

1447-2554 (On-line)

<https://museumsvictoria.com.au/collections-research/journals/memoirs-of-museum-victoria/>

DOI <https://doi.org/10.24199/j.mmv.2024.83.01>

New Goniasteridae and *in situ* observations significant to deep-sea coral predation

CHRISTOPHER L. MAH

Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, MRC-163, PO Box 37012, Washington D.C. 200560, United States of America. [brisinga@gmail.com]

Abstract

Mah C.L. 2024. New Goniasteridae and *in situ* observations significant to deep-sea coral predation. *Memoirs of Museum Victoria* 83: 1–35.

Eight new species, including one new genus, *Armaster chondros* n. gen. sp., *Atheraster luma* n. sp., *Atheraster phaeos* n. sp., *Atheraster umbo* n. sp., *Circeaster dux* n. sp., *Evoplosoma besseyae* n. sp., *Evoplosoma mystrion* n. sp. and *Evoplosoma pharos* n. sp. are newly described from Australian waters. *Atheraster*, *Circeaster* and *Evoplosoma* have been reported previously as predators on deep-sea octocorals. *Evoplosoma*, *Gilbertaster* and *Hippasteria* are members of the Hippasterinae, which have also been reported as predators on deep-sea corals and other cnidarians, suggesting that this interaction occurs in Australian deep-sea settings. *Atheraster*, *Circeaster* and *Armaster* are referred to a new subfamily, the Circeasterinae. Ecological and systematic implications for the Goniasteridae are discussed. An *in situ* observation of a myxasterid preying upon an octocoral is also reported.

Keywords

Coral predation, deep-sea, Goniasteridae, Hippasterinae Myxasteridae, Australia, Tasmania, Indian Ocean

Introduction

Deep-sea coral biology and especially its management have become important to the understanding of ecology and biodiversity in ocean conservation as part of the human influence on the marine environment (e.g. Roberts & Hirshfield, 2004; Miller et al. 2009). However, studies of deep-sea communities in Australian waters and the species that comprise them, especially those below bathyal and abyssal depths (>1000 m) are in their infancy, because trawl surveys have only recently begun sampling these settings (e.g. MacIntosh et al. 2018; O'Hara et al. 2020).

Deep-sea corals are typically assemblages of diverse colonial cnidarians, particularly octocorals, but also scleractinians, such as *Lophelia*, and antipatharians (aka black corals) (e.g. Rogers 2013; Lauria et al. 2017; Horowitz et al. 2018). These assemblages provide habitat for numerous other associated organisms, thus forming diversity hotspots on the deep-sea floor (e.g. Hovland 2008). Many deep-sea colonial octocorals, such as the Isididae, are ecologically significant, providing habitat for numerous species in marine ecosystems (Etnoyer and Morgan, 2003). Deep-sea octocoral taxa in Australian waters (e.g. Alderslade and McFadden, 2012; Alderslade et al. 2014; O'Hara et al. 2020) may not be as well studied as in some other regions, but likely possess comparable importance (e.g. Alderslade et al. 2014).

Prominent among these deep-sea coral communities are echinoderms, notably sea urchins and sea stars, the latter observed preying on coral tissue, especially on octocorals (e.g. Stevenson and Rocha, 2013; Mah 2020, 2022). The

Goniasteridae, particularly members of the Hippasterinae, as well as *Circeaster* and related taxa, have been the most frequently observed preying on octocoral colonies. Although an empirical assessment of the ecological impact of asteroid predation on deep-sea corals has yet to be undertaken, comparisons with shallow-water asteroid coral predators, such as the crown-of-thorns sea star, *Acanthaster* spp. (e.g., Birkeland and Lucas, 1990), or *Hippasteria* on the sea pen *Ptilosarcus* (e.g. Birkeland 1974), suggest importance for community structure.

Introduction to The Goniasteridae

The Goniasteridae includes over 300 species in approximately 70 genera (updated from Mah and Blake, 2012) present in all of the world's ocean basins, with a rich fossil record extending into the Mesozoic, especially in the Cretaceous of Europe (e.g. Breton, 1992). Modern faunas are diverse and occur across a wide depth distribution, from intertidal to over 4000 m (Mah, 2016). Attempts at groupings within the Goniasteridae have not found success, because many genera have remained unclassified and proposed subfamilies have not persisted (e.g. Spencer and Wright, 1966).

At a global scale, goniasterids from bathyal to abyssal habitats (700–6000 m) have been collected and occurrence is reasonably well documented (e.g. Clark and Downey, 1992; Mah, 2016). Recent specimen collections and *in situ* video has shown extensive imagery of Goniasteridae in significant ecological roles, notably as predators (Mah 2020, 2022), especially of important “ecosystem engineer” type taxa that

provide habitat for numerous other organisms (Meadows et al., 2012) including Porifera, Octocorallia and other cnidarians, such as antipatharians. Feeding preference varies among goniasterid taxa, with some, such as *Ceramaster* or *Peltaster*, observed feeding on Porifera (Mah, 2020), whereas others, such as the Hippasterinae, are regularly observed feeding on various octocoral species.

Goniasterid octocoral predators

The Hippasterinae includes four genera, *Evoplosoma*, *Gilbertaster*, *Hippasteria* and *Sthenaster*, all of which include one or more species documented feeding on octocoral tissue in the Atlantic and Pacific oceans. *Sthenaster emmae* Mah, Nizinski & Lundsten, 2010 and *Gilbertaster caribbaea* (Verrill, 1899) have been documented feeding on *Eunicella* (now *Dacrygorgia*) (Eunicellidae), 252–874 m, and *Plumarella* sp. (Primnoidae), 500–901 m (Mah, 2020). A new observation of potential predation by the Pacific *Gilbertaster acanthus* is included herein.

Evoplosoma is one of the most frequently observed hippasterines at abyssal depths (approximately 1000–3000 m) in Atlantic and Pacific waters. One Indian Ocean species is described, but none have been observed in situ from this region. Video and imagery by *Okeanos Explorer* document diverse species feeding on bamboo corals (family Isididae) (Mah, 2015a, 2015b, 2020, 2022; Mah et al., 2010). During the *Okeanos Explorer* CAPSTONE expedition to the Hawaiian Islands and adjacent regions in the North/Central Pacific, hundreds of *Evoplosoma* were observed feeding on various isidid octocorals (Mah, unpublished data) with the exception of *Evoplosoma voratus* Mah et al. 2010 from the North Pacific, which was recorded feeding on the antipatharian *Trissopathes* (Mah et al., 2010). *Evoplosoma* has not been observed feeding on scleractinians or sea anemones.

Hippasteria is the most widespread of the hippasterine Pacific coral predators, with further species in the Atlantic and Indian Oceans at depths ranging from 10–1500 m, potentially the widest bathymetric range for all the hippasterines. Population phylogeography of *Hippasteria* showed multiple nominal species were members of a single widely-ranging species, *Hippasteria phrygiana*, present across the Atlantic, Pacific and Indian oceans. Recorded prey of *Hippasteria* in shallow-water North Atlantic settings includes sea anemones (*Stomphia* and *Metridium*) and zoanthids (Jangoux, 1982) whereas at scuba depths in the North Pacific, *Hippasteria* predated upon the sea pen, *Ptilosarcus* (Birkeland, 1974). This contrasts with the relatively deep-sea (200–215 m) feeding habits of North Atlantic *H. phrygiana* on the continental shelf of North America which include the soft coral *Anthomastus* and primnoid octocorals (Mah, 2015b). Although the observed prey were chiefly cnidarians, detrital materials including nudibranch eggs, polychaetes and sediment were also taken (Jangoux, 1982).

Although not historically considered members of the Hippasterinae, molecular phylogenetic data (Mah and Foltz, 2011a) has shown *Calliaster* as a possible sister group. *Calliaster*

shares several distinctive morphological characters, notably large prominent spines, and although feeding behavior is poorly understood, shallow-water species, such as the South African *Calliaster baccatus* Sladen, 1889 have been observed feeding on octocorals (Mah, unpub. observations), suggesting affinities.

Goniasterids in the subfamily Circeasterinae nov. subfam. (e.g., *Circeaster* and *Atheraster*) are also frequently observed deep-sea coral predators. The Atlantic *Circeaster americanus* feeds on *Chrysogorgia* and the soft-coral *Paragorgia* (Mah, 2020). *Circeaster pullus* Mah 2006, a Pacific species with close affinities to *Circeaster americanus*, was observed in the Hawaiian North Pacific region feeding on isidid octocorals (Mah, 2015b). The CAPSTONE expedition recorded *Atheraster* feeding on octocorals in the Musicians Seamount region (Mah, 2022). Goniasteridae other than those in the Hippasterinae and Circeasterinae observed feeding on octocorals include observations of *Astroceramus eldredgei* in the North Pacific Hawaiian region (Mah 2015b).

Possible deep-sea coral predators in Australian waters

The last accounting of Australian Goniasteridae (Rowe and Gates, 1995) reported few deep-sea species. One possible coral predator among those listed was a member of the southern population of *H. phrygiana*, previously known as *Hippasteria trojana*, at 366–1152 m in New South Wales and Victoria. Rowe and Gates (1995) also included *Calliaster*, a genus that includes coral predators, from the west and south-east coasts of Australia, at 80–923 m.

New collections of deep-water (800–3000 m) specimens from southeast Australia (Museums Victoria, NMV) and the Western Australian coast (Western Australian Museum, WAM) add to listings of deep-sea taxa that include genera with species that have previously demonstrated predatory behaviour on deep-sea corals. A single myxasterid was observed *in situ* preying on an octocoral, without a specimen collection, and is reported herein.

Materials & methods

Materials examined herein are housed primarily in the collections of the WAM in Perth and NMV in Melbourne, Australia. Reference material from the National Museum of Natural History (USNM) was also cited.

Video from the R/V *Falkor*'s deep-sea expeditions (>200 m) in Australia (FK200126, FK 200429, FK200930, FK 200802) were reviewed, but given the amount of recorded video, further discoveries remain possible.

GONIASTERIDAE Forbes 1841

Comments. Australian Goniasteridae have been recorded primarily from shallow-water and continental shore and slope habitats. The last census of Australian goniasterid taxa recorded 34 species in 19 genera (Rowe and Gates, 1995). Composition of Australian Goniasteridae has been complicated by taxonomic overlap with the Oreasteridae (e.g. *Nectria*, see Marsh and Fromont, 2020) and more recently with the Pseudarchasteridae and the Ophidiasteridae (Mah and Foltz, 2011a).

Although predominantly shallow, goniasterids have historically been among the deepest known of Australian asteroids, with some species, such as *Nymphaster moebii* (Studer, 1884) known to 1655 m. Goniasteridae described herein are among the deepest known asteroids from Australian waters.

Circeasterinae nov. subfamily

Diagnosis. Body strongly stellate ($R/r=3.0-4.0$), arms elongate, slender to broad based. Abactinal plates variably flat to weakly convex, covered by large, coarse granules. Abactinal plate surfaces mostly smooth but with large granules, scattered to absent. Distinctly coarse granules mark periphery. Arm plates in *Circeaster* and *Arthaster* 2–3 times the size of those on the disk but more consistent in size in *Lydiaster* and *Armaster*. Marginal plates blocky, wide, forming prominent border variably bare or with pronounced large conical spine and/or spinelets; granules on plate surfaces, scattered. Actinal surface covered by spinelets or granules. Adambulacral spination with enlarged, thickened subambulacral spine(s), alveolar pedicellariae with variable morphology but valves weakly concave to flat with teeth or prongs. Furrow spines number 6–20, mostly 7–15.

Included Genera: *Armaster*, *Atheraster*, *Circeaster* (type genus), *Lydiaster*

Comments. As descriptions of further diversity within *Circeaster* and related genera progress, it is apparent that described genera share characters and life habits that warrant a subgrouping within the Goniasteridae. This includes the type genus, *Circeaster* Koehler 1909, *Lydiaster* Koehler 1909, as well as *Atheraster* Mah 2022 and *Armaster* gen. nov., described herein. Based on current *in situ* observations, species in *Circeaster* and *Atheraster* are documented as deep-sea predators, preying primarily on octocorals (Mah, 2006, 2022). As indicated elsewhere here, some genera, such as *Armaster* and *Atheraster*, show affinities with members of the Hippasterinae, which are thought to be primarily coral or cnidarian predators, notably the pronounced conical spines present on the abactinal and marginal plate surfaces.

Key to the Circeasterinae subfam. nov.

- (0) Single large or small multiple spines present on both marginal plate series. Variably among specimens, a strongly arched tumescence located centrally on superomarginal or inferomarginal plate surface where a spine would be present. Granules absent from marginal plate surfaces. (1)
- (1) Granules, if present, flush with plate surface. Otherwise absent. *Atheraster*
- (1') Surficial granules abundant, completely covering abactinal surface. *Armaster*
- (0') Spines absent from all marginal plates, which have flat surfaces. Granules, widely spaced, coarse, on superomarginal surfaces. (2)
- (2) Arm plates larger than adjacent disk plates. Abactinal arm plates with abrupt transition from disk. *Circeaster*

- (2') Arm plates not larger than adjacent disk plates. Abactinal plate sizes gradually changing between disk and arm. *Lydiaster*

Armaster nov. gen.

urn:lsid:zoobank.org:act:D65E4A5E-D3FC-4805-8E60-312D35D9F1A8

Etymology and Diagnosis: as for genus and species.

Armaster chondros nov. gen. nov. sp.

urn:lsid:zoobank.org:act:B120E152-22CE-4AC3-8AE5-A01042932CC5

Figure 1a–f

Etymology. The genus is derived from the Latin *arma* for “armed” or “weapons”, alluding to the prominent spines present on the marginal plate series. The species epithet *chondros* is Greek for “grain”, alluding to the granules present on the abactinal surface.

Diagnosis. Body stellate, arms elongate, triangular, interradial arcs weakly curved. Abactinal surface with continuous layer of granules covering surfaces, obscuring plate boundaries. Most abactinal arm plates do not show the abrupt enlarged size as they do in *Atheraster* or *Circeaster*, although exceptionally plates 1–3 are smooth and 2–3 times the size of adjacent plates. Most superomarginals with a large single spine or strongly arched central area where spine has been broken, spination more weakly expressed distally. Inferomarginals with granulation on surface interradially but not along plates more distally. Oral surface covered by granules similar to those on aboral, marginals; pedicellariae, 6–7 per interradius, paddle-shaped, valves broad. Furrow spines, 3 to 5, most with a single large subambulacral spine and a paddle-shaped pedicellariae.

Comments. *Armaster* n. gen. shows arm plates consistent in size with those on disk and similar to those of *Lydiaster* but differing in the presence of prominent conical spines on superomarginal and inferomarginal plates, much in the way that *Atheraster* displays marginal plate spines relative to *Circeaster*. *Armaster* is further distinguished from other circeasterines by a dense granular cover on the abactinal plate surface that completely covers the plates and obscures boundaries between them.

Arm shape, marginal plate spination, surficial granulation and pedicellariae in *Armaster* resembles those in the hippasterine *Evoplosoma*, suggesting that the Hippasterinae and the Circeasterinae share characteristics.

Occurrence. Huon Seamount, Tasman Sea, 900 m.

Description. Body stout, stellate ($R/r=3.0$). Arms tapering, elongate, triangular tips pointed. Interradial arcs weakly curved.

Abactinals abutted, ranging in shape from quadrate to irregularly polygonal, larger proximally becoming smaller and more homogeneous distally adjacent to superomarginal contact. Abactinals covered by coarse, round granules, 8–15 per plate, 2–3 along a 1.0 mm line. Granular cover obscuring

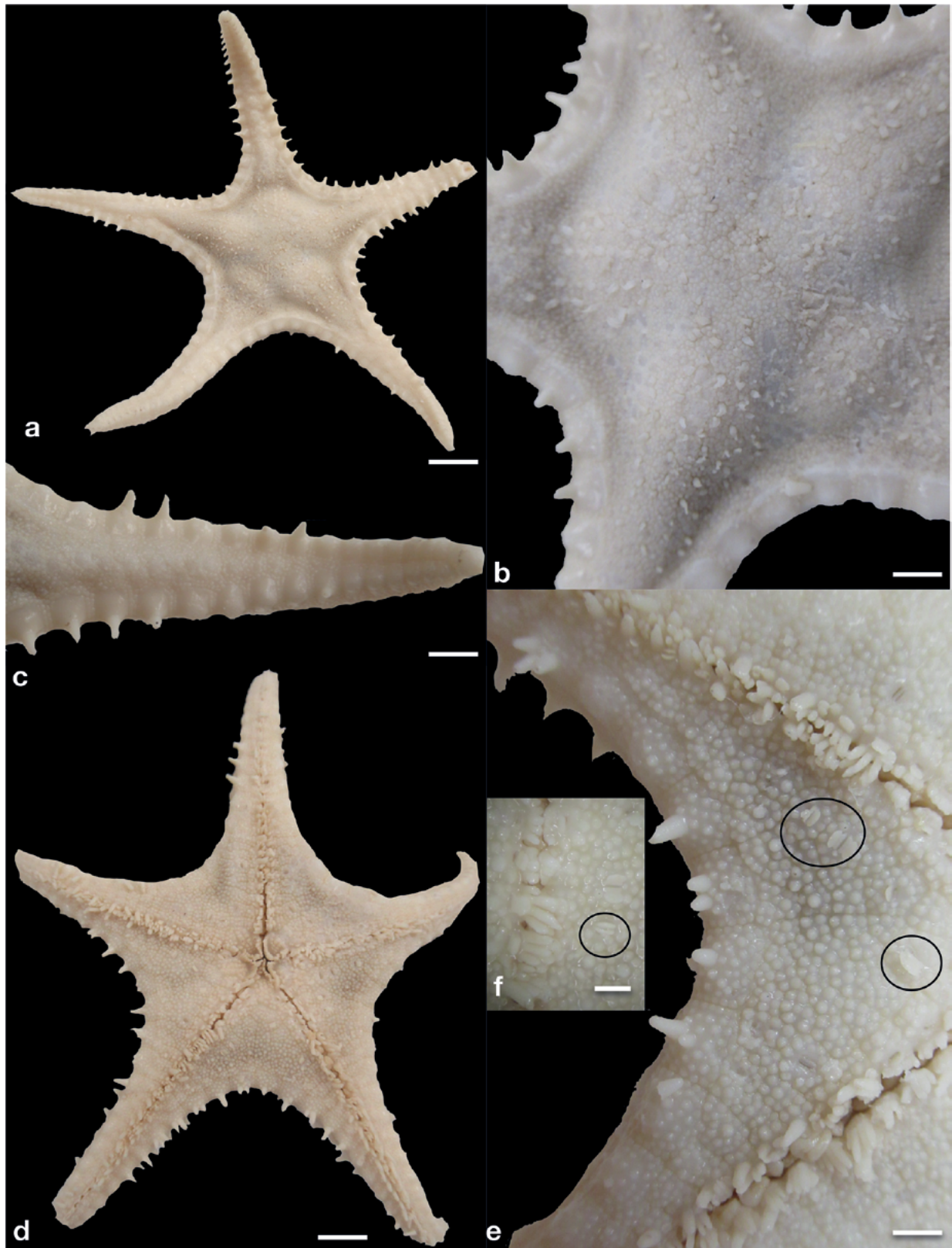


Figure 1. *Armaster chondros* n. gen., n. sp. holotype, HNMV F240317: a, abactinal surface; b, abactinal surface detail; c, Abactinal arm surface; d, Actinal surface; e, Actinal surface, detail; f, Furrow spines. Pedicellariae circled. Scale: a, d=10.0 mm; b, e=3.0 mm; c=5.0 mm; f=1.0 mm.

plate boundaries; granules round to polygonal. Plates extend onto arms for at least 70% of arm distance; superomarginals abutted, 4–6 (mostly five), adjacent to the terminus. Granules present on abactinal plates on arms and disk. Most arm plates similar to those on disk; only one to three larger plates smooth and devoid of granulation. Surface with no enlarged spines or tubercles. Papulae tentacular, extended from pores, relatively abundant on radial regions on disk and proximally on arms, becoming absent midway to distally along arms. Madreporite pentagonal, flanked by five plates. No pedicellariae observed.

