

# Mollusca from Preangerian deposits of Mandul Island, northeastern Kalimantan Timur (East Borneo)

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The present paper gives the result of work on a collection of molluscs which was made in 1916 by W. H. van Holst Pellekaan on behalf of the Bataafsche Petroleum Maatschappij, now Shell Internationale Petroleum Maatschappij. A preliminary examination of the fossils was made by K. Martin, also in 1916, his conclusion, based on 22 species, being that their age was either 'uppermost Old Miocene' (i.e., Njalindung) or 'Upper Miocene'. According to modern usage, this would imply a dating of the fauna as Preangerian.

A total of 42 species, including a few new ones, has now been more fully examined. It appears that their combined geologic ranges point unwaveringly to a Preangerian age, thus confirming Martin's preliminary verdict. As is by no means exceptional among the Bornean Neogene faunas, the Mandul assemblage shows better relationships with the distant classical faunas of Javanese Preangerian than with the contemporaneous faunas of the Sangkulirang/Mangkalihat region nearby.

Three new species are described, *Lodderia mandulana*, *Proterato tenuirugosa* and *Apollon perlberalis*, and a new subspecies, *Paphia sinuosa mandulana*. Apropos the examination of a rare bivalve in the Mandul fauna, *Acanthocardia? greenoughi* (d'Archiac & Haime), a new species is described from Junghuhn's locality K (Tjidamar), Java: *A.? carolimartini*.

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## Introduction

The molluscan fauna described in the present paper was collected in 1916 by Dr W. H. van Holst Pellekaan in the course of a geological exploration of the Island of Mandul, north of well-known Tarakan Island, northeast Kalimantan, on behalf of the Bataafsche Petroleum Maatschappij (B.P.M.), at present Shell Internationale Petroleum Maatschappij (S.I.P.M.). A preliminary examination of the fossils was carried out by Dr K. Martin and his results, based on 22 species, given in a report to B.P.M. dated 27-6-1916. Martin concluded that the fauna was either of an 'uppermost Old Miocene' age (i.e., Njalindung) or 'Upper Miocene' (unspecified). In other words, he placed the fauna in what subsequently was called Preangerian, without however specifically mentioning the 'Upper Miocene' Tjilanang fauna, the other constituent of the Preangerian of modern usage.

It may be recalled that in a paper on an obviously mixed collection of fossils of different ages from Mandul (which was dispatched to Holland after the Miocene lot), the writer, on information received, reported that the Miocene molluscs discussed below had been collected from marly deposits in the southwestern part of the island (Beets, 1950c, p. 292). It now transpires that this information was almost certainly incorrect: new findings emerged as a result of perusal of old B.P.M. reports kindly made available to the writer by S.I.P.M. in 1981, for the purpose of pinpointing the Miocene locality.

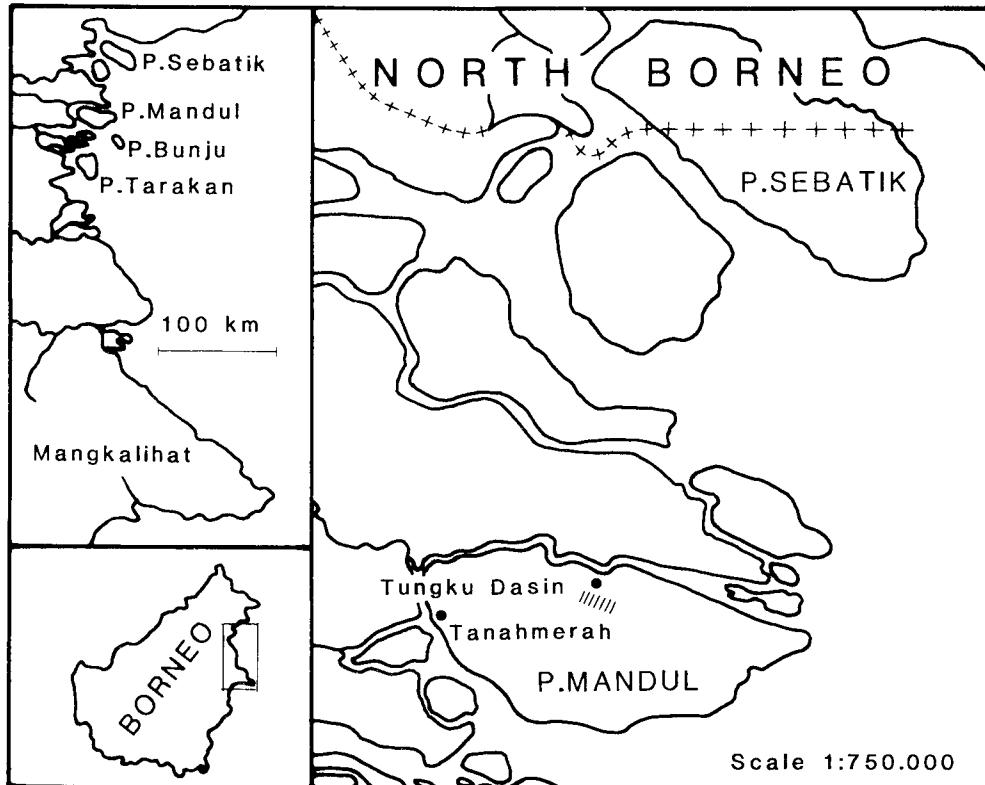


Fig. 1. Sketch map of Mandul Island; possible collecting area of Miocene fossils indicated by hachures. P. = Pulu (island).

First, it was established that van Holst Pellekaan did in fact collect Mollusca and other fossils in the western part of the island, i.e., about 3 to 4 km NE of Kampung (village) Mandul. However, these derived from littoral deposits (occurring below Holocene sands) which he called Post-Pliocene, a complex of clays and calcareous clays with many fossils. It seems almost certain now that the majority of the fossils discussed by the writer in 1950, actually derives from this source, as indeed surmised at the time, but neither this supposition nor the precise locality could be confirmed by even the most thorough investigation of old reconnaissance reports.

Second, judging from the exploration activities in Mandul up to the middle of the year 1916, the Miocene fossils, and also a number of mislaid Miocene specimens among the molluscs discussed in 1950, must have derived from the Mandul Marl Formation in the Tungku Dasin domal structure in the north-central part of the island, their precise locality, unfortunately, not being known (see below). On the other hand, any 'Pliocene?' fossils listed in 1950 and mentioned, again on information received, as being possibly derived from cores of the Tungku Dasin exploration well located in the centre of the structure of that name and outcropping Miocene Mandul Marls, would now appear to be of a Miocene provenance too, as there is not the slightest evidence of the presence of Pliocene in the core of the dome or in neighbouring areas. Needless to say, the conclusion cannot be better than conjectural.

From what little that has been published about the geology of Mandul (Leupold & van der Vlerk, 1931, pp. 624-625; Marks, 1956, pp. 89, 159, 176), the following stratigraphy may be gleaned, some supplementary information having been obtained from old B.P.M. reports.

	Post-Pliocene		
Th	?Bunju Beds	Upper lignite member	
	Tarakan Formation	Sand and gravel, 600-700 m Lower lignite member 130-190 m	
Tg	Mandul Marl Formation	Soft sandy marls and clays, marly and impure limestones, with much molluscan debris, corals and Small Foraminifera, without <i>Lepidocyclusina</i>	
	contact not exposed		
Tf	Simengaris or Sebatik		
to	Formation	Monotonous sandy/clayey formation	
Te	(top part)		

According to Leupold & van der Vlerk (1931), the Mandul Marls correlate with the Antjam Beds (Tg) of nearby Salimbatu-Antjam, considered as Odengian by the writer and thought to be Pliocene by Marks (1956, pp. 7, 89).

In the Mandul Marl Formation outcropping in the Tungku Dasin area, an upper limestone/marl succession is distinguished, separated from a similar lower complex by some 460 m of sands and clays. At the base of the upper succession occur, to the southwest of Tungku Dasin, brown tuffaceous to brecciose volcanic deposits and fossiliferous clays. As the clayey reddish brown to greyish matrix or filling of the fossils discussed below is not tuffaceous, it seems hardly likely that they derive from these deposits. However, in a report to B.P.M. dated 21-5-1916, van Holst Pellekaan stated that there are in the upper limestone/marl complex, apart from coral limestone beds, also finely sandy marls with Foraminifera and 'numerous Mollusca' and again, grey fossiliferous marly clays, with 'similar fossils', all approximately due south of Tungku Dasin. Here, about 2 km southeast of the tuffaceous deposits mentioned above, van Holst Pellekaan indicated on his map

four fossil localities close together, the molluscs discussed below presumably deriving from one or more of these fossiliferous outcrops. Two coral species in the same collection sent to Martin were subsequently identified by Gerth (1923, p. 47, loc. 47), their age being left undecided but later stated to be Miocene (Gerth, 1931). Regrettably, it proved impossible to establish a definite link between any outcrops and the fossils concerned, which otherwise would have relegated the upper Mandul Marls here and now to Preangerian, Tf3, instead of Tg, even if only to some as yet unspecifiable extent, and the possibility is merely mentioned in the interest of future investigation.

