

Two new species of *Barycypraea* (Gastropoda: Cypraeidae) from the Miocene of Java, Indonesia

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ABSTRACT Two new species of *Barycypraea* Schilder, 1927 described from the middle Miocene Epoch on Java, Indonesia. The new species are compared to 140 specimens of related congeners belonging to *Barycypraea* using a morphological analysis concerning outline, callosities, extremities and teeth. The study includes a discussion of the type locality and the site's stratigraphy.

KEY WORDS Gastropoda, Cypraeidae, *Barycypraea*, *abbasi*, *alessandrovesi*, Miocene, Nyalindung, Indonesia.

INTRODUCTION

The superfamily *Cypraeoidea* was founded by Rafinesque in 1815 and today consists of five families, all closely linked to marine ecosystems. In the family *Cypraeidae*, some authors still place all species in the single genus *Cypraea* Linnaeus, 1758, sometimes recognising subgenera, and others prefer using separate genera (*e.g.* Lorenz, 2002). Six subfamilies are recognised in the taxonomy of Bouchet *et al.* (2017), together sharing 77 genera of recent and fossil species, among which there is the genus *Barycypraea* Schilder, 1927 with one living and nine extinct species. Seven of those nine extinct species are presented in this discussion.

The genus *Barycypraea* is characterized by medium-sized (generally length < 70 mm) robust and calloused shells. The distinctive features of the fossil species of *Barycypraea* are: outline, dorsal callosities, extremities and teeth (Fehse, 2012). Three fossil shells found in Nyalindung District, West Java, Indonesia were examined and compared with 140 specimens of *Barycypraea* spp. from the same site. The study found the new fossils discovered have an outline, callosities, extremities and teeth that are

not attributable to previously described *Barycypraea* species. Therefore, it is justified to describe these species as new to science, namely *Barycypraea abbasi* n.sp. and *Barycypraea alessandrovesi* n.sp.

GEOLOGICAL SETTING

The Sunda convergent margin in southern Indonesia represents the collision zone of the Sunda plate with the actively moving Indian and Australian plates (Jones *et al.*, 2014). The rocks at such a boundary are crumpled, folded and faulted, causing uplift and frequent earthquakes on the Sunda plate. The subduction of the other plates causes occasional volcanic eruptions from magma feeding the Sunda Arc. Another important aspect of Indonesian geology is alternating changes in sea level caused by successive ice ages and tectonic subsidence or uplift. The result of all these processes is that large areas of marine rocks and sediments are raised to the surface, and often the fossils they contain exposed by earthquakes and erosion.

Java is a large island in the Indonesian archipelago, located on the southern edge of Sundaland (Figure 1). It has undergone a

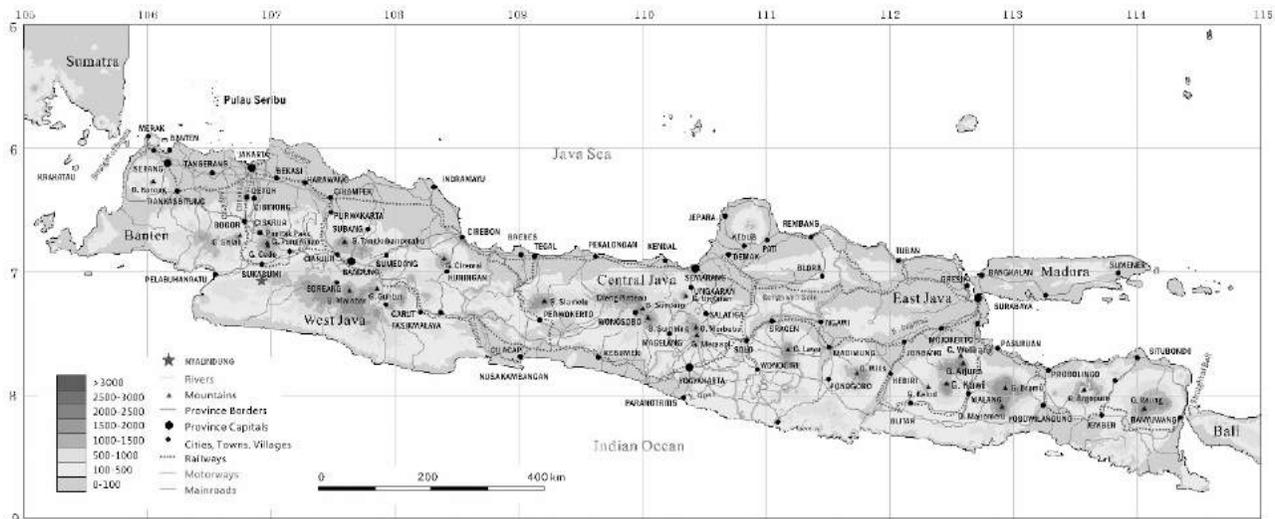


Figure 1. Map of Java, Indonesia. The star indicates the Nyalindung study site (OrangeSmile, 2021).

