

A new species of *Thromidia* (Echinodermata: Asteroidea) from Western Australia

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Abstract – A fourth species of *Thromidia*, *T. brycei* sp. nov. is described in the family Mithrodiidae. *Thromidia brycei* is found on the inner continental shelf of Western Australia from the Houtman Abrolhos Islands to north of 80 Mile Beach, west of Broome.

INTRODUCTION

The genus *Thromidia* was described by Pope and Rowe (1977) for two new species in the family Mithrodiidae, *T. catalai* Pope and Rowe, 1977 from New Caledonia and *T. seychellesensis* Pope and Rowe, 1977 from the Seychelles Islands; *Mithrodia gigas* Mortensen, 1935 from South Africa was transferred to the new genus as it shares the characteristics of being a large, obese mithrodiid, lacking the rows of large abactinal and lateral spines of *Mithrodia*.

Since 1978 eight specimens which, despite their difference in colour from *T. catalai* were thought to represent the young of that species, were collected off north-western Australia. A ninth specimen, comparable in size with the type specimen of *T. catalai*, collected off the Houtman Abrolhos, Western Australia, made it apparent that the Western Australian specimens were not conspecific with any of the three previously described species and are here described as a new species, *Thromidia brycei*.

The family Mithrodiidae was included in the order Spinulosida by Spencer and Wright (1966) and earlier authors and by Pope and Rowe (1977). Blake (1980, 1981) regarded the Mithrodiidae as a sub-family (Mithrodiinae) of the Ophidiasteridae in the Valvatida but in 1987, on the basis of cladistic analysis of skeletal characters, he restored the Mithrodiidae to family status with close affinities to Ophidiasteridae, and restricted the Spinulosida to a single family the Echinasteridae. A.M. Clark (1993) and Rowe and Gates (1995) follow Blake's classification, the course followed in this publication.

METHODS

All specimens were in the dry invertebrate collections of the Western Australian Museum,

collected by trawling and scuba diving off north Western Australia. Paratypes have since been distributed to other museums as indicated under material examined. Abbreviations of these institutions are BMNH, Natural History Museum, London; USNM, United States National Museum at the Smithsonian Institution, Washington; BPBM, Bernice P. Bishop Museum, Honolulu, Hawaii; AM, The Australian Museum, Sydney, NSW; WAM, Western Australian Museum, Perth.

Abbreviations for measurements are: R, major radius from disc centre to arm tip; r, minor radius from disc centre to edge of disc; br, breadth of arm at base. All measurements are in mm.

Specimens were dried after formalin fixation and examined by hand lens and a Zeiss stereo dissecting microscope.

Order Valvatida Perrier, 1884

Family Mithrodiidae Viguiet, 1878

Genus *Thromidia* Pope and Rowe, 1977

Thromidia Pope and Rowe, 1977: 202–203

Type species

Thromidia catalai Pope and Rowe, 1977 by original designation.

Thromidia brycei sp. nov.
Figures 1–3

Material examined

Holotype

Australia: Western Australia: off the north-western corner of the Pelsaert Group, Houtman Abrolhos, 28°50.48'S, 113°48.81'E, 19 April 2000, C.

Bryce, scuba at 43 m, rock, sand, sponges, red algae and corals (WAM Z1716).

Paratypes

Australia: Western Australia: Paratype 1: north-western Australia, 53 nm (115 km) N of "Wallal Downs", 80 Mile Beach, 18°44'S, 120°37'E, 2 June 1978, CSIRO on *Courageous*, 70 m (AM J24581). **Paratype 2:** Western Australia, north-east of the Montebello Islands, 20°20'S, 115°38'E to 20°19'S, 115°39'E, 5 December 1979, S. Slack-Smith and L. Marsh on *Soela*, stn S01/79/42, otter trawl, 52 m, sponges, Alcyonacea, gorgonians (BMNH 2001.6801). **Paratype 3:** Western Australia, outside reef north of North West Island, Montebello Islands, 20°20.9'S, 115°29.4'E, 13 August 1993, P. Berry *et al*; scuba at 17 m, algal covered pavement (USNM 1114791). **Paratype 4:** Western Australia, NE of the Montebello Islands, 20°20'S, 115°41'E to 20°21'S, 115°39'E, 5 December 1979, S. Slack-Smith and L. Marsh on *Soela* stn S01/79/40, otter trawl, 55–53, large sponges and Alcyonacea, (BPBM-W3734). **Paratype 5:** Western Australia, 67 nm NNW of Dampier, 19°33.1'S, 116°30.2'E to 19°33.1'S, 116°26.5'E, 30 September 1982, L. Marsh and M. Bezant on *Soela*, stn S05/82/33, otter trawl, 74–82 m, sand (WAM Z13369). **Paratype 6:** Western Australia, NE of the Montebello Islands, 20°05'S, 115°48'E, 8 November 1981, J. Marek, from Taiwanese trawler, trawled c 73 m (WAM Z13372).

