

# New occurrences and a new genus and species of ‘Toothless’ Odontasteridae (Asteroidea) from Australian waters

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**ABSTRACT** – Odontasteridae (Asteroidea) are important members of Antarctic faunas. Less well-known are odontasterid species present outside of high-latitudes, which occur primarily in the deep-sea. Multiple new odontasterids were identified from deep-sea settings in Australian waters, including a new genus and species, *Marshastra loisettae* gen. nov. sp. nov., from the shelf off Western Australia, and *Hoplaster oloughlini* sp. nov. from Tasmania and the south Pacific region. A phylogeny of *Hoplaster* suggests diversification from a Southern Hemisphere setting into the Atlantic and northward as well as across Tasmanian seamounts, indicating diversification into deep-sea habitats from shallower waters.

**KEYWORDS:** deep-sea, Asteroidea, New Zealand, Australia

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## INTRODUCTION

Exploration of deep-sea settings and documentation of the biodiversity around Australia are in their infancy, despite extensive sampling efforts in recent years (e.g. McEnulty et al. 2011, MacIntosh et al. 2018, O’Hara et al. 2020). Accounts of Australian marine species estimate that nearly 250,000 marine species remain to be discovered (Butler et al. 2010). Preliminary faunal reports of these sampling efforts, such as that of O’Hara et al. (2020) who documented results from a survey of bathyal and abyssal metazoan fauna of eastern Australia suggest that up to 58% of the collected material was undescribed.

Odontasterids are best known as components of high-latitude, Southern Hemisphere faunas, especially in Antarctic and sub-Antarctic waters, having significant roles in community structure as predators on sessile and other benthic faunas such as sponges (e.g. Paine 1966, 1969; Dayton et al. 1970, 1974; Dearborn 1977) in Antarctic settings. However, a minority of odontasterid species, mostly in the genus *Odontaster* occur away from high-latitude settings and are found throughout deep-sea habitats as far away as the North Atlantic (e.g. Clark and Downey 1992). A single odontasterid species, *Odontaster benhami* (Mortensen, 1925) has been recorded from Australian waters (Rowe and Gates 1995).

This unusual distribution has made the Odontasteridae, prime subjects for biogeographic studies in the Southern Hemisphere (e.g. Fell 1962). More recent molecular evolutionary and phylogeography have further elucidated diversification events within *Odontaster* and among odontasterid genera across their range (e.g. Janosik et al. 2011; Janosik and Halanych 2013).

Two new species, an undescribed genus, and several new occurrences were discovered as part of curation of deep-sea collections during research visits to the Western Australian Museum in Perth and the Museum Victoria in Melbourne, Australia. Two genera, *Hoplaster* and *Marshastra* gen. nov. are reported from Australian waters.

## MATERIALS AND METHODS

Specimens described herein are housed at the Museum Victoria (NMV) in Melbourne, Victoria, Australia and the Western Australian Museum (WAM) in Perth, Western Australia.

Measurements of specimens herein are in centimetres (cm), except where indicated otherwise.

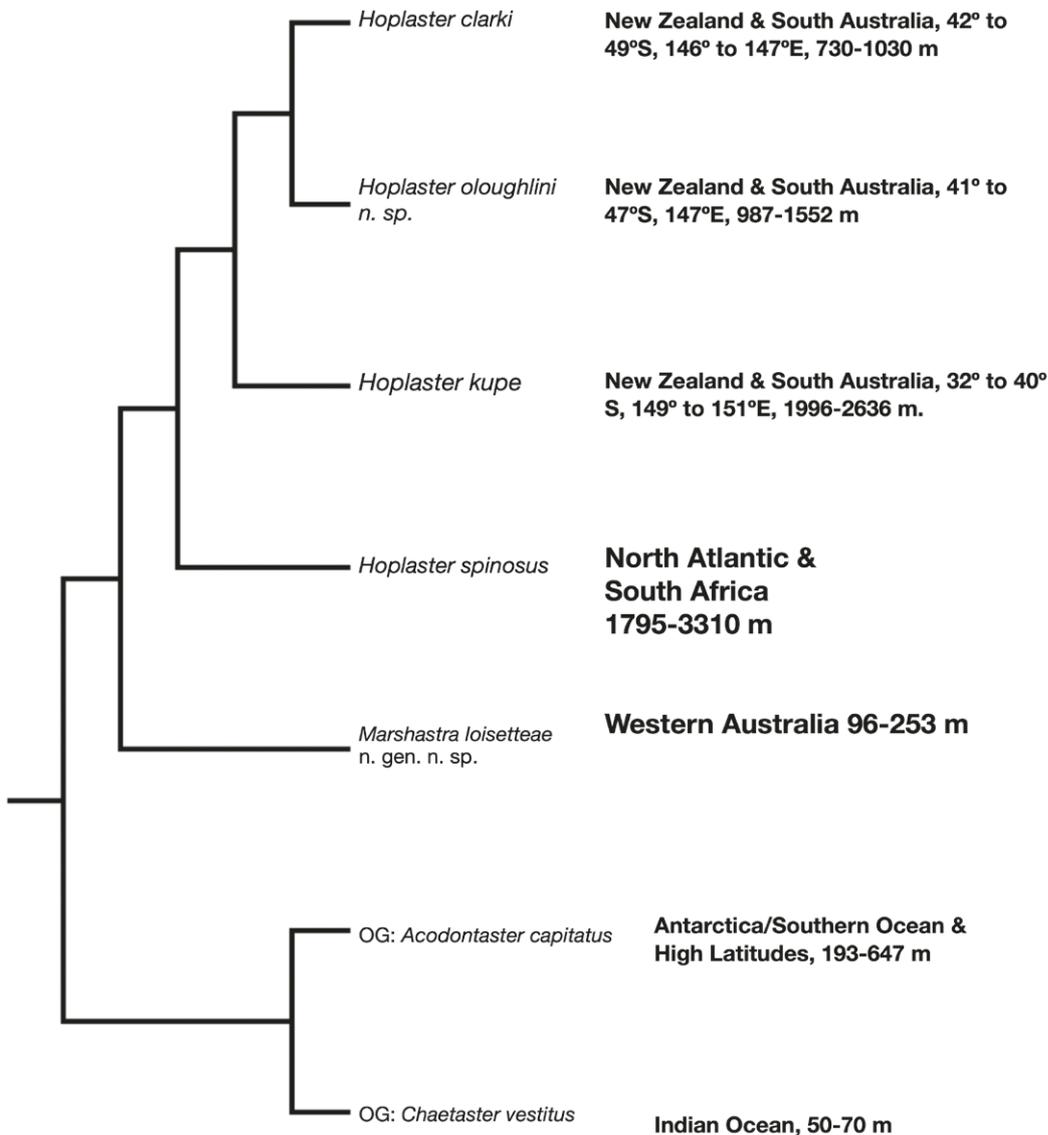
## OBJECTIVES AND CONSTRAINTS OF THE PHYLOGENETIC ANALYSIS

The phylogeny provided in Figure 1 was developed primarily to support *Marshastra* gen. nov. as a separate

genus from *Hoplaster*. Although it includes putative outgroups, it was beyond the scope of this investigation to fully resolve relationships among genera in the Odontasteridae and this treatment should be considered preliminary, providing a hypothesis for further testing of relationships.

A phylogenetic analysis was run using the heuristic algorithm with Mesquite version 3.04 (build 725) resulting in 11 unrooted, most parsimonious trees. The analysis utilised 19 morphological characters and included *Acodontaster capitatus* (E13699), and *Chaetaster vestitus* (USNM 47151) as outgroups based on prior molecular phylogenetic results (Mah and Foltz 2011;

Janosik and Halanych 2013) with the five in-group taxa treated herein (*Marshastra* and four species of *Hoplaster*). *Acodontaster*, as the sister taxon, was the sister branch to *Hoplaster* based on 16S and cytochrome c oxidase subunit I molecular markers as well as 29 morphological characters (Janosik and Halanych 2013). *Chaetaster* was supported as sister group to the Odontasteride in a three gene analysis of the Valvatacea (Mah and Foltz 2011) and was included as a further outgroup. Rooting of the two outgroups consistently resulted in a consistent tree topology across the resultant 11 tree topologies, as seen in Figure 1. Generated tree topologies support *Marshastra loisetteae* as the sister clade to a monophyletic *Hoplaster*.



**FIGURE 1** Phylogenetic tree including *Marshastra* and *Hoplaster* species. One consistent topology from 11 unrooted analyses after the outgroups were constrained by Mesquite.

## SYSTEMATICS

### Family Odontasteridae Verrill, 1899

#### DIAGNOSIS

Body pentagonal to strongly stellate ( $R/r = 1.1-4.0$ ), five rays, arms triangular, varying from short and triangular to elongate with tapering ends. Interradial arcs weakly curved/straight to acute. Abactinal plates variably paxillate with short spinelets arranged in longitudinal to oblique series to flattened, imbricate, lobate polygonal plates with variable types of surficial granulation. Most genera lacking any kind of prominent spination. Marginal plates forming variable periphery ranging from wide, distinct peripheral frame clearly observed from abactinal surface, very pronounced in some genera, to more indistinct smaller series present around lateral edge. Marginal plates variably covered with short spinelets in most, presenting a hirsute appearance, but some genera, such as *Acodontaster*, with granules, forming continuous surficial covering. Actinal intermediate plates, numerous in some taxa, arranged in chevron formation. Actinal plate surface covered with spinelets or granules, in similar fashion to abactinal plate surface. Prominent spines absent from abactinal and marginal plates, but tubercles present in some species. Oral plates in most genera with a single enlarged, recurved hyaline spine(s). Two spines present in *Diplodontias*, but spine absent in *Hoplaster* and *Marshastra* gen. nov. Furrow spines in most genera are slender, pointed.

