

SYSTEMATIC STUDIES ON THE NON-MARINE MOLLUSCA OF THE INDO-AUSTRALIAN ARCHIPELAGO

published by

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IV. Critical Revision of the Freshwater Bivalves of Java

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INTRODUCTION

Compared with the number of species of land mollusks living in Java,¹⁾ 171 species in all, the number of freshwater mollusks (Gastropods and Lamellibranchs) is much lower. They will be treated in two parts; the Bivalves, belonging to the families Unionidae, Sphaeriidae and Corbiculidae, are presented here first; the Gastropods will follow later.

The Bivalve shell is composed of two valves, a left and a right, connected by an elastic ligament (fig. 2).

This ligament lies on the dorsal side, behind the apex of the shell, hence it is always easy to distinguish front and back, left and right side of the shell. The ligament can be exterior (Corbiculidae and Unionidae), or partly interior (genus *Pisidium*).

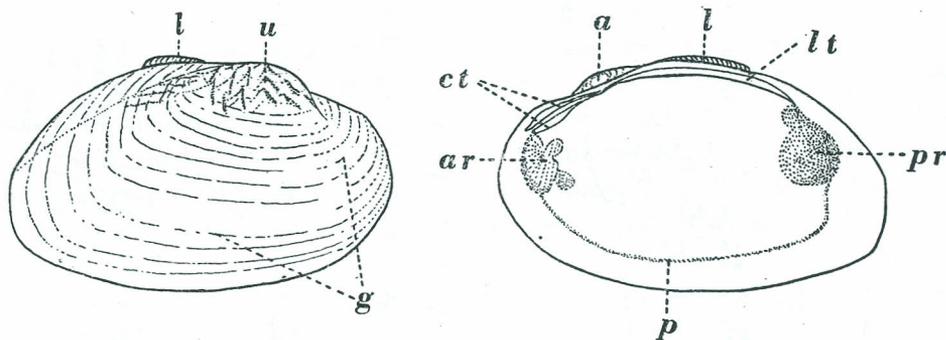


Fig. 1. *Contradens contradens* (LEA). Outline sketch of exterior and interior of right valve. a. apex; ar. scar of anterior retractor muscle; ct. cardinal teeth; g. growth lines; l. ligament; lt. lateral tooth; p. pallial line; pr. scar of posterior retractor muscle; u. umbo. Author del.

¹⁾ See Treubia, 19 (1948), p. 539-604; 20 (1950), p. 381-505 and 21 (1952), p. 291-435.

In addition to the ligament the two valves in the living animal are also united by two adductor muscles, an anterior and a posterior, placed transversely to the plane of symmetry of the animal. The function of the adductor muscles is to keep the valves closed. They are the antagonists of the ligament which draws the valves apart.

The points of attachment of the adductor muscles in the interior of the valves are always recognisable by the somewhat different texture of the porcelainous or of the mother-of-pearl layer in these spots. Their form and position are generically distinctive and are therefore of taxonomic importance.

The muscle scars of each valve are connected by a curved line, almost parallel to the basal margin of the shell and at some distance from it. This mantle line or pallial line indicates the line of attachment of the mantle margin to the shell. The course of the pallial line, whether it is simply curved, or has an additional sinus in the posterior part of the shell, is also characteristic for each genus.

In addition the two valves articulate by means of hinge teeth in the dorsal region of the shell. These teeth prevent any longitudinal or vertical rocking of the two valves. Shape and position of the hinge teeth are generically distinctive and are therefore important for taxonomic purposes.

The initial (oldest) part of each valve is the apex. From this point the valve grows in concentric rings, in anterior, basal and posterior directions, sometimes even in a dorsal direction. In the latter case the highest point of the valve, the umbo, lies higher than the apex.

The concentric ribs and growth rings on the exterior of each valve have no regular periodicity. They are not "annual rings". Even in European countries it is difficult to ascertain the exact age of a Lamelibranch from its concentric rings, because not only the alternation of the seasons, but also food-shortage, sand-displacement or other phenomena can cause interruptions in growth. The explanation of the origin of the ribs and rings is even more difficult in a tropical country where no marked difference in seasons occurs and where ecological factors have been so little studied.

It is a remarkable fact that the species of Unionidae and Corbiculidae, especially the genera *Polymesoda* and *Batissa*, possess such thick, heavy shells, much thicker and much heavier than in most other freshwater mollusks (Bivalves as well as Gastropods) which, generally, have thin and delicate shells.

It proves that the water in which the Naiads and the Corbiculidae live must be rich in carbonate of lime, and, also, that the animals are able

to take up these lime-compounds in their tissues and to prepare shell-substance out of it. This shell-substance is secreted by the mantle-edge and by the entire mantle epidermis.

As we have no information on the length of time which the mussels require for the production of this quantity of calcium carbonate, whether it is produced periodically, or the whole year round, we have no indication for the age of the animals.

With the exception of *Pisidium* the anatomy of the Javanese Bivalves has hardly been studied. With a more exact knowledge of the soft parts, it is not impossible that the interior organisation of Naiads and Corbiculidae would prove to be of as great taxonomic value as the shell characters.

Both the radula, and the mandibula, organs which are so important for classification in the Gastropods, are missing in all Bivalves.

Of the Javanese Bivalves which have been examined the Unionidae and Corbiculidae are unisexual, but *Pisidium* is hermaphroditic. During development the eggs of most (if not all?) Javanese Lamellibranchs are not liberated into the water, but deposited in the gills of the spawning mussel. Here they pass their first stages of development. In the Naiads the two outer gills serve as a brood-pouch, in *Pisidium* and Corbiculidae the two inner ones. In this way the embryos receive maternal protection during the young stages; in *Pisidium* they are even nourished by the parent.

The sperm cells can either be liberated freely into the water (Naiads) or find their way directly to the eggs without being expelled (*Pisidium*). In the latter case self fertilisation takes place. In the Corbiculidae the manner of fertilisation is unknown.

Whether the Javanese Naiads in their development have an obligatory parasitic stage on freshwater fishes, as is the case in their European and American relatives, is unknown. Reference to this point will be made later in the chapter on the Unionidae.

Of the other physiological functions of the Bivalves of Java: feeding, respiration, locomotion, nervous responses etc. nothing is known.

All over the world Bivalves are aquatic, either living in the sea or in inland waters. There are no terrestrial Bivalves. All the Javanese species live with their greater part buried in the mud or in the sand. Only the posterior part lies flush with the surface of the bottom, or emerges slightly.

Locally Naiads and Corbiculidae are used as food for man and poultry. As the Corbiculidae often act as intermediate hosts for Trematode parasites it is dangerous to eat them uncooked.

