

New species of *Bolma* (Gastropoda: Vetigastropoda: Turbinidae) from the tropical deep sea

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ABSTRACT

Five new species of *Bolma* are described, three from New Caledonia, one from Mozambique and one from French Polynesia, all from deep reef (75–155 m) to bathyal (230–580 m) depths. Four of the new species have been sequenced, and their holotypes are also voucher specimens for COI sequences, thus contributing to a new generation of name-bearing types. The descriptions and names are provided in advance of a forthcoming shell-based revision of the genus *Bolma*, and in advance of a detailed molecular- and morphology-based study of *Bolma* in New Caledonian waters.

INTRODUCTION

The gastropods of the turbinid genus *Bolma* Risso, 1826, live at tropical and warm-temperate latitudes in the Mediterranean, West African, South African, and Indo-West Pacific biogeographical provinces; there are no *Bolma* in the western Atlantic or eastern Pacific. With the exception of the type species *Bolma rugosa* (Linnaeus, 1767), which occurs commonly near-shore to about 200 meters deep, *Bolma* species are uncommon to rare, mostly on hard bottoms between 100 and 500–800 meters deep. Beu and Ponder (1979) revised the Recent and fossil species, and recognized 19 valid species (two of which with, respectively, 2 and 3 subspecies), from among 29 nominal species. Ongoing explorations have since added 12 more species, all from South Africa and the Indo-West Pacific. Some of the taxa treated by Beu and Ponder as synonyms or subspecies have also been re-evaluated, and the genus *Bolma*, with about 35 valid species, is the subject of a forthcoming monograph by Axel Alf and Kurt Kreipl, to appear in the *Conchological Iconography*. The purpose of the present paper is to describe several new species prior to the publication of that monograph. Three of them originate from New Caledonia, which has been intensively sampled since the late 1970s through the Tropical Deep-Sea Benthos program (Bouchet et al., 2008). Early in the program, Bouchet and Métivier (1983) reported three

species of *Bolma* from New Caledonia, namely *B. guttata* (A. Adams, 1863), *B. luenica* (Watson, 1885), and *B. opaoana* Bouchet and Métivier, 1983. Since then, the program has been extended to other island groups in the South Pacific and, more recently, in the Indian Ocean, revealing still more species of *Bolma*. One of the new species is thus described based on material collected from seamounts surveyed off Madagascar in 1980, and then again off Mozambique in April 2009. And finally, while this paper was being put together, another very distinctive new species was collected in September–October 2009 off the Society Islands in French Polynesia.

One difficulty of *Bolma* systematics—in common with other vetigastropods with their non-feeding short-lived planktonic larvae—is the understanding of what constitutes geographical vs. population variation (Meyer et al. 2005). In this respect, the *Bolmas* of New Caledonia and the Solomon Islands have been the subject of molecular work by Magalie Castelin, as part of her Ph.D. thesis, the results of which will be reported elsewhere. The purpose of the present paper is also to provide names and facilitate the presentation and discussion of this molecular work.

Abbreviations and Text Conventions: lv, live-taken specimen; dd, empty shell; stn, station; MNHN, Muséum National d'Histoire Naturelle, Paris, France; NMNZ, Museum of New Zealand Te Papa, Wellington, New Zealand; NMP, Natal Museum, Pietermaritzburg, South Africa; ZRC, Raffles Museum, Zoological Reference Collection, National University, Singapore.

SYSTEMATICS

Family Turbinidae Rafinesque, 1815

Genus *Bolma* Risso, 1826

Type Species: *Turbo rugosus* Linnaeus, 1767 (by monotypy).

Bolma castelinac new species
(Figures 1–7)

Description: Shell of average size for genus, trochoid with straight sides, as tall as wide, spire angle about 75°,

rather thin-shelled and light. Teleoconch of $6\frac{3}{4}$ whorls, first two planispiral, subadult and adult whorls convex with angular peripheral cord overhanging narrow, flat, subsutural ramp, giving the impression of deep suture. Basal cord delimiting distinct basal disc. Sculpture consisting of beaded spiral cords, number of cords increasing from single subsutural cord above periphery on third whorl, to 3 on last 3 whorls, and with 3 additional secondary cords on last 1/3 whorl behind aperture; strong peripheral and weaker basal cords bearing short, scaly spines; space between peripheral and basal cords almost vertical, overall smooth except for one cord bearing short, scaly spines; base smooth, polished. Columella smooth and evenly rounded, thickened, but basal callus indistinct. Aperture oval, outer lip sharp in holotype (expanded in fully adult specimens). No umbilicus. Background color pinkish salmon, beads, adapertural side of spines, and interspace between peripheral and basal cords lighter, base porcellaneous white; columella white and nacreous, aperture nacreous within. Operculum thick, convex, smooth, white. Dimensions of holotype: height 25.2 mm, diameter 25.1 mm. Adults may reach a height of 30 mm, diameter 28 mm.