#### COMMENTS

Outwardly, many odontasterids appear similar to members of the Goniasteridae, but have paxillate abactinal and actinal plates as well as blocky marginal plates covered by fine clavate spinelets, these reminiscent of paxillosidans. A conspicuously large, recurved oral spine or 'tooth' is a diagnostic character for most members of the group (e.g. Clark and Downey 1992; Janosik and Halanych 2013). Two genera, *Hoplaster* Perrier in Milne-Edwards, 1882 and *Diabocilla* McKnight, 2006 are unusual in that they lack the large, recurved oral spine present in most Odontasteridae (Janosik and Halanych 2013). Despite this inconsistency, *Hoplaster* and other odontasterids have been supported as monophyletic by molecular phylogenetic analysis (Mah and Foltz 2011, Janosik and Halanych 2013). Janosik and Halanych (2013) included all six genera with two genes and morphological data, including the 'untoothed' genus *Hoplaster*, which was supported a sister clade to *Acodontaster*. Although phylogenetic topologies differ between the 12S, 16S+histone H3 tree of Mah and Foltz (2011) and the 16S+COI tree of Janosik and Halanych (2013) some

similarities, such as the positions of *Eurygonias* and *Diplodontias* were present among stemward taxa. Work herein reviews known shared characters between toothed and untoothed taxa, synonymises *Diabocilla*, and provides the basis for a new genus from the Western Australian coast of the Indian Ocean.

### KEY TO 'TOOTHLESS' ODONTASTERIDAE

- 1 Body shape strongly stellate ( $R/r = 2.1-3.5$ ) (Figure 6A,D). Abactinal, marginal, actinal spines glassine, short, pointed (Figure 6B-C,E-F). Marginal plates approximately 16-24 per interradius (armtip to armtip) at  $R = 1.2-1.4$  (Figure 6A,D) .....  
.....*Marshastra loisetteae* gen. nov. sp. nov.  
  
Body shape pentagonal or weakly stellate ( $R/r = 1.1-1.7$ ). Abactinal (marginal, actinal) plates solid, strongly developed, with clavate to tuberculate tips, presenting a round, granular appearance from the surface in some species (e.g. Figures 2B, 4A-B). Overall, marginal plates 7-19 per interradius, but most species with 8-10 .....*Hoplaster* (2)
- 2 Abactinal, marginal and actinal plates covered with cylindrical granules with round tips, appearing more rounded when viewed from above (Figures 2B, 4A-B). Marginal plates number 9-10 (e.g. Figure 4A) at  $R = 1.1-1.6$  .....  
.....*Hoplaster oloughlini* sp. nov.  
  
Abactinal, marginal and actinal spinelets appearing slender, with pointed, clavate or tubercular tips. Actinal spinelets slender with blunt to pointed tips. Marginal plates number 9-15 at  $R = 1.0-1.5$  .....(3)
- 3 Spinelets on lateral surface and on inferomarginal plates with strongly clavate tips appearing tuberculate or granular (Figure 2B). Marginals 9-13, 13 at  $R = 1.25$  cm in the holotype. Australian specimens are smaller, 9-10 at  $R = 0.5-0.7$  .....  
.....*Hoplaster clarki* comb. nov.  
  
All spinelets on marginal and actinal plates slender, with pointed or clavate tips (e.g. Figures 2B, 3B,F) .....(4)
- 4 Marginal plates per interradius, 16-19 at  $R = 1.4-1.7$ . Armtips triangular with pointed tip (Figure 3A). Abactinal spinelets coarser, shafts thicker (Figures 3D,F). Known occurrence New Zealand and Australia (South Pacific) .....*Hoplaster kupe*  
  
Marginal plates per interradius, 9-13 at  $R \leq 1.8$ . Armtips more rounded with blunt arm tip (Figure 5A). Abactinal spinelets fine, relatively fine, shafts elongate (Figure 5A-B). Known occurrence Atlantic to South Africa .....*Hoplaster spinosus*

## TAXONOMY

*Hoplaster* Perrier in Milne–Edwards, 1882.

*Hoplaster* Perrier in Milne–Edwards 1882: 48; 1894: 323; Verrill 1899: 197; Mortensen 1927: 77, 439, Spencer and Wright 1966: U56; McKnight 1973: 227; Clark and Downey 1992: 151.

*Pentagonaster* (part) Sladen 1889: 275.

*Diabocilla* McKnight 2006: 103 new synonymy.

## DIAGNOSIS

Body pentagonal to weakly stellate ( $R/r = 1.3\text{--}1.7$ ), interradial arcs weakly curved to straight. Abactinal plates round to polygonal with weakly convex central mound (subtabulate) each topped with variably clavate spinelets ranging from very narrow to coarse and thick, superficially appearing tubercular to granular from a distance. Fasciolar grooves between plates formed by spinelets and plate convexity. Marginal plates, 9–20, blocky, forming distinct periphery. Marginal plate surfaces covered by spines similar or identical to spinelets present on abactinal surface, each with clavate or round tips. Actinal plates quadrate in chevron-like formation, each covered by spinelets, variably slender to coarse with pointed, rounded clavate, or denticulate tips. Furrow spines, 2–4, each pointed, slender, subambulacral spines, similarly slender and pointed, 1–6. Recurved oral spine on each oral plate absent (this characterises other members of the Odontasteridae).

## TYPE SPECIES

*Hoplaster spinosus* Perrier in Milne–Edwards, 1882.

## COMMENTS

Historically, *Hoplaster* has stood apart from other members of the Odontasteridae in lacking the prominent recurved hyaline spine present on the oral plates (A.M. Clark 1962; Clark and Downey 1992; H.E.S. Clark and McKnight 2001). *Hoplaster*'s other diagnostic morphological characters are consistent with other most other members of the Odontasteridae, including paxillate or highly spinose abactinal, marginal, and actinal surfaces.

*Hoplaster spinosus* was first described from lower bathyal to abyssal depths (1795–3310 m) in the Atlantic and later South African waters from soft bottom settings (sand, ooze and volcanic mud) (Clark and Downey 1992: 152). McKnight (1973) described the Pacific species, *Hoplaster kupe* from comparably deep-sea habitats (1995–2010 m). H.E.S. Clark and McKnight (2001) further reported on New Zealand *Hoplaster* species from New Zealand waters.

With the synonymy of *Diabocilla*, the account documents four species of *Hoplaster*, one from the Atlantic, including the North Atlantic and South Africa and three from New Zealand and Australian waters, all from relatively deep water, 730–2636 m.

## SYNONYMY OF *DIABOCILLA*

McKnight (2006) described a second ‘untoothed’ odontasterid genus, *Diabocilla* from Chatham Rise in New Zealand waters from 890–970 m. *Diabocilla* was characterised by the abactinal and marginal plates covered by tubercles rather than spines, as well as ‘barely elevated’ abactinal plates relative to *Hoplaster*, the other untoothed odontasterid (e.g. Clark and Downey 1992).

Examination of spinelets across species in Australian *Hoplaster* and images of the holotype of *Diabocilla clarki*, including the abactinal and marginal tubercles (Figure 2A–C) show that they are the same as the clavate-tipped spinelets present in other *Hoplaster* species. The abactinal plates described by McKnight (2006) as barely elevated and consistent with plates in other *Hoplaster* species. Without these characters serving to distinguish *Diabocilla* as distinct, this species is consistent with characters that identify *Hoplaster*. *Diabocilla* McKnight, 2006 is synonymised with *Hoplaster* Perrier in Milne–Edwards, 1882.

Included species: *Hoplaster clarki* (McKnight, 2006) nov. comb., *Hoplaster kupe* McKnight, 1973, *Hoplaster spinosus* Perrier in Milne–Edwards, 1882 (type species), *Hoplaster oloughlini* sp. nov.

## *Hoplaster clarki* (McKnight, 2006)

Figure 2A–F

*Diabocilla clarki* McKnight, 2006: 103.

## MATERIAL EXAMINED

**South Pacific:** NNMV F159245, Pedra site, south of Tasmania (–44.2585, 147.092), 850–1000 m, T. O’Hara, 2 April 2007, 2 wet specs ( $R = 0.8$ ,  $r = 0.6$ ;  $R = 0.6$ ,  $r = 0.4$ ); NMV F159246, Pedra site, south of Tasmania (–44.261, 147.097), 730–1000 m, T. O’Hara, 2 April 2007, 1 wet spec. ( $R = 0.7$ ,  $r = 0.4$ ); NMV F159247, Huon 1000 site, south of Tasmania (–44.1256, 147.248), 800–1000 m, T. O’Hara, 3 April 2007, 1 wet spec. ( $R = 0.7$ ,  $r = 0.4$ ); NMV F159248, Tasman 1000 site, south of Tasmania (–44.0658, 146.234), 800–880 m, T. O’Hara, 5 April 2007, 1 wet spec. ( $R = 0.5$ ,  $r = 0.3$ ); NMV F159249, Cascade 1000 site, south of Tasmania (–44.0658, 146.234), 780–870 m, T. O’Hara, 8 April 2007, 2 wet specs ( $R = 0.5$ ,  $r = 0.3$ ;  $R = 0.4$ ,  $r = 0.2$ ); NMV F159250, Huon 1000 site, south of Tasmania (–49.9337, 150.512), 840–1030 m, T. O’Hara, 31 March 2007, 1 wet spec. ( $R = 0.6$ ,  $r = 0.4$ ); NMV F159251, Huon 1000 site, south of Tasmania (–44.0306, 147.58), 830–1000 m, T. O’Hara, 31 March 2007, 1 wet spec. ( $R = 0.6$ ,  $r = 0.4$ ); NIWA 25638 holotype, *Diabocilla clarki* Off Chatham Rise, New Zealand (–42.766667, 179.926667), 900–970 m. 1 dry spec. ( $R = 1.25$ ,  $r = 0.85$ ) (images only).

## DIAGNOSIS

Body pentagonal to weakly stellate ( $R/r = 1.3-1.75$ ), interradial arcs weakly curved to straight. Species which shows abactinal spinelets with clavate to tuberculate tips, marginal plates covered by tuberculate granules as

well as actinals covered by cylindrical pointed spinelets. Marginal plates 9–13 per interradius. Australian specimens with furrow spines 2, decreasing to 1 distally. subambulacral spines 2–3, New Zealand (and type) specimens with furrow spines 3, decreasing to 2.

