

## A revision of the echinoderm genus *Bunaster* (Asteroidea: Ophidiasteridae)

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### Abstract

The four nominal species of *Bunaster*, previously known from very few specimens, are confined to the Philippines area, Indonesia and Australia. The holotype of *B. ritteri* has been re-examined and this species becomes the senior synonym of *B. lithodes* Fisher. *B. ritteri* is here recorded from Australian seas for the first time. *Bunaster uniserialis* and *B. variegatus*, described from north-eastern and south-western Australia respectively are confirmed as distinct species.

### Introduction

The species of *Bunaster* form a homogeneous group with relatively minor differences between the species and because of their rarity there has been little opportunity to study their variation. They are restricted to the south-east Asian and Australian region, from the Xisha (Paracel) Islands in the South China Sea to the northern, north-eastern and western coasts of Australia. They are usually cryptic in habit, at least in shallow water, and are found from the shore to nearly 200 metres.

The genus, *Bunaster* and type species, *B. ritteri* Döderlein, 1896, were described from a single specimen from Amboina (Ambon, Indonesia); a second species, *B. lithodes* Fisher, 1917 was described from a single specimen from the Philippines and *B. uniserialis* H.L. Clark, 1921, also from a single specimen, from Torres Strait. The fourth species, *B. variegatus* H.L. Clark, 1938 was described from 12 specimens from south-western Australia including specimens from the Houtman Abrolhos, previously identified as *B. lithodes* (H.L. Clark 1923).

With more material now to hand it is now possible to record the range of variation in characters (particularly those likely to be size dependent) of all three species.

The holotypes of all four nominal species have been examined and the enigmatic *B. ritteri* compared with the holotype of *B. lithodes* and with other specimens formerly identified as the latter species. *B. ritteri* is shown to be the senior synonym of *B. lithodes* and is here recorded from reefs in north-western Australian waters for the first time. The close similarity between *B. uniserialis* and *B. variegatus* led to a critical comparison of the types and a series of specimens from north Queensland and south-western Australia. Apart from their geographical separation there are consistent morphological differences between the two, which are confirmed as valid species.

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**Terminology and Abbreviations**

Standard measurements for Asteroidea are used: R is the major radius from mouth to arm tip, r is the minor radius from mouth to the interradial margin and br is the arm width at the base of the arm. The names of the institutions from which specimens were examined are abbreviated as follows: AM, Australian Museum, Sydney; MCZ, Museum of Comparative Zoology, Harvard; Munich, the Zoologische Staatssammlung, München; WAM, Western Australian Museum, Perth.

**Systematics*****Bunaster***

*Bunaster* Döderlein, 1896: 317

**Diagnosis**

A genus of Ophidiasteridae with small disc and elongate, more or less cylindrical arms; size small (maximum recorded R, 23 mm); abactinal and marginal plates bare, convex, with small granules between plates; marginal plates prominent, wider than long, when viewed from above, and set at an angle to the direction of the arm; intermarginal plates present; papulae in 6-10 rows; small bivalved pedicellariae usually present, excavate pedicellariae rare. Distributed from the South China Sea to Australia, from the shore to c. 200 metres.

**Type species:** *Bunaster ritteri* Döderlein, 1896: 317.

**Other species included:** *Bunaster uniserialis* H.L. Clark, 1921 and *B. variegatus* H.L. Clark, 1938; (*B. lithodes* Fisher, 1917 is referred to synonymy of *B. ritteri*).

**Remarks**

Despite their small size members of the genus are very distinctive while the species are superficially very similar to one another.

*Bunaster* is unlike other ophidiasterids in the strong development and angling of the marginal plates. In this respect and in the presence of intermarginal plates it resembles the Cretaceous species *Stauranderaster coronatus* (Forbes, 1848) (Stauranderasteridae). This species has entrenched pedicellariae of ophidiasterid type but as the ambulacral armature and actinal plates are not described (Spencer 1905, Spencer and Wright 1966), one can only speculate on a possible relationship and on the age and lineage of this otherwise Recent genus. Blake (1987) notes that the valvatid family Stauranderasteridae has Oreasteracean affinities but is in need of re-evaluation.

On the present evidence *Bunaster* is probably best placed in the Recent family Ophidiasteridae but the nature of the marginal plates and the presence of both bivalved and entrenched pedicellariae suggest affinities with the Oreasteridae and possibly with the extinct Stauranderasteridae.

**Key to the species of *Bunaster***

- 1 Papulae in 10 rows, 1-4 pores per papular area, actinal plates in two series; South China Sea to Timor Sea ..... *B. ritteri*
- 1<sup>1</sup> Papulae in 6-8 rows, single ..... 2
- 2 Papulae in 6 rows, actinal plates in a single series; Great Barrier Reef, Queensland ..... *B. uniserialis*
- 2<sup>1</sup> Papulae in 6-8 rows, actinal plates in two (occasionally 3 or 4) series; south Western Australia ..... *B. variegatus*