## Description of the Mollusca

The material is kept in the Rijksmuseum van Geologie en Mineralogie, the registration numbers being prefixed by the abbreviation RGM.

The shortened stratigraphical records of the species applied below correspond with the ones listed and explained in the next chapter.

*Lodderia mandulana* spec. nov.  
Pl. 3, figs. 1-3.

*Holotype* — RGM 315 201: Pl. 3, figs. 1-3; height 1.6 mm, maximum diameter 3 mm.

*Type-locality* — Not known, presumably in the north-central part of Mandul Island.

*Type-horizon* — Unknown, presumably some level in the Mandul Marl Formation.

*Name* — Derived from the name of Mandul Island.

*Range* — No previous records.

*Description* — The holotype is the only specimen available: small, with low spire, umbilicate, less ornamented spirally than the type of *Lodderia* Tate, 1899, but with the thickened peristome characteristic of the genus. Protoconch apparently consisting of nearly 2 smooth whorls separated from the teleoconch by a very indistinct axial 'riblet', which is followed by 2½ spirally ornamented whorls. First there are 3 faint threads which develop rapidly into smooth and sharp ridges, a fourth being visible in the abapical suture. On the last third of the body whorl the ridges first fade away in order to reappear thread-like near the peristome, while other threads remain visible unchangingly on the periphery of the shell. Base with several fairly close-set and faint spiral threads. Fine oblique growth lines cover all whorls. Umbilicus wide and deeply pitted, the umbilical wall with strong growth lines. It is bordered by a strong smooth rib, which is accompanied by a wide and deep groove on its adapical side. Aperture oblique, peristome smooth and thickened inside continuously along the whole apertural margin. A posterior canal is rather well developed between the outer and parietal lips. The writer is not aware of the existence of closely related species, fossil or living.

*Cyclostremiscus (Ponocyclus) cingulifer* (Adams, 1850)

*Material* — RGM 315 202.

*Range* — Preangerian to Recent: Tj - UM (Tg: Palau) - P - PQ (Togopi) - Q - Re.

*References* — Martin, 1911-1912, pp. 41, 47 (*Delphinula* spec. 2); Beets, 1941, pp. 5, 180 (*Vitrinella cingulifera*); Nuttall, 1965, pp. 161, 168 (*V. cingulifera*); Ladd, 1966, p. 80 (refs), pl. 16, figs. 15-17.

*Comments* — Four immature specimens are available (maximum diameter 2.3 mm) and two fragments. As both this species and its close relative, *C. novemcarinatus* (Melvill, 1906), are variable, it seems appropriate to add the following observations. Their protoconchs are not much different, with 2½-3 smooth whorls in *C. cingulifer*, while for Melvill's type of *C. novemcarinatus*, 2 whorls are mentioned and fossil specimens of the same species from Borneo have 2-2½ (Beets, 1941, p. 26). In the latter, however, as in co-types in the Rijksmuseum van Natuurlijke Historie, Leiden, the apical whorls pass almost imperceptably into the teleoconch, by first developing a spiral ridge on the middle of the whorl and later, even ½ or 1 whorl later, a second spiral adapically to the first, and a third in the abapical suture (Beets, 1941, p. 26, pl. 1, fig. 59). On the other hand, the apical whorls in *C. cingulifer* are sharply terminated by an oblique riblet, or rather, protruding edge of the former apical peristome, while subsequently, two spirals instead of one, appear suddenly (as does a third in the abapical suture and a weaker spiral along the adapical suture), over and adapically to the middle of the whorl. The adapical one of the two spirals may be more prominent than the other.

The specimen of *C. cingulifer* from the Tjilanang Beds bears finally seven 'primary' spirals; in addition a secondary one near, and a fine thread along the adapical suture. On its umbilical wall occur, first a secondary spiral, then a very fine lira and finally two threads close together in the middle of the inner wall.

The height of the spire, being quite variable (as in other species), is no useful distinctive point between the two species.

#### *Turritella cingulifera* Sowerby, 1825

*Material* — RGM 315 203 (a few more or less damaged specimens).

*Range* — Early Miocene to Recent: R - NT (Lower Menkrawit Beds: L.742; Sekurau; Mentawir Beds s. str.; West Borneo) - P - N - PQ (Togopi) - Q - Re.

*References* — Chapman, 1918, p. 10; Altena, 1938, p. 304 (refs); Beets, 1941, p. 191; Beets, 1950e, p. 330; Nuttall, 1965, p. 168; Beets, 1981a, pp. 4, 5; Beets, this vol. p. 10.

#### *Vermicularia (Vermicularia) lumbricalis* (Linné, 1758)

*Material* — RGM 305 204.

*Range* — Preangerian to Recent: NT (Gelingseh Beds: Source area of Sg. Gelingseh and Sg. Gelingseh, 'layer 2', also loc. 144) - Q - Re.

*Reference* — Tryon, 1879-1897, 8 (1886), p. 186, pl. 55, fig. 98.

*Comment* — One complete specimen and a few spires are present, matching Recent specimens beautifully.

*Triphora (Inella) javana berauensis* Beets, 1981

*Material* — RGM 315 205 (one specimen with fine riblets on its post-apical whorls.)

*Range* — Early to Late Miocene: Rr (R1) - NT (basal and Lower Menkrawit Beds: L.114, L.386; Gelingseh Beds: Sg. Gelingseh, 'layer 2'; Tapian Langsat; Gunung Madupar (Rutten & Wanner)) - UM (Antjam Beds: L.747).

*Reference* — Beets, 1981b, pp. 16, 23, 24.

*Miralda (Oscilla) aff. M. (O.) faceta* (Melvill, 1904)

*Material* — RGM 315 206 (one specimen).

*Range* — Preangerian: NT (Tapian Langsat).

*Reference* — Beets, 1981b, pp. 17, 23, 24.

*Tibia (Tibia) verbeekii* (Martin, 1899)

*Material* — RGM 315 207.

*Range* — Early to Late Miocene (to Recent?): R - Rr (Rm; Rl) - Nj - Ta - Pa - Bo - NT (Gelingseh Beds: Sg. Gelingseh, 'layer 1'; Sekurau; West Borneo) - UM (Tjirodeng). If actually conspecific with *T. fusus* (Linné, 1758), its range would include: NT (Kari Orang, Witkamp) - UM (Upper Dingle Formation) - M - P - PQ - Q? - Re.

*Reference* — Beets, this vol, p. 12.