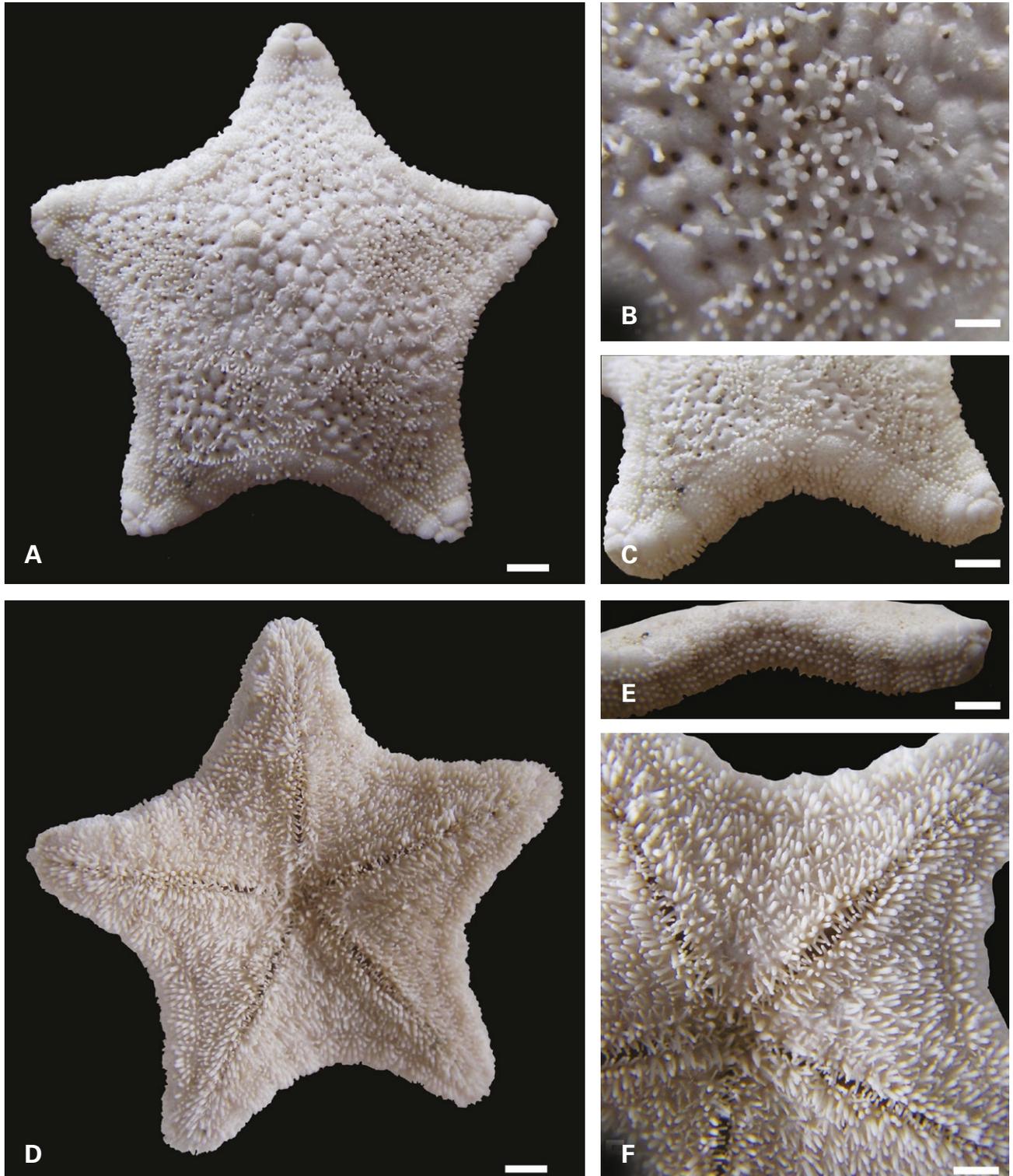


FIGURE 2 *Hoplaster clarki*, holotype (NIWA 25638): A) abactinal surface, scale = 1.5 mm; B) closeup of spinelets and abactinal plates. Arrow pointing to individual clavate/round-tipped spinelet, scale = 3 mm; C) abactinal-lateral view, scale = 1.5 mm; D) actinal surface, scale = 3 mm; E) Lateral view of marginal plates showing 'granules' (spinelets), scale = 2 mm; F) closeup of actinal surface, scale = 2 mm.

## DESCRIPTION

Body stout, pentagonal to weakly stellate ( $R/r = 1.3\text{--}1.75$ ), interradial arcs weakly curved to straight.

Abactinal surface composed of flat to mound-like plates (i.e. weakly convex) abutting to imbricate. Plates irregular in outline, larger proximally becoming smaller more distally. Plate surfaces covered by clavate spinelets, 4–15, abundant but evenly distributed, each with slender shaft and rounded, denticulate tips. Papulae present along proximal radial arm regions. Madreporite convex, flanked by approximately 5–6 plates.

Marginal plates 9–13 per interradius (arm tip to arm tip), approximately 5 per arm side. Individual plates quadrate in shape with deep fasciolar grooves. Surface covered by shorter, but still coarse, tuberculate granules, 20–40 per plate surface. Pitting present where granules have been removed. Supermarginals at armtip in contact over midline. Inferomarginals with more elongate, flattened spines, 10–25, mostly 20 with distinctly flattened tips, widely spaced spines forming edge around actino-lateral edge. Actinal surface on inferomarginal plates with glassy surfaces embedded on inferomarginal plate surface.

Actinal plates in full chevron-like series with irregular plates present interradially adjacent to inferomarginal contact. Each plate quadrate in shape bearing pointed, but blunt-tipped spines, 2–7, widely spaced on each plate.

Australian specimens with 2 furrow spines, pointed and elongate, decreasing to one distally, similar to those on actinal plate surface. Subambulacral spines, 2–3, in transverse series identical to those on actinal plate surface. New Zealand (and type) specimens with furrow spines 3, decreasing to 2. Subambulacral spines 5–6. Oral plate with four furrow spines, widely paced. Oral plate surface covered by elongate spines, 3–4 similar to those elsewhere. Two enlarged, recurved, non-hyaline, oral spines, one for each half plate, each of these spines with blunt tip, twice as thick as furrow spines, 20–40% taller than adjacent actinal spines, identical in texture, appearance to other actinal spines.

## OCCURRENCE

Chatham Rise, central New Zealand from Diabolical and Zombie Hill, 890–970 m.

In Australia, Pedra and several sites, including the Huon, Cascade and Tasman 1000 sites, south of Tasmania, 730–1030 m.

## COMMENTS

A species with an intermediate morphology between *Hoplaster oloughlini* sp. nov. and the more spinose *Hoplaster kupe*. The abactinal and marginal granular spinelets show strongly rounded tips, presenting a granuliform appearance most similar to *Hoplaster oloughlini* but actinal spinelets are slender with blunt, clavate tips, akin to *Hoplaster kupe*.

***Hoplaster kupe* McKnight, 1973**

Figure 3A–G

*Hoplaster kupe* McKnight 1973: 227, fig. 6; A.M. Clark 1993: 195; H.E.S. Clark and McKnight 2001: 150; Lorz et al. 2012: 49; Janosek and Halanych 2013: 823; O'Hara et al. 2020: 10.

## MATERIAL EXAMINED

**South Pacific:** NMV F241774, Flinders, Tasmania (-40.464, 149.101), 2298–2486 m, T. O'Hara aboard RV *Investigator* 3 Oct 2017, 1 wet spec. ( $R = 1.8$ ,  $r = 1.1$ ); NMV F241823, East Gippsland, Victoria (-37.792, 150.382), 2338–2581 m, T. O'Hara aboard RV *Investigator*, 25 May 2017, 1 wet spec. ( $R = 0.8$ ,  $r = 0.4$ ); NMV F241881, Hunter, New South Wales (-32.575, 153.162), 2595–2474 m, T. O'Hara aboard RV *Investigator*, 3 Oct 2017, 3 wet specs ( $R = 0.9$ ,  $r = 0.6$ ;  $R = 0.9$ ,  $r = 0.4$ ;  $R = 0.7$ ,  $r = 0.5$ ); NMV F241900.1 and F241900.2, Central Eastern CMR, E of Woolgoolga, New South Wales (-30.0977, 153.899), 2429–2518 m, 4 wet specs ( $R = 0.8$ ,  $r = 0.5$ ;  $R = 1.1$ ,  $r = 0.6$ ;  $R = 0.8$ ,  $r = 0.5$ ;  $R = 1.1$ ,  $r = 0.5$ ); NMV F241844, Jervis, New South Wales (-35.333, 151.258), 2650–2636 m, T. O'Hara aboard RV *Investigator*, 29 May 2017, 2 wet specs ( $R = 1.4$ ,  $r = 0.8$ ;  $R = 1.4$ ,  $r = 0.8$ ).

## DIAGNOSIS

Body pentagonal to weakly stellate ( $R/r = 1.4\text{--}1.7$ ), arms sort, triangular. Interradial arcs curved to straight. Marginal plates 15–19 per interradius, abactinal, marginal plates covered by relatively fine clavate spinelets with denticulate tips. Furrow spines 3–4, subambulacral spines 6–8, each pointed, approximately 10% longer and thicker than the furrow spine, in two rows, approximately 2–3 each.

## DESCRIPTION

Body weakly stellate to stellate ( $R/r = 1.4\text{--}1.7$ ), arms short, triangular. Interradial arcs curved to straight.

Abactinal surface with paxillate plates, each bearing weakly tuberculate spinelets, 8–50, with widely spaced denticulate club-shaped tips. Plates circular, but with a sharply mound-like aspect. Paxillate plates primarily along radial regions, interradial plates non-spinose, round in shape, abutted. Fasciolar grooves well-developed. Madreporite polygonal, flanked by five or six plates.