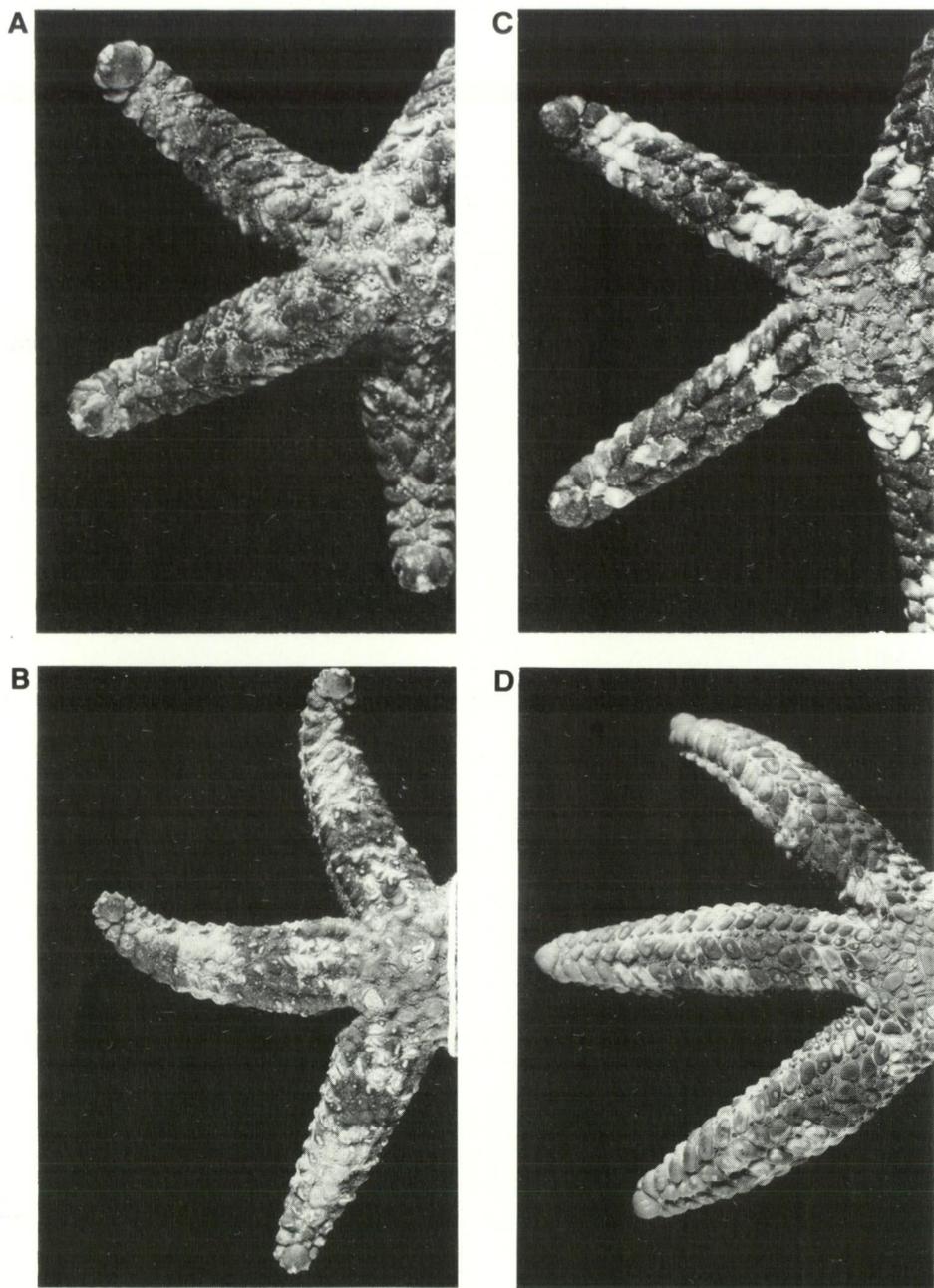


Figure 1. Abactinal views of holotypes of (a) *Bunaster ritteri* ( $R/r = 10.0/2.8$  mm); (b) *B. lithodes* ( $R/r = 22.0/5.0$  mm); (c) *B. uniserialis* ( $R/r = 11.3/2.7$  mm); (d) *B. variegatus* ( $R/r = 21.0/5.0$  mm).

***Bunaster ritteri* Döderlein**

Table 1, Figures 1a,b, 2a,b, 3a,b, 4a,b.

*Bunaster ritteri* Döderlein, 1896: 317-319, pl. 22, Figures 1a-g, Clark, H.L. 1921: 69; Clark and Rowe 1971: 34-35 (distrib.), 61 (key), Figure 15f; Jangoux *et al.* 1987: 305

*Bunaster lithodes* Fisher, 1917: 91; Fisher, 1919: 398, pl. 95, Figures 8-8b, pl. 124, Figure 4; Clark, H.L., 1921: 69; Clark and Rowe, 1971: 34-35 (distrib.), 61 (key); Liao, 1980: 157-158, Pl. 3.

non *B. lithodes*, H.L. Clark 1923: 241 (= *B. variegatus* Clark 1938).

**Material examined**

The holotypes of *B. ritteri* (Munich 935/1) and *B. lithodes* (MCZ 2498); 3 spec. MCZ 3708 from coral reef Aor I. (Alor?) South China Sea, June 1938, ex Raffles Museum; 1 spec. Munich, Siboga stn 282, 27-54 m; WAM 49-88 (2), one on top of a deal coral boulder, one on the under side, on the reef flat on the north side of Cartier Island (12°32'S, 123°33'E) L. Marsh, 20 Sept. 1986; WAM 50-88, under boulder on sea-grass covered reef flat north of West Island, Ashmore Reef, Timor Sea (12°14'S, 122°58'E) L. Marsh, 18 Sept. 1986; WAM 385-90 (3), Xisha Islands, South China Sea (16-17°N, 111-113°E approx.), Liao Yulin.

Photographs of *B. lithodes* Fisher, USNM E 10238 from Alor I., South China Sea.

**Diagnosis**

Disc convex, arms tapering, round in section, maximum known R of 23.0 mm. Abactinal plates separated by elongate granules, fairly closely spaced; papulae 1-3 (occ. 4) per area in 10 rows. Actinal plates in two series; enlarged granules at the base of the subambulacral spines vary from a few to a complete series along the ray; granules present between furrow and subambulacral spines. Distributed from the South China Sea to the Timor Sea, on coral reefs and to 54 metres.