Holotype: MNHN 22823 (lv).

Paratypes: 1, MNHN 22824 [EBISCO, stn CP2579, 20°21' S, 158°40' E, 440–455 m, 1 Oct. 2005]; 1, MNHN 22840 [HALICAL 1, stn DW02, 18°54' S, 163°24' E, 352–397 m, 23 Nov. 1994]; 1, ZRC.MOL.2954 [SMIB 4, stn DW34, 24°55' S, 168°22' E, 515 m, 7 March 1989]; 1, NMNZ M.297232 [SMIB 4, stn DW34].

Material Examined and Distribution: More than 60 lots, with several hundred live-taken specimens and empty shells, from the Norfolk Ridge, mainland New Caledonia off Ile des Pins, Grand Passage between mainland New Caledonia and Récifs d'Entrecasteaux, and banks on Lord Howe Ridge, alive at depths between 350 and 580 meters. Not found during research cruises to the Solomon Islands, Vanuatu, or Fiji.

Type Locality: South of New Caledonia: Norfolk Ridge, Kaimon Maru Bank, 24°45' S, 168°06' E, 600–896 m [NORFOLK 2, stn DW 2091].

Remarks: Throughout their range, populations of *Bolma castelinae* are remarkably stable in shape and sculpture, and do not show geographical or bathymetrical variation. In Magalie Castelin's molecular tree (pers. comm.), *B. castelinae* is nearest to a possibly new species from the Solomon Islands tentatively identified by us as *B. cf. bartschii* (Dall, 1913). The latter has a peripheral cord with fewer, stronger spines, overhanging a broader, concave subsutural ramp; the spiral cords are broad, with narrow interspaces; and the basal disc is sculptured with beaded cords and bears a thin callus. Of the species present in New Caledonia, *B. castelinae* most resembles *B. recens* (Dell, 1967), but molecular analyses have confirmed that they are distinct. *B. castelinae* always has 3 rows of short scaly spines on the middle part of the last

whorl: one on peripheral and basal angles and one between them, and a smooth and glossy base. In *B. recens*, the central row of spines is weak or absent, and flanked by numerous spiral grooves, and the basal disc is sculptured with concentric cords.

Etymology: The species is named after Dr (Ms) Magalie Castelin, whose molecular work has resulted in robust species delimitations in the genus *Bolma*.

Bolma pseudobathyraphis new species
(Figures 8–14)

Bolma guttata—Bouchet and Métivier, 1983: 10, figs. 4–6 [not figs. 7–8, which represent *B. fuscolineata* Alf and Kreipl, 2009].

Description: Shell large for genus, trochoid with very convex whorls, taller than wide, spire angle about 75°, rather thin shelled and light. Teleoconch of 7 to $7\frac{1}{2}$ whorls, first 2 whorls planispiral, next 3 rather flat-sided, last two strongly convex with narrow, flat, subsutural ramp and overhanging peripheral cord, giving impression of a very deep, channelled suture. Periphery and basal cords weakly delimited, peripheral cord bearing row of short to very short, triangular, scaly spines which become evanescent near the peristome. Sculpture of fine, prosocline, axial lamellae extending on spire as well as on base, and strong, beaded spiral cords; on third whorl, single subsutural cord above periphery, number increasing to 4 on penultimate whorl, and to 7 on last whorl; space between peripheral and basal cords with three cords, central one stronger, bearing short scaly spines; base with 5 beaded cords. Columella smooth and evenly rounded, basal callus thick around columellar margin, thin on basal disc. Aperture oval, outer lip expanded, but not flaring, in adult specimens. No umbilicus. Background color light brown or light purple, occasionally more white or pink, distinctly darker above periphery, and with or without small, purple-brown spots between the beads on spire as well as on base. Columella white and nacreous, aperture nacreous within. Operculum thick and heavy, oval with convex, sometimes wrinkled, surface, white. Dimensions of holotype: Height 42 mm, diameter 37.5 mm, operculum largest diameter 17.1 mm.