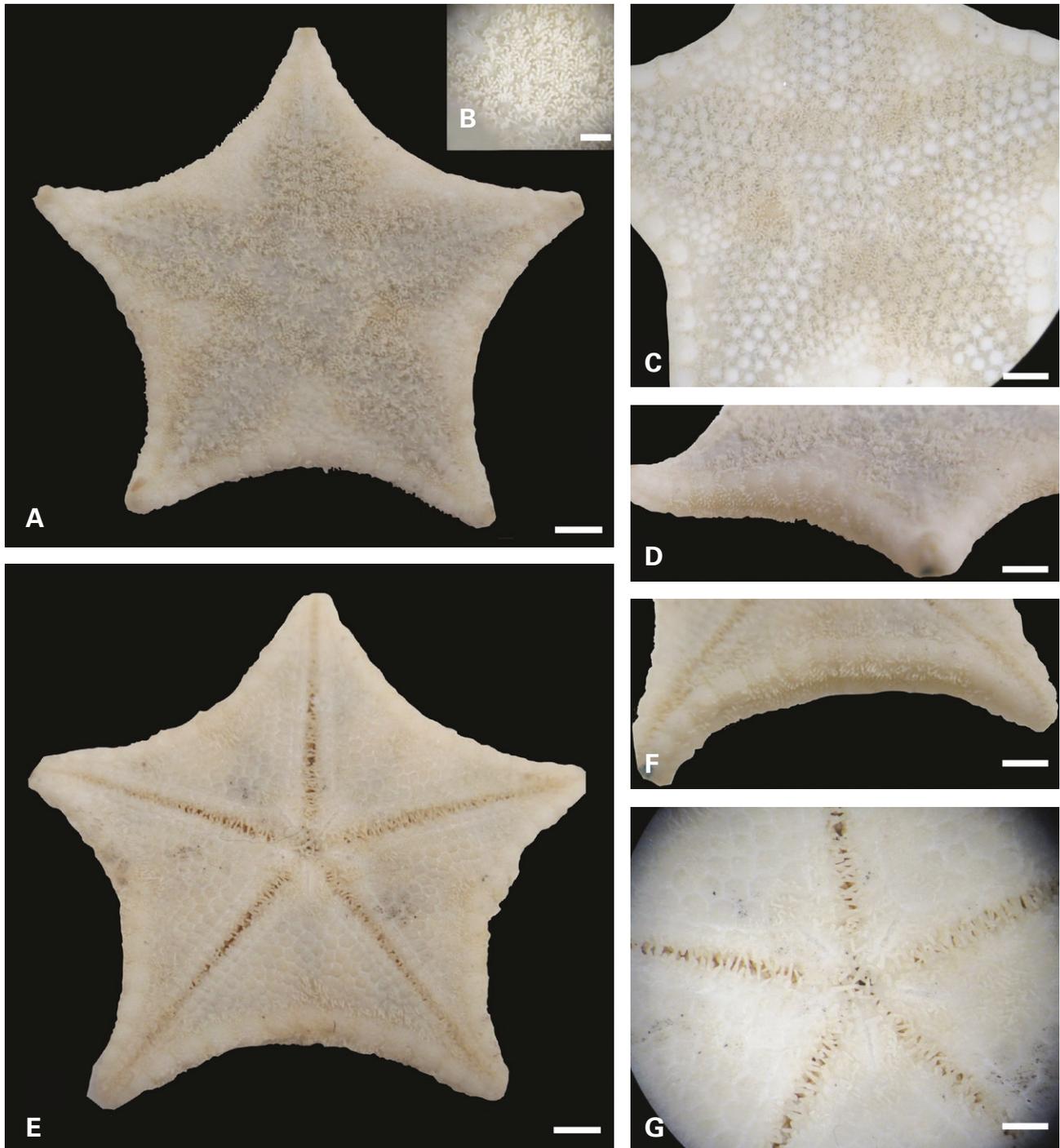
Marginal plates with convex surfaces, 16–19 per interradius at  $R = 1.4\text{--}1.8$ , each quadrate in shape with rounded edges, surfaces of both completely covered by spinelets, 50–200, essentially identical to those on abactinal plates. Spinelets with blunt tips, wide end. Supermarginal plates adjacent to terminal plates compressed, triangular shaped. Supermarginal and inferomarginal plates with rounded lateral angles, especially on the actinal-lateral angle. Inferomarginal

plates also covered by widely spaced spinelets, 50–300, identical in morphology to those on supermarginal plates. Terminal plate round, smooth.

Actinal plates composed of 3–4 full series of plates in irregularly arranged chevron-like pattern. Plates are quadrate, round to irregularly polygonal, abutted with tissue interspersed between plates. Individual plates

with widely spaced, slender spines with denticulate tips, 6–30, mostly 10–15. These spines lost during collection from many specimens.

Oral plates with 6–7 furrow spines, identical to those on adambulacral plates with a single pronounced spine directed into the mouth, paired slender spines, 6–7 on either side of the pronounced diastema present between



**FIGURE 3** *Hoplaster kupe* (NMV 241774): A) abactinal surface, scale = 2.5 mm; B) closeup of abactinal spination, scale = 2 mm; C) close up of abactinal view showing plate morphology and spination, scale = 2 mm; D) abactinal-lateral view showing abactinal and lateral spination, scale = 4 mm; E) actinal surface, scale = 2.5 mm; F) actinal-lateral view showing actinal and inferomarginal spination, scale = 2 mm; G) closeup of actinal surface, oral region, scale = 5 mm.

the two halves of the oral plates. Oral plate surface with 10–12 slender, pointed spines similar in stature to those on actinal plate surface.

Furrow spines 3–4, slender, conical and pointed, widely spaced. Subambulacral spines in two irregular rows, one series with 2–3 pointed spines, approximately 10% longer and thicker than the furrow spine and the second with shorter spines, 2–4, more similar to those on actinal plate surface.

#### OCCURRENCE

New Zealand, 1996–2062 m. In Australian waters: Tasmania, New South Wales, South Pacific region. 2298–2636 m.

#### COMMENTS

Sediment associated with the specimen suggests the bottom was composed of a fine mud.

### *Hoplaster oloughlini* Mah, sp. nov.

Figure 4A–E

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#### MATERIAL EXAMINED

##### *Holotype*

**South Pacific:** NMV F240373, southern Tasmania (-47.48, 148.50), 1056–1066 m, M. Gomon on RV *Soela*, S02-86-02, 17 March 1986, 1 wet spec. (R = 1.6, r = 0.9).

##### *Paratypes*

**South Pacific:** NMV F240360, 83.8 km SSE of South East Cape, 'J1' seamount, Tasmania (-44.27, 147.33), 987 m, T. Stranks et al., CSIRO, 3 wet specs (R = 1.5, r = 0.7; R = 1.1, r = 0.6; R = 1.1, r = 0.7); NMV F240361, 84.3 km SSE of South East Cape, 'Dory Hill' seamount, Tasmania (-44.33, 147.11), 1000 m, T. Stranks, Cruise SS01/97, St. 47, 2 wet specs (R = 1.2, r = 0.8; R = 1.3, r = 0.8). NMV F240362, 89.5 km SSE of South East Cape, 'K1' seamount (-44.29, 147.41), 1225 m, T. Stranks, Cruise SS01/97, St. 28, 3 wet specs (R = 1.3, r = 0.8; R = 1.3, r = 0.8; R = 1.3, r = 0.8). NMV F240363, 85.9 km SSE of South East Cape, 'B1' seamount (-44.31, 147.27), 1150–1552 m, T. Stranks et al., CSIRO, 5 wet specs (R = 1.2, r = 0.7; R = 1.2, r = 0.6; R = 1.1, r = 0.6; R = 1.0, r = 0.6; R = 1.1, r = 0.6); NMV F240364, 87.8 km SSE of South East Cape, 'A1' seamount, Tasmania (-44.33, 147.27), 1200–1400 m, T. Stranks, CSIRO, 2 wet specs (R = 1.1, r = 0.6; R = 0.7, r = 0.5); NMV F240365, 83.2 km SSE of South East Cape, 'Dory Hill' seamount (-44.32, 147.12), 1280–1400 m, 1 wet spec. (R = 1.1, r = 0.8); NMV F240366, 81.6 km SSE of South East Cape, '38' seamount, Tasmania (-44.23, 147.38), 1200–1400 m, T. Stranks, CSIRO, 1 wet spec. (R = 1.6, r = 0.8); NMV F240367, 89.2 km SSE of South East Cape, 'Sister 1' Seamount (-44.27, 147.29),

1100–1122 m, T. Stranks et al., CSIRO, 23 Jan 1997, 16 wet specs (R = 0.7, r = 0.3; R = 0.8, r = 0.5; R = 1.3, r = 0.8; R = 1.4, r = 0.8; R = 1.2, r = 0.8; R = 1.4, r = 0.8; R = 1.4, r = 0.7; R = 1.4, r = 0.8; R = 1.3, r = 0.8; R = 1.2, r = 0.8; R = 1.4, r = 0.8; R = 1.2, r = 0.6; R = 1.0, r = 0.6; R = 1.2, r = 0.8; R = 1.2, r = 0.5; R = 1.3, r = 0.7); NMV F240368, 82.6 km SSE of South East Cape, 'J1' seamount, Tasmania (-44.24, 147.36), 1200–1450 m, T. Stranks et al., CSIRO, 9 wet specs (R = 1.2, r = 0.7; R = 1.1, r = 0.6; R = 1.2, r = 0.7; R = 1.2, r = 0.6; R = 1.0, r = 0.6; R = 1.2, r = 0.7; R = 1.2, r = 0.7; R = 0.6, r = 0.3; R = 1.2, r = 0.7); NMV F240369, 89.2 km SSE of South East Cape, 'U' seamount, Tasmania (-44.32, 147.12), 1083–1448 m, T. Stranks et al., CSIRO, 1 wet spec. (R = 1.0, r = 0.6); NMV F240370, 81.3 km SSE of South East Cape, '38' seamount, Tasmania (-44.22, 147.38), 1140 m, T. Stranks, CSIRO, 4 wet specs (R = 1.5, r = 0.6; R = 1.3, r = 0.9; R = 1.3, r = 0.8; R = 1.3, r = 0.7); NMV F240371, 'Huon' seamounts (-44.2803, 147.138), 1260 m, RV *Southern Surveyor*, 2 wet specs (R = 1.6, r = 1.0; R = 1.1, r = 0.6); NMV F240372, East Hill, St Helens, Tasmania, Tasman Sea (-41.2431, 148.826), 1170–1380 m, RV *Southern Surveyor*, Cruise SS0308, sta. 139–013, 16 March 2008, 1 wet spec. (R = 1.3, r = 0.8); NMV F240374, 'Dory Hill' seamount, Tasmania (-44.3253, 147.112), 1180 m, R. Thresher and D.A. Staples, 1 wet spec. (R = 1.3, r = 0.7); NMV F240375, 'A1' seamount, Tasmania (-44.3225, 147.265), 1575 m, R. Thresher and D.A. Staples, 1 wet spec. (R = 1.2, r = 0.7).

