

Middle Miocene tonnoidean gastropods from near Wonosari, Yogyakarta, Java, Indonesia

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A well preserved tonnoidean gastropod fauna is described from Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia. In Bursidae, the second Indo-Pacific species of *Aquitano bursa* is described. In Cassidae, new species of *Cassis* and *Cypraecassis* are described, as well as the oldest known member of the genus *Casmaria*, and the first complete adult specimens of *Phalium menkrawitense* Beets, 1941 are recorded. In Cymatiidae, species represented are *Cymatiella fennemai* (Martin, 1899), *Monoplex rembangense* (Wanner & Hahn, 1935), a most unusual new species of *Monoplex*, and *Gyrineum bituberculare* (Lamarck, 1816). In Personidae, specimens assigned to *Distorsio dunggranganensis* (Martin, 1916) are the first adults of the species, and confirm distinction from the living species *D. habei* Lewis, 1972. In Tonnidae, two small (20 mm high) specimens of a *Malea* species with narrow spiral cords are assigned to *M. papuana* (Beets, 1943), the first record from Java.

Key words: Tonnoidea, Miocene, Indonesia, new species.

INTRODUCTION

Dekkers et al. (2020) gave a list of the main works dealing with Indonesian fossil mollusks, and introduced a previously undescribed gastropod assemblage occurring at a locality close to the village of Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia in describing two new fossil strombids. In this paper we continue the series and describe the tonnoideans in the assemblage. As discussed by Dekkers et al. (2020), although the exact locality is unknown, the deposit is dated accurately to the Langhian, and the preservation of the material is so good that it warrants attention.

GEOLOGICAL SETTING

The material originates from the area around the village of Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, 40 km SE of Yogyakarta, Java, Indonesia. The exact locality is unknown, but the deposits outcrop on the banks of a river or stream. The collection was donated to the Naturhistorisches Museum Wien (Vienna) in the framework of an exchange with K. Martin. Although this situation is far from ideal, the collection deposited represents the best preserved middle Miocene Indonesian assemblage we have seen, with many species that remain undescribed. The preservation of the fossils, and the attached matrix, is similar for the whole collection. Matrix was removed from three specimens and examined for microfossils. All three samples were identical in their microfossil content, and

we are therefore quite certain they all come from the same locality.

Dekkers et al. (2020) investigated the calcareous nannofossils in the samples. Based on the presence of *Sphenolithus heteromorphus* Deflandre, 1953, and the absence of *Helicosphaera ampliapertura* Bramlette & Wilcoxon, 1967 all samples were attributed to NN5 zone (Martini, 1971), which comprises the upper Langhian and lowermost Serravallian. However based on the similarity of our samples to the nannofossils association described by Marshall et al. (2015), our assemblages can be attributed to the Langhian part of NN5, lower middle Miocene. The frequent occurrences of small reticulofenestrids (*Reticulofenestra minuta* Roth, 1970) and ascidian spicules together with discoasters point to shallow, well stratified, warm marine waters.

MATERIAL AND METHODS

The material described here is deposited in the Natural History Museum Vienna (NHMW). Matrix for micropalaeontological dating was taken from three *Cassis* specimens at random (for further information see Dekkers et al., 2020).

SYSTEMATIC PART

Systematics follow Bouchet et al. (2017) and Strong et al. (2018).

Superfamily Tonnoidea Suter, 1913 (1825)

Family Bursidae Thiele, 1925

Genus *Aquitanobursa* Sanders, Merle & Puillandre, 2019

Aquitanobursa Sanders, Merle & Puillandre, 2019: 256.

Type species (by original designation): *Ranella grateloupi* d'Orbigny, 1852. Miocene, France.

Remarks. — Sanders et al. (2019) showed that the genus *Bursa* Röding, 1798 as used historically was not monophyletic, and proposed the genus *Aquitanobursa* for a group of thick-shelled fossil species characterised by their strongly developed, sharply delimited varices with prominent nodules at the shoulder angle, varices slightly offset from whorl to whorl, a short but moderately wide posterior apertural canal with at most a weak protrusion of the outer lip at the top of the canal, six primary spiral cords on the convex part of the whorl (although spiral cord P2 is very reduced over both the varices and intervariceal intervals), and with strongly shouldered whorls. Species included in the genus have been recorded from the lower Miocene of France, the lower Miocene to lower Pliocene of the Caribbean, and one species from the Miocene of Pakistan. This is the second record of the genus in the Indo-Pacific. Sanders et al.

(2019) used a similar numbering system for the spiral cords to that introduced by Merle (1999, 2001) for Muricidae. In the present group the most important terms are IP (infra-sutural primary cord), P1 (first primary spiral cord placed at the shoulder), and P2–P6 (primary spiral cords below the shoulder). We adopt this terminology for this species.

Aquitanobursa javana spec. nov.

(Figs 1-3)

Type series and dimensions. — Holotype NHMW 1901/0034/0025, height 50.2 mm, width 34.5 mm (Fig. 1); paratype 1 NHMW 1901/0034/0026, height 36.3 mm, width 23.7 mm (Fig. 2); paratype 2 NHMW 1901/0034/0027, height 39.5 mm, width 23.6 mm (Fig. 3); paratype 3 NHMW 1901/0034/0071, height 25.8 mm, width 17.3 mm (subadult).

Other material. — Known only from the type series.

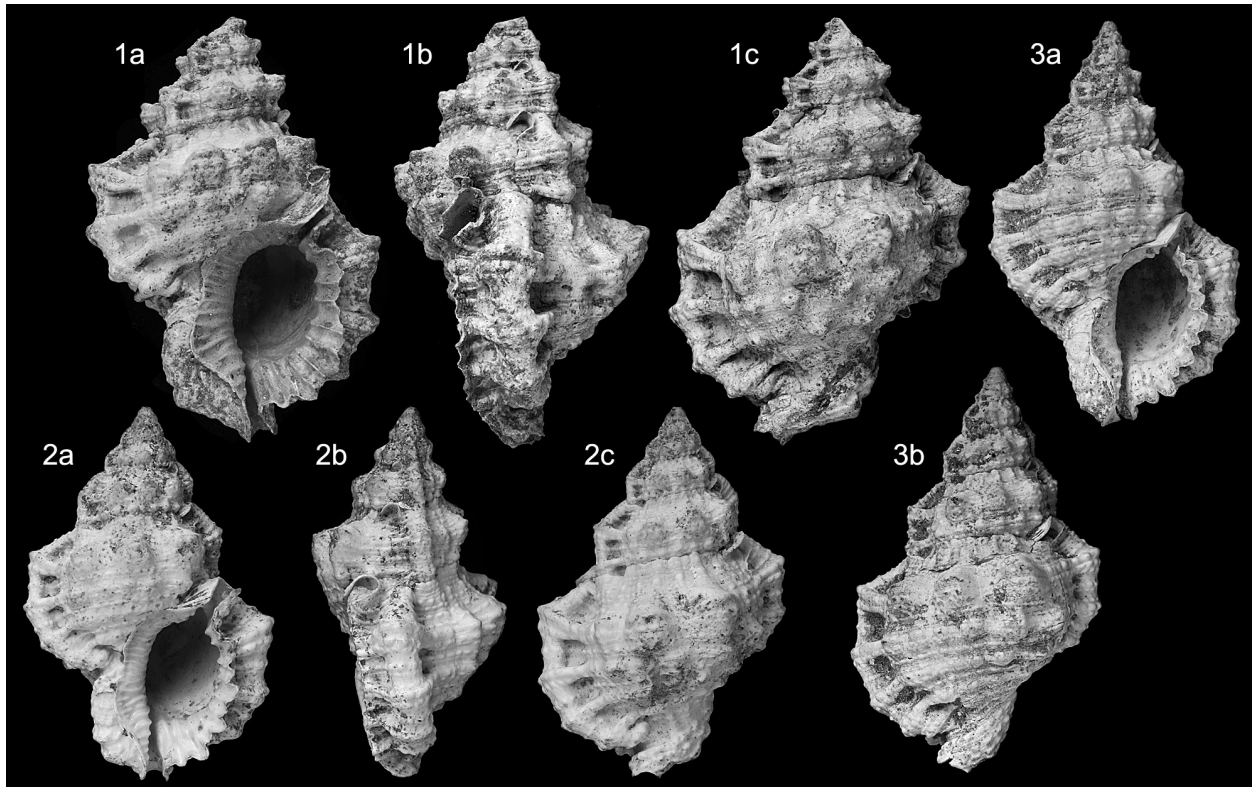
Type locality. — Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia.

Type stratum. — Langhian portion of NN5, middle Miocene.

Etymology. — Named after the Island of Java where it occurred.

Diagnosis. — *Aquitanobursa* species of medium size, whorls sharply angled, two very prominent, narrow varices per whorl, three or four prominent intervariceal tubercles on P1 in each intervariceal interval, P2 hardly developed, P3–P6 tubercular, weakening abapically, anal canal deep, tubular.

