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TAXONOMIC REEVALUATION OF *GEMMULOBORSONIA* SHUTO, 1989 (GASTROPODA: CONOIDEA), WITH A DESCRIPTION OF NEW RECENT DEEP-WATER SPECIES

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ABSTRACT

The genus *Gemmuloborsonia* Shuto, 1989, until now known only from Upper Miocene-Lower Pleistocene deposits of the Tethys, is recorded in Recent faunas, with five new bathyal species from New Caledonia, Indonesia, Mozambique Channel, and the Philippines. Radular morphology indicates that *Gemmuloborsonia* belongs to the subfamily Turrinae, and not to Borsoniinae, where it had been allocated based on shell morphology. Columellar pleats, which have long been considered a synapomorphy of the borsoniid group of genera, have thus been acquired independently in the Turrinae. The consequence of this finding is that the current (sub)family allocation of some genera, based on shell characters only, may need reevaluation.

INTRODUCTION

The genus *Gemmuloborsonia* was established by Shuto (1989) for a peculiar turrid species, *G. fierstinei* Shuto, 1989, from uppermost Pliocene to Lower Pleistocene of the Philippines. This species possesses features characteristic of two different turrid subfamilies, i.e., Turrinae and Borsoniinae (= Clathurellinae according to Taylor, Kantor & Sysoev, 1993). The presence of a columellar pleat, a landmark of the borsoniid and bathytomid groups of Clathurellinae, allowed the author to assign the genus to this subfamily, despite the overall similarity to the turrine genus *Gemmula* Weinkauff, 1875. Besides the type-species, Shuto also included in his genus three extinct species from the Upper Miocene of Indonesia (*G. coronifera* (Martin, 1879) = *G. miocoronifera* (Powell, 1964)) and Italy (*G. bicoronata* (Bellardi, 1877) and *G. lapugyensis* (Mayer in Bellardi, 1877)).

In the course of studying a large collection of Indo-Pacific conoidean gastropods collected by French expeditions and stored in the Muséum national d'Histoire naturelle, Paris, five additional species of *Gemmuloborsonia* were found. The genus is recorded here for the first time in the Recent conoidean fauna. The morphology of the radula shows that the subfamilial placement of the genus must be changed to the subfamily Turrinae.

Descriptions of the new species are given below.

ABBREVIATIONS

MNHN—Muséum national d'Histoire naturelle, Paris, France, NM—Natal Museum, Pietermaritzburg, South Africa; NMNZ—National Museum of New Zealand, Wellington, New Zealand; PPPO-LIPI—Pusat Penelitian dan Pengembangan Oseanologi LIPI, Jakarta, Indonesia; ZMMSU—Zoological Museum of Moscow State University, Moscow, Russia.

SYSTEMATIC DESCRIPTIONS

Family **Turridae** H. & A. Adams, 1853
Subfamily **Turrinae** H. & A. Adams, 1853
Genus ***Gemmuloborsonia*** Shuto, 1989

Type-species *Gemmuloborsonia fierstinei* Shuto, 1989 (original designation)

From our new data, the original diagnosis of the genus should be supplemented as follows. The protoconch is either paucispiral, of about 1.5–2 whorls, globose, smooth or with minute granules arranged in spiral rows, with brephic, arcuate, axial ribs just before the transition to the teleoconch; or multispiral, protoconch I consisting of 1.7 whorls with a sculpture of minute granules, protoconch II of 1–1.5 whorls

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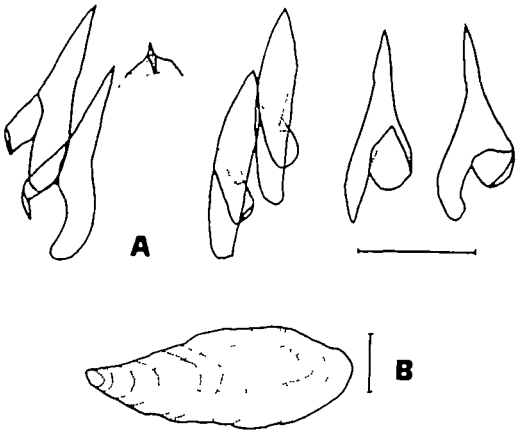

Figure 1. *Gemmuloborsonia neocaledonica*. **A.** Radula, scale bar = 0.05 mm. **B.** Operculum; scale bar = 1 mm.

sculptured by strongly arcuate axial ribs not reaching the abapical suture. The operculum is narrow, leaf-shaped, with a terminal nucleus. The radula consists of central and marginal teeth. The central tooth is weak, but with a prominent spine-like centre cusp. Marginal teeth are of wishbone type, robust, with a short and broad accessory limb.

Distribution. Plio-Pleistocene of the Philippines, Upper Miocene and Early Pleistocene of Indonesia, and Upper Miocene of Italy. Recent species recorded from the upper bathyal of Eastern Indonesia, New Caledonia, Mozambique Channel, and the Philippines.

Gemmuloborsonia neocaledonica new species
Figs. 1; 2A,D; 3A-D

Material examined. New Caledonia. R.V. 'Coriolis', CHALCAL 2, sta DW73, 573 m. 24°40′S-168°38′E, 29.10.1986, 1 shell; sta. DW74, 650 m, 24°40′S-168°38′E, 29.10.1986, 2 shells including the holotype; R.V. 'Jean-Charcot', BIOCAL, sta. DW104, 375–450 m, 21°31′S-166°21′E, 08.09.1985, 1 shell; R.V. 'Vauban', SMIB 3, sta. DW5, 502–512 m, 24°55′S-168°22′E, 21.05.1987, 1 shell, MUSORSTOM 4, sta. DW161, 550 m, 18°39′S-163°11′E, 15.09.1985, 1 specimen; sta. DW156, 525 m, 18°54′S-163°19′E, 15.09.1985, 1 shell; sta. CC247, 435–460 m, 22°09′S-167°13′E, 04.10.1985, 1 specimen. New Hebrides Arc. R.V. 'Alis', VOLSMAR, sta. DW51, 450 m, 20°59′S 170°03′E, 04.07.1989, 2 shells, sta. DW55, 710 m, 20°59′S-170°02′E, 05.07.1989, 1 shell. Loyalty Ridge. MUSORSTOM 6, sta. DW393, 420 m, 20°48′S-167°10′E, 13.02.1989, 1 specimen; sta. DW410, 490 m, 20°38′S-167°07′E, 15.02.1989, 1 specimen.

Type material. Holotype and 9 paratypes in MNHN, 1 paratype in ZMMSU, 1 paratype in NM, and 1 paratype in NMNZ.