#### DIAGNOSIS

Body pentagonal to weakly stellate (R/r = 1.6). Identified by the abundant, coarse, granular spinelets on the abactinal, marginal and actinal surface. Marginal plates 9–10 per interradius. Furrow spines 2 decreasing to 1 distally.

#### DESCRIPTION

Body pentagonal to weakly stellate (R/r = 1.4–1.8), interradiar arcs weakly curved. Actinal surface weakly concave, body arched.

Abactinal surface composed of abutted plates. Each plate irregularly shaped, ranging from ovate to bilobate in outline, with arched central region forming a mound-like surface. Plates with lower peripheral areas in contact forming shallow fasciolar grooves between plates. Plates with 2–15 blunt, coarse bullet-shaped strongly granuliform spinelets evenly but densely distributed on plate surface. Stature of each spinelet variable with some nearly twice as thick as most other spinelets. Tips of spinelets round and bulbous, appearing pebbly and granuliform from a distance. Approximately 2–3 counted along a 1.0 mm line. The granuliform spinelets present among plates on the abactinal surface contributing to the shallow fasciolar groove. Each plate surface covered by 2–8 embedded glassy nodules. Large papulae, 1–4 between and in depressions between plate contacts. Madreporite triangular in outline, flanked by 5–6 plates.

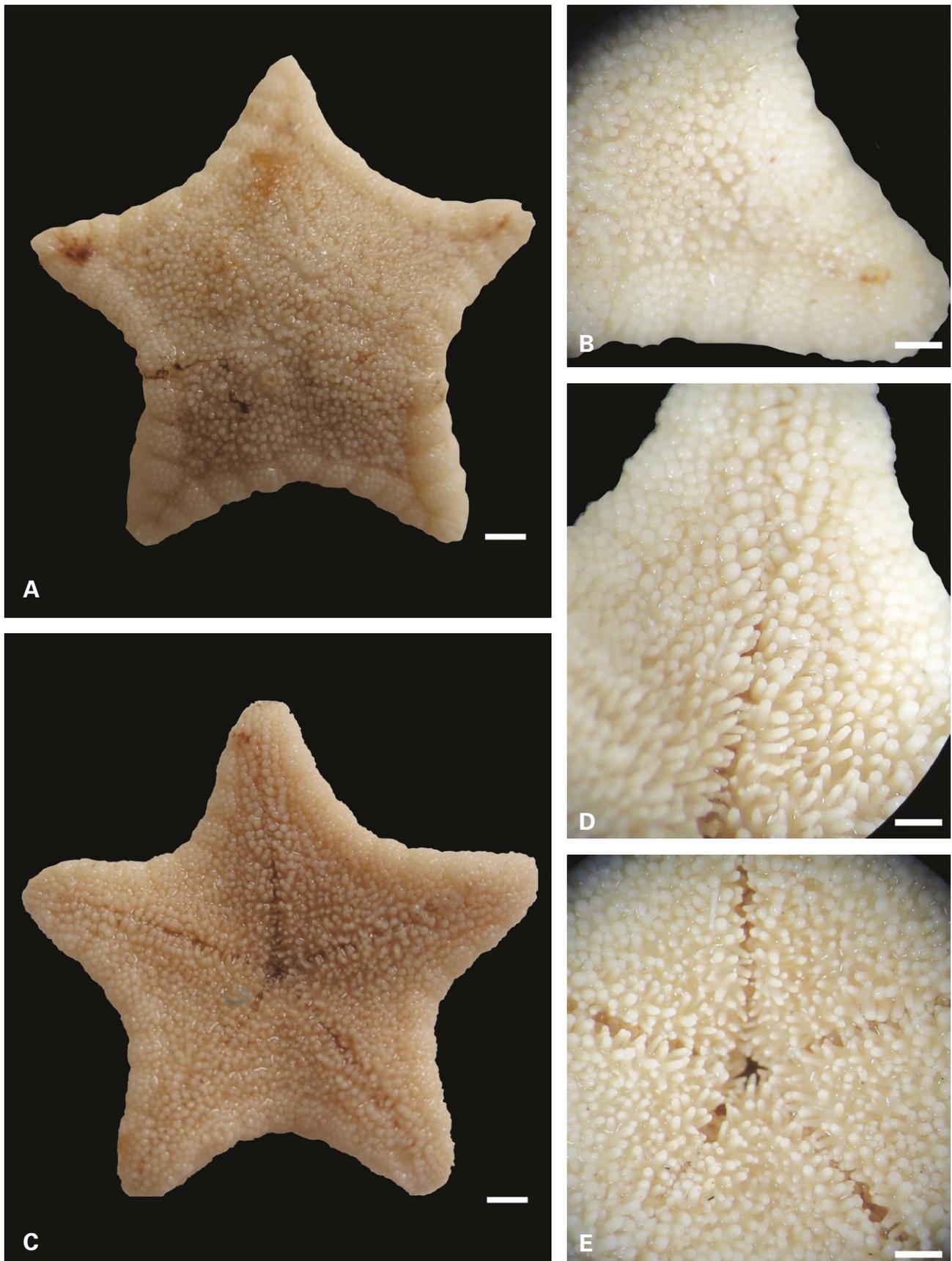


FIGURE 4 *Hoplaster oloughlini* sp. nov. holotype (NMV F240373): A) abactinal surface, scale = 3 mm; B) closeup of abactinal, marginal granules/spinelets, scale = 2 mm; C) actinal surface, scale = 3 mm; D) actinal surface showing spination/granules, scale = 2 mm; E) closeup on oral region showing furrow spines and spination, scale = 2 mm.

Superomarginal plates 9–10 per interradius, inferomarginals 8–10, corresponding 1:1 interradially becoming more offset distally. Superomarginals seven at  $R = 0.7$ . Plates quadrate in cross-section with weakly developed lateral edge. Plate surface covered by coarse, cylindrical granuliform spinelets, 30–60 per plate surface, similar to those on abactinal surface. Those on abactinal superomarginal surface identical to those on abactinal plates, but those on lateral surface slightly more pronounced, approximately two on a 1.0 mm line. Inferomarginal surface with similar distribution of coarse granuliform spinelets, larger on the lateral side and slightly smaller ones present on the actinal surface. Some inferomarginal accessories becoming quite large, with individual ossicles nearly 1.0 mm across with bulbous tips. Fasciolar groove present between marginal plates, but strongly developed between superomarginal and inferomarginal plate series. Terminal plate triangular with glassy nodules embedded on surface.

Actinal plates in irregular chevrons, with plates similar in shape to those on the abactinal surface. Irregular to quadrate in shape with convex surface, mound-like. Each plate with coarse, thick cylindrical granuliform spinelets, 1–6, with rounded tips, similar to those observed on the abactinal surface, widely spaced. Continuous with granuliform spinelets on actinal surface of adjacent inferomarginal plates.

Furrow spines two decreasing to a single spine distally, blunt but pointed, slightly.

Subambulacral spines, four (proximal) to two (distal). Subambulacrals, 3–4 times the thickness of the furrow spines, arranged proximally in a widely spaced floret pattern. Oral plates with four furrow spines, one spine directed into the mouth. Three series of spines present on the oral plate surface. Proximalmost spines two, large conical and directed into mouth, followed by four spines (i.e. two per oral plate) and then two behind it. Surface of oral plate otherwise smooth with no other accessory features (no granuliform spinelets etc.).

#### OCCURRENCE

Tasmania and seamounts in the South Pacific region. 987–1552 m.

#### COMMENTS

This species displays the most coarse granuliform-tipped spinelets among all the *Hoplaster* species. These spinelets with strongly rounded and clavate tips) expressed on the abactinal, marginal and actinal surfaces. The granule-like spinelets on the abactinal plates and marginals of *Hoplaster oloughlini* sp. nov. are most similar to those on *Hoplaster clarki* suggesting affinity between the two species.

#### ETYMOLOGY

This species is posthumously named in honor of Peter Mark O'Loughlin, Research Associate at Museum Victoria (1935–2022), who contributed greatly to the systematics and biodiversity of Australian and Antarctic Echinodermata.

### *Hoplaster spinosus* Perrier in Milne-Edwards, 1882

Figure 5A–B

*Hoplaster spinosus* Perrier in Milne-Edwards 1882: 48; 1894: 324; Verrill 1899: 197; Mortensen 1927: 77, 439; Gage et al. 1983: 278; Clark and Downey 1992: 151; Howell et al. 2002: 1911. *Pentagonaster lepidus* Sladen, 1889: 275.

#### MATERIAL EXAMINED

**North Atlantic:** (all images only) NOC 50304, Rockall Trough (56.2, -12.00), 2600 m. R.R.S. *Challenger*, 31 Oct 1978. 1 wet spec.; NOC 51603.2, Porcupine Seabight, (50.3066666667, -13.395), 2730–2740 m, RRS *Challenger*, 18 July 1982. 1 wet spec.; NOC 51611.1, Porcupine Seabight (50.2866666667, -13.4133333333), 2640–2700 m, RRS *Challenger*, 21 July 1982, 1 wet spec.; NOC 10112.1, (50.4166666667, -13.3183333333), 2640–2660 m, RRS *Discovery*, 9 September 1979, 1 wet spec.; NOC 51110.3, (50.2733333333, -13.515), 2785–2800 m, RRS *Challenger*, May 28, 1981, 1 wet spec.

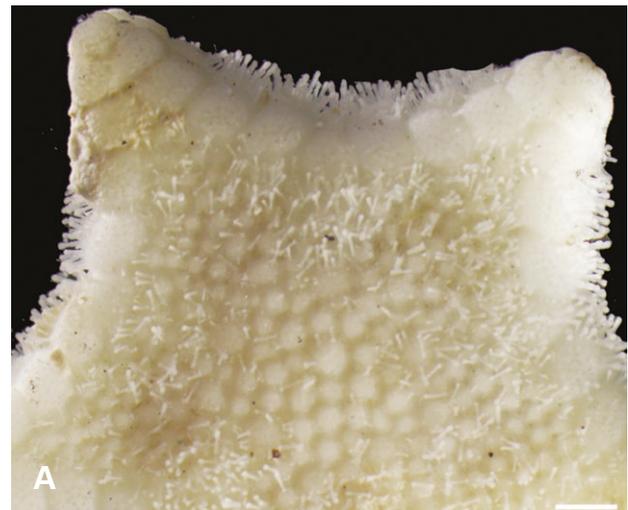


FIGURE 5 *Hoplaster spinosus*: A) abactinal surface; B) actinal surface. Scale = 1 mm.