Marginal plates, 18–20, in each interradius from arm tip to arm tip; each plate with 14–30 peripheral granules, 6–10 per side. Each superomarginal with either a single, prominent cone-shaped spine or a strongly arched central surface where the spine is absent, central surface strongly arched; alternatively, plate surface low rounded and with 1–6 granules. Distalmost superomarginal plates with or without prominent spines. Inferomarginal plates spineless, proximal plates with large granules, 15–30 covering plate surface with enlarged tubercular granules present centrally on plate. These granules present interradially, with inferomarginals on arms lacking accessories on plate surface. No pedicellariae observed on either series.

Actinal surface composed of 2–3 full series with most elongate actinal plates extending to base of arm. Individual plates quadrate to irregular, surface covered by coarse granules, 4–15, widely spaced, variably round to polygonal. Exceptionally 4–7 large tubercular granules in each interradius. Large paddle-shaped pedicellariae present, 6–8 in actinal interradial region, primarily adjacent to adambulacral plates.

Furrow spines quadrate, 3–5, tips thick, blunt; series weakly palmate to straight. One paddle-shaped pedicellaria adjacent to each furrow spine series; one enlarged blunt spine, approximately twice the thickness of furrow spines. Subambulacral spines more elongate and prominent distally, thickness approaching 2–3 times that of the furrow spines. Remaining cover on adambulacral plates composed of 4–8 widely spaced ground granules.

Oral plate form identical to adambulacral, a single enlarged spine projecting into the mouth, 9–10 furrow spines. Remainder of oral plate surface with 8–10 hemispherical granules, 4–5 present along the edge of the central diastema, with the remainder on the oral plate surface adjacent to the actinal plate contact.

Material examined. **Holotype.** NMV F240317, Huon seamounts, Tasman Sea, Australia. 44.2771° S, 147.266° E, 900 m, coll. R/V *Southern Surveyor*. 1 wet spec, R=4.9, r=1.6.

***Atheraster* Mah 2022**

Mah 2022: 28

Diagnosis. Body strongly stellate (R/r=3.8–4.0) with arms, elongate and tapering. Abactinal arm plate size 2–3 times those on disk. Sharp, thorn-like spines, well developed to incipient, on all superomarginal and inferomarginal plates, forming regular series. Granules with pointed tips. Pedicellariae paddle-like. Furrow spines number 5–15 in known species.

Included Species: *Atheraster arandae* (Mah 2006),

Atheraster pheos n. sp., *Atheraster luma* n. sp., *Atheraster symphonia* Mah 2022, *Atheraster umbo* n. sp

Comments. *Atheraster symphonia* and *Circeaster arandae* Mah 2006 exhibit acutely larger abactinal arm plates than those on the disk and large conical spines on marginal plates (Mah, 2022). Occurrences are described from the Musician Seamounts in the North Pacific, and Madagascar and New Caledonia, respectively. Although the abactinal surface is not covered by granules, the prominent marginal plate spination, pedicellariae and elongate arms are similar to the hippasterine *Evoplosoma*. Overall body shape, including the tapering arms, the marginal plate spination and the numerous actinal pedicellariae, is also similar to *Armaster* nov. gen.

Imagery from the NOAA ship *Okeanos Explorer* has permitted numerous observations of *Atheraster*, including at least two apparent observations of undescribed species from the Pacific and the Atlantic (e.g. Mah, 2022 and in preparation), which were not collected.

Key to Atheraster species

- (0) Marginal plates with strongly arched tumescence present on superomarginal arm plates, more weakly developed on inferomarginals. *Atheraster umbo* n. sp.
- (0') Marginal plates with a well-developed, pointed or conical spine present on most marginal plates, especially on the arm. Interradial or disk plates with a single spine or smaller, more variable spines or granules. (1)
- (1) Coarse, prismatic granules present in abundance on abactinal plate surface or forming periphery around each plate. *Atheraster symphonia* Mah 2022
- (1'') Granules absent from abactinal plate surface. Peripheral granules around abactinal plates, widely spaced. (2)
- (2) Interradius with multiple conical pointed spinelets. (3)
- (2') Interradius with a single prominent spine. *Atheraster luma* n. sp.
- (3) All marginal plates, arms and interradia with spinelets. No single spines. *Atheraster pheos* n. sp.
- (3') Spinelets present interradia, single spines present along arms. *Atheraster arandae* (Mah 2006)

***Atheraster arandae* (Mah 2006)**

Circeaster arandae Mah 2006: 934; 2022: 26.

Diagnosis. Body stellate (R/r>4.0), disk small, arms narrow. Abactinal arm plates bare, transition between large arm plates and smaller disk plates abrupt. Marginal plates with prominent spine and abundance of smaller secondary spinelets, especially on ventrolateral edge. Furrow spines 12–15, distinct adambulacral pedicellariae, paddle-shaped. Adambulacral plate surface covered by 5–7 spinelets or rough-tipped granules.

Occurrence. Hawaiian Islands, American Samoa region, New Caledonia, Madagascar, 1600–2439 m.

***Atheraster luma* n. sp.**

urn:lsid:zoobank.org:act:904FBE9F-371B-48B5-9165-1358E6B574F4

Figure 2a–g

Etymology. A Latin word for thorn, alluding to the many conical spines present on the marginal plates.

Diagnosis. Body shape weakly stellate to stellate ($R/r=2.0$ – 3.3), arms triangular, relatively short. Abactinal plates bare, flat. No spines. All marginal plates with a single, conical spine in series; plate surface otherwise bare. Pedicellariae paddle-like in shape. Actinal plates with pedicellariae, angular granules. Furrow spines, 4 to 9. A single large, thick subambulacral spine present behind furrow spines with large, distinct, bivalve paddle-shaped pedicellariae proximal to the spine on each adambulacral plate.

Comments. *Atheraster luma* n. sp. shares a full series of single, conical spines present on all marginal plates with *A. symphonia* but differs from the other two *Atheraster* species, which have multiple spines present in each interradius. The functional significance of different, larger spination in each interradius is unclear, perhaps representing phenotypic variation relative to predation by differing prey species.

Occurrence. Tasmanian seamounts. 900–1450 m.

Description. Body strongly stellate ($R/r=3.06$ – 3.2), arms elongate to triangular, interradiar arcs weakly curved to straight. Disk surface formerly inflated with deflated texture. Arms upturned.

Abactinal surface flat, individual plates polygonal and triangular to round, directly abutted. Plates extending to arm tips, size variable, relatively homogeneous on disk acutely heterogeneous on arms with smaller plates (~25% of the size of larger plates) adjacent to larger ones. Disk plates flatter on disk, becoming more convex along arms. Individual plates each surrounded by 10–40, mostly 15–30, quadrate to polygonal granules forming a single series around the periphery of every plate. Most plates bare with no granules or other accessories but central disk region plates covered with 5–10 small granules, especially adjacent to the madreporite, with one plate showing especially large granules. Madreporite convex, sulci well developed. Plates on arm in approximately three irregular series, decreasing to one distally. Carinal disk plates appear widest and largest along arm. Papulae present along radial regions, 4–6 per plate, each papula at disk edge. Pedicellariae paddle-shaped, present on a minority of plates, especially on radial and interradiar regions.

Superomarginal plates 32–56 per interradius (arm tip to arm tip), inferomarginals 32–58 (larger plate count in larger individuals, $R=7.3$). Individual plates wide ($W>L$) throughout but with more lateral facing interradially. Marginal plates associated 1:1. Each superomarginal plate with a single prominent tubercle or short conical spine, especially interradially, becoming flattened out distally near arm terminus. Superomarginal plate surface bare save for small 2.0 mm pedicellariae present on lower lateral facing adjacent to peripheral granules and contact with inferomarginal plate.

Spines/tubercles on marginal series arranged in distinct linear series in parallel to one another. Inferomarginal plates with single spines/tubercle absent interradially but present in three of the five arms from arm base to tip, one paratype (F240317) with one or two spines present on interradiar inferomarginals. Distal-most superomarginals and inferomarginals strongly convex with swollen distinct region, but lacking spines. Interradiar inferomarginal plates with 5–30 angular, irregularly shaped granules, especially on the actinal plate facing. Lateral inferomarginal plate facing is mostly bare except for one small 2.0 mm paddle-shaped pedicellaria present on the inferomarginal adjacent to the contact with the peripheral granules and the superomarginal plate. Each marginal plate with approximately 50–80 quadrate-shaped granules forming periphery around the edge. Smaller individuals ($R=3.9$) with fewer pedicellariae present on inferomarginal plates. Terminal plates large, triangular, surface smooth with two short spines.

Actinal surface composed of three or four rows of plates in chevron-like pattern. Each plate covered by 2–12 irregular-shaped angular to polygonal granules, densely arranged. Centrally present on most of these plates is a large bivalve paddle-shaped pedicellariae (1.0 mm across for each valve), especially proximally adjacent to oral plates. Granules adjacent to pedicellariae are approximately twice as large as other granules. Actinal plates with large, blunt spines distally.

Furrow spines 4–9, with some individuals showing 5–8 and others (e.g. at $R=3.6$) with nine, quadrate in cross-section but variably thin or thick. Furrow spines straight to weakly palmate in arrangement. A single large, thick subambulacral spine present behind furrow spines with large, distinct, bivalve paddle-shaped pedicellariae proximal to the spine on each adambulacral plate. Subambulacral spine becomes larger and more pronounced distally, especially as other ambulacral spination accessories become smaller.

Oral furrow spines 9–12 per plate, each with a single blunt spine directed into mouth. Oral plate surface with two series of nine angular granules paired across the contact between oral plates. Remainder of oral plate with irregularly arranged granules present on surface.

Material examined. **Holotype.** NMV F122778, 82.6 km SSE of South East Cape, “J1” seamount. 44.24° S, 147.36° E, 1200–1450 m, 27 Jan 1997, coll. Museums Victoria and T.N. Stranks, CSIRO, R/V *Southern Surveyor* “Seamount” cruise (SSO)197. 1 wet spec, $R=7.3$, $r=2.2$.

***Atheraster pheos* n. sp.**

urn:lsid:zoobank.org:act:4084989D-EA1D-4137-9D8B-944AA7547A94

Figure 3a–g

Etymology. The species epithet *phaeos* is Greek for a spiny plant alluding to the prickly spines present on the marginal plates.

Diagnosis. Body strongly stellate ($R/r=3.4$), arms elongate, arm tips strongly upturned. Abactinal plates bare with no accessories. Abactinal arm plates larger than those of disk, but gradually changing proximally on each arm. Marginal plates bearing 6–10 spines, interradially with a single prominent conical spine on arm spines. Pedicellariae paddle-shaped.

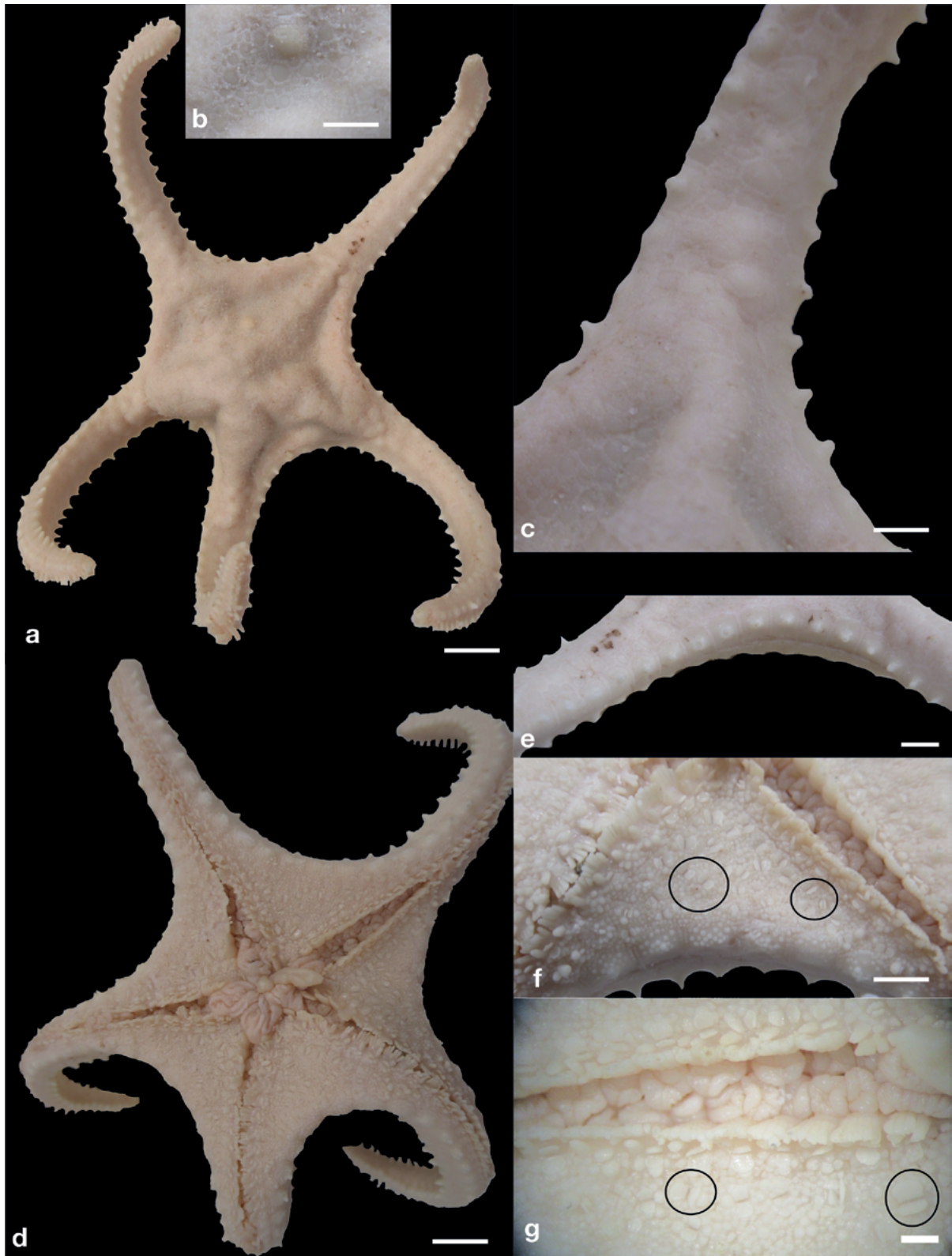


Figure 2. *Atheraster luma* n. sp. holotype, NMV F122778: a, abactinal surface; b, abactinal surface detail; c, abactinal arm surface; d, actinal surface; e, lateral surface, superomarginal plates; f, actinal surface, details; g, furrow spines and adjacent regions. Pedicellariae circled. Scale: a, d=10 mm; c, e=2.0 mm; c, g=5.0 mm; f=3.0 mm.



Figure 3. *Atheraster pheos* n. sp. holotype, WAM Z110039: a, abactinal surface; b, abactinal surface detail; c, abactinal arm surface; d, marginal plate surface showing spinelets; e, actinal surface; f, actinal surface, details; g, furrow spines, adambulacral spination. Pedicellariae circled. Scale: a, e=10 mm; b=3.0 mm; c, d, f=5.0 mm; g=3.0 mm.

Nearly all actinal plates with a prominent paddle-shaped pedicellaria, pointed granules. No actinal spines. Furrow spines, 6–9, spines blunt, quadrate. Proximal adambulacral plates, adjacent to furrow spines, large paddle-shaped pedicellariae, valves rectangular and edges smooth, succeeded distally by subambulacral spines, four to each plate.

Comments. Rather than a single large conical spine, most proximal marginal plates on *A. pheos* variably display 3–4 short spines, with a single spine on more distal plates.

