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A NEW SPECIES OF *PHALIUM* LINK, 1807 (GASTROPODA: TONNOIDEA: CASSIDAE) FROM THE SUNDA SHELF

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ABSTRACT. — A new cassid species of the genus *Phalium* Link, 1807 is described from material trawled in the Sunda Shelf. *Phalium pseudobandatum*, new species, is superficially close to *P. bandatum* (Perry, 1811) because of similarities in shell colour and markings. However, the new species can be separated from *P. bandatum* by conchological characteristics. The position of the posterior sinus in the new species is at or extends above the shoulder, accompanied by a low spire with a side profile that is smooth and not step-like. It also has a less rotund body whorl with a more angular shoulder compared to *P. bandatum*. A distinct groove on the parietal shield where it adjoins the body whorl is also present on shells of the new species. In addition, the thickened middle part of the outer lip is not seen in similarly sized specimens of *P. bandatum*. The siphonal canal of the new species is not pigmented, and the crenulations at the anterior edge of the outer lip are more numerous but less distinct than in *P. bandatum*. We also suggest that *P. exaratum* (Reeve, 1848) is a distinct Indian Ocean species rather than a geographical subspecies of *P. bandatum*.

KEY WORDS. — Mollusca, Cassidae, Sunda Shelf, *Phalium pseudobandatum*, new species

INTRODUCTION

Members of the family Cassidae form a well-known group of mostly medium to large sized predatory gastropods with a worldwide distribution in tropical and temperate seas. They are known to feed exclusively on echinoids (Hughes & Hughes, 1981). Most of the living species can be easily separated by their shell characteristics, which have been treated excellently by Abbott (1968) and more recently, in a monograph by Kreipl (1997). At present, the Indo-Pacific genus *Phalium* Link, 1807, sensu stricto, comprises eight Recent taxa, namely *P. areola* (Linnaeus, 1758), *P. bandatum* (Perry, 1811), *P. decussatum* (Linnaeus, 1758), *P. exaratum* (Reeve, 1848), *P. fimbria* (Gmelin, 1791), *P. flammiferum* (Röding, 1798), which was treated as *P. strigatum* (Gmelin, 1791 [non Müller, 1774]) in Abbott (1968), *P. glaucum* (Linnaeus, 1758), and *P. muangmani* Raybaudi Massilia & Prati Musetti, 1995.

Amongst material referable to the family Cassidae trawled from the Sunda Shelf, specimens that superficially resembled *P. bandatum* in colouration were obtained. As more material became available, a comparative study with congeners from a larger number of localities was undertaken. It then became apparent that these specimens represented a hitherto undescribed species. This species is described herein.

MATERIAL AND METHODS

Material of the new species described herein was obtained from trawler fishermen based in Sedili, Johor, on the southeast coast of Peninsular Malaysia, with the locality data and other information personally communicated to us. Types and comparative material used to support this study are deposited in the following collections: ZRC (Zoological Reference Collection) of the Raffles Museum of Biodiversity Research, National University of Singapore (NUS); RGM (Nationaal Natuurhistorisch Museum Naturalis, in Leiden);

CSY (Collection of Chan S. Y.); CNHE (Collection of Ng H. E.); CLN (Collection of L. H. S. Nguang); and TSK (Collection of Tan S. K.). Other abbreviations used: SH = shell height; SW = shell width. Shell height is defined as the distance from the shell apex to the lowest part of the basal side of the peristome, and shell width is the distance between the edges of the widest region of the body whorl (including the lip) perpendicular to the coiling axis. Some specimens examined had part of the apex broken off, thus measurements may not reflect their true size. This is indicated by the addition of an asterisk (SH*), but specimens with a slightly chipped or imperfect protoconchs are not indicated. All measurements are in millimetres.

TAXONOMIC ACCOUNT

CASSIDAE Latreille, 1825

Phaliinae Beu, 1981

Phalium Link, 1807

Type species. — *Buccinum glaucum* Linnaeus, 1758, subsequent designation by Dall (1909).

Phalium pseudobandatum, new species
(Figs. 1, 2 A–C, 3B, 5)

Phalium bandatum (Perry, 1811) – Dharma, 2005: p. 198, pl. 74, fig. 5a ([in part] non *Cassidea bandata* Perry, 1811).