Other material

Australia: Western Australia: AIMS North West Cape Survey stn 1030802 15 nm NNE of North West Cape, 21°32.72'S, 114°15.78'E, dredged, 149 m, mud with Bryozoa and crinoids, 8 March 2001 (WAM Z12020); west of Carnarvon, trawled 73 m, 1977, R. Walker, on *Miss Boomerang* (WAM Z13374).



Figure 1 *Thromidia brycei* sp. nov. on algae and sponge covered rock substrate at 45 m, off the Houtman Abrolhos Islands.

Diagnosis

Thromidia brycei is generally a large obese species of *Thromidia* with a fairly small disc, R/r (dry) is up to 280/39 mm and R ranges from about 6 to 8 r; the five arms are more or less constricted at the base, widest at about 40 mm from base then taper to a usually slightly pointed tip; the body is covered by thick skin over a reticulate skeleton bearing tubercles 1–2.5 mm in height, covered by granules, the apical ones are usually convex, those on the sides pointed; minute spinelets between the tubercles are usually conical with sharp points; the tubercles continue at the same size and density to the arm tips; papular areas between the skeletal meshes are small, triangular to irregular in shape, rarely more than 5 mm in diameter with 12–30 pores and are present on the disc, abactinal and actinal surfaces of the arms; in places the papular areas appear confluent, with up to 60 pores and small tubercles which arise from skeletal trabeculae subdividing the papular areas in large animals. The furrow spines are in a webbed fan of usually 11 spines, mid-arm, their tips covered in granules in the larger animals, there is one subambulacral spine per plate, granule covered except for part of the side nearest the furrow spines; a smaller, often thicker actinal spine or tubercle is opposite every 2nd to 4th subambulacral spine, sometimes there is another incomplete row of enlarged actinal tubercles; the rest of the actinal surface is covered in tubercles as on the abacterial surface; pedicellariae of four or five, slender, upright valves, are found between the subambulacral and actinal rows of spines and are often also present on the general actinal surface, sometimes also on the abactinal surface of the disc and arms, occasionally pedicellariae are lacking altogether; the colour is variable, usually light pink to light brown, mottled with dark brown, arm tips undifferentiated; a few specimens are orange-pink with dark arm tips. Tubercles yellow to white.

Description

Holotype (WAM Z1716)

A large, obese species with a small disc, five arms constricted at base; after preservation and drying, R = 270, 300, 295, 270, 260 (mean 279 mm), r = 40, 37, 32, 40, 45 (mean 38.8 mm), R = 7.2 r, br at arm base is 40 mm (mean), at 40 mm from arm base it is 53 mm (mean) (Figures 1, 2A). The skeleton, covered by thick skin, is composed of small plates linked by radiating trabeculae (Figure 2A); each plate and the larger trabeculae have an indented boss to which the tubercles are articulated; marginal plates are indistinguishable from other skeletal plates; abactinal tubercles are 2–2.5 mm high by 1.3 mm diameter, covered apically by rounded polygonal granules and on their sides by small,