## DIAGNOSIS

Body pentagonal to weakly stellate ( $R/r = 1.5-1.6$ ), interradial arcs weakly curved to straight. Abactinal plates with broad almost circular convex elevation with flat primary disk plates. Abactinal plates paxillate with slender clavate spinelets, 12–18. Marginal plates 9–13 per interradius, blocky with convex surface covered with crystal bodies. Odd interradial plate present, tapering. Distalmost superomarginals abutted over midline in some individuals. Marginal plate surface covered with 'papillose' clavate spinelets similar to those on the abactinal surface whereas those on the inferomarginal plates are longer and thicker. Furrow spines 3 then 2, backed by subambulacral spines, 4–5. No pedicellariae. (Based on Clark and Downey 1992; Sladen 1889; Perrier 1894). Two enlarged, recurved, non-hyaline, oral spines, one for each half plate, each of these spines with blunt tip, twice as thick as furrow spines, 20–40% taller than adjacent actinal spines, identical in texture, appearance to other actinal spines.

## OCCURRENCE

North Atlantic, Azores and south-west of Ireland up to the Rockall Trough. Cape Town, South Africa. 1795–3310 m. Howell et al. (2002) reported *Hoplaster spinosus* from the Porcupine Seabight and Abyssal Plain from 2645–2780 m. Collectively 1795–3310 m.

## COMMENTS

*Hoplaster spinosus* is thought to be the most deeply occurring of the known *Hoplaster* species, present in the lower bathyal zone at 2645–2780 m, and is distinctive, displaying the slenderest and least clavate of spinelets on the abactinal, marginal and actinal surfaces (Figure 5A–B).

Full collection data for the specimens cited below were obtained from Gordon (1978), Herring (1979), Rice (1981), and Thurston (1983).

**Genus *Marshastra* gen. nov.**

urn:lsid:zoobank.org:act:B248929E-076A-4BDC-82EA-F91956A79505

## TYPE SPECIES

*Marshastra loisetteae* sp. nov.

## DIAGNOSIS

As for genus and species by monotypy.

## COMMENTS

A new genus characterised by a more strongly stellate body shape, greater numbers of marginal plates and with a covering of fine spines on the abactinal, marginal, and actinal plate surface. The single, prominent recurved hyaline spine present on the oral plate of other members of the Odontasteridae are absent from *Hoplaster* and *Marshastra*. In addition to the oral spine character, *Hoplaster* and *Marshastra* share mound-shaped abactinal and blocky marginal plate morphology.

Compared to *Hoplaster*, *Marshastra* shows differing abactinal and marginal plate morphologies and shows a more stellate body shape. In *Hoplaster*, the actinal plate fields are larger and occupy the majority of the disk and arms. Actinal plate series in *Marshastra* gen. nov. are fewer and arranged differently from *Hoplaster* in that there is one complete series extending along the arm in addition to two incomplete series along the disk and arm. The shorter actinal plate series along the arm in *Marshastra* attenuates approximately halfway along the arm length.

## ETYMOLOGY

This new genus is named in honor of Loisetete Marsh, longtime curator of Echinoderms at the Western Australian Museum and the author of Marsh and Fromont (2020).

***Marshastra loisetteae* sp. nov.**

Figure 6A–F

urn:lsid:zoobank.org:act:30C8DB9B-5EC6-4553-94CD-5E4E1837D09D

*Hoplaster* sp. 1 McEnnulty et al. 2011: 23, 97, 171.

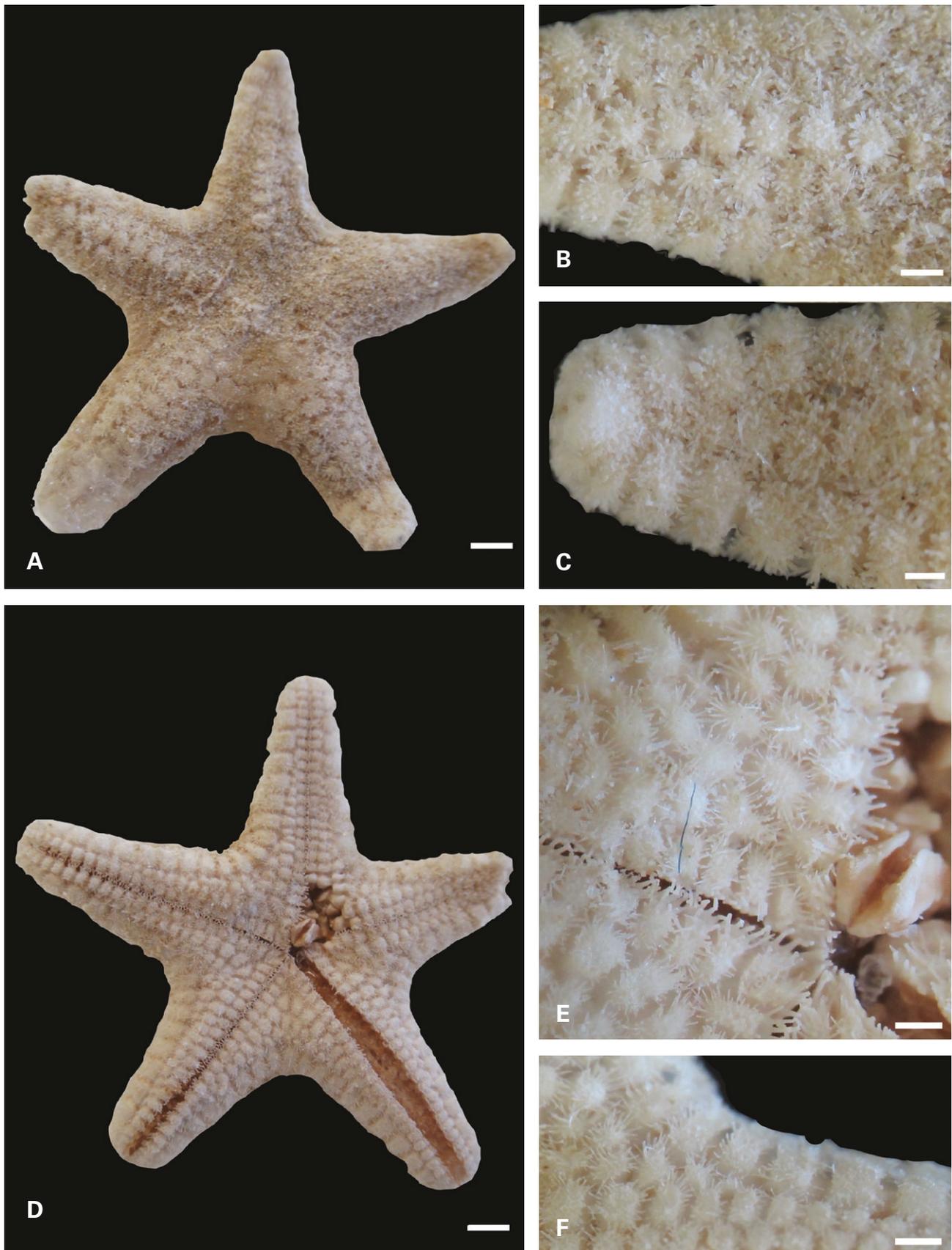
## MATERIAL EXAMINED

*Holotype*

**Indian Ocean:** WAM Z37382, Point Hillier (-35.3735, 117.1970 to -35.3734, 117.2040), 195–196 m, J. Fromont, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 1 dry spec. ( $R = 1.4$ ,  $r = 0.6$ ).

*Paratypes*

**Indian Ocean:** WAM Z37383, Mentelle (-33.9797 114.7339 to -33.9836 114.7347), 96–97 m, J. Fromont, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 1 wet spec. ( $R = 1.2$ ,  $r = 0.4$ ); WAM Z37384, Perth Canyon (-31.9208, 115.2019 to -31.9238, 115.1958), 194–232 m, J. Fromont, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 1 wet spec. ( $R = 1.7$ ,  $r = 0.7$ ); WAM Z37385, Bald Island (-35.1905, 118.6447 to -35.1875, 118.6506), 147–157 m, J. Fromont, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 1 wet spec. ( $R = 1.7$ ,  $r = 0.8$ ). WAM Z37386, Kalbarri (-27.9283, 113.1378 to -27.9336, 113.1439), 252–253 m, M. Salotti, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 3 wet specs ( $R = 2.1$ ,  $r = 0.8$ ,  $R = 2.1$ ,  $r = 0.6$ ;  $R = 1.3$ ,  $r = 0.6$ ); WAM Z37422 Zuytdorp (-35.1905, 118.6447 to -35.1875, 118.6506), 106 m, M. Salotti, CSIRO RV *Southern Surveyor* Cruise SS1005 Nov/Dec 2005, 1 wet spec. ( $R = 1.1$ ,  $r = 0.4$ ); WAM Z40690, WSW of Cape Leeuwin (-34.416806, 114.583333), 190–174 m, HMAS *Diamantina*, 1 dry spec. ( $R = 1.7$ ,  $r = 0.6$ ); WAM Z40691, NW of Green Head (-29.983333, 114.416667), 146 m, HMAS *Diamantina*, 1 dry spec. ( $R = 1.5$ ,  $r = 0.6$ ). For a complete list of specimens, especially reference vouchers. Refer to Table 1.



**FIGURE 6** *Marshastra loisetteae* gen. nov. sp. nov. holotype (WAM Z37382): A) abactinal surface, scale = 2 mm; B) closeup of abactinal surface, plates and spination, scale = 1.5 mm; C) closeup of arm tip showing surficial spination on abactinal, marginal plates, scale = 1.5 mm; D) actinal surface, scale = 2 mm; E) closeup around oral region, actinal intermediate plates showing spination, scale = 1.5 mm; F) closeup on actinal intermediate, inferomarginal plate surface, scale = 1.5 mm.