Description. — Shell medium-sized, solid, bulbous, somewhat dorsoventrally flattened, with scalate spire. Protoconch abraded in all specimens. Teleoconch of five sharply angled whorls, with concave sutural ramp, shoulder marked by strong tubercles, whorl profile below shoulder tapered inwards to suture, suture linear, somewhat irregular, impressed. Two elevated varices on each whorl deeply excavated on each side to form convex outer variceal surface; varices not aligned, but slightly displaced up spire, strongly offset on last whorl. Sculpture on spire whorls of two spiral cords, adapical cord broad, delimiting shoulder, bearing three or four strongly developed tubercles per intervariceal interval, abapical cord narrower than others, entire surface covered in beaded secondary cords giving surface finely verrucose appearance. Last whorl globose; subsutural ramp bearing 6-8 irregular axial rugae per intervariceal interval on adapical half; IP scarcely developed; P1 broad, bifid over varices; P2 marked by subobsolete thread; P3–P6 tubercular, tubercles weakening abapically, P5 and P6 closely spaced. Aperture ovate, outer lip thickened by varix, inner edge of outer lip sharp, everted, flattened and fluted, with crenulated edge, bearing 10 narrow lirae extending from outer edge across everted face of lip, weakening rapidly within aperture. Anal canal deeply



Figs 1-3. *Aquitanoobursa javana* spec. nov. **1.** Holotype NHMW 1901/0034/0025, height 50.2 mm, width 34.5 mm. **2.** Paratype 1 NHMW 1901/0034/0026, height 36.3 mm, width 23.7 mm. **3.** Paratype 2 NHMW 1901/0034/0027, height 39.5 mm, width 23.6 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

U-shaped, tubular, delimited by low extensions of outer lip edge laterally and parietal callus medially. Siphonal canal relatively short, narrow, deep, twisted to right. Columella evenly excavated. Columellar and parietal callus continuous, sharply delimited, moderately expanded, closely appressed to last whorl, sculptured over entire height by narrow, weakly anastomosing lirae extending across entire callus width and into aperture; lirae coarsen abapically. Siphonal fasciole prominent, weakly delimited, strongly convex, bearing finely tubercular cords.

Variation. — The three specimens available are remarkably constant in sculpture. The only significant difference is that paratype 2 (Fig. 3) is slightly taller-spined than the others. It evidently represents a younger specimen.

Remarks. — Sanders et al. (2019: fig. 7) numbered the primary spiral cords P1–P6 in *Aquitanoobursa* and noted that P2 is weak. In *A. javana* spec. nov. P2 can hardly be distinguished and is no more prominent than the very weak secondary spiral cords developed between P3–P4 and P4–P5. *Aquitanoobursa chipolana* (Schmelz, 1997) is closely similar to the Javanese species in all characters, but differs in having P2 weak, but clearly developed (see Schmelz, 1997: pl. 1, fig. 1b, pl. 2, fig. 1b; Sanders et al., 2019: figs 5F, G). Moreover, the secondary spiral cords on the last whorl are more

strongly developed in *A. chipolana* than in *A. javana* spec. nov. *Aquitanoobursa tuberosa* (Grateloup, 1833) from the Atlantic lower Miocene of the Aquitaine Basin, France, differs in being more slender than *A. chipolana* and *A. javana* spec. nov., more strongly dorso-ventrally compressed, the shoulder tubercles are smaller, and the anal canal is less well developed than in either of the other two species. The anal canal is a little deeper and made more tubular by short adapical extensions of the outer lip and parietal callus in *A. javana* spec. nov., a little more obvious than in its European congeners. *Aquitanoobursa inaequicrenata* (Cossmann & Peyrot, 1924), also from the lower Miocene of France, is immediately separated by having more numerous and smaller tubercles at the shoulder and, like *A. tuberosa*, has a weaker anal canal. *Aquitanoobursa amphitrites* (Maury, 1917), from the middle Miocene–lower Pliocene of the Caribbean, differs from *A. javana* in having more numerous, smaller and more evenly rounded tubercles at the shoulder and markedly wider secondary spiral cords bearing many small, rounded nodules. Also, cords IP and P2 are more prominent in *A. amphitrites* than in all other species assigned to *Aquitanoobursa*.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper).

Family Cassidae Latreille, 1825**Subfamily Cassinae Latreille, 1825****Genus *Cassis* Scopoli, 1777**

Cassis Scopoli, 1777: 393. Type species (designated by Montfort, 1810: 598, 599): *Buccinum cornutum* Linnaeus, 1758. Miocene to present-day, Indo-West Pacific. For generic synonymy see Beu (2010: 210).

***Cassis robusta* spec. nov.**

(Figs 4-6)

Type series and dimensions. — Holotype NHMW 1901/0034/0001, height 65.1 mm, width 44.7 mm (Fig. 4); paratype 1, NHMW 1901/0034/0002, height 70.0 mm, width 43.8 mm (Fig. 5); paratype 2 NHMW 1901/0034/0003, height 56.8 mm, width 39.8 mm (Fig. 6); paratype 3 NHMW 1901/0034/0004, height 51.5 mm, width 35.4 mm.

Other material. — Known only from the type series.

Type locality. — Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia.

Type stratum. — Langhian portion of NN5, middle Miocene.

Etymology. — Latin '*robustus*, -a', adjective meaning solid. *Cassis* gender feminine.

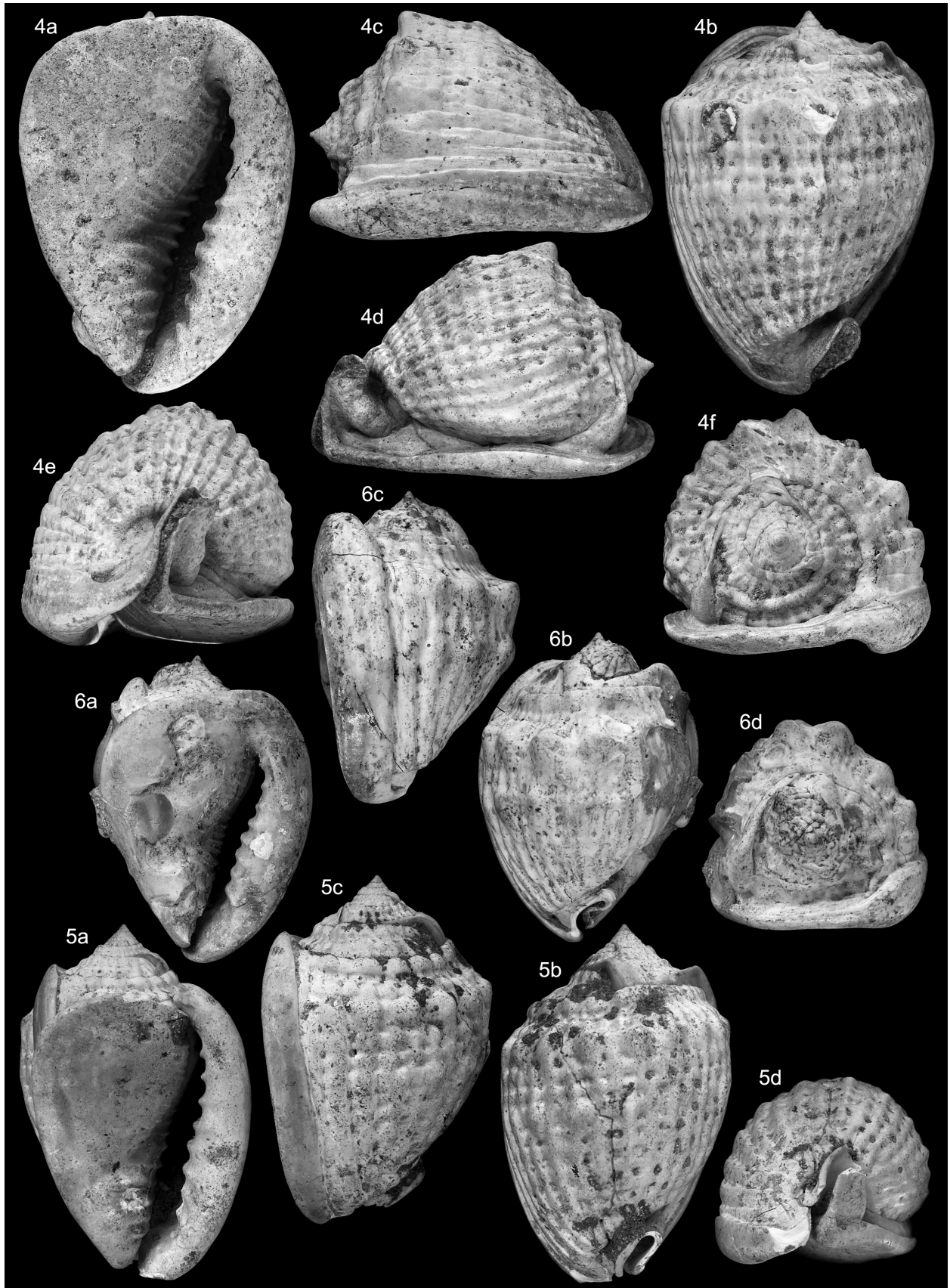
Diagnosis. — *Cassis* species of small size, stocky, robust, spire relatively tall, two rows of small tubercles on last whorl; with coarsely cancellate sculpture of flattened axial ribs and spiral cords at shoulder and mid-whorl, axials slightly predominant, with rectangular pits developed in interspaces.

Description. — Shell small for genus (largest seen 70.0 mm high), stocky, ovate, with moderately high spire for genus. Protoconch abraded in all specimens. Teleoconch of seven whorls; first two whorls weakly convex, mid-whorls straight-sided, last three whorls weakly concave on sutural ramp, separated by weakly impressed suture, abapically crenulated around tubercles. Sculpture on first three whorls absent (or abraded in all specimens). Row of small tubercles develops at abapical suture on third whorl. On fourth whorl two rows of low tubercles develop in contact with sutures, strengthening abapically; about 30 tubercles on penultimate whorl. Prominent, smooth, flattened varix develops at intervals of about 240°, with crest developed abapically, extending backwards along suture to fuse with abapical portion of previous varix. On penultimate whorl a further row of smaller tubercles develops mid-whorl, so that intervariceal whorl surface is covered with 3-4 rows of small, poorly defined tubercles with shallow pits between. Last whorl up to 85% total height, ovate, with relatively narrow, shallow, weakly concave subsutural ramp, shoulder delimited by row of larger tubercles, regularly con-

vex below, base strongly constricted. Sculpture of up to 20 low, rounded, weakly opisthocline axial ribs, each roughly equal in width to their interspaces, and about ten rounded spiral cords, each slightly narrower than their interspaces and weaker than axial ribs, fusing with ribs, either flattened at intersections or forming subobsolete tubercles, except delimited at shoulder and mid-whorl by a row of 8-10 larger tubercles, shoulder row largest, developed on alternate ribs. Sculpture renders surface irregularly, coarsely cancellate, forming shallow, weakly rectangular pits between ribs. Siphonal fasciole well developed, rounded, strongly twisted, separated from base by deep, narrow groove. Aperture narrow, elongate, 68-72% of total height; posterior canal poorly developed, siphonal canal relatively long, very narrow, sharply posteriorly recurved at 90° to shell axis and twisted. Outer lip strongly thickened by broad, smooth labial varix; lip moderately thickened internally in mid-portion, bearing ten stout denticles along inner edge, most strongly developed on thickened mid-portion of lip. Columella almost straight, relatively strongly excavated in lower third, bearing 4-6 broad, rounded, horizontally elongate ridges in lower third, extending into aperture; numerous horizontal lirae in upper two-thirds. Columellar and parietal callus continuous, strongly to very strongly thickened, round-edged, extending over and beyond venter to form prominent, flattened, ovate-triangular callus shield.