Material examined. — Holotype: 1 ex. (SH* 61.1 × SW 37.2) (ZRC.MOL.3688), Peninsular Malaysia, Johor, off Sedili, trawled 20–25 m, on muddy sand bottom, coll. by local fishermen, 2010. Paratypes: **Malaysia**: 1 ex. (SH* 60.3 × SW 34.4) (ZRC.MOL.3689; paratype #1), 2 ex. (SH* 60.5 × SW 36.4, SH* 62.9 × SW 36.4) (CNHE; paratype #2 & #3), same data as holotype; 1 ex. (SH 62 × SW 39) (CLN; paratype #13), Johor, off Sedili, trawled, 1991. **Indonesia**: 3 ex. (SH 41.6 × SW 24.5 – SH* 59.3 × SW 37.3) (ZRC. MOL.3690; paratype #4–#6); 2 ex. (SH* 58.8 × SW 35.8, SH* 64.6 × SW 38.6) (CNHE; paratype #7 & #8), 2 ex. (SH* 52.1 × SW 30, SH* 63.4 × SW 37.5) (CSY 409.3.63.0; paratype #9 & #10), 2 ex. (SH* 56.7 × SW 35.6, SH* 59.3 × SW 35.9) (CLN; paratype #11 & #12), Riau, off Natuna Islands, trawled ca. 20–32 m on muddy sand bottom, coll. by fishermen, Feb.–Aug.2008.

Type locality. — Sedili, Johor, Peninsular Malaysia.

Description. — Shell medium-sized, ovate, pale cream to greyish-brown with five very faint indistinct spiral and/or a few wavy axial bands on the body whorl, surface usually smooth, occasionally malleated (with many small shallow indentations), body whorl shouldered by a row of white pointed triangular knobs, sometimes with a former varix on the spire or body whorl, spire concave in profile, whorls slightly convex. Outer lip strong and recurved, dorsal side white with 6 squarish brown blotches, ventral side white with 5–6 faint orange blotches, inner edge of lip denticulate, middle part thicker with a straight or convex profile, base of outer lip crenulate with 2–6 (usually obsolete) knobs, aperture dark cream colour with a brown zone at the anterior end. Parietal shield with a distinct groove at body whorl, lower half wrinkled, a few wrinkles present near the posterior sinus, parietal side of posterior sinus calloused, posterior sinus positioned at or extending above shoulder. Siphonal canal recurved, white darkening to a shade of cream at the edge.

Etymology. — The species epithet is derived from its morphological affinity to *P. bandatum*, with which it has been confused; the prefix 'pseudo' meaning false.

Distribution. — Sunda Shelf, in an area encompassing the eastern region of peninsular Malaysia and the Sunda Islands of Borneo, Sumatra and Java (Fig. 5; Dharma, 2005: 198).

Remarks. — Only empty shells of *Phalium pseudobandatum* were obtained for this study, and its operculum and soft parts remain undescribed. Apart from the locality data no other information is available. This species seems to be rather rare. We found a single record that could be confirmed after a search of the literature; from Mesuji, South Sumatra (Dharma, 2005: 198; in part as *P. bandatum*). Most *P. pseudobandatum* specimens seen for this study are about 60 mm in shell height, and appear to be mature.

Fig. 1. *Phalium pseudobandatum*, new species, holotype (SH 61.1 × SW 37.2) (ZRC.MOL.3058).