Corbicula shells are also used for the local industry of lime burning. For classification the "Handbuch der systematischen Weichtierkunde" by J. THIELE, II, part 3, 1934 is followed.

The Javanese species belong to three families: Unionidae (6 species), Corbiculidae (7 species) and Sphaeriidae (3 species).

Of the other families of freshwater Lamellibranchs: Margaritanidae, Mutelidae, Aetheriidae and Dreissenidae no species have been recorded in Java or in the Oriental region.

The total number of 16 species of Bivalves living in Java is not much indeed for a tropical country with a reasonable diversity of watery habitations (running and stagnant water).

The smallness of this number gives rise to the suspicion that the list of 16 species living in the island is incomplete, and that in the future closer investigation will raise this total by at least 50%.

The largest Javanese Bivalve is *Batissa violacea* (LAM.) of 150 mm maximum length. The smallest is *Pisidium sundanum* RENSCH with a length of 3.7 mm.

The author is very much indebted to the authorities of the Museum Zoologicum at Bogor (Buitenzorg) Java, of the Rijksmuseum van Natuurlijke Historie at Leiden, of the Naturmuseum Senckenberg at Frankfurt-on-Main, of the Staatliches Museum für Naturkunde at Stuttgart, of the Naturhistorisches Museum at Basle, of the Museum of Comparative Zoology at Cambridge (Mass.), and of the Zoologisches Museum at Zürich for the loan of specimens and for the permission to study the collections in their museums. The last mentioned institution contains several of the original specimens of MOUSSON which were of the utmost importance for this revision.

To Prof. Dr N. H. ODHNER my special thanks are due for the loan of his excellent drawings of the anatomy of *Pisidium floresianum* and *P. javanum*, and for the permission to reproduce them in the following pages.

SYSTEMATIC PART

Systematic Account of the Lamellibranch Families *Unionidae*,
Corbiculidae and *Sphaeriidae*

Phylum Mollusca

Classis Lamellibranchia

Familia UNIONIDAE

Pseudodon vondenbuschianus (LEA)

Rectidens sumatrensis (DUNKER)

Contradens contradens (LEA)

Elongaria orientalis (LEA)

Pilsbryoconcha exilis (LEA)

Physunio eximius (LEA)

Familia CORBICULIDAE

Polymesoda bengalensis (LAMARCK)

Polymesoda erosa (SOLANDER)

Polymesoda expansa (MOUSSON)

Batissa violacea (LAMARCK)

Corbicula javanica (MOUSSON)

Corbicula rivalis (PHILIPPI)

Corbicula pulchella (MOUSSON)

Familia SPHAERIIDAE

Pisidium floresianum RENSCH

Pisidium javanum VAN BENTHEM JUTTING

Pisidium sundanum RENSCH

Familia UNIONIDAE

Shells of various sizes, some of large dimensions. Exteriorly mostly yellowish-brown or greenish, interiorly nacreous, in many exotic species with a thick layer of mother-of-pearl which make the species desired objects for pearl fishing and button industry.

Umbones in most species sculptured with nodules and undulations. The rest of the shell can be sculptured also, but not so in the Javanese species. Hinge with distinct cardinal and lateral teeth, or without such hinge elements.

Animals with two gills on either side of the body. The outer gill is partly or entirely connected with the mantle. As far as observations have been made the outer gills (and sometimes part of the inner ones also) serve as brood-pouches (marsupium) for the larvae.

These larvae, called glochidium-larvae, are of microscopical size and have a peculiar shape and structure, quite unlike the adult mussel. After an incubation of several weeks in the gills of the mother, the glochidia are liberated into the water. Here the larvae attach themselves to fishes, settling on the gills or the fins of their hosts. The fish reacts to the little intruders by making a capsule of tissue over them. In this capsule the glochidium lives at the expense of the body fluid of its host. After the

metamorphosis to the young mussel stage the capsule is ruptured by the little Unionid which now commences its definite free life.

Distribution: All continents, with the exception of Australia. Always in fresh water. In the Malay Archipelago only found in Sumatra, Java and Borneo. Not in Celebes, the Lesser Sunda Islands and Moluccas. Towards the East Naiads are recorded again from Misool and New Guinea.

In Java there occur six genera, each with one species. The following key to the genera is, therefore, at the same time a key to the species.

1. Hinge without teeth **Pilsbryoconcha exilis**
- Hinge with teeth 2.
2. Hinge with 1 knob-like tooth in each valve
- **Pseudodon vondenbuschianus**
- Hinge with 2 or more lamelliform teeth in each valve 3.
3. Shell rounded-oblong to trapezoidal, with high posterior wing . .
- **Physunio eximius**
- Shell more stretched 4.
4. Shell broad-oval, umbones rather inflated, umbonal sculpture elaborate **Contradens contradens**
- Shell elongate-oval, umbones little inflated, umbonal sculpture less developed 5.
5. Umbonal sculpture distinct. Left posterior cardinal knob-like. Small opening between the two cardinals of left valve
- **Rectidens sumatrensis**
- Umbonal sculpture weak. Left posterior cardinal elongate. Larger opening between the two cardinals of left valve **Elongaria orientalis**

Of all the Javanese Naiads of which I could investigate soft parts only one specimen of *Contradens contradens* (LEA) contained glochidia (see under that species). Both outer gills served as a marsupium. All other animals were either males or spent females. Of the further development nothing is known, not whether the larvae have an obligatory parasitic stage on fishes to achieve their life cycle as do the European and American species. Yet it is probable that a similar development can also be expected for the Javanese species.

In the paragraphs dealing with *Pseudodon vondenbuschianus*, *Contradens contradens* and *Elongaria orientalis* mention will be made of the elaborate variation in shell form of these species. Since several species of Naiads are notorious for their easy response to environment, observed

in the first place in their shell-form changing according to the habitat, it is not advisable to give these forms the rank of variety or subspecies, because there is no evidence whether the modifications are hereditary. On the contrary, it is more likely that they are "Reaktionsformen", called into existence by the milieu factors.

Of the ecological conditions in which the Javanese Naiads live very little is known. From the localities quoted at each species we see that lakes and rivers are the usual habitats, but further details on environment and behaviour are totally lacking. It seems that *Pseudodon vondenbuschianus* is chiefly a river form, whereas *Contradens contradens*, *Elongaria orientalis*, *Rectidens sumatrensis* and *Pilsbryoconcha exilis* prefer lakes, but this is only a tentative classification and must be investigated further.

Compared with a marine biotope where generally are found (1) an immense volume of water and (2) a relatively limited shore and bottom territory, the freshwater biotope on the contrary is characterised by a much higher ratio for shore line and bottom at the expense of the total water capacity.