Variation. — Although represented by a relatively small number of specimens, *Cassis robusta* spec. nov. shows some intraspecific variability. Fully adult specimens have a strongly thickened labial varix and parietal shield. As with other cassids, adult size is variable. The smallest specimen (paratype 2; Fig. 6) has the most strongly thickened apertural armature. It also has the stockiest last whorl and the most strongly developed tubercles on the last whorl. On this specimen a *Sabia* Gray, 1840 shell (Hipponicidae; probably *Sabia conica* Schumacher, 1817) is attached close to the apex (Figs 6b, 6d). Paratype 1 (Fig. 5), although being the largest specimen, has the least thickened apertural shield, with the cancellate surface sculpture showing through the callus. Possibly this variation in tubercle and callus development reflects the sexual dimorphism demonstrated by some other *Cassis* species, most notably *C. cornuta* (Linnaeus, 1758). In *C. cornuta* the largest specimens are female and have many, relatively small tubercles around the shoulder, whereas males are markedly smaller and have much fewer, larger, narrow shoulder nodules (Abbott, 1968: 47).

Remarks. — *Cassis robusta* spec. nov. is characterised by its small, stocky shell, relatively tall spire, two rows of small, rounded tubercles developed at the shoulder and mid-whorl on the last whorl, and coarsely cancellate sculpture composed of flattened axials and spirals, the axials slightly predominant, with squarish pits developed between the ribs. The presence of *Cassis* in Indonesian Tertiary assem-



Figs 4-6. *Cassis robusta* spec. nov. **4.** Holotype NHMW 1901/0034/0001, height 65.1 mm, width 44.7 mm. **5.** Paratype 1 NHMW 1901/0034/0002, height 70.0 mm, width 43.8 mm. **6.** Paratype 3 NHMW 1901/0034/0004, height 51.5 mm, width 35.4 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

blages was reviewed by Beu (2005). He recognised potentially up to three species in the Miocene of Java. These three species are:

Cassis cornuta (Linnaeus, 1758) from Preanger [Priangan], upper Miocene of Java, differs from *C. robusta* in having a lower spire, in being broader at the shoulder and in having a much finer reticulated surface sculpture. *Cassis cornuta* is a large, still extant species, adults reaching 350 mm in height (Abbott, 1968). As noted by Beu (2005: 35, figs 66, 67), the illustrated specimen from the upper Miocene of Java, 59 mm in height, shows juvenile characters.

Cassis depressior Martin, 1879, also from the upper Miocene of Java, is similar in size to the Indonesian fossil specimens of *C. cornuta* and *C. robusta* spec. nov. (*C. depressior* 51–63 mm in height). It is low-spined and broad-shouldered, similar to the juvenile specimen of *C. cornuta* illustrated by Beu (2005, figs 66–67), but differs in having sculpture of sharp axial ridgelets with no spiral component, unlike the other two species, both of which have cancellate sculpture.

Cassis preangerensis Martin, 1879, the third species from the upper Miocene of Java, attains a height of about 88 mm (Dharma, 2005: pl. 142, fig. 5). It is closely similar to *C. cornuta* in shape, with a low spire and a broad, high-placed shoulder, but is said to differ in having the nodules around the periphery smaller and more clearly aligned into one spiral cord than in other material of *C. cornuta*, and the spiral and axial sculpture is a little more prominent and denser than usual for *C. cornuta* (Beu, 2005: 35). However, based on the material available, doubt remains whether they are two separate species. Either way, *C. preangerensis* clearly differs from *C. robusta* spec. nov. in being lower-spined, broader, with a higher-placed shoulder and in having finer cancellate surface sculpture, and especially more numerous axial riblets.

In the extant Indo-Pacific fauna there are only two species more or less similar to *C. robusta* spec. nov. The first that can be compared is *C. cornuta*. As discussed above, apart from attaining a far greater adult height, having a lower spire, a higher-placed shoulder and finer cancellate surface sculpture, *C. cornuta* also has more numerous rows of tubercles on the last whorl and the shoulder spines are developed into elevated, horizontally flattened tubercles or a complex of sexually dimorphic tubercles on large specimens (Kreipl in Poppe, 2008: pl. 233, fig. 2).

Cassis robusta is more closely similar to the extant species *C. (Hypocassis) patamakanthini* Parth, 2000 from Western Australia. Beu (2005, 2008, 2010) synonymised *Hypocassis* Iredale, 1927 with *Cassis*, on the grounds that its sole distinguishing character, the large paucispiral protoconch, is a developmental difference of no phylogenetic significance. *Cassis patamakanthini* is the smallest member of the genus, attaining only 27 mm in height. It has a relatively elevated spire, like *C. robusta* spec. nov., but an even shorter

last whorl. The last whorl is also covered in rows of tubercles, stronger and more numerous than in *C. robusta*, but it lacks the cancellate surface sculpture that is so prominent in *C. robusta*. *Cassis patamakanthini* also lacks the strongly developed triangular parietal shield seen in *C. robusta* and almost all other species of *Cassis*. Beu (2010: 211) suggested that the living southern Australian species *C. fimbriata* (Quoy & Gaimard, 1833) and *C. patamakanthini* are more closely related to French Atlantic Miocene species such as *C. mamillaris* (Grateloup, 1827), with which it shares a similar sculpture of rows of tubercles and surface cancellation. *Cassis mamillaris* is also similar in sculpture to *C. jogjartensis* Martin, 1914, an Eocene species from Java. Indeed, in a species list given by Piccoli & Savazzi (1983: 38), they suggested that *C. jogjartensis* was a junior synonym of *C. mamillaris*. In any case, this group of Neogene European and Indonesian, and extant Western Australian species has more in common than any of the species reviewed by Beu (2010) from tropical America.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper).

Genus *Cypraecassis* Stutchbury, 1837

Cypraecassis Stutchbury, 1837: 214. Type species (by original designation): *Buccinum rufum* Linnaeus, 1758, Miocene to present-day, Indo-Pacific. For generic synonymy see Beu (2010: 225).

Cypraecassis minirufa spec. nov.

(Fig. 7)

Cypraecassis sp. — Beu, 2005: 37.

Cypraecassis sp. 1 — Dharma, 2005: 354, pl. 142 fig. 2.

Type series and dimensions. — Holotype NHMW 1901/0034/0028, height 30.0 mm, width 19.1 mm (Fig. 7).

Other material. — One specimen from the middle Miocene of Nyalindung, West Java illustrated by Dharma (2005, pl. 142, fig. 2), height 35 mm, seems to be the same species.

Type locality. — Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia.

Type stratum. — Langhian portion of NN5, middle Miocene.

Etymology. — Prefix ‘mini-’, meaning a miniature version of, derived from Latin.

Diagnosis. — *Cypraecassis* species of small size, stocky, robust, spire strongly depressed, six rows of tubercles on last whorl, tubercles on successive rows smaller and more numerous abapically; callus shield strongly developed, extending over entire venter and adapically to just above apex.

Description. — Shell small for genus, stocky, ovate, solid. Protoconch and early whorl surface abraded. Teleoconch of about four whorls; spire strongly depressed, surface abraded. Last whorl 89% total height, ovate, with, shallow, straight subsutural ramp, shoulder delimited by a row of tubercles; convex below, not constricted at base. Sculpture of six rows of tubercles, adapical row of seven larger tubercles placed at shoulder, second, broadest row placed at periphery, abapically rows of successively more numerous tubercles, weaker and more closely spaced. Siphonal fasciole very short, rounded, strongly twisted, separated from base by deep, narrow groove. Aperture narrow, elongate, 90% of total height; posterior canal a narrow groove in apical portion of outer lip; siphonal canal very short, narrow, sharply posteriorly recurved at 90° to shell axis and twisted. Outer lip strongly thickened by broad, smooth labial varix; lip moderately thickened internally in mid-portion, bearing ten stout denticles along inner edge, more prominent on thickened mid-portion than above and below, inner edge bearing 16 denticles. Columella almost straight, bearing numerous horizontal lirae along entire length, denticulate at inner edge of columella. Columellar and parietal callus continuous, very strongly thickened, forming ovate callus shield that covers entire venter and extends apically to just above apex.