pointed granules, sometimes scale like; the skin between the tubercles and in the papular areas is covered by minute spinelets or pointed thorny granules. The abactinal tubercles continue at the same size and density to the arm ends (Figure 2B). Papular areas in the skeletal reticulum are irregular in shape and size, near the arm base they are 2–5 mm in diameter, at mid-arm some are 6 mm, often they are ill-defined and some have tubercles within attached to skeletal trabeculae; small papular areas have c. 12 papular pores, large confluent areas have up to 60 pores. On the actinal surface the tubercles are larger, up to 4 mm high, and more widely spaced, with smaller tubercles between them, sometimes in indistinct rows, at right angles to the ambulacral furrow. The furrow spines are in fans of 11–13, the outer ones very small, the larger ones are granule covered only near the tips (Figures 2C and 3B), there is one large, 5.0 by 1.3 mm, partly bare subambulacral spine per plate, rarely a small second spine, behind these is a row of irregular sized granule covered spines up to 3.5 by 1.5 mm opposite every second or third subambulacral spine; pedicellariae, in the form of a cluster of four or five erect spinelets (Figure 3C), are found

between the subambulacral and outer row of spines and are also scattered on the actinal surface. The oral plates carry a continuation of the furrow spines with granule-covered sub-oral spines. Contraction of the specimen makes it impossible to see details in the holotype. The madreporite is concealed by spines within a fold of the disc.

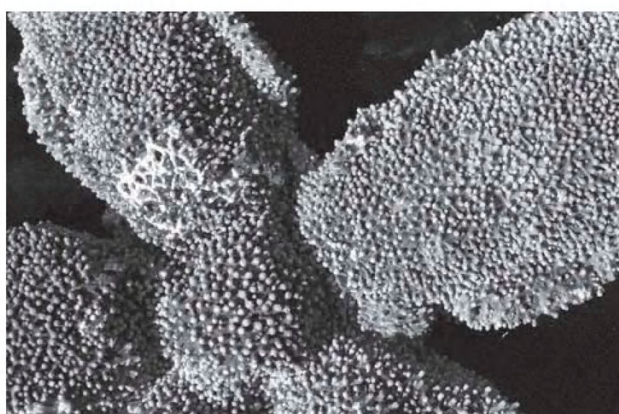
Colour (alive)

Pinkish cream with large brown blotches on disc and arms. Dry (after formalin fixation): the disc and arms are grey-brown irregularly blotched with dark brown, arm ends not differentiated in colour.

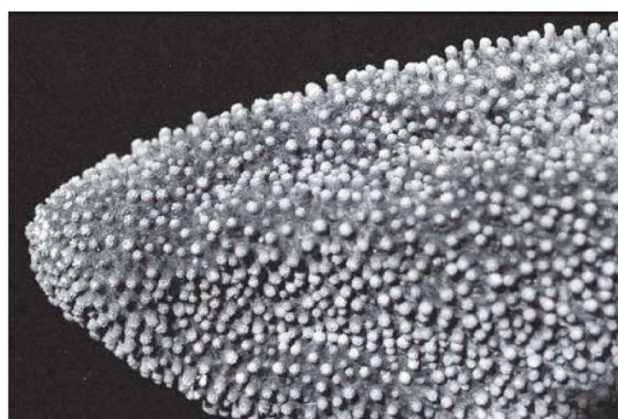
Habitat and distribution

Thromidia brycei is found on sand, mud or rock usually with red and brown algae or encrusting organisms and often with large sponges, gorgonians and alcyonaceans, from 17 to 149 m but most specimens are from 40–80 m. *T. brycei* is believed to be an endemic north-western Australian species, so far found from the Houtman Abrolhos (28°44'S) to north of 80 Mile Beach (18°44'S).

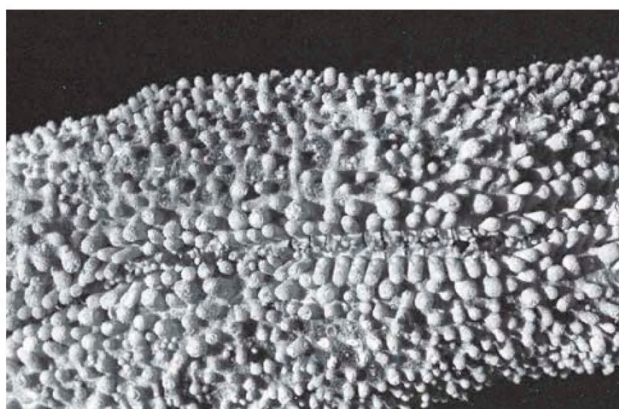
Data for variable characters of all specimens of *T.*