If then such a freshwater basin is to contain many large Bivalves, living in the littoral zone, each requiring its share of food and oxygen, we can take it that this habitat is a highly fertile water, well aerated, carrying a sufficient amount of lime and a large quantity of plankton and detritus.

Moreover, as most Naiads are dependent on certain fishes for their breeding cycle, the environment must be roomy and fertile enough to allow the corresponding fish species to find their existence here also.

According to BONNE, BRAS and LIE KIAN JOE (1948, *Medisch Maandbl.* no. 23, p. 456-465) the Javanese Unionid *Contradens contradens* can act as a second intermediate host for *Echinostoma* infection (Vermes, Trematoda).

Geologically speaking the Naiads are a rather modern factor in the natural history of Java. The oldest ones appear in the Pliocene, all previous layers yielding sea shells only.

Of the six genera of Naiads now inhabiting Java (*Pseudodon*, *Rectidens*, *Contradens*, *Elongaria*, *Pilsbryoconcha* and *Physunio*) only three are represented in fossiliferous layers (*Pseudodon*, *Rectidens*, *Elongaria*). Must the remaining three be regarded as later immigrants? *Contradens*, at any rate, was a contemporary of the primitive people inhabiting the rock shelter at Ponorogo (Central Java) in prehistoric centuries (VAN BENTHEM JUTTING, 1932, *Treubia*, 14, p. 103). The other two (*Pilsbryoconcha* and *Physunio*) are hitherto only recorded from the recent fauna.

Genus *Pseudodon* GOULD, 1844.

Shell broad-oval to wedge-shaped oval, or trapezoidal or lozenge-shaped, moderately inflated. Higher behind the umbo than before it, in some species even with a distinct, compressed posterior "wing". From the apex two to three low ridges diverge backwards over the shell. In many specimens they are hardly discernible.

Dark greenish-brown to black, young shells generally lighter.

Umbones little projecting and little inflated, with a few undulations in a double loop. Hinge with one knob-like cardinal in each valve. When the two valves are closed the left cardinal fits behind the right one.

Distribution: Most species live in Burma, Indo China, Malaya, Sumatra, Borneo and Java. A few species in Southern China and one in Japan.

The few scanty observations on the soft parts of *Pseudodon moreleti* CROSSE & FISCHER from Indo China have been put on record by HAAS (1920, Mart.-Chemn. N. Syst. Conch. Cab. 9, Abt. II², p. 306-307, fig. 14-15, pl. 39, fig. 1).

In Java only one species:

Pseudodon vondenbuschianus (LEA, 1840) (fig. 3).

- 1840 LEA, Proc. Americ. Philos. Soc. 1, p. 288 (*Margaritana*).
- 1843 LEA, Trans. Americ. Philos. Soc. 8, p. 222, pl. 18, fig. 39 (*Margaritana*).
- 1849a MOUSSON, Land & Süßw. Moll. Java, p. 96, pl. 18, fig. 1-2 (*Alasmodonta zollingeri* inclus. var. *vulgaris* and var. *angulosa*), p. 97, pl. 19, fig. 1 (*Alasmodonta crispata*) and p. 97 (*Alasmodonta vondenbuschiana*).
- 1849b MOUSSON, Zeitschr. f. Malak. 6, p. 185 (*Margaritana zollingeri*, von dem *Buschiana*, *crispata* and *fragilis*).
- 1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 (*Margaritana (Alasmodonta) zollingeri*, *crispata*, van de *Buschiana*).
- 1862 KÜSTER, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II¹, p. 295, pl. 98, fig. 3 (*Margaritana von dem buschiana*), p. 294, pl. 98, fig. 1 (*M. zollingeri*) and p. 295, pl. 98, fig. 2 (*M. fragilis*).
- 1867 MARTENS, Malak Blätt. 14, p. 13 (*Alasmodonta vondembuschiana* and *A. crispata*).
- 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 308 (*Pseudodon vandembuschianus*, *zollingeri*, *crispatus*).
- 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 267 (*vondembuschianus* and *zollingeri*).
- 1914 SIMPSON, Descr. Catal. Naiades, p. 1085 (*vondembuschianus*) and p. 1087 (*zollingeri*).
- 1920 HAAS, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 324, pl. 45, fig. 1-2 (*zollingeri*) and p. 326, pl. 44, fig. 4-5 (*vondembuschianus*).
- 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 87 (*vondembuschianus* and *zollingeri*).
- 1932 VAN BENTHEM JUTTING, Treubia, 14, p. 103 (*zollingeri*).
- 1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 159.