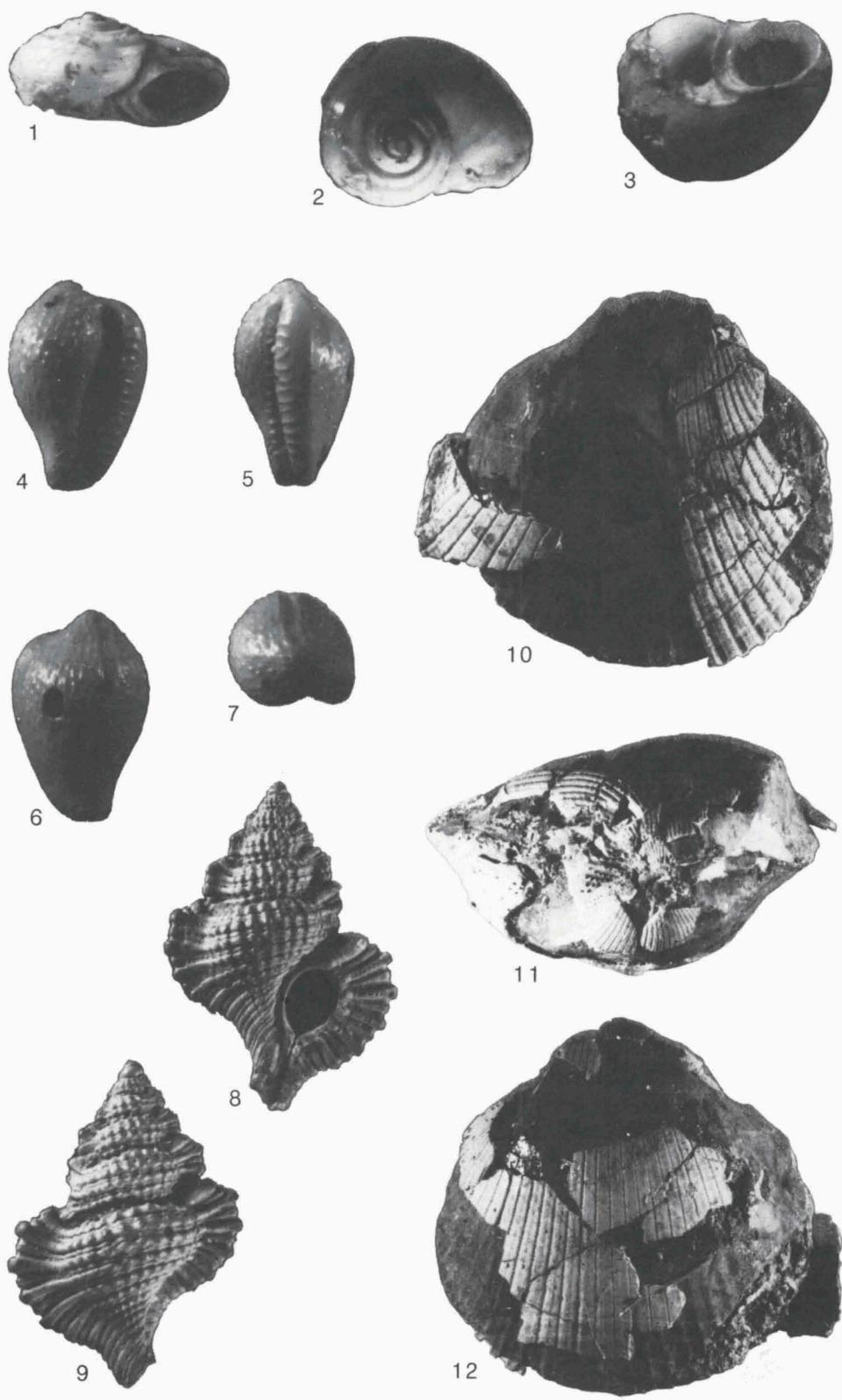
*Comment* — Nine damaged but otherwise well preserved specimens are available, their whorls sometimes less inflated than usual, as in the Javanese shells from Selatjau (= Parungponteng) and Rembang.

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### Plate 3

- Figs. 1-3. *Lodderia mandulana* spec. nov. Holotype, RGM 315 201, height 1.6 mm, maximum diameter 3 mm. Loc. Mandul Island.
- Figs. 4-7. *Proterato (Eratoena) tenuirugosa* spec. nov. Holotype, RGM 315 208, length 4.1 mm. Loc. Mandul Island.
- Figs. 8-9. *Apollon (Biplex) perlberalis* spec. nov. Holotype, RGM 315 217, height 18.8 mm. Loc. Mandul Island.
- Fig. 10-12. *Acanthocardia?* cf. *A? greenoughi* (d'Archiac & Haime). RGM 315 241, length 57 mm, height 56 mm, diameter 30.5+ mm. Right valve: fig. 10; left valve: fig. 12; umbonal view: fig. 11. Loc. Mandul Island.

Plate 3



*Proterato (Eratoena) tenuirugosa* spec. nov.  
Pl. 3, figs. 4-7.

*Holotype* — RGM 315 208: Pl 3, figs. 4-7; height 4.1 mm.

*Type-locality* — Not known, presumably in the north-central part of Mandul Island.

*Type-horizon* — Unknown, presumably some level in the Mandul Marl Formation.

*Name* — From Latin *tenuis* (fine, subtle) and *rugosus* (wrinkled).

*Range* — No previous records.

*Description* — Shell small, stout, its protoconch and low spire covered with shelly coating, a faint spiral depression hinting at the presence of the suture of perhaps two whorls in all. Body whorl strongly inflated, its abapical end constricted. Aperture narrow, widening in the middle. Outer lip fairly sharply marginate, smooth but for the presence of 15 fine transverse ridges and an oblique ridge along the siphonal canal. Inner lip bearing a row of short and fine, often sharp, somewhat unequally long teeth and four irregularly arranged ridges at its abapical end, and a rather sharp terminal ridge of the fossula along the siphonal canal, but weaker along the fossula which is long, shallow and smooth.

The surface of the shell, but for narrow zones of the outer lip and adapical outlet, and a broader zone around the siphonal canal, is either corrugated or bears protuberances to pustules, the ridges particularly between the dorsal groove and outer lip and on both sides of the groove, usually axially or near-axially arranged in rows. Dorsal groove wavy, flat-bottomed and smooth.

The outer lip is appreciably more marginate than is normal in *Proterato*, and this distinguishes the new species readily from its nearest relatives, *P. corrugata* (Hinds, 1844) and *P. nana* (Sowerby, 1859), judging from specimens from Lifu and Hongkong labelled *P. corrugata*, as well as others labelled *P. sulcifera* (Sowerby, 1832) and *P. nana*, both from Mauritius, in the Rijksmuseum van Natuurlijke Historie, Leiden. All of these seem to represent one species, which may be *P. corrugata*. This living species (see Cate, 1977) also has a thicker outer lip, with more ridges (17-25?) and more regularly arranged abapical end ridges of its inner lip; its dorsal groove is straighter and its rugose ornament slightly coarser. Yet there is a chance that future finds may help pronounce *P. tenuirugosa* an extinct subspecies of *P. corrugata*.

'*Cypraea*' spec. indet.

*Material* — RGM 315 209.

*Comment* — This is a compressed damaged specimen whose systematical position remains uncertain.

'*Cypraea*' spec. indet.

*Material* — RGM 315 210.

*Comment* — A damaged specimen is available which, due to its poor condition, defies identification.

*Amaurellina (Pachycrommium) bandongensis* (Martin, 1879)

*Material* — RGM 315 211.

*Range* — Early Miocene to Preangerian: R - Nj — Tj (and loc. O, Junghuhn).

*References* — *Natica bandongensis*, Martin, 1879-1880, p. 82, pl. 13, figs. 15-16; Martin, 1891-1922, p. 267, pl. 40, fig. 644; Martin, 1911-1912, pp. 9, 11, 21, 41, 47, 152, 159. *Ampullira bandongensis*, Martin, 1919, pp. 100, 127, 128, (omitted on p. 140); Martin, 1921-1922, pp. 476, 493, pl. 3, fig. 83; Martin, 1928a, p. 116.

*Comment* — A damaged but otherwise well preserved specimen is available, its height 33+ mm. It resembles particularly Javanese shells from Tjiangsana and Junghuhn's loc. O.

*Polinices (Polinices) cumingianus* (Récluz, 1844)

*Material* — RGM 315 212 (two characteristic specimens, their umbilicus narrower than usual).

*Range* — Early Miocene to Recent: R - Rr (Ra, Rl) - UG (Sind) - Nj - Tj (and loc. O, Junghuhn) - Ta - Pa - NT (Muara Kobun; West Borneo; Tjikarang, loc. R, Junghuhn) - M - P - N (e.g., Tjigugur) - PQ - Q - Re.

*References* — Altena, 1941, p. 58 (refs); Abrard, 1942, p. 57, pl. 6, p. 17 (*Natica Powisiana*) Altena & Beets, 1945, pp. 38, 60; Wissemra, 1947, p. 126; Beets, 1983a, pp. 5, 14, 16.

*Natica helvacea* Lamarck, 1822

*Material* — RGM 315 213 (8 specimens).

*Range* — Early Miocene to Recent: Rr (Rm) - UG (Assam) - Nj - Tj - NT (basal and Lower Menkrawit Beds: L.114, L.386, L.391; Gelingseh Beds: loc. 150; Sekurau; West Borneo; Tjilanang/Tjiangsana; Lower Palembang Beds) - Um (Tjiodeng; Palabuanratu; Talar Beds) - M - P - N - PQ - Q - Re.

*References* — Altena, 1941, p. 70 (refs); Beets, this vol. p. 13.

*Natica rostalina* Jenkins, 1864

*Material* — RGM 315 214 (a single fine specimen).

*Range* — Early Miocene to Pliocene: R - Rr (Rl) - UG (Assam) - Nj - Tj (and loc. O, Junghuhn) - NT (West Borneo; Lower Palembang Beds) - UM (Tjiodeng) - M - P.