Diagnosis. Shell of medium size, biconic-fusiform, brownish-grey in colour, usually with brown spots and bands on subsutural fold, peripheral keel, and shell base. Protoconch multispiral, protoconch I of 1.75 minutely granular whorls, protoconch II of 1.5 whorls with arcuate axial ribs. Microsculpture of the protoconch consists of minute granules arranged in spiral and, on the lower part of the whorls, oblique rows. Subsutural fold of about the same width as the peripheral keel, and gemmulate. Spiral cords on the shell base are rather distant from each other, often granular. Columellar pleat distinct to almost obsolete. Anal sinus deep, U-shaped.

Description of holotype. The shell is biconic-fusiform and rather thick and strong. The protoconch is dark-brown and consists of minutely granular protoconch I (partly broken) and protoconch II of 1.5 whorls covered by arcuate and strongly oblique axial ribs, which do not reach the lower suture. Ribs become more distant from each other towards the transition from proto- to teleoconch. Interspaces between ribs are very finely spirally striated. The teleoconch consists of 8 3/4 low whorls separated by deeply channelled sutures. The profile of spire is initially flat, but then becomes slightly convex. Whorls bear a wide subsutural fold and a strong peripheral keel. The subsutural fold is narrower than the keel on initial teleoconch whorls, but rapidly widens and already on 4th-5th whorls it becomes of about the same width. Both sculptural elements become more flattened towards the body whorl. They are covered by gemmules which have the shape of blunt tubercles on initial whorls but become longitudinal and more obsolete towards the body whorl. Gemmules on the subsutural fold also become oblique, whereas those on the peripheral keel become arcuate. The number and position of gemmules on the subsutural fold more or less correspond to those of the peripheral keel. There are 22 gemmules on the penultimate whorl and about 30 on the body. Both subsutural fold and peripheral keel of last whorls bear two indistinct spiral cords forming tubercles at intersection with gemmules. The upper edge of

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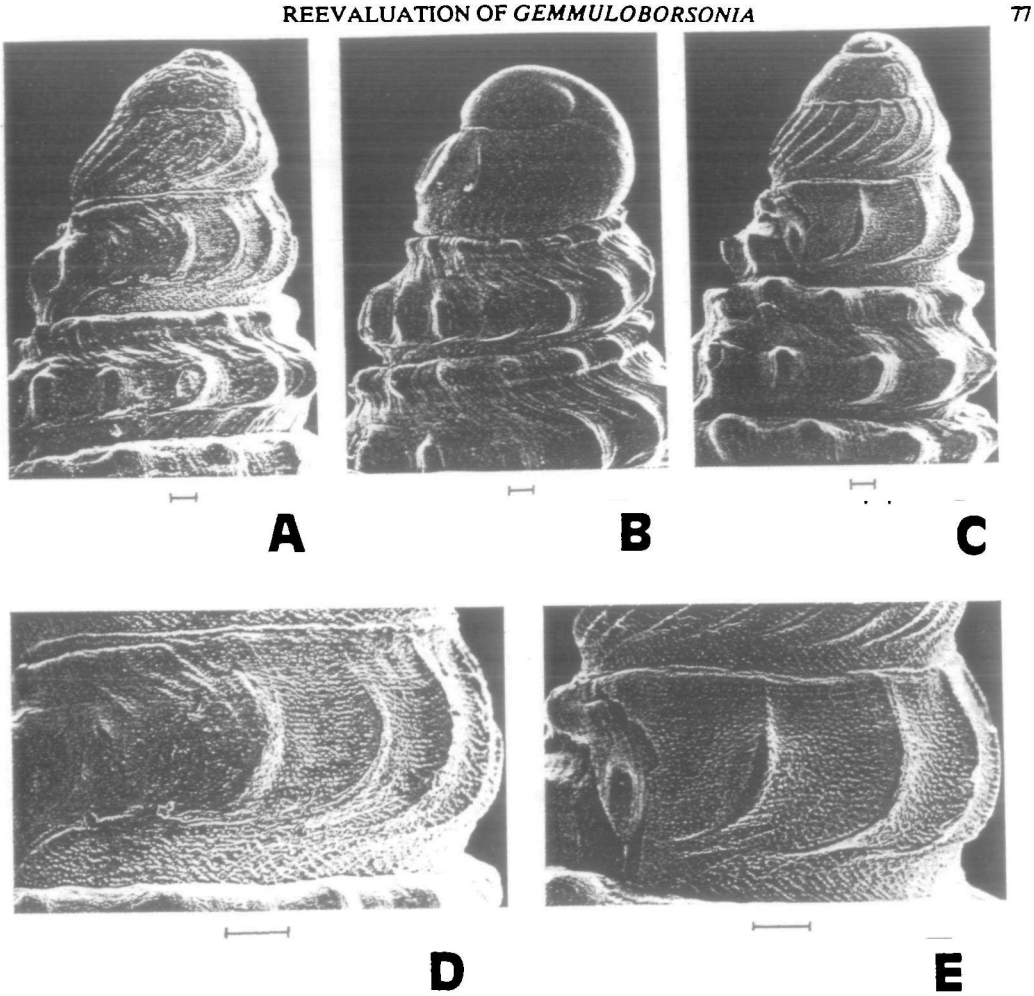

Figure 2. Protoconchs. **A, D.** *G neocaledonica.* **B.** *didyma.* **C, E.** *G. moosai.* Scale bars = 0 1 mm.

the peripheral keel also bears a strong and wavy spiral cord bordering the deeply excavated interspace between the keel and subsutural fold. The keel on initial whorls is set close to the lower suture, and the distance between the suture and the keel is approximately the same as between the keel and subsutural fold. However the keel position becomes higher towards the body whorl, and on the penultimate whorl the keel is rather distant from the suture. A weak cord below the keel appears on 5th–6th whorls; 4 additional cords develop on the penultimate whorl. The body whorl occupies about 60% of the shell height. Its periphery below the keel is covered by 7 flattened and rounded cords separated by rather narrow interspaces. Cords on the shell base are broader, with interspaces exceeding the cord width. The cords are granular at intersections with growth lines. On the canal the cords become narrower, but the interspaces are still wide. The aperture is narrow, its width slowly decreases to the short and obliquely truncated canal. The inner lip is covered by thick white callus with longitudinal wrinkles near its edge. The columellar pleat is obsolete. The outer lip projects strongly forward below the sinus. The anal sinus is deep, U-shaped, slightly constricted at the entrance, with edges turned outside. The sinus is directed slightly adapically.

Shell height 30.3 mm, body whorl height 18.6 mm, aperture height 14.7 mm, shell diameter 10.6 mm.

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The shell colour is brownish-grey, with brown spots between gemmules on the subsutural fold and, sometimes, peripheral keel, and two brown bands on the shell base, the upper being broader. The protoconch is dark-brown.