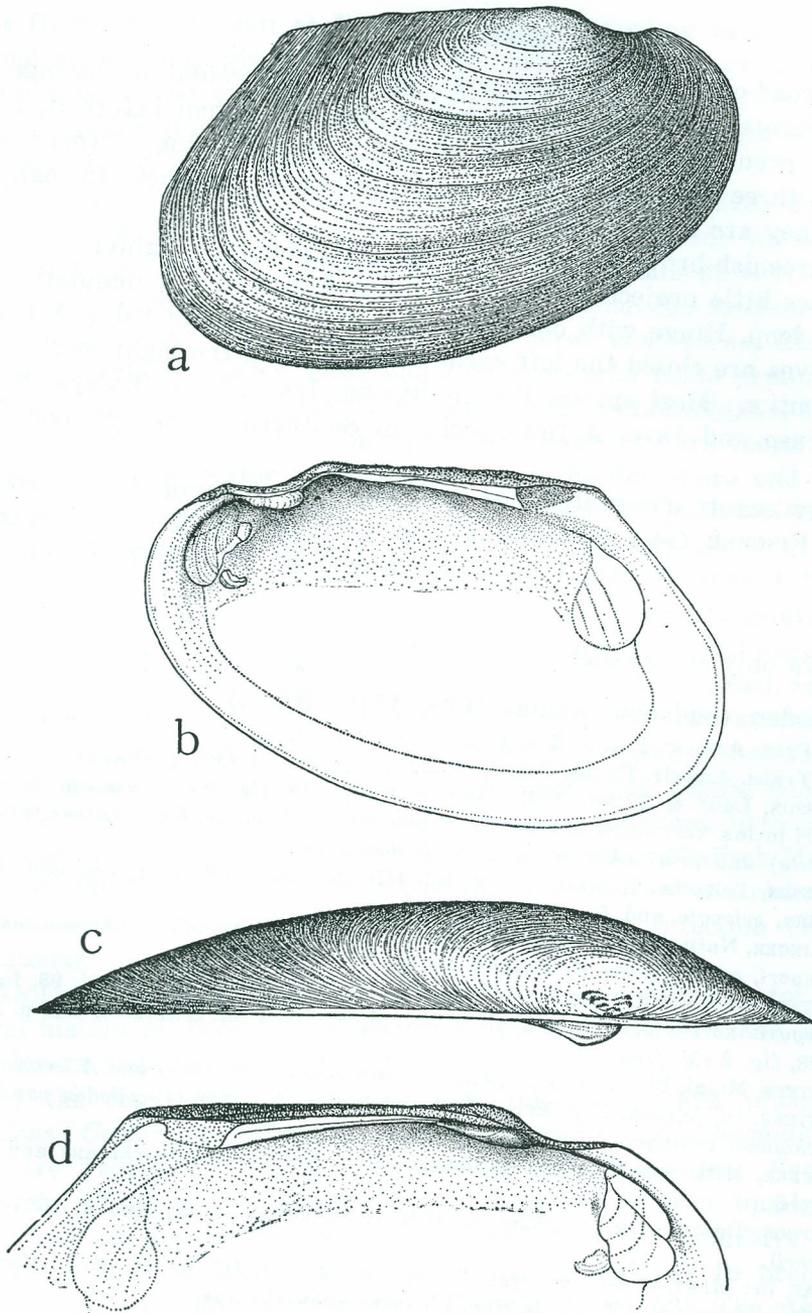


Fig. 3. *Pseudodon vondenbuschianus* (LEA). a. exterior of right valve; b. interior of right valve; c. dorsal side of left valve; d. hinge of left valve. a. and b. about $\frac{3}{4}$ nat. size, c. and d. about nat. size. ABDULKADIR del.

Shell broad-oval to wedge-shaped oval, moderately inflated. Higher behind the umbo than in front of it. Dark greenish-brown to blackish, only the young shells are straw-yellow with a greenish posterior part and a few obscure green radiating stripes.

Young shells thin and transparent, and a little shining. Old ones thicker to rather heavy, little or not transparent, and almost without lustre, covered by a coarse fibrous periostracum. Apex at $2/9$ to $2/7$ of the entire shell length. Striated concentrically according to the growth lines.

Umbones little projecting and a little inflated. In old specimens always eroded, in young shells ornamented with 3 to 4 small, double-looped undulations. From the umbo 2 to 3 faint, hardly palpable keels radiate obliquely to the posterior margin. Occasionally, however, these keels fade away completely.

Dorsal side arcuated. Before the umbo generally somewhat concave and ending in a "nose" at the junction with the front margin. Behind the umbo the dorsal margin rises obliquely, forming a more or less well developed "wing" towards the meeting point with the posterior margin. Anterior margin evenly rounded. Basal margin slightly curved or stretched. In old shells the anterior and posterior angles (the "nose" and the "wing") are less prominent. Ligament behind the umbo reaching as far as the angle between dorsal and posterior margins.

Interior somewhat iridescent. In young shells with shades of green and pink. In old shells the nacre becomes dull brownish purple, often with lustreless flecks of the same colour or of dirty green-yellow.

Muscle scars in the dorsal half of the shell. They are connected by a pallial line without sinus.

Hinge with one cardinal tooth, as a triangular or rounded knob in each valve. In the closed shell the left cardinal fits behind the right one. The ligament is supported by a narrow crest of shell substance which, however, is not a lateral tooth.

Dimensions: length up to 108 mm, height up to 62 mm, diam. up to 36 mm.

Distribution: Malaya, Sumatra, Java, Borneo.

Habitat in Java: Rivers and lakes. Always in fresh water.

West Java: Tji Durian in North Bantam; Tjikoja (MOUSSON, 1849a); near Djakarta (MARTENS, 1867); environs of Djakarta (HAAS, 1920); Krawang (HAAS, 1920); Tjiandjur (HAAS, 1920); Tjitarum near Mt. Seladjau, West of Bandung, 867 m alt.; Bandung (HAAS, 1920); Tjitarum above Bandung; Sangkurian near Bandung in the Tjitarum.

Central Java: Sampung Cave, near Ponorogo; Trinil (VAN BENTHEM JUTTING, 1937); River Soko, right tributary of River Solo (HAAS, 1920).

East Java: Modjokerto (HAAS, 1920); Surabaya.

The species is very variable which explains the long list of synonyms as are e.g. quoted by HAAS (1920).

After having examined several scores of *Pseudodon* from Java in the museums of Amsterdam, Leiden, Basle, Zürich and Frankfort I give it as my opinion that *Pseudodon vondenbuschianus* (LEA, 1840) and *P. zollingeri* (MOUSSON, 1849) are but modifications of one and the same species. This species must bear the name *Pseudodon vondenbuschianus* (LEA). Young shells of both "species" are similar or almost identical, and so is also the course of the growth lines of the young stages on the adult shells of the two forms. Different modes of development in later growth stages have led to the forming of either high, blunt-topped, rounded and rostrated shells (*P. zollingeri*), or of lower, stretched, quadrangular shells (*P. vondenbuschianus*).

HAAS (1920, p. 325-326 and p. 328-329) made already similar suggestions; yet he maintained *P. zollingeri* and *P. vondenbuschianus* as separate species. His conclusions were (p. 328): "The just mentioned differences are, however, anything but constant, and depend on the mode of life of the animals. Hence it is not impossible that both are modifications of one single species. Only the anatomy, the glochidia and, chiefly the examination of ample living material can make out this question."

HAAS (1920, p. 329) even suggested that the closely related *P. chaperi* (DE MORGAN, 1885) from Malaya, Siam and Cambodia could be only the continental representative of the *zollingeri-vondenbuschianus* "Formenkreis".

The varieties *vulgaris* MOUSSON and *angulosa* MOUSSON of *P. zollingeri* and *P. crispata* (MOUSSON) and *P. fragilis* (KÜSTER) are all more or less well defined forms of *P. vondenbuschianus*. As our knowledge of the ecological and topographical conditions in which the Javanese *Pseudodon* occur is so very defective it is not advisable to create names on such an insufficient basis. The "Reaktionsformen" are the effect of different environment. Although influencing the Naiad's individual shape these ecological factors do not modify the species permanently and therefore are not of genotypical significance.

From a prehistoric cave at Ponorogo, Central Java, where the late Dr P. V. VAN STEIN CALLENFELS made excavations in 1928 several valves of *Pseudodon vondenbuschianus* were reported (VAN BENTHEM JUTTING, 1932, s.n. *zollingeri*).

A robust subspecies, *P. vondenbuschianus trinilensis* (DUBOIS), occurred in great numbers in the Pleistocene Trinil layers of Central Java (VAN BENTHEM JUTTING, 1937).

