1967: 178; Clark & Rowe 1971: 36, 63; Liao 1980: 159; Jangoux 1986: 140;

Diagnosis

Disk small, arms elongate, body strongly stellate. Abactinal plates strongly convex to hemispherical and projecting above the body surface. Superomarginal plates variably hemispherical, the height of these equal to the basal diameter. (modified from A.M. Clark & Rowe, 1971).

Comments

This species was identified by the large round, hemispherical tubercles present on the abactinal and superomarginal surface.

This represents the first occurrence of this species in Australia and at this lower depth limit.

Ecological Comments

This species was collected from a loosely consolidated bottom composed primarily of foraminifera tentatively identified as *Cycloclypeus* Carpenter 1856 as well as miscellaneous encrusting and other organic material covering the bottom.

Occurrence/Distribution

Australia. Ashmore Reef, Western Australia, 49.4 m. Outside Australia. Andaman Islands to Parcel Islands, South China Sea, Philippines, Caroline Islands and New Caledonia. 3–45 m.

Material Examined

WAM Z97657 Ashmore Reef, northeast side, outer reef slope, Western Australia, 12.13417298°S 123.18733147°E, 49.4 m. Coll. N. G. Wilson, C.S. Whisson, FK210409/SO416, 22 April, 2021. 1 wet spec. R=10.0 r=1.0.

OREASTERIDAE Fisher, 1908

Fisher 1908: 93

Diagnosis

Body variable, ranging from pentagonal, cushion-shaped round bodies to more strongly stellate forms. Disk and arms strongly arched with large coeloms in large sized specimens (R>~4.0 cm). Abactinal skeleton reticulate papular regions well-developed. Marginal plates well-developed but variably obscured by heavily granulate dermal layer, well-developed body wall or other covering. Surface covered by large primary spines, tubercles and/or other accessory structures. Adambulacral plates tall, articular surfaces prominent. Ambulacral and adambulacral ossicles stout, closely spaced, forming diamond-shaped chamber over ambulacral groove. Actinal papulae absent. Calcareous interbrachial septum present. Coelomic openings large. Upturned, terminal arm tip. Spicules in tube feet. Modified from Marsh and Fromont (2020) and Mah (2003).

Comments

The family Oreasteridae contains approximately 74 species in 20 genera, which occur primarily from shallow-water (0–100 m), tropical Indian and Pacific ocean regions with one genus and two species in the tropical Atlantic. Although most adult oreasterids show certain generalized characters, including large (R> 6.0 cm) size with large spines and/or granules or tubercles and bright conspicuous colors, morphologically, oreasterids occupy two fundamental types, either a more "*Anthenea*"-like form with a more flattened pentagonal shape similar to the Goniasteridae or a much more strongly arched form, ranging from cushion or mound-shaped (e.g., *Halityle*) to strongly stellate with a preponderance of prominent conical spines (e.g., *Pentaceraster*).

Marsh & Fromont (2020) reported 15 genera and 38 species from Australian waters. Two of these species are reported from mesophotic settings on Ashmore Reef. Mah (2023) has recently presented an overview of mesophotic Oreasteridae with new records of the unusual *Astrosarkus* from Australia.

Halityle Fisher, 1913

Halityle Fisher, 1913: 211; 1919: 362
Culcitaster H.L. Clark, 1914: 144

Diagnosis. Monotypic, as for species.

Comments

A monotypic genus with a wide-ranging distribution across the tropical Indo-Pacific. *Halityle* is superficially similar to *Culcita* with which it shares a strongly arched disk and arms which are largely confluent but differs in having a distinctly tesselate series of actinal plates as well as a well-defined reticulate pattern on its abactinal surface. The body form is further reminiscent of *Astrosarkus*, which shows a strongly arched and thickened body wall (Mah 2023). On living specimens, actinal plates adjacent to the oral region have a distinctly darker color than others on the actinal intermediate surface. Furrow spines, 8–11 composed of closely adpressed, flat spines. Subambulacral spines 2–3 with round, blunt tips. Full variation is documented by Baker & Marsh (1976) and Fisher (1913).

Halityle regularis Fisher 1913
Figure 27A–D

Halityle regularis Fisher 1913: 211; James 1973: 557; Baker & Marsh 1976: 107; Rowe & Gates 1995: 102; Branch *et al.* 2010: 224; Marsh & Fromont 2020: 422

Culcitaster anamesus H.L. Clark 1914: 145

Diagnosis

Specimens massive, bodies pentagonal to weakly stellate, thickened (R/r= 1.18–1.66) with distinct lateral surfaces, Abactinal surface with distinctive reticulate pattern. Body

FIGURE 27. *Halityle regularis in situ.* A. Uncollected specimen abactinal. B. Actinal. WAM Z97571 B. Abactinal. D. Actinal. No scale, but R=14.5 cm.

surface covered by continuous fine granular cover. Up to 22 superomarginals and 40–50 inferomarginals in each interradius. Actinal surface with distinct rhombic shaped plates with strikingly dark colored regions around mouth. Adambulacral plates with furrow spines, 8–11 closely adpressed, flat. Subambulacrals 2–3, domed with wrinkled tips. (modified from Baker & Marsh 1976).

Comments

The individual documented herein displayed an abactinal surface with a deep purple/blue with dark highlights and an actinal surface which was darker brown to purple becoming closer to champagne proximally. The four plates adjacent to the mouth were a deep blue. Adambulacral and oral spination was white. Marsh & Fromont (2020) documented a similar coloration from a specimen imaged from the Philippines. Other color morphs of this species range from red and orange to a lighter violet and beige/champagne with dark brown highlights (Marsh & Fromont 2020; Ryansky, 2020). This species has recently been documented from mesophotic depths from throughout the Indo-Pacific (Mah, 2023).

Ecological Comments

This species is documented from sandy rubble, coral or coralline algae (Marsh & Fromont, 2020). The specimen herein was collected from a sedimented bottom consistent with prior accounts.

During collection, this species was observed with a small shrimp associate. Australian shallow water specimens of *Halityle regularis* are associated with a pontoniine shrimp, *Periclimenes soror* Nobili 1904 (Bruce, 1983). It is unclear if this was the same species.

Halityle regularis has also been recorded with eulimid parasites (Gosliner *et al*. 1996) and commensal/symbiotic polynoid polychaetes (Antokhina & Britayev 2012).

Occurrence/Distribution

Australia.Known off Ningaloo Reef, Exmouth Gulf, the northwest shelf of Western Australia, Townsville, Keppel Bay and Heron Island (23º30'S), Queensland.

Outside of Australia. Madagascar, east Africa, Somalia, southern India and the Lakshadweep Archipelago, the Philippines, Indonesia, north to Japan and east to New Caledonia.

3–275 m.

Material Examined

WAM Z97571 Outer reef slope, west side, Ashmore Reef, Western Australia, 12.2575136°S 122.92744939°E, 85.6 m. Coll. N.G. Wilson, N.G. & C.S. Whisson, FK210409/SO408, 14 April, 2021. 1 wet spec. R=14.5 r=8.5.

Pentaceraster Döderlein, 1916

Döderlein, 1916: 424; 1936: 331; Clark & Rowe 1971: 55; A.M. Clark 1993: 310 (checklist)

Comments

A genus containing approximately 15 species, which form a complex across the tropical Pacific and Indian Oceans. *Pentaceraster* is in need of revision, as it contains several problematic species which are both poorly defined taxonomically and/or highly variable. Marsh & Fromont (2020) list four species from Australian waters, which occur primarily in shallow-water settings but one species, *Pentaceraster gracilis* was recorded from 146 m.

Pentaceraster alveolatus (Perrier 1875)

Figure 28A–D, 30A

Pentaceros Perrier 1875: 243 (1876: 59); Koehler 1910: 95
*Oreaste*r Bell 1884: 73; Domantay & Roxas 1938: 212
Pentaceraster Döderlein, 1916: 428; Jangoux 1986: 126; Mah 2023: 157.

Diagnosis

Body stellate to strongly stellate. Carinal spines and some distal superomarginal spines well-developed, spines absent interradially. Most abactinal and marginal spines slender and conical, with arm tips relatively narrow. Dorsolateral armament present primarily on the disk, rather than on the arms. Intermarginal plates absent. R/r=2.4–3r. (Modified from Marsh & Fromont, 2020).

Comments

Identified on the basis of the well-developed carinal spines and the absence of dorsolateral and interradial spines on the disk.

Coloration of this specimen *in situ* was white on the dorsolateral surface with a deep red along the radial and adradial series. Spines were orange at the base becoming a dark yellow at the tips. The dark red highlights were present along the superomarginal plate series to the the region adjacent to the arm tip. Underside was white with red tube feet. Inferomarginal plates showed an irregular mix of white and red plate coloration. Both series of marginal spines were similar to coloration on the abactinal surface with orange base and yellow tips.

This specimen represents only the second occurrence of this species from Australian waters and from greater depth (52 m). First occurrence of this species was from Houtman Abrolhos, Western Australia in 35 m (Marsh & Fromont, 2020). Shallow water occurrence from Australia have not been recorded. Mesophotic occurrence of this species has been documented to 70 m by Mah (2023).

Outside Australia, *Pentaceraster alveolatus* occurs widely across the tropical Pacific in a shallower depth range (0–54 m) and displays a wide range of color and spine pattern variation within individuals (Döderlein 1936). Although some spination patterns in published (e.g. Döderlein 1936, pl. 25–26) and online accounts (iNaturalist, 2023) were similar to the individual collected here, the striking color patterns, especially the combination of red and yellow coloration from WAM Z97659 and the pronounced, sharp spine tips were unusual compared to

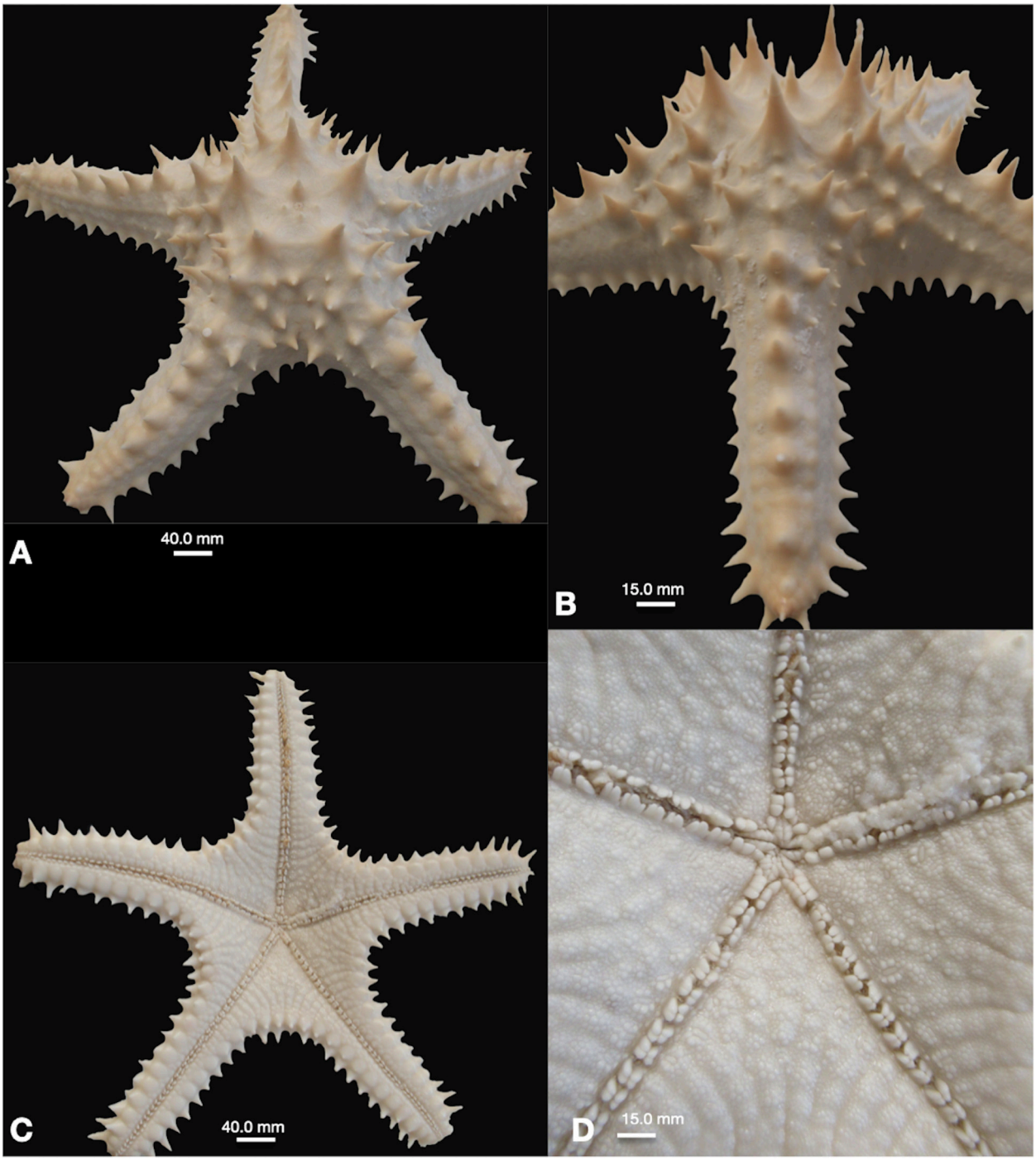

FIGURE 28. *Pentaceraster alveolatus* WAM Z97659 A. Abactinal. B. Abactinal–lateral. C. Actinal. D. Oral region.