Remarks. The paratypes are smaller (the largest is 28.5 × 9.7 mm). The diameter to height ratio varies from 0.34 to 0.40. Variability of paratypes mostly concerns the sculpture. The gemmules may slightly vary in prominence. Spiral cords may be somewhat narrower or broader and more or less granular. The fissure between the subsutural fold and the suture is sometimes rather wide. The columellar pleat is developed to various extent, but usually much stronger than in the holotype. The shell coloration is sometimes very faint, especially in alcohol-preserved specimens.

The operculum is narrowly leaf-shaped, with a terminal nucleus. The radula (paratype from sta. DW 410, shell height 21.5 mm) is typical of the subfamily Turrinae and consists of central and marginal teeth. The central tooth is weak but with a prominent spine-like central cusp Marginal teeth are of wishbone type, robust, with short and broad accessory limb. The marginal tooth is 82 μm long.

The new species is most similar to *G. jarrigei*, but differs in having a multispiral protoconch and more prominent, usually granular spiral cords with wider interspaces, especially on the shell base and canal. The subsutural fold in *G. neocaledonica* is equal to, or even wider than the peripheral keel. Besides, these species seem to have somewhat different bathymetric ranges: *G. neocaledonica* was not found shallower than 375 m, whereas *G. jarrigei*—not deeper than 350 m. The two species co-occur in the area northward of New Caledonia (MUSORSTOM 4 stations).

G. neocaledonica much resembles the type-species of the genus, differing in having multispiral protoconch and almost twice larger shell at almost the same (8+ vs. 7+ in the type-species) number of teleoconch whorls which bear less prominent and more numerous gemmules on the peripheral keel.

The species also shows a striking similarity to some forms of *Bathytoma* Harris & Burrows, 1891, particularly to *B. oldhami* (Smith, 1899). The latter species mainly differs in having a shell about 1.5 times larger, with paucispiral protoconch, and possesses a true toxoglossate radula with long and curved hollow teeth (Sysoev, 1996).

Distribution. New Caledonia, Loyalty Islands, and southern New Hebrides Arc; alive in 420–550 m, shells recorded down to 710 m.

Etymology. Named after the area of distribution.

Gemmuloborsonia jarrigei new species
Fig. 3E-G

Material examined. Coral Sea. R.V. 'Coriolis', MUSORSTOM 5, sta. 345, 305–310 m, 19°40'S-158°32'E, 16.10 1986, 1 shell. New Caledonia, R V 'Vauban', MUSORSTOM 4, sta. DW181, 350 m, 18°57'S-163°22'E, 18.09.1985, 2 shells including the holotype

Type material. Holotype and paratypes in MNHN.

Diagnosis. Shell rather small, biconic-fusiform, brownish-grey in colour, with irregular light-brown or brown spots on subsutural fold, peripheral keel, and shell base. Protoconch paucispiral, globose, initial 1.5 volutions smooth, subsequent 1/6 whorl with arcuate axial ribs. Subsutural fold narrower than the peripheral keel; both sculptural elements rather weakly gemmulate. Spiral cords rather prominent, often with subrectangular profile, with interspaces narrower than the cords, weakly granular. Columellar pleat distinct. Anal sinus deep, U-shaped.

Description of holotype. The shell is biconic-fusiform and rather thick and strong. The protoconch is globose, greyish-white, and consists of smooth and glossy 1.5 initial volutions and 1/6 whorl covered by arcuate axial ribs. The border between protoconch and teleoconch is indistinct. The teleoconch consists of 6.5 low whorls separated by channelled sutures. The spire has a flat profile. The whorls bear a rather wide subsutural fold and a moderately strong peripheral keel. The subsutural fold is narrower than the keel. Both sculptural elements become more flattened towards the body whorl. They are covered by gemmules which have the shape of blunt tubercles on initial whorls, but become longitudinal and more obsolete towards the body whorl. Gemmules on the peripheral keel become arcuate. Gemmules on these sculptural elements more or less correspond to each other. There are 25 gemmules on the penultimate and 30 on the body whorl. The subsutural fold bears one spiral cord on its adapical part. The peripheral keel is generally smooth in its central portion, but two very indistinct spiral cords are dis-

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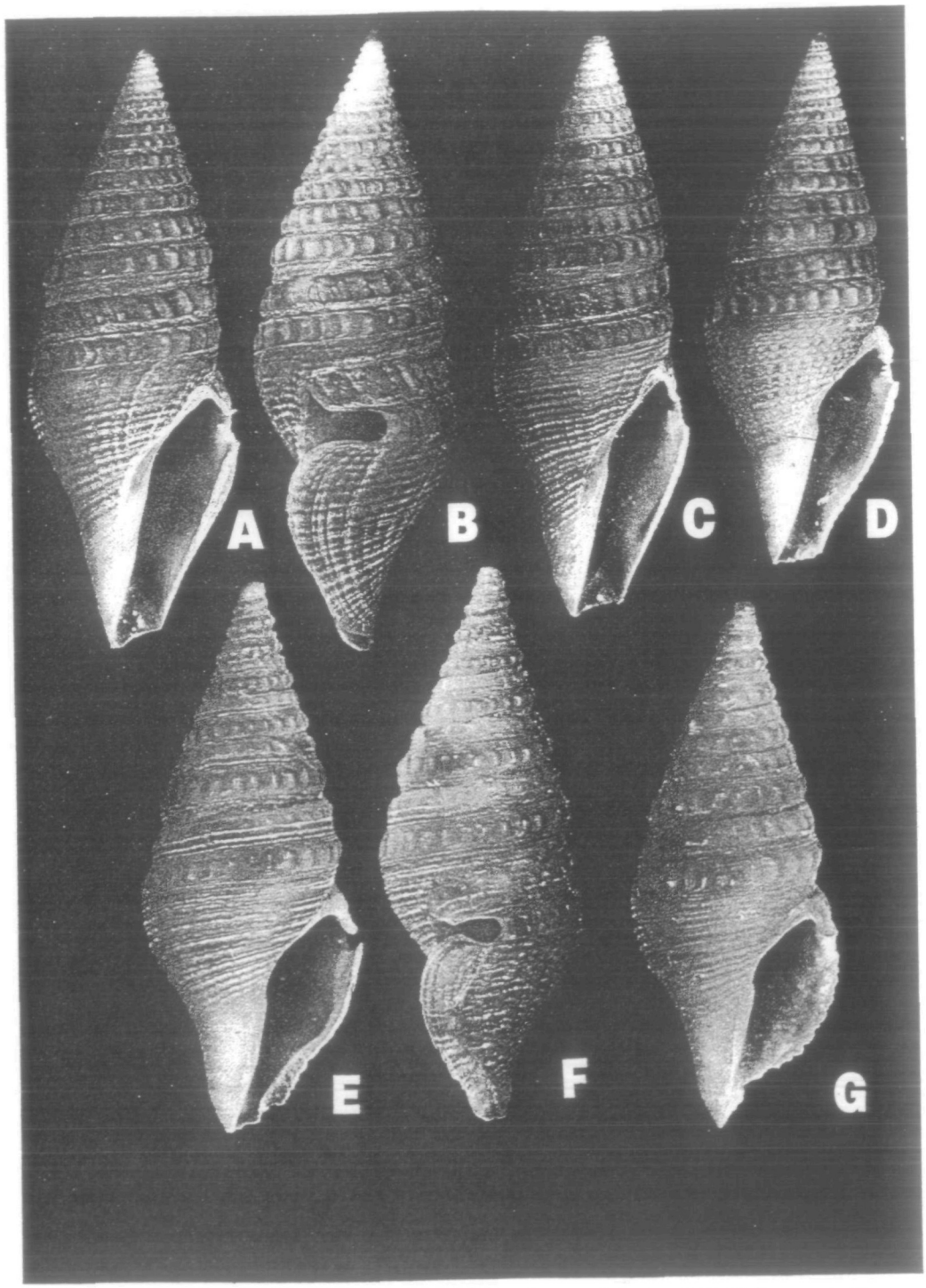