**Description**

Disc convex, arms tapering, round in section,  $R/r = 10.0/2.8$  mm (3.6/1),  $br = 2.6$  mm (holotype of *B. ritteri*),  $R/r$  of 22.0/5.0 mm, (4.4/1),  $br = 6.0$  mm (holotype of *B. lithodes*) (Figure 1a,b) to 23.0/6.0 (3.8/1), (WAM 385-90 (1 of 3)). Abactinal and marginal plates very convex, resembling "in miniature, irregular boulders set in coarse pebbly mortar" Fisher (1919). Abactinal plates appear bare, separated by one or more series of elongate granules, fairly closely spaced. Papulae 1-3 (occ. 4) per area in 10 rows; carinal plates in a somewhat irregular series but some elongate and angled to the direction of the arm; an irregular series of up to 14 dorsolateral plates lie either side of the carinals; marginal plates 10-11 (holotype of *B. ritteri*), 17-18 (holotype of *B. lithodes*) to 18-19 in WAM 385-90 with up to 16 intermarginal plates in one, occasionally two series; surface texture of the plates with microscopic roughness (Figures 3a,4a); actinal intermediate plates convex, in two series of similar sized plates or with larger plates in the outer row (Figure 2a,b); subambulacral spines separated from each other and from the furrow series by granules some of which, at the base of the subambulacral spines, are enlarged and tend to form a distinct row on some rays; small white bivalved pedicellariae among granules near many papular pores (Figure 4a). Spatulate tongs-shaped pedicellariae are embedded in some superomarginal and disc plates of the holotype of *B. lithodes* (Fisher, 1919 pl 95, Figures 8a, b) and two specimens from the Xisha Islands (WAM 385-90,

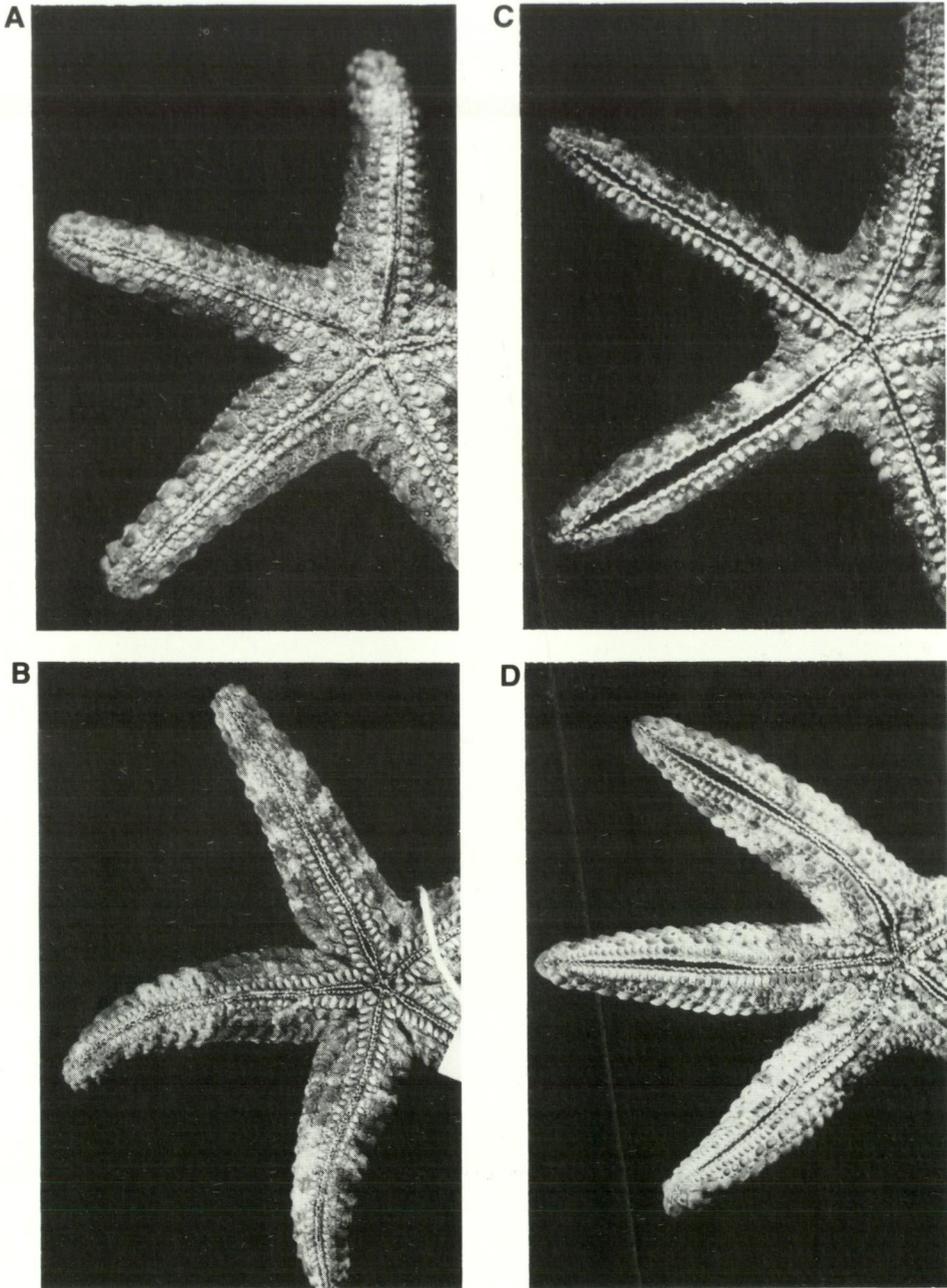


Figure 2. Actinal views of holotypes of (a) *Bunaster ritteri*; (b) *B. lithodes*; (c) *B. uniserialis*; (d) *B. variegatus*.

Figure 4b). Colour (alive) mottled shades of greenish grey, dried these are shades of brown, peaks of some plates white, skin where visible, usually white.