This species very closely resembles *A. arandae*, with which it shares the presence of multiple spines on the interradial marginal plates in conjunction with more pronounced single spines on the distal marginal plates. It differs in possessing fewer furrow spines (6–9 versus 12–15 on *A. arandae*), possessing thorny spinelets on the abactinal arm plates (lacking in *A. arandae*), more weakly stellate body shape ($R/r=3.5$ versus >4.0 in *A. arandae*), and much broader proximal arm width. *Atheraster arandae* from Madagascar and New Caledonia is found at similar depth, 1600–2160 m, to *A. pheos* n. sp., which occurs at 1852 m.

The significance of the smaller-sized interradial spination is unclear. Other deep-sea goniasterids with similar morphology have been observed in complex, acrobatic positions on octocoral prey, suggesting that interradial spines are related to arm flexure. Alternatively, spination on these plates may represent phenotypic variation relative to differing types of predators.

Occurrence. Australia. Gascoyne Marine Preserve, circa 273 km WNW of Low Point, Western Australia. 20° 48'08.1612" S, 111° 36' 55.5984" E, 1852 m.

Description. Body stout, strongly stellate ($R/r=3.4$), arms narrow, tapering, strongly upturned. Interradial arcs weakly curved to straight. Marginal plates lateral facing.

Abactinal surface composed of two sizes of plates, disk plates abutted, round to irregularly polygonal, distinctly smaller than those on arms. Central surface on disk plates smooth and bare with no accessories. Arm plates gradually intergrading with those on disk to become larger distally, each becoming approximately 2–3 times the overall size of plates on the disk region. Disk plates homogeneous in size, shape relative to those on arm, which are larger but also more heterogeneous in size and shape. Disk plates each with peripheral granules, quadrate in shape, 6–16 per plate, homogeneous in size, peripheral granules forming approximately 20% of the total plate diameter. Granular periphery in contact with other granules forming doubled granule around plates on the abactinal surface. Papulae single, present most abundantly around radial regions, absent from arm surface. Pedicellariae paddle-shaped, present on a minority of plates. Madreporite large, irregular in shape, mound-like, flanked by 6–7 adjacent abactinal plates.

Marginal plates, 27–30 per arm side, 54–60 per interradius (arm tip to arm tip). Marginal plates individually wide, predominantly with lateral-facing superomarginals forming narrow periphery when viewed from abactinal surface; inferomarginals prominent from actinal surface but not evident from abactinal surface. Superomarginal plate series most clearly quadrate in shape, with rounded abactinal-lateral angle

distalmost on arm, plates interradially jumbled, arrangement irregular, some plates appearing fragmented and smaller than adjacent plates in series. Plates develop a more ordered and consistent appearance at arm base. Superomarginal plates with a pronounced armament, 6–10 short pointed spines, most strongly expressed interradially. More distally along arms 8–10 superomarginals away from the terminus, single, short thorn-like spines present on the plate surface. Superomarginals in the intervening distance along the arm with irregular alternation between single thorn-like spines and multiple smaller spines. Single large paddle-shaped pedicellaria present on a minority of superomarginal plates. Other than spines and pedicellariae, superomarginal plate surfaces are bare and smooth. Peripheral quadrate-shaped granules, 20–60, around superomarginal and inferomarginal plates. Inferomarginal plates with more pronounced facing on actinal surface. Surficial armament similar to that on superomarginal plates, irregularly alternating between six and ten spines proximally (especially interradially), becoming a single thorn-like spine distally along arm adjacent to terminus. Paddle-like pedicellariae on a minority of inferomarginal plates, but usually one per plate, especially numerous on those interradially. Inferomarginal plates similarly irregular in morphology and distribution interradially, with plate variability extending over midway along arm distance. A minority of superomarginal and inferomarginal plates distally along arm devoid of any armament, surface smooth. Spineless plates present distally on arms. Shallow fasciolar grooves present between superomarginal and actinal plates.

Actinal regions composed of two complete series, with irregular arrangement of plates adjacent to inferomarginal plate contact, these series limited to disk with no plates extending onto arms. Individual actinal plates weakly quadrate to irregularly polygonal in shape each with pointed granules, 5–20, widely spaced, present along each plate periphery. Most plates with broad paddle-shaped pedicellariae, each with valves bearing smooth to weakly developed “teeth”, four to five along top edge. Actinal plate surface otherwise bare and smooth. Shallow fasciolar grooves present.

Adambulacral plates quadrate in shape. Furrow spines, 6–9 in straight to weakly convex series. Spines blunt, quadrate in cross-section. Adjacent to furrow spines, a large paddle-shaped pedicellaria with rectangular valves and smooth edges. Remainder of adambulacral plate covered by a single series of four subambulacral spines, pointed but thick and quadrate in cross-section and relatively low, thick granules with pointed tips similar to peripheral granules on actinal plates. Oral plates with approximately 15 furrow spines, similar to those on the adambulacral plates, blunt and quadrate in cross-section. A larger spine, triangular in cross-section, pointed into mouth. Remainder of oral plate with an irregular number of short blunt spines, 2–4 per plate, and large rectangular pedicellariae, 1–4, identical to those on the adambulacral plates.

Material examined. **Holotype.** WAM Z110039 (CSIRO barcode 10051582), Gascoyne Marine Preserve, circa 273 km WNW of Low Point, Western Australia. 20° 48'08.1612" S, 111° 36' 55.5984" E, 2013 m, coll. RV *Investigator*, Gascoyne Expedition, 3 Dec 2022. 1 wet spec, $R=11.6$, $r=3.4$.

Atheraster symphonia Mah 2022

Diagnosis. Strongly stellate body ($R/r=3.85$), arms elongate. Abactinal and actinal plate surfaces covered by continuous layer of coarse granules. Superomarginal and inferomarginal plates with 1–3 conical spines, but surface is otherwise smooth. Furrow spines, 8–12. Paddle-shaped pedicellariae present on adambulacral plate.

Occurrence. North Pacific, Sibelius Seamount (Musicians Seamounts), 27°15'N, 160°38'W, 2437 m.

Atheraster umbo n. sp.

urn:lsid:zoobank.org:act:049A6DE1-0722-4252-A363-D373EE1C1E25

Figures 4a–f, 5a–f

Etymology. The species epithet, *umbo*, is Latin for a boss or swelling, alluding to the tumescent projections present on the marginal plates.

Diagnosis. Body stout, strongly stellate ($R/r=3.2$), arms elongate, triangular, interradial arcs weakly curved to straight. Abactinal plates irregular, bare, extending to arm tip. Arm plates variably flat to strongly convex, acutely large relative to adjacent disk plates. Pedicellariae abundant, 4–12, along depression in each interradius. Five plates across proximally on arms decreasing to a single series to terminus. Marginal plates, 40–44 per interradius, 20–22 per arm side, interradially with 2–10 small granules/tubercles, but otherwise smooth and bare. Marginal plates along the arms with single distinct tumescence. Granules coarse, nearly tubercular, most abundant (1–15) interradially on marginal plates, decreasing then absent along arm surface. Actinal plates with distinct alveolar pedicellariae flanked on either side by bisected hemispherical granules. Furrow spines 5–15, but mostly seven or eight, with a prominent single tong-like pedicellaria with quadrate valves on each adambulacral plate. Spine, large thick, 2–3 times the thickness of the furrow spines, identical in length to the longest of the furrow spines, present at oblique angle to pedicellariae. Oral plates, each with large, paddle-shaped pedicellaria per plate, thus two per interradius, but not symmetrically positioned.

Comments. Although lacking well-developed spines, the tumescent structures on the marginal plates display a strongly arched shape and pattern that appears very similar to spines in other *Atheraster* species. This species' marginal plate ornamentation pattern parallels *A. pheos* n. sp. in showing interradial superomarginal plates with 2–10 minute surficial accessory structures (i.e. granules/tubercles) relative to the larger, single arched tumescence present on superomarginal arm plates present on each arm. *Atheraster pheos* also displays many small spines, 6–10 on each interradial superomarginal, which are succeeded by a single conical spine on each superomarginal plate along the arm.

The three type specimens, which were collected from distinctly different localities (the Cocos/Keeling Islands and Tasmanian/southeast Pacific), show the same arched or tumescent marginal plates. Additional specimens could show

these to be damaged or be some sort of incipient spine, but examination of material on hand suggests they are a diagnostic character of this distinct species.

This species invites comparison with two Pacific *Circeaster* species, *C. sandrae* Mah 2006 and *C. pullus* Mah 2006. *Atheraster umbo* n. sp. differs in lacking any granulation on the marginal plates surface, displaying large strongly convex abactinal arm plate and in showing a large number of abactinal granules around the madreporite.

Although no direct association was observed, the New Caledonia specimen, IE-2013-7118, was collected from a station that also included members of the Isididae (bamboo corals), which goniasterid predators feed upon frequently.

Occurrence. Cocos (Keeling) Islands Territory, Indian Ocean, Australia, Lord Howe Rise, Southeast Cape, Tasmania, New Caledonia 1896–1589 m.

Description. Body stout, strongly stellate ($R/r=2.1-3.2$), arms elongate, triangular, interradial arcs weakly curved to straight.

Abactinal surface, weakly arched, plates abutted, polygonal, extending from disk to arm tip. Arm and disk plates round to irregularly polygonal in shape but relatively similar in size. The holotype, from Ningaloo, has arm plates only slightly larger than those on disk with gradual transition, but a minority of arm plates, variably 1–4 per arm, are strongly convex, rising well above the body surface. Tasmanian specimens show arm plates up to three or four times the size of disk plates, most arm plates with strongly convex surface, appearing nearly hemispherical. Arm plate surfaces all smooth, devoid of granules with gradually decreasing number of abactinal plates, 3–5 at arm base, decreasing to a single row adjacent to the terminus. Superomarginals with two or three pairs abutted at arm tip on the Tasmanian specimens, but plates continue to terminus on the Ningaloo specimen. Disk plates mostly bare save for dense aggregation of granules surrounding the madreporite. Pedicellariae present in abundance on the Ningaloo specimen, but largely absent from the surface of the Tasmanian ones. Paddle-shaped pedicellariae with flat, round valves present on a minority of disk plates, each pedicellaria within a distinct alveolus or pit. Pedicellariae are most abundant, 4–12, in a distinct valley-like depression present in each interradius. Each plate surrounded by 9–30 polygonal to quadrate granules in close-set series. Each abactinal plate central region flat to weakly concave. Madreporite convex, round in shape with well-developed sulci. Surrounding region with large, coarse granules, 1–12 per plate.

Marginal plates, 40–44 (20–22 along each arm), present in each interradius (arm tip to arm tip, forming a wide boundary around body periphery. Interradial marginal plates with a laterally-directed facing becoming more dorsal facing along arms. Disk superomarginal plates bare, smooth save for 2–10, distinct, spherical granules or tubercles, leaving concave pitting on surface, centrally present on each interradial plate. Ornamentation on superomarginal plate surface along arm with a single distinct tumescence, variably arched with a tip becoming more rounded distally, forming a distinctly crenulated periphery along the arm. Pedicellariae alveolar,



Figure 4. *Atheraster umbo* n. sp. holotype, NMV F307974: a, abactinal surface; b, abactinal surface/marginal plates detail; c, abactinal surface detail; d, lateral view showing marginal plate surfaces e, actinal surface; f, actinal surface detail including pedicellariae, furrow spines. Pedicellariae circled. Scale: a, e=10.0 mm; b, d, f=5.0 mm; c=3.0 mm.

1–4, tong-like with triangular blades on marginal plate surface. Superomarginal plate surface weakly concave, no granules on superomarginal plate surface. Each superomarginal plate with a rounded edge, each plate round in cross-section. Marginal

plates with 40–100 peripheral granules, quadrate to polygonal. Inferomarginals with 1–20 distinct, coarse granules, highest interradially, with 10–15 on central inferomarginal plate surfaces decreasing to a single granule at arm base.

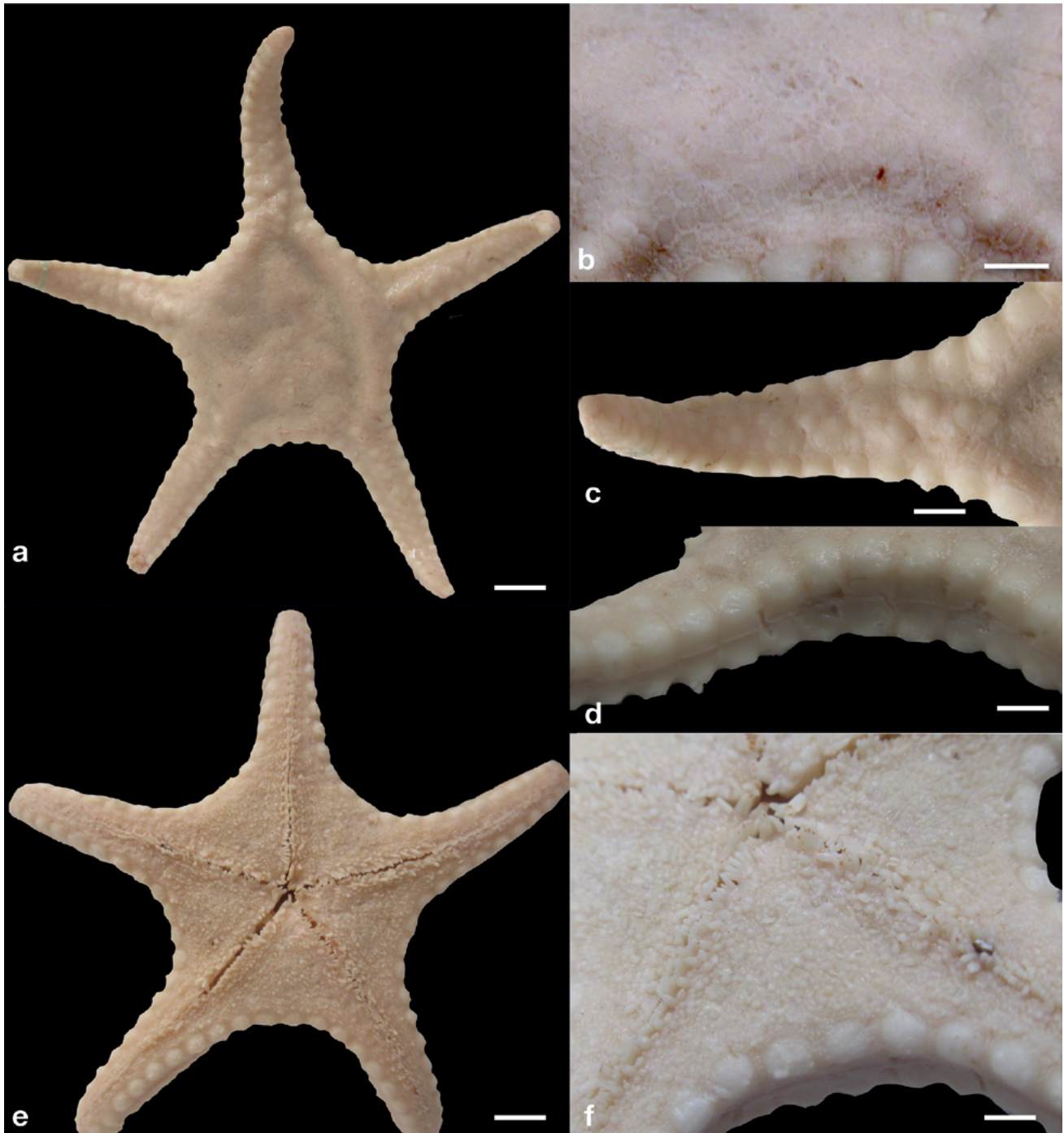


Figure 5. *Atheraster umbo* n. sp. variation paratype, NMV F84959: a, abactinal surface; b, abactinal surface detail; c, abactinal arm surface detail; d, lateral view showing marginal plate surfaces e, actinal surface; f, actinal surface detail including pedicellariae, furrow spines. Scale: a, e=10.0 mm; b, c, d, f=5.0 mm.

Pedicellariae, 1–6, mostly 3–4, alveolar with triangular valves decreasing distally and absent along arms.

Actinal plates in three full series arranged in chevrons, individual plates, irregularly polygonal to round. Each plate with distinctly large, alveolar, paddle-shaped pedicellariae, approximately 1.0 mm in length with quadrate tips, flanked on either side of paired valves by bisected hemispherical granules. Single actinal plate series continues to proximal arm region, where it ends. Actinal plates covered by large round tubercles, coarse granules abundant, closely arranged adjacent to inferomarginal plates. Each actinal plate with coarse granules, 6 to 15 present around periphery.

Furrow spines 5–8, quadrate in cross-section with rounded tips. Furrow spines 12–15 on adambulacral plate adjacent to the oral plate, these furrow spines flattened to spatulate with quadrate-shaped tips. Most adambulacral plates have a prominent, alveolar, paddle-shaped pedicellaria. Remaining surface of each adambulacral surface with a single, large blunt spine on distal side of plate, this spine 2–3 times the width of the furrow spines, extending to approximate height of tallest furrow spine. One to five thick subambulacral spines, short to granular in size on remainder of plate, but especially on side in contact with actinal plates.

Oral plates, each with a large, paddle-shaped pedicellaria approximately 2.0 mm in length, thus two per interradius but unevenly present per interradius. Furrow spines on oral plates, 18–25, closely arranged, each flattened with tallest plates projecting into mouth. Each oral plate with 8–10 granular spines with angular tips, quadrate to polygonal in cross-section, along the central fossae on the side of each plate. Peripheral oral plate with 5–7 angular granular spines along edge adjacent to contact with adambulacral plates.

Material examined. Holotype. NMV F307974 Cocos (Keeling) Islands Territory, Indian Ocean, Australia. 11.832222° S, 96.626667° E, 1896–1589 m. Coll. Tim O'Hara et al. aboard RV *Investigator*, IN 2022 V08 IOT 2, Marine Invertebrates Team, 14–15 Oct 2022. 1 wet spec, R=7.7, r=2.4

Paratypes. NMV F84959. 84 km SSE of South East Cape, Tasmania on J1 seamount. 44.27° S, 147.33° E, 1300–1450 m, coll. T.N. Stranks CSIRO, R/V *Southern Surveyor*. 27 Jan 1997. 1 wet spec, R=6.2, r=2.0.