complex geological evolution between the Cretaceous and the late Tertiary (Neogene). During the Upper Cretaceous, a continental fragment rifted from the Australian margin of Gondwana collided with the southern margin of Sundaland, causing subduction to cease and formed the basement of the Southern Mountains in what is now eastern Java (Smyth *et al.*, 2007). Renewal of subduction during the Middle Eocene caused partial melting of this continental fragment to mix with the magma feeding the Southern Mountains Arc. The early Miocene saw a phase of explosive arc volcanism in southern Java, which diminished or ceased by the middle Miocene and allowed widespread carbonate deposition prior to volcanism resuming in the late Miocene, depositing debrites and turbidites in the NW Java Sea (Clements & Hall, 2007). Relative concentrations of shells are of fundamental importance as indicators of the numerous changes in sea level, recorded as faunal changes in depositional sequences (Abbott, 1997; Kondo *et al.*, 1998).

This study is concerned with the siliciclastic shallow marine sediments widespread in West Java. The fossiliferous layer containing the new

Barycypraea species is called the Nyalindung Formation (Aswan & Ozawa, 2006; Aswan *et al.*, 2008; Figure 2), or the Nyalindung Beds (Van Bemmelen, 1949). In Jampang Kulon area it is considered as the Nyalindung Member of the Cimandiri Formation (or Complex) (Van Bemmelen, 1949; Sukamto, 1975; Figure 3). It was deposited in the southern part of the Bogor Basin (Van Bemmelen, 1949; Baumann *et al.*, 1973; Figure 2), also known as the Bogor Trough (Koesoemadinata & Siregar, 1984), and is located north of the modern convergence of Sundaland with the Indian and Australian plates (Jones *et al.*, 2014). This formation is exposed along several rivers in western Java, such as Citalahab, Cileungsir, Cigadog and Cijarian (Aswan, 2006; Aswan & Ozawa, 2006; Syarifin, 2011). In the northern part of the Nyalindung District, it stretches along the Cimandiri (Mandiri River) valley to Desa Bantarkalong and the Cimerang highlands, and to the southeast of Bojonglopang (Syarifin, 2011). Depending on location, the lower section of the Nyalindung formation overlies the Lengkong Formation or Jampang Formation, or grades laterally into the Bojonglopang Member (mostly limestone) of the Cimandiri Formation; and the upper section is separated from the Beser