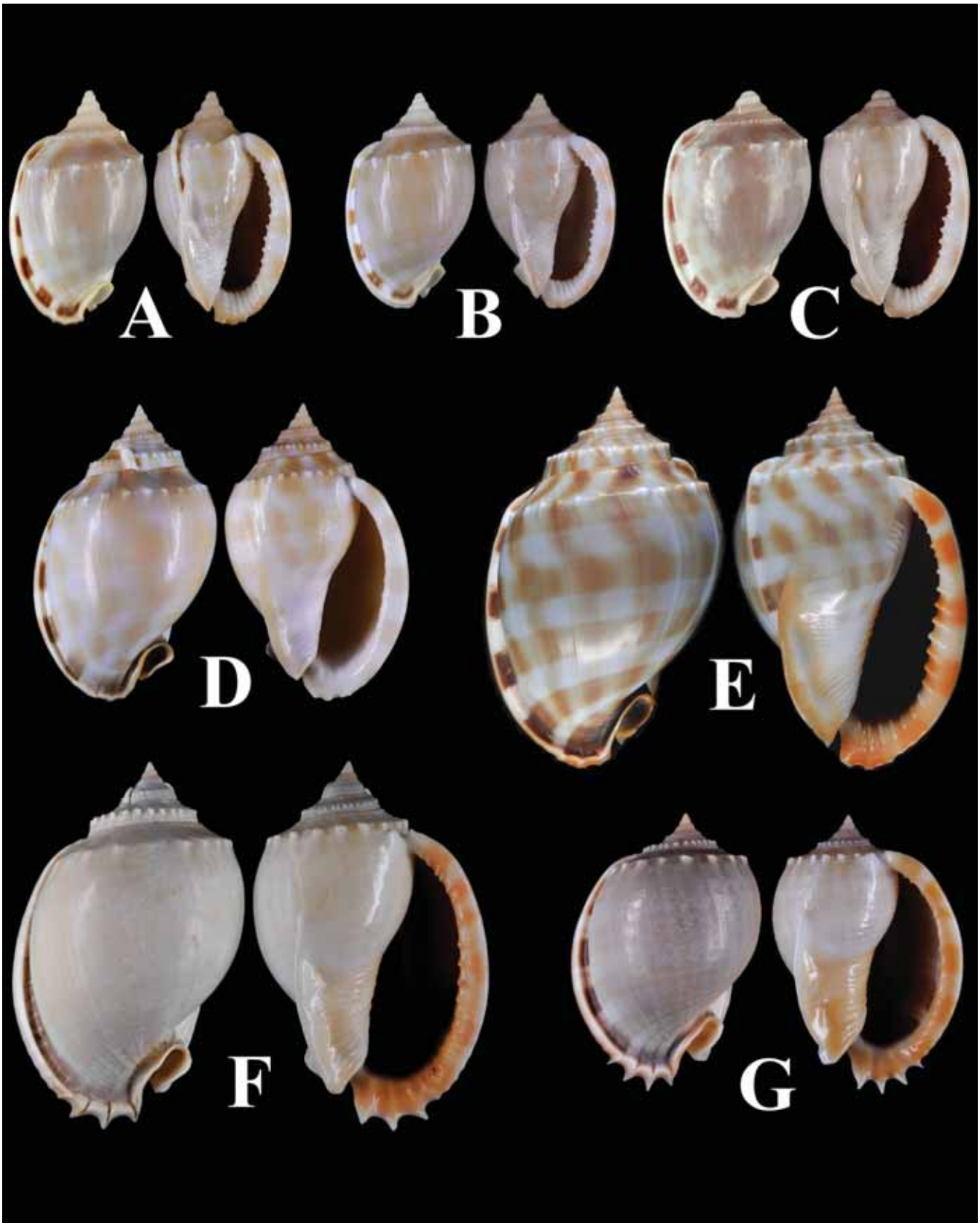

Fig. 2. Shells of *Phalium pseudobandatum*, new species (A–C), *P. bandatum* (Perry, 1811) (D–E), and *P. glaucum* (Linnaeus, 1758) (F–G). A, off Sedili, Johor, Malaysia, (SH 60.3 × SW 34.4) (ZRC.MOL.3689; paratype #1); B–C, Natuna Islands, Riau, Indonesia, (SH 55.2 × SW 33.6, SH 59.3 × SW 37.3) (ZRC.MOL.3690; paratype #5 & #6). D, Townsville, Queensland, Australia (SH 83.1 × SW 52.1) (CLN); E, Olango Island, Cebu, Philippines (SH 110.9 × SW 72.2) (CNHE). F, Endau, Johor, Peninsular Malaysia (SH 101.4 × SW 67.4) (CNHE); G, Chek Jawa, Pulau Ubin, Singapore (SH 73.8 × SW 50.6) (ZRC.MOL.3687).