NMV F159690 Lord Howe Rise, 27.4136833333° S, 161.70035° E, 1532 m. Coll. Geoscience Australia aboard R/V *Tangaroa*, 17 Oct 2007. 1 wet spec, R=3.9, r=1.8.

MNHN IE-2013-7118 New Caledonia, 23° 1.7' S, 168° 9.3' E, 1373–1407 m. Coll. KANADEEP 2, CP 5108. 1 wet spec, R=5.3, r=1.6.

***Circeaster* Koehler 1909**

Circeaster Koehler, 1909: 83. Halpern, 1970a: 265. Downey, 1973: 47, 55, pl. 21A, B. Clark & Downey, 1992: 237. Clark, 1993: 250; Mah, 2006: 927

Diagnosis. Body weakly stellate to stellate, R/r > 2.5. Disk strongly arched, large. Arms elongate, tapering, tips upturned. Interradial arcs linear to curved. Abactinal arm plates 2–3 times larger than disk plates, changing gradually to abruptly between disk to arm. Abactinal arm and disk plates bare. Superomarginal plates abutted over midline in several species. Marginal plates bare, but variably with spinelets or granules present along

dorsolateral/ventrolateral edges and surfaces of marginal plates. Greater density of spinelets/granules on inferomarginals than on superomarginals. Pedicellariae uncommon. Adambulacral furrow spines 6–15. Enlarged subambulacral spine or spines present. Prominent, paddle-like, bivalve or sunken pedicellariae with jagged teeth present on adambulacral plates.

Comments. *Circeaster* occurs widely, including eight species in the Atlantic, Pacific and Indian Oceans, primarily in lower bathyal to abyssal depths, 320–2160 m (Mah, 2006). Two species, *Circeaster loisetteae* and *Circeaster helenae*, have been documented from Western Australia (Mah, 2006).

***Circeaster dux* n.sp.**

urn:lsid:zoobank.org:act:F8D87DCB-8F25-4794-B304-CC2CFEBC8429

Figure 6a–h

Etymology. The specific epithet *dux* is Latin for “commander” or “leader”, alluding to this species’ striking appearance.

Diagnosis. Body stellate (R/r=3.06), arms elongate, triangular. Body covered by hemispherical granules, spinelets absent. Abactinal plates flat to weakly convex, bare other than pedicellariae. Large abactinal plates on arms, strongly tumid, in 4–6 series, arm plates at least twice as large as those on disk. Superomarginal plates forming distinct frame when viewed dorsally. Marginal plate lateral surface with 2–4 paddle-shaped alveolar pedicellariae; three or more present interradially, decreasing to two or fewer distally. Marginal plates smooth and bare, save for flattened, round granules, 20–30 on abactinal surface of superomarginals, lower surface of inferomarginals. Furrow spines 6–8, triangular in cross-section. Subambulacrals three, with jagged, broad tips, each approximately twice as thick as the adjacent furrow spine. Each adambulacral plate with a large clam-like pedicellaria similar to those on abactinal surface with four jagged, well-spaced teeth on each valve.

Comments. This species resembles *Circeaster kristinae* Mah 2006 and *Circeaster magdalanae* Koehler 1909: all share a similar arm and disk shape, prominent superomarginal frame, and similar abactinal plates when viewed on the abactinal surface. It differs in lacking a spinelet-covered surface, and is instead covered by numerous smooth, hemispherical granules. Granules are present in abundance on the abactinal arm plates, but sparingly present on *C. kristinae* and *C. magdalanae*. Three subambulacral spines are present in *Circeaster* n sp., whereas only one or two are present in *C. kristinae* and none occur on *C. magdalanae*.

Most distinctive about this species is the numerous alveolar pedicellariae on the surface of both superomarginal and inferomarginal plates in regular series.

Occurrence. Known only from the type locality, Site 30 Gascoyne Marine Park, 19 km W. of Lakeside, Western Australia, 22.00276° S, 113.733333° E, 713 m.

Description. Body stout, thickened, strongly stellate (R/r=3.06), arms triangular, elongate, proximally wide narrowing at arm tip. Interradial arcs weakly curved to straight.

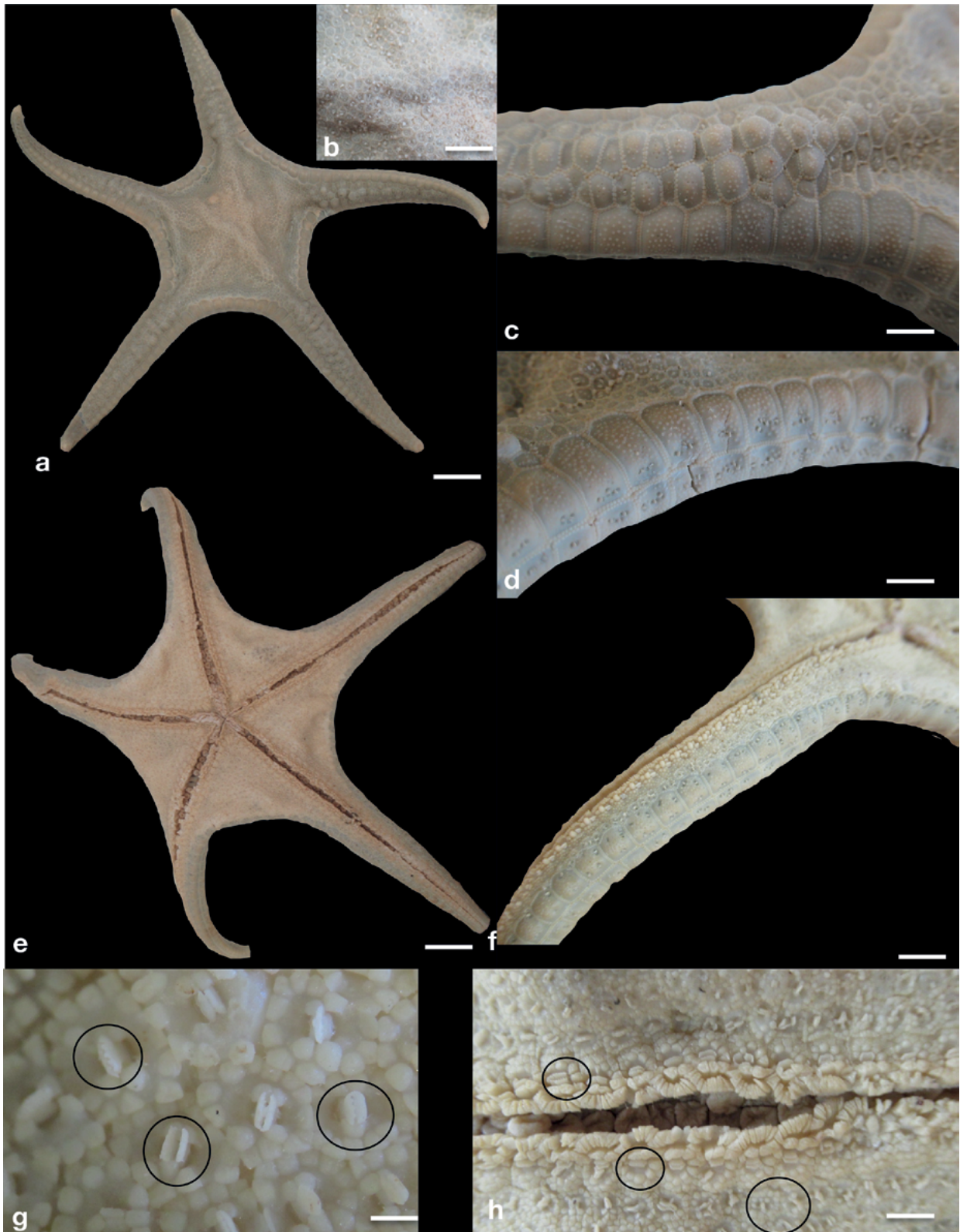


Figure 6. *Circeaster dux* n. sp. WAM Z110163: a, abactinal surface; b, abactinal surface detail; c, abactinal arm surface, detail; d, lateral view showing marginal plate surfaces; e, actinal surface; f, actinal surface showing inferomarginal plates and furrow spines; g, actinal pedicellariae (circled); h, furrow spines, adambulacral spination, pedicellariae (circled). Scale: a, e=20.0 mm, b, c, d=5.0 mm, f=10.0 mm, g=1.0 mm, h=3.0 mm.

Abactinal surface mostly flat on disk, many strongly convex plates on arms. Plates on arms gradually transition to larger and differing from those on disk. Disk plates round to polygonal in shape, each with 1–30 widely separated, coarse, deciduous granules. Plates on disk with many granules and pedicellariae. Pedicellariae paddle-shaped, valves thin, each with 7–10 teeth, present on approximately 40% of plates, with greatest occurrence proximally, especially along papular and other proximal regions. Interradial regions, adjacent to superomarginal contact with plates smaller bearing fewer (1–3) granules, and no pedicellariae. Abactinal arm plates at base wider and larger, 1–3 times the width of proximal disk plates. Disk plates adjacent to the arms similar in size to basal arm plates. Carinal and adradials along arm acutely convex with greater numbers of granules, each bearing up to 25 at arm midpoint. Granules begin to disappear 8–10 superomarginals away from arm tip. Plates flat, surfaces bare and smooth. Abactinal plates along arm decrease at this point from three or four at arm base to a single series adjacent to arm tip. Distalmost superomarginal plates abutted approximately three superomarginals from arm tip. Madreporite hexagonal, convex, rising above body surface with strongly developed sulci, flanked by eight plates. Anus not evident.

Marginal plates, approximately 27–30 per arm side (full interradius 54–60, arm tip to arm tip). All marginal plates with quadrate granules, approximately 15–20 per side, 60–80 surrounding the plate periphery of each. Superomarginal and inferomarginal plates with strong 1:1 association in each interradius showing associated plates to arm tip. Lateral edge rolled, showing not just the superomarginal but the inferomarginal plate surface from dorsal view. Superomarginal plates wide, quadrate in shape, with rounded edges. Superomarginal abactinal-lateral edge round; plate in cross-section is mound-like. Superomarginal surface with 1–35 widely spaced coarse granules, mostly 20–25 on superomarginal plate surface, in addition to 1–3 clam-shell pedicellariae, identical to those on the abactinal surface. Granule and pedicellariae abundance greatest interradially, decreasing from 35 proximally to a single or absent granule or near arm tip. Inferomarginal plates with identical types of granules and pedicellariae but in greater numbers (up to 50), decreasing to none on inferomarginal adjacent to arm tip. Inferomarginal pedicellariae, 1–8, greatest number interradially. Approximately half positioned at upper end of inferomarginal plate, other half on inferomarginal plate surface adjacent to actinal plate contact. Distalmost superomarginal plates abutted, with no granules, pedicellariae on surface. Terminal plates triangular to conical in shape.

Actinal region large with six or seven full series in chevron formation, with remainder adjacent to inferomarginal plates in irregular formation. Individual plates quadrate to irregular in shape. Each actinal plate with a peripheral ring of 10–30 (mostly 20–25) widely spaced angular, quadrate granules. A large clam shell-shaped pedicellaria with multiple valves is present at the centre of nearly all actinal plates.

Furrow spines 6–8, decreasing in number proximally to distally. Spines are pointed, with jagged tips, angular to triangular in cross-section, arranged in concave arc. Subambulacral three, with jagged, broad tips, each approximately twice as thick as the adjacent furrow spine. Each

adambulacral plate has a large clam-like pedicellaria similar to those on the abactinal surface, with four jagged, well-spaced teeth on each valve. Further subambulacral spination/granules on adambulacral plate similar in shape and size to granules on actinal plate surface.

Oral plates with 10–15 furrow spines in straight series, each with jagged, denticulate tips, quadrate in cross-section, each triangular to quadrate in cross-section, similar to those on adambulacral furrow spines. Granules, 10, paired, molar-shaped, along either side of the diastema between the paired oral plates. Irregular array of flattened quadrate, angular granules present on oral plate and adjacent areas.

Material examined. Holotype. WAM Z110163 (CSIRO barcode 10055627), Site 30 Gascoyne Marine Park, 19 km W. Lakeside, Western Australia. 22.00276° S, 113.733333° E, 794 m, coll. RV *Investigator*, 8 Dec. 2022. 1 wet spec, R=13.2 r=4.3 cm.

Hippasterinae Verrill 1899

Verrill, 1899: 174; Fisher, 1906: 1165; 1910: 223; Spencer & Wright, 1966: U58; Mah et al., 2010: 270; Mah et al. 2014: 425.

Diagnosis. Pulp tissue covering plates. Abactinal plates with spiny-granular or angular accessory fringe. Abactinal plates tightly abutted. Superomarginal and inferomarginal plates, variably round to quadrate with large, prominent spines or tubercles in most taxa. Pedicellariae enlarged, abundant, and on raised base. Disk thick and strongly arched in most.

Included Genera. *Evoplosoma* Fisher 1906, *Gilbertaster* Fisher 1906, *Hippasteria* Gray 1840, *Sthenaster* Mah 2010

Comments. The Hippasterinae includes, at present, 26 species in four genera, nearly all of which occur in relatively deep-sea (>200 m) settings. Although *Sthenaster* is known only from the Atlantic, the remaining genera are widely known throughout the Pacific, Atlantic and Indian Oceans. The Hippasterinae is monophyletic and has been supported from morphology (Mah et al., 2010) and molecules (Mah & Foltz, 2011a; Mah et al., 2014). A key to genera is presented in Mah et al. (2014). Various taxa show morphological affinities with other Goniasteridae, such as *Calliaster* and *Atheraster*, with which they might also share ecological/predatory affinities, suggesting that the groupings to which these other genera belong (i.e. the “*Calliaster*” and “*Circeaster*” groups) are related.

Two hippasterines, *H. phrygiana* (formerly *H. trojana*) and *Evoplosoma tasmanica*, have been recorded from Australian waters (Rowe and Gates, 1995; Mah, 2015b). Specimens described herein significantly increase the known hippasterine diversity in Australian waters.

Evoplosoma Fisher 1906

Fisher, 1906: 1065; Koehler, 1909: 96; Spencer & Wright, 1966: U58; Clark & Downey, 1992: 241; A.M. Clark, 1993: 253; Mah et al., 2010: 278; Mah, 2015b: 2; 2022: 42

Diagnosis (from Mah, 2015b). Body strongly stellate. Arm narrow, elongated. R/r 2.3–4.11 (most 3.0–4.0). Interradial arcs straight to weakly curved. Abactinal plates, flat and platform-

like. Carinal series poorly distinguished. Abactinal plates tightly articulated. Body covered by tissue layer with thick, rough texture that overlies plates and spines (seen more clearly in wet specimens). Prominent spines on abactinal, superomarginal, inferomarginal and actinal plates in most species. Spine morphology variable from blunt conical to pointed, to cylindrical or small and spinelet-like. Granules with spiny tips in most species, with some having rounded surfaces. Granules present but with variable abundance among species. Tong-like pedicellariae with serrated valves present or absent on abactinal, marginal or actinal surfaces. Marginal plates generally quadrate in shape, some showing direct 1:1 superomarginal/inferomarginal correspondence, but others being more offset. Marginals relatively numerous, 30–70 per interradius. Some species with bare marginal plate surface, but most with even to dense granule covering. Granules vary from having rounded surfaces to pointed or prismatic edges. Large prominent spine or spines known in all but one species. Large single spines observed as a linear series in several species. Spinelets or multiple shorter spines observed on marginal plate surfaces of other species. Pedicellariae variably present on either supero or inferomarginal series. Actinal intermediate regions relatively small with fewer than six rows present (three or four present in most species). Actinal plate boundaries obscured by pulpy tissue layer and/or granulation. Granules round or with spiny edges on all species. Primary spines on actinal plate surface in most species. Furrow spines varying in number from 2 to 12. Spines generally compressed, quadrate to polygonal in cross-section. Tips varying from smooth and blunt to jagged with furrowed tips. Felipedal (clamp-like bivalve) pedicellariae present among the subambulacra in most species. Subambulacra variable, with spination ranging from blunt spines, pointed spinelets to pointed or rounded granules.

Based on *in situ* observations herein and from prior accounts (e.g. Mah et al., 2010), the color of most species ranges from yellow to deep orange.

Comments. *Evoplosoma* includes 11 species known from lower bathyal to abyssal settings (1000–3000 m) primarily in the Atlantic and the Pacific, with a single species, *Evoplosoma augusti* Koehler 1909, known from the Indian Ocean. Mah (2015b) provided an overview and key to known *Evoplosoma* species. Most species have been recorded from relatively few specimens, in many cases only from the holotype (e.g. Mah et al., 2010, Mah, 2015). As remotely operated video investigation has become increasingly common and deep-sea coral habitats are explored, *Evoplosoma* and/or related hippasterines, such as *Hippasteria*, are now observed with increasing frequency (e.g. Mah, 2015, 2022) and *in situ* density and abundance recorded.

Evoplosoma shows morphological affinities, such as prominent spines on abactinal and marginal plates as well as granule-covered abactinal plates, with other newly described goniasterid genera, such as *Atheraster*. *Atheraster* in turn, shares characters such as the presence of enlarged abactinal arm plates relative to disk plates, with *Circeaster*.

Prior to the four species reported herein, only *E. tasmanica* (McKnight, 2006), from Tasmanian waters, was known from the South Pacific adjacent to Australia and New Zealand.