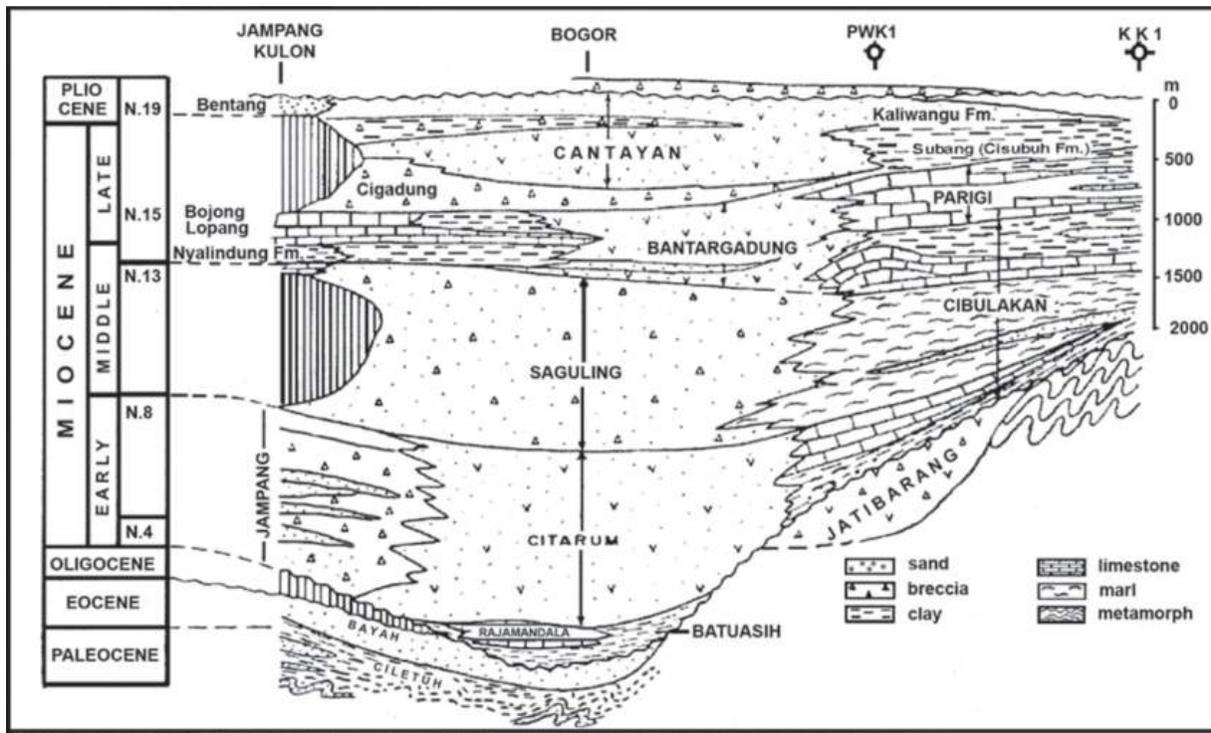


Figure 2. Chronostratigraphy and sequence stratigraphy of West Java, includes Planktonic Foraminiferal biozones N4 to N19 (Blow, 1969) (Martodjojo, 1984 in Aswan *et al.*, 2008).

Formation by an unconformity (Sukamto, 1975; Aswan & Ozawa, 2006; Aswan *et al.*, 2008; Syarifin, 2011; Figure 3).

Using molluscan assemblages and index fossils, Oostingh (1938) compiled the Tertiary (Neogene) stratigraphic stages of Java (Pandita *et al.*, 2013). His Preangerian Stage is characterised by species such as: *Vicarya verneuilli callosa* (Martin, 1899), *Turritella angulata* (Martin, 1905) and *Barycypraea caputviperae* (Martin, 1899). Oostingh ascribed the Citalahab (River) near Nyalindung as the type locality of the Preangerian Stage, and designated the type stratigraphy as the Cimandiri Complex (Van Bemmelen, 1949; Kase *et al.*, 2015). The estimated geological age is the middle Miocene (Van Bemmelen, 1949; Aswan, 1997; Aswan & Zaim, 1994; Aswan *et al.*, 2008), equivalent to the Serravallian Stage. This stage is represented by the Nyalindung

Formation in West Java and according to Syarifin (2011) the age estimate for this formation based on foraminifers varies between sites, and covers Blow's Zones N12 to N14 (Van Bemmelen, 1949) or N14 (Sukamto, 1975) (Figure 3). Whereas in sediments containing *Tridacna* at Ci Angsana (River), Batenburg *et al.*, (2011) suggest the foraminiferal fauna indicate an age referable to the last part of the Serravallian and base of the Tortonian, or ~10-13 Ma.

At the Nyalindung research site, mollusc fossils are very abundant in sandstones and siltstones, and also in grey or blackish tuff. Interesting species of the family *Cypraeidae*, such as *Barycypraea* spp., can be found in abundant numbers. They are found with many other benthic fossils, such as the following gastropod genera: *Phos*, *Thais* and *Liotia* (Van Bemmelen, 1949); *Ancilla*, *Cerithium*, *Columbella*, *Conus*,

Nassa, *Nassarius*, *Natica* and *Turbo* (Syarifin, 2011; Dharma, 2005); *Cymatium*, *Melongena*, *Nerita*, *Volema* and *Vasum* (Dharma, 2005). It can therefore be assumed from this assemblage that *Barycypraea* spp. were common at that time and lived in shallow water (Dharma, 2005).

EPOCH	FZ	Van Bemmelen, 1949		Sukamto, 1975		
		Jampang		Jampang		
HOLOCENE	N22	Alluvium	Alluvium and coastal deposits			
			Young terrace deposits and Coral reef limestone	Volcanic breccia and Andesite		
PLEISTOCENE	N21	Young volcanic deposits	Citanglar beach deposits	Old terrace deposits		
		Old volcanic deposits				
PLIOCENE	N20	Volcanic, marl and clay deposits	Upper part of Bentang Formation			
	N19					
	N18					
MIOCENE	UPPER	Bentang Series	Upper	Lower part of Bentang Formation	Cibodas Formation	
			Lower			
	MIDDLE	N16	Beser Beds	Kalongrang (Beser Beds)	Beser Formation	Cikondang Member
		N15				
		N14	Tjimandiri Complex	Nyalindung Beds	Cimandiri Formation	Bojonglopang Member
		N13		Reef Limestones		
		N12		Lengkong Beds		
		N11	Tjiodeng Series	Lengkong Formation		
		N10				
		LOWER	N9	Djampang Series	Upper	Cikarang Member
N8						
N7						
N6						
OLIGOCENE	P22 ↑ P18	"Oligocene" of the Tjimandiri Valley (Bandung Zone)	Lower	Ciseureuh Member	Rajamandala Formation	
						N4
						N5
						N3

Figure 3. Chronostratigraphy and sequence stratigraphy for the study site within the Jampang quadrangle, West Java (Van Bemmelen, 1949; Sukamto, 1975), includes Planktonic Foraminiferal biozones (FZ; Blow, 1969) [Modified and corrected from translation of Syarifin, 2011].

MATERIALS AND METHODS

The material examined in the present study consists of 3 type shells for the new species, collected between April and May 2019 from the Miocene sediments of Nyalindung (West Java, Indonesia), and 140 specimens of various *Barycypraea* spp. from the same site for comparison (Matteo Dovesi collection, Italy).