known variation for this species and could not be found elsewhere in the literature. The most obvious characters shared between this specimen and other individuals fitting the *Pentaceraster alveolatus* species morphotype are the spination patterns. These include (i) the spines on the primary circlet of the disk, (ii) the spines along the carinal series, and (iii) the absence of dorsolateral spination along the arms.

Ecological Comments

This individual was collected from a field of a large foraminifera, tentatively identified as *Cycloclypeus* Carpenter 1856, amidst a patch of algae and/or hydroids. During collection, the specimen showed adhesion to several of the foraminiferan specimens.

Ostracods (WAM C76537) were collected in association with the specimen.

Occurrence/Distribution

Australia. Houtman Abrolhos, Ashmore Reef, Western Australia. 35–52 m.

Outside Australia. occurs widely from Indonesia, the Philippines, Guam, and east to New Caledonia and Samoa. 1–70 m.

Material Examined
WAM Z97659 NE side of outer reef slope, Ashmore Reef, Western Australia, 12.13415667°S 123.18751738°E, 52.1 m, Coll. N.G. Wilson & C.S. Whisson aboard R/V *Falkor*. Station FK210409/SO416, 22 April, 2021. 1 wet spec. (ostracod associated with specimen) R=10.4 r=3.7

PODOSPHAERASTERIDAE Fujita & Rowe, 2002

Sphaerasteridae A.M. Clark and Wright, 1962: 243; Spencer and Wright 1966: 1966: U55; Clark and Downey 1992: 224
Podosphaerasteridae Fujita and Rowe 2002: 317

Diagnosis & Comments. Monotypic. As for genus.

Podosphaeraster A.M. Clark in Clark & Wright, 1962

Podosphaeraster A.M. Clark in Clark & Wright 1962: 243; Spencer & Wright 1966: U55; Cherbonnier 1970: 206; Rowe & Nichols 1980: 289; Rowe *et al*. 1982: 83; 1985b: 305; Clark & Downey 1992: 225; A.M. Clark 1993: 290; Fujita & Rowe 2002: 321; McKnight 2006: 104

Diagnosis
Body spherical to subsphaerical (HD/W=1.08) to more cushion shaped (HD/W=1.82). Skeletal plates polygonal to hexagonal. Plates variably covered by granules or spines, generally widely spaced. Marginal plates (following Blake's 1976 criterion) present between terminus and interradial primary circlet plate. Series composed of 3–8 plates arched between terminal plates in each inter radii. Primary circlet plates on surface prominent and with variable arrangement.

Adambulacral plates rhomboidal. All closely abutting. Corners with single papular pores. Furrow spines variably 3–6 short furrow spines. No pedicellariae.

Comments
Podosphaeraster is the sole genus in the family Podosphaerasteridae as established by Fujita & Rowe (2002). This was designated to accommodate *Podosphaeraster* which was described by A.M. Clark in Clark & Wright (1962). This genus was originally described in the Sphaerasteridae, a fossil taxon which included members primarily known from the Mesozoic. Fujita & Rowe (2002) argued that *Podosphaeraster* was more properly assigned to its own family separate from the Sphaerasteridae. This treatment is followed herein.

Podosphaeraster currently includes six species, *P. gustavaei* Rowe 1985b, *P. polyplax* A.M. Clark 1962, *P. pulvinatus* Rowe & Nichols 1980, *P. somnambulator* McKnight 2006, P. *thalassae* Cherbonnier 1970, and *P. toyoshiomaruae* Fujita & Rowe 2002. Two species, *P. gustavei* and *P. thalassae* are known from the Atlantic whereas the remainder are known from the Pacific. No Indian Ocean species are known. All occur at mesophotic to deep depths (90–700 m).

Note that due to the unusual spherical shape of *Podosphaeraster,* a different set of measurements is used to characterize overall shape, following measurements used by Clark & Wright (1962), Rowe *et al*. (1982) and Fujita & Rowe (2002) including height (HD) and width (W). Sometimes VD (for vertical diameter is used).

Podosphaeraster bola Mah sp. nov.
Figure 29A–D, 30B

Etymology
The species epithet *bola* is derived from the Indonesia word for ball, alluding to this species' shape and plate pattern. Noun is held in apposition.

Diagnosis
Body with HD:W=0.928. Abactinal plates polygonal, surface covered by 4–12 blunt, conical spines, spaced widely over plates. Marginal plates, 3–4 per interradius. Furrow spines 4, subambulacral spine one pointed conical.

Comments
The spines that cover the plates of this species differentiate it from other known Pacific species which are covered primarily with granules. One species, the New Zealand *Podosphaeraster somnambulator* as described by McKnight (2006), also shows spines on its surface, but these are spaced more widely and display a different shape from *Podosphaeraster bola* **sp. nov.** *Podosphaeraster somnambulator* displays primarily one or two spines per plate, present on each plate surface with no other pattern whereas *P. bola* **sp. nov.** displays spines around the periphery, lacking spines on the central plate region.

This is the first occurrence of *Podosphaeraster* in the Indian Ocean and in Australian waters (Rowe & Gates, 1995).

Ecological Comments
This is the first *in situ* observation of this unusual taxon. Tube feet were extended approximately 50% of the animal's radius away from the tube foot groove.

The substrate appeared to be a mix of soft and pebbly, coarse sediment and loose rock, but covered by encrusting organic material, which were possibly sponges and/or hydroids. Fujita and Rowe (2002) observed the Japanese *Podosphaeraster toyoshiomaru* collected in association with a large quantity of sponges and octocorals with one specimen found in direct association with a demosponge suggesting a possible habitat. *Podosphaeraster bola* **sp. nov.** showed no clear association with sponges but the organic materials present on the adjacent bottom were consistent with sponges as possible habitat or prey.

Occurrence/Distribution
Known only from Ashmore Reef, Western Australia, 162 m.

Description
Body spherical, high aspect, HD/W=0.928, interradial

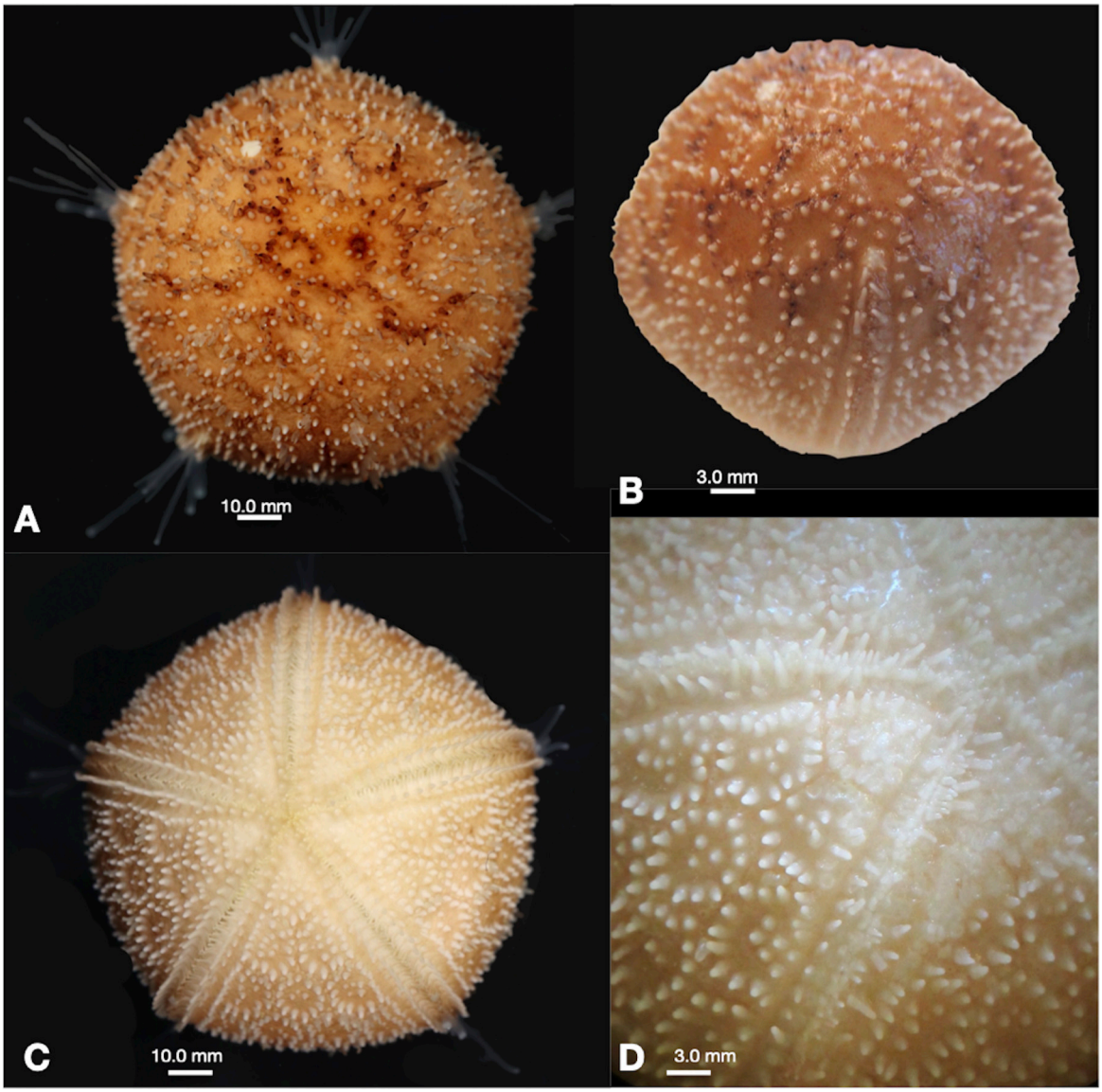

FIGURE 29. *Podosphaeraster bola* **sp. nov.** Holotype. WAM Z97557. A. Abactinal. B. Lateral view. C. Actinal. D. Closeup oral, adambulacral regions.

surfaces weakly convex. Body covered with dark brown, parchment-like dermis, which when accidentally scratched off reveals the white stream below.

Surface plates irregularly polygonal to hexagonal. Each plate with single papular pores, 1–20 present on abactinal surface (upper hemisphere). Papulae "pinch out" with no papulae present below inferomarginal plate series. A central plate present at apex of test with carinal plates, 4–5 in each series in direct, if somewhat irregular, association with terminal plates along abactinal surface. Each plate with short, conical spines, 4–12, each approximately 0.5 mm in length. Abactinal plates with spines primarily around plate periphery with few to no spines on central plate surface. Where spines are absent, surface is smooth and clear with no other accessories. Madreporite sits on a single plate, irregularly shaped, surrounded by approximately 10 widely spaced spines. Anus with 3 blunt, short spines, anal opening flanked by three abactinal plates.