Key to *Evoplosoma* in Australian and adjacent waters

- (0) Fleшы dermis invested with granules, abactinal spines present or absent. Granules absent from marginal plate surface. (1)
- (1) No spines on abactinal surface. Furrow spines 4–6.
..... *Evoplosoma voratus* Mah
- (1') Abactinal surface invested with conical spines. Furrow spines nine to ten. *Evoplosoma pharos* n. sp.
- (0') Dermis not fleshy or soft, surface covered by coarse, granules and distinct, or conical abactinal spines. Granules present on marginal plate surface. (2)
- (2) Furrow spines 5–8. Spines, large, widely spaced, thick, conical with pointed or blunt tips present on abactinal and marginal surface. *Evoplosoma timorensis* Aziz and Jangoux 1985a
- (2') Furrow spines four or fewer. Abactinal spination present, but spines short, bullet-like, weakly expressed or absent. ... (3)
- (3) Abactinal surface with no primary spines, covered by plates with pointed to coarse-sized granules, widely spaced. *Evoplosoma tasmanica* McKnight 2006
- (3') Short, conical spines covering abactinal surface. Coarse granules forming continuous covering on abactinal, marginal and actinal surface. (4)
- (4) Superomarginal plates each with a single prominent, conical spine in series along the arm, although two or three are present on interrarial plates. Granules angular with convex to pointed tips, cover abactinal, marginal, actinal surface. *Evoplosoma mystrion* n. sp.
- (4') Interrarial plates with three prominent spines decreasing to two then a single spine with none on distalmost marginal plates. Granules coarse, blunt tipped and blocky, forming continuous cover over abactinal, marginal, actinal surface. *Evoplosoma besseyae* n. sp.

Evoplosoma besseyae n. sp.

urn:lsid:zoobank.org:act:32A34022-126F-4EAE-867D-3D981C46D136

Figure 7a–g

Etymology. This species is named for Dr Cindy Bessey, benthic ecologist at CSIRO, in honour of her contributions to our understanding of Australian marine ecology.

Diagnosis. Body shape stellate ($R/r=3.19$), arms elongate, disk distinctly pentagonal, interrarial arcs weakly curved to straight. Abactinal plate surface covered by blocky granules. Prominent cone shaped spines and tubercles present on radial regions proximally on disk and arms. Marginal plates 50–52, lateral facing. Interrarial plates with 3–5 prominent spines decreasing to two then a single spine, with none on distalmost marginal plates. Marginal plate surface covered by low, round granules, polygonal in shape. Actinal plate surface covered by



Figure 7. *Evoplosoma besseyae* n. sp. holotype NMV F122735: a, abactinal surface; b, abactinal surface detail; c, abactinal surface and lateral view showing marginal plate surfaces; d, actinal surface; e, actinal surface detail; f, actinal surface showing pedicellariae (circled); g, furrow spines, actinal surface. Scale: a, d=10.0 mm; b, e=3.0 mm; c, f=5.0 mm; g=1.0 mm.

similar granules, prominent conical spines and keyhole-shaped pedicellariae, valves lacking teeth. Furrow spines 2–4 (mostly four). Prominent elongate, paddle-shaped pedicellariae, each valve with 4–6 teeth.

Comments. This species is similar to *E. tasmanica* (McKnight 2006) in number of marginal plates per interradius, spines on both marginal plate series, and a covering of granules that extends over the abactinal, marginal and actinal plate surfaces. Although furrow spine number differs, it is similar—three to four (mostly four) versus 2–4 (mostly three) in *E. tasmanica*. *Evoplosoma besseyae* differs in the possession of well-developed abactinal conical spines, numerous interradial spines on the superomarginal and inferomarginal plates, larger, more abundant granules on abactinal, marginal and actinal surfaces, more elongate arms, four rather than three furrow spines, and actinal pedicellariae with differing morphology than those in *E. tasmanica*.

Polynoid associations? Based on collection notes, three commensal polynoid polychaetes were found in association with this specimen. In situ videos show deep-sea polynoid worms in association with Atlantic goniasterids such as *Ceramaster* and *Nymphaster* (Mah, 2020). Polynoids were also observed in association with *Hippasteria* during the CAPSTONE expedition and by the R/V *Nautilus* (Mah, unpublished data) in the tropical North Pacific, appearing to reside on the animal's surface among the spines on the abactinal and marginal spines.

The precise relationship of the worms with NMV F122735 is unclear. Three polynoid specimen lots were collected from this station, including NMV F133659, NMV F133867, NMV F155868. NMV F133659 is a specimen of an apparently undescribed species of *Brychionoe* (Polynoidae), which is known currently from a single species, *Brychionoe karenae* Hanley & Burke 1991, which was described from 1100 m off the east coast of Tasmania as a commensal on the antipatharian *Leiopathes* (R. Wilson, Museums Victoria, pers. comm.). Because the species is undescribed, it is unclear which host, if any, this worm lived with in association.

The remaining two specimens, NMV F133867 and NMV F155868, were identified as a species in *Macellicephalo*, which includes approximately 26 species (R. Wilson, Museums Victoria, pers. comm.). Relationships with asteroids are apparently unknown.

Occurrence. South of Tasmania, 1100–1273 m.

Description. Body strongly stellate ($R/r=3.19$), arms elongate, gradually tapering triangular with pointed arm tips. Interradial arcs weakly curved to straight.

Abactinal plates irregular to polygonal, abutted, infused in tissue, extending from disk to terminal plate. Surface completely covered by abundant blocky granules, polygonal to irregular in shape, in clusters of 1–5, with each cluster distinctly spaced from others, forming a distinct layer over the abactinal surface. Granular density more abundant adjacent to contact with superomarginal plates. Conical blunt tubercular spines present throughout the abactinal surface, especially along disk and radial regions, with few to none interradially.

Each spine is flanked by 8–12 surface granules. Papulae elongate and tentacular, present only on disk and along radial regions. Spines most abundant on disk, proximally on arms, becoming fewer and then absent distally on arm adjacent to terminus. Madreporite round, oval to polygonal in shape, flanked by six plates. Pedicellariae absent.

Marginal plates, 50–52 per interradius (arm tip to arm tip), individually quadrate in shape, with rounded edges. Interradial marginal plates with distinct lateral facing becoming more dorsal facing along arms. Superomarginal and inferomarginal plate contact with more interradially, becoming more offset distally. Superomarginal series both with prominent spines, three to four (mostly three) distinct pointed cone-shaped spines on interradial plates, sitting on a raised base, and proximally along arms, decreasing to two and then a single distinct single conical spine distalmost along arms. Inferomarginal plates with four or five shorter but similar conical spines, with irregular round tubercles, then similarly decreasing to fewer or smaller spines distally. Marginal plate surface covered by granules, hemispherical, evenly spaced over plate surface interradially. Granules, coarse, 40–60, arranged around edge in peripheral series, then on surface around spines, 20–40. Damaged marginal plates show repair, with irregular plates present between superomarginal and inferomarginal series, and granules covering irregular plate surfaces.

Actinal plates in full series, chevron-like arrangement. A full actinal series extending along arm to terminus. Granules, 10–15 per plate, round, smooth, widely spaced, covering plate surface. Prominent tubercles and/or conical spines present on nearly every actinal plate, with smaller spines or tubercles present on actinal plates adjacent to the inferomarginal series. Pedicellariae keyhole/paddle-shaped with round edges, no teeth, present on approximately 50% of actinal plates.

Furrow spines, three or four (mostly four), unwebbed, round in cross-section, variably flattened, with blunt tips in straight to weakly palmate series. Adambulacral plate with prominent subambulacral spine, round in cross-section, approximately 2–3 times as thick as each furrow spine, set off from furrow spines by a distinct diastema. Proximally on adambulacral plate is a distinct paddle-like pedicellaria, similar in size to the subambulacral spine, with six teeth on each valve. A third, smaller subambulacral spine variably present adjacent or distal to the subambulacral spine and pedicellariae. Remainder of subambulacral plate surface with flat, rounded granules identical to those on actinal surface.

Oral plates with 10–11 flattened furrow spines with a single spine from each half projecting into mouth. Individual round, smooth granules, 8–10, present on either side of the diastema of the oral plates. Granules, 5–10, similar to those on the actinal surface, cover oral plate surfaces.

Material examined. **Holotype.** NMV F122735 41 km NE of Cape Tourville. 41.909° S, 148.752° E, 1273–1190 m. 1 wet spec, $R=11.5$, $r=3.6$.

Paratype. NMV F159243° S of Tasmania, Hill U Site, Southern Ocean. 44.3257° S, 147.175° E, 1100–1160 m. Coll. T. O'Hara & T. Costa 2 April 2007, R/V *Southern Surveyor*. 1 wet spec, $R=8.2$, $r=2.4$.

***Evoplosoma mystrion* n. sp.**

urn:lsid:zoobank.org:act:927B5868-A059-4A3B-839E-CA30F6C2E4EA

Figure 8a–f

Etymology. The specific epithet *mystrion* is derived from the Greek for “spoon”, alluding to the shape of the pedicellariae on the actinal surface.

Diagnosis. Body stellate ($R/r=3.48$), arms elongate, interradial arcs acute. Pedicellariae absent from abactinal, marginal surfaces. Granules with round to spinose tips, forming continuous cover over abactinal, marginal and actinal plate surface. Superomarginal and inferomarginal series each with a single prominent, conical spine present in series along arm, although two or three per plate in each interradius. Pedicellariae present on actinal surface, paddle or spoon-shaped, numbering 2–10 on plates adjacent to the adambulacral groove and on the adambulacral plates adjacent to the subambulacral spine. None known on abactinal or marginal surface. Furrow spines, two or three (mostly three), thick, blunt. Subambulacral one, thick, approximately twice the thickness of a furrow spine. Pedicellariae with rectangular valves on most adambulacral plates adjacent to subambulacral spine.

Comments. A hippasterine species placed within *Evoplosoma* based on the presence of spatulate pedicellariae, complete spinose granulate covering of the body surface, especially over the marginal plates, the prominent abactinal, marginal and actinal spines, and the overall stellate body shape.

This species shares several characters with *E. besseyae*, including the continuous coarse, granular cover present on abactinal, marginal and actinal surfaces as well as similar numbers of furrow and subambulacral spines. This species is most similar to the Atlantic *Evoplosoma watlingi* Mah 2015, *Evoplosoma scorpio* Downey 1981, and *Evoplosoma virgo* Downey 1982, which all display a continuous cover of pointed granules or spinelets over the entire body surface, including the marginal plates. *Evoplosoma virgo* lacks any large spines on the abactinal or marginal plates. *Evoplosoma scorpio* differs in having a greater number of furrow spines (8–10), and in displaying interradial marginal plates with a single large spine in addition to smaller subsidiary spines (4–8), in association with the large primary one. In *E. mystrion* n. sp. furrow spines are fewer (two or three) and larger, and consistently large conical spines are present in each interradius. Abactinal spination in *E. scorpio* also displays more irregularly distributed, widely occurring abactinal spination versus *E. mystrion* n. sp., which is present as a singular carinal series with adjacent ordered radial spine series. *Evoplosoma watlingi* has a widespread and evenly spaced distribution of conical spines on the abactinal surface, five or six furrow spines and two subambulacral spines per plate, in contrast to *E. mystrion*, with only two or three furrow spines, a single subambulacral spine, and an incomplete distribution of pointed spines on the abactinal surface.

Occurrence. Tasmanian Seamounts, 915–1182 m.

Description. Body stout, stellate ($R/r=3.48$) in shape. Arms triangular, elongate, gradually tapering. Interradial arcs acute.

Abactinal, marginal and actinal surface covered by granule-invested integument. Individual granules, round to irregularly polygonal, evenly spaced. Abactinal surface mostly obscured by integument, plates concealed. Prominent conical spines abundant except interradially, especially adjacent to superomarginal contact. Large round tubercles present proximally and on central disk region. Angular granules covered with more strongly developed tissue, differing from round granules present elsewhere and on central disk, covered by a thin translucent mucus. No pedicellariae observed. Madreporite weakly inset on abactinal plates, convex. Sulci well developed.

Marginal plates quadrate, surfaces flush with abactinal and actinal plate surfaces. Approximately 24–26 plates per arm side, 48–52 per interradius, arm tip to arm tip. Each plate with roughly equal dimensions ($L=W$), surface covered by granules, round to pointed, smooth, evenly spaced, 50–200 (mostly 70–100) per plate surface. Granular layer appears continuous with those on abactinal and actinal surface, such that they incompletely obscure contact between marginal, abactinal and actinal plates. Superomarginal plates each with a single prominent, conical spine along the upper plate surface adjacent to abactinal plate contact, rising well above the plate surface and taller than those on the abactinal plates. Spine base lacking granules. Inferomarginal plates have 2–6 similar, prominent, conical spines, interradially decreasing to a single spine along arms. Interradial spines approximately 10% shorter than those on arms, clustered on plate centre rather than upper edge. Variably, some distalmost inferomarginal plates lack spines. Shallow grooves present between superomarginal and inferomarginal plates. No pedicellariae observed.

Actinal surface covered by 7–15 (mostly 8–10) irregularly polygonal granules encased in a translucent, very thin skin or mucus. Abactinal plates polygonal to quadrate, present in 3–5 series, of which only one or two extend completely onto the arms. Granules abundant and continuous, plate boundaries weakly defined. Pedicellariae, paddle-shaped, alveolar, present only on 2–10 proximal actinal plates adjacent to adambulacral plates along each tube foot groove, 4–20 per interradius.

Furrow spines, two or three, blunt tipped, but round to oblong in cross-section. Single subambulacral spine, approximately twice as thick as a single furrow spine. Proximal on the plate, a large single tong-like pedicellariae with rectangular valves. Remainder of adambulacral plate surface adorned with 4–7 pointed to blunt, irregularly polygonal granules, with a single large tubercular granule adjacent to the subambulacral spines.

Oral plate furrow spines 10, thin to triangular in cross-section, with a single, enlarged spine projecting into the mouth with a tip rounded, tong shaped. Oral plate surface with large blunt subambulacral spines corresponding to the furrow spines, similar in appearance to those on other adambulacral plates. Oral plate surface with 4–6 (mostly five) polygonal granules, quadrate in cross-section on either side edge of the diastema between oral plates in each interradius. Polygonal granules, low, blunt, 2–4 on remainder of oral plate surface. Thin, membranous skin similar to those elsewhere covering oral plates.



Figure 8. *Evoplosoma mystrion* n. sp. NMV F307999: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces; d, actinal surface; e, actinal surface detail including pedicellariae (circled), furrow spines; f, adambulacral spination, furrow spines, details. Scale: a, d=15.0 mm; b, c, e=5.0 mm; f=3.0 mm.

Material examined. Holotype. NMV F307999 Pedra southern flank, Tasmanian seamounts, Tasmania, Australia. 44.2678° S, 147.109° E, 915–1182 m. Coll. A. Williams, A.A. Weber, R-L Erickson, 25 Nov. 2018. 1 wet spec, R=115.0, r=33 mm.

***Evoplosoma pharos* n. sp.**

urn:lsid:zoobank.org:act:4D9D9E7C-E98B-45D0-8493-FCCBDA6617C6

Figure 9a–f

Etymology. The species epithet, *pharos*, is Greek for “mantle” or “shroud”, alluding to the fleshy granule-invested dermis.

Diagnosis. Body stellate (R/r=3.9) with arms elongate and tips pointed. Disk pentagonal with arms distinct, interradial arcs weakly angular to straight. Abactinal and actinal surfaces covered by granule-invested dermis. Granules round to irregularly polygonal in shape. Surface with blunt tubercles and weakly pointed conical spines. Marginal plates 50–52, individual plate surface smooth and bare with no granular cover. Single central spine or arched mount present on most plates. Furrow spines mostly 9–10, each round and blunt, quadrate in cross-section. Subambulacral pedicellariae and spine present, but specimen damage did not permit characterisation.

Comments. This species shows distinct similarities with the North Pacific *Evoplosoma claguei* Mah et al. 2010, including the granule-invested fleshy dermis, the presence of short conical spines on the abactinal surface, granules absent from the marginal plate surface, and one or two blunt single spines on each marginal plate. Many of the superomarginal and inferomarginal plates along the arm have only a prominent arched projection where the spine would be on other plates, suggesting that these were damaged and are recovering.

This species is distinguished by the greater number of furrow spines, nine or ten versus 4–6 in *E. claguei*, the single spines present on the interradial marginal plates versus the multiple spines in *E. claguei*, and the shape of the interradial marginal plate series is also different (wide in *E. pharos* n. sp. but more square in *E. claguei*).

Occurrence. Off New South Wales, Australia. 2595–2474 m.

Description. Body stellate (R/r=3.93), arms narrow, elongate with tips pointed. Interradial arcs weakly angular to straight.

Abactinal surface arched, forming sunken region adjacent to contact with superomarginals (disk membrane may have deflated). Abactinal plates concealed by a granule-invested dermis. Abactinal plates extend from disk along arms where plate number decreases to 3–5 rows, then to a single row extending to terminus. Surface covered by small, round to irregularly shaped granules, evenly but widely distributed. Moderately large, hemispherical tubercles to short conical spines present uniformly on abactinal surface (specimen lacking many of these, presumably lost during collection). Arm plates with larger, more distinct, conical spines, one per plate. Madreporite convex, polygonal, flanked by approximately six plates. Sulci well developed. No pedicellariae.

Marginal plates 50–54, 52 in each interradius (arm tip to arm tip), with plates interradially and arm plates displaying

lateral facing with distalmost plates encroaching upon abactinal surface adjacent to terminus, number of plates decreasing along arm. Marginal plates wide with rounded lateral edge, overall shape quadrate. Marginal plate surface tumid, becoming more so distally. Both superomarginal and inferomarginal plates with a single, prominent spine with a blunt tip. Distally, adjacent to the terminus, spines absent from superomarginal and inferomarginal plate surface. Most marginal plate surfaces lacking accessories (granules, spinelets, etc.). Interradial superomarginal and inferomarginal plates with 3–30 small granules and 1–3 tubercles, variably present on different plates. Marginal plates granulate, evenly spaced, approximately 40, 10 per side, but with some directly interradial plates granules are numerous at contact between superomarginal and inferomarginal plates. No pedicellariae.

Actinal plates in approximately three full series; none extends along arm. Individual plates quadrate to polygonal, with same granule-invested dermis as on abactinal surface. Granules round to polygonal, covering plates completely, such that boundaries are invisible. Tubercles or spines present at approximately one per plate; spines present suggest short, pointed spines, but damage prevents clear assessment. Alveolar pits present, indicating pedicellariae, but damage has left no pedicellariae to characterise.