In order to better evaluate the morphological variations of the shells described, a batch of 20 specimens for each *Barycypraea* species was retained for sufficient comparison. From these a range of shell morphological characters were analysed for the types of the new species, and the 140 selected samples.

SYSTEMATICS

Class : Gastropoda Cuvier, 1795
 Subclass : Caenogastropoda Cox, 1960
 Order : Littorinimorpha Golikov & Starobogatov, 1975
 Superfamily : Cypraeoidea Rafinesque, 1815
 Family : Cypraeidae Rafinesque, 1815
 Genus : *Barycypraea* (f.) Schilder, 1927
 Type species: *Cypraea caputviperae* (f.) Martin, 1899 † (type by original designation)

Barycypraea abbasi n.sp. †
 Dovesi and Parsons, 2021
 (Plate 1, Figure 1a)

Description. Shell robust, rhombus-ovoidal in outline; centre of gravity shifted rearward where there are two lateral callused protrusions, which make an angular outline. Anterior terminals longer than posterior terminals; posterior terminal tip thicker than half the height of the shell and deeply indented; anterior tip elongated, slightly indented with the extremity facing upwards. Dorsum callused; central area half-moon shaped, convex and smooth. Dorsal

callosities include two posteriorly and one anteriorly, central and slightly irregular. Protoconch and apex covered by callus. Ventrums convex with recurved terminals and rounded margins; ventral margin callused; posterior extremity thick, triangular, protruding and slightly inclined; anterior extremity elongated, straight, with thin margins. Aperture narrow and almost straight, of the same width along the entire length; anal and siphonal canals deeply indented, bordered by a strong protruding callus; anal canal deep, half shell height; siphonal canal deep, one third of shell height. Columella wide and rounded; central part flattened, descending toward apertural opening. Labral lip wide and rounded, inner margin slightly sinuous, straight posteriorly; outer margin callused and more rounded posteriorly. Parietal lip narrow, almost straight, a little callused; inner edge almost straight without denticles. Fossula flattened with two protuberances on the terminal ridge. Medium sized for genus; length exceeds width and height. Labral teeth deep, not very thick and fairly regular, linear; more widely spaced on posterior third, finer and denser anteriorly, and from the inner labral margin they extend 2-3 mm onto the base. Columellar teeth coarser and equally spaced up to half of length, and then become shorter, thick and shallow towards posteriorly. Eleventh columellar tooth non-linear, "comma"-shaped and more distant from previous ones. Pattern obsolete; base light beige, teeth slightly paler and dorsum darker, with the central part greyed.

Type material. Holotype: IGF 104323, length 43.8 mm, width 29.1 mm, height 21.0 mm, 20 labral teeth and 15 columellar teeth, preserved in the Museo di Scienze Naturali dell'Università di Firenze (Firenze, Italia). Paratypes (4 shells, not measured, nor figured): Paratype 1 Paris Museum (MNHN.F.A81731); Paratype 2 Jeff

Parsons collection; Paratype 3 John Abbas collection; and Paratype 4 Steven Lie collection.

Type locality. From landslides beyond the normal perimeter of the Nyalindung fossil beds in northern part of Nyalindung District, Sukabumi Regency, West Java Province, Indonesia.

Distribution. Currently known only from the extended perimeter of the normal 50 x 100 metres fossil bed at Nyalindung.

Type stratum. Nyalindung Formation.

Geological age. Preangerian (Serravallian) Stage of middle Miocene.

Etymology. Name honours John Abbas, who initially recognised this fossil species as new and kindly brought it to Matteo's attention.

Barycypraea alessandrovesi n.sp. †
Dovesi, 2021
(Plate 1, Figures 1b-c)

Description. Robust shape, ovoidal shell outline, smooth and sinuous without callus; anterior extremity is longer than the posterior; posterior terminal tip thicker than half of the height of the shell and deeply indented, elongated anterior tip, slightly indented; smooth, rounded, almost spherical dorsum with a convex and smooth central part not restricted; dorsal callosities are two single posterior nodules on both sides of the anal canal; protoconch and apex covered by callus; ventrum slightly convex with rounded edges; ventral callous margins, thick posterior ventral extremity, protruding, slightly inclined; elongated anterior ventral extremity, straight, with thin margins; aperture narrow and curved, of the same width along the entire length; anal and siphonal canals deeply indented, bordered

by a strong protruding callus; anal canal deep half the height of the shell, siphonal canal deep one third of the height of the shell; wide and rounded labral lip, wide and rounded columella with flattened central part descending towards the opening; inner labial margin non-sinuuous, curved posteriorly; outer labral margin callused and more rounded posteriorly; thin parietal lip, almost straight, little callused; inner edge almost straight without denticles; flattened fossula with a protuberances in the initial part of the terminal ridge. Medium sized for genus; the length exceeds the width and height. Coarse, shallow labial teeth, not extended on the lip, more spaced and not very evident in the third part towards the posterior extremity, finer and thicker in the anterior extremity; coarse, thick and shallow columellar teeth disappear towards the posterior extremity, not extended on the lip or on the fossula. Light brown uniform colour in the dorsum and base, teeth of the same colour as the base. Almost absent design without mantle lines.