*References* — Jenkins, 1864, p. 56, pl. 6, fig. 8; Martin, 1879-1880, p. 81, pl. 13, figs. 11, 11a; Martin, 1891-1922, p. 256, pl. 38, fig. 611; Martin, 1907, p. 146; Cossmann, 1910, p. 55, pl. 4, figs. 1-2(?); Martin, 1911-1912, pp. 9, 21, 41, 47, 159; Martin, 1919, pp. 98, 125,

127, 128, 140; Martin, 1921-1922, pp. 475, 493; Wayland & Davies, 1923, p. 577; Martin, 1928a, p. 116; Haanstra & Spiker, 1932b, p. 1314; Pannekoek, 1936, pp. 8, 12; Eames, 1950b, pp. 240, 247.

*Natica rufa* (Born, 1778)

*Material* — RGM 315 215.

*Range* — Early Miocene to Recent: R - UG (Quilon) - Nj - Tj (and loc. O, Junghuhn) - Ta - Pa - NT (Gelingseh Beds: Sg. Gelingseh, 'layer 1'; West Borneo; Lower Palembang Beds) - UM (Upper Dingle Formation) - M - P - N - PQ - Q - Re.

*References* — Altena, 1941, p. 73 (refs); Beets, 1941, pp. 192, 196, 197; Wissemann, 1947, p. 134; Beets, 1950c, p. 293; Dey, 1962, p. 54; Shuto, 1969, p. 79, pl. 5, figs. 13, 15-18; pl. 6, figs. 5, 14.

*Comment* — Nine specimens are available. Their funicle is comparatively weak, as in shells from Tjadasngampar.

*Apollon (Apollon) bitubercularis* (Lamarck, 1816)

*Material* — RGM 315 216.

*Range* — Early Miocene to Recent: R - Rr (Rm, Rl) - UG (Assam) - Ta - Pa - NT (basal Menkrawit Beds: L.114; Gunung Batuta; Gunung Madupar (Wanner); Tjilintung/Tjiang-sana; Lower Palembang Beds) - UM (Talar Beds) - P - N - PQ (e.g., Togopi) - Q - Re.

*References* — Beets, 1941, pp. 88, 169, 188, 194, 201 (*Argobuccinum bituberculare*); Altena, 1943, p. 96 (*Gyrineum bituberculare*); Abrard, 1946, p. 68, pl. 4, fig. 42 (*Ranella* sp.); Wissemann, 1947, p. 143; Beets, 1950a, p. 245; Nuttall, 1965, p. 171; Ladd, 1977, p. 33, pl. 12, figs. 7-9 (*Gyrineum bituberculare*); Beets, 1981b, pp. 20, 23, 26.

*Comment* — One fine specimen is available, agreeing particularly well with shells from Selatjau (= Parungponteng) and Sondé.

*Apollon (Biplex) perlberalis* spec. nov.  
Pl. 3, figs. 8-9.

*Holotype* — RGM 315 217: Pl. 3, figs. 8-9; height 18.8 mm.

*Type-locality* — Not known, presumably in the north-central part of Mandul Island.

*Type-horizon* — Unknown, presumably some level in the Mandul Marl Formation.

*Name* — From Latin *perlberalis*, well-bred.

*Range* — No previous records.

*Description* — Shell small, protoconch consisting of three whorls, including the small nucleus, its limit being marked by the sudden appearance of the ornament of the four teleoconch whorls: four spiral cords and a number of axials forming nodes at their

intersections, a fifth cord finally appearing near the abapical suture. In each spiral interval a secondary cord overruns the axials without forming nodes. On the varices the cords broaden — the most adapical one in particular being wedge-shaped — while they are inflated on the apertural side of each varix. There are initially 5 or 6, and subsequently 9-10 axials in the half-whorls between the varices. The same ornament is continued on the base of the shell, the axials however disappearing near, or on the neck. Aperture ovate.

*A. perca* (Perry, 1811), a wide-spread species both fossil and Recent (whose range is: UG (Sind; Quilon) - UM (Upper Dingle Formation) - P - N - PQ (e.g., Togopi) - Q - Re), is definitely closely related, not so much its typical form as particularly the variety *pulchella* Forbes, 1852 (known living from Queensland to the Torres Strait) of which the type in the British Museum (Natural History) and specimens in the Rijksmuseum van Natuurlijke Historie were compared. Juvenile shells of this variety approach the new species closely but have 2-2½ apical whorls and, while likewise showing little tendency to spinose development of the varices, the latter are thinner and hence, more leaf-like and finally, much more expanded. Again, the spirals broaden much more rapidly (wedge-like) on the varices than in *A. perliberalis* and the secondary spirals fill the interspaces of the primary ones wholly, or almost so. Again, all spirals are much flatter. As to ornament, specimens of the typical form of *A. perca* come closer to *A. perliberalis* than the var. *pulchella*, but usually bear a not so close axial ribbing and hence their whorls (which are fairly sharply, though weakly shouldered) have a less reticulate appearance.

*Murex (Murex) brevispina* Lamarck, 1822

*Material* — RGM 315 218.

*Range* — Early Miocene to Recent: LM (Pemba I.) - Rr (Rl) - Nj - P - N - Q - Re.

*References* — Martin, 1891-1922, p. 126, pl. 19, figs. 291, 291a; Martin, 1911-1912, pp. 8, 10, 20; Martin, 1919, pp. 85, 126, 132; Martin, 1921-1922, pp. 464, 492; Martin, 1926, pp. 11, 17, 21; Cox, 1927, p. 28, pl. 10, figs. 2a-b; Martin, 1928b, pp. 10, 25, 35; Altena, 1950, p. 210.

*Comment* — There are five specimens which do not differ from fossil and Recent shells compared. There seems indeed to be no justification for maintaining Martin's variety described in 1895 as a separate entity.

*Murex (Murex) trapa* Roeding, 1798

*Material* — RGM 315 219.

*Range* — Pliocene to Recent: P - PQ (e.g., Togopi) - Q - Re.

*References* — Wissema, 1947, p. 174; Cox, 1948, p. 43, pl. 4, figs. 7a-b; Altena, 1950, p. 209; Nuttall, 1965, p. 171.

*Comments* — Also known as *M. martinianus* Reeve, 1845. From Mandul, four damaged specimens and fragments are available. Axial riblets are present on the earlier whorls but vanish rapidly, the last whorl being devoid of costae.

*Cantharus (Pollia) bucklandi* (d'Archiac, 1850)

*Material* — RGM 315 220 (a single damaged specimen).

*Range* — Early Miocene to Pliocene, Neogene (to Recent?): R - Rr (RI) - K - UG (Sind; Katch) - Nj - Tj - Ta - Pa - NT (Gelingseh Beds: Sg. Gelingseh, 'layer 1' and loc. 144; Gunung Batuta) - UM (Japan) - P - N. If actually synonymous with *C. erythrostoma* (Reeve, 1846), which seems probable, its range would include: P - Q - Re.

*References* — Beets, 1981b, pp. 21, 23, 26.

*Pugilina (Pugilina) ickei* (Martin, 1906).

*Material* — RGM 315 221 (a single characteristic specimen).

*Range* — Preangerian: Nj - Tj - Ta.

*References* — *Melongena ickei*: Martin, 1891-1922, p. 309, pl. 45, fig. 731; Martin, 1919, pp. 82, 130; Martin, 1928a, pp. 111, 114.

*Clavilithes (Clavilithes) fennemai* (Martin, 1906)

*Material* — RGM 315 222 (all that is available is the last whorl of a very large specimen).

*Range* — Preangerian to Pliocene: Nj - NT (Gelingseh Beds: loc. 144; Gunung Batuta) - P.

*References* — Martin, 1891-1922, p. 307, pl. 45, figs. 729, 729a (*Fusus Fennemai*); Martin, 1911-1912, pp. 8, 10, 13, 19; Martin, 1919, pp. 81, 126 (*Clavilithes fennemai*); Martin, 1921-1922, pp. 454, 492, pl. 1, figs. 26-27; Martin, 1928a, p. 122; Beets, 1941, pp. 195, 197; Beets, 1981b, pp. 21, 23, 26.

*Buccinofusus?* spec. indet.

*Material* — RGM 315 223 (a fragment bearing a well preserved protoconch).

*Range* — Preangerian: NT (Sekurau).

*Reference* — Beets, this vol., p. 17.

*Oliva (Anazola) cf. O. (A.) acuminata* Lamarck, 1811

*Material* — RGM 315 224.

*Range* — Early Miocene to Recent: Rr (RI) - P - Re.

*Reference* — Oostingh, 1938-1940, prt. 4, p. 114 (refs), pl. 7, figs. 135-138.