A



B



C



D

Figure 2 *Thromidia brycei* sp. nov.: A–C, holotype, WAM Z1716 (dry): A, with small area cleaned to show skeletal meshes; B, arm tip showing even-sized tubercles extending to end; C, actinal surface showing furrow spines (see also Figure 3B of paratype 5 [WAM Z13369]); D, abactinal surface of paratype 1 (AM J24581), dry.

Table 1 Variable characters of *T. brycei* sp. nov., *T. catalai*, *T. seychellesensis* and *T. gigas*, all measurements in mm, except depth (m). 0 = absence, – = no data

| <i>Thromidia brycei</i> | R/r | R range (mean) | r range (mean) | br at arm base (mean) | br at 40 mm from base (mean) | Abact. tubercules height x diameter | No of furrow spines mid-arm | Subamb. spines height x diam. | Enlarged actinal spines, height x diam. | Papular areas max. size mm | Arm tips | Depth |
|---|------|-----------------|----------------|-----------------------|------------------------------|-------------------------------------|-----------------------------|-------------------------------|---|----------------------------|------------------|---------|
| Holotype (WAMZ1716) Houtman Abrolhos, WA | 7.2 | 260–300 (279) | 32–45 (38.8) | 35–45 (40) | 45–60 (53) | 2.5 x 1.3 | 11 | 5.0 x 1.3 | 5.0 x 1.8 | 6 | undifferentiated | 43 m |
| Paratype 1, (AM J24581) N of 80 Mile Beach, WA | 6.56 | 220–238 (229.6) | 30–40 (35) | 30–40 (35) | 55–58 (56.5) | 2.0 x 0.8 | 11–13 | 6.0 x 1.5 | 5.0 x 2.2 | 4 | undifferentiated | 70 m |
| Paratype 2, (BMNH 2001.6801) NE Montebello Is, WA | 8.15 | 200–220 (209.3) | 25–27 (25.6) | 25–30 (28.3) | 35–38 (36.6) | 1.5 x 0.7 | 11 | 4.5 x 1.6 | 3.7 x 1.8 | 4 | undifferentiated | 52 m |
| Paratype 3, (USNM 114791) N of Montebello Is, WA | 6.4 | 170–185 (176.2) | 25–30 (27.5) | 27–35 (31.8) | 35–40 (38.2) | 1.6 x 0.8 | 11 | 4.0 x 1.3 | 3.8 x 2.0 | 4 | undifferentiated | 17 m |
| Paratype 4, (BPBM W-3734) NE of Montebello Is, WA | 6.7 | 140–180 (161.2) | 21–25 (24) | 25–33 (27.2) | 32–35 (33.5) | 1.5 x 0.8 | 11 | 3.2 x 1.0 | 3.3 x 1.4 | 3 | undifferentiated | 55–53 m |