Type material. Holotype IGF 104322, length 48.7 mm, width 29.7 mm, height 23.8 mm, 17 labral teeth and 15 columellar teeth, preserved in the Museo di Scienze Naturali dell'Università di Firenze (Firenze, Italia). Paratype length 41.0 mm, width 25.0 mm, height 21.0 mm; 18 labral teeth and 16 columellar teeth, preserved in the Matteo Dovesi collection (Bologna, Italia).

Type locality. Northern part of Nyalindung District, Sukabumi Regency, West Java Province, Indonesia.

Type stratum. Nyalindung Formation.

Geological age. Preangerian (Serravallian) Stage of middle Miocene.

Etymology. Named in honour of Matteo's son Alessandro Dovesi, for his seriousness and interest in *Barycypraea* fossils.

COMPARISON MATERIAL EXAMINED

The following *Barycypraea* taxa have been described from the Miocene Epoch in Indonesia. All descriptions are based on opinions of Fehse (2012) and modified by personal observations.

Barycypraea beberkiriana (Martin, 1899)[†]
(Plate 2, Figure 2a)

Description. Oval drop-shaped outline, short anterior aperture and rounded callous posterior aperture, rounded dorsum sometimes a little flattened not restricted by callosities, normally without anterior dorsal nodules but sometimes there are two distinct and not very evident nodules, two posterior dorsal nodules distinct in each side of the anal canal. Absent anterior callosities and absent or poorly evident posterior callosities. Labial and columellar teeth coarse and little extended on each lip.

Barycypraea caputviperae (Martin, 1899)[†]
(Plate 2, Figure 2b)

Description. Rather triangular outline, slightly elongated anterior aperture and slightly prominent posterior, irregular dorsum and restricted by callosities, there are two anterior dorsal callosities vertically extended similar to walls separated by a sulcus more or less deep, there are two distinct irregular or deformed posterior dorsal nodules in each side of the anal canal. The dorsal structure is variable and complex. No or sometimes not very evident anterior callosities, irregular posterior callosities. Coarse and close labial teeth, fine and slightly furrowed columellar teeth. The teeth are little extended on each lip.

Barycypraea murisimilis (Martin, 1879)[†]
(Plate 2, Figure 2c)

Description. Oval drop-shaped outline, slightly elongated anterior aperture and slightly prominent and calloused posterior, rounded dorsum not restricted by callosities, without anterior dorsal nodules, normally without posterior dorsal nodules but sometimes there are two distinct, irregular and not very evident nodules in each side of the anal canal. Absent anterior callosities and posterior absent or poorly evident. Labial and columellar teeth coarse and little extended on each lip.

Barycypraea orangensis (Beets, 1942)[†]
(Plate 2, Figure 2d)

Description. Triangular outline, short anterior aperture and posterior slightly prominent, flattened dorsum, with rectangular or circular shape, restricted by callosities, single dorsal anterior nodule with vertical development like a wall without groove, two distinct and irregular posterior dorsal nodules in each side of the anal canal. Anterior callosities absent and posterior prominent and sharp. Coarse labial teeth, fine and spaced columellar teeth, both not very extended on the lip.

Barycypraea quadrinodosa (Fehse, 2012)[†]
(Plate 2, Figure 2e)

Description. Hexagonal outline, very short anterior aperture and rounded posterior, cross-shaped dorsum restricted by callosities, 4 uniform and distinct dorsal nodules, 2 anterior and 2 posterior in each side of the anal canal. Anterior callosities absent and posterior callosities usually absent, sometimes not very evident. Coarse labial teeth, columellar variable from coarse to fine and distinct.

Barycypraea subtetragona (Martin, 1879)[†]
(Plate 2, Figure 2f)

Description. Rhomboid outline, elongated anterior and slightly prominent posterior aperture, rounded dorsum not restricted by callosities, anterior dorsal nodules absent and 2 posterior not very evident in each side of the anal canal. Anterior callosities absent sometimes not very evident, not very evident posterior ones. Coarse labial and columellar teeth not very extended on the lip. This species has an intermediate form between *B. beberkiriana* and *B. murisimilis*, with more rounded dorsum.

Barycypraea suryai (Beets, 1942)[†]
(Plate 2, Figure 2g)

Description. Triangular outline, very short anterior aperture and flattened posterior, flattened dorsum with circular or rectangular shape restricted by callosities, single anterior dorsal nodule vertical like a wall that extends from margin to margin, distinct and roundish posterior nodules in each side of the anal canal. Anterior callosities absent sometimes not very evident, irregular posteriors. Coarse and dense labial teeth, fine and spaced columellar teeth, both extended on the lip.