**Comments** — Two small specimens are available. The species was already known from Mandul (Beets, 1950c, p. 295), occurring in a stratigraphically mixed collection. The above identification seems correct but as no equally small (21.5 mm long) specimens could be compared, it is given as somewhat doubtful.

*Oliva (Oliva) ispida* (Roeding, 1798)

**Material** — RGM 315 225.

**Range** — Late Miocene to Recent: UM (Tjiodeng) - M - P - Q - Re.

**References** — *O. ispidula*, Etheridge, 1889, p. 174; Martin, 1891-1922, p. 58, pl. 8, figs. 134-136; Tesch, 1915, p. 41, pl. 7, figs. 86a-b; Martin, 1919, pp. 77, 123, 125, 131, 141; Martin, 1928b, p. 11; MacNeil, 1960, p. 89, pl. 4, fig. 14; Ladd, 1982, p. 53, pl. 13, figs. 12-13 (*Oliva ispida*).

**Comment** — Two specimens and a couple of fragments are available, agreeing very well with Recent shells from Obi in the Rijksmuseum van Natuurlijke Historie, Leiden.

*Mitra sowerbyi sedanensis* Martin, 1906

**Material** — RGM 315 226.

**Range** — Early Miocene to Preangerian: W - R - Rr (Ra) - Nj - NT (basal Menkrawit Beds: L.114; Gelingseh Beds: Sg. Gelingseh, 'layer 1'; loc. 144, Rutten).

**Reference** — See a forthcoming paper on the fauna of the Gelingseh Beds.

**Comment** — A single damaged specimen is available, slender, its ornament being close to the figs. 373-374 of *Mitra bayeri* Beets (1941, p. 112, pl. 9, figs. 368-374), which Cernohorsky in recent years rightly considered a synonym of *M. sedanensis*, but showing slightly more distant spirals and comparatively prominent axial ornament, hence the spirals being granulate.

*Mitra (Tiara) cf. M. (T.) interlirata tegalensis* Oostingh, 1935

**Material** — RGM 315 227.

**Range** — Pliocene: P.

**Reference** — Oostingh, 1938-1940, part 6, p. 11, pl. 10, figs. 183-184.

**Comments** — There are four specimens whose whorls bear the adapical sutural to near-sutural weaker spiral characteristic for the subspecies *tegalensis*. Yet, there is more secondary ornament which is also better developed than in Oostingh's material, though definitely not as in the subspecies *ickeae* (Oostingh, 1939). The aperture of the Bornean shells occupies 60-64% of the overall shell length. Growth lines very much finer than in Recent specimens of the forma typica but the same as in other fossil shells.

*Turricula (Surcula) nelliae spurius* (Hedley, 1922)

*Material* — RGM 315 228.

*Range* — Early Miocene to Recent: R - UG (Sind: var.) - Nj - Tj - Bo - UM (Talar Beds) - P - PQ (Togopi) - Re.

*References* — *Pleurotoma* or *Surcula sucabumiana*, Martin, 1891-1922, p. 30, pl. 5, figs. 75, 75a-b; Martin, 1911-1912, pp. 8, 10, 12, 19, 44, 45, 158; Martin, 1919, pp. 74, 126, 128, (omitted on p. 140); Martin, 1921-1922, pp. 448, 492, pl. 1, figs. 9-10; Martin, 1928b, p. 12. (Also quoted from Middle Bodjongmanik Beds by Oostingh, Jaarb. Mijnw. Ned. Indië, 59, (1930), Algemeen Ged., p. 244)). *Turricula nelliae*, Cox, 1948, p. 57 (syn.), pl. 6, figs. 2a-c; Nuttall, 1965, p. 174.

*Comments* — Four specimens are available. The spirals abapically to the periphery of the last whorl are conspicuously tubercled. *T. sucabumiana* is inseparable from *T. nelliae* (Smith, 1877), particularly its subspecies *spurius*: Powell, 1969, p. 23-232, pl. 197, figs. 2-7. Martin's type specimen was poorly figured, it is definitely not a *Nihonia*: compare Powell, l.c., p. 23-389, pl. 255, figs. 5-6 (*Nihonia sucabumiana* (K. Martin, 1895)).

*Gemmula (Gemmula) granosa woodwardi* (Martin, 1884)

*Material* — RGM 315 230 (little more than the apical portion of a shell).

*Range* — Early Miocene to Pliocene, Neogene: R - Rr (Ra; Rm; Rl) - K - UG (Assam) - NT (Muara Kobun; Pulu Senumpah, loc. 156; Gelingseh Beds: loc. 144; Mentawir Beds s. str.; West Borneo; Tjikao; Lower Palembang Beds) - UM (Upper Dingle Formation) - P - N.

*References* — Beets, 1981a, pp. 4, 6; Beets 1983a, pp. 7, 11, 14, 16, 17.

*Lophiotoma indica* (Roeding, 1798)

*Material* — RGM 315 229.

*Range* — Preangerian to Recent: Tj - NT (Muara Kobun) - UM (Tjiodeng) - P - N - PQ (Togopi) - Q - Re. (Wrongly recorded from loc. 156, Rutten, by the present writer: 1983c, p. 55).

*References* — *Turris indica*, Oostingh, 1938-1940, part 1, p. 26 (syn.); Altena & Beets, 1945, p. 46, 60; Cox, 1948, p. 54, pl. 5, figs. 8a-b; Beets, 1983a, pp. 7, 14, 16; Beets, 1983c, pp. 54, 59, 61 (non: loc. f, Pulu Senumpah).

*Comments* — Three specimens, identified by Martin as *Pleurotoma gendinganensis* Martin, 1895, are available, one showing the protoconch: three smooth whorls, the fourth (damaged) bearing axials. Martin (1891-1922, p. 32, pl. 5, figs. 79-84) claimed the presence of three whorls in all but the top of the protoconch shown in his fig. 84 (RGM 7810) is clearly damaged.

The writer fully agrees with Oostingh that *P. gendinganensis* is conspecific with *L. indica*. Of Martin's type specimens only one of the shells (RGM 7810; loc. Sondé) shows the transition between the apical part and the post-embryonal whorls, the latter's keel definitely bearing no 'coarse granule-like gemmules' as claimed by Shuto (1969, p. 184) but being smooth, perhaps slightly wavy more adapically above the peripheral keel than is the keel itself. The writer suspects that quite possibly Shuto got numbers mixed, as on the other hand, the biggest of the Sondé specimens (RGM 7813; Martin's fig. 83), shows (pseudo-)granules over 1½ whorl, not only on the peripheral keel, but even on the adapical sutural cord. However, after repeated careful examinations the writer cannot but ascribe these irregular 'granules' to the poor preservation of the spire whorls of this specimen, probably due to corrosion, as also shown by one of the Mandul shells. In this context it is curious that fossil specimens from Timor originally assigned to *P. gendinganensis* should have turned out to belong to *Unedogemmula* (Powell, 1964, p. 22-932).

The writer agrees with Shuto that *P. odengensis* Martin, 1895 is synonymous with *P. gendinganensis* (compare Powell, l.c., p. 22-931). The biggest shell from Mandul is quite like Martin's type material of *odengensis* with rounded body whorl.

*Conus dingleanus* nom. nov.

*Material* — RGM 315 231-315 232.

*Range* — Early Miocene to Pliocene: Rr (Ra?) - Nj - UM (Upper Dingle Formation) - P.

*Comments* — This is *Phasmoconus martini* Shuto, 1969 non *Conus martini* Wanner & Hahn, 1935.

The type of *C. jenkinsi* Martin, 1879 from the Tjilanang Beds is indeed very different from the Njalindung shells subsequently referred to it by Martin: 1921-1922, pp. 448, 492, pl. 1, figs. 7-8 (perhaps also: Martin, 1928b, pp. 13, 23, 27; Oostingh, 1938-1940, prt 1, p. 20). The Njalindung shells were therefore very properly renamed by Shuto (1969, p. 222, pl. 22, figs. 7, 10, text-fig. 42) as *Phasmoconus martini*; but, by believing the latter to be congeneric with *Conus martini* Wanner & Hahn (1935, p. 241, pl. 17, figs. 3-4), the writer prefers providing *P. martini*, as junior secondary homonym, with the new name *Conus dingleanus*, the name being derived from the Dingle Formation of Panay.

In de Mandul collection is a series of twenty specimens, on the whole well preserved, which match Martin's Njalindung shells beautifully. Spiral ornament may in exceptional cases cover the entire body whorl, though gradually getting weaker towards the shoulder or even vanishing but for the presence of very fine spiral striations. Due to poor preservation of the apical portion it is still impossible to say how many whorls make up the protoconch.

*Conus spec. indet.*

*Material* — RGM 315 233.