Remarks. — Unfortunately, the holotype is not as well preserved as the specimen illustrated by Dharma (2005) from Nyalindung, West Java, but the shell characters are quite distinctive. The shell sculpture and the strong development of the callus shield are similar to the type species *C. rufa* (Linnaeus, 1758), but as noted by Beu (2005: 37), extant *C. rufa* is not smaller than 65 mm in height, and most adults range between 100–140 mm in height, reaching 185 mm. The specimens from Java are fully adult, as indicated by the prominent labial varix and the strongly thickened callus shield, but it is unlikely that we are dealing with a dwarf population, as the holotype and Dharma's specimen come from different middle Miocene localities within Java. Other small differences between *Cypraecassis minirufa* spec. nov. and *C. rufa* are that the last whorl is less inflated in *C. minirufa* spec. nov. and there is no trace of secondary spiral cords between the rows of tubercles, as seen in *C. rufa*. It is unlikely that *C. minirufa* is a small-shelled ancestor to the present-day species, as Beu (2005: 38) recorded *C. rufa* from the Miocene of Java. This record of presumed *C. rufa* is from Karas, Rembang, Java, presumably of Langhian (middle Miocene) age (Beu, 2005: 5); we are not aware of older records of *C. rufa*.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper).

Subfamily Phaliinae Beu, 1981

Genus *Casmaria* H. Adams & A. Adams, 1853

Casmaria H. Adams & A. Adams, 1853: 216. Type species (designated by Harris, 1897: 200): *Buccinum vibex* Linnaeus, 1758 (= *B. erinaceus* Linnaeus, 1758), present-day, Indo-West Pacific. For generic synonymy see Beu (2005: 44).

Casmaria primitiva spec. nov.

(Fig. 8)

Type series and dimensions. — Holotype NHMW 1901/0034/0035, height 28.1 mm, width 15.7 mm (Fig. 8).

Other material. — Known from holotype only.

Type locality. — Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia.

Type stratum. — Langhian portion of NN5, middle Miocene.

Etymology. — Name reflecting its position as the oldest known member of the genus, retaining features common to other Phaliinae.

Diagnosis. — *Casmaria* species of small size, light shell, well-developed subsutural cord, axial riblets on last whorl, poorly developed columellar callus, small sharp denticles developed at edge of inner lip.

Description. — Shell relatively small and light for genus, with slender ovate profile and tall spire. Protoconch multispiral dome-shaped (surface abraded). Teleoconch of four convex whorls with well-developed, beaded subsutural cord. Whorls separated by impressed linear suture. Sculpture of fine axial riblets, most strongly developed on adapical portion of whorl, weakening towards lower suture. Last whorl ovate-elongate, axials developed only on adapical third of whorl, except for last quarter whorl over outer lip, where ribs continuous along entire whorl. Base poorly delimited, bearing three narrow spiral grooves. Aperture elongate; outer lip thickened by well-developed labial varix, lip bearing small, sharp denticles at outer edge, continued a short distance within the lip as lirae; anal canal small, narrow U-shaped; siphonal canal short, open, sharply recurved and twisted to right. Columella weakly excavated mid-height, bearing irregular folds on abapical half and three small parietal folds. Columella callus thickened, erect abapically; parietal callus thin, polished, poorly delimited, expanded over venter. Siphonal fasciole sharply delimited by deep groove, short, strongly rounded, bearing narrow cords.

Remarks. — Shells of the genus *Casmaria* H. Adams & A. Adams, 1853 are characterised by their elongate shape, poorly developed columellar shield, and one or two rows of sharp denticles at the edge of the outer lip (Abbott, 1968: 189). The genus in the Recent faunas was reviewed by Buijse et al. (2013) and found to be more speciose than previ-

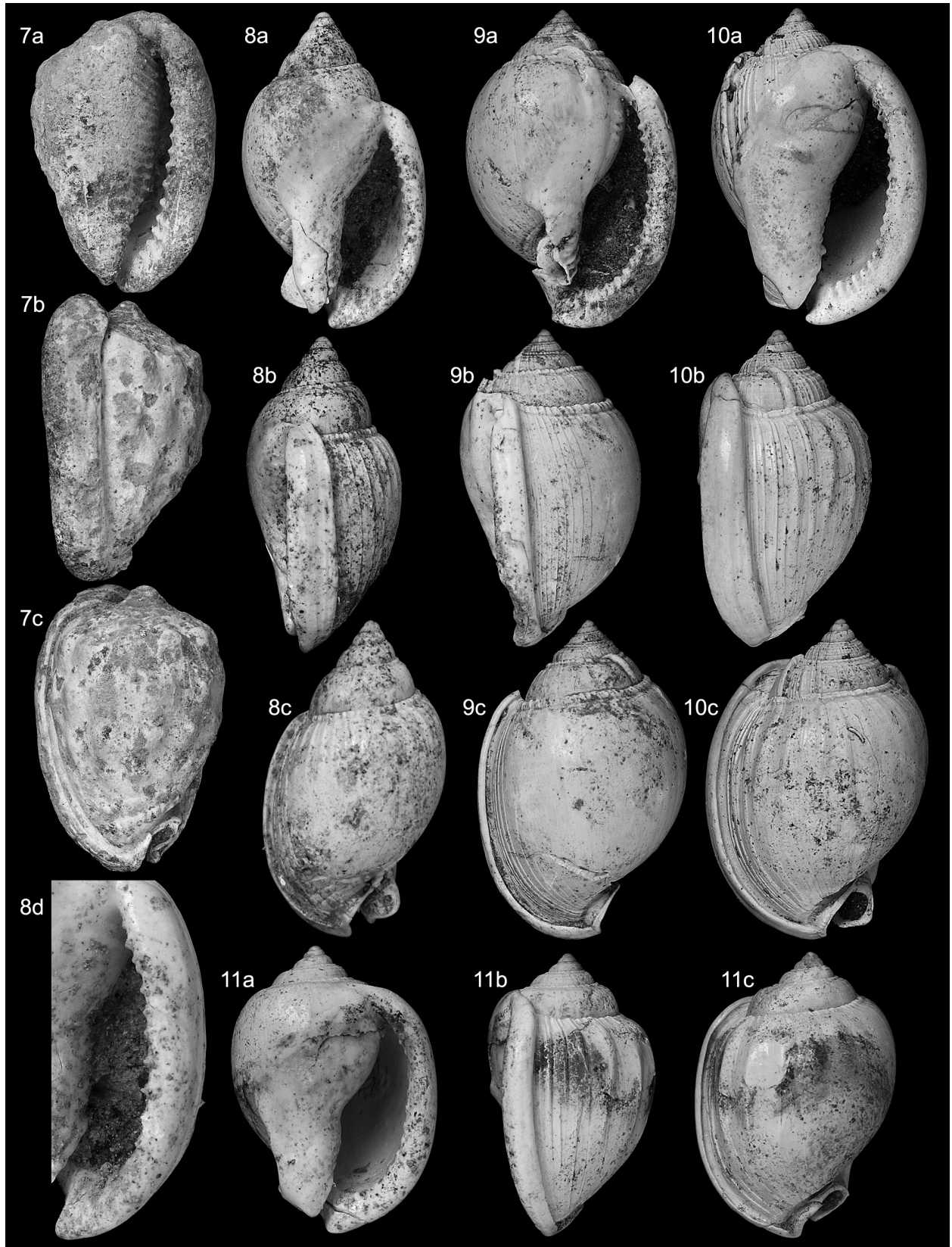


Fig. 7. *Cypraecassis minirufa* spec. nov., holotype NHMW 1901/0034/0028, height 30.0 mm, width 19.1 mm. **Fig. 8.** *Casmaria primitiva* spec. nov., holotype NHMW 1901/0034/0035, height 28.1 mm, width 15.7 mm. **Figs 9–11.** *Phalium menkrawitense* Beets, 1941. **9.** NHMW 1901/0034/0029, height 34.4 mm, width 22.6 mm. **10.** NHMW 1901/0034/0030, height 36.1 mm, width 24.8 mm. **11.** NHMW 1901/0034/0031, height 29.6 mm, width 21.2 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

ously thought. However, it is almost unknown as a fossil. Beu (2005: 44) figured specimens identified as *C. erinaceus* (Linnaeus, 1758) from the Pleistocene of Sumatra and Sulawesi, and specimens of *C. unicolor* (Pallary, 1926) from the upper Pleistocene of the Red Sea are present in the NHMW collection (Hurghada, Egypt). The description of this new species is therefore an important contribution to the understanding of the genus and stratigraphically is by far the oldest record.

Casmaria primitiva spec. nov. differs from all its congeners in having fine axial sculpture on the last whorl, but lacks the shoulder tubercles seen in many of its extant congeners. Some specimens of *C. kayae* Buijse et al., 2013 from the central and south-western Pacific have axial sculpture, but this consists of irregular axial rugae rather than regular riblets. Apart from this axial sculpture, which is unusual for the genus, *C. primitiva* also has a well-developed subsutural cord. Both of these characters are more commonly seen in *Phalium* Link, 1807 and *Semicassis* Mörch, 1853, and indeed Beu (2005: 45) questioned the validity of *Casmaria* as a separate genus. *Casmaria primitiva* could be considered a primitive member of the genus, retaining characters of *Phalium* or *Semicassis*, from which the genus most likely evolved. At present we consider it best to retain the new species in *Casmaria*, awaiting a more definitive study of the status of the genus *Casmaria*.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper).

Genus *Phalium* Link, 1807

Phalium Link, 1807: 112. Type species (designated by Herrmannsen, 1852: 104): *Buccinum glaucum* Linnaeus, 1758. Miocene to present-day, Indo-West Pacific. For generic synonymy see Beu (2005: 46).

Phalium menkrawitense Beets, 1941

(Figs 9-12)

Phalium menkrawitense Beets, 1941: 85, pl. 4 figs 180-186.

Phalium menkrawitense Beets, 1941 — Abbott, 1968: 89, pl. 64; Beu, 2005: 49, figs 100-103.

Material and dimensions. — Maximum height 36.1 mm, width 24.8 mm. NHMW 1901/0034/0029-0031 (3), NHMW 1901/0034/0072 (1).