## DIAGNOSIS

Body strongly stellate ( $R/r = 2.1\text{--}3.5$ ), arms triangular with rounded tips, elongate, interradial arcs acute. Abactinal plates low, convex, each covered by 40–200 fine, spinelets forming dense cover, presenting a hirsute appearance over the surface. Marginal plates blocky, 16–24 per interradius (8 per arm side), with superomarginal and inferomarginal plates covered by dense covering of fine spinelets, 80–300. Actinal surface relatively small with approximately two actinal plates series limited to disk and only proximally on arm. Furrow spines, 6–9, remainder of adambulacral plate covered by cluster of fine spinelets, 20–60. Single, large recurved spine absent from oral plate (character which defines other Odontasteridae). Collection notes indicated a soft substrate with a high abundance of sponges, a potential prey item which would be consistent with prior accounts of food items devoured by odontasterids (Dayton et al. 1970, 1974; Dearborn et al. 1977; McClintock 1994).

## DESCRIPTION

Body stout, stellate to more strongly stellate ( $R/r = 1.1\text{--}2.83$ ). Arms triangular with rounded tips, elongate, interradial arcs acute.

Abactinal plates composed of relatively short paxillate plates bearing 40–200 fine spinelets, widely spaced over plate surface. Spinelets on central plate surface shorter than those around periphery, these appearing almost bare. Overall spinelet cover presents abactinal surface with hirsute appearance. Paxillar plates themselves with convex surfaces. Plate size, shape overall is homogeneous across disk and arms. Carinal plates distinct with approximately two series of adradial plates, pinch out adjacent to armtip.

Marginal plates 8–12 per arm side, 16–24 per interradius (arm tip to arm tip), well-developed fascicles present between superomarginal and inferomarginal plate contacts. Superomarginal plates tumid wide, larger in size than inferomarginal plates, forming curved angle between abactinal and lateral surface, blocky shape. Pre-terminal superomarginals slightly larger than plates preceding presenting appearance of a thickened arm tip. Superomarginal plates covered by fine spinelets, 80–300 similar to those on abactinal surface, widely spaced over the surface, but more densely arranged, perhaps 20–40 per side at each contact between plates. Inferomarginal plates also wide, similarly covered in fine spinelets with comparable numbers. Terminal plates triangular in shape.

Actinal surface of two full series, one incomplete, composed of irregular plates adjacent to contact with inferomarginal plates. Individual plates round to approximately quadrate in shape, each bearing fine spinelets, 20–100 per plate, with denticulate, bifid to multifid tips projecting from plate surface, widely spaced. Well-developed fascolar channels between actinal plates present. One actinal plate series extends onto proximal arm region, disappearing halfway along arm.

Furrow spines fine, 6–9 in straight to palmate series, interlacing with spines on opposite side of ambulacral furrow. Furrow spine number increases distally. Distinct space behind furrow spines, adambulacral plate covered by cluster of fine spinelets, 20–60, identical to those on actinal plate surface. Oral plates with six furrow spines, elongate, slender, and a distinct ridge flanking the diastema between both oral plates, plate surface otherwise covered by fine spinelets similar to those on actinal plates. No large recurved spines on oral plates. Colour in life, abactinal surface light to deep orange, actinal surface light yellow with orange highlights.

## OCCURRENCE

Known from along the shelf of Western Australia, including the Houtman Abrolhos, Cliff Head, Dongara, Jurien Bay, Cervantes, Green Island, Guilderton, Rottnest Island, Bunbury, off Cape Leeuwin, off Fremantle, Beagle Island, and Lancelin Island. 96–253 m.

## COMMENTS

*Marshastra loisettae* gen. nov. sp. nov. occurs at much shallower depths, 96–253 m, than *Hoplaster*, 900–1500 m, and is the first odontasterid known from temperate to subtropical latitudes in the Indian Ocean. This is in contrast to high-latitude/Antarctic odontasterids from Kerguelen and adjacent waters [e.g. *Odontaster penicillatus*, *Acodontaster hodgsoni*, e.g. from Feral et al. (2019)]. This species has been previously identified in reports on Australian benthic faunas as 'cf. *Hoplaster*' (e.g. McEnnulty et al. 2011).

## ETYMOLOGY

The genus and species honors Loisetta Marsh (1928–2021), a long-time researcher of echinoderms and marine zoology in Australia at the Western Australian Museum (1970–1993).

## DISCUSSION

### PHYLOGENETIC CONTEXT

*Marshastra* gen. nov. is argued as the sister taxon to *Hoplaster*, which was supported as the sister clade to the typological *Acodontaster* clade (Janosik and Halanych 2013). Based on the Janosik and Halanych topology, *Hoplaster* is derived, with the oral tooth spine character argued as a loss relative to the presence of oral spines among stemward odontasterids such as *Diplodontias* and *Eurygonias*. Thus, it is argued that Figure 1 shows support for *Marshastra* and *Hoplaster* as separate but closely related genera, closely related taxa relative to *Acodontaster*. *Hoplaster* and *Marshastra* share the absence of a recurved oral spine and display similarities in abactinal and marginal plate shape and arrangement. Based on the implied position in the phylogeny by Janosik and Halanych (2013), this suggests that the loss of the oral spine is also a derived loss in *Marshastra*. However, it was beyond the scope of this study to survey and test relationships with other Odontasteridae, and further work is in preparation.

TABLE 1 List of *Marshastra loisetteae* types and vouchers.

WAM Z	R	r	R/r	Locality (all Western Australia)	Depth in m	Specimen Type
Z37382	1	1	1.86	Point Hillier	195–196	Holotype
Z37383	2	1	2.83	Mentelle	96–97	Paratype
Z37384	2	1	2.71	Perth Canyon	194–232	Paratype
Z37385	2	1	2.14	Bald Island	147–157	Paratype
Z37386A	2	1	2.13	Kalbarri	252–253	Paratype
Z37386B	2	1	2.63	Kalbarri	252–253	Paratype
Z37386C	2	1	2.71	Kalbarri	252–253	Paratype
Z37422	1	1	1.60	Zuytdorp	106	Paratype
Z40690	2	1	2.83	WSW of Cape Leeuwin	174–190	Voucher
Z40691	2	1	2.50	NW of Green Head	146	Voucher
Z40692	1	1	2.20	NW of Green Island	137–144	Voucher
Z40693	1	1	2.40	c. 13 km W of Wooded Island, Houtman Abrolhos	150	Voucher
Z40694	1	0	2.00	40 km W of Jurien Bay	165	Voucher
Z40695	2	1	2.29	NW of Bunbury	161–165	Voucher
Z40696A	1	1	2.33	Off Lancelin Is.	115–119	Voucher
Z40696B	2	1	2.13	Off Lancelin Is.	115–119	Voucher
Z40697	1	1	2.80	W of Rottneest Island	182	Voucher
Z40698	1	1	2.00	W of Guilderton	146	Voucher
Z40699	1	1	1.86	WSW of Dongara	108	Voucher
Z40700	2	1	2.14	WNW of Lancelin	183	Voucher
Z40701	1	1	2.00	NW of Rottneest Island	155	Voucher
Z40702	1	1	2.00	NW of Rottneest Island	155–163	Voucher
Z40703	1	1	2.00	W of West end, Rottneest Island	155–163	Voucher
Z40704	1	1	2.20	NW of Rottneest Island	177–185	Voucher
Z40705A	1	1	2.17	WNW of Rottneest Island	155	Voucher
Z40705B	1	1	2.00	WNW of Rottneest Island	155	Voucher
Z40706A	1	1	2.60	Off Fremantle	120	Voucher
Z40706B	1	1	1.83	Off Fremantle	120	Voucher
Z40707	1	0	2.33	Off Fremantle	137	Voucher
Z40708	2	1	2.43	Off Beagle Island	135	Voucher
Z40709	1	0	2.75	Off Fremantle	137	Voucher
Z40710	1	1	2.20	Off Fremantle	137	Voucher
Z40711	1	1	1.86	Off Murchinson	108	Voucher
Z40712	1	1	2.00	Off Murchinson	108	Voucher

WAM Z	R	r	R/r	Locality (all Western Australia)	Depth in m	Specimen Type
Z40713A	2	1	2.86	Off Beagle Island	135	Voucher
Z40713B	2	1	1.88	Off Beagle Island	135	Voucher
Z40714A	2	1	2.25	Off Beagle Island	135	Voucher
Z40714B	2	1	2.14	Off Beagle Island	135	Voucher
Z40715A	2	1	2.29	Off Beagle Island	135	Voucher
Z40715B	2	1	2.25	Off Beagle Island	135	Voucher
Z40715C	1	1	2.00	Off Beagle Island	135	Voucher
Z40716	2	1	2.13	Off Lancelin Island	119	Voucher
Z40717	2	1	2.22	Off Lancelin Island	119	Voucher
Z40718	1	1	1.75	Off Lancelin Island	128–137	Voucher
Z40719	2	1	2.13	Off Jurien Bay	146	Voucher
Z40720A	2	1	2.29	NW of Rottnest Island	146	Voucher
Z40720B	1	1	2.33	NW of Rottnest Island	146	Voucher
Z40720C	1	1	2.40	NW of Rottnest Island	146	Voucher
Z40720D	1	0	2.75	NW of Rottnest Island	146	Voucher
Z40721	1	0	1.66	W of Easter Group, Houtman Abrolhos	183	Voucher
Z40722	1	1	2.40	NW of Green Island	146	Voucher
Z40723A	2	2	1.16	Off Cervantes	139–146	Voucher
Z40723B	2	1	2.50	Off Cervantes	139–146	Voucher
Z40723C	2	1	2.71	Off Cervantes	139–146	Voucher
Z40723D	2	1	3.20	Off Cervantes	139–146	Voucher
Z40723E	1	1	2.60	Off Cervantes	139–146	Voucher
Z40724	2	1	2.29	c. 79 km W of Cliff Head	183	Voucher
Z40725A	2	1	2.50	c. 40 km W of Jurien Bay	137.2	Voucher
Z40725B	1	1	1.80	c. 40 km W of Jurien Bay	137.2	Voucher
Z40726	2	1	2.75	c. 40 km W of Jurien Bay	137.2	Voucher
Z40727	1	1	2.00		117	Voucher
Z40728A	2	1	2.29	SW of Jurien Bay	146	Voucher
Z40728B	2	1	1.88	SW of Jurien Bay	146	Voucher
Z40729A	1	1	2.33	SW of Jurien Bay	146	Voucher
Z40729B	2	1	2.43	SW of Jurien Bay	146	Voucher
Z40729C	2	1	2.43	SW of Jurien Bay	146	Voucher
Z40730A	2	1	2.83	SW of Jurien Bay	146	Voucher
Z40730B	2	1	2.25	SW of Jurien Bay	146	Voucher
Z40730C	2	1	2.29	SW of Jurien Bay	146	Voucher

## BIOGEOGRAPHY

The proposed phylogenetic tree (Figure 1) shows *Marshastra loisetteae* at present known only from off the coast of Western Australia as the putative sister taxon to *Hoplaster*, a clade containing species including an Atlantic/South African lineage and a further complex throughout the South Pacific region of Tasmania and New South Wales to New Zealand. Based on the phylogenetic tree, *Hoplaster spinosus* diversified in Atlantic deep-sea settings adjacent to events in the South Pacific in the Australian/New Zealand region. The tree topology suggests a northward diversification into the Atlantic relative to specimens from South Africa, but South African specimens were not examined and further sampling from this area is desirable. A broadly similar pattern was observed among genera within the Pentagonasterinae, which showed the South African-Atlantic goniasterid *Toraster* as the sister clade to *Tosia* and *Pentagonaster*, which had undergone diversification in Australia and Australia-New Zealand, respectively (Mah 2007).