Figure 3. Shells of *Gemmuloborsonia* new species. **A-D**. *G. neocaledonica*. **A-B**. Holotype. **C**. Paratype, CHALCAL sta. DW73, 28.5 mm. **D**. Paratype, VOLSMAR sta. DW51, 22.9 mm. **E-G**. *G. jarrigei*. **E-F**. Holotype. **G**. Paratype, MUSORSTOM 4 sta. DW81, 13.8 mm.

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cernible on parts of it only. The keel is bordered by 2–3 narrow cords. The space between subsutural fold and the keel is rather wide, slightly excavated, and bears 1 (on initial whorls) or 2 strong spiral cords. The keel on initial whorls is set close to the lower suture, and the distance between the suture and the keel is even less than that between the keel and subsutural fold. However, the keel position becomes higher towards the body whorl, and on the penultimate whorl the keel is rather distant from the suture. There are 3 cords below the keel on the penultimate whorl. The body whorl comprises about 60% of the shell height. Below the keel it is covered by strongly unequal, wavy, spiral cords with subrectangular profile. The cords are separated by narrow interspaces which do not exceed the cord width. Towards the canal the width of the cords becomes more uniform. The cords are very weakly granular at intersections with growth lines, only near the aperture does the granulation become more distinct. The aperture is narrow, it gradually narrows to the short and obliquely truncated canal. The inner lip is covered by a thick white callus with longitudinal wrinkles near its edge. The columellar pleat is distinct and obliquely encircles the columella. The outer lip projects strongly forward below the sinus. The anal sinus is deep. Judging from growth lines, it is U-shaped, with almost parallel sides. However, the actual sinus is strongly constricted at the entrance, probably due to damage and repair of the outer lip. The edges are slightly reflexed.

Shell height 14.5 mm, body whorl height 8.9 mm, aperture height 6.9 mm, shell diameter 5.8 mm.

The shell colour is brownish-grey, with irregular light-brown spots on the subsutural fold, peripheral keel, and shell base.

Remarks. The paratypes are smaller (13.8 × 5.2 and 12.9 × 4.8 mm). The diameter to height ratio is 0.37 to 0.40. They are basically similar to the holotype, but the paratype from sta. 345 has a more strongly gemmulate subsutural fold and peripheral keel, and brown spots on the shell.

This species is most similar to *G. neocaledonica*, but differs in having a paucispiral protoconch, flattened, closely-set, strongly unequal spiral cords with only weak nodules at intersections with growth lines. The subsutural fold in the former species is narrower than the peripheral keel and separated from the latter by a wider space covered by spiral cords.

Distribution. Chesterfield Islands and north of New Caledonia, dead at 305–350 m.

Etymology. Named in honour of François Jarrige, head of oceanography at ORSTOM at the time of the MUSORSTOM 4 and 5 expeditions, currently Director of the ORSTOM Center in Noumea. F. Jarrige has given much support to the researches of the second author.

Gemmuloborsonia karubar new species
Fig. 4A-B, E

Material examined. R.V 'Baruna Jaya 1', KARUBAR, sta. CC56, 552–549 m, 08°16′S-131°59′E, 31.10.1991, 1 shell, sta. CC57, 603–620 m, 08°19′S-131°53′E, 31 10.1991, 1 shell, holotype.

Type material. Holotype in MNHN, paratype in PPPO-LIPI.

Diagnosis. Shell of medium size, biconic-fusiform, with a massive coronate spire, uniformly brown in colour. Subsutural fold with overhanging lower edge, slightly narrower than the peripheral keel. Both sculptural elements are very strong, gemmulate, and separated by very deeply excavated interspace. Spiral cords obsolete except for the lower part of the shell base and the canal. Columellar pleat distinct inside the aperture. Anal sinus deep, U-shaped.

Description of holotype. The shell is biconic-fusiform and rather thick and strong. The protoconch is missing and the upper part of teleoconch eroded. The beginning of the teleoconch is, however, clearly marked by a bluntly closed initial whorl. The teleoconch consists of 6 whorls separated by deeply channelled sutures. The profile of the spire is weakly convex. Whorls bear a very prominent subsutural fold and a strong peripheral keel. The subsutural fold is only slightly narrower than the keel, with downwards sloping surface and overhanging lower edge. A shallow groove borders the rather sharp, wide and wavy upper edge of the fold, that covers the upper suture. Both sculptural elements become relatively less prominent towards the body whorl. They are covered by longitudinally elongate gemmules which are slightly oblique on the subsutural fold and arcuate on the peripheral keel. The number and position of gemmules on the fold more or less correspond to those on the keel. Gemmules on the peripheral keel become less distinct and, finally, obsolete on the body