*Comments* — There are six small specimens, shaped like *C. stigandi* Cox (1948, p. 60, pl. 6, figs. 6a-b) but bearing spirals on the adapical surface of the whorls. *C. mucronatus* Reeve, 1843 is related but its body whorl spirals are coarser. *C. sondeianus* Martin, 1895 may seem similar but has a clearly nodose shoulder-angle. Perhaps *C. lizardensis* Crosse, 1865 comes closest but is plumper and the spiral cords on its body whorl are divided.

*Ringicula (Ringicula) goujoni* de Folin, 1867

*Material* — RGM 315 234.

*Range* — Preangerian to Recent: NT (Gunung Madupar (Rutten & Wanner)) - Re.

*References* — De Folin, 1867-1881, vol. 1, prt 1, p. 67, pl. 6, fig. 4; Morlet, 1878, p. 120, pl. 5, fig. 4; Thiele, 1925, p. 230, pl. 30, fig. 28.

*Comments* — The height of living specimens is given as 1.6-2.1 mm. A 1.8 mm high shell in the Mandul collection matches Thiele's figure perfectly, although the main tooth on the inside of its outer lip is tripartite, at the main swelling, just as in a specimen in Wanner's and another in Rutten's collection from G. Madupar. In another 1.8 mm long specimen from Rutten's collection, the most abapical labral tooth is not developed at all while it is reasonably well developed in yet another shell. The largest specimen is from Wanner's collection and is 2.3 mm high.

*Dentalium* spec. indet.

*Material* — RGM 315 235.

*Comment* — A few remains of small, sharply ribbed shells are available.

*Dentalium* spec. A

*Material* — RGM 315 236.

*Range* — Early Miocene: R.

*Comment* — A few specimens are available of an unidentified species also present in the Rembang fauna, from Ngampel, in the RGM collection.

*Acila (Truncacila) granulata* (Smith, 1906)

*Material* — RGM 315 237 (a small valve).

*Range* — Preangerian to Recent: NT (West Borneo) - Re.

*Reference* — Beets, 1950e, p. 337, Nr. 92.

*Arcopsis (Arcopsis) sculptilis* (Reeve, 1844)

*Material* — RGM 315 238.

*Range* — Early Miocene to Recent: UG (Quilon) - NT (basal and Lower Menkrawit Beds: L.114, L.386; Gelingseh Beds: Sg. Gelingseh, 'layer 2', and loc. 149; Tapian Langsat; Gunung Madupar (Wanner)) - PQ (Togopi) - Q? - Re.

*References* — Beets, 1950e, p. 337, Nr. 99; Nuttall, 1965, p. 176; Beets, 1981b, pp. 18, 23, 24.

*Comment* — A single beautifully preserved left valve is available, 4.9 mm long, bearing 15 posterior and 10 anterior hinge teeth.

*Chlamys* spec. indet.

*Material* — RGM 315 239.

*Comment* — This is a damaged valve decorated with fine ribs which was vainly compared with other fossil and Recent species.

*Laevicardium (Fulvia?) njalindungense* (Martin, 1922)

*Material* — RGM 315 240 (an internal mould and another one with part of the shell attached).

*Range* — Preangerian: Nj - NT (basal Menkrawit Beds: L. 114; Muara Kobun; Sekurau; Batu Panggal; West Borneo; Lower Palembang Beds; Lower Pitogo Formation).

*References* — *Cardium njalindungense*, Beets, 1941, pp. 162 (refs), 171, 186, 200, pl. 8, fig. 313; Beets, 1950b, pp. 272, 277, 279 (*L. njalindungense*); Kotaka & Noda, 1977, p. 137, pl. 23, figs. 18-26 (*Vasticardium njalindungense*); Beets, 1983a, pp. 10, 14, 15, 16 (*L. njalindungense*); Beets, this vol., p. 32.

*Acanthocardia? cf. A? greenoughi* (d'Archiac & Haime, 1853)  
Pl. 3, figs. 10-12.

*Material* — RGM 315 241.

*Range* — Early Miocene: UG (Sind).

*References* — *Cardium greenoughi*, d'Archiac & Haime, 1853-1854, p. 258, pl. 21, figs. 21, 21a-b; Vredenburg, 1928, p. 446.

*Comments* — This is an interesting find as it concerns an exceedingly rare species, the type specimen so far having been the sole bearer of the name for 130 years. Now, a damaged internal cast is available from Mandul which does show the shape very well while fairly big fragments of the shell are still adhering to it. Although much larger (length 57 mm, height 56 mm, diameter 30.5+ mm) than the type (l. 29, h. 28, d. 19 mm), it has the same outlines and almost the same ornament, although there are some irregularly spaced, small median nodes on the ribs of its anterior half, and quite numerous ones near the beak where too, the edges of the ribs are serrated. The type specimen is undoubtedly not well preserved, which could account for the absence of the nodular ornament. Nevertheless, it seems only prudent to express some doubt as to the correctness of the identification.

The species has the shape, but not the ribs, of *Hedocardium* Marwick, 1944. Vredenburg (1928, p. 446) compared the species with *Cardium setosum* Redfield, 1846

which has however a very different shape, and is much more like Martin's *C. greenoughi* renamed below.

*Acanthocardia? carolimartini* spec. nov.  
Pl. 4, figs. 6-10.

*Holotype* — RGM 5454: Pl. 4, figs. 6-10; right valve, length 19.1 mm, height 15.3 mm?, inflation 5 mm.

*Type-locality* — Sindangbarang, Junghuhn's loc. K, district Tjidamar, West Java.

*Type-horizon* — Not known, age uncertain: Late Miocene or younger (see Altena & Beets, 1945, pp. 66-67).

*Name* — This species is named after Dr Karl Martin.

*Range* — No other records.

*Discussion* — The type specimen was first described by Martin as *Cardium greenoughi* d'Archiac & Haime: Martin, 1883, p. 247, pl. 12, fig. 42. Martin's description appears adequate except for his stating that the shape of this specimen is exactly like that of the true *C. greenoughi* (see above). In fact, its asymmetrical shape is very different, coming much closer to *Cardium setosum* Redfield, 1846 which was somewhat mystifyingly quoted as 'related' to the true *C. greenoughi* by Vredenburg (1928, p. 446). Certain smooth variants of *C. setosum* are in ornament not unlike *A.? carolimartini* but the nodes are very differently arranged in the umbonal region fore and aft.

The type of *A.? carolimartini* clings to an *Architectonica* so that its hinge could not be entirely made visible, yet the cardinals and laterals can be observed: pl. 4, fig. 10.

*Tridacna (Persikima) derasa* (Roeding, 1798)

*Material* — RGM 315 242 (part of a valve).

*Range* — Preangerian to Recent: NT (Gelingseh Beds: loc. 150) - P - Re.

*References* — Beets, 1950d, pp. 312, 314, 315 (*T. squamosa*); Rosewater, 1965, p. 62-057, pls 280-282.

*Comment* — The low radial ornament of the available fragment indicates *T. derasa*. The juvenile specimen from the Pliocene of Sekurau which the writer misidentified as *T. squamosa*, must be relegated to *T. derasa*.

*Cultellus (Cultellus) dilatatus* Martin, 1879

*Material* — RGM 315 243.

*Range* — Preangerian: Nj - Tj (and loc. O, Junghuhn) - Bo - NT (Sekurau; Lower Palembang Beds).

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## Plate 4

Figs. 1-5. *Paphia (Protapes) sinuosa mandulana* subsp. nov. Holotype, RGM 315 247, length 32.6 mm, height 23.3 mm?, inflation 15.2 mm. Loc. Mandul Island.

Figs. 6-10. *Acanthocardia? carolimartini* spec. nov. Holotype, right valve, RGM 5454, length 19.1 mm, height 15.3 mm, inflation 5 mm. Loc. K, Junghuhn, Tjidamar, Java.

Plate 4



*References* — Martin, 1879-1880, p. 90, pl. 15, figs. 3, 3a; Martin, 1911-1912, p. 43; Martin, 1919, pp. 66, 126, 128; Martin, 1921-1922, pp. 491, 493; Martin, 1928a, p. 117; Oostingh, 1938, p. 511; Beets, this vol., p. 33.

*Comment* — Two specimens are available, damaged but quite well identifiable and agreeing particularly well with Javanese shells from Tjitalahab.

'*Tellina*' spec. indet.

*Material* — RGM 315 244 (a single mould).

*Gari preangerensis* (Martin, 1922)

*Material* — RGM 315 245.

*Range* — Preangerian: Nj - NT (West Borneo).