Furrow spines mostly 9–10, some with as few as six. Each spine with round, blunt tip, quadrate in cross-section. Large alveolar pit suggests the presence of a pedicellaria adjacent to the furrow spines, but these were absent. Broken spine base suggests a prominent subambulacral spine was also present distally on the subambulacral plate. Remainder of subambulacral plate covered by round granules, approximately two irregular rows, each with 4–7 granules. Oral plates with 11–12 furrow spines, with a single prominent spine from each plate projecting into mouth (two per interradius); blunt, flattened, quadrate in cross-section. Oral plate surface covered with 8–10 irregular, angular granules on either edge of the diastema present between the oral plates.

Material examined. Holotype. NMV F241878, New South Wales, Hunter CMR 32.575° S, 153.162° E, 2595–2474 m. Coll. T. O'Hara et al. RV *Investigator*, IN2017 V03 abyss, 3 June 2017. 1 wet spec, R=11.8, r=3.0.

***Evoplosoma timorensis* Aziz & Jangoux 1985a**

Figure 10a–f

Aziz & Jangoux, 1985a: 263, Clark, 1993: 253; Mah, 2015b: 7.

Diagnosis. Body shape strongly stellate (R/r=3.5–4.0), arms elongate, interradial arcs rounded. Abactinal, marginal and actinal plate surfaces covered by thickened dermis invested with granules. Abactinal surface bearing spines, large, variably blunt tipped to conical. Superomarginal plates mostly with one or two conical spines, inferomarginals with four or five shorter, variable spines; all spines with rough tips in addition to smaller secondary spines. Actinal surface covered by granule-invested dermis, 1–3 thorny spinelets. Furrow spines, 5–8, in angular arrangement, blunt tipped. quadrate in cross-section.

Comments. The specimen figured here and the specimen from the Solomons differ from the Wallis and Futuna specimen



Figure 9. *Evoplosoma pharos* n. sp. holotype NMV F241878: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces; d, interradiar marginal plate surface; e, actinal surface, pedicellariae circled; f, furrow spines and adjacent spination. Scale: a, e=10.0 mm; b, c, d, f=5.0 mm.

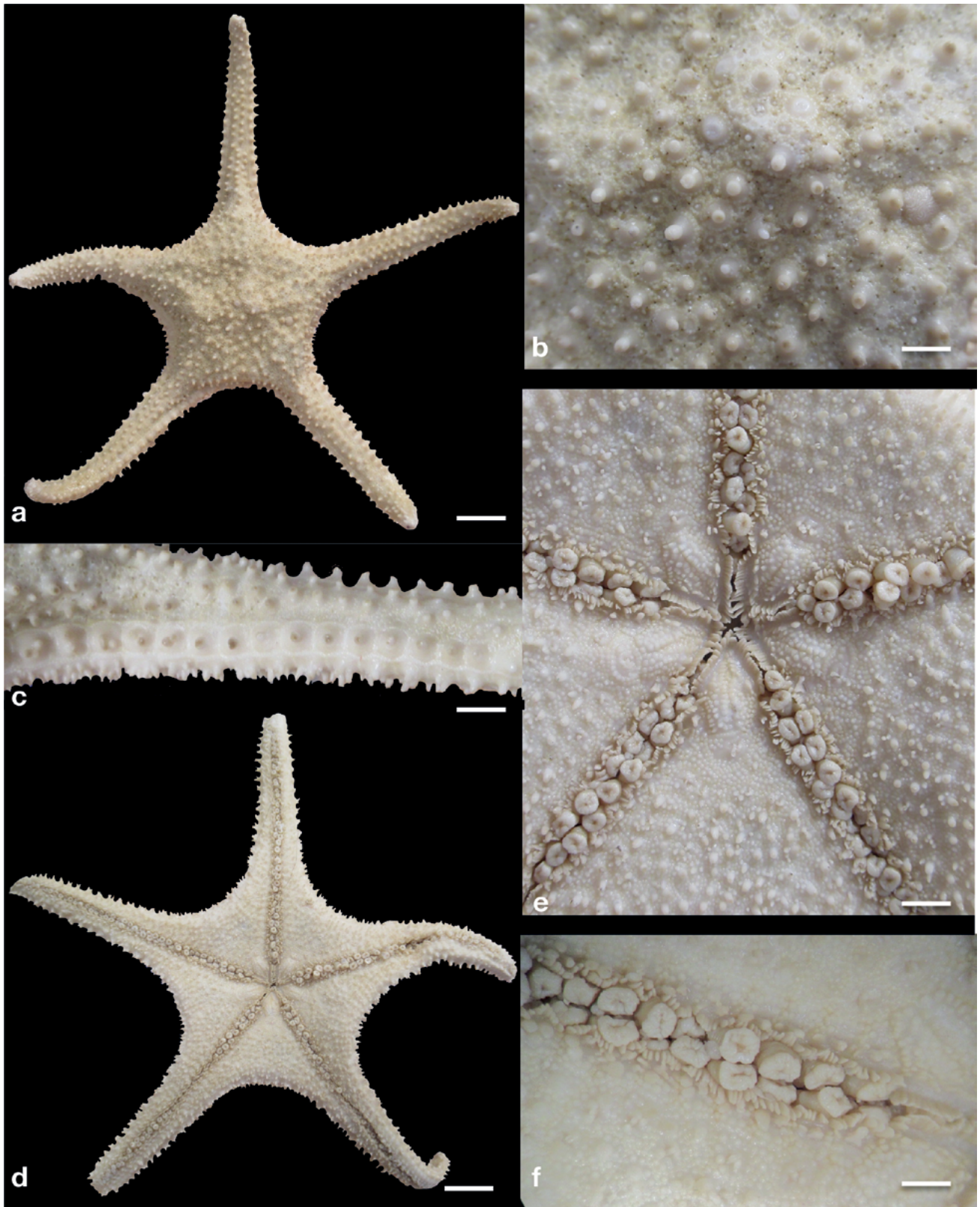


Figure 10. *Evoplosoma timorensis* NMV F307986: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces, spination; d, actinal surface; e, actinal surface detail; f, adambulacral spines, furrow spines, pedicellariae. Scale: a, d=15.0 mm; b, c, e, f=5.0 mm.

(latter two specimens from Mah, 2015b) in displaying a much more flattened radial disk region. Observations of in situ *Evoplosoma* specimens (Mah, pers. obs.) suggest that when alive, the disk is strongly arched or expanded, perhaps with seawater, during feeding. This more curved or arch body wall is explained as likely variation resulting from this behaviour. Abactinal spines on NMV F307986 appears much less abundant than on the Wallis and Futuna specimen and more similar to the specimen from the Solomons. NMV F307986, at R=9.5 cm, shows fewer and much smaller and narrower actinal spines than Aziz & Jangoux's (1985a) holotype specimen, which has numerous, thickened and much larger actinal spines at R=9.0 cm.

Occurrence. Outside Australia. Solomon Islands, Wallis and Futuna Islands, Tahiti/Tuamotu, Papua New Guinea, East Timor Region and Celebes Sea, Indonesia. 795–1279 m.

Australian Range Extension. Cocos Keeling Islands, 932–965 m.

Material examined. NMV F307986 Muirfield Seamount, Indian Ocean Territories, Cocos (Keeling) Islands. 13.242° S, 96.2919° E, 932–965 m. Coll. T. O'Hara et al. IN2022 V08 IOT 2, 21 Oct 2022. 1 wet spec, R=9.5, r=2.7.

***Evoplosoma voratus* Mah et al. 2010**

Figure 11a–b, 12a–b

Mah et al., 2010: 279.

Diagnosis. Body stellate (R/r=2.0–3.11), arms, elongate, slender. Interradial arcs weakly curved. Abactinal spines (conical and pointed) absent, although conical tubercles (short and rounded) present on a minority of plates. A thick, pulpy dermis on the abactinal surface, invested with granules. Paddle-shaped pedicellariae present, but on a minority of plates. Marginal plates bare with a single conical spine, mostly on proximal plates with 4–6 short spinelets, spines attenuating distally. Superomarginals, approximately 44–45 per interradius (arm tip to arm tip). Actinal intermediate region relatively small with only 2–4 full chevron series, limited to disk, few to no actinal plates on arms. Surface covered by granules, distalmost plates with short, conical spines. Furrow spines, 6 or 7 (as few as four in the holotype), roughly comparable to two or three furrow spines in thickness, with a single large subambulacral spine and a single pedicellaria, paddle-like, large, comparable in size to the subambulacral spine.

Comments. There are nearly no morphological differences between the holotype and WAM Z100665, although the distance between collection localities is over 14,000 km (Davidson Seamount off the coast of California versus Ningaloo Canyons, off the northwest coast of Western Australia).

Ecological comments. In situ observations of this individual prior to its collection show it adjacent to a solitary colony of an untouched “bamboo coral” (family Isididae), known to be a primary prey item for other observed species in *Evoplosoma* (Fig. 12 a–b). In other observed instances from the tropical North Pacific, predation by *Evoplosoma* results in the removal of tissue from the stalk.

Occurrence. Davidson Seamount, North Pacific, 2670 m.

Ningaloo Canyons, Western Australia, 2913.5 m.

Material examined. WAM Z 100665 Ningaloo, Western Australia. 21.9016° S, 112.904° E, 2913.5 m. Coll. Wilson N, Rouse, G., Kirkendale, L., Ritchie, J. aboard RV *Falkor*, 17 March 2020. 1 wet spec, R=6.8, r=2.3.

***Gilbertaster* Fisher 1906**

Fisher, 1906: 1062; McKnight, 1973: 192; Mah, 1998: 66; H.E.S. Clark and McKnight, 2001: 49; Mah et al., 2010: 270

Diagnosis. Arms triangular, narrow and tapering. Disk weakly swollen. Thick and pulpy tissue covering abactinal, marginal and actinal plates. Abactinal plates low, polygonal, covered by 1–12 closely articulated angular granules elongate to round in shape, flattened, surface texture smooth to rough. Fasciolar grooves shallow. Secondary plates present. Abactinal plates with angular accessories. Pedicellariae large, bivalved with smooth valves, the length of one to two plates and abundant on abactinal surface. Marginal plates, 50–70 per interradius (arm tip to arm tip), squarish in outline with edges rounded, covered by angular granules similar to those on abactinal surface. Variable surfaces smooth (on *Gilbertaster anacanthus*) to roughened (on *Gilbertaster caribaea*). Pedicellariae large, bivalve similar to those on abactinal surface on marginal plate surface, many bisecting the width of the plate. Spines absent from superomarginal and inferomarginal plate series. Granules, densely arranged, covering superomarginal and inferomarginal plate series. Superomarginal and inferomarginal plates quadrate at interradius. Fasciolar grooves on marginal and actinal surfaces absent. Fringe of accessories on marginal plates poorly differentiated. Superomarginal plates forming prominent dorsolateral fringe. Actinal plates covered by 1–15 flattened, polygonal, angular granules. Large bivalve pedicellariae similar to those on abactinal and marginal plate surfaces, abundant on actinal plates. Actinal plates with granules but lacking large spines or spinelets. Pedicellariae, bivalved, present on plate series at perpendicular angle, adjacent to ambulacral furrow. Pedicellariae, flat-tong shaped, with serrated blades present on actinal plates. Pedicellariae on raised bases, abundant. Furrow spines two to four (usually three) blunt, thickened spines, horizontally flattened (*G. anacanthus*) to triangular/quadrate in cross-section (*G. caribaea*). Subambulacral spines, 1–4, blunt, flattened. Round to quadrate (*G. anacanthus*) to triangular in cross-section (*G. caribaea*). Pedicellariae, bivalved, enlarged on first adambulacral (similar to others) replacing subambulacral spination and sometimes replacing furrow spination. Subambulacral spines smaller in size, more abundant. Furrow spines round in cross-section.

Comments. *Gilbertaster* was placed within the Hippasterinae by Mah et al. (2010) and includes two species, the Indo-Pacific *G. anacanthus* and the tropical Atlantic *G. caribaea*. Mah (2020) reported on four observations of *G. caribaea* feeding on primnoid octocorals, identified as *Plumarella* sp., consistent with the predatory habits observed in other members of the Hippasterinae.



Figure 11. *Evoplosoma voratus* WAM Z100665: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces; d, actinal surface; e, actinal surface detail including pedicellariae, furrow spines. Original photos by Oscar Gomez, WAM. Scale: a, d=10.0 mm; b, e=5.0 mm; c=3.0 mm

***Gilbertaster anacanthus* Fisher 1906**

Figures 12c-d, 13a-g

Gilbertaster anacanthus Fisher, 1906: 1063; A.M. Clark, 1993: 223; H.E.S. Clark & McKnight, 2001: 49; Mah et al., 2010: 272; Atkinson & Sink, 2018: 417.

Gilbertaster brodie McKnight, 1973: 192; A.M. Clark, 1993: 223.

Diagnosis. Body stellate, $R/r=2.26-3.0$, disk thick, arms triangular, interradial weakly curved to straight. Abactinal surface covered by abactinal plates, round to polygonal, each covered by coarse polygonal granules, 1-11 rounded centrally, peripheral granules quadrate, 4-12, surface additionally covered by large bivalve pedicellariae, such that they bisect the plates on

which they sit. Marginal plates covered by coarse, smooth polygonal granules identical to those on abactinal and actinal surfaces. Actinal surface adjacent to the adambulacral plates, with prominent bivalve pedicellariae similar in size to the adambulacral plate width. Furrow spines three, subambulacral spines polygonal to angular, 3-6, irregular but uniform in size.

Comments. This represents the first occurrence of this species from the Tasman Sea and Wanganella Bank, the region between Australia and New Zealand. This record is also from significantly deeper (1195-1200 m) than had been previously recorded (277-868 m).

Compared to the holotype of this species from the Hawaiian Islands region, this specimen shows much broader arms and is



Figure 12. *In situ* observations: a-b, *Evoplosoma voratus*, WAM Z100665; c-d, *Gilbertaster anacanthus* (no specimen).

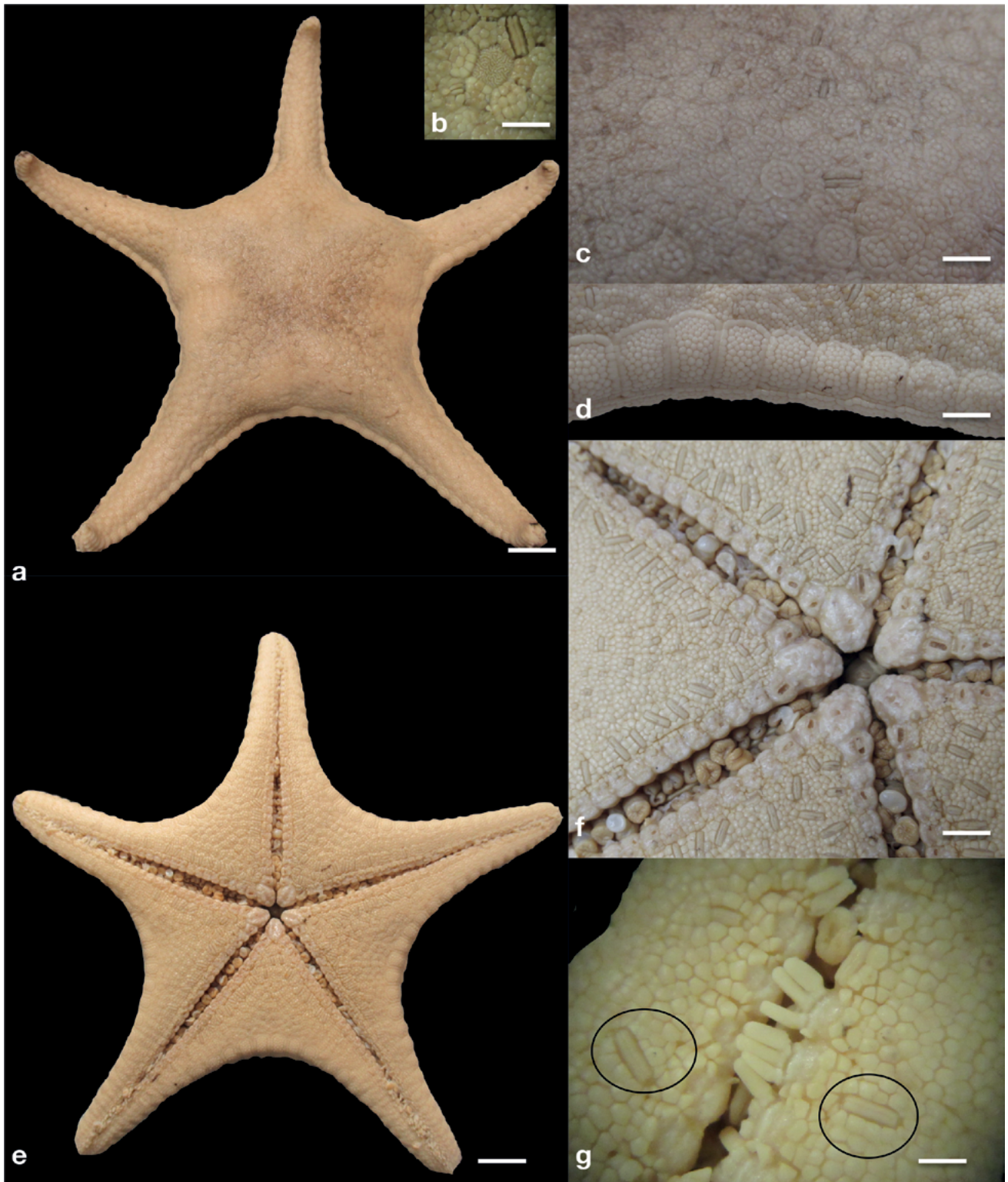


Figure 13. *Gilbertaster ancanthus* NMV F240690: a, abactinal surface; b, abactinal plates, madreporite, pedicellariae; c, abactinal surface, detail; d, lateral view showing marginal plate surfaces; e, actinal surface; f, actinal surface detail including pedicellariae, furrow spines; g, adambulacral spination including furrow spines, pedicellariae (circled). Scale: a, e=15.0 mm; b=2.0 mm; c=3.0 mm; d, f=5.0 mm; g=2.0 mm.

much less stellate ($R/r=2.26$ versus 3.0 in the holotype). Abactinal granules on the holotype are elongate and irregular in shape in contrast to those on this specimen, which are more polygonal to round in shape. Abactinal plates on the arms also occur in many more numerous rows than in the holotype.