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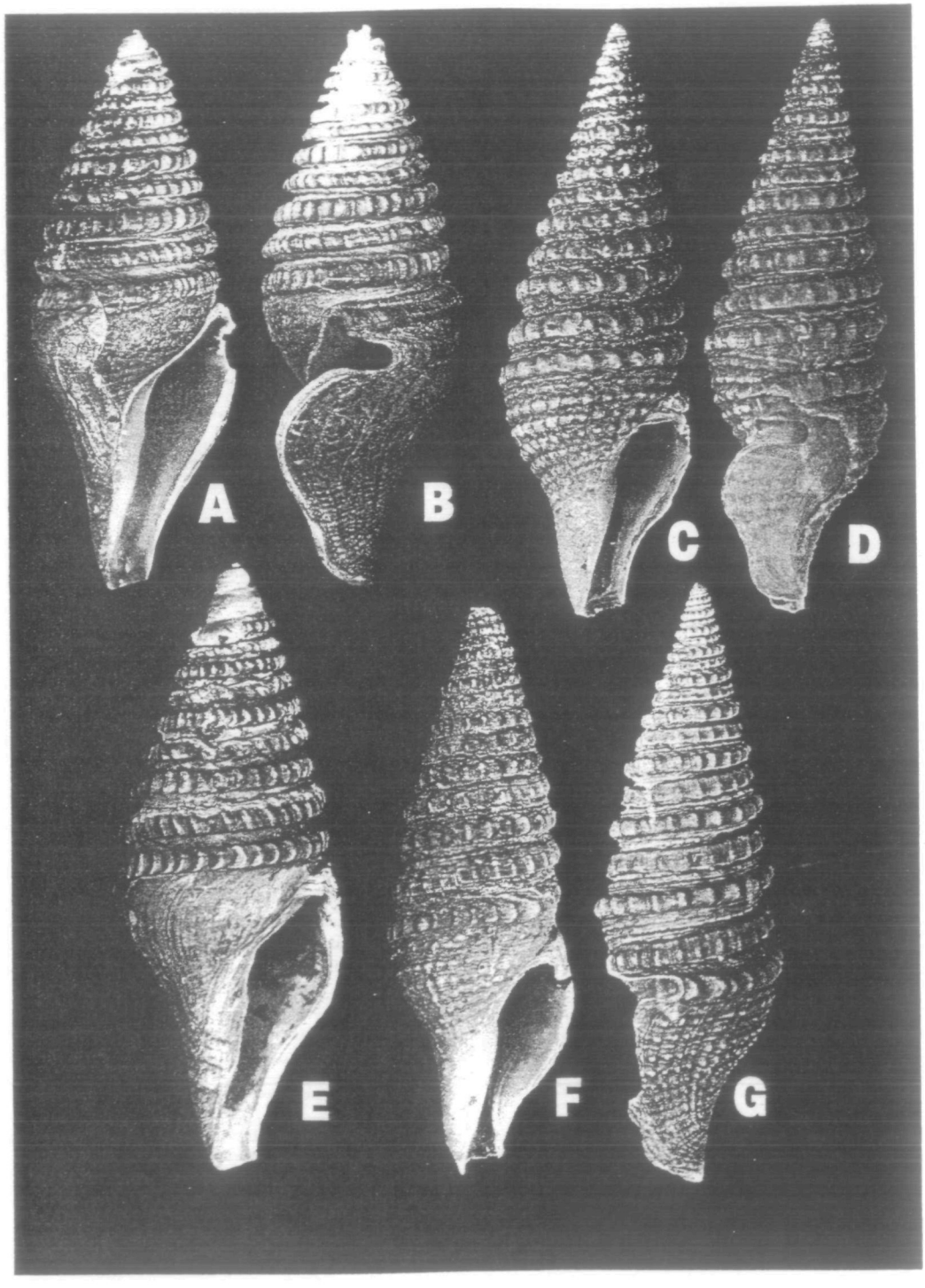

Figure 4. Shells of *Gemmuloborsonia* new species. **A-B, E.** *G. karubar.* **A-B** Holotype. **E.** Paratype. **C-D, F-G.** *G didyma.* **C-D.** Holotype. **F.** Paratype, KARUBAR sta. CP35, 21.3 mm. **G** Paratype, KARUBAR sta DW13, 22.3 mm.

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whorl. There are 34 gemmules on the penultimate whorl and 42 on the body. The subsutural fold is separated from the keel by very deeply excavated, smooth, asymmetrical interspace, the deepest part of which is situated just below the fold. Both subsutural fold and peripheral keel bear 1–2 very indistinct spiral cords. The keel on all whorls is set close to the lower suture, and the distance from the keel to the suture is less than to the subsutural fold. Spiral cords are absent on the spire whorls. The body whorl occupies about 2/3 of the shell height. Its periphery below the keel and the upper shell base are smooth, and only the lower part of the shell base and the canal are covered by weak and narrow spiral cords (about 20). The aperture is narrowly oval. The inner lip is covered by a thick white callus with longitudinal wrinkles near its edge. The columellar pleat is superficially obsolete, but well seen inside the aperture. The outer lip strongly projects forward below the sinus. The anal sinus is deep, U-shaped, with almost parallel and somewhat reflexed edges. The sinus is directed adapically.

Shell height 28.0 mm, body whorl height 18.4 mm, aperture height 15.4 mm, shell diameter 10.2 mm.

The shell is covered by rather thick brown periostracum.

Remarks. The paratype is slightly larger (29.5 × 10.6 mm) but in not so good condition. It differs from the holotype by a broader subsutural fold even exceeding the keel in width, and stronger gemmules, which are quite distinct on the body whorl.

This species is very similar to *G. hertzeli* (Martin, 1933) (originally described (Martin, 1933, p. 21, pl. 3, figs 16, 16a) as *Bathytoma*) from Mio-Pliocene (see Beets, 1953) deposits of Buton (Butung) Island, Indonesia, and apparently represents a direct descendant of that species. The main difference between these species is that the subsutural fold in *G. hertzei* is much narrower than the peripheral keel, whereas in *G. karubar* these sculptural elements are of approximately equal width.

G. karubar can be very easily distinguished from other species of the genus by the strong peripheral keel and subsutural fold with a very deeply excavated surface between them, and weakly developed spiral cords, which are present only on the lower part of the shell base and canal.

Distribution. Tanimbar Islands, Arafura Sea, dead in 552–620 m.

Etymology. Named after the KARUBAR expedition during which this and the following species were collected. KARUBAR is an acronym for the Kai, Aru, and Tanimbar archipelagos of the Arafura Sea, and is used here as a noun in apposition.