Still older is another subspecies, *P. vondenbuschianus vandervlerki* (OOSTINGH) from the Kali Glagah beds of the Bumiaju fauna (Upper Pliocene) (OOSTINGH, 1935, Wetensch. Meded. no. 26, Dienst Mijnb. Ned.-Indië, p. 164).

Genus *Rectidens* SIMPSON, 1900.

Shell elongate-oval, rounded in front, somewhat pointed behind. Striated concentrically according to the growth lines. Umbones little projecting, sculptured by some nodules and undulations. From the umbones 1 to 3 ridges diverge obliquely in backward direction, reaching almost to the posterior margin.

Dorsal and ventral sides nearly parallel, the dorsal one somewhat more arcuate. Ligament reaching about halfway the dorsal side posterior of the apex.

Muscle scars situated in the upper half of the shell, connected by a pallial line without sinus. Cardinal teeth knob-shaped to lamelliform, grooved. Lateral teeth long, smooth.

Only the animal of *Rectidens prolongatus* (DROUET) and its glochidium larva have been studied (HAAS, 1914, in: MART-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 223-224, fig. 6-7, pl. 26, fig. 4-5). Both gills on each side of the body served as a marsupium for the larvae. Of the Javanese species nothing is known of the anatomy.

Distribution: Malaya, Sumatra, Java, Borneo.

In Java only one species:

Rectidens sumatrensis (DUNKER, 1852) (fig. 4). Sundanese name: Kidjing.

1852 DUNKER, Zeitschr. f. Malak. 9, p. 52 (*Unio*).

1860 PFEIFFER, Novit. Conch. 2, p. 152, pl. 39, fig. 10-12 (*Unio*).

1867 MARTENS, Malak. Blätt. 14, p. 15 (*Unio*).

1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 308 (*Unio*).

1914 HAAS, in: MART-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 232, pl. 28, fig. 3-6.

1914 SIMPSON, Descr. Catal. Naiades, p. 1158.

1932 VAN BENTHEM JUTTING, Treubia, 14, p. 103, fig. 3, 4B and 5B.

1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 159.

Shell elongate-oval, rounded in front and somewhat pointed behind. The thickest part of the shell is in the middle or somewhat in front of it. Brownish, greenish or olive. Striated concentrically according to the growth lines. From the apex 2 to 3 keels diverge obliquely backwards.

These keels are somewhat stronger than in *Elongaria orientalis*. In old specimens they become obsolete towards the periphery.

Young shells thin and transparent, and a little shining. Older ones thicker and less transparent, and less glossy.

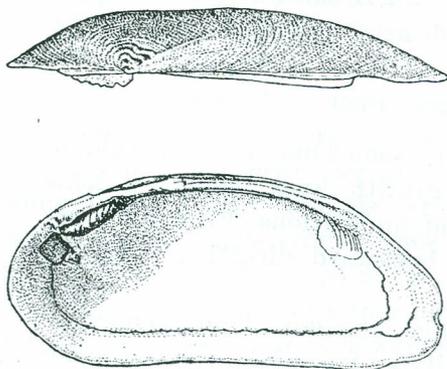


Fig. 4. *Rectidens sumatrensis* (DKR.).
Right valve from dorsal side and
from inside. Nat. size. ABDULKADIR
del.

Dorsal and ventral margins almost parallel, the dorsal one more arcuate, especially in old shells, the lower one straight or a little concave. Front margin evenly rounded, with an obtuse "nose" at the junction with the dorsal margin. Posterior margin pointed, without sharp limitations, towards dorsal and ventral sides. In exceptional cases the posterior part of the shell bends down, forming a rostrum.

Ligament reaching about midway between apex and the meeting point of dorsal and posterior margin.

Apex at $\frac{1}{5}$ to $\frac{1}{4}$ of the entire shell length. Umbones little projecting. In adult shells they are always more or less eroded. In young and fresh shells two radiating rows of each 2 to 5 nodules diverge from the apex over the umbo, forming the commencement of the two diverging ridges. Anteriorly of the nodules the apex is ornamented with an irregular pattern of several (8 to 10) oblique undulations.

Interior of the shell iridescent, the colour varying from white to pink, yellow or green. Muscle scars in the upper half of the shell. They are connected by a faint pallial line without sinus.

In the left valve there are 2 cardinals and 2 laterals, in the right one 2 cardinals and 1 lateral. All the laterals are smooth, but the cardinals are transversely or obliquely grooved.

Between the cardinals of the left valve there is not such a wide gap as in *Elongaria orientalis*. The posterior cardinal in this valve is stronger than the corresponding one in *Elongaria orientalis*. In the right valve the principal cardinal begins anteriorly of the point where apex and hinge line meet.

Dimensions: length up to 75 mm, height up to 31 mm, diam. up to 22 mm.

Distribution: Sumatra, Java.

Habitat in Java: in lakes, marshes and rivers; always in fresh water.

West Java: environs of Batavia (HAAS, 1914); Lake Leles.

Central Java: Sampung Cave near Ponorogo; River Solo, near Trinil (HAAS, 1914); River Soko, right tributary of River Solo (VAN BENTHEM JUTTING, 1937); River Sulang.

East Java: Surabaja.

HAAS (1914, p. 234) suggested that the specimens of *Unio tumidus* RETZ. published by MOUSSON (1849, Land & Süßsw. Moll. Java, p. 95) from Java might belong to *Rectidens sumatrensis* (DKR.). This opinion, however, cannot longer be maintained. A full discussion of the problem is given under "Doubtful species of Naiads".

From a prehistoric rock shelter near Ponorogo, Central Java, where the late Dr P. V. VAN STEIN CALLENFELS made excavations in 1928 a few valves of *Rectidens sumatrensis* were secured (VAN BENTHEM JUTTING, 1932).

The species also occurred in a small number in the Trinil layers (Pleistocene) of Central Java (VAN BENTHEM JUTTING, 1937).

Genus *Contradens* HAAS, 1912.

Shell irregularly oblong, rather inflated. Low and rounded in front, but with a higher, angular, hind part which is often compressed and ending beak-like. At the transition to anterior and posterior margins the dorsal side generally makes a distinct angle.

Striated according to the growth lines. Umbones inflated, with many undulations and a few stronger knobs. Ligament behind the umbo, not quite reaching the angle between dorsal and posterior sides.

Cardinal teeth short, lamelliform, grooved; lateral teeth long, smooth. Muscle scars in the upper half of the shell, connected by a pallial line without sinus.