### Variation

The holotypes of *B. ritteri* and *B. lithodes* have been examined together with ten other specimens. The variation in size dependent characters is shown in Table 1. The specimens range in size from R/r of 10.0/2.8 mm to 23.0/6.0 mm, the R/r ratio varies from 3.6 to 4.7/1; marginal plates range from 13 in the smallest to 18-19 in the largest (WAM 385-90); dorsolateral plates range from 6 to 16 and intermarginals from 4 to 16; actinal plates in two rows in all specimens, the outer row usually with larger plates at least basally; papulae are in 10 rows in all specimens with 1-2 papulae per area in the smallest to 3 (occasionally 4 on the disc) in the largest; papulae in a single actinal row, two intermarginal and two dorsolateral rows (making a total of 10 rows); subambulacral spines elongate in the holotype of *B. lithodes* and in specimen USNM E 10238 but shorter, more almond shaped in WAM specimens and the holotype of *B. ritteri*; enlarged granules at the base of the subambulacral spines vary from a few to a complete series along the ray; granules between the bare plates are everywhere small and close packed; small white bivalved pedicellariae are abundant, but entrenched tongs-shaped pedicellariae are rare.

### Holotype

Zool. Staatssammlung, Munich, ref. 935/1 (dry).

### Type Locality

Amboina (Ambon, Indonesia).

### Habitat

Coral reefs. The Australian specimens were found on and under boulders on reef flats. The Siboga specimen is from 27-54 metres.

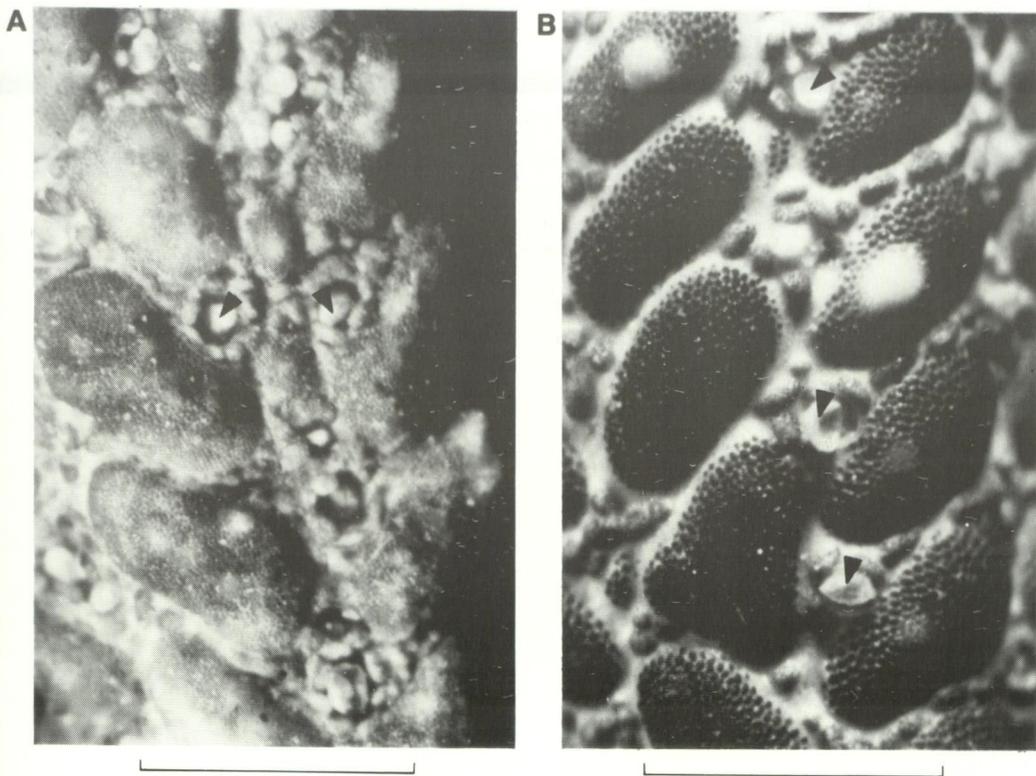
### Distribution

Xisha (Paracel) Islands in the South China Sea; Philippines; Indonesia; Ashmore and Cartier reefs in the Timor Sea.

### Remarks

*Bunaster ritteri* has been distinguished from the other species of *Bunaster* by the presence of curious "ball and socket" organs (Fisher 1919; Clark and Rowe 1971). Examination of the holotype shows that these enigmatic structures are actually partly inflated papulae (Figure 3a). The white granules described by Döderlein are small bivalved pedicellariae (Figure 4a).

Fisher (1919) noted the difference in shape of the subambulacral spines between the holotypes of *B. ritteri* and *B. lithodes* but examination of a series of specimens shows a good deal of variation in this character and in the relative size of actinal plates of the two series. Fisher (1919) notes that the granules between the naked areas of the plates are smaller and more numerous in the holotype of *B. lithodes* than in that of *B. ritteri* but this character too is subject to some individual variation.



**Figure 3.** Detail of abactinal and superomarginal plates showing surface texture, interstitial granules and partly inflated papulae (arrowed) (a) *Bunaster ritteri* (holotype); (b) *B. uniserialis* (AM J9690). Carinal plates on left of each photograph, superomarginals on right, scale bar = 1 mm.

No characters can be found to separate *B. lithodes* from *B. ritteri* so that the former becomes a junior synonym of the latter.

*B. ritteri* is distinguished from *B. uniserialis* by the presence of 10 rows of 1-3 (occ. 4) papulae and two rows of actinal plates and from *B. variegatus* by the 10 rows of 1-4 papulae and the more irregular convexity of the abactinal plates. The granules separating the bare plates form a more complete cover in *B. variegatus* than in *B. ritteri*. The distribution of *B. ritteri* does not overlap that of either *B. uniserialis* or *B. variegatus*.