Holotype: MNHN 22825 (lv).

Paratypes: 1, MNHN 22826, same locality as holotype; 1, ZRC.MOL.2955 [SMIB 4, stn DW65, 22°55' S, 167°15' E, 400–420 m, 10 Mar. 1989]; 1, NMNZ M.297233 [SMIB 2, stn DW6, 22°56' S, 167°16' E, 442–460 m, 17 Sep. 1986].

Material Examined and Distribution: *Bolma pseudobathyraphis* is the most abundant *Bolma* species in New Caledonia, with about 200 lots comprising ca. 1000 live-taken specimens and shells, from the Norfolk Ridge, mainland New Caledonia off Ile des Pins, Grand Passage between mainland New Caledonia and Récifs d'Entrecasteaux, banks on Lord Howe Ridge, and the

Loyalty Ridge, alive at depths between 240 and 530 meters. Not found during research cruises to the Solomon Islands, Vanuatu or Fiji.

Type Locality: Norfolk Ridge, south of New Caledonia, 23°42' S, 168°16' E, 377 m [NORFOLK 2, stn CP2050, 24 Oct. 2003]

Remarks: *Bolma pseudobathyraphis* is very stable in shape, sculpture and size, except on Lord Howe Ridge where there exists a morph with long spines on the periphery (Figure 14), which however is not molecularly distinct.

Bouchet and Métivier (1983) had assigned their New Caledonia material to *Bolma guttata* (A. Adams, 1863), because of its superficial resemblance to the Indian Ocean populations described as *Bolma bathyraphis* (E.A. Smith, 1899), treated by Beu and Ponder (1979) as a subspecies of *B. guttata*. However, *B. pseudobathyraphis* differs from *B. bathyraphis* by its very convex whorls and deep suture, and a spiral sculpture of spiny, rather than rounded, beads. Juveniles of *B. pseudobathyraphis* also superficially resemble *B. fuscolincata* Alf and Kreipl, 2009, and had been confused with it by Bouchet and Métivier (1983), but they differ by their much higher last whorl and aperture, more widely spaced peripheral and basal cords, and more uniform color pattern (Figures 11–12 vs. 15–16).

In Magalie Castelin's molecular tree, *Bolma pseudobathyraphis* is nearest to *B. millegranosa* (Kuroda and Habe, 1958) and to material from off Mozambique identified by us as *B. gilchristi* (Sowerby, 1903) [which may or may not be a synonym of *B. bathyraphis*]. *Bolma millegranosa* and *B. gilchristi* have smaller adult size, less convex whorls, and a peripheral cord situated very low on the whorl, bearing long deltoid spines on the periphery, albeit shorter in *gilchristi* than in *millegranosa*. *Bolma millegranosa* also differs by having a flaring outer lip in fully adult specimens.

Two other species which have not been sequenced resemble *Bolma pseudobathyraphis* because of their relatively high spire, namely *B. girgylla* (Reeve, 1843) and *B. kermadecensis* Beu and Ponder, 1979. *Bolma girgylla* is broadly distributed but rare in the Southwest Pacific (including New Caledonia); it differs by its flatter base, primary rows of wide, bilobed spines on the peripheral and basal cords, and the orange color of the columellar callus covering only part of the umbilical region. *Bolma kermadecensis*, only known from the dead and worn holotype from the Kermadec Islands, also has a flatter base, and has a dark piny fawn color.

Etymology: From its superficial resemblance with *Bolma bathyraphis*, with which it had originally been identified.

Bolma kreipli new species
(Figures 17–20)

Description: Shell small for genus, trochoid, slightly taller than wide, spire angle 70°, thick and solid.