| | | | | | | | | | | | | | |
|----------------------------------|--|---------|--------------------|-----------------|-----------------|-----------------|---------------|-----|-----------|----------------------|-----|--------------------------------------|---------|
| | Paratype 5, (WAM Z13369) NNW of Dampier, WA | 7.16 | 145–175 (161.2) | 20–25 (22.5) | 19–28 (24.2) | 27–29 (27.7) | 1.8 x 0.8 | 12 | 3.6 x 1.3 | 2.6 x 1.3 | 3 | undifferentiated | 74–82 m |
| | Paratype 6, (WAM Z13372) NE of Montebello Is, WA | 6.1 | 190–215 (205) | 30–35 (33.4) | 35–45 (40) | c 50 | 1.6 x 0.8 | 13 | 5.5 x 1.5 | 4.3 x 2.3 | 4 | undifferentiated | c 73 m |
| | (WAM Z12020) NINE of NW Cape, WA | 6.55 | 158–170 (165.3) | 23–28 (25.2) | 20.27 (23.3) | 30–37 (32.3) | 1.55 x 0.8 | 11 | 4.3 x 1.0 | 3.5 x 1.3 | 3 | undifferentiated | 149 m |
| | WAM Z13374) W of Carnarvon, WA | 6.03 | 200–220 (208.6) | 30–40 (34.6) | 30–40 (34) | 35–37 (35.5) | 1.3 x 0.7 | 11 | 4.3 x 1.3 | 3.4 x 1.5 | 6 | undifferentiated | 73 m |
| <i>Thromidia catalai</i> | Holotype, New Caledonia. (Pope and Rowe, 1977) | 4–5.2 | 220–296 (283) | 50–66 (58) | – | – | 1.5 x 1.0 | 8 | 8 x 2 | 6 x 3 | 11 | spaced plates with small tubercles | 10 m |
| <i>Thromidia catalai</i> | Moluccas (WAM Z13376) | 4.8 | 170–180 (175.4) | 30–45 (36) | 40–45 (42.4) | 35–45 (38.6) | 1.8 x 0.8 | 8 | 3.9 x 1.3 | 3.3 x 1.5 | 5–8 | spaced plates with small tubercles | 40 m |
| <i>Thromidia scychellesensis</i> | Holotype (Pope and Rowe, 1977) | 5.5 | 123–124 (123.5) | 22–23 (22.5) | – | – | 0.75 x 0.6 | 8 | 4.5 x 1.5 | 3.5–4.5 x 1.5–2.0 | 3.5 | close packed ‘cobbled’ plates | 12 m |
| <i>Thromidia scychellesensis</i> | Sumatra (WAM Z13375) | c 3.7 | 173–195 (184.5) | 45–53 (49.5) | 36–50 (42.2) | 35–40 (36.5) | 1.8 x 0.7 | c 7 | 5 x 1.1 | 3.3 x 1.7 | 5 | close packed ‘cobbled’ plates | 10 m |
| <i>Thromidia gigas</i> | Holotype, South Africa (Mortensen, 1935) | 7.3–7.7 | 330–347 | 45 | 50–60 | – | c 2 x 2 | 8 | 5–6 | 0 | – | spaced globular bosses, 5mm diameter | 46–55 m |
| <i>Thromidia gigas</i> | Madagascar (Cherbonnier, 1975) | c 7.2 | 200–230 | c 30 | 45–50 | – | c 2.5 x 1–2.5 | 11 | 6 x 2 | – | c 5 | spaced globular bosses, 5mm diameter | 50 m |