#### ***Bunaster uniserialis* H.L. Clark**

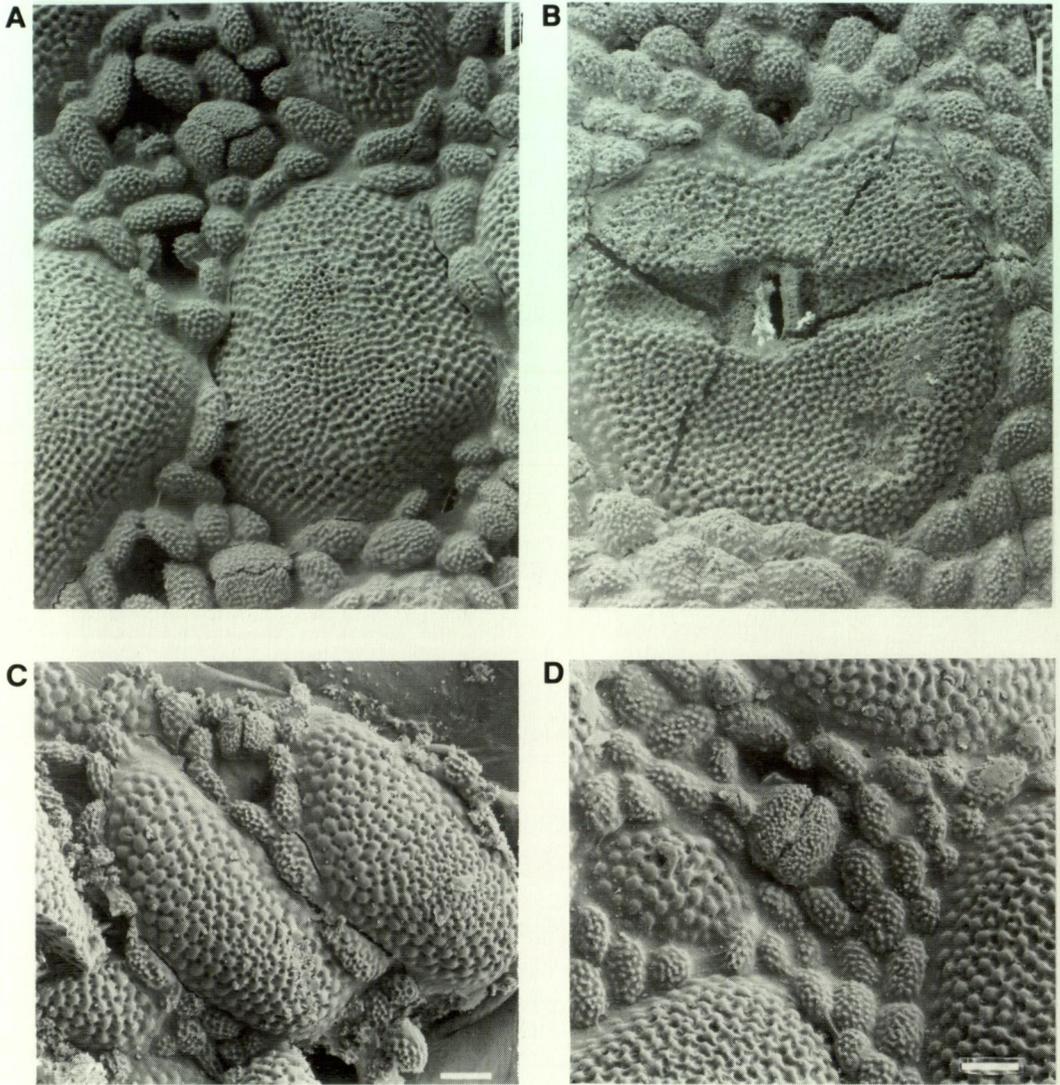
Table 1, Figures 1c, 2c, 3b, 4c.

*Bunaster uniserialis* H.L. Clark, 1921: 69-71, pl. 7 Figure 2, pl. 36, Figures 5-7; H.L. Clark 1946: 118; Clark and Rowe 1971: 34-35 (distrib.), 61 (key).

#### **Material examined**

The holotype (MCZ 2313) and 16 specimens from the Great Barrier Reef, Queensland. AM J9237, 5 m, Wistari Reef, Capricorn Gp, G.B.R., Queensland, N. Coleman, 14 July 1975; AM J17304, no loc., 3 m; AM

J19401, 25 m on overhanging wall, outer slope, Osprey Reef, Coral Sea (13°56'S, 146°32' E) I. Loch, 17 Dec. 1984; AM J21513 fore reef, on crest, 1 m, Robertson Reef, G.B.R., J. Davidson, 21 Nov. 1986; AM J21514,



**Figure 4.** SEM photographs of abactinal plates, interstitial granules and pedicellariae of (a) *Bunaster ritteri* (WAM 49-88), 2 and 3 valved pedicellariae (arrowed); (b) *B. ritteri* (WAM 385-90), alveolus of entrenched pedicellaria in a disc plate (damaged); (c) *B. uniserialis* (WAM 426-90) bivalved pedicellaria (arrowed); (d) *B. variegatus* (WAM 1542-74), bivalved pedicellaria (arrowed). Scale bar = 100 microns.

fore reef, on crest, 0 m, Old Reef, G.B.R., J. Davidson, 30 Nov. 1986; AM J21515, fore reef, on crest, 1 m, Hope Reef, G.B.R., J. Davidson, 7 Sept. 1986; AM J 21516, AM J21517, fore reef, on crest, 0 m and at base of fore reef 13 m, Square Reef, G.B.R., J. Davidson, 23 Nov. 1986; AM J21518, fore reef, on crest, 2 m, Lodestone Reef, G.B.R., J. Davidson, 19 July 1986; AM J 21519, fore reef, on crest, 0 m, Keeper Reef, G.B.R., J. Davidson, 18 July 1986; AM J16815, 3m, Carter Reef, G.B.R., L. Vail and A. Hoggett, 16 Oct. 1982; AM J9242, 18 m, Heron I., Qld, N. Coleman, 19 Nov. 1974; AM J9245 (2), 18 m in hole in coral bommie, Heron I., Qld, N. Coleman, July 1975; AM J9690, under coral slab on reef flat, Macgillivray's Reef, Lizard I., Qld, N. Coleman, 13 Nov. 1975; WAM 426-90, 4 m, Showers Reef, G.B.R., J. Davidson, 9 Sept. 1986.