*Reference* — *Psammobia preangerensis*, Martin, 1921-1922, pp. 486, 493, pl. 4, fig. 110.

*Comment* — A damaged left valve and cast are available.

*Solecurtus exaratus* (Philippi, 1848)

*Material* — RGM 315 246.

*Range* — Preangerian to Recent: NT (West Borneo) - Re.

*Reference* — Sowerby, in Reeve, 1843-1878, 19, *Solecurtus*, pl. 1, spec. 1.

*Comments* — Two specimens are present, which are partly preserved as casts and agree very well with Recent shells from Madura in the Rijksmuseum van Natuurlijke Historie, Leiden. The writer is not aware of any previous recording of the species as a fossil.

*Paphia (Protapes) sinuosa mandulana* subspec. nov.

Pl. 4, figs. 1-5.

*Holotype* — RGM 315 247: Pl. 4, figs. 1-5; length 32.6 mm, height 23.3 mm?; inflation 15.2 mm.

*Paratypes* — RGM 315 248-315 249.

*Type-locality* — Not known, presumably in the north-central part of Mandul Island.

*Type-horizon* — Unknown, presumably some level in the Mandul Marl Formation.

*Name* — Derived from the name of Mandul Island.

*Range* — No previous records.

*Description* — The new subspecies comes closest to the Recent *P. sinuosa* (Lamarck, 1818), its ribs being equally clearly continuous, but not lamellate, over lunule and area. In fact, none of its ribs are lamellate (non-lamellate ribs incidentally not being exceptional in Recent shells, as opposed to the rule given for them by Lyngé: 1909, p. 238), and they are

finer and mostly more closely packed than in *P. sinuosa sinuosa*. Furthermore, the posterior truncation is more abrupt, rising more steeply, than in the Recent specimens and another in Rutten's collection from G. Madupar. In another 1.8 mm long specimen saw identical specimens, but the differences noted do not seem to justify upholding a separate status of the fossils on a species level.

*Placamen isabellina* (Philippi, 1849)

*Material* — RGM 315 250.

*Range* — Preangerian to Recent: Tj (and loc. O, Junghuhn) - NT (Sekurau; West Borneo) - P - PQ? (Togopi, ?) - Q - Re.

*Reference* — Beets, this vol., p. 35.

*Comment* — A juvenile valve is available which evidently belongs to the same species as the material from Sekurau.

*Corbula solidula* Hinds, 1843

*Material* — RGM 315 251.

*Range* — Early Miocene to Recent: Rr (RI) - NT (basal Menkrawit Beds: L.114; Gelingseh Beds: Source area of Sg. Gelingseh, and Sg. Gelingseh, 'layer 2'; Gunung Mendong; Sekurau; Tapian Langsat; Gunung Madupar (Rutten & Wanner); Mentawir Beds s. str.) - P - N - Re.

*References* — Beets, 1981a, pp. 4, 6; Beets, 1981b, pp. 18, 23, 24; Beets, this vol. p. 36.

*Comment* — A complete specimen and a right valve represent this small species.

*Penicilllus?* spec. indet.

*Material* — RGM 315 252.

*Comment* — A poorly preserved, compressed tube of a member of the Clavagellidae is at hand.

### Stratigraphic records and faunal list

The abbreviations and names listed on pp. 7-9, this volume, correspond with the stratigraphic records of the species discussed in the previous chapter where full use has been made of them, whereas their number has for obvious reasons been rather severely restricted in the faunal list (Table 1). The latter is however supplemented with a breakdown of the Preangerian records (Table 3 below).

Table 1. Stratigraphic records of the species from Mandul.

## Age determination

In this particular case, a curious situation imposes handicaps on the age determination; viz., one has to keep in mind that in all probability we are dealing with a mutilated collection of fossils, a number of Miocene specimens somehow — presumably in the process of being packed in a jungle camp for shipment to B.P.M.'s Head Office — getting mixed with Quaternary molluscs. The stratigraphically mixed lot was long ago described by the writer (Beets, 1950c). These fossils have now been most carefully reexamined as to their mode of preservation, with results confirming, and adding to, the earlier observations. The species which initially seem to have formed part of the Miocene collection, including a few originally thought to be of a 'Pliocene?' provenance, may be quoted as follows from the writer's earlier paper, their ranges being added to the right:

9. <i>Cerithium karangense</i> Martin	: Pr - P - Q
10. <i>Cerithium leupoldi</i> Beets	: pPr - Pr
16. <i>Natica rufa</i> (Born) *)	
26. <i>Pyrene flavidaeformis</i> (Martin)	: P
27. <i>Nassa (Preangeria) talahabensis</i> (Martin)	: Pr
33. <i>Oliva (Strephona) australis</i> Duclos var. Martin Ms	: pPr - Pr - P
34. <i>Oliva (Anazola)</i> spec. (= <i>O. cf. O. acuminata</i> , this paper)*)	
37. <i>Vexillum (Costellaria) ickei</i> (Martin)	: Pr
41. <i>Turridula (Turridula)</i> spec.	: P
42. <i>Clavus</i> spec.	
44. <i>Conus odengensis</i> Martin	: pPr - Pr - UM - P
45. <i>Terebra (Strioterebrum) indrai</i> Beets	: Pr
46. <i>Terebra (Noditerebra)</i> spec.	: Pr
47. <i>Ringicula glabra</i> Martin	: P
48. <i>Dentalium michelottii</i> Hoernes	: Pr - Re
49. <i>Yoldia subquadrata</i> (Martin)	: P
57. <i>Arca (Arca) hulshofi</i> Martin	: pPr - Pr
61. <i>Pinna</i> cf. <i>vexillum</i> Born	: Pr - P - Q - Re
63. <i>Pecten (Pecten) javanus</i> Martin	: P
65. <i>Chama</i> spec.	
67. <i>Venus (Ventricola) sumatrana</i> Martin	: UM
69. <i>Clementia (Clementia) papyracea</i> (Gray)	: pPr - Pr - UM - P - PQ - Q - Re
74. <i>Aloidis socialis</i> (Martin)	: pPr - Pr - UM - P
75. <i>Aloidis tijuhanensis</i> (Martin)	: Pr - UM - P

\*Also represented in the collection discussed in the present paper.

There is no saying whether the list is complete or not, and to which extent it may be faulty, but this hardly matters as the species listed above remain excluded from the age determination as a matter of course, and anyway only a very exhaustive resampling at the same locality, still to be re-located, can show the full composition of the Miocene Mandul fauna. However, at this stage it is certainly curious — and perhaps not merely coincidence — that no less than 22 out of 24 species listed are not represented in the Miocene collection at all. This suggests that they may indeed be complementary to the latter assemblage and also, that the whole fossil collection at the time had been sorted in the Mandul camp before a number of Miocene specimens drifted into the Quaternary lot.

Keeping the above in mind, one would be very incautious indeed in this case to trust application of the percentage method, quite apart from its innate questionable character anyway when applied to small faunas. Nevertheless, it has to be tried. We see then that out of 42 species listed in Table 1, 20 (22?) or 47.6 (52.4?) % are still represented in the Recent fauna. This would indicate an uppermost Late Miocene to Pliocene age, an absurd result when considering the composition of the fauna.

If now, only for the sake of argument, one assumes that the species listed above from the mixed collection, at what is hopefully considered a reasonable guess, may be accepted as originally belonging to the same Miocene fauna, one would obtain an addition of some 22 species, 3 of which are known from the Recent fauna. If so, 23 - 25? out of a total of 64 species being known from the Recent fauna, the correct percentage figure would be 35.9 - 39?%, and this would indicate a Preangerian age.

Leaving this hypothetical consideration aside, we now turn to the actual records of the 42 species of Table 1. Although of course still dealing with the same mutilated collection, we now face mitigating circumstances, for presently, the whole combined stratigraphical record of all the species examined is taken into account, whereas the value of the percentage method rests on a single factor, viz. whether a species is still living or extinct. Moreover, the damage to the original Miocene collection cannot well be supposed to have happened by selection, that is, due to a deliberate act, but to a case of mischance which places the assemblage of 42 species more or less on a par (1) with collections bearing the flaws of random or hasty and in any case, incomplete sampling (after all, most fossil collections suffer from this defect, as opposed to the results of really exhaustive sampling and sifting of fossiliferous sediment), and (2), with Martin's basing the age determination on 22 out of 42 species.