DISCUSSION

The distinctive aspects of *Barycypraea* fossils from Indonesia are: shell outline (shape), dorsal callosities, extremities and teeth. The dorsal callosities and shape help in distinguishing the taxa (Fehse, 2012). It is useful to refer to the drawing in Figure 4 when comparing the new species with previous taxa. A summary of the distinctive features of Indonesian *Barycypraea* are given in Table 1 for ease of comparison.

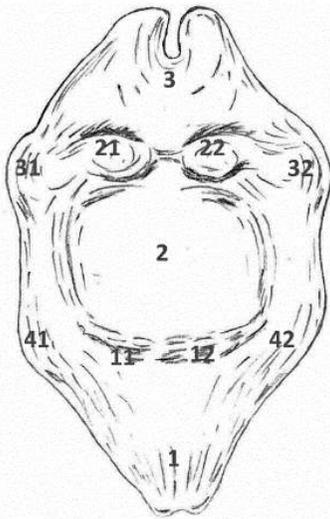


Figure 4. Dorsal features of *Barycypraea* species discussed, marked by the following numbers: (1) anterior extremities, (2) dorsum, (3) posterior extremities, (11-12) anterior nodules, (21-22) posterior nodules, (31-32) posterior callosities, and (41-42) anterior callosities. (Illustration by M. Dovesi, modified from Schilder, 1939 and Fehse, 2012).

Barycypraea abbasi n.sp. has a rhombus-ovoid shape with elongated extremities, raised anteriorly; rounded dorsum with a half-moon shaped central area restricted by a callosity; and a single anterior nodule, all differentiating it from the other species. Also, its teeth are spaced further apart, more so posteriorly, and extend onto each side of the lip, which are different from other *Barycypraea* species.

Barycypraea alessandrovesi n.sp. has an ovoid shape with elongated extremities; smooth and almost spherical dorsum with a convex and smooth central part lacking callosities, these aspects are not found in the other *Barycypraea* species. Its posterior extremities are prominent and elongated, also different from other species.

This set of four morphological characteristics (outline, dorsum, nodules and teeth) is not attributable to the other *Barycypraea* taxa, and characterise the two new species from the middle Miocene Nyalindung Formation in West Java, Indonesia.

ACKNOWLEDGEMENTS

Special thanks to John Abbas (Bekasi, Indonesia) for providing the type material sent to us for studies. Thanks go to Stefano Dominici (Natural Science Museum, University of Florence, Italy) for the numerous discussions in terms of taxonomy, geostatigraphy and geology. Finally, thanks to Alessandro Dovesi, Matteo's son, with which he shared excavations and serious studies in this field of *Barycypraea* fossils, as well as small paleontological works, with great enthusiasm, curiosity and interest.

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		<i>Barycypraea</i> sp.								
		<i>beberkiriana</i>	<i>caputviperae</i>	<i>murisimilis</i>	<i>orangensis</i>	<i>quadrinodosa</i>	<i>subtetragona</i>	<i>suryai</i>	<i>abbasi</i>	<i>alessandrovesi</i>
Dorsal structure	Outline	Drop	Triangular	Drop	Triangular	Hexagonal	Rhomboidal	Triangular	Rhomboidal	Ovoidal
	Anterior aperture (1)	Short, tapered	Slightly elongated	Slightly elongated	Short	Very short	Elongated	Very short	Elongated, raised	Elongated
	Dorsum (2)	Not restricted	Irregular, restricted by callosities	Slightly rounded	Flat, circular or rectangular, restricted by callosities	Cross like, restricted by callosities	Not restricted	Flat, circular or rectangular, restricted by callosities	Crescent-shaped, restricted by callosities	Rounded, not restricted
	Posterior aperture (3)	Rounded, callous	Slightly prominent	Slightly prominent, callous	Slightly prominent	Rounded, callous	Slightly prominent, callous	Flattened	Prominent, callous	Prominent, callous
	Anterior nodules (11-12)	Absent, sometimes two distinct little evident	2 similar to walls divided by groove	Absent	2 similar to wall	2 distinct	Absent	1 similar to wall	1 central in backward position	Absent
	Posterior nodules (21-22)	2 distinct	2 distinct	Absent, sometimes two distinct little evident	2 distinct irregular	2 distinct	2 distinct slightly evident	2 distinct rounded	2 distinct	2 distinct
	Posterior callosities (31-32)	Absent, sometimes slightly evident	Irregular	Absent or slightly irregular	Prominents and acuminate	Absent, sometimes slightly evident	Slightly evident	Irregular	Slightly present	Absent
	Anterior callosities (41-42)	Absent	Absent, sometimes slightly evident	Absent	Absent	Absent	Absent, sometimes slightly evident	Absent, sometimes slightly evident	Absent	Absent
Ventral structure	Labial teeth	Coarse not extended on the lip	Coarse, closed, little extended on the lip	Coarse little extended on the lip	Coarse not extended on the lip	Coarse little extended on the lip	Coarse not extended on the lip	Coarse, dense, extended on the lip	Clear, distinct, extended on the lip	Coarse not extended on the lip
	Columellar teeth	Coarse little extended on the lip	Fine, close together, little furrowed	Coarse little extended on the lip	Fine, spaced, little extended on the lip	Variables, from coarse to fine and distinct	Coarse little extended on the lip	Fine, spaced, extended on the lip	Fine, distinct, spaced extended on the lip	Fine, little furrowed, little extended on the lip
	Anterior extremities	Short	Short	Slightly elongated	Short	Short	Slightly elongated	Short	Elongated	Elongated
	Posterior extremities	Calloused, rounded	Calloused, squared	Calloused, rounded	Calloused, squared	Calloused, rounded	Calloused, rounded	Calloused, flattened	Calloused, prominent	Calloused, prominent