### Diagnosis

Abactinal surface flat, rays slender, quadrangular in section, maximum known R of 11.3 mm. Abactinal plates separated by rounded well spaced granules; papulae single in 6 rows. Actinal plates in a single series; enlarged granules at base of subambulacral spines in a continuous row, no granules between subambulacral and furrow spines. Only known from the Great Barrier Reef, Queensland.

### Description

Abactinal surface flat, rays slender, quadrangular in section, maximum known size,  $R/r = 11.3/2.7$  mm, (4.2/1),  $br = 2.8$  mm (holotype) (Clark gives  $R/r$  of 11.0/2.3 mm, (4.8/1) (Figure 1c); papulae single, in 6 rows; carinal series of somewhat irregular convex plates, some elongate, angled; dorsolateral plates small, 4-11 in a row; marginal plates up to 15 with up to 5 intermarginal plates; actinal intermediate plates in a single series (Figure 2c); surface texture of bare plates coarse (Figures 3b,4c); granules between plates rounded and well spaced, showing white skin between; enlarged granules at the base of subambulacral spines in a continuous row, no other granules between these and the furrow spines; subambulacral spines sometimes pointed; small, white, bivalved, pedicellariae among the granules (Figure 4c), none to many, similar in shape to those of *B. Ritteri*; colour of holotype alive, variegated maroon, brown and bluish-white (Clark 1921 pl. 7 Figure 2); dried specimens are shades of brown or violet.

### Variation

The holotype, with R of 11.3 mm is the largest specimen so far recorded. It has 14-15 superomarginals and inferomarginals, 8-9 dorsolateral plates, 5-6 intermarginals, a single row of actinal plates, 6 rows of single papulae and a row of enlarged granules between the furrow and subambulacral spines. Other specimens examined range from  $R/r$  of 5.5/1.5 mm to 9.6/2.5 mm with  $R/r$  ratio from 3.4 to 5.2/1; with 10-15 marginal plates, 4-11 dorsolateral plates, 1-6 intermarginals (Table 1). All have a single series of actinal plates, 6 rows of single papulae and a coarse surface texture on the bare plates. All have well spaced granules between the plates and lack granules (apart from the row of enlarged ones) between the furrow and subambulacral spines. Pedicellariae are variable in abundance, sometimes lacking. Some specimens from Heron Island are violet coloured when dry, others are various shades of brown, disc sometimes rust, sometimes with light bands on arms. Bosses on plates and skin between plates, white.

### Holotype

MCZ No. 2313.

**Table 1.** Comparison of size dependent characters of the three species of *Bunaster*. Size classes (or size of single specimens) are R in mm. Mean values for the characters are given, the range is given in brackets.

<i>Bunaster</i> species	No. of specimens	Size classes	Supero-marginal plates	Carinal plates	Inter-marginal plates	Plates in second actinal series	Rows papulae	Papulae per area
<i>B. ritteri</i>	1 (Holo.)	10.0	13	6-7	4-5	3-4	8-10	1-2
	2	11-15.9	14.5(14-15)	9.3(7-12)	7(6-8)	7(6-8)	10	1.8(1-3)
	7	16-20.9	16.8(16-18)	11.1(6-14)	9.5(8-12)	10.4(6-16)	10	2.3(1-4)
as <i>B. lithodes</i>	1 (Holo.)	22.0	17-18	15-16	15-16	15	10	3
<i>B. ritteri</i>	1	23.0	18-19	16-17	16	15	9-10	2-5
<i>B. uniserialis</i>	1	5.5	13	6-8	4	0	6	1
	14	6-10.9	13(11-15)	7.1(4-11)	3.9(1-6)	0	6	1
	1 (Holo.)	11.3	14-15	8-9	5-6	0	6	1
<i>B. variegatus</i>	2	2-5.9	10.0(9-11)	4.0(3-5)	2.5(2-3)	0	0-6	1
	13	6-10.9	13.3(12-15)	5.8(4-9)	3.7(1-6)	2.5(0-4)	6	1
	25	11-15.9	15.2(12-17)	7.0(5-12)	5.0(3-10)	5.3(2-8)	6.0(6-8)	1
	12	16-20.9	16.0(14-17)	7.1(4-12)	5.4(3-11)	6.4(3-11)	6.6(6-8)	1
	2							
	(incl. Holo.)	21.0	17.7(16-20)	10.0(8-14)	9.2(5-4)	10.5(6-14)	7.0(6-8)	1

**Type locality**

South-western reef, Mer, Murray Islands, Torres Strait, coll. H.L. Clark, 18 Oct. 1913.

**Habitat**

*B. uniserialis* is a coral reef species occurring cryptically on reef flats, on seaward reef crests and outer reef slopes of the Great Barrier Reef from a depth of 0 to 25 m (from the specimens available).

**Distribution**

Known only from the Great Barrier Reef, Queensland, Australia from Mer, Torres Strait (09°56'S, 144°04'E) to Wistari Reef, Capricorn Group (23°29'S, 151°53'E) and Osprey Reef in the Coral Sea.

**Remarks**

H.L. Clark named this species *uniserialis* in reference to the single series of abactinal plates (the carinals) on the rays although he also notes the presence of inconspicuous dorsolateral plates. The name is more appropriately applied to the single series of actinal plates which is constant in all the specimens so far known. *B. uniserialis* appears to be smaller than the other species except *B. ritteri*, the holotype of which, although smaller than that of *B. uniserialis*, has two series of actinal plates and 10 rows of papulae, compared with a single row of actinal plates and 6 rows of papulae in *B. uniserialis*. The surface texture of the plates is coarser in *B. uniserialis* than in *B. ritteri* and the granules between the plates are more widely spaced.

*B. uniserialis* resembles *B. variegatus* of the same size in having single papulae in 6 rows. It differs in having a single row of actinal plates whereas *B. variegatus* even with R of only 6.7 mm has a few plates of a second row. It also differs from *B. variegatus* in having coarser texture on the bare plates, much sparser granulation between the plates and no granules except the row of enlarged ones between the furrow and subambulacral spines.