DISCUSSION

Among the living species of the genus *Phalium* sensu stricto, *P. pseudobandatum* appears most similar to *P. bandatum*, but the new species differs from *P. bandatum* in the position of the posterior sinus, which is at or extends above shoulder in the new species. There is also a distinct groove on the parietal shield where it abuts the body whorl that is absent in *P. bandatum*. The shell of the new species also possesses a lower profile spire that is not stepped in outline, a less rotund and a more angular shoulder, as well as a siphonal canal without pigmentation, when compared to *P. bandatum*. The middle part of the outer lip of *P. pseudobandatum* is also thickened with a straight to convex profile on inner edge, which is seen only in large specimens of *P. bandatum*. In addition, there are 2–6 obsolete knobs (or crenulations) at the base (anterior edge) of the outer lip of *P. pseudobandatum* as opposed to 3–4 weak knobs or teeth in *P. bandatum* (see also Table 1).

Shells of *P. glaucum* and *P. exaratum* with knobbed shoulders also resemble *P. pseudobandatum*. However, *P. glaucum* (Fig. 2F, G) can usually be easily distinguished from *P. pseudobandatum* by its grey and more rotund shell, and the prominent spine-like teeth at the anterior edge of its outer lip, and *P. exaratum* (Fig. 4) by the spirally grooved shell, well developed parietal shield, and coarsely beaded sculpture on the spire (see also Table 1). Diagnosis of small juvenile shells is more difficult as many of the characters mentioned are not yet developed (see Fig. 3).

Since Abbott (1968), *P. exaratum*, a rare Mascarene Islands endemic (Fig. 5), has been regarded as a subspecies of *P. bandatum* by recent authors (e.g., Kreipl, 1997; Jarrett, 2000; Drivas & Jay, 2001; Robin, 2008). Abbott (1968) regarded the two as subspecies based on allopatry and on the presence of spiral grooves in juveniles of *P. bandatum*, a character that is shared with most, if not all species assigned to the genus (see also Fig. 3). Although only one specimen of *P.*