Gemmuloborsonia moosai new species
Figs. 2C, E; 5A-G

Material examined. Indonesia. R.V 'Baruna Jaya 1', KARUBAR, sta. CP35, 390–502 m, 06°08′S-132°45′E, 27.10.1991, 14 shells; sta. CP39, 477–466 m, 07°47′S-132°26′E, 28.10 1991, 1 shell; sta CP59, 405–399 m, 08°20′S-132°11′E, 31 10.1991, 3 shells including the holotype; sta. CP69, 356–368 m, 08°42′S-131°53′E, 02.11.1991, 3 shells, sta. CP70, 413–410 m, 08°41′S-131°47′E, 02.11 1991, 7 shells. Mozambique Channel. Trawl 50, 15°19,0′S-46°11,8′E, 405 m 8.11.1972, 4 shells; trawl 61, 23°36,1′S-43°31,0′E, 445 m, 27.2.1973, 5 shells; trawl 95, 22°21,6′S-43°04,3′E, 450 m, 27 2.1973, 3 shells; trawl 97, 22°25′S-43°04,5′E, 550–555 m, 27 2.1973, 1 shell; trawl 114, 22°14,7′S-43°04,5′E, 450–475 m, 12.2.1973, 8 shells; st. 65, 22°26′S-43°05′ E, 520 m, 20.10.1986, 2 shells; st. 81, 22°23′S-43°03′E, 525 m, 25.10 1986, 1 specimen. Philippines. R.V. 'Corriolis', MUSORSTOM 2, sta. CP78, 441–550 m, 13°49′N 120°28′E, 01.12.1980, 2 shells; MUSORSTOM 3, sta. CP118, 448–466 m, 11°58′N-121°06′E, 03.06 1985, 1 shell.

Type material. Holotype and 48 paratypes in MNHN, 2 paratypes in PPPO-LIPI, 2 paratypes in NM, 2 paratypes in ZMMSU.

Diagnosis. Shell of medium size, fusiform, covered by brown periostracum. Protoconch multispiral, with 1.7 smooth initial volutions and 1–1.4 whorls with arcuate axial ribs. Subsutural fold weaker than the peripheral keel, especially on later whorls, flattened, with a relatively narrow gemmulate cord. Sutural fissure formed by subsutural fold, is narrow. Spiral cords on the body whorl usually rather narrow and rounded, with wide interspaces, and granular. Columellar pleat distinct to obsolete. Anal sinus deep, U-shaped.

Description of holotype. The shell is fusiform and rather thick and strong. The protoconch is missing and the upper teleoconch whorls are eroded. The teleoconch consists of at least 10 whorls separated by deeply channelled sutures. The profile of spire is flat. Whorls bear a rather wide subsutural fold which is prominent and markedly narrower than the peripheral keel on initial whorls, but becomes wider, much flattened, and with indistinct border on last

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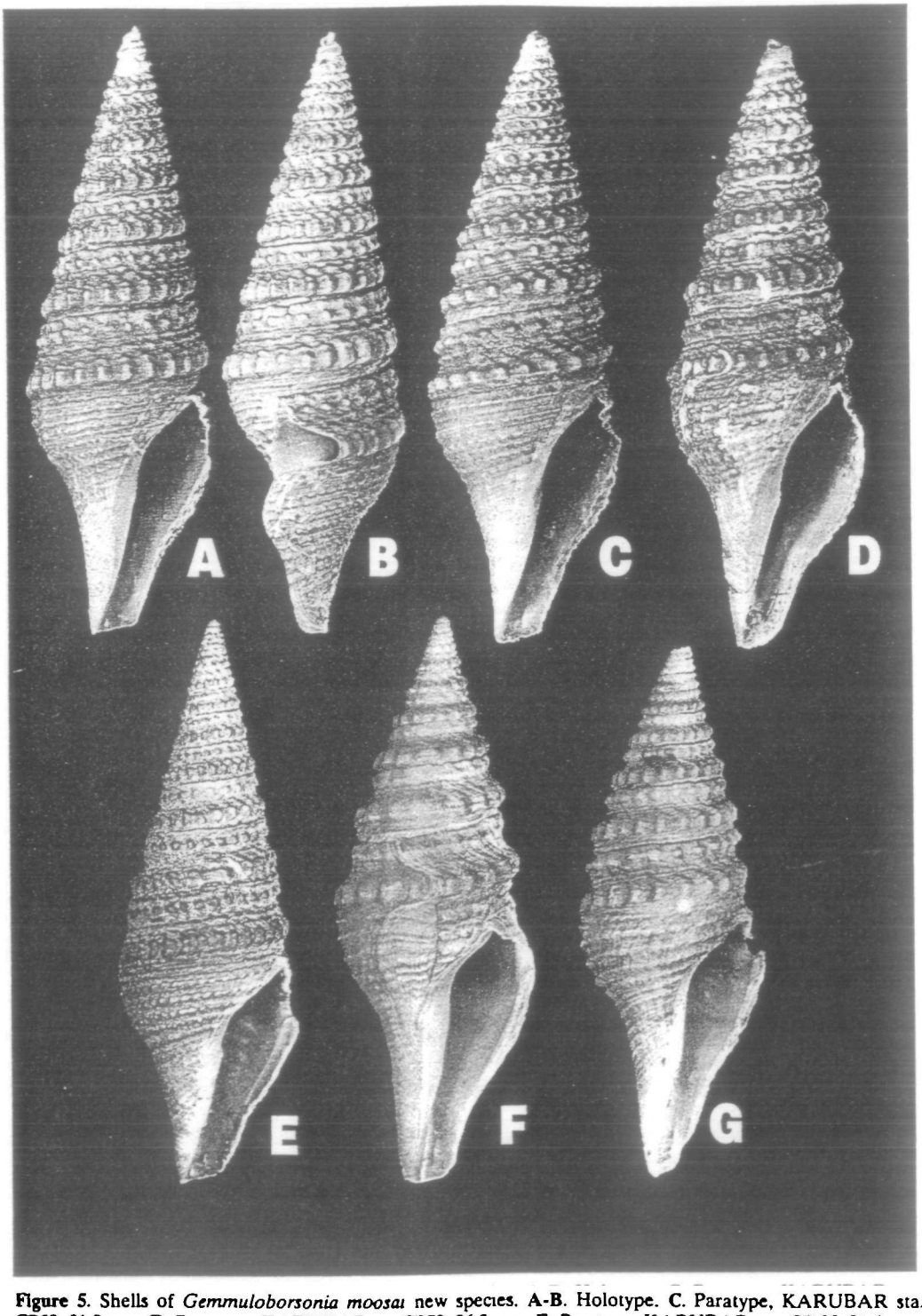

Figure 5. Shells of *Gemmuloborsonia moosai* new species. **A-B.** Holotype. **C.** Paratype, KARUBAR sta. CP59, 31.0 mm. **D.** Paratype, KARUBAR sta CP70, 26 3 mm. **E.** Paratype, KARUBAR sta. CP 35, 31.6 mm **F** Paratype, trawl 97, 28.6 mm. **G.** Paratype, trawl 95, 24.8 mm