Marginal plates in superomarginal and inferomarginal series, as outlined by Blake (1978), tracking from the interradius to the terminal plate. As with abactinal and actinal plates, marginal plates are composed of distinct, specifically polygonal or hexagonal shaped plates. Superomarginal and inferomarginal plates, approximately 3 or 4 per interradius. As indicated above, these are consistent with the boundary between the presence and absence of papulae on the abactinal and actinal surface.

Actinal plates with 12–18 short spinelets around each plate periphery, in addition to 1 to 7, but mainly 3 or 4 spinelets located on actinal plate central surface. Papulae absent.

Furrow spines, fine, small, 3–4, mostly 4 in linear series. Subambulacral spines enlarged, slender, conical with blunt tip, one per plate. Each subambulacral approximately twice the thickness and height of individual furrow spines. Oral plate spines crowded, furrow spines four along each plate side.

Abactinal surface dark brown, actinal surface white to tan.

Material Examined

Holotype. WAM Z97557 Ashmore Reef, SE side, outer reef slope, Western Australia, 12.31984366°S 123.0.9043533°E, 161.69 m, Coll. N.G. Wilson, C.S. Whisson. Station FK210409/S406, 11 April 2021, 1 wet spec. HD=2.6 Width=2.8.

PTERASTERIDAE Perrier, 1875

Perrier 1875: 17, 38; Sladen 1882: 189; Perrier 1884: 216, 1894: 180, 186: 40; Fisher 1910: 167, 1911: 344; Verrill 1914: 266; 1915: 80; H.L. Clark 1923: 297; Mortensen 1927: 101; Bernasconi 1937: 167; Djakonov 1950: 77; Hayashi 1940: 187; A.M. Clark 1962: 58; Bernasconi 1964: 260; Grainger 1966: 29; A.M. Clark & Courtman-Stock 1976: 81; Clark & Downey 1992: 306.

Pterasterinae: Sladen 1889: xxxvi, 470; Perrier 1893: 850.

Hymenasterinae Perrier 1893: 850

Diagnosis

Bodies stellate to pentagonal, disk and arms thick, numbering 5–8. Taxa characterized by the presence of a supradorsal membrane, a secondary cover suspended by paxillae over the surface of the animal. A central opening, called the osculum present centrally on the supradorsal membrane, with peripheral webbed spines or valves, opening into a chamber between the supra dorsal membrane and the body surface. Actinolateral spines webbed with a distinct membrane. Oral plates plow-share-shaped.

Comments

The Pterasteridae includes approximately 116 species in eight extant genera (Mah & Blake 2012), occurring primarily in cold-water to temperate settings, specifically at high-latitudes or in deep-sea habitats with some taxa (e.g. *Hymenaster*) present at hadal (approximately 6000 m) depths. *Euretaster* differs from all other pterasterids and is present in shallow-water tropical habitats throughout the Indo-Pacific.

Shallow-water pterasterids such as *Pteraster* have been recorded as predators on sponges (e.g. Mauzey *et al*. 1968) but feeding habits and ecology of most pterasterids is poorly understood. Some Pterasteridae, such as the North Pacific *Pteraster tesselatus* Ives, are able to produce copious amounts of mucus as a defense mechanism (e.g. Nance & Braithwaite, 1979). Other genera, such as the deep-sea *Hymenaster*, can demonstrate a similar substance (Mah, pers. obs.) but it is unclear if it does so to the extent that shallow-water species are able to do or if it serves the same purpose.

Phylogenetic position of the Pterasteridae has shown them to be the most diverse group within the Velatida, one of three major lineages within the Asteroidea, which displays a highly divergent morphology from other crown-group sea stars. Molecular phylogenetic data (e.g. Linchangco *et al*. 2017; Mah & Foltz, 2011) has shown the Velatida as a possible lineage which diverged early in the crown group with possible interest for broader scale phylogenetic questions.

Rowe & Gates (1995) list only three species of Australian Pterasteridae. The shallow-water *Euretaster insignis* as well as two species of *Pteraster* from the continental shelf. Further occurrences of this group are anticipated as there is additional sampling in deep–water settings.

Euretaster Fisher, 1940

Fisher 1940: 198; Marsh & Fromont 2020: 443–44

Diagnosis

Body stellate, variably with tapering to elongate arms. Characterized by the presence of a well-developed supradorsal reticulum, composed of ligamentous bands with the open mesh filled with numerous small spiracles.

Comments

H.L. Clark (1923) constrained and defined the genus *Retaster* Perrier as the most appropriate name to accommodate those species with a well-developed supradorsal reticulum forming an open mesh filled with numerous small spiracles. However, as outlined by Fisher (1940), *Retaster* had been synonymized with *Pteraster*, making it unavailable. As a result, Fisher (1940) established *Euretaster* in order to accommodate *Pteraster cribrosus* and *Retaster insignis*, which displayed these characters.

Euretaster currently includes three species, *Euretaster cribrosus* (von Martens 1867), *Euretaster insignis* (Sladen, 1882) and *Euretaster attenuatus* Jangoux 1984. The former two species were synonymized by Döderlein (1888) but this was met with historical disagreement by Fisher (1919) and ultimately the two species were left separate by Clark & Rowe (1971). However, the distinction between *E. cribrosus* and *E. insignis* in their key is based on an adambulacral spine number difference which varies across its range, suggesting that the two species are likely synonyms. *Euretaster attenuatus*, as described by Jangoux (1984) is characterized by its slender, triangular-shaped arms, short and irregularly arranged abactinal paxillae, a membranous supradorsal membrane subdivided with ill-defined contours and five webbed adambulacral spines arranged in an L-shaped formation.

Rowe & Gates (1995) and Marsh & Fromont (2020) recognize a single species, *Euretaster insignis* from Australian waters. Rowe & Gates (1995) acknowledge that the relationship between *E. cribrosus* and *E. insignis* is unresolved.

***Euretaster magnificus* Mah sp. nov.**
Figure 30C, 31A–E, 32A–D

Etymology
The species epithet *magnificus* is Latin for magnificent, alluding to this species' stunning appearance.

Diagnosis
Supradorsal membrane with fine pores, **ornate striped/marbled pattern throughout reticulated plates. Prominent and well-developed thorny spines present on abactinal and lateral surfaces.** Furrow spines 3 or 4. Subambulacral spines forming fence-like fringe adjoining

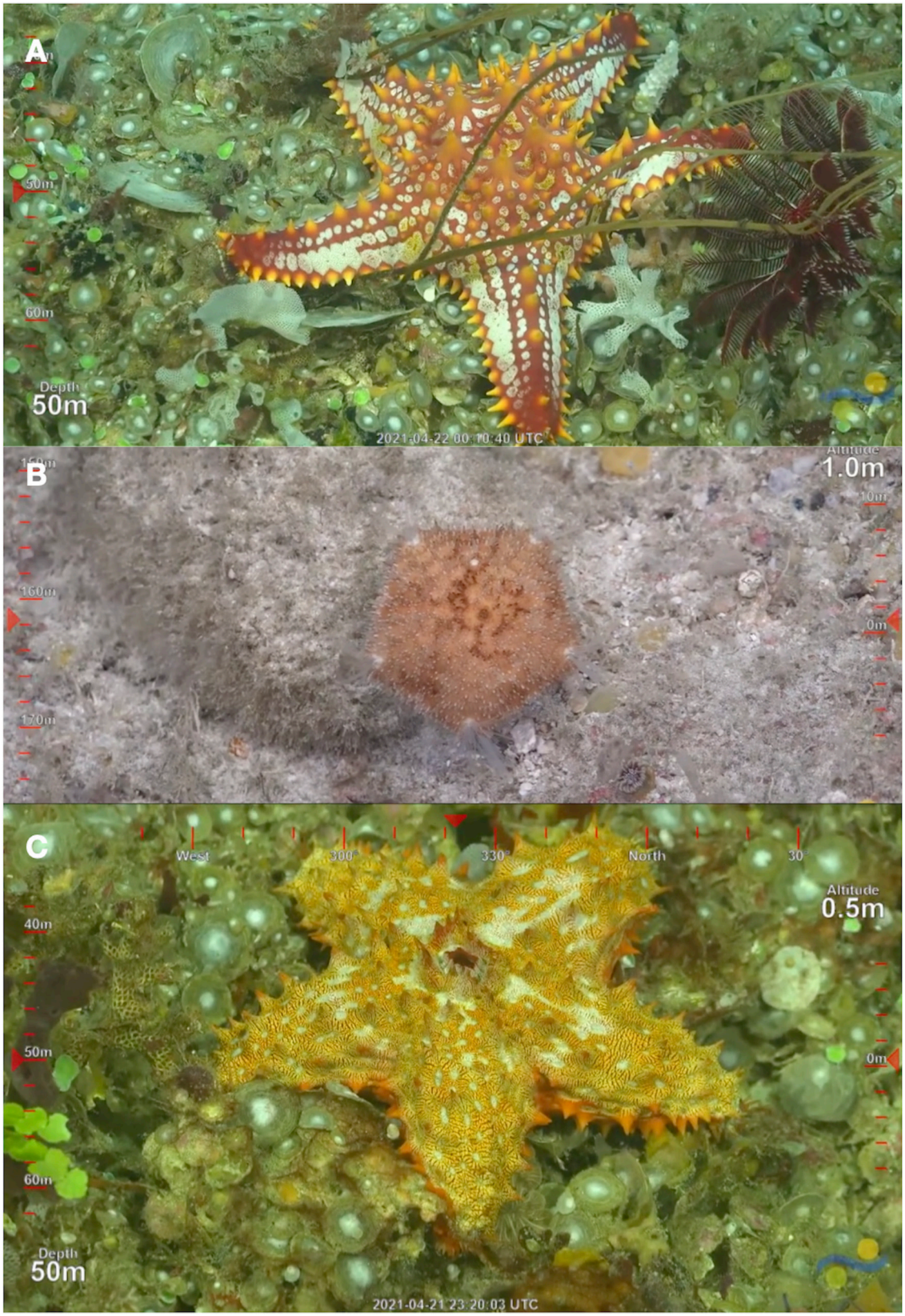

FIGURE 30. Oreasteridae, Podosphaeriasteridae, Pterasteridae *in situ*. A. *Pentaceraster alveolatus* WAM Z97659 B. *Podosphaeraster bola* **sp. nov.** WAM Z97557 C. *Euretaster magnificus* **sp. nov.** WAM Z97658