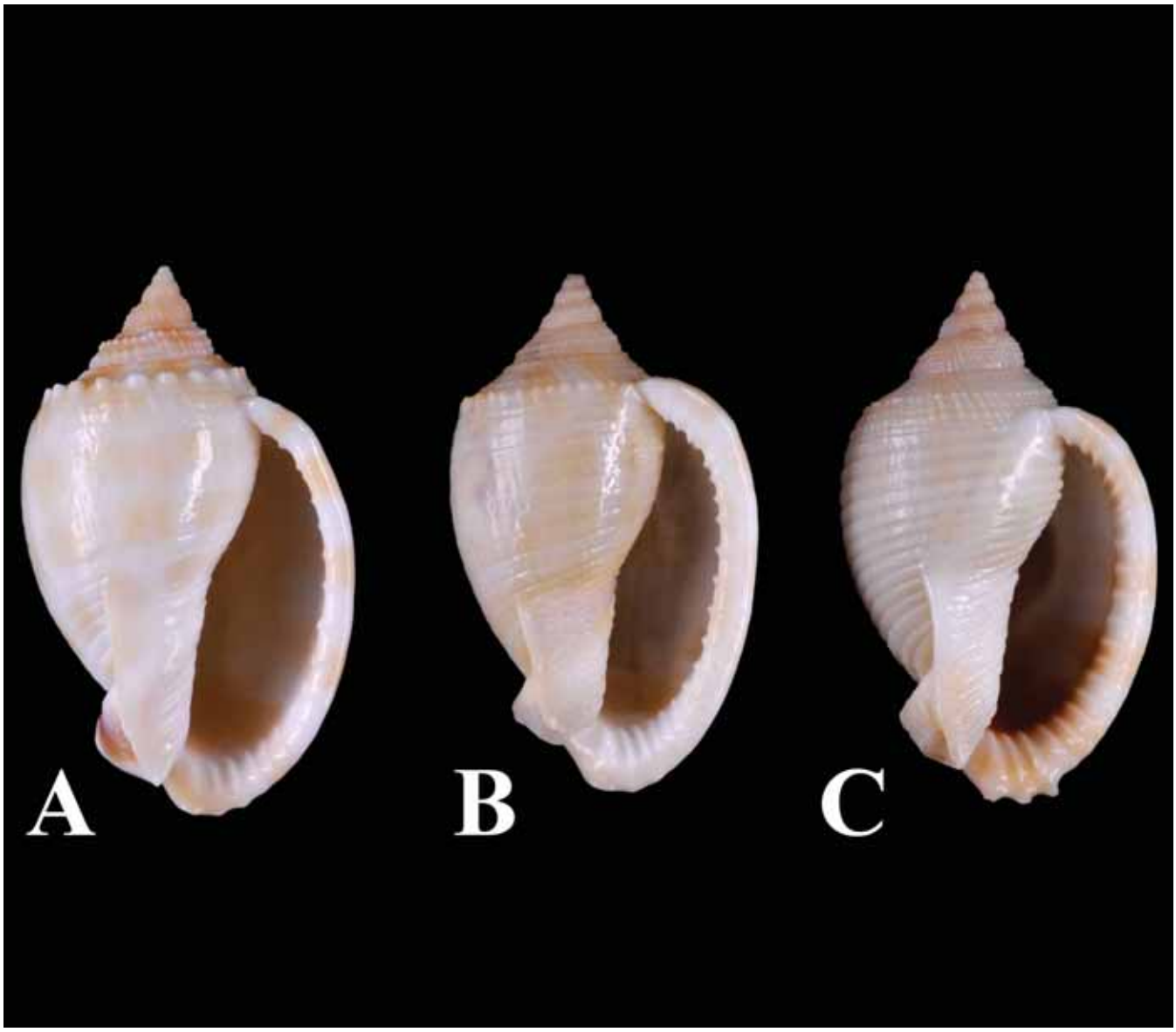

Fig. 3. A comparison of the shells of similarly sized juveniles: A, *Phalium bandatum* (SH 44.4 × SW 26.4), Queensland, Australia; B, *P. pseudobandatum* (SH 41.6 × SW 25.5), Natuna Islands, Riau, Indonesia; C, *P. glaucum* (SH 43 × SW 25.5), Natuna Islands, Riau, Indonesia. Note the sculptural differences and the relatively narrow aperture of *P. pseudobandatum*.

Table 1. Conchological characteristics of *Phalium pseudobandatum*, new species, compared with three closely related congeners: *P. bandatum*, *P. exaratum*, and *P. glaucum*. Character states distinctive to the respective species are denoted by an asterisk (*).

Conchological characteristics	***Phalium pseudobandatum*, new species**	***Phalium bandatum* (Perry, 1811)**	***Phalium exaratum* (Reeve, 1848)**	***Phalium glaucum* (Linnaeus, 1758)**
General shell colour and pattern	Pale cream to greyish-brown, with very faint indistinct orangey spiral bands and/or wavy axial bands	Pale cream to light bluish grey, with pronounced orange to light brown spiral bands and lighter wavy axial bands crossed to form squarish patterns	White to pale yellowish-white, with orange to light brown spiral and axial bands crossed to form squarish patterns	Very light ash grey to bluish-grey, with very light yellow to beige bands usually only discernible near lip*
General shell shape	Ovate, spire moderately low, about 1/4 to 1/5 of shell height	Rotund, spire drawn out, about 1/4 to 1/5 of shell height	Elliptically ovate; spire drawn out, about 1/3 to 1/4 of shell height	Rotund; spire low, about 1/5 to 1/6 of shell height
Shell surface of body whorl of adult specimens	Smooth, occasionally malleated	Smooth, occasionally malleated	Smooth with numerous spiral grooves*	Smooth or malleated
Colour of siphonal canal	Pale whitish cream without obvious dark pigmentation*	Entirely brown or a brown blotch	Entirely brown	Small purplish brown blotch
Position of posterior sinus	Aligned with shoulder, sometimes extending above*	Well below the shoulder	Aligned with the lowest beaded spiral ridge below shoulder	Just below the shoulder, often touching the lower edge of shoulder knobs.
Spire whorls	Fine cancellate sculpture, angled by a stronger row of beads	Cancellate sculpture, rather step-like, prominently angled by a keel of large beads	3 to 4 coarsely granulated ridges, straight to slightly convex*	Fine cancellate sculpture, prominently angled by a keel of large beads
Shoulder profile	Flat to somewhat convex	Flat to concave	Flat to convex	Flat to concave
Shoulder angle	30° to 45°	30° to 50°	About 50°	20° to 40°
Shoulder knobs	Triangular and pointed*	Triangular to squarish	Rounded to pointed, closely set on a raised ridge*	Triangular to squarish (commonly absent in large specimens)
Parietal shield and callus	Distinct groove on the posterior half where it abuts the body whorl*; callus thin	Shallow gradual depression where it adjoins the body whorl; callus thin and indistinct	Fringe rather deflected away from body whorl; callus thick and well developed, forming a complete 'shield'*	Shallow gradual depression where it adjoins the body whorl; callus thin and indistinct
Apertural side of outer lip	Middle part thickened with a straight to convex profile on inner edge	Middle part thickened in large specimens, with a straight to convex profile on inner edge	Middle part thickened with a straight profile on inner edge	Middle part thickened in large specimens, but maintaining a concave profile*
Basal edge of outer lip	2–6 obsolete knobs or crenulations	3–4 weak knobs or teeth	Indistinct bumps or entirely smooth	3–4 prominent spine-like teeth*