Species patterns among *Hoplaster* species surveyed from Australian and New Zealand seamounts and adjacent areas are difficult since localities are incompletely sampled. However, O'Hara (2007) tested seamount-related diversity hypotheses in the South Pacific, surveying a diversity of invertebrate taxa and found that although endemic diversity could be high, in general they reflected the faunas from surrounding areas. Further sampling and understanding of seamount habitats will yield further insight into the *Hoplaster* species in this region.

## BATHYMETRIC PATTERNS

Bathymetric shifts, primarily from shallow to deep-water settings, are perceived at different scales among Odontasteridae as treated herein. These are largely 'onshore-offshore' trends, as postulated by Jablonski and Bottjer (1988) who argued for the origination of deep-water lineages from shallow-water taxa. Onshore-offshore trends have been reported in asteroids on different scales. For example, within the Forcipulatacea (Mah and Foltz 2011b), within the deep-sea Brisingida (Mah 1998, 1999) as well as within the Goniasteridae at the species level (Mah 2005). The opposite, offshore-onshore trends (deep-sea settings as the origination of shallow-water taxa) have also been observed (Mah 2007).

Stemward Odontasteridae such as *Eurygonias* and *Diplodontias* appear to be present in Australian and/or New Zealand waters in relatively shallow water settings (0–10 and 0–100 m respectively, as per H.E.S. Clark and McKnight 2001). If *Marshastra* + *Hoplaster* are supported as the sister lineage to *Acodontaster* species (following Janosik and Halaynych 2013), considering the more stemward, deep-water *Acodontaster capitatus*

(193–700 m as per A.M. Clark 1962) this would imply a shift from shallow-water to deep-water settings for the 'untoothed' + *Acodontaster* odontasterid clade.

Figure 1 outlines bathymetry patterns among the 'untoothed' Odontasteridae. *Marshastra* is known only from continental shelf/margin habitats (e.g. McEnulty et al. 2011) from relatively shallow depths (96–253 m) whereas *Hoplaster* was collected from deeper-water settings (730–3310 m). The Atlantic/South African *Hoplaster spinosus* shows the broadest and deepest depth distribution (1795–3310 m). The Australian/New Zealand *Hoplaster* species were collected from a slightly shallower depth range (730–2062 m). *Hoplaster* may have diversified at deeper depths relative to the shallower water *Marshastra*.

*Hoplaster kupe* was collected from the deepest depth (1996–2062 m) and showed greatest number of marginal plates ( $n = 16$ – $19$ ), including much finer spination present on abactinal, marginal and actinal surfaces in contrast to *Hoplaster oloughlini* sp. nov. which occurs at the shallowest depth (730–1030 m) but displays thicker and heavier spination but with fewer marginal plates. Calcification of the endoskeleton in these taxa may show some association with depth or depth-related factors.

## ORAL PLATE SPINES

*Hoplaster* and *Marshastra* gen. nov. lack the diagnostic recurved hyaline tipped oral spine present in other odontasterid genera. Although reported as a diagnostic character in numerous accounts (e.g. Fisher 1910; Dearborn 1977; Janosik and Halaynych 2013; Pearse 2013), the function of this pronounced recurved tooth has never been documented. An extensive review of *Odontaster validus* (Pearse 2013) reviewed feeding and ecology but with no mention of a specific predatory mechanism. The presence of a similar recurved oral spine or 'tooth' in other spongivorous asteroids, such as *Odontohenricia* and *Pteraster* spp. (Rowe and Albertson 1988; Clark and Downey 1992 respectively) suggests that such a spine is relevant to predation, perhaps to assist in the scraping of sponge tissue into the mouth.

Phylogenetic accounts (Janosik and Halaynych 2013) show that *Hoplaster* occurs in a derived position, which implies that the oral spine absence is an apomorphic or derived loss rather than a plesiomorphic absence. Although it is argued here that *Hoplaster* and *Marshastra* are sister taxa, further evidence could show that is not the case, and that it is possible that the absent recurved hyaline tooth has a different status in *Marshastra*.

Two species, *Hoplaster clarki* and *Hoplaster spinosus*, possess a pair of enlarged oral spines in each interradius, with a single spine on each oral plate (Figures 2F, 5B). These spines are twice as thick and approximately 20–30% longer than adjacent furrow and actinal spines and are reminiscent of the large, recurved hyaline spine present in other odontasterids, especially *Diplodontias*,

which displays two large, recurved spines with hyaline tips. Further phylogenetic evidence could result in a different topology implying different relationships within *Hoplaster* and the Odontasteridae. Further ecological data showing these enlarged oral spines might further elucidate their function.

### TAXONOMIC CONCLUSIONS

1. *Marshastra loisetteae* gen. nov. sp. nov. from Western Australia and *Hoplaster oloughlini* sp. nov. from Tasmanian seamounts, both family Odontasteridae are described from Australian waters.
2. *Diabocilla* McKnight, 2006 is a junior synonym of *Hoplaster* Perrier in Milne-Edwards, 1882.

### ACKNOWLEDGEMENTS

This paper is dedicated to Loisette Marsh and Mark O'Loughlin whose work has been instrumental in understanding echinoderm diversity in Australian waters. My visit to Perth and the Western Australian Museum was supported by a Fellowship awarded by the Western Australian Museum Foundation for which I owe a huge debt of gratitude. Logistics and further support for this visit was facilitated by Dr. Zoe Richards, and Museum Technical Officer Oliver Gomez. Further assistance with measurements was performed by Mr. Liam Bailey to whom I am very grateful. Dr. Tim O'Hara provided financial support for several visits to the Museum Victoria, providing assistance with logistics and hospitality. 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. Ms. Kate Neill of the New Zealand Institute of Water and Atmosphere (NIWA) graciously provided photos of the holotype of *Diabocilla clarki*. Dr. Tammy Horton Research Scientist and Discovery Collections Manager at the Discovery Collections at the National Oceanography Centre at Southampton provided invaluable photographs of *Hoplaster spinosus*. I thank the captains and crews of the RRS *Challenger*, RRS *Discovery*, and RRS *James Cook* on the many cruises to the Porcupine Abyssal Plain Sustained Observatory since 1985, and we are particularly grateful to the benthic teams on all cruises for their assistance in collecting and preserving the samples. The crew and scientists on board the RRS *James Cook*, during the ECOMAR cruises 2007–2010 are further thanked for collecting samples. In particular we are very grateful to Ben Boorman, and Alan Hughes for operating the baited traps and dealing with the samples at sea. Dr. Daniel Blake, University of Illinois, Urbana-Champaign and Dr. Loïc Villier, Sorbonne Université, as always, provided critical reviews and useful insights which significantly improved the manuscript.

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## APPENDIX Morphological character data.

<b>Morphological data matrix</b>	'OG: <i>Acodontaster capitatus</i> '	0001001100120000011
	'OG: <i>Chaetaster vestitus</i> '	1220110020001000001
	<i>Hoplaster oloughlini</i> sp. nov.	0011022102121111110
	<i>Hoplaster clarki</i>	1112022102221111120
	<i>Hoplaster kupe</i>	1112022010211011220
	<i>Hoplaster spinosus</i>	1110022011011011200
	<i>Marshastra loisetteae</i> gen. nov. sp. nov.	1210112020011000001

**Morphological character matrix and character states**

1.1 Abactinal spinelets granuliform	0-present, 1-absent
1.2 Abactinal spinelets	0-absent spinelets, 1-clavate, 2-denticulate
1.3 Abactinal plate morphology	0-flat, 1-mound-like, 2-paxillate
1.4 Abactinal spinelet gauge	0-fine, 1-heavy, 2-moderate
1.5 Abactinal accessory type	0-non-denticulate, 1-denticulate
1.6 Abactinal spinelet number	0-absent, 1-numerous, 2-moderate
2.1 Marginal plate shape	0-paxillate, 1-mound, 2-blocky
2.2 Marginal granules	0-absent, 1-present
2.3 Marginal spinelets	0-absent, 1-non-denticulate, 2-denticulate
2.4 Marginal plate number per interradius	0-high (15–24), 1-moderate (15–19), 2-low (9–13)
2.5 Marginal spinelet gauge	0-fine, 1-heavy, 2-moderate
3.1 Actinal accessory type	0-granuliform, 1-pointed spine, 2-blunt spine
3.2 Recurved oral spine	0-present, 1-absent
3.3 Oral furrow spines	0-six or so, 1–4 or so
3.4 Furrow spine number	0-high (6 or more), 1-low (2–3)
3.5 Subambulacral spines	0-high (20–60), 1-low (2–5)
3.6 Actinal spine number per plate	0-high (n = 20–100), 1-low (n = 1–7), 2-moderate (6–30)
3.7 Actinal spinelet gauge	0-fine, 1-heavy, 2-moderate
4.1 Body shape	0-pentagonal to weakly stellate (R/r = 1.1–1.7), 1-strongly stellate (R/r ≥ 2.1)