The soft parts of *Contradens hageni* (STRUB.) and *C. verbeeki* (MARTS) were examined by HAAS (in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 173, pl. 22, fig. 6 and p. 200, fig. 2-3). The outer gills served as a marsupium. The glochidium larvae of *C. contradens* will be discussed under that species.

Distribution: Cambodia, Cochin China, Siam, Malaya, Sumatra, Java, Borneo.

In Java only one species:

Contradens contradens (LEA, 1838) (fig. 1 and 5). Sundanese name: kidjing.

1838 LEA, Trans. Americ. Philos. Soc. 6, p. 75, pl. 18, fig. 58 (*Unio*).

1840 LEA, Proc. Americ. Philos. Soc. 1, p. 285 (*Unio javanus*).

1843 LEA, Trans. Americ. Philos. Soc. 8, p. 220, pl. 18, fig. 37 (*Unio javanus*).

1846 DUNKER, Zeitschr. f. Malak. 3, p. 109 (*Unio exilis*).

1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 269 (*Unio exilis*) and p. 270 (*Unio mutatus*).

1849 MOUSSON, Land & Süßw. Moll. Java, p. 92, pl. 16, fig. 3 (*Unio exilis*) and pl. 16, fig. 1-2 (*Unio mutatus* inclus. vars. *inflatus*, *curvatus* and *obscurus*).

1850 MOUSSON, Zeitschr. f. Malak. 7, p. 46 (*Unio mutatus* = *U. javanus*).

1856 KÜSTER, in: MART-CHEMN. N. Syst. Conch. Cab. 9, Abt. II¹, p. 138, pl. 41, fig. 3 (*Unio javanus*).

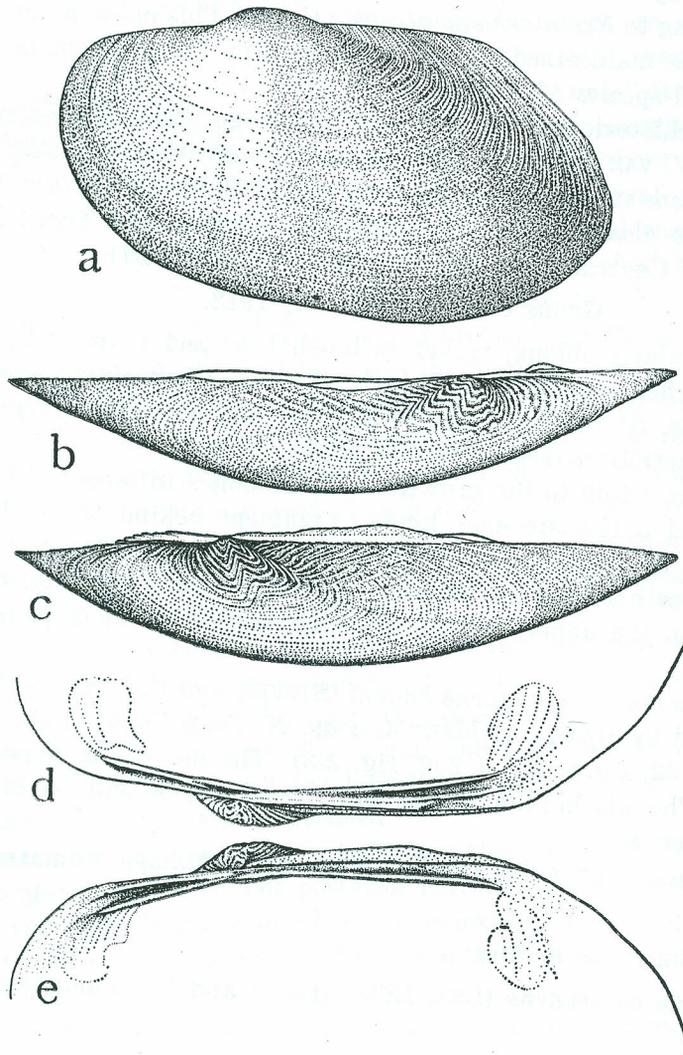


Fig. 5. *Contradens contradens* (LEA). a. exterior of left valve; b. and c. right and left valves from dorsal side; d. and e. hinge of left and right valves. All figures about nat. size. ABDULKADIR del.

- 1860 ZOLLINGER, *Natuurk. Tijdschr. Ned. Indië*, 21, p. 319 [*Unio exilis* and *U. javanus* (*mutatus*)].
- 1861 KÜSTER, in: MART.-CHEMN. *N. Syst. Conch. Cab.* 9, Abt. II¹, p. 236, pl. 79, fig. 4, 6 (*Unio javanus*) and p. 242, pl. 80, fig. 7 (*Unio mederianus*).
- 1867 MARTENS, *Malak. Blätt.* 14, p. 14 (*Unio javanus, exilis, mederianus, mutatus*).
- 1897 MARTENS, in: WEBER, *Erg. Reise Nied. Ost Indien*, 4, p. 308 (*Unio javanus, exilis, mederianus, mutatus*).
- 1913 HAAS, in: MART.-CHEMN. *N. Syst. Conch. Cab.* 9, Abt. II², p. 174, pl. 18, fig. 2-5.
- 1914 LESCHKE, *Mitt. Naturh. Mus. Hamburg*, 31, p. 266 (*Nodularia*).
- 1914 SIMPSON, *Descr. Catal. Naiades*, p. 1005 (*Nodularia*).
- 1929 VAN BENTHEM JUTTING, *Treubia*, 11, p. 87 (*Nodularia*).
- 1931 MODELL, *Trop. Binnengew.* 1, p. 680-687.
- 1932 VAN BENTHEM JUTTING, *Treubia*, 14, p. 103, fig. 1.
- 1934 RENSCH, *Trop. Binnengew.* 5, p. 248.
- 1935 PARAVICINI, *Arch. Moll. Kunde*, 67, p. 175 (*Nodularia*).
- 1937 VAN BENTHEM JUTTING, *Zool. Meded.* 20, p. 159.

Shell irregularly oblong or rhombic, rather inflated. Low and rounded in front, but with a high, angular hind part. Greatest diameter before the middle of the shell. Young shells thin and transparent, and somewhat shining. Older ones thicker and less transparent, and less glossy. Young specimens vivid bluish green, older ones more brownish or brownish-green. From the umbo to the lower posterior angle a vague dark green zone runs obliquely over the shell.

Concentrically striated according to the growth lines. Dorsal and basal margins can be more or less parallel, but generally the dorsal line goes up, forming a not very distinct "wing" behind the umbo at the point where it joins the posterior side.

In front of the umbo the dorsal line is sometimes concave and forms a nose-like angle with the anterior margin. Basal margin straight or slightly curved, passing almost imperceptibly into the front margin. The transition into the posterior margin is, on the contrary, angular.