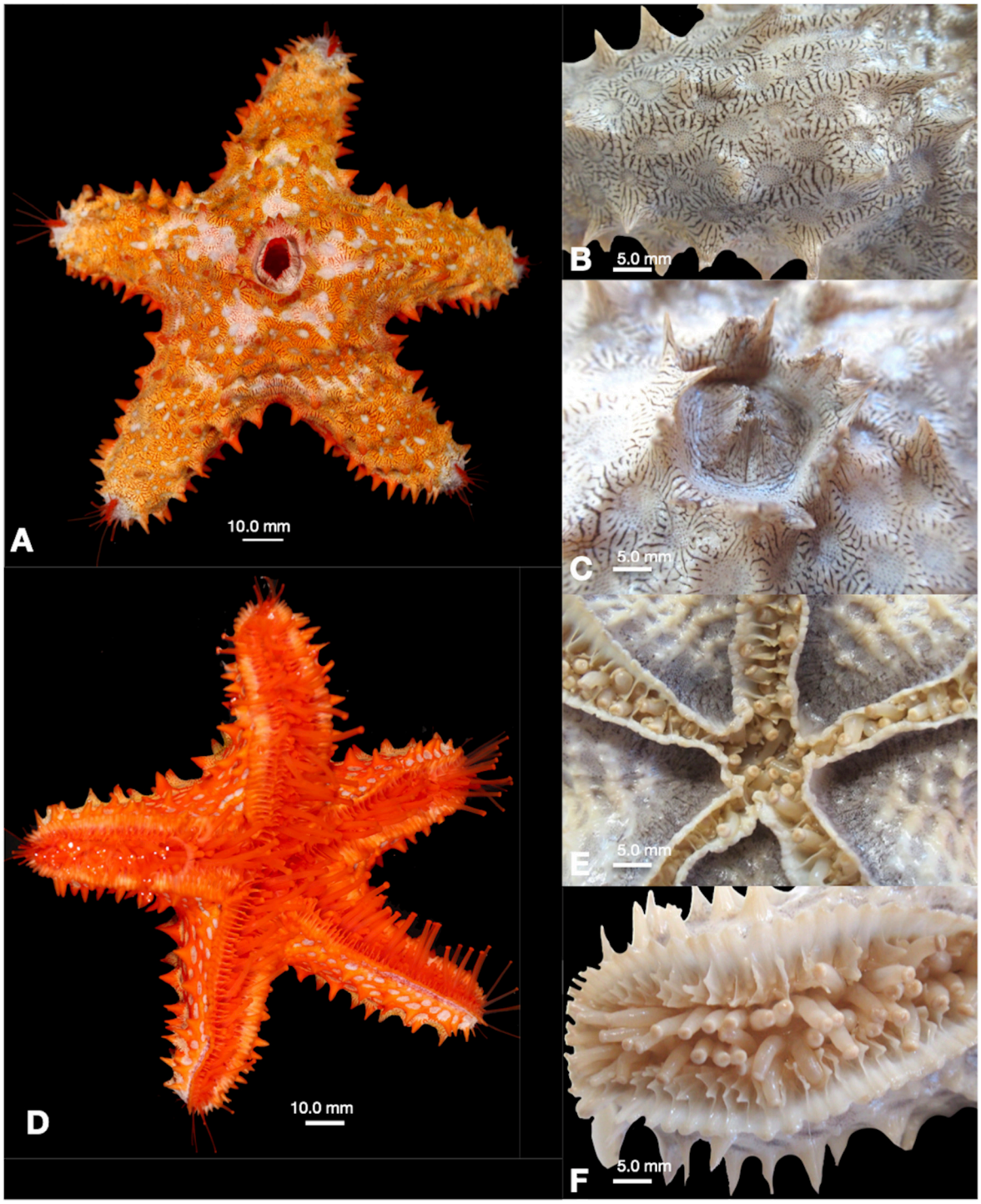

FIGURE 31. *Euretaster magnificus* **sp. nov.** Holotype. WAM Z97658. A. Abactinal. B. Closeup showing pattern. C. Osculum. D. Actinal. E. Oral region. F. Adambulacral furrow.

ambulacral groove with transversely arranged webbed furrow spines, 2–3 m every plate.

Comments

Among the most diagnostic of characters for this species is the striped pattern present on the reticulated supradorsal membrane, which remains evident after fixation and preservation in ethanol. No other described *Euretaster* species is known to display a pattern with this level of preserved retention.

A survey of iNaturalist *Euretaster* imagery revealed further images of species displaying the intricate pattern present on *Euretaster magnificus* **sp. nov.**, suggesting it is distributed more widely and in shallower water. Figure 32 shows two shallow-water individuals from Pulau Hantu in Singapore. Further images from social media suggest indicate similar individuals from Indonesia, and Papua New Guinea.

Several other characters diagnose *Euretaster magnificus* **sp. nov.** but are not necessarily known to be

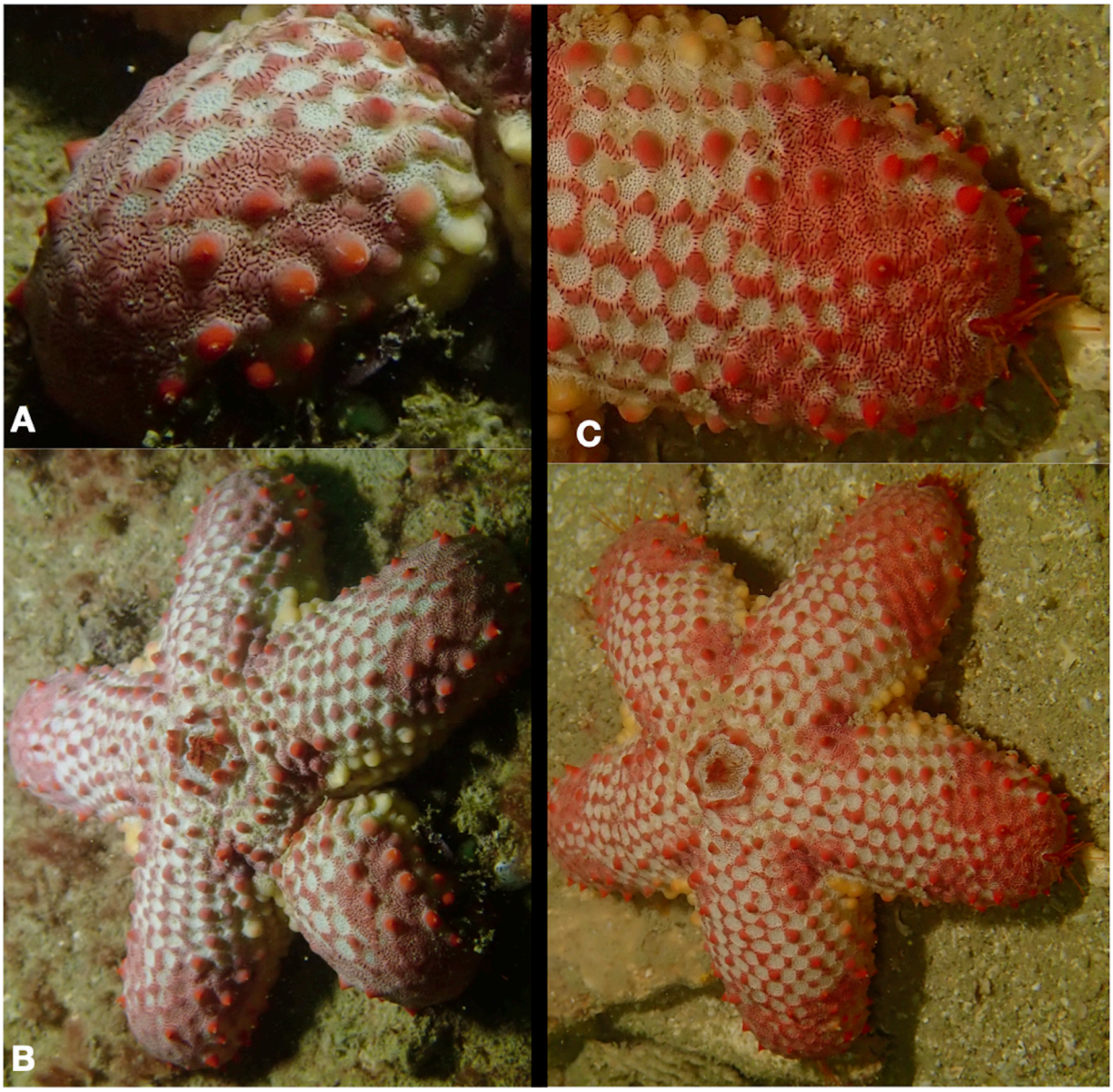

FIGURE 32. *Euretaster* sp. similar to *E. magnificus* from Pulau Hantu, Singapore showing similar marbled pattern. A. B. White with purple-red highlights. C.D. White with orange highlights. Photos courtesy of Tsu Soo Tan.

unique. This includes the spination, which in this species appears well-developed with a specific thorny tip. Furrow spines in this species (2–3) are fewer than other known species at this size (R=5.0) which can range from 3–6, depending on size, but with larger individuals (R>5.0) showing up to 6 webbed spines.

Ecological Comments

WAM Z97658 was observed on a mixed substrate composed primarily of large discoid foraminifera, *Cycloclypeus* as well as algae, bryozoans and other encrusting organisms. When observed the spines directly around the osculum opened and closed suggesting water entering and/or departing the supradorsal chamber.

No observations of slime production were made.

Occurrence/Distribution

Known only from Ashmore Reef, Western Australia. 52 m.

Outside of Australia. Possibly from Singapore, Indonesia and Papua New Guinea.

Description

Body thick, stellate (Rr=2.17), arms triangular in shape, round and thick in cross-section.

Interradial arcs acute.

Supradorsal membrane surface composed of wide plates forming an open reticulate pattern. Supradorsal reticulations with an ornate marbled black on grey pattern present on abactinal surface, absent from actinal surface. Supradorsal membrane with irregularly placed prominent, single spines with distinct pointed tips present on the disk and arms. Large “papular” regions formed by reticulations, each containing papulae, 40–150, mostly 80–120 per region. These areas each with a single delicate paxillae bearing 5 webbed spinelets underlying each opening. Each pore with dark coloration, widely spaced,

TABLE 1.

Name	#	Coordinates	depth in m	Family
***Paranepanthia hyalinostyrax* sp. nov.**	WAM Z97546	12.32324579 S 123.12174057 E	124	Asterinidae
***Paranepanthia obliqua* sp. nov.**	WAM Z97579	12.26007813 S 122.92652428 E	145	Asterinidae
Seriaster regularis Jangoux, 1984	WAM Z97599	12.14439852 S 123.04234911 E	25-313	Asterinidae (Hyalinothricinae)
***Asterodiscides conulus* sp. nov.**	WAM Z97603	12.14428905 S 123.04127446 E	156	Asterodiscidae
Asteroidscides soleae Rowe, 1985	WAM Z97660	12.13434682 S 123.18785844 E	20-80	Asterodiscidae
Brisingaster robillardi deLoriol, 1883	WAM Z 97549	12.31993468 S 123.09036509 E	100-1220	Brisingasteridae
Echinaster luzonicus (Gray, 1840)	WAM Z97677	12.22968711 S 123.25706623 E,	0-60	Echinasteridae
Echinaster stereosomus Fisher, 1913	WAM Z 97667	12.23137041 S 123.27525646 E	5 to 149	Echinasteridae
n. gen.* sp. nov. *(in prep)	WAM Z97638	12.13922643'S 123.20777125'E	97	Echinasteridae
Calliaster corona n sp.	WAM Z97556	12.32008409 S 123.0902967 E	122-200	Goniasteridae
Churaumiastra hoshi Mah, Kogure, Fujita & Higashi, 2024	WAM Z97558 (although not described here-this is one of the paratypes from Mah 2024)	12.32001331' S 123.09032385 E	100-200	Goniasteridae
***Dissogenes dorikos* sp. nov.**	WAM Z97587	12.1878581 S 122.96773299 E	154	Goniasteridae
Fromia monilis (Perrier, 1869)	WAM Z97570	12.28078751°S 122.97542548°E	0-101	Goniasteridae
***Fromia ui* sp. nov.**	WAM Z97606	12.13390124 S 123.07613337 E	44-103	Goniasteridae
Iconaster uchelbeluuensis Mah 2005	WAM Z97641	12.13931737 S 123.20672703 E	68-122	Goniasteridae
Neoferdina antigorum Mah, 2017	WAM Z97568	12.28131641S 122.97546605 E	80-200	Goniasteridae
Neoferdina insolita Livingstone, 1936	WAM Z97616	12.13064985 S 123.07628123 E	3-88	Goniasteridae
Rosaster mammilatus Fisher, 1913	WAM Z97586	12.18706329 S 122.97052776 E	112-135	Goniasteridae
***Luidia pola* sp. nov.**	WAM Z97666	12.2300898642 S 123.27471273 E	146	Luidiidae
Thromidia catalai Pope & Rowe, 1977	WAM Z97609	12.1341071 S 123.7647971º E	99-104	Mithrodiidae
Andora (Andora) faouzii (Macan, 1938)	WAM Z97656	12.13421768 S 123.18751562 E	52.4	Ophidiasteridae
Leiaster sp. juv.	WAM Z97674	12.22970773°S 123.25685726°E	48	Ophidiasteridae
Nardoa frianti Koehler, 1909	WAM Z97657	12.13417298°S 123.18733147°E	3-49	Ophidiasteridae
Halityle regularis Fisher, 1913	WAM Z97571	12.2575136°S 122.92744939°E	3-75	Oreasteridae

.....continued on the next page

TABLE 1. (Continued)

Name	#	Coordinates	depth in m	Family
Pentaceraster alveolatus (Perrier, 1869)	WAM Z97659	12.13415667°S 123.18751738°E	1-54	Oreasteridae
***Podosphaeraster bola* sp. nov.**	WAM Z97557	12.31984366 S 123.0.9043533 E	162	Podosphaerasteridae
***Euretaster magnificus* sp. nov.**	WAM Z97658	12.13420261 S, 123.18750607 E	52	Pterasteridae
Linckia guildingi (Gray, 1840)	no specimen (image only)	location 6	52	Ophidiasteridae

arranged serially within each pore space. Larger papular pores proximally becoming smaller distally along arms. Osculum periphery flanked by by 18 spines, covered by supradorsal membrane. Oscular spines (those covering over the oscular opening), approximately 40–60 each covered by thick dermis.