Ecological observation. NOAA ship *Okeanos Explorer* first observed this species *in situ* in 2017 from the Johnston Atoll region in the North Pacific. The specimen was observed on a vertical, rocky surface in close proximity to the base of a large antipatharian colony. Other hippasterines are known to feed on octocorals and other colonial cnidarians, including antipatharians (e.g., *Evoplosoma voratus* on *Trissopathes* in the North Pacific, Mah et al. [2010]). This antipatharian may have been a potential prey item.

Papule of this species, observed on the disk and the proximal regions of the arms, were yellow-brown in colour and fully extended. The remainder of the abactinal surface was a uniform light orange.

Occurrence. Range Extension: Johnston Atoll region, Norfolk Ridge (Tasman Sea), 1200–1195 m.

Hawaiian Islands, Palau, West New Zealand (east coast). South Africa. 277–868 m.

Images examined. Unnamed Guyot, Johnston Atoll region, 16.72752416° N, 169.3629705° W, 473 m.

EX1706_IMG_20170715T234926Z_ROVHD.jpg

Material examined. NMV F240690 Wanganella Bank, West Norfolk Ridge, Tasman Sea, 34.2389° S, 168.47° E, 1200–1195 m. Coll. M.F. Gomon & NORFANZ Team, R/V *Tangaroa*, 3 June 2003. 1 wet spec. $R=10.7$, $r=3.7$.

***Hippasteria* Gray 1840**

Diagnosis. Body weakly pentagonal to stellate ($R/r=1.5–2.3$). Disk and arms thick. Arms relatively broad and short. Tissue with pulpy texture covers abactinal plates. Shallow fasciolar grooves present. Secondary plates present. Abactinal plates, tightly articulated, polygonal to irregular in outline, flat and elevated over surface. Carinal series are poorly distinguished. Abactinal spinelets (sometimes granular) forming fringe around abactinal plates. Spines, large, conical; granules common on abactinal plates. Large spines present on superomarginal and inferomarginal plates of most species. Superomarginal and inferomarginal plates bare, quadrate to rounded in outline at interradii with no other accessories other than large spines. Spinelets present on marginal plates. Shallow fasciolar grooves present between marginal plates. Marginal accessories (granules, spinelets, etc.) differentiated into a fringe on superomarginal and inferomarginal plates. Superomarginal plates dorsal facing in most species, Actinal fasciolar grooves shallow. Large actinal spines and spinelets present. Subambulacral spines large (and thus few in number). Furrow spines large, blunt, and round, usually few. Enlarged bivalved pedicellariae on raised bases on body surface. Modified from Mah et al. (2010, 2014).

Comments. *Hippasteria* includes 12 species, including the widespread *H. phrygiana*, which was determined to be a wide-

ranging species present in the Pacific, Atlantic and Indian Oceans (Foltz et al., 2013; Mah et al., 2014). *Hippasteria* is most immediately distinguished from *Evoplosoma* based on the presence of large (bisecting the plate on which it sits) bivalve pedicellariae and more broadly shaped disk and arms, and relatively few furrow spines (fewer than four), which are blunt and round in cross-section.

Morphology varies widely within *H. phrygiana*, with some populations showing more morphological resemblance (e.g. Atlantic and Pacific *H. phrygiana*) than others (e.g. the Japanese *Hippasteria imperialis*). Distinction and characterisation of these populations remains ongoing, because it is unclear how or if they should be formally recognised below a species level, especially as new occurrences of *H. phrygiana* are discovered.

In addition to *H. phrygiana*, Mah et al. (2014) recognised at least two other species lineages of *Hippasteria*, *H. californica* and *H. heathi*, with closely related and wide-ranging members. *Hippasteria muscipula* was also described therein (Mah et al., 2014) and is a wide-ranging species throughout the tropical Pacific (Mah, 2023, unpublished data).

***Hippasteria mcknighti* Mah et al. 2014**

Figure 14a–e

Diagnosis. Body stellate ($R/r = 1.85–2.27$), disk tumescent, confluent with triangular arms. Abactinal surface ornamentation is primarily composed of widely spaced tubercles and pedicellariae, large and homogeneously sized, covering abactinal surface. Tubercles, smooth, thickened, and short, sit on bases surrounded by distinct, wide fasciolar grooves. Marginal plates, 40 per interradius (at $R = 6.1$ to 7.5), quadrate in shape. Each plate has 1–5 large but squat cone-shaped tubercles, and one or two (mostly one) large bivalve pedicellaria. Granules coarse, closely distributed, rounded to angular in shape, especially on actinal surface. Actinal plates covered by large, squat tubercles and large bivalve pedicellariae (1–2 mm in length). Furrow spines, blunt, two or three (mostly two) per plate, each spine flattened and oval in cross-section. Subambulacral spines, blunt, 1–3, in transverse series, often thick and triangular to quadrate in cross-section, thicker than furrow spines but about 80–90% of furrow spine length.

Comments. This species shows close affinities with *H. heathi*, as outlined by Mah et al. (2014), and is largely consistent with the species description therein. The actinal surface, showing the rounded tubercles and the obliquely angled bivalve pedicellariae, are nearly identical. In contrast, the abactinal tubercles on this specimen are significantly smaller than on the holotype.

Occurrence. Australia. Tasmanian seamounts, 817 m.

New Zealand, 720–1015 m.

Material examined. NMV F240217 Mongrel (southern) seamount, Tasmania, Australia. 44.2569° S, 147.114° E, 817 m. Coll. R. Thresher and D.A. Staples, RV Thompson with ROV *Jason*, 23 Dec 2008. 1 wet spec. $R=8.4$, $r=4.1$.



Figure 14. *Hippasteria mcknighti* NMV F240217: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces; d, actinal surface; e, actinal surface detail including pedicellariae, furrow spines. Scale: a, d=15.0 mm; b, c, e=3.0 mm.

***Hippasteria phrygiana* (Parelius 1768)**

Figure 15a–f

Asterias phrygiana Parelius 1768: 425, see Mah et al. (2014) for full synonymy.

Hippasteria phrygiana H.E.S. Clark & McKnight, 2001: 54, pl. 13.

Hippasteria trojana Fell, 1958: 11, pl. 1, figs A, G; 1959: 136, fig. 21; 1960: 61, pls. 2,3; 1962: 33; McKnight, 1967: 300; H.E.S. Clark, 1970: 3; A.M. Clark, 1993: 259; Rowe and Gates, 1995: 65; Koslow & Gowlett-Holmes, 1998: 44.

Diagnosis. Body stout, weakly stellate ($R/r=1.69-2.0$) arms short. Abactinal plates with a single, short conical spine or large, bivalve pedicellariae, which are surrounded by 6–20 enlarged quadrate to polygonal granules. Marginal plates 35–36 per interradius (arm tip to arm tip), each with 1–3 (mostly one) short, conical spines, but those interradially with two. Marginal plates otherwise bare with smooth surface. Bivalve pedicellariae on many, if not most, proximal marginal plates extending to the arm base, but absent on distalmost plates. Actinal intermediate region large with numerous bivalve pedicellariae, especially large on actinal plates adjacent to the adambulacral plates. Furrow spines, 1–3 (mostly 2), subambulacral spines, 1–3. All adambulacral spines robust, round in cross-section. Paddle-shaped pedicellariae large, one or two present immediately behind furrow spines.

Comments. These specimens are identical with *H. trojana* as originally described by Fell (1958) from New Zealand. NMV F307998 (Tasmania) is nearly identical to a New Zealand specimen (USNM E13768). This is one of multiple *Hippasteria* found to be morphotypes of the widely occurring species *H. phrygiana*, present in the Atlantic, Pacific and Indian Oceans (Mah et al., 2014; Foltz et al., 2013). These morphotypes are consistent with species described from specific areas, including *H. trojana*.

Tasmanian specimens, while similar to those from New Zealand, were collected from much greater depths (1080–1221 m).

Occurrence. Australian. Tasmanian Seamounts, Southeast of New South Wales, 1080–1221 m.

East of Peninsula, South Island, New Zealand, Chatham Rise, 402–585 m.

Outside of Australia – North Atlantic, North Pacific, Southern Indian Ocean, globally 10–1221 m.

Description – small form. Body weakly stellate, $R/r=1.95$, appearing nearly pentagonal. Arms triangular, interradial arcs wide, weakly curved. Abactinal surface with conical tubercles present along carinal plate series. Spines absent elsewhere, remaining surface covered by enlarged bivalve pedicellariae. Spines and pedicellariae and other abactinal plates with 3–10 widely spaced round to polygonal granules. Marginal plates, 18–20, with a single spine present on the central surface of each superomarginal and inferomarginal plate, with one or two plates per interradius with one or two extra tubercles or short spines. Marginal plate surface more strongly arched distally adjacent to terminus. Actinal plates each with a distinct bivalve pedicellaria that bisects the plate on which it sits. Granules, 2–10, round to polygonal, present around each actinal plate periphery. Furrow

spines proximally three then two for remainder of arm series. Single, enlarged subambulacral spine present adjacent to furrow spines, adjacent to relatively small tong-like pedicellariae. Oral plate with furrow spines, four per side, with a single large spine projecting into mouth. All spines blunt. Oral plate with two series of paired granules, polygonal to quadrate in cross-section, along either edge of the diastema present between the two halves of the oral plate. Similar granules, 2–6, present on remainder of oral plate surface.

Material examined. NMV F307998 St Helens flat, Tasmanian seamounts, Tasmania, Australia, 41.2043° S, 148.788° E, 1221–1202 m. Coll. A. Williams, A.A. Weber and R-L Erickson, 17 Dec. 2018. 1 wet spec, $R=9.7$ $r=4.3$.

NMV F123458 40 km East South East of Ulladulla, New South Wales, Australia. 35.5092° S, 150.882° E, 1080–1090 m. Coll. M. D. Norman, 16 May 1988. 1 wet spec, $R=4.1$, $r=2.1$.

USNM E13768 east of Banks Peninsula, South Island, New Zealand. 43.9° S, 174.598° E, 585 m. Coll. 27.viii.1971.1. Dry spec, $R \sim 10.1$, $r = 6.1$.

VELATIDA**MYXASTERIDAE Perrier 1885**

Comments. As outlined by broad-based molecular phylogenetic revisions by Mah and Foltz (2011a, b) and Linchango et al. (2017), members of the Velatida occupy a divergent position within the post-Paleozoic Asterozoa relative to the other major clades, the Forcipulatida and the Valvatacea. This includes the Pterasteridae, Korethrasteridae and the Myxasteridae. The Myxasteridae includes several rarely encountered taxa that occur at great depths (>1000 m) known from relatively few badly damaged specimens (e.g., Alton, 1966). Observations and collections of myxasterids by submersibles (e.g. Mah, 2020, 2022) have provided new data on feeding and occurrence of these taxa. This in situ observation is the first observation of this group from the Southern Hemisphere.

cf. *Asthenactis*

Figure 16

Comments. Only one other observation of asteroid-octocoral predation could be located in the R/V *Falkor* video. During Sebastian Dive 324, Feb 15, 2020, in Leeuwin Canyon, at 768 m, an 11-armed asteroid in the Myxasteridae, similar to *Asthenactis*, was observed. The individual showed what might have been actinolateral fringes, but could not be determined definitively due to the angle of the imagery, and as such, the identification is tentative. cf. *Asthenactis* was observed with its arms wrapped around what appears to be an octocoral in the Chrysogorgiidae, possibly *Chrysogorgia*. The oral surface and cardiac stomach were appressed against the prey item with tube feet extended over the surface and tissues.

This is the first record of a member of the Myxasteridae in Australian waters and the first published record of a myxasterid feeding on a deep-sea octocoral. An account of the Atlantic myxasterid *Pythonaster atlantidis* A.H. Clark, 1948 records that species feeding on a hexactinellid sponge (Mah, 2020).



Figure 15. *Hippasteria phrygiana* (formerly *H. trojana*) NMV F307999: a, abactinal surface; b, abactinal surface detail; c, lateral view showing marginal plate surfaces; d, actinal surface; e, actinal surface detail including pedicellariae, furrow spines; f, adambulacral spination, including furrow spines, pedicellariae. Scale: a, d: 10 mm; b, c, e, f=5.0 mm.



Figure 16. *In situ* cf. *Asthenactis* feeding observation.

Video Source: <https://www.youtube.com/live/HexuAFr7yY8?si=5bQ8VzjXIVHhw2zf>

Discussion

Morphological trends consistent among Goniasteridae predatory on corals

Mah (2022) outlined several characters consistently present in most predatory Goniasteridae, which feed on octocorals. This includes large, prominent spination, large and often numerous pedicellariae, prominent adambulacral spination, and large size (approaching $R=15.0$ cm). All taxa reported herein are morphologically consistent with accounts of goniasterid predation on colonial octocorals (e.g. Mah, 2006, 2015a,b, 2020, 2022). All the known genera of Hippasterinae have been observed feeding on octocorals, as have *Circeaster* and *Atheraster* (Mah, 2020, 2022). Based on morphological similarities, including prominent marginal spination, *Armaster* n. sp. could be a coral predator.

These characters could represent adaptation to the environment associated with coral predation. Specimens of *Evoplosoma* and *Hippasteria*, when observed feeding on colonial octocorals, are frequently perched in prominent locations on high branches well above the substratum, where mobile vertebrate predators could attack. As Mah (2020) noted, pedicellariae on *Hippasteria* sp. were observed opening and closing during predation on a colony of *Corallium*.

It is also possible that these characters, such as the prominent abactinal, marginal and adambulacral spines, are shared, derived apomorphies that support these taxa as members of a unified group. Whilst the Hippasterinae and the Circeasterinae include very dissimilar members, several of the taxa described herein provide intermediate morphologies that suggest affinities between them. *Armaster* and *Atheraster*, for example, display characters that suggest affinity with *Evoplosoma*. Hippasterines, in turn, appear closely related to other spine-covered Goniasteridae (Mah and Foltz, 2011). The “*Calliaster* group” was initially defined by Aziz and Jangoux (1985b) and later Mah (2018, 2020) to include *Calliaster* as well as related genera, such as *Milteliphaster*. Molecular data for the Valvatacea showed *Calliaster elegans* and “*Milteliphaster*” (= *Calliaster*) *wanganellensis* as sister taxa to *Pergamaster*, subtending a clade containing the Hippasterine clade and *Neoferdina* (Mah and Foltz, 2011a). Although “*Calliaster* group” species occur at shallower depths than the other predatory goniasterids, which feed on octocorals, their life habits and feeding preferences are not as well understood, with relatively few feeding observations. *Calliaster pedicellaris* has been observed feeding on unidentified branching, colonial organisms (e.g. Mah, 2015b), and the shallow-water *C. baccatus* has been observed feeding on undefined colonial cnidarians in South African waters (Jones, 2023, pers. comm., iNaturalist). Australian waters contain numerous representatives of the “*Calliaster* group” and further study is desirable.

Coral predation in non-goniasterid deep-sea asteroids

The imagery of cf. *Asthenactis* feeding is one of the few non-goniasterid/non-valvatacean feeding observations on octocoral prey. Most observed octocoral predation has been that of various Goniasteridae, such as those of the hippasterines or others discussed herein. Few accounts of non-goniasterids can be located. For example, the asterinid *Tremaster mirabilis* has been documented as feeding on the sea pen, *Anthoptiluma armata* (Gale et al., 2013) and the shallow to deep-water *Porania pulvillus* feeds on the soft coral *Alcyonium digitatum* (Ericsson & Hansson, 1973).

The observation of cf. *Asthenactis* feeding is one of the few observations of a member of the Velatida predating on an octocoral. Other taxa within the Velatida, whilst poorly understood, have largely been observed feeding on sponges. In the Atlantic, the five-rayed myxasterid *Pythonaster* and the korethrastrerid *Remaster* have both been observed feeding on sponges (Mah, 2020). Pterasterids such as *Pteraster tessellatus*, *P. militaris*, *P. pulvillus* and *P. willisi* have been documented as predators on sponges (Jangoux, 1982; Jewett et al. 2015).

Although descriptions of phylogeny-based feeding trends in the Goniasteridae are premature, taxonomic groups appear to correspond with feeding behaviour in groups such as the Hippasterinae and possibly the Circeasterinae. This possible feeding trend may also be the case for *Asthenactis* and the morphologically similar myxasterid *Myxaster*, especially within the context of the Velatida.

Australian bathyal/abyssal Asteroidea

Species described and reported herein add to the growing number of bathyal/abyssal (>1000 m occurrence) asteroid taxa described since the last assessment of Australian species (Rowe and Gates, 1995). New taxa include the first Poraniidae *Bathymarginaster* (850–1650 m) and a new species of *Poraniomorpha tararus* from 3850–3853 m (Mah, 2023); the latter was, at the time of writing, the deepest known asteroid from Australian waters.

Most Australian Goniasteridae are known from the continental shelf/slope, approximately 100–1000 m, with many species reaching nearly 1000 m, with none 2000 m or deeper (Rowe and Gates, 1995). Members of the newly described Circeasterinae occur between 320–1852 m. Recorded occurrence of *Atheraster* appears to be distributed within a much deeper range than *Circeaster* and *Armaster*, but full data on these taxa is likely incomplete pending further study.

Within the Hippasterinae reported herein, nine species in four genera, including *Evoplosoma*, *Gilbertaster* and *Hippasteria*, are recorded from 817–2000 m, which are novel records for Australian waters. Three species of *Evoplosoma* – *E. besseyae*, collected from south of Tasmania (1100–1273 m), *E. voratus*, collected from Ningaloo Canyon (2914 m), and *E. pharos* n. sp., from New South Wales (2595–2474 m) – show occurrence in the bathyal zone (1000–3000 m), adding two species to those known from 2000–4000 m. *Evoplosoma timorensis*, the remaining species occurs throughout the central Indo-Pacific region from a shallower range, 795–1279 m, but with lower range in the bathyal zone.