Remarks. — Until now, this species has been known from incomplete material, presumed juvenile (Abbott, 1968: 89). Beu (2005: 50) characterised the species as being weakly sculptured, with varices retained on the spire, an area of low axial ridges behind each varix, a subsutural spi-

ral groove on spire whorls that fades out down the shell and sculpture on the last whorl of very narrow, shallow, widely spaced axial grooves; the surface is superficially smooth. Although the three specimens illustrated here all vary somewhat, we consider them all to represent *Phalium menkrawitense* Beets, 1941. Constant shell characters in all three, the varices retained on the spire whorls, a narrow subsutural cord and the absence of spines on the exterior of the outer lip, all agree with the description by Beu (2005: 50). All three are of similar size to the holotype from the Miocene of the Mangkalihat Peninsula, East Kalimantan. One specimen (Fig. 9) is remarkably similar to the holotype. However, the others (Figs 10-12) add an important range of variability to the species description. The spire can be more or less depressed, the shoulder placed slightly higher, the subsutural cord can be strongly beaded by fine axial growth lines or almost smooth, and the dorsum is weakly ribbed in some specimens. Slight variation in sculpture is seen in some other *Phalium* species, and in view of the sparse material of *P. menkrawitense* seen to date it seems likely that this material represents a single species. Retention of full varices down the spire and the general type of sculpture, although weak for the genus, demonstrate that *P. menkrawitense* is correctly referred to *Phalium* rather than *Semicassis*.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper). Miocene (indeterminate): Mangkalihat Peninsula, East Kalimantan (Beets, 1941).

Family Cymatiidae Iredale, 1913

Genus *Cymatiella* Iredale, 1924

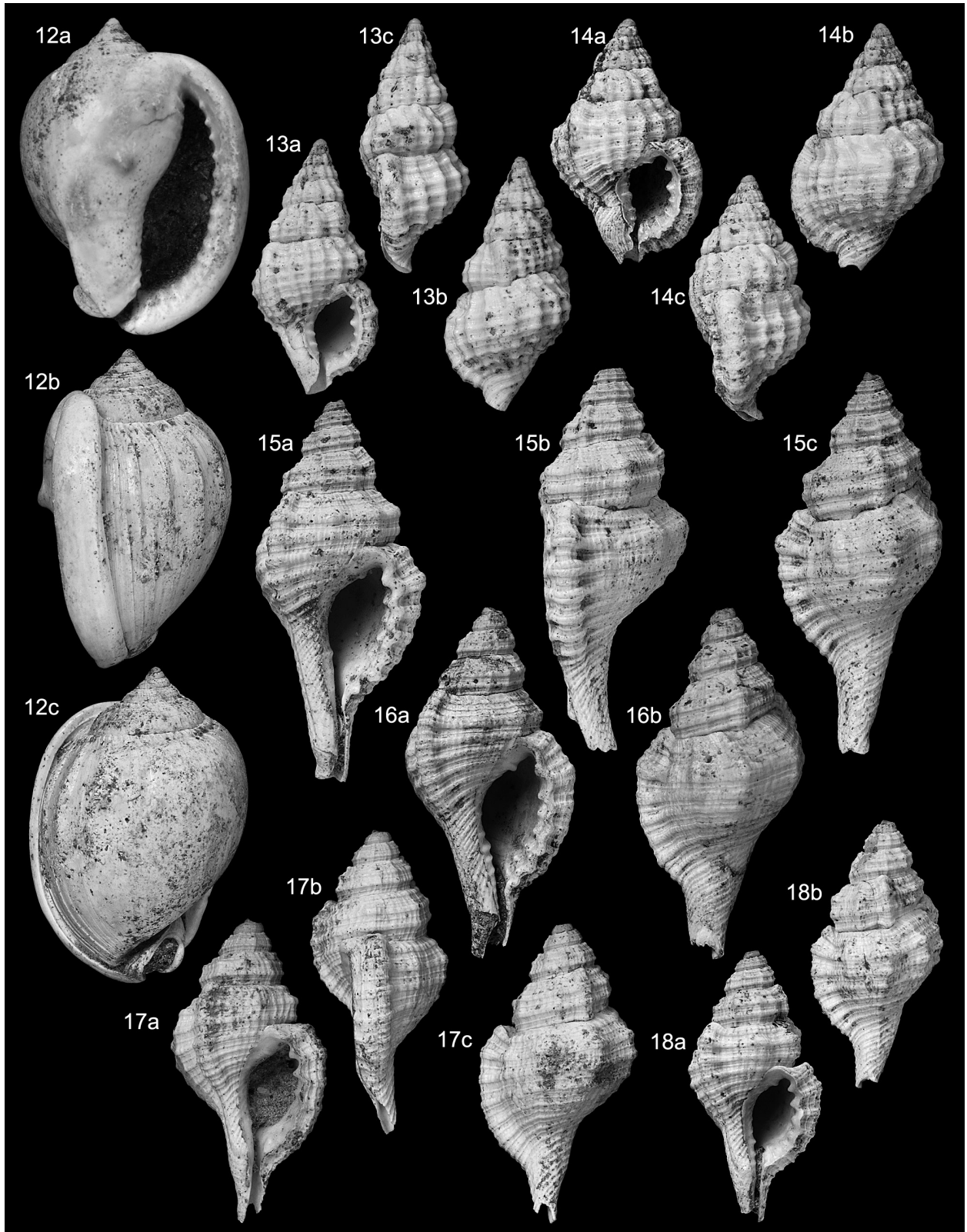
Cymatiella Iredale, 1924: 253. Type species (by original designation): *Triton quoyi* Reeve, 1844. Present-day, southern Australia. For generic synonymy see Beu (2010: 208).

Remarks. — Following the molecular phylogeny of Tonnoidea by Strong et al. (2018), *Ranella* Lamarck, 1816 is placed in a family of its own, and the family Cymatiidae was reinstated by Strong et al. (2018) for most taxa previously included in Ranellidae. Within Cymatiidae, many distinct genera were recognised and, in particular, the taxa resembling *Sassia* Bellardi, 1873 were segregated into numerous widely separated genera. Following this phylogeny, we recognise *Cymatiella* and *Monoplex* as genera.

Cymatiella fennemai (Martin, 1899)

(Figs 13-14)

Triton (Colubraria) fennemai Martin, 1899: 141, pl. 22 fig. 322.



Figs 12-18. *Phalium*, *Cymatiella* and *Monoplex* from Wonosari. **Fig. 12.** *Phalium menkrawitense* Beets, 1841, NHMW 1901/0034/0072, height 34.7 mm, width 24.5 mm. **Figs 13-14.** *Cymatiella fennemai* (Martin, 1899). **13.** NHMW 1901/0034/0042, height 16.8 mm, width 7.8 mm. **14.** NHMW 1901/0034/0043, height 15.2 mm, width 9.1 mm. **Figs 15-18.** *Monoplex rembangensis* (Wanner & Hahn, 1935). **15.** NHMW 1901/0034/0045, height 38.5 mm, width 16.7 mm. **16.** NHMW 1901/0034/0046, height 31.7 mm, width 15.2 mm. **17.** NHMW 1901/0034/0047, height 29.5 mm, width 14.3 mm. **18.** NHMW 1901/0034/0073, height 28.8 mm, width 15.2 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

Sassia (*Cymatiella*) *fennemai* (Martin) — Beu, 2005: 104, figs 270-280; Dharma, 2005: 356, pl. 143 figs 14a-c; Leloux & Wesselingh, 2009: 107, pl. 211 figs 5-10.

Material and dimensions. — Maximum height 18.7 mm, width 9.1 mm. NHMW 1901/0034/0042-0043 (2), NHMW 1901/0034/0044 (15).

Remarks. — The specimens from Wonosari are just over half the maximum height for the species recorded by Beu (2005: 104) of 30 mm. They are more constant in sculpture than the series illustrated by Beu, and none have the dense axial sculpture illustrated by Beu (2005: fig. 279). However, they are variable in width (compare two specimens herein illustrated; Figs 13-14).

Distribution. — Miocene (indeterminate): Sangkulirang, Mangkalihat Peninsula, East Kalimantan (Beets, 1986a; Beu, 2005). Lower Miocene: Nyalindung, West Java (Beu, 2005). Middle Miocene: Citalahab, West Java (Beu, 2005); Yogyakarta, central Java (Beu, 2005; this paper). Upper Miocene: Selacau, West Java (Beu, 2005).

Genus *Monoplex* Perry, 1810

Monoplex Perry, 1810: M7. Type species (by subsequent designation, Dall, 1904: 138): *Monoplex australasiae* Perry, 1811 (= *Murex parthenopeus* von Salis Marschlin, 1793), present-day, almost cosmopolitan in warm seas. For generic synonymy see Beu (2010: 142).

Monoplex rembangensis (Wanner & Hahn, 1935)

(Figs 15-18)

Triton (*Simpulum*) *pilearis* var. — Martin, 1899: 141, pl. 22 figs 323, 323a.