Although a marginal plate series is absent on the supra dorsal membrane, coloration abruptly changes between abactinal and actinal surface. Two irregular series of lateral papular regions more oval in shape including dark colored papulae, 40–120, mostly 80–100.

Actinal surface with rounder, wider and larger papular regions, variably containing 40–150 pores in each papular region. Actinal surface is lighter in color with no patterns. Actinal region adjacent to the adambulacral spines with an abundant concentration of dark colored papular pores and linear markings which appear continuous from the abactinal/lateral/actinal surface.

Subambulacral spines prominent in linear series, each enclosed in a membrane. These spines forming continuous serial webbed boundary adjacent to ambulacral furrow. Furrow spines, 2–3, webbed in transverse series. Furrow spine arrays correspond with subambulacral spines but occur slightly offset. Subambulacral spine+membrane series terminates at oral plate with prominent blunt-tipped spine. Three webbed spines present on oral plate projecting into mouth.

Color in life was an orange supra dorsal reticulum, which was covered by extensive dark banding and dark coloration extending from the abactinal to the actinal surface. Spines on the abactinal and lateral surface were identical in color and pattern to those on the reticulation but each had an orange tip. The reticulate regions between the reticulum was bright yellow with dark colored spiracles. Lateral and actinal regions were a solid bright orange.

Tube feet in biserial series, well-developed suckers on tips.

Material Examined

Holotype. WAM Z97658 Ashmore Reef, Western Australia, 12.13420261°S, 123.18750607°E, 51.9 m, Coll. N.G. Wilson, C.S. Whisson. Station FK210409/SO416, 22 April 2021, 1 wet spec. R=5.0 r=2.3

Discussion

Widely Distributed Mesophotic Asteroidea

Prior surveys of mesophotic Asteroidea from throughout the North, East and South Pacific (Mah 2021, 2024) demonstrate that several of these species, similar to their shallower-water counterparts, occur widely across the Indo-Pacific. *Linckia profunda* Mah, 2021 was found to occur between New Caledonia and Rapa Nui, between 76–540 m. The unusual oreasterid *Astrosarkus idipi* Mah 2003 has been observed from Japan to New Caledonia and east to the Maldives in the Indian Ocean (Mah, 2023). The goniasterid *Churaumiastra hoshi* described by Mah *et al*. 2024 and recorded herein shows a similarly wide-ranging distribution with occurrence recorded from Okinawa, the Philippines and herein from Ashmore Reef, Australia.

Composition of the Mesophotic Ashmore Reef Asteroid Fauna

Surveyed collectively, the mesophotic Asteroidea of the Ashmore Reef region appears to be a composite of species from shallow depths, including species present at littoral depths ranging to those from deep-sea settings. Of the total 28 species recorded from mesophotic settings on Ashmore Reef, one new genus and 11 species were undescribed. Comparisons were based on depth ranges compiled from Rowe & Gates (1995), Marsh & Fromont (2020), A.M. Clark (1989, 1993, 1997), and A.M. Clark & Mah (2001).

Among the known species, nearly all were described from shallow-water habitats, but with a lower limit approaching or bordering mesophotic depths (30–150 m). Several of these shallow-water species, such as *Fromia monilis,* 0–101 m, *Echinaster luzonicus*, 0–60 m or *Pentaceraster alveolatus*, 1–54 m, are commonly observed from littoral habitats.

In contrast, other asteroid taxa show an apparent deep-sea distribution but occur at mesophotic depths at the upper end of their known distribution. *Brisingaster robillardi*, a member of the Brisingida, is a group known for exclusively inhabiting deep-sea (approximately 100–6000 m) settings, albeit in a shallower range than most other taxa. This species has been recorded as deep as 1220

m but is most frequently observed at approximately 200–600 m depths (e.g Mah, 1999).

The goniasterid *Dissogenes*, while recorded from 154 m here, is otherwise regarded as present primarily in deep-sea settings. The Philippine *Dissogenes styracia* Fisher, 1913 was recorded from 240 m, whereas *Dissogenes petersi* Jangoux, 1981 from New Caledonia and New Zealand is recorded from 195–500 m.

Associates Overview

Summary overview of the Ashcroft asteroids yields 7 specimens of different taxonomic associates from 5 asteroid species. Most abundant were polychaetes in the family Polynoidae found in association with 3 species of the Goniasteridae, *Churaumiastra hoshi, Neoferdina insolita* (Fig 20D), and *Rosaster mammilatus.*

Goniasterids have not historically been reported with these types of relationships, however ROV observations of deep-water taxa, such as *Hippasteria muscipula* and *Nymphaster* sp. show associated polynoid worms living on the surface (e.g. Mah, 2020) of or adjacent to the star, suggesting that they would probably not have been sampled by trawls or nets as the more closely affiliated worm-star associations have been. Among deep-sea worm-goniasterid associations, polynoids have been observed *in situ* are the tropical west Atlantic *Nymphaster arenatus* and *Ceramaster grenadensis* (Mah, 2020). The North American west coast *Hippasteria californica* Fisher, 1905 has been recorded in association with *Harmothoe* (Pettibone, 1969) and the deep-sea tropical Pacific *Hippasteria muscipula* has been observed in association with multiple unidentified polynoids (Mah, unpublished data).

Other asteroid taxa are well-documented as hosts to polynoid worms, in some cases with strong physical associations (Wagner *et al*., 1979), in some cases with worms living in the ambulacral grooves of their host stars, displaying mutualism with the host star (e.g. the North Pacific *Dermasterias imbricata,* Wagner *et al*. 1979).

Two worm specimens were found in association with *Luidia polo* **sp. nov.** Polynoid associates of *Luidia* spp. have been documented across from several different habitats. Antokhina & Britayev (2012) have recorded multiple macrosymbionts across multiple taxa from Vietnam.

The final associate was an endoparasite gastropod, apparently in the family Eulimidae which had burrowed within the coelom of *Asterodiscides conulus* **sp. nov.** (Fig. 7D). Eulimids are relatively well-documented parasites of several valvatidan asteroids, especially within the Ophidiasteridae (e.g. Antokhina & Britayev 2012), Goniasteridae (e.g. Mah 2017), and Oreasteridae (Antokhina & Britayev, 2012), no references to those inhabiting *Asterodiscides* were located, suggesting this association has not been previously observed.

Conclusions

A total of 27 specimens were collected, including one new genus and 10 new species. Nine new species of Asteroidea are described herein with one described elsewhere. This account includes multiple new occurrences and *in situ* observations of species known from shallower habitats that are also present at mesophotic and deeper-water settings. Insights from the diversity of these taxa suggest further undescribed species from habitats, some of which are likely to occur widely across the Indo-Pacific.

List of Species (* are new occurrence)

ASTERINIDAE
- ***Paranepanthia hyalinostyrax* sp. nov.**
- ***Paranepanthia obliqua* sp. nov.**

HYALINOTHRICINAE
- **Seriaster regularis* Jangoux 1984

ASTERODISCIDIDAE
- ***Asterodiscides conulus* sp. nov.**
- **Asterodiscides soleae* Rowe, 1985

BRISINGASTERIDAE
- **Brisingaster robillardi* deLoriol, 1883

ECHINASTERIDAE
- **Echinaster luzonicus* (Gray 1840)
- **Echinaster stereosomus* Fisher, 1913
- **Echinasteridae, n. gen. sp. nov. (description in prep)**

GONIASTERIDAE
- ***Calliaster corona* sp. nov.**
- **Churaumiastra hoshi* Mah, Kogure, Fujita & Higashiji, 2024
- ***Dissogenes dorikos* sp. nov.**
- ***Fromia ui* sp. nov.**
- **Fromia monilis* (Perrier, 1869)
- **Iconaster uchelbeluuensis* Mah, 2005
- **Neoferdina antigorum* Mah, 2017
- **Neoferdina insolita* Livingstone, 1936
- **Rosaster mammilatus* Fisher, 1913

LUIDIIDAE
- ***Luidia pola* sp. nov.**

MITHRODIIDAE
- **Thromidia catalai* Pope & Rowe, 1977

OPHIDIASTERIDAE
- **Andora (Andora) faouzii* (Macan, 1938)
- **Leiaster* spp. indet.
- *Linckia guildingi* Gray, 1840 (image only)
- **Nardoa frianti* Koehler, 1910

OREASTERIDAE
- **Halityle regularis* Fisher, 1913
- **Pentaceraster alveolatus* (Perrier, 1875)

PODOSPHAERASTERIDAE
- ***Podosphaeraster bola* sp. nov.**

PTERASTERIDAE
- ***Euretaster magnificus* sp. nov.**

Acknowledgements

CM gratefully acknowledges the Western Australian Museum, the Western Australian Museum Foundation, and Dr. Zoe Richards for supporting and facilitating his research fellowship to study the Western Australian Museum Asteroid collection. CM thanks ZR, OG, and the Aquatic Zoology team for their generous hospitality during the visit. We thank Karen Miller (AIMS), Corey Whisson (WAM), Amy Carmignani (Curtin/AIMS), Declan Stick (UWA), Chloe Anderson (UWA/WAM) and the crew of the R/V *Falkor* for their assistance with sample collection. Samples were collected in 2021 using ROV under permits issued by the Australian Government Director of National Parks (PA2019-00098-2) and the Australian Government Parks Australia (AU-COM2021-508). Specimen collection and processing was made possible through the Schmidt Ocean Institute, the Western Australian Museum (WAM), Parks Australia, Australian Government Department of Agriculture, Water, and the Environment (DAWE), and the Australian Institute of Marine Science (AIMS). The authors are grateful to Zoe Holdsworth for her work developing Figure 1. Amanda Robinson, USNM is thanked for facilitating loans and curatorial support. Special gratitude is extended to Mr. Tsu Soo Tan of Nanyang Polytechnic University in Singapore who permitted use of his photographs. The authors are grateful to Dr. Marine Fau formerly of the Dept. of Paleobiology, USNM, now at the Muséum d'histoire naturelle Genève, Ms. Kate Naughton, Museum Victoria and a third anonymous reviewer whose comments substantially improved the manuscript.

References

Antokhina, T.I. & Britayev, T.A. (2012) Sea stars and their macrosymbionts in the Bay of Nhatrang, Southern Vietnam. *Paleontological Journal*, 46, 894–908. https://doi.org/10.1134/S0031030112080023

Arai, M. & Fujita, T. (2021) Sea Stars of families Ophidiasteridae and Goniasteridae (Echinodermata: Asteroidea) from the Mesophotic Zone of the Ogasawara Islands, including two new species. *Species Diversity*, 26 (1), 7–21. https://doi.org/10.12782/specdiv.26.7

Aziz, A. (1986) *La faune d'asterides (Ecinodermata) de la region indo-malaise: taxonomie, zoogéographie et bathymétrie*. Marine Biology Laboratory, Université libre de Bruxelles, Brussels, 598 pp.