Table 1. Comparison of the distinctive characteristics of the *Barycypraea* species.

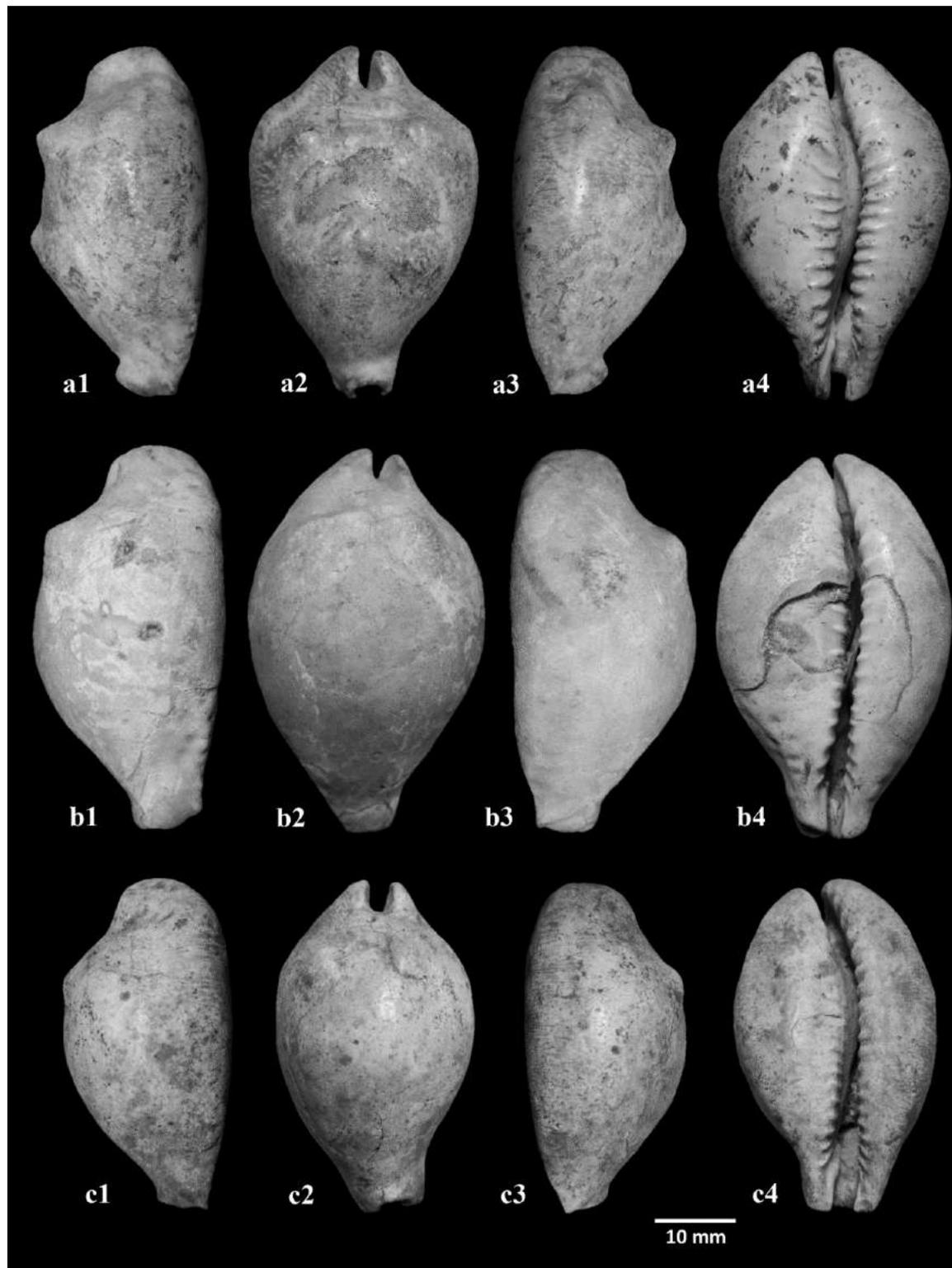


Plate 1. New middle Miocene *Barycypraea* species from Nyalindung, West Java: **a)** *B. abbasi*. sp. Holotype, IGF104323, 43.8 mm; **b-c)** *B. alessandrovesi* n. sp., **b)** holotype, IGF104322, 48.7 mm, and **c)** paratype 41.0 mm. Various views of the same specimen are designated by letters 1 through 4.