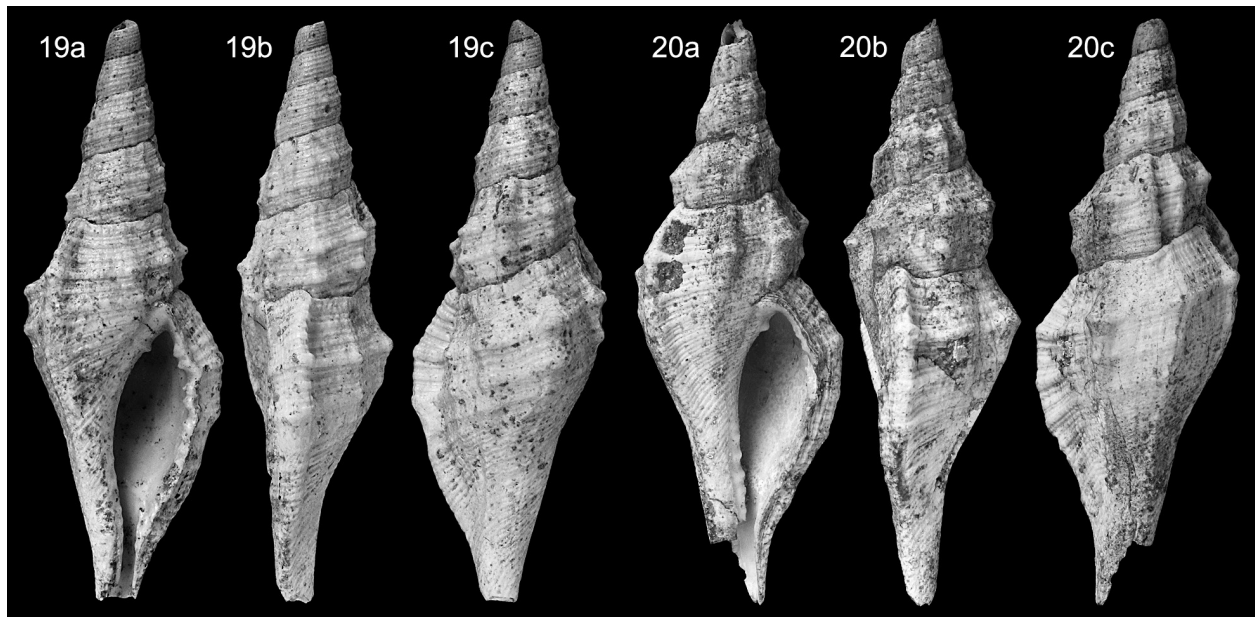
Eutritonium rembangense Wanner & Hahn, 1935: 255, pl. 19 figs 14-15.

Cymatium (*Monoplex*) *rembangense* (Wanner & Hahn) — Beu, 2005: 85, figs 201-202.

Material and dimensions. — Maximum height 38.5 mm, width 16.7 mm. NHMW 1901/0034/0045-0047 (3), NHMW 1901/0034/0048 (5), NHMW 1901/0034/0073 (1).

Remarks. — *Monoplex rembangensis* (Wanner & Hahn, 1935) differs from the two closely similar species *M. aquatilis* and *M. mundus* (Gould, 1849) in its markedly taller and wider, consistently more obviously concave subsutural ramp, in its fewer, more prominent peripheral tubercles forming a consistently prominent shoulder angle, and in its markedly larger nodules inside the outer lip (Beu, 2005: 85). The present beautifully preserved, complete specimen reveals many low, narrow, but obvious, moderately widely spaced axial riblets over the entire exterior. It also demonstrates that spiral cord P₁ is subdivided into two weakly distinguished cords by a median groove over its entire length on the last whorl, and all three uppermost cords IP, P₁ and P₂ are weakly subdivided where they cross the varices on the last whorl.

Distribution. — Lower Miocene: Nyalindung, West Java (Beu, 2005). Middle Miocene: Citalahab, West Java (Beu,



Figs 19-20. *Monoplex dissimilis* spec. nov. **19.** Holotype NHMW 1901/0034/0075, height 31.4 mm, width 10.3 mm. **20.** Paratype 1 NHMW 1901/0034/0076, height 40.2 mm, width 14.1 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

2005); Yogyakarta, central Java (Beu, 2005; this paper). Upper Miocene: Cijarian, Cilang, West Java (Beu, 2005). Pliocene (indeterminate) Cirebon, Pasir Ipi, West Java (Beu, 2005).

***Monoplex dissimilis* spec. nov.**

(Figs 19-20)

Type series and dimensions. — Holotype NHMW 1901/0034/0075, height 31.4 mm, width 10.3 mm (Fig. 15); paratype 1 NHMW 1901/0034/0076, height 40.2 mm, width 14.1 mm (Fig. 16).

Other material. — Known from type series only.

Type locality. — Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia.

Type stratum. — Langhian portion of NN5, middle Miocene.

Etymology. — Latin ‘dissimilis, -e, -ior’, adjective meaning unlike, dissimilar, reflecting the difference between this species and all its congeners.

Diagnosis. — *Monoplex* species of small-medium size, very slender fusiform, subdued sculpture with tubercles developed at intersections, varices placed at 120° on last two whorls, aperture elongate, labial varix thin, denticulate within, denticles arranged in pairs, siphonal canal moderate length, straight.

Description. — Shell small-medium size for genus, very slenderly fusiform. Protoconch not preserved. Five tall teleoconch whorls preserved, separated by weakly impressed linear suture. First two whorls weakly convex, bearing seven subequal spiral cords. Abapically, two cords strengthen; adapical cord delimiting shoulder, abapical cord placed midway between shoulder and lower suture. Weak axial ribs develop on third whorl and strengthen abapically, forming pointed tubercles at intersections with primary cords; other cords weakly and irregularly beaded. Subsutural ramp develops on third whorl, slightly concave, very steep, delimited by prominent, tubercular shoulder cord. Four varices developed on last three whorls at about 120° intervals. Last whorl slenderly fusiform, weakly constricted at base. Base and siphonal fasciole not delimited; axial ribs weaken and disappear over base; base sculptured with spiral cords of primary to tertiary strength. Aperture elongate-ovate; labial varix thin, with 14 low denticles at inner edge arranged in seven pairs, adapical pair slightly stronger; anal sinus U-shaped, well developed; siphonal canal of moderate length, open, straight, narrow. Columella weakly and evenly excavated, with 3-4 strongly oblique, weakly developed folds on abapical portion; small parietal tooth narrow. Columellar and parietal calluses hardly developed, poorly delimited, forming narrow rim of thin callus.

Remarks. — *Monoplex dissimilis* spec. nov. is distinguished immediately from all other named species in the genus and, indeed, from all other Cymatiidae, by its tall, narrow form and most unusually tall, almost straight-sided spire. We know of no other species that resemble it in shape. The sculpture of the interior of the outer lip resembles that of *M. aquatilis* (Reeve, 1844) in its low nodules, and is very distinct from the interior of the outer lip of the common living tropical species *M. pilearis* (Linnaeus, 1758) in lacking spiral ridges deep within the aperture, but no specimens of *M. aquatilis* have been seen with such a tall, narrow shape. This is the most distinctive of all the extinct Indonesian fossil tonnoideans, helping to reveal the greater diversity of gastropods during the Miocene warm period than at present in the Indo-West Pacific.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper).

Subfamily Argobuccininae Kilius, 1973 [recognised by Bouchet et al., 2017: 343]

Genus *Gyrineum* Link, 1807

Gyrineum Link, 1807: 123. Type species (by subsequent designation, Dall, 1904: 131): *Murex gyrinus* Linnaeus, 1758 (= *Gyrineum verrucosum* Link, 1807). Present-day, Indo-West Pacific. For generic synonymy see Beu (2005: 64).

***Gyrineum bituberculare* (Lamarck, 1816)**

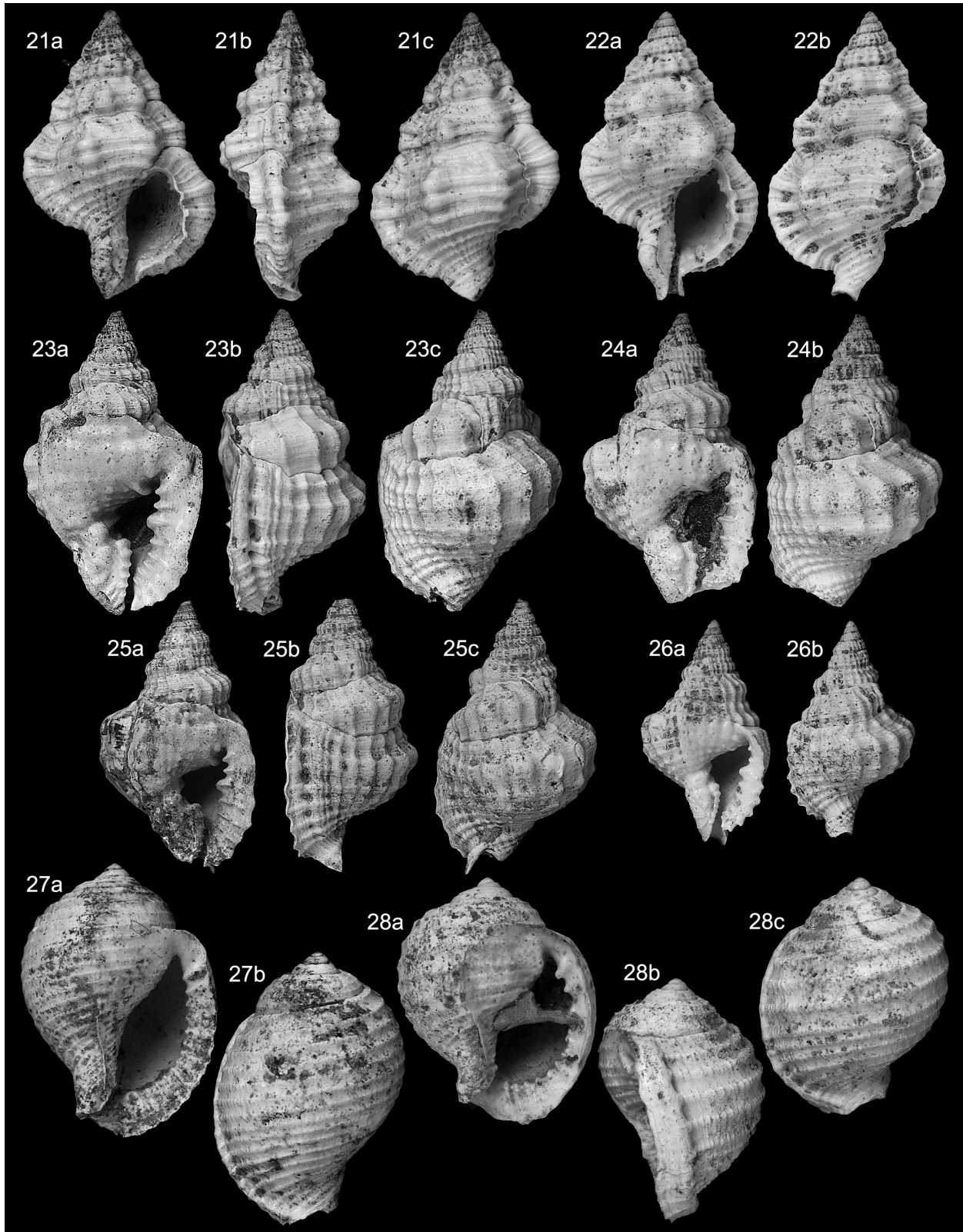
(Figs 21-22)

Ranella bitubercularis Lamarck, 1816: “liste”: 4, pl. 412 fig. 6. *Gyrineum bituberculare* (Lamarck) — Beu, 2005: 64, figs 164-167 (cum syn.); Harzhauser et al., 2018: 14, pl. 2 figs 13-14.