Aziz, A. & Jangoux, M. (1985) On the status and affinities of the goniasterid genus *Calliaster* Gray, 1840. *In*: Keegan, B.F. & O'Connor, B.D.S. (Eds.), *Proceedings of the 5th International Echinoderm Conference, Galway*, 1984, pp. 585–586. https://doi.org/10.1201/9781003079224-116

Baker, A.N. & Marsh, L.M. (1976) The rediscover of *Halityle regularis* Fisher (Echinodermata: Asteroidea). *Records of the Western Australian Museum*, 4 (2), 107–116.

Baker, E., Puglise, K.A. & Harris, P.T. (2016) Mesophotic coral ecosystems: A lifeboat for coral reefs? UN Environment, GRID-Arendal, Norway. Available from: https://policycommons.net/artifacts/2390329/mesophotic-coral-ecosystems/3411646/ (accessed 1 June 2023) [CID: 20.500.12592/mq8sjt]

Bell, F.J. (1884) Contributions to the Systematic Arrangement of the Asteroidea.-II. The Species of *Oreaster*. *Proceedings of the Zoological Society of London*, 52 (1), 57–87. https://doi.org/10.1111/j.1096-3642.1884.tb02810.x

Bernasconi, I. (1937) Asteroideos argentinos.1. Familia Pterasteridae. *Anales del Museo argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires*, 39, 167–187.

Birkeland, C. & Lucas, J.S. (1990) *Acanthaster planci: Major Management Problem of Coral Reefs*. CRC Press, Boca Raton, Florida, 257 pp.

Blake, D.B. (1980) On the affinites of three small sea-star families. *Journal of Natural History*, 14, 163–182. https://doi.org/10.1080/00222938000770171

Bongaerts, P. & Smith, T.B. (2019) Beyond the "Deep Reef Refuge" hypothesis: a conceptual framework to characterize persistence at depth. *In*: Loya, Y., Puglise, K.A. & Bridge, T.C.L. (Eds.), *Mesophotic Coral Ecosystems*. *Coral Reffs of the World. Vol. 12.* Springer, Cham, pp. 881–895. https://doi.org/10.1007/978-3-319-92735-0_45

Bongaerts, P., Cooke, I.R., Ying, H., Wels, D., den Haan, S., Hernandez-Agreda, A., Brunner, C.A., Dove, S., Englebert, N., Eyal, G., Forêt, S., Grinblat, M., Hay, K.B., Harii, S., Hayward, D.C., Lin, Y., Mihaljević, M., Moya, A., Muir, P., Sinniger, F., Smallhorn-West, P., Torda, G., Ragan, M.A., van Oppen, M.J.H., & Hoegh-Guldberg, O. (2021) Morphological stasis masks ecologically divergent coral species on tropical reefs. *Current Biology*, 31 (e8), 2286–2298. https://doi.org/10.1016/j.cub.2021.03.028

Branch, G.M., Griffiths, C.L., Branch, M.L. & Beckley, L.E. (2010) *Two Oceans: A guide to the marine life of southern Africa*. Struik Nature, Cape Town, 456 pp.

Bridge, T.C., Done, T.J., Friedman, A., Beaman, R.J., Williams, S.B., Pizarro, O. & Webster, J.M. (2011) Variability in mesophotic coral reef communities along the Great Barrier Reef, Australia. *Marine Ecology Progress Series*, 428, 63–75. https://doi.org/10.3354/meps09046

Bruce, A.J. (1983) The Pontoniine shrimp fauna of Australia. *Australian Museum Memoir*, 18, 195–218. https://doi.org/10.3853/j.0067-1967.18.1984.385

Carmignani, A., Radice, V.Z., McMahon, K.M., Holman, A.I., Miller, K., Grice, K. & Richards, Z. (2023) Levels of autotrophy and heterotrophy in mesophotic corals near the end photic zone. *Frontiers in Marine Science*, 10, 1089746. https://doi.org/10.3389/fmars.2023.1089746

Cherbonnier, G. (1970) *Podosphaeraster thalassae*, nov.sp., espece actuelle d'Asterie de la famille jurassique des Sphaerasteridae. *Comptes Rendus Academie des Sciences, Paris*, 271, 203–206.

Clark, A.H. (1916) Seven new genera of echinoderms. *Journal of the Washington Academy of Sciences*, 6 (5), 115–122. https://doi.org/10.5962/bhl.part.10912

Clark, A.H. (1952) Echinoderms from the Marshall Islands. *Proceedings of the U.S. National Museum*, 102, 265–303. https://doi.org/10.5479/si.00963801.102-3302.265

Clark, A.M. & Wright, C.W. (1962) A new genus and species of recent starfishes belonging to the aberrant family Sphaerasteridae,

with notes on the possible origin and affinities of the family. *Annals of the Magazine of Natural History*, Series 13, 5 (52), 243–251.
https://doi.org/10.1080/00222936208651241

Clark, A.M. (1967) Notes on asteroids in the British Museum (Natural History) V. *Nardoa* and some other ophidiasterids. *Bulletin of the British Museum (Natural History)*, Zoology, 15 (4), 169–198.
https://doi.org/10.5962/bhl.part.27517

Clark, A.M. (1974) Notes on some echinoderms from southern Africa. *Bulletin of the British Museum of Natural History (Zoology)*, 26 (6), 423–487, 3 pls., 16 figs., 1 map, 3 tabs.
https://doi.org/10.5962/bhl.part.210

Clark, A.M. (1989) An index of names of recent Asteroidea. Part 1. Paxillosida and Notomyotida. *In*: Jangoux, M. & Lawrence, J.M. (Eds.), *Echinoderm Studies*, 3 (2), pp. 25–347.

Clark, A.M. (1993) An index of names of recent Asteroidea. Part 2. Valvatida. *Echinoderm Studies*, 4, 187–366.
https://doi.org/10.1201/9781003072553-4

Clark, A.M. (1997) An index of names of recent Asteroidea. Part 3. Velatida and Spinulosida. *Echinoderm Studies*, 5, 183–250.
https://doi.org/10.1201/9781003077909-5

Clark, A.M. & Mah, C. (2001) An index of names of recent Asteroidea. Part 4. Forcipulatida and Brisingida. *Echinoderm Studies*, 6, 229–347.

Clark, A.M. & Courtman-Stock, J. (1976) *The Echinoderms of Southern Africa*. British Museum of Natural History, London, 277 pp.

Clark, A.M. & Downey, M.E. (1992) *Starfishes of the Atlantic*. Chapman and Hall, London, 794 pp.

Clark, A.M. & Rowe, F.W.E. (1971) Monograph of Shallow-water Indo-West Pacific Echinoderms. *British Museum (Natural History) Publications*, 690, i–ix + 1–238, 31 pls.

Clark, A.M. & Wright, C.W. (1962) A new genus and species of recent starfishes belonging to the aberrant family Sphaerasteridae, with notes on the possible origin and affinities of the family. *Annals of the Magazine of Natural History*, Series 13, 5 (52), 243–251.
https://doi.org/10.1080/00222936208651241

Clark, H.E.S. & McKnight, D.G. (2000) The marine fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars), Order Paxillosida. *NIWA Biodiversity Memoir*, 116, 1–196.

Clark, H.E.S. & McKnight, D.G. (2001) The marine fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars), Order Valvatida. *NIWA Biodiversity Memoir*, 117, 1–269.

Clark, H.L. (1914) The echinoderms of the Western Australian Museum. *Records of the Western Australian Museum*, 1 (3), 132–173.

Clark, H.L. (1921) The echinoderm fauna of Torres Strait: its composition and its origin. *Department of Marine Biology of the Carnegie Institute*, 10, i–vi + 1–223, 38 pls.
https://doi.org/10.5962/bhl.title.14613

Clark, H.L. (1926) Some sea stars from the Riksmuseum, Stockholm. *Arkiv for Zoologi*, 18A (8), 1–8.

Clark, H.L. (1946) The Echinoderm fauna of Australia. Its composition and its origin. *Publications of the Carnegie Institution of Washington*, 566, 1–567.

Coleman, H.L. (1911) Scientific results of the trawling expedition of H.M.C.S. *Thetis* off the coast of New South Wales, in February and March, 1989. Supplement to Echinodermata. *Memoirs of the Australian Museum*, 4 (14), 699–701, pl. 83.
https://doi.org/10.3853/j.0067-1967.4.1911.1510

Döderlein, L. (1888) Echinodermen von Ceylon. Bericht über die von den Herren Dres Sarasin gesammelten Asteroidea, Ophiuroidea und Echinoidea. *Zoologische Jahrbücher*, 3, 821–846.
https://doi.org/10.5962/bhl.part.1933

Döderlein, L. (1916) Uber die Gattung *Oreaster* und verwandte. *Zoologische Jahrbücher*, 40, 409–440.

Döderlein, L. (1922) Uber die Gattung *Calliaster* Gray. *Bijdragen tot de Dierkunde*, 1922, 47–52.
https://doi.org/10.1163/26660644-02201008

Döderlein, L. (1935) Die Asteriden der *Siboga*-Exped. III. Oreasteridae. *Siboga-Expedition*, 46 (2), 71–110, pls. 15–20.

Döderlein, L. (1936) Die Asteriden der *Siboga*-Exped. III. Die unterfamile Oreasterinae. *Siboga-Expedition*, 46 (2), 295–369, pls. 21–32.

Domantay, J.S. & Roxas, H.A. (1938) The littoral asteroidea of Port Galera Bay and adjacent waters. *Philippine Journal of Science*, 65 (3), 203–237.

Downey, M. (1968) A note on the Atlantic species of the starfish genus *Linckia*. *Proceedings of the Biological Society of Washington*, 81, 41–44.

Downey, M.E. (1973) Starfishes from the Caribbean and the Gulf of Mexico. *Smithsonian Contributions to Zoology*, 126, 1–158.
https://doi.org/10.5479/si.00810282.126

Dujardin, M.F. & Hupé, M.H. (1862) *Histoire naturelle des zoophytes échinodermes: comprenant la description des crinoïdes, des ophiurides, des astérides, des échinides et des holothurides*. Paris: Libraire Encyclopédique de Roret, 627 pp., 10 pls.
https://doi.org/10.5962/bhl.title.10122

Eernisse, D.J. & Strathmann, M.F. (2010) A surprising species diversity in west coast *Henricia* (Asteroidea: Spinulosida). *In*: Harris, L.G., Böttger, S.A., Walker, C.W. & Lesser, M.P. (Eds.), *Echinoderms: Durham*. *Proceedings of the 12th International Echinoderm Conference, 7–11 August 2006, Durham, New Hampshire, U.S.A*. CRC Press, Boca Raton, Florida, pp. 350–353.
https://doi.org/10.1201/9780203869543-8

Fisher, W.K. (1908) Necessary changes in the nomenclature of starfishes. *Smithsonian Miscellaneous Collections, Quarterly*, 52, 87–93.

Fisher, W.K. (1911) *Hyalinothrix*, a new genus of starfishes from the Hawaiian Islands. *Proceedings of the United States National Museum*, 39, 659–664.
https://doi.org/10.5479/si.00963801.39-1807.659

Fisher, W.K. (1913) New starfishes from the Philippine Islands, Celebes, and the Moluccas. *Proceedings of the United States National Museum*, 46, 201–222.
https://doi.org/10.5479/si.00963801.46-2022.201

Fisher, W.K. (1919) Starfishes of the Philippine seas and adjacent waters. *Bulletin of the United States National Museum*, 3 (100), 1–547, 156 pls.

Fisher, W.K. (1940) Asteroidea. *Discovery Reports*, 20, 69–306.