Taxonomic conclusions*List of species*

Bold= New Taxon

* =New Occurrence

Circeasterinae nov. subfamily

***Armaster chondros* n. gen. n. sp.**

***Atheraster luma* n. sp.**

***Atheraster phaeos* n. sp.**

***Atheraster umbo* n. sp.**

***Circeaster dux* n. sp.**

Hippasterinae

***Evoplosoma besseyae* n. sp.**

***Evoplosoma mystrion* n. sp.**

***Evoplosoma pharos* n. sp.**

**Evoplosoma timorensis* Jangoux

**Evoplosoma voratus* Mah et al. 2010

**Gilbertaster anacanthus* Fisher 1906

**Hippasteria mcknighti* Mah et al. 2014

**Hippasteria phrygiana* (Parelius 1768)

Acknowledgements

Specimens described and reported here are primarily the result of museum visits in February–March 2023, supported by a Fellowship awarded by the Western Australian Museum Foundation, facilitated by Dr Zoe Richards with curatorial and logistical support from Museum Technical Officer Oliver Gomez. CSIRO specimens from the Gascoyne survey were examined at the Western Australian Museum with support from Dr John Keesing, who provided metadata and other logistical support. Dr Tim O'Hara provided financial support for several visits to Museums Victoria, providing assistance with logistics and hospitality. Dr Robin Wilson, Museums Victoria, provided identifications for polynoid worms. Marine Invertebrates Collection Manager Melanie Mackenzie further provided essential museum and curatorial support during my visit and facilitated the location of metadata and other essential services. The author wishes to thank the CSIRO Marine National Facility for its support in the form of sea time on RV *Investigator*, support personnel, scientific equipment and data management. All data and samples acquired on the voyage are made publicly available in accordance with MNF Policy. We also thank all the scientific staff and crew who participated in voyage IN2017_V03. Project funding was provided by the Marine Biodiversity Hub, supported through the Australian Government's National Environmental Science Program. The author graciously thanks the crews and personnel of the RV *Falkor* who collected specimens and provided video observations. Amanda Robinson and the collection management team in the Invertebrate Zoology department at USNM provided curatorial support. Dr Daniel Blake, University of Illinois Urbana-Champaign, provided critical reviews and useful insights that improved the manuscript significantly. I am grateful to Dr. Richard Marchant, Ella Meave, and the Museums Victoria publishing team for their constructive editorial contributions.

References

- Alderslade, P., Althaus, F., Mcennulty, F., Gowlett-Holmes, K., and Williams, A. 2014. Australia's deep-water octocoral fauna: historical account and checklist, distributions and regional affinities of recent collections. *Zootaxa*, 3796(3): 435–452. <https://doi.org/10.11646/zootaxa.3796.3.2>
- Alderslade, P., & McFadden, C. S. 2012. A new genus and species of the family Isididae (Coelenterata: Octocorallia) from a CMAR Biodiversity study, and a discussion on the subfamilial placement of some nominal isidid genera. *Zootaxa*, 3154(1): 21–39. <https://doi.org/10.11646/zootaxa.3154.1.2>
- Alton, M. 1966. A new sea-star from the northeastern Pacific Ocean, *Asthenactis fisheri* n. sp., with a review of the family Myxasteridae. *Deep-Sea Research* 13: 687–697. [https://doi.org/10.1016/0011-7471\(66\)90600-0](https://doi.org/10.1016/0011-7471(66)90600-0)
- Atkinson, L.J., & Sink, K.J. 2018. *Field guide to the offshore marine invertebrates of South Africa*. Malachite Marketing and Media: Pretoria. 498 pp. DOI: 10.15493/SAEON.PUB.10000001
- Aziz, A., and M. Jangoux. 1985a. Four new species and one new subspecies of asteroidea (Echinodermata) collected by the 'Siboga' expedition in the Indo-Malayan region. *Bijdragen tot de Dierkunde* 55(2): 263–274. <https://doi.org/10.1163/26660644-05502005>
- Aziz, A., & Jangoux, M. 1985b. On the status and affinities of the goniasterid genus *Calliaster* Gray, 1840. Pp. 585–586 in: Keegan, B.F. & O'Connor, B.D.S. (eds), *Proceedings of the 5th International Echinoderm Conference*, Galway, 1984. Balkema: Rotterdam. <https://doi.org/10.1201/9781003079224-116>
- Birkeland, C. 1974. Interactions between a sea pen and seven of its predators. *Ecological Monographs* 44: 211–232. <https://doi.org/10.2307/1942312>
- Birkeland, C., and Lucas, J.S. 1990. *Acanthaster planci: Major management problem of coral reefs*. CRC Press: Boca Raton, FL. 257 pp.
- Breton, G. 1992. *Les goniasteridae (Asteroidea, Echinodermata) Jurassiques et Cretacés de France: taphonomie, systématique, biostratigraphie, paleobiogéographie, évolution*. Thèse de Doctorat d'Etat Sciences, Université de Caen, Editions du Museum du Havre, Cité du Havre. 588 pp.
- Clark, A.H. 1948. Some interesting starfishes and brittle-stars dredged by the Atlantis in mid-Atlantic. *Journal of the Washington Academy of Science* 38: 75–85.
- 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., and Downey M.E. 1992. *Starfishes of the Atlantic*. Chapman and Hall: London. 794 pp.
- Clark, H.E.S. 1970. Sea-stars (Echinodermata: Asteroidea) from *Eltanin* cruise 26, with a review of the New Zealand asteroid fauna. *Zoology Publications from Victoria University of Wellington* 52: 1–33.
- Clark, H.E.S. & McKnight, D.G. 2001. The marine fauna of New Zealand: Echinodermata: Asteroidea (Sea-stars), Order Valvatida. *NIWA Biodiversity Memoir*, 117, 1–270.
- 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>
- Downey M.E. (1981) A new goniasterid seastar, *Evoplosoma scorpio* (Echinodermata: Asteroidea), from the northeastern Atlantic. *Proceedings of the Biological Society of Washington* 94, 561–563.
- Downey, M.E. 1982. *Evoplosoma virgo*, a new goniasterid starfish (Echinodermata: Asteroidea) from the Gulf of Mexico. *Proceedings of the Biological Society of Washington*. 95(4): 772-773.
- Ericsson, J., and Hansson, H.G. 1973. Observations on the feeding biology of *Porania pulvillus* (OF Müller), (Asteroidea), from the Swedish west coast. *Ophelia* 12(1-2): 53–58. <https://doi.org/10.1080/000785326.1973.10430119>
- Etnoyer, P., and Morgan, L. 2003. *Occurrences of habitat-forming deep sea corals in the Northeast Pacific Ocean*. NOAA Office Habitat Protection: Silver Spring, MD. 30 pp.
- Fell, H.B. 1958. Deep-sea echinoderms of New Zealand. *Zoology Publications from Victoria University of Wellington* 24: 1–40.
- Fell HB. 1959. Starfishes of New Zealand. *Tuatara* 7: 127–142 <https://doi.org/10.1080/00480169.1959.33355>
- Fell, H.B. 1960. Biological results of the Chatham Islands 1954 Expedition. Part 2. Archibenthal and littoral echinoderms. *New Zealand Department of Scientific and Industrial Research Bulletin*, 139: 55-75, pls. 1-10.
- Fell H.B. 1962. *Native sea-stars*. Nature in New Zealand. Wellington: A.H. & A.W. Reed.
- Fisher, W.K. 1906. The starfishes of the Hawaiian islands. *Bulletin of the United States Fish Commission* 23: 987–1130.
- Fisher W.K. 1910. New genera of starfishes. *Annals of the Magazine of Natural History* 5: 171–173. <https://doi.org/10.1080/00222931008692747>
- Foltz, D., Fatland, S., Eléaume, M., Markello, K., Howell, K., Neil, K., and Mah, C. 2013. Global population divergence of the sea star *Hippasteria phrygiana* corresponds to onset of the last glacial period of the Pleistocene. *Marine Biology* 160(5): 1285–1296. <https://doi.org/10.1007/s00227-013-2180-1>
- Forbes, E. 1841. *A history of British Starfishes and other animals of the class Echinodermata*. London; John Van Voorst. 267 pp. <https://doi.org/10.5962/bhl.title.2129>
- Gale, K.S.P., Hamel, J.-F., & Mercier, A. 2013. Trophic ecology of deep-sea Asteroidea (Echinodermata) from eastern Canada. *Deep-Sea Research I* 80: 25–36. <https://doi.org/10.1016/j.dsr.2013.05.016>
- 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*, 6: 275–290. <https://doi.org/10.1080/03745484009443296>
- Halpern, J.A. 1970. Goniasteridae (Echinodermata: Asteroidea) of the Straits of Florida. *Bulletin of Marine Science* 20(1): 193–286.
- Hanley, J.R., and Burke, M. 1991. A new genus and species of scaleworm (Polycheta: Polynoidae) from the Cascade Plateau, Tasman Sea. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* 8(1): 97–102. <https://doi.org/10.5962/p.262813>
- Horowitz, J., Opresko, D.M., and Bridge, T.C.L. 2018. Black corals (Anthozoa: Antipatharia) from the deep (916 m – 2542 m) Coral Sea, north-eastern Australia. *Zootaxa* 4472(2): 307–326. <https://doi.org/10.11646/zootaxa.4472.2.5>
- Hovland, M. 2008. *Deep-water coral reefs: unique biodiversity hot-spots*. Springer Science & Business Media, Praxis Publishing: Chichester. 304 pp.
- Jangoux M. 1982. Food and feeding mechanisms: Asteroidea. Pp. 117–159 in: Jangoux, M. and Lawrence, J.M. (eds), *Echinoderm Nutrition*. Balkema: Rotterdam. <https://doi.org/10.1201/9781003078920-6>
- Jewett, S.C., Clark, R.N., Chenelot, H., Harper, S., and Hoberg, M.X. 2015. *Field guide to sea stars of the Aleutian Islands*. Sea Grant Alaska, University of Alaska: Fairbanks. 165 pp.
- Koehler, R. 1909. An account of the deep-sea Asteroidea collected by the Royal Indian Marine Survey Ship Investigator. *Echinoderma of the Indian Museum* 5:115–131.
- Koslow, J.A., Gowlett-Holmes, K. 1998. *The seamount fauna off southern Tasmania: ethnic communities, their conservation and impacts of trawling*. Final report to Environment Australia & the Fisheries Research Development Corporation. CSIRO: Hobart.

- Lauria, V., Garofalo, G., Fiorentino, F., Milisenda, G., Piraino, S., Russo, T., & Gristina, M. 2017. Species distribution models of two critically endangered deep-sea octocorals reveal fishing impacts on vulnerable marine ecosystems in central Mediterranean Sea. *Scientific Reports* 7: 8049. <https://doi.org/10.1201/9781003078920-6>
- 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., and Janies, D.A. 2017. The phylogeny of extant starfish (Asteroidea: Echinodermata) including *Xyloplax* based on comparative transcriptomics. *Molecular Phylogenetics and Evolution* 115: 161–170. <https://doi.org/10.1016/j.ympev.2017.07.022>
- MacIntosh, H., Althaus, F., Williams, A. et al. 2018. Invertebrate diversity in the deep Great Australian Bight (200–5000 m). *Marine Biodiversity Records* 11: 23. <https://doi.org/10.1186/s41200-018-0158-x>
- Mah, C. 1998. New Records, Taxonomic Notes and a Checklist of Hawaiian Starfish. *Bishop Museum Occasional Papers* 55: 65–71
- Mah, C.L. 2006. Phylogeny and biogeography of the deep-sea goniasterid, *Circeaster* (Echinodermata: Asteroidea) including descriptions of six new species. *Zoosystema* 28(4): 917–954.
- Mah, C.L. 2015a. New species, corallivory, *in situ* video observations and overview of the Goniasteridae (Valvatida, Asteroidea) in the Hawaiian Region. *Zootaxa* 3926(2): 211–228. <https://doi.org/10.11646/zootaxa.3926.2.3>
- Mah, C.L. 2015b. A new Atlantic species of *Evoplosoma* with taxonomic summary and *in situ* observations of Atlantic deep-sea corallivorous Goniasteridae (Valvatida; Asteroidea). *Marine Biodiversity Records* 8(e5): 1–8. <https://doi.org/10.1017/S1755267214001407>
- Mah, C.L. 2016. Deep-sea (>1000 m) Goniasteridae (Valvatida; Asteroidea) from the North Pacific, including an overview of *Sibogaster*, *Bathyceramaster* n. gen. and three new species. *Zootaxa* 4175(2): 101–141. <https://doi.org/10.11646/zootaxa.4175.2.1>
- 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. 2022. New genera, species and occurrence of deep-sea Asteroidea (Valvatataceae, Forcipulatataceae, 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. First occurrence of the Poraniidae (Valvatataceae; Asteroidea) in Australia with further records from adjoining waters. *Memoirs of the Museum Victoria* 82: 119–131. <https://doi.org/10.24199/j.mmv.2023.82.06>
- Mah, C. and D.B. Blake. 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., and Foltz, D.W. 2011a. Molecular phylogeny of the Valvatataceae (Asteroidea, Echinodermata). *Zoological Journal of the Linnean Society* 161: 769–788. <https://doi.org/10.1111/j.1096-3642.2010.00659.x>
- Mah, C., and Foltz, D. 2011b. Molecular phylogeny of the Forcipulatataceae (Asteroidea: Echinodermata): systematics & biogeography. *Zoological Journal of the Linnean Society*. 162: 646–660. <https://doi.org/10.1111/j.1096-3642.2010.00688.x>
- Mah, C.L., Nizinski, M., and Lundsten, L. 2010. Phylogenetic revision of the Hippasterinae (Goniasteridae; Asteroidea): systematics of deep sea corallivores, including one new genus and three new species. *Zoological Journal of the Linnean Society* 160: 266–301. <https://doi.org/10.1111/j.1096-3642.2010.00638.x>
- Mah, C.L., Neill, K., Eleaume, M., and Foltz, D. 2014. New species and global revision of *Hippasteria* (Hippasterinae: Goniasteridae; Asteroidea; Echinodermata). *Zoological Journal of the Linnean Society* 171: 422–456. <https://doi.org/10.1111/zoj.12131>
- Marsh, L.M., and Fromont, J. 2020. Field guide to shallow-water seastars of Australia. Western Australian Museum, Welshpool DC. 543 pp.
- McKnight, D.G. 1967. Additions to the echinoderm fauna of the Chatham Rise. *New Zealand Journal of Marine and Freshwater Resources* 1: 291–313. <https://doi.org/10.1080/00288330.1967.9515206>
- McKnight, D.G. 1973. Additions to the asteroid fauna of New Zealand: families Radiasteridae, Solasteridae, Pterasteridae, Asterinidae, Ganeriidae and Echinasteridae. *NZOI Records* 2, 1, 1–15.
- 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., and 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>
- Miller, K., Neil, H., and Tracey, D. 2009. Recent advances in deep-sea coral science and emerging links to conservation and management of deep-sea ecosystems. *Marine Ecology Progress Series* 397: 1–5. <https://doi.org/10.3354/meps08452>
- O'Hara, T.D., Williams, A., Ahyong, S.T., Alderslade, P., Alvstad, T., Bray, D., Burghardt, I., Budaeva, N., Criscione, F., Crowther, A.L., Ekins, M., Eleaume, M., Farrelly, C.A., Finn, J.K., Georgieva, M.N., Graham, A., Gomon, M., Gowlett-Holmes, K., Gunton, L.M., Hallan, A., Hosie, A.M., Hutchings, P., Kise, H., Kohler, F., Kongsrud, J.A., Kupriyanova, E., Lu, C.C., Mackenzie, M., Mah, C., MacIntosh, H., Merrin, K.L., Miskelly, A., Mitchell, M.L., Moore, K., Murray, A., O'Loughlin, P.M., Paxton, H., Pogonoski, J.J., Staples, D., Watson, J.E., Wilson, R.S., Zhang, J., and Bax, N.J. 2020. The lower bathyal and abyssal seafloor fauna of eastern Australia. *Marine Biodiversity Records* 13(11). <https://doi.org/10.1186/s41200-020-00194-1>
- Parelius, J. 1768. Beskrivelse over Nogle Korstroid. *Kongelige Norske Videnskabers Selskab Skrifter*. 4: 423–428.
- Perrier, E. 1885. Sur les stellérides recueillis durant la mission du Talisman. *Comptes-rendus Hebdomadaires des Seances de l'Académie des Sciences* (Paris). 101: 884–887.
- Roberts, S., and Hirshfield, M. 2004. Deep-sea corals: out of sight, but no longer out of mind. *Frontiers in Ecology and the Environment* 2(3): 123–130. [https://doi.org/10.1890/1540-9295\(2004\)002\[0123:DCOOSB\]2.0.CO;2](https://doi.org/10.1890/1540-9295(2004)002[0123:DCOOSB]2.0.CO;2)
- Rogers, A.D. 2013. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. *International Review of Hydrobiology* 84(4): 315–406. <https://doi.org/10.1002/iroh.199900032>
- Rowe F. W.E., and Gates, J. 1995. Echinodermata. *Zoological catalogue of Australia* 33. CSIRO: Melbourne 510 pp.
- Spencer, W.K., and Wright, C.W. 1966. Asterozoans, Part U: Echinodermata. Pp. U4–U107 in: Moore R.C. (ed), *Treatise on invertebrate paleontology*. University of Kansas Press: Lawrence, KS.
- Stevenson, A., and Rocha, C. 2013. Evidence for the bio erosion of deep-water corals by echinoids in the Northeast Atlantic. *Deep-Sea Research I* 71: 73–78. <https://doi.org/10.1016/j.dsr.2012.09.005>
- Studer, T. 1884. Verzeichnis der während der Reise S.M.S. "Gazelle" um die Erde, 1874–76 gesammelten Asteriden und Euryaliden. *Abhandlungen der Preussischen Akademie der Wissenschaften*. 2, 1–64.
- 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>