Material and dimensions. — Maximum height 24.6, width 14.5 mm. NHMW 1901/0034/0040 (1), NHMW 1901/0034/0041 (1), NHMW 1901/0034/0074 (10).

Remarks. — *Gyrineum bituberculare* (Lamarck, 1816) is extremely common and widespread in the Indonesian Miocene to present-day assemblages. For full discussion and distribution see Beu (2005: 66).

Distribution. — Middle Miocene to Pleistocene beds throughout Java (see Beu, 2005: 65) and northern Sarawak and Brunei (Nuttall, 1961; Harzhauser et al., 2018). Plio-Pleistocene Dent Peninsula, Sabah, Malaysia (Cox, 1948). Pleistocene: Manado Island, northern Sulawesi (Beu, 2005). Present-day: moderately widespread in the western tropical Pacific, from the Philippines to Indonesia.



Figs 21-28. *Gyrineum*, *Distorsio* and *Malea* from Wonosari. **Figs 21-22.** *Gyrineum bituberculare* (Lamarck, 1816). **21.** NHMW 1901/0034/0040, height 22.5, width 14.5 mm. **22.** NHMW 1901/0034/0041, height 24.6, width 14.5 mm. **Figs 23-26.** *Distorsio djunggranganensis* (Martin, 1916). **23.** NHMW 1901/0034/0036, height 42.2 mm, width 26.7 mm. **24.** NHMW 1901/0034/0037, height 39.5 mm, width 21.5 mm. **25.** NHMW 1901/0034/0038, height 35.4 mm, width 22.0 mm. **26.** NHMW 1901/0034/0039 (juvenile), height 24.4 mm, width 13.9 mm. **Figs 27-28.** *Malea papuana* (Beets, 1943). **27.** NHMW 1901/0034/0032, height 20.3, width 13.6 mm. **28.** NHMW 1901/0034/0033, height 20.6, width 16.2 mm. All specimens from near Wonosari, Gunung Kidul Regency, Special Region of Yogyakarta, Java, Indonesia Langhian, lower middle Miocene.

Family Personidae Gray, 1854

Genus *Distorsio* Röding, 1798

Distorsio Röding, 1798: 133. Type species (by subsequent designation, Pilsbry, 1922: 357): *Murex anus* Linnaeus, 1758. Present-day, Indo-West Pacific. For generic synonymy see Beu (2010: 79).

***Distorsio djunggranganensis* (Martin, 1916)**

(Figs 23-26)

Persona djunggranganensis Martin, 1916: 242, pl. 2 fig. 41.

Distorsio djunggranganensis (Martin) — Beu, 1998: 198, figs 60a-b; Beu, 2005: 56, fig. 145; Dharma, 2005: 358, pl. 144 fig. 1; Leloux & Wesseligh, 2009: 111, pl. 215 figs 9-10.

Material and dimensions. — Maximum height 42.2 mm, width 26.7 mm. NHMW 1901/0034/0036-0039 (4).

Remarks. — Until now, the discussion surrounding this species (Beu, 1998, 2005) has been based on juvenile specimens. This is the first time fully adult specimens of *Distorsio djunggranganensis* (Martin, 1916) have been illustrated; the specimen illustrated by Beu (2005, fig. 145) is 25 mm high. However, the differences outlined by Beu (2005: 57) between this species and the closely similar present-day Indo-Pacific species *D. habei* Lewis, 1972 hold true; the siphonal canal in *D. djunggranganensis* is much shorter, recurved, and twisted slightly to the left, whereas that in *D. habei* is long, almost straight and deviated to the right. Surface sculpture is very similar in the two species. A further difference is that the last whorl is even more gibbose in *H. habei*, giving the shell an even more distorted appearance. The present specimens demonstrate that the ventral apertural callus shield in adult specimens reaches a similar width to that of other *Distorsio* species, extending the full height and width of the last whorl, and slightly up onto the previous whorl as well as bridging the space between the last whorl and the siphonal canal. The shallowly concave gap between the upper and lower groups of spiral cords on the dorsum of the last whorl is more marked than in the juvenile holotype, but presumably merely widens as the shell grows.

Distribution. — Middle Miocene: Rembang, Yogyakarta, central Java (Beu, 2005; this paper).

Family Tonnidae Suter, 1913 (1825)

Genus *Malea* Valenciennes, 1832

Malea Valenciennes, 1832: 324. Type species (by subsequent designation, Herrmannsen, 1847: 13): *Malea latilabris* Valenciennes, 1832 (= *Cassis ringens* Swainson, 1822).

Miocene to present-day, Mexico (Pacific). For generic synonymy see Beu (2010: 254).

***Malea papuana* (Beets, 1943)**

(Figs 27-28)

Galeodea papuana Beets, 1943: 441, pl. 1 figs 4-6.

Malea papuana Beets — Beets, 1986b: 110, pl. 8 figs 10-12; Beu, 2005: 112, figs 303-304.

Material and dimensions. — Maximum height 20.6, width 16.2 mm. NHMW 1901/0034/0032-0033 (2), NHMW 1901/0034/0034 (3).

Remarks. — We ascribe these tiny, presumably immature *Malea* specimens to *M. papuana* (Beets, 1943), which was first described from the upper Miocene of Irian Jaya. This species was fully discussed by Beu (2005: 113), who illustrated the incomplete 30 mm-high holotype. *Malea papuana* differs from the similarly small Pliocene to present-day Indo-West Pacific species *M. pomum* (Linnaeus, 1758) in having much narrower, more widely spaced spiral cords, rather than the wide, convex, closely spaced spiral cords of *M. pomum*. The holotype lacks the anterior end and these two specimens, if conspecific with the holotype, have complete, untwisted anterior ends with a simple, open anterior siphonal canal, demonstrating that *M. papuana* is correctly referred to *Malea*. The sculpture varies considerably in the two specimens illustrated; in one (Fig. 27) the cords are relatively close-set, not unlike those of the holotype. In the second specimen (Fig. 28), the last whorl is more inflated and the spiral cords are more widely spaced, and are crossed by narrow axial riblets. We provisionally consider them conspecific pending further material. This is the first record of the species from Java.

Distribution. — Middle Miocene: Yogyakarta, central Java (this paper). Upper Miocene: Irian Jaya (Beets, 1943; Beu, 2005).

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REFERENCES

ABBOTT, R.T., 1968. The Helmet shells of the world (Cassidae). Part 1. — Indo-Pacific Mollusca 2 (9): 7-201.