Fujita, T. & Rowe, F.W.E. (2002) Podospherasteridae fam. Nov. (Echinodermata: Asteroidea: Valvatida) with a new species, *Podospheraster toyoshiomaruae* from Southern Japan. *Species Diversity*, 7, 317–332.

https://doi.org/10.12782/specdiv.7.317
Gosliner, T.M., Behrens, D.W. & Williams, G.C. (1996) *Coral Reef Animals of the Indo-Pacific*. Sea Challengers, Monterey, California, 314 pp.
Grainger, E.H. (1966) Sea Stars (Echinodermata: Asteroidea) of Arctic North America. *Bulletin of the Fisheries Research Board of Canada*, 152, 1–70.
Gray, J.E. (1840) XXXII. A synopsis of the genera and species of the class Hypostoma (*Asterias*, Linnaeus). *Annals of the Magazine of Natural History*, Series 1, 6 (37), 275–290. https://doi.org/10.1080/03745484009443296
Halpern, J.A. (1970a) Goniasteridae (Echinodermata: Asteroidea) of the Straits of Florida. *Bulletin of Marine Science*, 20 (1), 193–286.
Halpern, J.A. (1970b) *A monographic revision of the goniasterid sea stars of the North Atlantic*. Unpublished PhD Thesis, University of Miami, Coral Gables, Florida, 253 pp.
Hayashi, R. (1938) Sea-stars in the vicinity of the Seto Marine Biological Laboratory. *Bulletin of the Biogeographical Society of Japan*, 8, 271–292, pls. 5–7.
Hayashi, R. (1938b) Sea stars of the Ogasawara Islands. *Annotationes Zoological Japonenses*, 17 (1), 59–68.
Hayashi, R. (1973b) *The Sea-Stars of Sagami Bay*. Biological Laboratory, Imperial Household, Tokyo, 114 pp., 18 pls.
Hernández-Agreda, A., Huckeba, J., Prata, K.E., Vermeij, M.J.A. & Bongaerts, P. (2024) Hybridization and inbreeding affect the survival of a critically endangered coral. *Current Biology*, 34 (21), e4, 5120–5129. https://doi.org/10.1016/j.cub.2024.09.035
Holstein, D.M., Smith, T.B., Gyory, J. & Paris, C.B. (2015) Fertile fathoms: Deep reproductive refugia for threatened shallow corals. *Scientific Reports*, 5, 12407. https://doi.org/10.1038/srep12407
Imaoka, T., Irimura, S., Okutani, T., Oguro, C., Oji, T. & Kanazawa, K. (1991) *Echinoderms from the continental shelf and slope around Japan. Vol. II*. Japan Fisheries Resource Conservation Association, Tokyo, 159 pp.
iNaturalist for *Pentaceraster alveolatus* (2023) Available from: https://www.inaturalist.org/observations?taxon_id=255918 (accessed 22 March 2023)
James, D.B. (1973) Studies on Indian Echinoderms. 5. New and Little Known starfishes from the Indian Seas. *Journal of the Marine Biological Association of India*, 15 (2), 556–559.
Jangoux, M. (1978) Biological results of the Snellius Expedition (Echinodermata, Asteroidea). *Zoologische Mededelingen, Leiden*, 52, 287–300.
Jangoux, M. (1980) Le genre *Leiaster* Peters (Echinodermata, Asteroidea: Ophidiasteridae). *Journal of African Zoology*, 94 (1–2), 87.
Jangoux, M. (1981a) Une nouvelle espèce d'astéride bathyale des eaux de Nouvelle-Calédonie (Echinodermata, Asteroidea). *Bulletin du Muséum national d'histoire naturelle*, Section A: Zoologie, Biologie et Écologie Animales, 4 (3), 709–712. https://doi.org/10.5962/p.285846
Jangoux, M. (1981b) Echinodermes: Astéroïdes. *In*: Forest, J. (Ed.), Résultats des campagnes MUSORSTOM: 1. Philippines (18–28 Mars 1976). *Mémoires du Muséum national d'Histoire naturelle*, Série A, Zoologie, 91, pp. 457–476.
Jangoux, M. (1984) Les asterides littoraux de Nouvelle-Calédonie. *Bulletin du Museum National D'Histoire Naturelle (Zoologie)*, Series, 6 (2), 279–293. https://doi.org/10.5962/p.285919
Jangoux, M. (1986) Les astérides. *In*: Guille, A., Laboute, P. & Menou, J.L. (Eds.), Guide des étoiles de mer, oursins et autres échinodermes du lagon de Nouvelle-Caleodnie. *Faune Tropicale*, 25, pp. 111–153.
Keesing, J.K., Mortimer, N., Hellmrich, L., Godoy, D., Babcock, R.C., Heyward, A., Paton, D. & Harvey, E.S. (2023) The short spined crown-of-thorns starfish *Acanthaster brevispinus* is a corallivore too. *Coral Reefs*, 42 (2), 399–404. https://doi.org/10.1007/s00338-023-02351-1
Koehler, R. (1910) An account of the shallow-water Asteroidea. *Echinoderma of the Indian Museum*, 6, 1–192. https://doi.org/10.5962/bhl.title.11614
Kogure, Y. & Kaneko, A. (2010) A solasterid asteroid *Seriaster regularis* (Echinodermata, Asteroidea, Velatida) found in the Okinawa Islands: The first record from Japanese waters. *Bulletin of the Biogeographical Society of Japan*, 65, 97–102. [in Japanese]
Kogure, Y., Hashimoto, J. & Yamawaki, N. (2011) A large goniasterid sea star, *Astrothauma euphylacteum* (Echinodermata, Asteroidea) discovered at the northeastern edge of the East China Sea: a new record in Japanese waters. *Biogeography*, 13, 83–86.
Lane, D.J. & Rowe, F.W.E. (2009) A new species of *Asterodiscides* (Echinodermata, Asteroidea, Asterodiscididae) from the tropical southwest Pacific, and the biogeography of the genus revisited. *Zoosystema*, 31 (3), 419–429. https://doi.org/10.5252/z2009n3a2
Liao, Y. (1980) The echinoderms of Xisha Islands, Guangdong Province, China. 4. Asteroidea. *Studia Marina Sinica*, 17, 153–171, 6 pls. [in Chinese with English summary]
Liao, Y. & Clark, A.M. (1995) *The Echinoderms of Southern China*. Science Press, Beijing, 614 pp., 23 pls.
Linchangco, G.V., Foltz, D.W., Reid, R., Williams, J., Nodzak, C., Kerr, A.M., Miller, A.K., Hunter, R., Wilson, N.G., Nielsen, W.J., Mah, C.L. & Rouse, G.W., Wray, G.A. & Janies, D.A. (2017) The phylogeny of extant starfish (Asteroidea: Echinodermta) including *Xyloplax* based on comparative transcriptomics. *Molecular Phylogenetics and Evolution*, 115, 161–170. https://doi.org/10.1016/j.ympev.2017.07.022
Livingstone, A.A. (1931) On the restriction of the genus *Ferdina* Gray. *Australian Zoology*, 6 (4), 305–309.
Livingstone, A.A. (1934) Two new asteroids from Australia. *Records of the Australian Museum*, 19 (3), 177–180. https://doi.org/10.3853/j.0067-1975.19.1934.697
Livingstone, A.A. (1936) Descriptions of new Asteroidea from the Pacific. *Records of the Australian Museum*, 19 (6), 383–390. https://doi.org/10.3853/j.0067-1975.19.1936.708
Lopes, E.M., Pérez-Portela, R., Paiva, P.C. & Ventura, C.R.R. (2016) The molecular phylogeny of the sea star *Echinaster* (Asteroidea: Echinasteridae) provides insights for genus taxonomy. *Invertebrate Biology*, 135 (3), 235–244. https://doi.org/10.1111/ivb.12135
de Loriol, P. (1883) Catalogue Raisonne des Echinodermes recueillis par M.V. de Robillard a l'ille Maurice. *Memoires de la Société de physique et d'histoire naturelle de Genève*, 28 (8), 1–64.
Loya, Y., Puglise, K.A. & Bridge, T.C.L. (Eds.) (2019) *Mesophotic*

Coral Ecosystems. Springer, Cham, XV + 1003 pp. https://doi.org/10.1007/978-3-319-92735-0

Macan, T.T. (1938) Asteroidea. *Scientific Reports, John Murray Expedition 1933–1934*, 4 (9), 323–435, pls. 1–6.

Mah, C. (1998) Preliminary phylogeny and taxonomic revision of the Brisingida (Asteroidea: Forcipulatacea). *In*: Mooi, R. & Telford, M. (Eds.), *Proceedings of the 9th International Echinoderm Conference*. Ballkema, San Francisco, California, pp. 273–277.

Mah, C. (1999) Re-description and taxonomic notes on the South Pacific brisingidan *Brisingaster robillardi* (Asteroidea) with new ontogenetic and phylogenetic information. *Zoosystema*, 21 (3), 535–546. https://doi.org/10.5962/p.270149

Mah, C.L. (2005) A phylogeny of *Iconaster* and *Glyphodiscus* (Goniasteridae; Valvatida; Asteroidea) with descriptions of four new species. *Zoosystema*, 27 (1), 131–167.

Mah, C.L. (2017) Overview of the *Ferdina*–like Goniasteridae (Echinodermata: Asteroidea) including a new subfamily, three new genera and fourteen new species. *Zootaxa*, 4271 (1), 1–72. https://doi.org/10.11646/zootaxa.4271.1.1

Mah, C.L. (2018) New genera, species and occurrence records of Goniasteridae (Asteroidea; Echinodermata) from the Indian Ocean. *Zootaxa*, 4539 (1), 1–116. https://doi.org/10.11646/zootaxa.4539.1.1

Mah, C.L. (2020) New Species, Occurrence Records and Observations of Predation by Deep–sea Asteroidea (Echinodermata) from the North Atlantic by NOAA Ship *Okeanos Explorer*. *Zootaxa*, 4766 (2), 201–260. https://doi.org/10.11646/zootaxa.4766.2.1

Mah, C.L. (2021) The East Pacific/South Pacific Boundary: New Taxa and Occurrences from Rapa Nui (Easter Island), New Caledonia and adjacent regions. *Zootaxa*, 4980 (3), 401–450. https://doi.org/10.11646/zootaxa.4980.3.1

Mah, C.L. (2022) New Genera, Species and Occurrence of Deep-Sea Asteroidea (Valvatacea, Forcipulatacea, Echinodermata) collected from the Tropical Pacific Ocean by the CAPSTONE Expedition. *Zootaxa*, 5164 (1), 1–75. https://doi.org/10.11646/zootaxa.5164.1.1

Mah, C.L. (2023) A new species of *Astrosarkus* from Western Australia including new Mesophotic occurrences of Indian Ocean Oreasteridae (Valvatida, Asteroidea). *Memoirs of Museum Victoria*, 82, 143–165. https://doi.org/10.24199/j.mmv.2023.82.08

Mah, C.L. (2024) New Taxa and Occurrences of Mesophotic and Deep-sea Goniasteridae (Valvatida, Asteroidea) from Okinawa and adjacent regions. *Zootaxa*, 5403 (1), 1–41. https://doi.org/10.11646/zootaxa.5403.1.1

Mah, C.L., Kogure, Y., Fujita, T. & Higashiji, T. (2024) New Taxa and Occurrences of Mesophotic and Deep-sea Goniasteridae (Valvatida, Asteroidea) from Okinawa and adjacent regions. *Zootaxa*, 5403 (1), 1–41. https://doi.org/10.11646/zootaxa.5403.1.1

Mah, C. & Blake, D.B. (2012) Global Diversity and Phylogeny of the Asteroidea (Echinodermata). *PLoS ONE*, 7 (4), e35644. https://doi.org/10.1371/journal.pone.0035644

Mah, C.L. & Foltz, D.W. (2011) Molecular Phylogeny of the Valvatacea (Asteroidea, Echinodermata). *Zoological Journal of the Linnean Society*, 161, 769–788. https://doi.org/10.1111/j.1096-3642.2010.00659.x

Mah, C. & Fujita, T. (2020) New species and occurrence records of Japanese Solasteridae and Ganeriidae including a new species of *Paralophaster* from the North Pacific with an overview of *Hyalinothrix*. *Zootaxa*, 4750 (1), 67–100. https://doi.org/10.11646/zootaxa.4750.1.4

Marsh, L.M. (1976) Western Australian Asteroidea since H.L. Clark. *Thalassia Jugoslavica*, 12 (1), 213–225.