Teleoconch of 5 $\frac{3}{4}$ whorls, first two whorls planispiral, third whorl with flat sides, last two whorls rather convex with low peripheral cord bearing strong, projecting spines (the spines were significantly chipped during shipping after the photos were taken), basal cord weakly delimiting convex base. Sculpture of indistinct, fine axial lamellae and beaded spiral cords, number of cords increasing from 4 on third whorl to 10 above periphery of last whorl, adapical cord stronger; interspace between periphery and basal cord with 3 beaded cords; base axially (radially) lamellate with 6 beaded cords, unevenly spaced with gap between the 2 cords that surround umbilical callus and rest of cords. Columella smooth and evenly rounded, bearing an indistinct tooth abapically, basal callus very thin, transparent, aperture oval, outer lip barely expanded. No umbilicus. Color and color pattern variable, background color creamy white, light brown or beige, with irregular purple, red or brown flames, base with purple dots irregularly placed between beads. Columella white, aperture nacreous within. Operculum thick and heavy, oval with a convex, wrinkled surface and small, flat marginal edge, white. Dimensions of holotype: height 14.2 mm, diameter 13.5 mm. Operculum diameter 4.9 mm.

Holotype: MNHN 22827 (lv).

Paratype: 1 (lv), MNHN 22828, from 22°32' S, 167°32' E, 155 m, 9 Sept. 1989 [SMIB 5, stn DW82].

Other Material Examined: MUSORSTOM 4: stn DW203, 22°36' S, 167°05' E, 105–110 m, 27 Sept. 1985, 2 dd. LAGON: stn 316, 22°35.3' S, 166°54.0' E, 68 m, Nov. 1984, 1 lv; stn 386, 22°37' S, 167°09' E, 128 m, Nov. 1984, 1 dd; stn 397, 22°39' S, 167°11' E, 125 m, Nov. 1984, 1 lv.

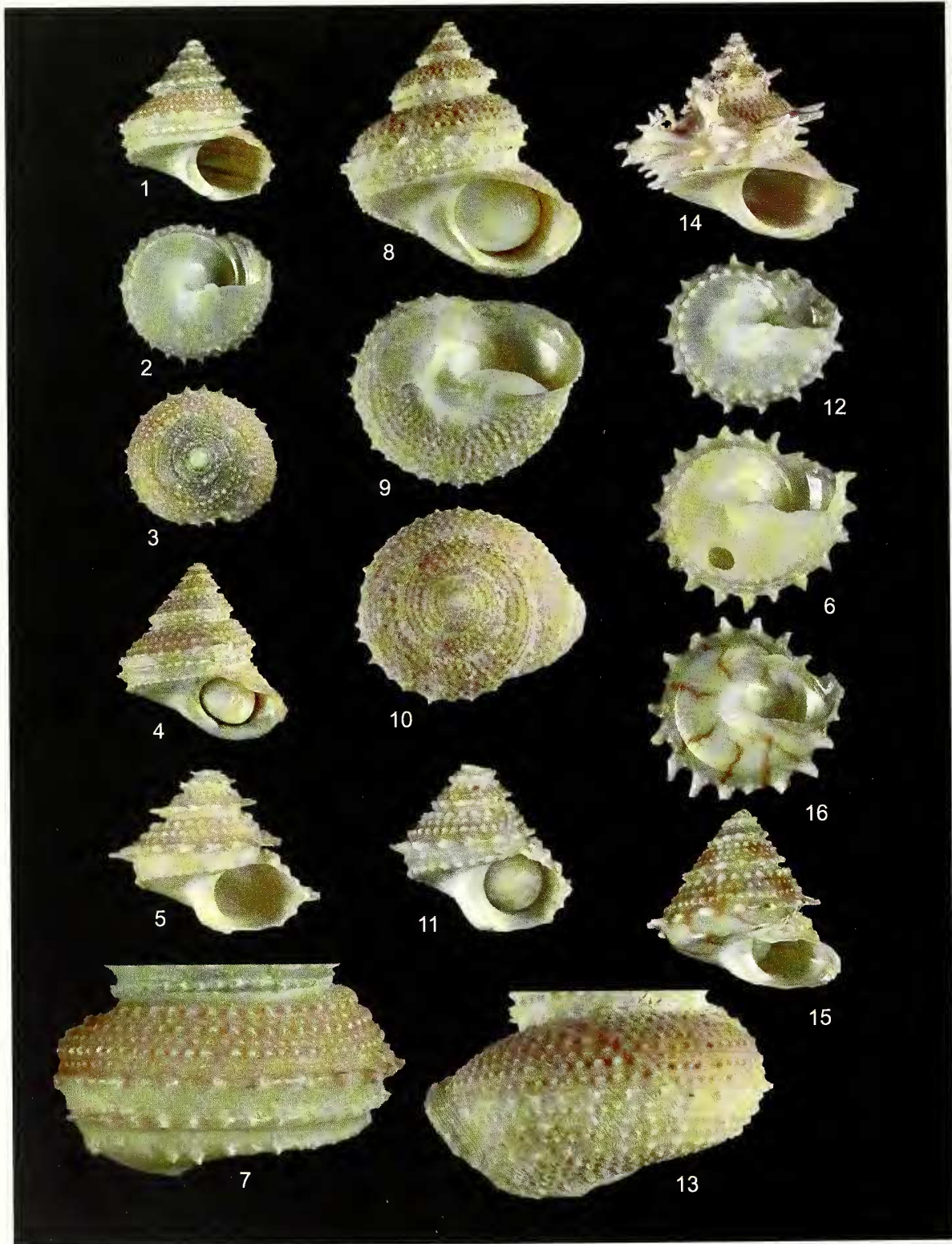
Type Locality: Between New Caledonia and Ile des Pins, 22°34' S, 167°10' E, 75 m [MUSORSTOM 4, stn DW231, 1 Oct. 1985].