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whorls. The subsutural fold is covered by rounded blunt tubercles, which occupy the whole fold on early whorls, but on later whorls they are confined to a relatively narrow and flattened cord in the middle of the subsutural fold. There is a wavy cord at the upper edge of the subsutural fold, that forms a fissure above the adapical suture. The peripheral keel is strong and bears longitudinally elongate gemmules (25 on the body whorl and 22 on the penultimate), which becomes arcuate on the last whorls. The gemmules more or less correspond to tubercles on the subsutural fold. The keel is bordered by two cords, the upper being strongly wavy. On the two last whorls, these cords become more distant from the keel, and their place is occupied by two narrow riblets. One more cord is situated in the middle of the interspace between the keel and the subsutural fold. The keel is covered by three rather indistinct spiral cords, the upper is the strongest and is thickened at intersections with gemmules. The keel on all whorls is set at a small distance from the upper edge of the subsutural fold. This distance is slightly less than the interspace between the keel and the subsutural fold. The body whorl comprises 55% of the shell height. Its periphery below the keel and the shell base is covered by rather narrow granular cords, sometimes with a thinner cord in the broad interspaces between cords. The cords on the canal are weaker and narrower There are 25 cords below the keel. The aperture is narrow, and its width slowly decreases to rather short and obliquely truncated canal. The inner lip is smoothly curved in its upper part and almost straight at the columella. It is covered by a white callus with fine longitudinal wrinkles. The columellar pleat encircles the columella obliquely and is well seen inside the aperture. The outer lip projects strongly forward below the sinus. The anal sinus is deep, U-shaped, with diverging branches. The sinus is directed slightly adapically.

Shell height 32.6 mm, body whorl height 18.0 mm, aperture height 14.3 mm, shell diameter 9.8 mm.

The shell is covered by light-brown periostracum.

Remarks. The paratypes are mostly smaller, from 17.9 × 7.0 to 35.6 × 11.2 mm at up to 11 teleoconch whorls. The diameter to height ratio varies from 0.30 to 0.39, usually 0.31–0.36, the higher ratio being characteristic of smaller shells.

Two shells from KARUBAR sta. CP35 have intact protoconchs consisting of 1.7 dark-brown smooth initial volutions with minutely granular surfaces, followed by 1.4 whorls with arcuate axial ribs, which do not reach the lower suture and become larger and more distant from each other towards the beginning of teleoconch. The protoconch surface is covered by a microsculpture of minute granules forming spiral and oblique rows (Fig. 2E). However, there is some geographical variability in the protoconch morphology. A single specimen with an intact protoconch from the Mozambique Channel has the same number of smooth light-brown initial volutions, but only one whorl bears axial ribs. In another shell with a partly preserved protoconch from the same locality, the axial ribs cover slightly less than one whorl.

The species is rather variable in the shell sculpture. The subsutural fold may be stronger and narrower than in the holotype, with a well-expressed cord bearing tubercles. The position of the tuberculate cord may also vary. The peripheral keel may be set lower and closer to the suture, and sometimes it has a sloping profile. The sutural fissure formed by the subsutural fold, varies in width, but usually it is rather shallow. The interspace between the fold and the keel is covered by up to 6 cords. Cords on the shell base can also vary in number, width, and prominence. They may be weakly to heavily gemmulate. The lower and upper branches of the anal sinus may be almost parallel or diverging. The prominence of the columellar pleat varies from well-expressed to obsolete, even in shells from the same sample.

The shells from Mozambique Channel (Fig. 5F,G) also differ from Indonesian shells in having a higher body whorl. We measured 20 shells from each population and calculated the ratio of body whorl height to the shell height. The respective values are 51.6–61.8% (mean 56.8±3.0%) for the Indonesian population and 60.0–66.9% (mean 63.7±2.1%) for the Mozambique Channel one. The difference is significant at $p<0.001$. However, we do not consider it to be of taxonomic importance, because the ranges of this character overlap. Rather, it is an expression of geographical variability in such distant populations.

The species is very similar to *G. didyma*, and it is sometimes difficult to distinguish these species in the absence of shells with a more or less intact protoconch. *G. moosai* differs from *G. didyma* in having a larger shell with usually weaker and narrower spiral cords on the shell

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base and a weaker subsutural fold, which bears small and rounded tubercles occupying only a portion of the fold on last whorls. The sutural fissure formed by the subsutural fold, is much narrower than in *G. didyma*.

The species is also similar to *G. fierstinei*, while differs in having a larger and somewhat narrower shell with a higher spire, a typically weaker and narrower subsutural fold, and a less developed columellar pleat.

Distribution. Tanimbar Islands (Banda and Arafura seas), the Philippines, and Mozambique Channel, at 288–575 m.

Etymology. Named in honour of Dr Kasim Moosa of the Institute of Oceanology, LIPI (Jakarta), senior scientist of the KARUBAR expedition.

Gemmuloborsonia didyma new species
Figs. 2B, 4C-D, F-G

Material examined Indonesia. R V. 'Baruna Jaya 1', KARUBAR, sta. DW07, 283–285 m, 05°46′S-132°21′E, 22.10 1991, 2 shells; sta. D13, 417–425 m, 05°26′S-132°38′E, 24.10.1991, 2 shells; sta. CP25, 336–346 m, 05°30′S-132°52′E, 26.10 1991, 1 shell; sta. DW31, 288–289 m, 05°40′S 132°51′E, 26 10.1991, 1 shell, holotype; sta. CP35, 390–502 m, 06°08′S-132°45′E, 27.10.1991, 1 shell; sta DW44, 291–295 m, 07°52′S-132°48′E, 29 10.1991, 1 shell; sta. CP71, 477–480 m, 08°38′S-131°44′E, 02.11 1991, 1 shell.

Type material. Holotype and 7 paratypes in MNHN, 1 paratype in PPPO-LIPI.

Diagnosis. Shell of medium size, fusiform, covered by brown periostracum. Protoconch paucispiral, with 1.5 smooth initial volutions and 0.3–0.4 whorl with arcuate axial ribs. Subsutural fold wide and prominent, with more or less longitudinally elongate tubercles. Subsutural fold forms deep and wide sutural fissure. Spiral cords on the shell base usually wide and strongly gemmulate. Columellar pleat distinct to obsolete. Anal sinus deep, U-shaped.