exaratum was examined in this study (Fig. 4; see ***Comparative material examined***), the species has been excellently figured by many authors (e.g., Reeve, 1848: pl. XII, figs. 32a, 32b; Tryon, 1885: Cassidae, pl. 6, figs. 82, 83; Abbott, 1968: pl. 7, fig. 17, and pl. 60 [lectotype]; Abbott & Dance, 1986: 111; Kreipl, 1997: pl. 11, figs. 31, 31a; Jarrett, 2000: 43, fig. 175; Drivas & Jay, 2001: pl. 14, fig. 7; Robin, 2008: 141, fig. 3), which allowed for reasonably good comparisons. Based on morphological characteristics (see Table 1), we consider it more parsimonious to recognise *P. exaratum* as a distinct species.

The fossil *P. rembangense* (Martin, 1899) from Java, Indonesia, is the only taxon that cannot be clearly dismissed as distinct from *P. pseudobandatum*, new species. It was regarded as a synonym of *Semicassis bisulcata* (Schubert & Wagner, 1829) by Abbott (1968), but was treated by Beu (2005) as a *Phalium* species, possibly synonymous with *P. glaucum*. This lack of consensus is probably due to the fact that the types of *P. rembangense* comprise a few juvenile specimens and a larger fragment (see Beu, 2005; see also Leloux & Wesselingh, 2009). The syntypes RGM.9976 and RGM.9977 lack shoulder knobs and appear different from *P. pseudobandatum* in shell shape, form of the outer lip, and presence of finer surface sculpture in *P. rembangense* (see Beu, 2005: 175, figs. 104, 105, and Leloux & Wesselingh, 2009: 617, pl. 215, figs. 3–6). We conclude that although the validity and identity of *P. rembangense* cannot be determined without additional fossil material, this species is not conspecific with *P. pseudobandatum*.

Phalium glaucum, which ranges from the western Africa to Melanesia, and from southern Japan to northern Australia, is the most widespread species among morphologically similar congeners (Table 1). *Phalium bandatum* ranges further north in Japan, further south along the coasts of Australia, but do not extend to the Indian Ocean or as far eastwards as *P. glaucum*, while *P. exaratum* appears to be restricted to the Mascarene Islands region in the Indian Ocean (Fig. 5). *Phalium pseudobandatum* is currently known only from a small area of the Sunda Shelf where the distribution ranges of *P. bandatum* and *P. glaucum* overlap (see Fig. 5), but it is probably more widespread, especially in the region of the South China Sea and Sunda Islands. An accurate geographical distribution of *P. pseudobandatum* can only be confirmed and elucidated by future reports.

The other congeners *P. areola*, *P. decussatum*, *P. flammiferum*, and *P. muangmani* have shells with a rounded shoulder devoid of knobs, varices that are regularly retained, and are entirely smooth at the anterior edge of the outer lip. These characters set them apart from *P. pseudobandatum*. The axially ribbed shell of *Phalium fimbria* is unique (see also Abbott, 1968: 93–94). Comparisons of *P. pseudobandatum* with these congeners are thus not treated in detail here since they can be easily separated conchologically.