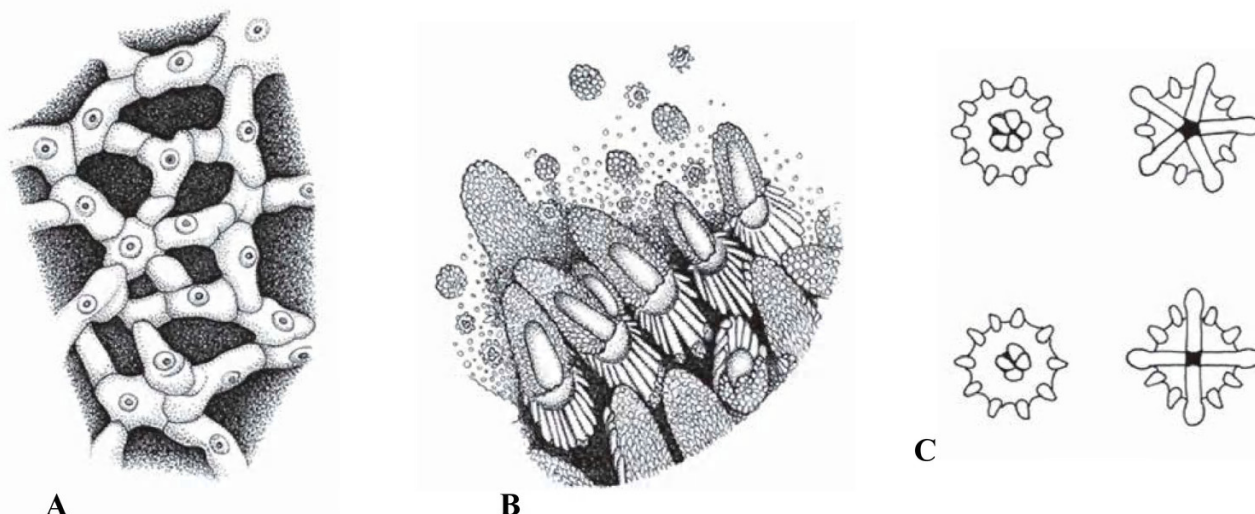


Figure 3 *Thromidia brycei* sp. nov.: A, skeletal meshes of holotype showing articulations for tubercles; B, oblique view across furrow showing partly bare subambulacral spines of paratype 5 (WAM Z13369); C, closed and open pedicellariae of paratype 5 (WAM Z13369).

brycei and comparative data for the holotypes and some other specimens of *T. catalai*, *T. seychellesensis* and *T. gigas* are presented in Table 1. Brief notes on other variable characters of *T. brycei*, particularly colour, follow.

Paratype 1 (AM J24581): No pedicellariae (Figure 2D).

Paratype 2 (BMNH 2001.6801): The colour (dry) is light pinkish brown with dark brown blotches and dark arm tips. Pedicellariae on both surfaces.

Paratype 3 (USNM 1114791): The colour (alive) was mottled light and dark brown, the arm tips not distinguished from the rest of the arms. No pedicellariae.

Paratypes 4 (BPBM W-3734) and 5 (WAM Z13369): The colour (dry) is dark brown with a few lighter patches (Figure 3C, paratype 5).

Paratype 6 (WAM Z13372): The colour (dry) is light brown with darker brown arm tips. Pedicellariae on both surfaces.

WAM Z12020: This specimen is unique in having a few actino-lateral tubercles, 2 mm high, 10–15 mm apart. There are five on one side of one arm, fewer on the others. The colour (alive) was orange-pink with arm ends cinnamon, shading to dark brown at the tips, no mottling. Pedicellariae on both surfaces.

WAM Z13374: The colour (freshly dried) was red-brown with dark brown blotches and red-brown arm tips. Pedicellariae abundant on both surfaces.

Etymology

I have pleasure in naming this species in honour of Mr Clayton Bryce, who collected and photographed the holotype, and who has contributed immeasurably as dive master, underwater photographer, collector and Technical Officer in the Dept of Aquatic Zoology at the WA Museum for more than 25 years.

Remarks

The new species has been compared with descriptions *T. catalai*, *T. seychellesensis* and *T. gigas* and has been directly compared with specimens of *T. catalai* and *T. seychellesensis* from Indonesia. The specimen of *T. catalai* from Sanana Island, and a photograph of one from the Yu and Uta Islands, both in the Moluccas, agree closely with the original description. However the one from Sanana Island (WAM Z13376) has numerous pedicellariae on the actinal surface and a few on the abactinal side (unlike the holotype); the abactinal tubercles are up to 1.5 mm high with elongate sharply pointed apical granules and pointed granules on the sides, near the arm ends the tubercles become widely spaced and the surface is covered only by pointed granules between them: the skeletal plates in this area are larger than elsewhere leaving space for only single papulae as in the holotype; furrow spines are 10 near the base of the arm, 8 mid-arm and near the arm ends. The skeletal plates of *T. catalai* are larger and more stellate than those of the new species, papular areas larger and better defined, furrow spines are fewer and tubercles are widely spaced near the arm ends. The Indonesian specimen of *T. catalai* agrees closely with the type specimen in colour.

The specimen of *T. seychellesensis* (WAM Z13375) from Pula Wé at the north-western tip of Sumatra was recorded by Marsh and Price (1991). It has the arms tightly folded over the actinal surface of the disc making it impossible to see details of the furrow or to make accurate measurements of R or r. Papular areas are 4 mm across, abactinal tubercles are low, rounded, with mostly smaller ones in the papular areas, the tubercles form a close cobbled pavement at the arm ends as described for the holotype.