- ADAMS, H. & ADAMS, A., 1853-1858. The genera of Recent Mollusca; arranged according to their organization. [Published in parts: Vol. 1: i-xl (1858), 1-256, pls 1-32 (1853); 257-484, pls 33-60 (1854). Vol. 2: 1-92, pls 61-72 (1854); 93-284, pls 73-96 (1855); 285-412, pls 97-112 (1856); 413-540, pls 113-128 (1857); 541-661, pls 129-138 (1858)]. Van Voorst, London.
- BEETS, C., 1941. Eine Jungmiozäne Mollusken-Fauna von der Halbinsel Mangkalihat, Ost-Borneo (nebst Bemerkungen über andere Faunen von Ost-Borneo; die Leitfossilien-Frage). — *Verhandelingen van het Geologisch-Mijnbouwkundig Genootschap voor Nederland en Koloniën, Geologische Serie*, 13 (1): 1-219, pls 1-9.
- BEETS, C., 1943. Beiträge zur Kenntnis der angeblich oberoligocänen Mollusken-Fauna der Insel Buton, Niederländisch-Ostindien. — *Leidsche Geologische Mededeelingen* 13: 256-328, pls 27-30.
- BEETS, C., 1986a. Molluscan fauna of the Lower Gelingseh Beds s. str., Sangkulirang area, Kalimantan timur (East Borneo). — *Scripta Geologica* 82: 1-82.
- BEETS, C., 1986b. Neogene Mollusca from the Vogelkop (Bird's Head Peninsula), West Irian, New Guinea. — *Scripta Geologica* 82: 101-134.
- BEU, A.G., 1998. Indo-West Pacific Ranellidae, Bursidae and Personidae. A monograph of the New Caledonian fauna and revisions of related taxa. *Résultats du Campagnes Musorstom*, 19. — *Mémoires du Muséum National d'Histoire Naturelle* 178: 1-255.
- BEU, A.G., 2005. Neogene fossil tonnoidean gastropods of Indonesia. — *Scripta Geologica* 130: 1-189.
- BEU, A.G., 2008. Recent deep-water Cassidae of the world. A revision of *Galeodea*, *Oocorys*, *Sconsia*, *Echinophoria* and related taxa, with new genera and species (Mollusca, Gastropoda). In: HÉROS, V., COWIE, R.H. & BOUCHET, P. (eds.) *Tropical Deep-Sea Benthos* 25. — *Mémoires du Muséum National d'Histoire Naturelle* 196: 269-387.
- BEU, A.G., 2010. Neogene tonnoidean gastropods of tropical and South America: contributions to the Dominican Republic and Panama Paleontology Projects and uplift of the Central American Isthmus. — *Bulletins of American Paleontology* 377-378: 1-550.
- BOUCHET, P., ROCROI, J.P., HAUSDORF, B., KAIM, A., KANO, Y., NÜTZEL, A., PARKHAEV, P., SCHRÖDL, M. & STRONG, E.E., 2017. Revised classification, nomenclator and typification of gastropod and monoplacophoran families. — *Malacologia* 61: 1-526.
- BUIJSE, J.A., DEKKER, H. & VERBINNEN, G., 2013. On the identity of *Casmaria* species (Gastropoda, Cassidae), with descriptions of two new species. — *Acta Conchyliorum* 14: 3-93.
- COX, L.R., 1948. Neogene mollusca from the Dent Peninsula, British North Borneo. — *Schweizerische Paläontologische Abhandlungen* 66 (2): 4-70.
- DALL, W.H., 1904. An historical and systematic review of the frog-shells and tritons. — *Smithsonian Miscellaneous Collections* 47 (1475): 114-144.
- DALL, W.H., 1909. Contributions to the Tertiary paleontology of the Pacific coast. I. The Miocene of Astoria and Coos Bay, Oregon. — *United States Geological Survey Professional Paper* 59: 1-278.
- DEKKERS, A.M., LIVERANI, V., ĆORIĆ S., MAXWELL, S.J. & LANDAU, B.M., 2020. A new genus for Indo-Pacific fossil strombids, and two new species from the Miocene of Java and Borneo (Caenogastropoda, Strombidae). — *Basteria* 84 (1-3): 1-9.
- DHARMA, B., 2005. Recent and fossil Indonesian shells: 1-424. ConchBooks, Hackenheim.
- HARRIS, G.F., 1897. Catalogue of Tertiary Mollusca in the Department of Geology British Museum (Natural History). Part I. The Australasian Tertiary Mollusca: i-xxvi, 1-407, pls 1-8. British Museum (Natural History), London.
- HARZHAUSER, M., RAVEN, J.G.M., LANDAU, B.M., KOCSIS, L., ADNAN, A., ZUSCHIN, M., MANDIC, O. & BRIGUGLIO, A., 2018. Late Miocene gastropods from northern Borneo (Brunei Darussalam, Seria Formation). — *Palaeontographica, Abt. A: Palaeozoology – Stratigraphy* 313 (1-3): 1-79.
- HERRMANNSEN, A.N., 1846-1852. *Indicis generum malacozoorum primordia. Nomina subgenerum, generum, familiarum, tribuum, ordinum, classium: adjectis auctoribus, temporibus, locis systematicis atque literariis, etymus, synonymis. Praetermittuntur Cirripedia, Tunicata et Rhizopoda.* 1 (1): 1-xxvii, 1-104 (1846); 1 (2): 105-232 (1846); 1 (3): 233-360 (1847); 1 (4): 361-488 (1847); 1 (5): 489-616 (1847); 1 (6): 617-637 (1847); 2 (6): 1-104 (1847); 2 (7): 105-232 (1847); 2 (8): 233-352 (1847); 2 (9): 353-492 (1848); 2 (10): 493-612 (1849); 2 (11): 613-717, xxix-xliii (1849); *Supplementa et corrigenda*: 1-v, 1-140 (1852). T. Fischeri, Cassel.
- IREDALE, T., 1924. Results from Roy Bell's molluscan collections. — *Proceedings of the Linnean Society of New South Wales* 49 (3): 179-278, pls 33-37.
- KREIPL, K., 2008. Cassidae. In: POPPE, G.T. (ed.), *Philippine marine mollusks, volume 1: 575-593*. ConchBooks, Hackenheim.
- LAMARCK, J.B.P.A. DE M. DE., 1816. *Tableau encyclopédique et méthodique des trois règnes de la nature ... Vingt-troisième partie. Mollusques et polypes divers. Liste des objets représentés dans les planches de cette livraison: 16 pp, pls. 391-488, 431 bis, 431 bis**. Mme Veuve Agasse, Paris.
- LELOUX, J. & WESSELINGH, F., 2009. Types of Cenozoic Mollusca from Java in the Martin collection of Naturalis. — *NNM Technical Bulletin* 11: 1-765.
- LINK, D.H.F., 1806-1808. *Beschreibung der Naturalien-Sammlung der Universität zu Rostock. Erste Abtheilung: 1-50 (1806); Zweite Abtheilung: 51-100 (1807); Dritte*

- Abtheilung: 101-165 (1807); Vierte Abtheilung: 1-30 (1807); Fünfte Abtheilung: 1-38 (1808); Sechste Abtheilung: 1-38 (1808). A. Erben, Rostock.
- MARSHALL, N., NOVAK, V., CIBAJ, I., KRIJGSMAN, W., RENEMA, W., YOUNG, J., FRASER, N., LIMBONG, A. & MORLEY, R., 2015. Dating Borneo's deltaic deluge: Middle Miocene progradation of the Mahakam delta. — *Palaios* 30 (1): 7-25.
- MARTIN, K., 1895-1906. Die Fossilien von Java auf Grund einer Sammlung von D^r. R. D. M. Verbeek. I. Band. Gasteropoda. — Sammlungen des Geologischen Reichs-Museums in Leiden, Neue Folge 1: 1-132, pls 1-20 (1895); 133-220, pls 21-33 (1899); 221-281, pls 34-41 (1905); 282-332, pls 42-45 (1906).
- MARTIN, K., 1916. Die Altmiocäne Fauna des West-Progebirges auf Java. Gasteropoda. — Sammlungen des Geologischen Reichs-Museums in Leiden, Neue Folge 2 (6): 223-262, pls 1-5.
- MARTINI, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. — *Proceedings of the Second Planktonic Conference (Roma)*, 2: 739-785.
- MERLE, D., 1999. La radiation des Muricidae (Gastropoda: Neogastropoda) au Paléogène: approche phylogénétique et évolutive: i-vi, 1-499. Paris. Unpublished thesis, Muséum national d'Histoire naturelle.
- MERLE, D., 2001. The spiral cords and the internal denticles of the outer lip in the Muricidae: terminology and methodological comments. — *Novapex* 2 (3): 69-71.
- MONTFORT, P. DENYS DE, 1810. *Conchyliologie systématique, et classification méthodique des coquilles*. Tome 2: 1-676, 1-16, Schoell, Paris.
- NUTTALL, C.P., 1961. Gastropoda from the Miri and Seria Formations. The Geology and Hydrocarbon Resources of Negara Brunei Darussalam. In: WILFORD, G.E. (ed.): *The geology and mineral resources of Brunei and adjacent parts of Sarawak with descriptions of Seria and Miri oilfields*. — *British Borneo Geological Survey Memoir* 10: 73-87.
- PICCOLI, G. & SAVAZZI, E., 1983. Five shallow benthic mollusc faunas from the Upper Eocene (Baron, Priabona, Garoowe, Nanggulan, Takashima). — *Bollettino della Società Paleontologica Italiana* 22 (1-2): 31-47.
- PILSBRY, H.A., 1922. Revision of W. M. Gabb's Tertiary Mollusca of Santo Domingo. — *Proceedings of the Academy of Natural Sciences of Philadelphia* 73 (2): 305-435, pls 16-47.
- RÖDING, P.F., 1798. *Museum Boltenianum, sive catalogus cimeliorum e tribus regnis naturae quae olim collegerat Joa. Fried. Bolten, M.D.p.d. per XL annos proto physicus Hamburgensis. Pars secunda. Conchyliia sive Testacea univalvia, bivalvia & multivalvia: I-VIII, 1-199*. Johan. Christi. Trappii, Hamburgi.
- SANDERS, M.T., MERLE, D. & PUILLANDRE, N., 2019. A review of fossil Bursidae and their use for phylogeny calibration. — *Geodiversitas* 41 (5): 247-265.
- SCHMELZ, G.W., 1997. Notes on the fauna of the Chipola Formation XLI. A reexamination of *Bursa* (Mollusca: Gastropoda) from the Chipola Formation, with the description of a new species. — *Tulane Studies in Geology and Paleontology* 30 (2): 105-108.
- SCOPOLI, J.A., 1777. *Introductio ad historiam naturalem, sistens genera lapidum, plantarum, et animalium, hactenus detecta, caracteristibus essentialibus donata, in tribus divisa, subinde ad leges naturae: i-viii, 1-506*. Wolfgang Gerle, Praga.
- STRONG, E.E., PUILLANDRE, N., BEU, A.G., CASTELIN, M. & BOUCHET, P., 2018. Frogs and tuns and tritons – a molecular phylogeny and revised family classification of the predatory gastropod superfamily Tonnoidea (Caenogastropoda). — *Molecular Phylogeny and Evolution* 130: 18-34.
- STUTCHBURY, S., 1837. On *Cypraecassis*, a supposed new genus of univalve shells, for the reception of certain species of Bruguière's genus *Cassis*. — *Magazine of Natural History, New Series*, 1 (4): 214-217.
- VALENCIENNES, A., 1832 [in 1832-1833]. *Coquilles univalves marines de l'Amérique équinoxiale, recueillies pendant le voyage de MM. A. de Humboldt et A. Bonpland*: 262-339, pl. 57. In: HUMBOLDT, A. VON & A. BONPLAND, A. (eds.), *Observations de zoologie et d'anatomie comparée, faites dans l'Océan Atlantique, dans l'intérieur du nouveau continent et dans la Mer du Sud ... Zoologie, Deuxième volume*. J. Smith & Gide, Paris.
- WANNER, J. & HAHN, E., 1935. Miocäne Mollusken aus der Landschaft Rembang (Java). — *Zeitschrift der Deutschen Geologischen Gesellschaft* 87 (4): 222-273.