Description of holotype. The shell is fusiform and rather thick and strong. The protoconch consists of 1.5 white smooth whorls with microsculpture of minute granules arranged in spiral rows, and followed by about 0.3 whorl with few arcuate axial ribs, rapidly passing into the definitive sculpture. The teleoconch consists of 9.2 whorls separated by deeply channelled sutures. The profile of spire is flat. A strong peripheral keel is situated below the middle of spire whorls. It is covered by rounded and longitudinally elongate gemmules, which become somewhat arcuate towards the body whorl. There are 22 gemmules on the body whorl and 21 on the penultimate. On the body whorl, the peripheral keel is rather low, but the prominence of gemmules remains the same. The keel bears no distinct spiral sculpture. The subsutural fold is strong and wide. It appears on the second half of the first teleoconch whorl, initially as a narrow tuberculate cord, but then widens, and finally its width on the body whorl even slightly exceeds that of the peripheral keel. The upper edge of the fold forms a broad fissure above the suture. The fold is sculptured only by longitudinally elongate tubercles occupying its entire width Towards the body whorl the tubercles become drop-shaped, with their narrowest part not always reaching the upper edge of the fold. The deeply excavated space below the overhanging lower edge of the fold is smooth and bordered from below by a strong wavy cord situated mid-way between the fold and the keel. Another narrower cord runs along the upper edge of the keel. Below the keel there are two narrow cords, which appear on the 6th teleoconch whorl, and one stronger granulate cord just above the suture. The body whorl forms 55% of the shell height. It bears two cords below the keel and 5 very strong and heavily gemmulate cords on the shell base. Then there are 13 cords which become much narrower and plain towards the end of canal. The aperture is narrow and elongate-oval. The inner lip is smoothly curved in its upper part and slightly convex at the columella. It is covered by thick white callus which is tuberculate in the upper part due to underlying gemmulate spiral cords. The columellar pleat is distinct and obliquely encircles the columella. The outer lip projects strongly forward below the sinus. The anal sinus is deep, U-shaped, with almost parallel branches. The sinus is directed slightly adapically.

Shell height 20.6 mm, body whorl height 11.3 mm, aperture height 8.0 mm, shell diameter 7.0 mm.

The shell is covered by light-brown periostracum.

Remarks. The shell size of paratypes is from 11.2 × 4.5 to 22.4 × 7.3 mm. The diameter to height ratio varies from 0.33 to 0.40. Protoconchs of different shells have slightly varying length of the portion with axial ribs. The spiral

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cords on the shell base may vary in width and prominence; sometimes there are additional thin cords in interspaces between main cords. The anal sinus in one paratype has a constricted entrance.

The species is close to *G. moosai*, differing in having paucispiral protoconch, a smaller shell with generally coarser spiral sculpture on the shell base, a more pronounced subsutural fold, which forms a wide sutural fissure, and elongated tubercles usually occupying the entire width of the subsutural fold.

Distribution. Tanimbar Islands, Banda and Arafura seas, dead at 283–502 m.

Etymology. Didymos (Gr.)—twin, referring to great similarity with *G. moosai*.

DISCUSSION

The genus *Gemmuloborsonia*, previously considered as extinct, now appears to be rather widely distributed through the Indo-Pacific. A similar species, probably belonging to this genus, was recorded and figured by Azuma (1960) from off Tosa, Japan, in 100 fms, as '*Hemipleurotoma* (?) *abesigerui* Kuroda (MS)'. However, the name is a *nomen nudum* and thus unavailable. Later the name was listed by Higo & Goto (1994) as *Kuroshioturris abesigerui* Kuroda, MS, but these authors also did not provide any diagnosis to validate the name. Unfortunately, the photograph given in the paper by Azuma is too poor to discuss the relationship between this species and other representatives of the genus.

Another species, similar in shell outline to *Gemmuloborsonia*, is *Pleurotoma optata* Smith, 1899 (non Harris, 1897; = *indagatoris* Finlay, 1927). However, judging from the figure (Alcock & McArdle, 1901), the species lacks a columellar pleat. The taxonomic position of this species remains unclear. Finlay (1927) included it into *Gemmula*, whereas Powell (1964) with some doubt considered it to be a member of *Lucerapex* Iredale, 1936. Recently Robba *et al.* (1989) recorded this species from the Early Pleistocene of Timor (Indonesia). The illustrated shell (Robba *et al.*, 1989, pl. 4, figs 6a, 6b) undoubtedly belongs to *Gemmuloborsonia* and seems to be closely related to *G. moosai*. However, its identity with *indagatorius* is questionable, because the original figure of that species (Alcock & McArdle, 1901, pl. 9, figs 1, 1a) shows obsolete subsutural tubercles on the body whorl, whereas on the spire whorls the subsutural tubercles are connected with gemmules on the peripheral keel by oblique folds. The latter character has not been observed in any species of *Gemmuloborsonia*.

The genus *Gemmuloborsonia* probably derived from *Gemmula*-like turrine ancestors, and later acquired a convergent similarity to clathurelline genera. This suggestion is particularly supported by the fact that the Miocene species differ from the Plio-Pleistocene and Recent ones in having weakly gemmulated or plain subsutural cord, and bear more resemblance to typical *Gemmula* than to any clathurelline genus.

If we assume that a multispiral protoconch is a plesiomorphic character state and a paucispiral protoconch is apomorphic, then the occurrence of a multispiral protoconch in Recent species of *Gemmuloborsonia* indicates that this genus diverged from *Gemmula* before the loss of planktotrophy. Consequently, we can expect that fossil species with multispiral protoconchs will be also discovered in future.

The presence of columellar pleats had long been considered a landmark of the 'borsoniid' and 'bathytomid' groups of genera of the subfamily Clathurellinae. Therefore, the case of convergent appearance of this character in *Gemmuloborsonia* is of particular interest. Specifically, this may require a reevaluation of application of this character in assigning some genera to the family-group taxa. A similar case of presence of columellar plication in the crassispirine genus *Buridrillia* was recently described by Emerson & McLean (1992).

The occasional presence of some sort of sculpture on the columella is also characteristic of *Gemmula congener* (Smith, 1894). The presence of 'a kind of nodule or swelling on the upper part of the columella' in some specimens was mentioned by the author of the species (Smith, 1894, p. 160). Later the same feature was recorded by Schepman (1913) and Robba *et al.* (1989). Through the courtesy of R. Moolenbeek of the Zoologisch Museum, Amsterdam, we had an opportunity to examine the material described by Schepman. One of the two shells from 'Siboga' sta. 139 (shell height 50.6 mm) has a low but rather wide and rounded fold encircling the upper part of the columella. It is very similar to that of the shell illustrated by Robba *et al.* (1989, pl. 3, fig. 2a). However the appearance and position of this fold is quite dissimilar from the columellar pleats found in *Gemmuloborsonia* and representatives of Clathurellinae.

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Differences in the protoconch morphology (i.e., multispiral or paucispiral protoconchs) in the Conoidea have long been considered as the basis for separating genera and subgenera. However, it is presently recognised that the number of protoconch whorls, indicating the type of larval development, is not a character of major taxonomic significance at supraspecific levels (Bouchet, 1990). The presence of two protoconch types in *Gemmuloborsonia* in fact reflects only the difference between planktotrophic and non-planktotrophic development, because the protoconchs actually differ only in the extent of the part with arcuate axial ribs. This part is present in both protoconch types and marks the transition from 'protoconch I to teleoconch.

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