Discussion: We have had no molecular material of *Bolma kreipli*, and our comparisons are entirely based on phenotypic resemblance. *Bolma kreipli* resembles *B. persica* (Dall, 1907) but differs from it by its overall higher shape, more convex whorls and base, less angular periphery and basal angle, distinct periumbilical cords, and non-nacreous columella. At 22 mm, *Bolma persica* also reaches a larger adult size than *B. kreipli*.

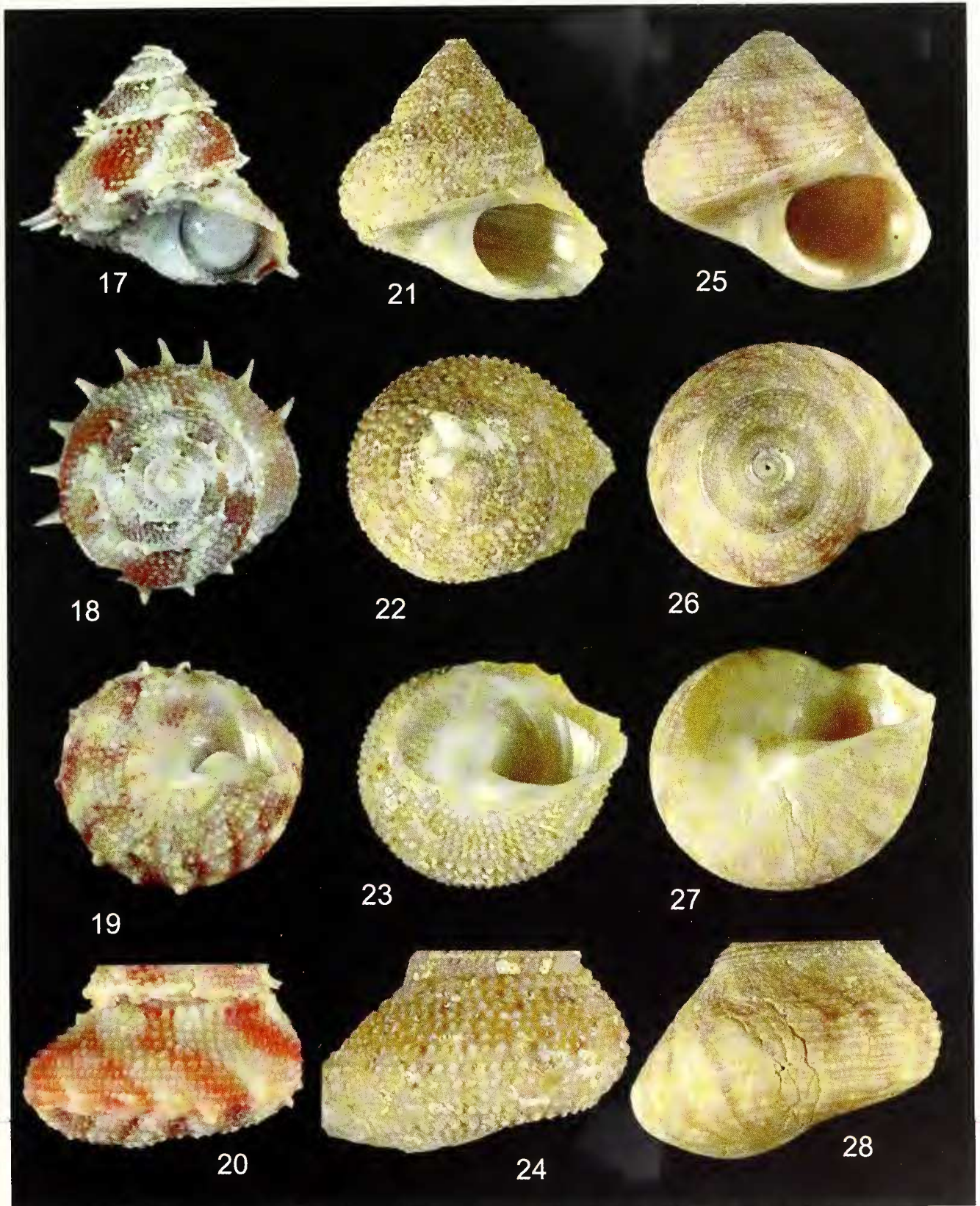
Etymology: After Kurt Kreipl, an authority on *Bolma* and other turbinids.