Apex in $\frac{1}{4}$ to $\frac{1}{3}$ of the entire shell length. From the apex 2 to 3 keels run obliquely backward. The strongest one originates from a row of about 5 nodules at the apex. Umbones rather inflated, in old shells eroded, but in fresh ones elegantly sculptured by small undulations in 3 or more irregular loops. Behind the umbo the wrinkles continue in chevrons or zigzags on the posterior slope. Ligament rather strong, stretching from the apex backward, but not quite reaching the junction between dorsal and posterior margins.

Interior of the shell nacreous, the colour varying between white, pink or green, in the umbones often salmon. Muscle scars in the upper half of the shell, connected by a pallial line without sinus.

Left valve with 2 cardinals and 2 laterals. The cardinals are separate in young and semi-adult shells only; in old ones they are generally fused to one single cardinal. Right valve with 2 cardinals and 1 lateral. All laterals are smooth, all cardinals obliquely grooved.

Dimensions: length up to 76 mm, height up to 45 mm, diam. up to 29 mm.

Distribution: Java.

Habitat in Java: Lakes, ponds and rivers. Always in fresh water.

West Java: Tji Durian in North Bantam; environs of Pardana and Tjikoja (MOUSSON, 1849); river near Djakarta; beach E of harbour canal of Pasar Ikan, Djakarta; Tji Liwong (RENSCH, 1934); Bogor, pond in Botanic Gardens; Krawang (HAAS, 1913); Lasarang, between Indramaju and Kandanghaur (PARAVICINI, 1935); Palimanan, near Cheribon (PARAVICINI, 1935); Kali Paprik, near Palimanan, Kadipaten, in draining ditch, running water, Tjipelang near Udjungdjadja.

Central Java: Sampung Cave near Ponorogo; River near Kedungwuni, near Pekalongan; Wirosari, in river; River Panowan, near Rembang (VAN BENTHEM JUTTING, 1937); between Rembang and Blora; River Trinil and Rawah Wadjak (VAN BENTHEM JUTTING, 1937); River Solo, near Trinil (VAN BENTHEM JUTTING, 1937); River Soko, right tributary of River Solo, near Trinil (VAN BENTHEM JUTTING, 1937).

East Java: Ngawi; Modjokerto; near Surabaya.

Contradens contradens is very variable and no description will ever apply to all the forms of this species. MOUSSON (1849, p. 92) distinguished three forms of his *Unio mutatus*: (1) *inflatus*, with obtuse umbones, a pallid olivaceous shell, a subconcave area and almost straight lateral teeth, (2) *curvatus*, with a subcompressed, pallid olivaceous shell, a flat area and incurved lateral teeth, (3) *obscurus*, with a thick shell of transverse subelongate form and obscure olivaceous shell, with a flat area and nearly incurved lateral teeth. It is easy to see that these forms are very unimportant from a taxonomic point of view, and that all fall under the variation range of the polymorphic *Contradens contradens*.

From a prehistoric cave near Ponorogo, Central Java, where the late Dr P. V. VAN STEIN CALLENFELS made excavations in 1928 a few valves of *Contradens contradens* were secured (VAN BENTHEM JUTTING, 1932).

Most of the specimens of which I could examine the soft parts were either males or spent females. Only one female (length of shell 64 mm, height 34 mm, diam. 22 mm) from the big pond in the Botanic Gardens at Bogor, collected August 6, 1926, by Miss Dr A. G. VORSTMAN, was gravid, containing numerous glochidia in both outer gills.

The glochidia were about 0.2 mm long, irregularly oval. The side along which its two valves articulate is indicated in fig. 6 by two arrows. Both valves are minutely perforated. Evidently the glochidia were not yet ripe for spawning; this may explain why a larval thread, or hook-shaped teeth along the free margins of the valves could not be discerned.

As was already mentioned in the introduction of the family Unionidae, *Contradens contradens* can act as an intermediate host of a fluke infection.

Genus *Elongaria* HAAS, 1912.

Shell elongate-oval, rounded in front, somewhat pointed behind. Epidermis greenish, brownish or blackish.

Striated concentrically according to the growth lines. Umbones little or not projecting, with a few irregular nodules and undulations.

Dorsal and ventral sides almost parallel, the dorsal one somewhat arcuate, the basal one straight or a little concave. Ligament reaching about half way between the apex and the point where dorsal and posterior margins meet.

Cardinal teeth short, lamelliform, grooved. Lateral teeth long, smooth. Muscle scars in the upper half of the shell, connected by a pallial line without sinus.

Of the soft parts nothing is known.

Distribution: Java, Borneo.

In Java only one species:

Elongaria orientalis (LEA, 1840) (fig. 7).

- 1840 LEA, Proc. Americ. Philos. Soc. 1, p. 285 (*Unio*).
 1843 LEA, Trans. Americ. Philos. Soc. 8, p. 221, pl. 18, fig. 38 (*Unio*).
 1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 270 (*Unio productus*).
 1849 MOUSSON, Land & Süßw. Moll. Java, p. 93, pl. 17, fig. 3-5 (*Unio productus* inclus. vars. *normalis*, *fragilis* and *arcuatus*).
 1850 MOUSSON, Zeitschr. f. Malak. 7, p. 46 (*Unio productus* = *U. orientalis*).
 1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 [*Unio orientalis* (*productus*)].
 1861 KÜSTER, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II¹, p. 241, pl. 80, fig. 6 (*Unio*).
 1867 MARTENS, Malak. Blätt. 14, p. 15 (*Unio*), p. 16 (*Unio productior*).
 1893 KOBELT, Nachr. Blatt, 25, p. 152 (*Unio bithynicus*).
 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 308 (*Unio orientalis* and *U. productior*).

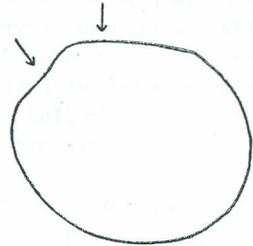


Fig. 6. *Contradens contradens* (LEA). Glochidium larva. Length about 2 mm. The region where the two valves articulate lies between the two arrows. Author del.

- 1912 HAAS, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 168, pl. 17, fig. 3-5.
 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 267 (*Nodularia*).
 1914 SIMPSON, Descr. Catal. Naiades, p. 1162 (*Rectidens*).
 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 87 (*Nodularia*).
 1932 VAN BENTHEM JUTTING, Treubia, 14, p. 103, fig. 2, 4A and 5A.
 1935 PARAVICINI, Arch. Moll. Kunde, 67, p. 175 (*Nodularia*).
 1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 159.
 1940 HAAS, Field Mus. Nat. Hist. (Zool. Ser.) 24, p. 141 (*Unio bythinicus* (sic!) KOBELT = *Elongaria orientalis* LEA).