Marsh, L.M. (1977) Coral Reef Asteroids of Palau, Caroline Islands. *Micronesica*, 13 (2), 251–281.

Marsh, L.M. (2000) Echinoderms of the Montebello Islands. *Records of the Western Australian Museum Supplement*, 59, 21–27.

Marsh, L.M. (2009) A new species of *Thromidia* (Echinodermata: Asteroidea) from Western Australia. *Records of the Western Australian Museum*, 25, 145–151. https://doi.org/10.18195/issn.0312-3162.25(2).2009.145-151

Marsh, L.M. & Fromont, J. (2020) *Field Guide to Shallow-Water Seastars of Australia*. Western Australian Museum, Welshpool, 543 pp.

Mauzey, K.P., Birkeland, C. & Dayton, P.K. (1968) Feeding behavior of asteroids and escape responses of their prey in the Puget Sound region. *Ecology*, 49, 603–619. https://doi.org/10.2307/1935526

McKnight, D.G. (2006) The marine fauna of New Zealand, Echinodermata: Asteroidea (Sea-stars). 3. Orders Velatida, Spinulosida, Forcipulatida, Brisingida with addenda to Paxillosida, Valvatida. *NIWA Biodiversity Memoir*, 120, 1–187.

Meadows, P.S., Meadows, A. & Murray, J.M.H. (2012) Biological modifiers of marine benthic seascapes: Their role as ecosystem engineers. *Geomorphology*, 157–158, 31–48. https://doi.org/10.1016/j.geomorph.2011.07.007

Mecho, A., Easton, E.E., Sellanes, J., Gorny, M. & Mah, C. (2019) Unexplored diversity of the mesophotic echinoderm fauna of the Easter Island ecoregion. *Marine Biology*, 166, 1–17. https://doi.org/10.1007/s00227-019-3537-x

Miller, J.E. (1984) Systematics of the ophidiasterid sea stars *Copidaster lymani* A.H. Clark and *Hacelia superba* H.L. Clark (Echinodermata: Asteroidea) with a key to the species of Ophidiasteridae from the western Atlantic. *Proceedings of the Biological Society of Washington*, 97 (1), 194–208.

Miller, K., Speed, C., Parnum, I., Wilson, N., Kok, J., Colquhoun, J. & Case, M. (2021) *Ashmore Reef Mesophotic Reef Survey and Sampling: Voyage Report. Report prepared for Parks Australia*. AIMS, Townsville, Queensland, 21 pp.

Mortensen, T. (1925) Papers from Dr. Th. Mortensen's Pacific Expedition 1914-16. XXIX. Echinoderms of New Zealand and the Auckland-Campbell Islands. III–V. Asteroidea, Holothuroidea and Crinoidea. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i København*, 79 (15), 261–420.

Mortensen, T. (1927) *Handbook of the Echinoderms of the British Isles*. Oxford University Press, London, 471 pp. https://doi.org/10.5962/bhl.title.6841

Müller, J. & Troschel, F.H. (1840) Ueber die Gattungen der Asterien. *Archiv für Naturgeschichte*, 6, 318–326.

Müller, J. & Troschel, F.H. (1842) *System der Asteriden.1. Asteriae. 2. Ophiuridae.* Vieweg, Braunschweig, xxx + 134 pp., 12 pls.

https://doi.org/10.5962/bhl.title.11715
Nardo, J.D. (1834) *De Asteriis*. Isis von Oken, 1834, 716–717.
Nance, J.M. & Braithwaite, L.F. (1979) The function of mucous secretions in the cushion star *Pteraster tesselatus* Ives. *Journal of Experimental Marine Biology and Ecology*, 40 (3), 259–266.
https://doi.org/10.1016/0022-0981(79)90055-8
Nobili, G. (1904) Diagnoses preliminaires de vingt-huit especes nouvelles de Stomatopodes et Decapodes Macroures de la Mer Rouge. *Bulletin du Muséum national d'histoire naturelle*, 10, 228–238.
O'Hara, T., Mah, C.L., Hipsley, C.A., Bribiesca-Contreras, G. & Barrett, N.S. (2018) The Derwent River seastar: re-evaluation of a critically endangered marine invertebrate. *Zoological Journal of the Linnean Society*, 186 (2), 483–490.
https://doi.org/10.1093/zoolinnean/zly057
O'Loughlin, P.M. & Waters, J.M. (2004) A molecular and morphological revision of genera of Asterinidae (Echinodermata: Asteroidea). *Memoirs of Museum Victoria*, 61, 1–40.
https://doi.org/10.24199/j.mmv.2004.61.1
Paine, R.T. (1966) Food web complexity and species diversity. *American Naturalist*, 100, 65–75.
https://doi.org/10.1086/282400
Paine, R.T. (1969) The *Pisaster-Tegula* interaction: prey patches, predator food preference and intertidal community structure. *Ecology*, 50, 950–961.
https://doi.org/10.2307/1936888
Perrier, E. (1875) Revision de la Stellerides du Museum d'Historie Naturelle de Paris. *Archives du Zoologie Experimentale et Generale*, 4, 265–450.
Perrier, E. (1881) Report on the Results of dredging in the Gulf of Mexico and in the Caribbean Sea, 1877–79, by the United States Coastal Survey Steamer Blake. 14. Description sommaire des espèces nouvelles d'Astéries. *Bulletin of the Museum of Comparative Zoology*, 9, 1–31.
Perrier, E. (1894) Stellérides. *Expéditions Scientifique Travailleur et du Talisman*, 3, 1–431, 26 pls.
Peters, W. (1852) Ubersicht der Seesterne (Asteridae) von Mossambique. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Konigl.Preuss.Akademie der Wissenschaften zu Berlin*, 1852, 177–178.
Pettibone, M. (1969) remarks on the North Pacific *Harmothoe tenebricosa* Moore (Polychaeta, Polynoidae) and its association with asteroids (Echinodermata, Asteroidea). *Proceedings of the Biological Society of Washington*, 82, 31–42.
Pope, E.C. & Rowe, F.W.E. (1977) A new genus and two new species in the family Mithrodiidae (Echinodermata: Asteroidea) with comments on the status of species of *Mithrodia* Gray, 1840. *Australian Zoology*, 19 (2), 201–216.
Pyle, R.L., Boland, R., Bolick, H., Bowen, B.W., Bradley, C.J., Kane, C., Kosaki, R.K., Langston, R., Longenecker, K., Montgomery, A., Parrish, F.A., Popp, B.N., Rooney, J., Smith, C.M. & Wagner, D. (2016) A comprehensive investigation of mesophotic coral ecosystems in the Hawaiian Archipelago. *PeerJ*, 4, e2475, 1–45.
https://doi.org/10.7717/peerj.2475
Riegl, B. & Piller, W.E. (2003) Possible refugia for reefs in times of environmental stress. *International Journal of Earth Science*, 92, 520–531.
https://doi.org/10.1007/s00531-003-0328-9
Rowe, F.W.E. (1977) A new family of Asteroidea (Echinodermata), with the description of five new species and one new subspecies of *Asterodiscides*. *Records of the Australian Museum*, 31 (5), 187–233.
https://doi.org/10.3853/j.0067-1975.31.1977.209
Rowe, F.W.E. (1977) The status of *Nardoa (Andora)* A.M. Clark, 1967 (Asteroidea: Ophidiasteridae), with the description of two new subgenera and three new species. *Records of the Australian Museum*, 31 (6), 235–245.
https://doi.org/10.3853/j.0067-1975.31.1977.210
Rowe, F.W.E. (1985) Six new species of *Asterodiscides* A.M. Clark (Echinodermata, Asteroidea) with a discussion of the origin and distribution of the Asterodiscididae and other 'amphi-Pacific echinoderms. *Bulletin du Muséum national d'histoire naturelle*, Section A: Zoologie, Biologie et Écologie Animales, 7 (3), 531–577.
https://doi.org/10.5962/p.285862
Rowe, F.W.E. (1985b) On the genus *Podosphaeraster* A.M. Clark and Wright (Echinodermata, Asteroidea) with description of a new species from the North Atlantic. *Bulletin du Muséum national d'histoire naturelle*, Section A, Zoologie, Biologie et Écologie Animales, Series 4, 7 (2), 309–329.
https://doi.org/10.5962/p.287568
Rowe, F.W.E. (1989) Nine new deep-water species of Echinodermata from Norfolk Island and Wanganella Bank, northeastern Tasman Sea, with a checklist of the echinoderm fauna. *Proceedings of the Linnean Society of New South Wales*, 111 (4), 257–291.
Rowe, F.W.E. & Gates, J. (1995) Echinodermata. *In*: Wells, A. (Ed.), *Zoological Catalogue of Australia*. *Vol. 33*. CSIRO, Melbourne, pp. 1–510.
Rowe, F.W.E. & Marsh, L.M. (1982) A revision of the asterinid genus *Nepanthia* Gray 1840 (Echinodermata: Asteroidea), with the description of three new species. *Memoirs of the Australian Museum*, 16, 89–120.
https://doi.org/10.3853/j.0067-1967.16.1982.360
Rowe, F.W.E. & Nichols, D. (1980) A new species of *Podosphaeraster* Clark and Wright, 1962 (Echinodermata: Asteroidea) from the Pacific. *Micronesica*, 16 (2), 289–295.
Ryansky, A. (2020) *Starfishes and other echinoderms of the tropical Indo-Pacific*. ReefID books, Middletown, DE, 91 pp.
Sladen, W.P. (1889) Asteroidea. *Report of the Scientific Results of H.M.S. Challenger*, 30, 1–893.
https://doi.org/10.1111/j.1096-3642.1882.tb02281.x
Soota, T.D. & Sastry, D.R.K. (1979) Notes on two species of *Echinaster* Muller & Troschel (Echinodermata: Asteroidea) from the Indian Ocean. *Records of the Zoological Survey of India*, 343–352.
https://doi.org/10.26515/rzsi/v75/i1-4/1979/161889
Spencer, W.K. & Wright, C.W. (1966) Asterozoans. Part U. Echinodermata. *In*: Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology*. *3 (1)*. University of Kansas Press, Lawrence, Kansas, pp. U4–U107.
Verrill, A.E. (1867) Notes on Radiata in the Museum of Yale College, with descriptions of new genera and species. No. 3. On the geographical distribution of the

echinoderms of the West coast of America. *Transactions of the Connecticut Academy of Arts and Sciences*, 1 (2), 323–351.

Verrill, A.E. (1899) Revision of certain genera and species of starfishes, with descriptions of new forms. *Transactions of the Connecticut Academy of Arts and Sciences*, 10 (1), 145–234.
https://doi.org/10.5962/bhl.part.7031

Viguier, C. (1878) Classification des Stellerides. *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 86, 681–683.

Wagner, R.H., Phillips, D.W., Standing, J.D. & Hand, C. (1979) Commensalism or mutualism: Attraction of a sea star towards its symbiotic polychaete. *Journal of Experimental Marine Biology and Ecology*, 39 (3), 205–210.
https://doi.org/10.1016/0022-0981(79)90126-6

Walenkamp, J.H.C. (1976) The asteroids of the coastal waters of Surinam. *Zoologische Verhandelingen*, 147, 1–91, 18 pls.

Zhang, R., Fau, M., Mah, C., Eléaume, M., Zhang, D., Zhou, Y., Lu, B. & Wang, C. (2024) Systematics of deep-sea starfish order Brisingida (Echinodermata: Asteroidea), with a revised classification and assessments of morphological characters. *Molecular Phylogenetics and Evolution*, 191, 107993.
https://doi.org/10.1016/j.ympev.2023.107993