Bolma mainbaza new species
(Figures 21–24)

Description: Shell medium-sized for genus, trochoid, as tall as wide, spire angle about 75°, rather thin shelled. Teleoconch of 6 whorls, first 2 whorls planispiral, next whorls regularly convex, separated by narrow, deep suture; on spire whorls, peripheral cord covered by successive whorl, on last whorl not demarcated and resembling any of the spiral cords; basal cord distinctly



Figures 1–16. *Bolma* species from New Caledonia. **1–7.** *Bolma castelinae* new species. **1–3.** Holotype, MNHN 22823, height 25.2 mm. **4.** Paratype, MNHN 22840, adult with fully developed outer lip, 18°54' S, 163°24' E, 352–397 m [HALICAL 1, stn DW02], height 27.5 mm. **5–6.** Juvenile, 24°56' S, 168°22' E, 520 m [SMIB 3, stn DW01], height 9.7 mm. **7.** Holotype, detail of last whorl. **8–14.** *Bolma pseudobathyrhaphis* new species. **8–10.** Holotype, MNHN 22825, height 42 mm. **11–12.** Juvenile, 18°56S, 163°24' E, 380–400 m, HALICAL 1, stn DW01], height 8.5 mm. **13.** Holotype, detail of last whorl. **14.** Specimen with unusually spinose sculpture, 24°45' S, 159°43' E, 328–463 m [EBISCO, stn CP2505], height 34.6 mm. **15–16.** *Bolma fuscolineata* Alf and Kreipl, 2009, 22°56' S, 167°15' E, 427–433 m [NORFOLK 1, stn DW1733], height 8.6 mm.



Figures 17–28. *Bolma* species. 17–20. *Bolma kreipli* new species, holotype, MNHN 22827, height 14.2 mm. 21–24. *Bolma mainbaza* new species, holotype, MNHN 22829, height 21.2 mm. 25–28. *Bolma tantalea* new species, holotype, MNHN 22831, height 23.4 mm.

stronger, delimiting poorly defined basal disc. Sculpture of fine prosocline lamellae and beaded spiral cords, number above peripheral cord increasing from 2 on third whorl, to 6 on penultimate whorl and 9 on last whorl, adapical cord stronger; peripheral cord bearing spines on spire whorls, simply beaded on last whorl; interspace between peripheral and basal cords bearing one beaded cord. Base moderately convex, sculptured by 5 beaded cords, unevenly spaced, with gap to basal cord. Columella smooth and evenly rounded, with thin, polished basal callus extending over the base. No umbilicus. Outer lip expanded in adult specimens. Background color light pinkish brown to fawn, beads usually lighter, white to brown, not forming any pattern. Columella porcellaneous white. Operculum ovate, outer side white, regularly convex, weakly pustulose at center. Dimensions of holotype: Height 21.4 mm, diameter 20.4 mm, operculum largest diameter 8.6 mm. Largest specimen reaching a size of about 24 mm.

Holotype: MNHN 22829 (lv).

Type locality: Mozambique Channel, off southern Mozambique, Almirante Leite Bank, 26°12' S, 35°02' E, 228–230 m [MAINBAZA, stn DW3167, 16 April 2009].

Paratypes: 14: MNHN 22830, 11 (6 lv, 5 dd); Natal Museum L7886/T2579, 1 (lv); Museu de Historia Natural de Maputo, Mozambique, 1 (dd); Coll. J. Rosado, Maputo, 1 (lv); all from the type locality.