Comparative material examined. — *Phalium bandatum*: **Japan**: 1 ex. (SH 110 × SW 63) (CHNE), Okinawa, Nago, 5–8 m, sand, 2010. **Taiwan**: 1 ex. (SH 101 × SW 58 mm) (CNHE), Green Island, 15–20 m, sand, 2010. **Philippines**: 1 ex. (SH 110.9 × SW 72.2) (CNHE), Cebu, Olango island, in shallow water, coll. local fisherman, Aug.2011; 1 ex. (SH* 106.4 × SW 65.6) (TSK), no other data; 1 ex. (SH* 58.3 × SW 34.0) (CSY 156.9.7.0), Samar, no date. **Indonesia**: 1 ex. (SH* 127.3 × SW 80.5) (CSY 156.9.7.1), Sulawesi, no other data; 1 ex. (SH* 85.8 × SW 56.2) (CSY 156.9.7.2), no other data; 13 ex. (SH 50.4 × SW 27.7 – SH* 75.4 × SW 43.2) (CNHE), off Natuna Islands, trawled ca. 20–32 m on muddy sand bottom, coll. fishermen, Feb.–Aug.2008; 1 ex. (SH 94.8 × SW 59.3) (CLN), Bali, 1–70 m. depth, 1991; 1 ex. (SH 74.6 × SW 43) (CLN), 1992, no other data. **Australia**: 2 ex. (SH 72.8 × SW 44, SH 73.3 × SW 43.7) (TSK), Queensland, Dingo Beach, on sand and rubble during extreme low tide, 2003; 1 ex. (SH 91.2 × SW 56.6) (CLN), Queensland, Prudhoe Island, trawled, no date; 1 ex. (SH 83.1 × SW 52.1) (CLN), Queensland, off Townsville, deep water, trawled, no date; 12 ex. (SH 32.2 × SW 18.9 – SH 76.2 × SW 44.3) (CLN), no other data.

Fig. 4. *Phalium exaratum* (Reeve, 1848) (SH 100.5 × SW 60.4) (CNHE [ex-T.-C. Lan Collection]), an Indian Ocean species often treated as a subspecies of *P. bandatum* (Perry, 1811).

Phalium exaratum: **Mauritius**: 1 ex. (SH 100.5 × SW 60.4) (CNHE [ex-T.-C. Lan Collection]), Saya de Malha Bank (Mascarene Ridge), 80 m, sandy silt and shell debris, no date.

Phalium glaucum: **Mozambique**: 3 ex. (SH 44 × SW 30 – SH 74 × SW 52) (CNHE), Inhambane, no other data. **South Africa**: 1 ex. (SH 53 × SW 33) (CNHE), North Zululand, off Natal, trawled, coll. local fishermen, no date. **Sri Lanka**: 1 ex. (SH* 54.2 × SW 34.3) (CSY 156.9.2.2), Jeffna, coll. local fisherman, no date. **China**: 1 ex. (SH 43.0 × SW 28.1) (ZRC 1980.12.19.12 [ex-Biology Dept., Nanyang University, 292: M5]), Hong Kong, no other data. **Japan**: 2 ex. (SH 99 × SW 64, SH 117 × SW 75) (CNHE), Okinawa, Nago, 5–8 m, sand, 2010. **Thailand**: 1 ex. (SH* 131.0 × SW 91.5) (CSY 156.9.2.0), west of Phuket Island, coll. local fisherman, no date; 1 ex. (SH* 76.1 × SW 51.2) (CLN), Phuket Island, 1992. **Malaysia**: 1 ex. (SH 101.4 × SW 67.4) (CNHE), Johor, Endau, in fish nets at 5–8 m, coll. H. E. Ng, Jun.2004; 2 ex. (SH* 58.2 × SW 38.7, SH 61.1 × SW 39.6) (CNHE), Johor, off Sedili, trawled 20–25 m, on muddy sand bottom, coll. local fishermen, 2010; 1 ex. (SH 96.1 × SW 64.4) (CLN), Kedah, Pulau Langkawi, Teluk Burau, sandy beach, trail in sand bank at night, coll. S. K.