From the actual records of the species we obtain the following picture:

Recent (Re)	:	20 (22?)
Quaternary (Q)	:	12 (15?)
Pliocene (P)	:	21 (22?)
Late Miocene (UM)	:	13
Preangerian (Pr)	:	32 (or 33 if K and UG should turn out to be Preangerian)
pre-Preangerian (pPr)	:	20 (or 18, if K and UG are Pr)

Obviously, the bias is in favor of Preangerian. This would also be the case when adding the records of 20 out of 22 species from the mixed lot, the figures then being: Re: 23 (25?); Q: 15 (19?); P: 32 (33?); UM: 18; Pr: 46 (or 47); and pPr: 26 (or 24)).

More logical results are obtained if we plot the inferred time ranges of the species (see Table 2).

Table 2. Inferred time ranges of the Mandul fauna.

pPr	Pr	UM	P	PQ	Q	Re
pPr					Re :	10
pPr		P	?	?	Re?	: 1
pPr		P				: 3
pPr		UM	?	?	Re?	: 1
pPr		UM				: 1
pPr	Pr					: 2
pPr						: 2
	Pr					: 6
	Pr	P				: 1
	Pr			Re	:	8
		UM			Re	: 1
		P				: 1
		P			Re	: 1
(a)	20	33	26	26	19	20 (38 species)
				(27?)	(21?)	(22?) (22?)
(b)	10	23	16	16	9	10 (28 species)
				(17?)	(11?)	(12?) (12?)

(a) Number of species recorded for each age (4 omitted).

(b) Ditto, when disregarding the 10 longest ranging species.

It may be added that even if the stratigraphical records of 20 out of 22 possibly complementary species selected from the mixed collection referred to before should be included, the overall results would not be appreciably different from the ones obtained for the 38 species taken into account above, except for the Pliocene record which would acquire more emphasis:

	pPr	Pr	UM	P	PQ	Q	Re
(a)	26	47	35	39 (40?)	24 (26?)	24 (26)	23 (25?) (58 species)
(b)	15	36	24	28 (29?)	13 (15?)	13 (15?)	12 (14?) (47 species)

Table 3. Preangerian records of the Mandul fauna (32 species).

	b	c	e	f	gb	gr	gm	i	j	k	l	m	n	p	pr	prx	lop
<i>Cyclostremiscus cingulifer</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	pr	—	—
<i>Turritella cingulifera</i>	—	c	—	—	—	—	i	—	—	—	—	n	p	—	—	—	—
<i>Vermicularia lumbricalis</i>	—	—	—	—	gb	—	—	—	—	—	—	—	—	—	—	—	—
<i>Triphora javana berauensis</i>	b	c	—	—	gb	—	—	j	—	l	—	—	—	—	—	—	—
<i>Miralda</i> aff. <i>M. faceta</i>	—	—	—	—	—	—	—	j	—	—	—	—	—	—	—	—	—
<i>Tibia verbeekii</i>	—	—	—	—	gb	—	i	—	—	—	—	p	pr	prx	—	—	—
<i>Amaurellina bandongensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	pr	—	—	—	—
<i>Polinices cumingianus</i>	—	—	e	—	—	—	—	—	—	—	—	p	pr	prx	—	—	—
<i>Natica helvacea</i>	b	c	—	—	gb	—	i	—	—	—	—	p	pr	prx	lop	—	—
<i>Natica rostalina</i>	—	—	—	—	—	—	—	—	—	—	—	p	pr	—	lop	—	—
<i>Natica rufa</i>	—	—	—	—	gb	—	—	—	—	—	—	p	pr	—	lop	—	—
<i>Apollon bitubercularis</i>	b	—	—	—	—	—	—	k	l	—	—	pr	prx	lop	—	—	—
<i>Murex brevispina</i>	—	—	—	—	—	—	—	—	—	—	—	pr	—	—	—	—	—
<i>Cantharus bucklandi</i>	—	—	—	—	gb	—	—	k	—	—	—	pr	—	—	—	—	—
<i>Pugilina ickei</i>	—	—	—	—	—	—	—	—	—	—	—	pr	—	—	—	—	—
<i>Clavilithes fennemai</i>	—	—	—	—	gb	—	—	k	—	—	—	pr	—	—	—	—	—
<i>Buccinofusus?</i> spec. indet.	—	—	—	—	—	—	i	—	—	—	—	—	—	—	—	—	—
<i>Mitra sowerbyi sedanensis</i>	b	—	—	—	gb	—	—	—	—	—	—	pr	—	—	—	—	—
<i>Turricula nelliae spurius</i>	—	—	—	—	—	—	—	—	—	—	—	pr	prx	—	—	—	—
<i>Gemmula granosa woodwardi</i>	—	—	e	f	gb	—	—	—	—	—	—	n	p	—	prx	lop	—
<i>Lophiotoma indica</i>	—	—	e	f	gr	—	—	—	—	—	—	pr	—	—	—	—	—
<i>Conus dingleanus</i>	—	—	—	—	—	—	—	—	—	—	—	pr	—	—	—	—	—
<i>Ringicula goujoni</i>	—	—	—	—	—	—	—	—	—	l	—	—	—	—	—	—	—
<i>Acila granulata</i>	—	—	—	—	—	—	—	—	—	—	—	p	—	—	—	—	—
<i>Arcopsis sculptilis</i>	b	c	—	—	gb	—	—	j	—	l	—	—	—	—	—	—	—
<i>Laevicardium njalindungense</i>	b	—	e	—	—	—	i	—	—	m	—	p	pr	prx	lop	—	—
<i>Tridacna derasa</i>	—	—	—	—	gb	—	—	—	—	—	—	—	—	—	—	—	—
<i>Cultellus dilatatus</i>	—	—	—	—	—	—	i	—	—	—	—	pr	prx	lop	—	—	—
<i>Gari preangerensis</i>	—	—	—	—	—	—	—	—	—	—	—	p	pr	—	—	—	—
<i>Solecurtus exaratus</i>	—	—	—	—	—	—	—	—	—	—	—	p	—	—	—	—	—
<i>Placamen isabellina</i>	—	—	—	—	—	—	i	—	—	—	—	p	pr	—	—	—	—
<i>Corbula solidula</i>	b	—	—	—	gb	—	gm	i	j	—	l	—	n	—	—	—	—

The number of species in common with: b: 7 (21.8 %); c: 4 (12.5 %); e: 4 (12.5 %); f: 2 (6.2 %); gb: 12 (37.5 %); gr: 1 (3.1 %); gm: 1 (3.1 %); i: 8 (25 %); j: 4 (12.5 %); k: 3 (9.4 %); l: 5 (15.6 %); m: 1 (3.1 %); n: 3 (9.4 %); p: 12 (37.5 %); pr: 20 (62.5 %); prx: 8 (25 %); lop: 7 (21.8 %).

Symbols used in the above distribution table:

b — basal Menkrawit Beds, L.114	k — Gunung Batuta
c — Lower Menkrawit Beds	l — Gunung Madupar
e — Muara Kobun	m — Batu Panggal
f — Pulu Senumpah, loc. 156	n — Mentawir Beds s. str.
gb — Gelingseh Beds	p — West Borneo
gr — loc. 141, Rutten, Kari Orang	pr — classical Preangerian, Java (Nj, Tj, Ta, Pa)
gm — Gunung Mendong	prx — other Preangerian deposits, Java
i — Sekurau	lop — Lower Palembang Beds, Sumatra
j — Tapian Langsat	

The frequency distribution of Table 2 once again strongly suggests Preangerian as out of 38 species, no less than 33 or 86.8 % occur in this age. Six species are seemingly even confined to that time span, were it not that two are rare and have as yet very little value as age indicators. Four other species of this group may be a little more valuable in this respect: *Pugilina ickei* (uncommon), *Laevicardium njalindungense*, *Cultellus dilatatus* (according to Oostingh, 1938, indicative of Preangerian), and *Gari preangerensis* (uncommon). However, time and again new finds have demonstrated the danger of attaching much reliance to the ranges of presumed index fossils, what with our knowledge of the Neogene faunas in S.E. Asia being very incomplete. On the other hand, the value of their potentially restricted stratigraphical range is not impaired, for the same reason, by the presence of species seemingly confined to either pre-Preangerian or post-Preangerian. Considering, therefore, the combined time ranges of all the species described as being of supreme value, the Miocene fauna from Mandul is unhesitatingly relegated to the Preangerian.

As usual, the occurrences of the species with Preangerian records are listed in a distribution table: Table 3.

As is by no means unusual in Borneo, nearly two-third (20) out of 32 species occur in the distant classical Preangerian of Java, while much fewer, namely 12 species are in common with the Gelingseh Beds and West Borneo, even lesser ties existing with Sekurau (8 species) and the basal Menkrawit Beds (7 species), while those with other roughly equivalent faunas listed, as with some not mentioned above, are weak to non-existent.

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