Although *B. uniserialis* is superficially very similar to small *B. variegatus* the differences noted above clearly separate them.

***Bunaster variegatus* H.L. Clark, 1938**

Table 1, Figures 1d, 2d, 4d.

*Bunaster variegatus* H.L. Clark, 1938: 134-136, Pl. 22, Figure 1; H.L. Clark 1946: 118-119; Marsh 1976: 218 (Table).

*B. lithodes* H.L. Clark 1923: 241.

**Material examined**

In addition to the holotype and 11 paratypes, 42 specimens all from south-western Australia: WAM 161-71, under intertidal granite boulders, north side of Cape Naturaliste, B.R. Wilson, 28 Dec. 1967; WAM 53-88, 183-176 m, stn. DM 1/72/22, S.W. of Cape Naturaliste 33°35.1'S, 114°31.4'E, B.R. Wilson on HMAS *Diamantina*; WAM 54-88, 183 m, stn. DM 1/72/71, west of Lancelin, 31°00'S, 114°52'E, B.R. Wilson on HMAS *Diamantina*; WAM 156-73(2), under rocks at 8 m, Hall Bank, Fremantle, N. Coleman, 9 April 1972; WAM 28-80, 9-12 m, Hall Bank, Fremantle, S.M. Slack-Smith, C. Bryce, L.M. Marsh, 25 Jan. 1980; WAM 1542-74, 55-88, 56-88, under rocks, 0-1 m, Bathurst Pt, Rottneest I., L.M. Marsh, 10 March 1960; WAM 57-88, under rock, Armstrong Pt, Rottneest I., R. Slack-Smith, 5 Jan. 1965; WAM 59-88, from

weed and rock, edge of reef flat pool, Armstrong Pt, Rottnest I., L. Marsh, 19 April 1975; WAM 60-88, under rock on platform, North Point, Rottnest I., E.P. Hodgkin, 7 March 1964; WAM 58-88, under ledge, reef at Nancy Cove, Rottnest I., L.M. Marsh, 14 March 1976; WAM 10-73, Pelsaert I., Houtman Abrolhos, N.N. Wilson, 8 Jan. 1968; WAM 284-77, Houtman Abrolhos, Br. Green, Feb. 1971; WAM 519-76, reef flat, Half Moon Reef, Houtman Abrolhos, L.M. Marsh, 8 April 1976; WAM 375-88, reef flat, Half Moon Reef, Houtman Abrolhos, S.M. Slack-Smith, 8 March 1988; WAM 358-88, 1-6 m, Jackson I., Pelsaert Gp, Houtman Abrolhos, S.M. Slack-Smith and L.M. Marsh, 3 March 1988; WAM 51-88(2), 52-88, reef flat, Easter Gp, Houtman Abrolhos, Aquinas College, 23 Aug. 1970, 30 Aug. 1972; WAM 575-77(2) reef flat, Beacon I., Wallabi Gp, Houtman Abrolhos, L.M. Marsh, 30 Aug. 1977; WAM 780-84 Beacon I., S.M. Slack-Smith and C. Bryce, 23 March 1983; WAM 1804-74 reef flat, North I., Houtman Abrolhos, Aquinas College, 27 Aug. 1974; WAM 45-80, from coral, 15-18 m, outside outer bar, South Passage, Shark Bay, 26°08'S, 113°10'E, L.M. Marsh, 15 April 1979; WAM 654-88, from dead *Acropora* on coral pinnacle, 6-9 m, Goss Passage, Wallabi Gp, Houtman Abrolhos, L.M. Marsh, 18 March 1987; WAM 656-88, 2-10 m, Goss Passage, off Beacon I., Wallabi Gp, Houtman Abrolhos, L.M. Marsh and R. Babcock, 20 March 1987; WAM 83-78, 192-179 m, S.W. of Mandurah, 32°43'S, 114°48'E, DM 1/72/29, 17 Mar. 1972; WAM 679-88, reef platform, W. side Garden I., L.M. Marsh, 17 Nov. 1948; WAM 712-88, 146-142 m, W.S.W. of Cape Leeuwin, 34°25'S, 114°36.5'E, DM 1/72/17, 16 March 1972; WAM 713-88(4), 190-174 m, W.S.W. of Cape Leeuwin, 34°25.5'S, 114°35'E, DM 1/72/16, 16 March, 1972; WAM 714-88, 161-165 m, N.W. of Bunbury, 33°15'S, 114°36'E, DM 1/72/25, 17 March 1972; WAM 715-88(2), 190-161 m, N.W. of Bunbury, 33°14'S, 114°27'E, DM 1/72/19, 16 March 1972; AM J6937(2), Wooded I., Easter Gp, Houtman Abrolhos, Percy Sladen Trust Exped., 1913 or 1915; AM J7436, Rottnest I., E.P. Hodgkin; AM J7838, Houtman Abrolhos, W.A., S. White, March 1970.

### Diagnosis

Disc moderately convex, arms tapering, with a maximum known R of 21.0 mm. Abactinal plates separated by closely spaced granules; papulae single in 6-8 rows. Actinal plates in two series, enlarged granules at base of subambulacral spines of variable occurrence, rarely forming a series; granules form a continuous cover between subambulacral and furrow spines. Only found in south-western Australia from shore to ca. 200 metres.