Thromidia gigas is clearly distinguished by the large spherical knobs up to 5 mm diameter near the arm ends. Mortensen (1935) recorded only 4 furrow spines but Pope and Rowe (1977) found 5–8 furrow spines on the holotype while Cherbonnier (1975) figured 11 spines in a specimen from Madagascar with 8 distally.

Clearly the number of furrow spines is not a good diagnostic character while the character of the distal arm tubercles is a reliable character in all four species. *T. brycei* seems to be closer to *T. gigas* in R/r ratio, constriction at the arm bases, in the number of furrow spines and in the irregular papular areas.

The four species of *Thromidia* are, as far as is known, not sympatric. *T. catalai* has been found in New Caledonia (the type locality), Papua New Guinea, the Philippines, Hawaii, Guam and the Ogasawara Islands (Japan) (Pope and Rowe 1977), from the Moluccas, Indonesia (WA Museum collection) and from the Great Barrier Reef, Queensland (Rowe and Gates 1995). *T. seychellesensis* is only known from the Seychelles (type locality) and the north-western tip of Sumatra (Marsh and Price 1991) while *T. gigas* is only known from South Africa (type locality) and Madagascar (Cherbonnier 1975) and Zanzibar (Rowe, pers. comm.). *T. brycei* sp. nov. is so far only known from north western Australia. The four species are distinguished in the following key, modified from that of Pope and Rowe (1977).

Key to species of *Thromidia*

1. R/r = 6–8/1.....2
 R/r < 6/1.....3
2. Arm tips with well spaced large, globular bosses (5 mm diameter) (eastern Africa, west coast Madagascar).....*T. gigas*
 Arm tips with a continuation of the same size and density of tubercles as on the rest of the arms (north-western Australia).....
 *T. brycei*
3. Arm tips with closely packed, rounded, convex plates, covered with even granules, giving a cobbled appearance (Seychelles and north-western Sumatra).....
 *T. seychellesensis*

4. Arm tips with well spaced small tubercles (Indonesia, Philippines, Japan, Papua New Guinea, Great Barrier Reef, Qld, New Caledonia and Hawaii).....*T. catalai*

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REFERENCES

- Blake, D.B. (1980). On the affinities of three small sea-star families. *Journal of Natural History* **14**: 163–182.
- Blake, D.B. (1981). A reassessment of the sea-star orders Valvatida and Spinulosida. *Journal of Natural History* **15**: 375–394.
- Blake, D.B. (1987). A classification and phylogeny of post-Palaeozoic sea stars (Asteroidea: Echinodermata). *Journal of Natural History* **21**: 481–528.
- Cherbonnier, G. (1975). Sur la présence, a Madagascar, de l'Astérie *Mithrodia gigas* Mortensen. *Bulletin du Muséum National d'Histoire Naturelle, Paris* (3) **300** Zoologie **210**: 639–644.
- Clark, A.M. (1993). An index of names of recent Asteroidea — Part 2: Valvatida (pp. 187–366). In: Jangoux, M. and Lawrence, J.M. (eds) *Echinoderm Studies*. A.A. Balkema: Rotterdam/Brookfield.
- Marsh, L.M. and Price, A.R.G. (1991). Indian Ocean echinoderms collected during the *Sinbad* voyage (1980–81): 2. Asteroidea. *Bulletin of the British Museum of the Natural History (Zoology)* **57**: 61–70.
- Mortensen, T. (1935). A new giant sea-star, *Mithrodia gigas* n. sp. from South Africa. *Annals of the South African Museum* **3**: 1–4.
- Pope, E.C. and Rowe, F.W.E. (1977). A new genus and two new species in the family Mithrodiidae (Echinodermata: Asteroidea) with comments on the status of the species of *Mithrodia* Gray 1840. *Australian Zoologist* **19**: 201–216.
- Rowe, F.W.E. and Gates, J. (1995). Echinodermata. In: Wells, A. (ed.) *Zoological Catalogue of Australia*, volume 33. CSIRO Publishing: Melbourne, VIC.
- Spencer, W.K. and Wright, C.W. (1966). Asterozoans. In: Moore, R.C. (ed.), *Part U, Echinodermata 3, Treatise on Invertebrate Palaeontology* (U4–U107). The Geological Society of America Inc., and the University of Kansas Press.

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