Remarks: Magalie Castelin has obtained DNA from the tissues of this new species, but sequencing has, at the time of writing, been unsuccessful. Our comparison with other species is thus purely phenotypical. Of the six species of *Bolma* recorded until now from the southwestern Indian Ocean, *Bolma mainbaza* resembles *B. flava* Beu and Ponder, 1979 [a full species, or a geographical subspecies of *B. tamikoana* (Shikama, 1973), as treated by Beu and Ponder] but the latter differs by having more depressed whorls, a distinct, spine-bearing peripheral cord, more numerous and finer spiral cords (10 above periphery of last whorl, 3 between peripheral and basal cords, 16 on base), and a color pattern consisting of brownish to purplish flames on a yellowish background; *B. mainbaza* lacks spines and is fawn-colored with irregularly scattered, small, well defined brown spots.

Etymology: Named after the cruise Mainbaza, an acronym for MAputo, INhambane, Bazaruto and ZAmbeze, Mozambique localities off of which deep-water transects were carried out.

Bolma tantalea new species
(Figures 25–28)

Description: Shell of average size for the genus, trochoid, slightly broader than tall ($h/d = 0.95$), spire angle about 85°, shell thick and solid. Teleoconch of about 5.5 whorls, suture shallow, adapical whorls almost flat, last whorl moderately convex, periphery and basal disc poorly demarcated. First 2.5 teleoconch whorls

smooth between subsutural, strongly beaded cord and peripheral cord bearing blunt spines, 14 per whorl, covered by successive whorl. Subadult and adult whorls with narrow smooth ramp adapically of subsutural cord, additional spiral beaded cords occupying space between subsutural and spineless, peripheral cord; 4 cords on 3rd whorl, 5 on exposed part of penultimate whorl, 7 plus a couple of secondary ones above periphery of on last whorl; 2 primary and 2 secondary cords between periphery and basal angle, beads on periphery and basal cord coalescent. Base slightly convex, sculptured with 2 weakly beaded and ca. 12 smooth spiral cords that become obsolete toward columellar region. Columella smooth and evenly rounded, umbilicus closed by thick, slightly yellowish white polished callus, covering about 1/3 of the basal disc. Outer lip hardly reflected at all. Background color pinkish ivory, with darker, brownish-purple axial veins. Columella and aperture nacreous. Operculum rounded, outer side white, nucleus very slightly depressed, greenish brown. Dimension of holotype: Height 23.4mm, diameter 26.3mm, operculum largest diameter 10.0 mm.

Holotype: MNHN 22831 (lv).

Paratype: MNHN 22832, 1 (dd) from off Raiatea, Society Islands, 16°53' S, 151°21' W, 440–490 m, 18 Oct. 2009 [TARASOC, stn DW3451].

Material Examined and Distribution: Only known from the type material and several fragments from the western part of the Tuamotus chain attributed to the species.

Type Locality: French Polynesia, Society Islands, Tahiti, 17°48' S, 149°22' W, 390–790 m [TARASOC, stn DW3488, 23 Oct. 2009].

Remarks: *Bolma tantalea* is very distinctive among South Pacific Bolmas by its very compact overall appearance. It vaguely resembles *B. recens* which differs by a pointed spire, deep and often even canaliculate suture, well marked peripheral and basal angles separated by an almost flat interspace, a spiral sculpture with fewer (usually up to 5 above periphery) beaded cords and short triangular spines on the periphery, at least on spire whorls. Spineless forms of *Bolma tamikoana* can be separated by their orange columellar callus. *Bolma opaoana* has a pointed spire and its color is fawn with brownish flames, and a slight orange blotch on the columella and columellar callus. *Bolma midwayensis* Habe and Kosuge, 1970, has a pointed spire and deep suture, and its color is whitish with pink clouds.

Etymology: *Tantaleus*, -a, -um, is an adjective formed after Tantalus, the mythological character symbolic of torment. During the TARASOC cruise only tantalizing shell fragments were first sampled, then during the third week a broken adult was taken, and the live-taken holotype was finally obtained after more than 120 dredge hauls, just three days before the end of the cruise.

ACKNOWLEDGMENTS

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and Loïc Le Goff. Finally, we are grateful to Magalie Castelin for having made her molecular results available to us to facilitate species-level comparisons of the new species described in this paper.

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