### Description

Disc moderately convex, arms tapering, with a maximum known size (the holotype) of  $R/r = 21.0/5.0$  mm (4.2/1),  $br = 6$  mm (Clark gives  $R/r$  of 23/6 mm (3.8/1) (Figure 1d); 6-8 rows of single papulae; abactinal and marginal plates oval to irregular in shape, more regular in shape and arrangement than in *B. ritteri*, carinal and marginal plates angled, 3-14 dorso-laterals, 9-20 marginals, 2-14 inter marginals, in a single row; surface texture of bare areas of plates finer than that of *B. uniserialis* but coarser than that of *B. ritteri* (Figure 4d); granules between bare areas of plates closely spaced, forming a continuous cover; actinal intermediate plates in two series in specimens with R of more than 7 mm (Figure 2d); enlarged granules at base of subambulacral spines of variable occurrence, rarely forming a series; granules form a continuous cover between subambulacral and furrow spines; small, white, bivalved pedicellariae, the same shape as those of *B. ritteri*, of variable occurrence, none to many (Figure 4d); colour, alive, variable, often shades of old rose, often with disc pink, arms cream with dark brown or pink bands or blotches, specimens may be pure white, tan or dark brown.

### Variation

The holotype has  $R/r$  of 21.0/5.0 mm (4.2/1), 19-20 superomarginals, 19-20 inferomarginals, 10-14 dorsolateral plates, 10-14 intermarginal plates, papulae single, in 8

rows, actinal plates in two rows, the outer with about 14 plates. These figures differ somewhat from those in the original description; in addition a few pedicellariae (not recorded by Clark, 1938) were observed.

The 53 other specimens examined range in size from R/r of 2.9/1.0 mm to 21.0/5.6 mm, mean R is 12.8 mm and the R/r ratio varies from 2.9/1 to 4.7/1 with a mean of 3.97/1. The number of superomarginal plates is size dependent ranging from 9-20 with 7-20 inferomarginals; the inferomarginals are frequently the same in number as the superomarginals but are sometimes one less and occasionally more. Specimens with R of 13 mm or more usually have about 16 supero- and inferomarginals. The variation in size dependent characters is shown in Table 1.

Intermarginal plates vary from 2 in the specimen with R of 2.9 mm to 10-14 in the holotype. The number is quite variable even among specimens of the same size.

The dorsolateral series of plates range from 3 in the specimen with R of 2.9 mm to 10-14 in the holotype. They are usually rather small and inconspicuous but occasionally are nearly as large and prominent as the carinals.

A second row of actinal plates is present in all but the smallest specimens with R of 4.2 mm or less. A specimen with R of 6.7 mm has 1-3 plates in the second row but one of 7.8 mm has only one. Specimens with R of 8 mm have 3-4 plates. A few of the larger specimens, with R of 15 mm or more have either a third series of small plates between the main row and the adambulacrals, or a few plates of a third outer row, however, most have the inner row the longest with the largest plates and a short second (outer row) of small plates.

The papulae are single even in the largest specimen, the holotype, and generally in 6 rows. Seven of the 54 specimens have 8 rows at least on some rays (including the holotype), with the extra rows on the actinal surface between the two rows of actinal plates. Inter-marginal papulae are always in a single row and there is one row either side between the carinal and superomarginal plates.

An enlarged granule sometimes occurs next to some of the subambulacral spines and occasionally forms a partial row, particularly in small specimens. All except the smallest specimen with R of 2.9 mm have close-set granules between the subambulacral and furrow spines.

Pedicellariae are present in 35 of the 54 specimens examined including the holotype. Clark (1938) did not observe pedicellariae in any of the paratypes but they are present in two of the Rottneest paratypes (WAM 18/22-31). The pedicellariae are similar in form to the bivalved pedicellariae of *B. ritteri* and *B. uniserialis*. No entrenched pedicellariae have been found.

The colour in life is variable from pure white to dark brown but many have a deep pink (old rose) disc with the arms either the same shade or darker with some predominantly white plates forming one or two indistinct light bands on the arms. There is sometimes also a darker band on the middle of the arms. A few specimens are entirely dark brown, one is light tan, others have various combinations of cream, dark brown and pink. The convexities of the abactinal plates are often white as are the pedicellariae. Twenty-two of the 54 specimens were entirely white, when alive. The actinal surface is

always lighter than the abactinal varying from white or cream to mottled fawn or pink. Unlike most asteroids the colour is retained with little fading after drying from fixation in formol saline and is also retained in alcohol (in one case after 40 years).

**Holotype**

MCZ no. 3214

**Type Locality**

Bunker Bay, Cape Naturaliste, Western Australia, coll. E. W. Bennett, in a shallow intertidal pool with loose rocks, a little muddy sand and clusters of short brown algae.

**Paratypes**

MCZ 3213(2) Bathurst Pt, Rottneest I.; MCZ 3215 Bunker Bay; WAM 18/22-31 Bathurst Pt, Rottneest Island. The registration number indicates five specimens but eight are present: nine are recorded by Clark (1938) who states that all "except the very young, with R less than 12 mm may be considered paratypes". Five of this series are larger than 12 mm in R so perhaps the registration numbers applied only to these. However all eight specimens are in one lot marked paratypes in H.L. Clark's hand.

**Habitat**

Cryptic, on the underside of boulders or coral slabs, or in crevices of rock or coral from intertidal pools to 190 metres.

**Distribution**

South-western Australia from Shark Bay (26°S) to west-south-west of Cape Leeuwin (34°25'S).

**Remarks**

*Bunaster variegatus* is distinguished from *B. ritteri* by having single papulae in 6-8 rows (1-4 papulae in 10 rows in *B. ritteri*). The abactinal plates are more regular in shape and less 'bouldery' than in *B. ritteri* and their surface texture is coarser. *B. variegatus* also differs in colour from *B. ritteri*.

*B. variegatus* is distinguished from *B. uniserialis* by the presence of a second row of actinal plates in specimens with R of 6 mm or more, with a third row sometimes present in very large specimens. *B. variegatus* also differs from *B. uniserialis* in having a very closely packed covering of flattened granules between the plates and between the subambulacral and furrow spines. Enlarged granules at the base of subambulacral spines occur in about half the specimens but nowhere do they form a complete row as in *B. uniserialis*.

Like *B. uniserialis* the papulae are single, usually in six rows but up to 8 rows are found in large specimens of *B. variegatus*. The three species have allopatric distributions.

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