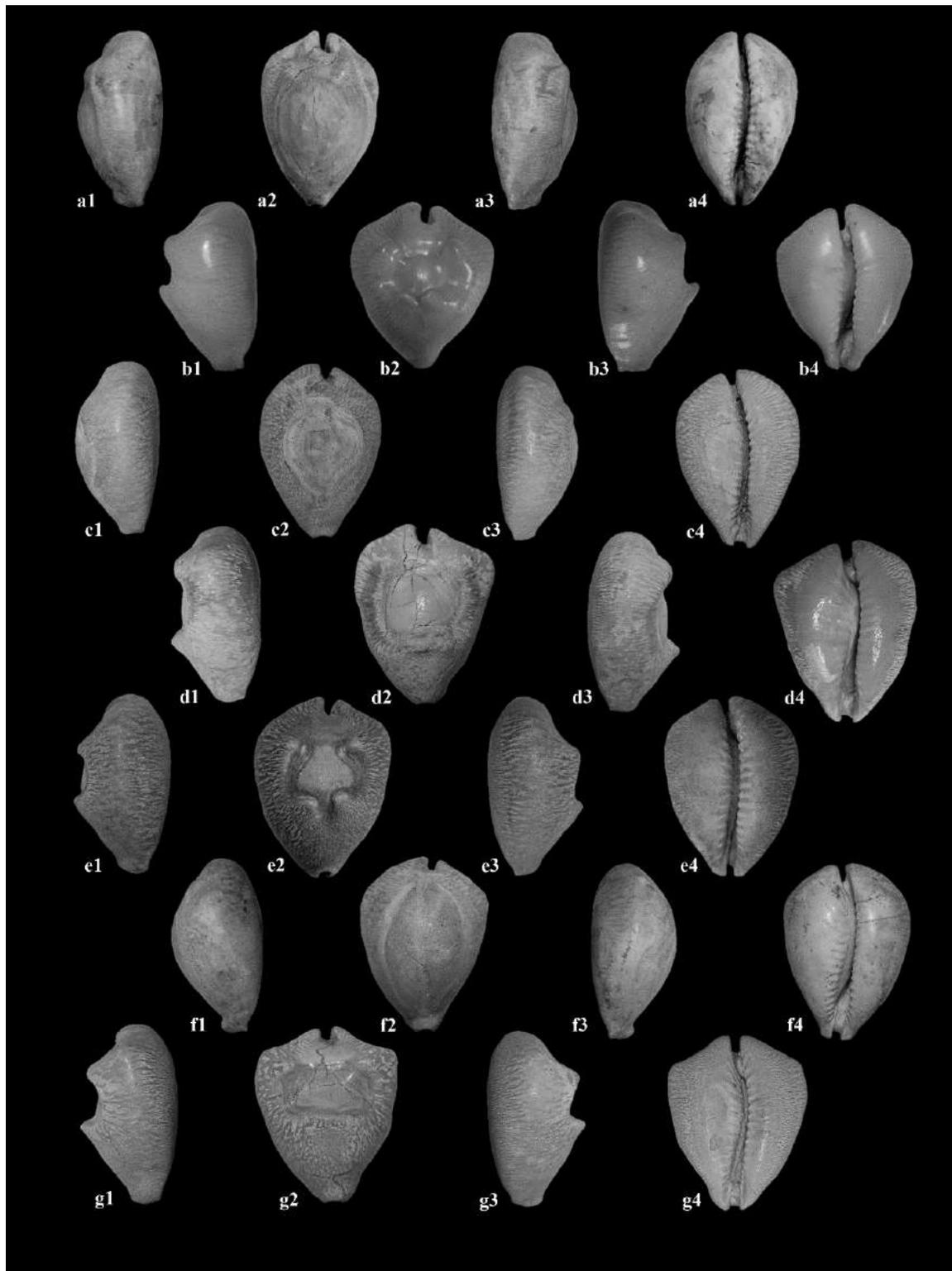


Plate 2. Other Miocene *Barycypraea* species from Nyalindung, West Java: **a)** *B. beberkiriana*; **b)** *B. caputviperae*; **c)** *B. murisimilis*; **d)** *B. orangensis*; **e)** *B. quadrinodosa*; **f)** *B. subtetragona*; and **g)** *B. suryai*. Various views of the same specimen are designated by letters 1 through 4.