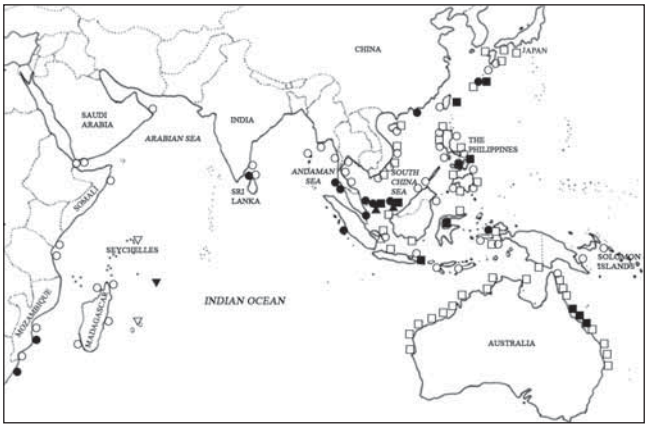

Fig. 5. Distribution of *Phalium bandatum* (square), *P. glaucum* (circle), *P. exaratum* (inverted triangle), and *P. pseudobandatum* (triangle). Solid symbols indicate material examined, while open symbols are literature records based on Abbott (1968), Kreipl (1997), Jarrett (2000), Qi (2004), Dharma (2005), and Thach (2005).

Tan, 29 Oct.2003. **Singapore**: 2 ex. (SH 65.5 × SW 45.1, SH 66.8 × SW 44.2) (ZRC.MOL.3083), Cyrene Reef, coll. C. H. Toh, 30 Aug.2011; 1 ex. (SH 73.8 × SW 50.6) (ZRC. MOL.3687), stn. DW 29, Pulau Ubin, off Chek Jawa, with hermit crab, dredged 13–25 m on sand/mud bottom, coll. CMBS, 18 Oct.2012; 1 ex. (SH* 84.8 × SW 61.5) (CSY 156.9.2.1), Changi Coast North, with hermit crab, coll. S. Y. Chan, 01 Jan.1995; 4 ex. (SH* 79.4 × SW 53.8 – SH* 95.6 × SW 64.5) (CSY 156.9.2.3), Changi, Red Cliff Shoal area, alive in sand during morning low tide, coll. S. Y. Chan, 20 May 1999; 1 ex. (SH 80.8 × SW 51.9) (CSY 156.9.2.5), Changi, Red Cliff Shoal area, alive in sand, afternoon low tide, coll. S. Y. Chan, 6 Jun.2005; 2 ex. (SH 72.0 × SW 45.4, SH 78.9 × SW 51.2) (CSY 156.9.2.4 [ex-J. Huang Collection]), off Changi, tangled in fish nets, coll. J. Huang, no date; 1 ex. (SH 79.0 × SW 52.7) (TSK), Changi, Red Cliff Shoal area, on sand in shallow water during low tide, coll. S. K. Tan, 7 Oct.1998; 1 ex. (SH 29.3 × SW 18.7) (TSK), Changi, Red Cliff Shoal area, strandline, coll. S. K. Tan, Oct.1998. **Indonesia**: 1 ex. (SH 64.5 × SW 42.6) (CNHE), Sumatra, Padang, Air Manis, from fishermen's nets at 10–15 m, coll. H. E. Ng, 30 Sep.1992; 4 ex. (SH 43 × SW 25.5 – SH* 59.8 × SW 40.3) (CNHE), off Natuna Islands, trawled ca. 20–32 m on muddy sand bottom, coll. fishermen, Feb.–Aug.2008; 1 ex. (SH 91.6 × SW 60.1) (CNHE), Maluku, Ambon, from fisherman at Liang, coll. H. E. Ng, Sep.2008; 1 ex. (SH 71.8 × SW 48.3) (CLN), 1993, no other data. **No locality data**: 2 ex. (SH* 65.4 × SW 44.5, SH* 70.7 × SW 50.1) (ZRC 1980.12.19.17–18 [ex-Biology Dept., Nanyang University, 281: M5]).

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