Shell elongate-oval, rounded in front, somewhat pointed behind. Young specimens vivid bluish-green, older ones brownish-green to brown, sometimes with green and brown zones alternating.

Striated concentrically according to the growth lines. The greatest diameter lies in the middle of the shell, anteriorly of it there is generally a shallow concavity in the flanks. From the apex 2 to 3 keels diverge obliquely backwards. On the whole they are weaker and fade away earlier than in *Rectidens sumatrensis*.

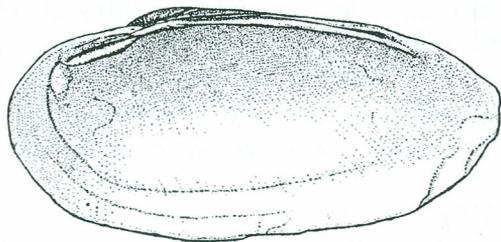
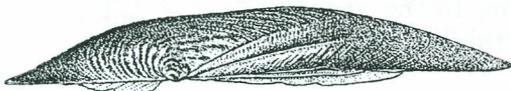


Fig. 7. *Elongaria orientalis* (LEA). Right valve from dorsal side and from inside. Nat. size. ABDULKADIR del.

Young shells thin and transparent, and a little shining. Older ones thicker, less transparent and less glossy. Epidermis greenish-brown, fibrous.

Dorsal and ventral margins almost parallel, the dorsal one more arcuate, especially in old shells, the lower one straight or a little concave. Front margin evenly rounded with an

obtuse nose-shaped angle at the junction with the dorsal margin. This "nose" is especially conspicuous in young individuals. Posterior margin pointed, without sharp limitations towards dorsal and ventral sides. Rather frequently (more often than in *Rectidens sumatrensis*) the posterior part of the shell is bent downwards, forming a rostrum.

Ligament reaching about midway between the apex and the meeting point of dorsal and posterior margins. Apex at $\frac{1}{5}$ to $\frac{1}{4}$ of the entire shell length. Umbones little projecting, in adult shells nearly always eroded. In young and fresh shell with a few (2 to 5) irregular nodules forming the commencement of the two dorsal diverging ridges. The umbonal

sculpture is less developed than in *Rectidens sumatrensis*, but the valves are not smooth, as HAAS (1912) stated.

Interior of the shell iridescent, varying between white, pink, yellow and green. Muscle scars in the upper half of the shell. They are connected by a little impressed pallial line without sinus.

In the left valve there are 2 cardinals and 2 laterals, in the right one 2 cardinals and 1 lateral. All the laterals are smooth, but the cardinals are transversely or obliquely grooved. Between the two cardinals of the left valve there is a distinct interruption (more distinct than in *Rectidens sumatrensis*). The posterior cardinal in this valve is weaker and more elongate than the corresponding tooth in *Rectidens sumatrensis*. In the right valve the principal cardinal originates at the point where apex and hinge line meet.

Dimensions: length up to 75 mm, height up to 31 mm, diam. up to 21 mm.

Distribution: Java, Madura.

Habitat in Java: in lakes and rivers; always in fresh water.

West Java: Pardana, in Bantam (MOUSSON, 1849); environs of Djakarta (VAN BENTHEM JUTTING, 1937); Krawang; Palimanan, near Cheribon; Tji Mandiri, near Pelabuanratu (PARAVICINI, 1935).

Central Java: Sampung Cave, near Ponorogo; River Trinil and marsh Wadjak (VAN BENTHEM JUTTING, 1937); River Solo, near Trinil (VAN BENTHEM JUTTING, 1937); River Soko, right tributary of River Solo, near Trinil (VAN BENTHEM JUTTING, 1937).

East Java: Ngawi; Wlingi; along dike of a waduk near Sumber Kepu, NNW of Kertosono; Modjokerto (MARTENS, 1867); near Surabaya; Lake Segaran, near Probolinggo (MOUSSON, 1849); Rogodjampi (HAAS, 1912); Banjuwangi.

Of this species MOUSSON (1849, p. 93) distinguished three "varieties": (1) *normalis*, a large, thick shell with a straight base, distinctly striated, and of an obscure brownish-green colour; (2) *fragilis*, a small, thin shell with weak striation and a pallid brownish-green colour, with small rugosities on the umbo, and (3) *arcuatus*, a small thin shell with weak striation, with a concave lower margin and an arcuate dorsal side, the basal angle being produced posteriorly.

It is evident from the diagnosis that the second form is only a juvenile stage of the normal one (see also MOUSSON's pl. 17, fig. 5). In the MOUSSON collection there are three samples of this form with resp. 1, 1 and 2 individuals, all from Java (without further comment). The largest shell is long 48, high 22 and thick 14 mm.

The last named variety is the rostrate form, a modification which is common in various species of Naiads. It is remarkable that MOUSSON described it as a small stunted form (length 51, height 21.5, diam. 15 mm), whereas the rostration is equally developed in old specimens. In his collection MOUSSON had much larger examples of this modification, even up to 71 mm length.

In my opinion the "varieties" *normalis* and *fragilis* are absolute synonyms of *Elongaria orientalis*. Only the "variety" *arcuata* could eventually be maintained as forma *arcuata*.

The *normalis* form and the *arcuata* form must be understood as adaptations to different ecological conditions, as so-called "Reaktionsformen", a kind of extremely labile modification induced by factors of the milieu and with only phaenotypical significance.

Most Naiads possess short siphons, and in agitated water they have to compensate for the trouble of being embedded through sand transport by elongating the posterior part of the body and the shell. This leads to the remarkable rostrate, stunted modification as described above.

From a rock shelter near Ponorogo, Central Java, where the late Dr P. V. VAN STEIN CALLENFELS made excavations in 1928 many valves of *Elongaria orientalis* were reported (VAN BENTHEM JUTTING, 1932).

The same species occurred in great numbers in the Trinil layers (Pleistocene) of Central Java (VAN BENTHEM JUTTING, 1937). Still older are the shells recorded by OOSTINGH from the Kali Glagah beds of the Bumiaju Fauna (1935, Wetensch. Meded. no. 26, Dienst Mijnbouw Ned. Indië, p. 162). This formation is considered to be of Upper Pliocene age.

Genus *Pilsbryconcha* SIMPSON, 1900.

Shell oval, elliptical or elongate, compressed, rounded in front, angular behind. Dorsal and ventral margins almost parallel or slightly diverging.

Umbones little projecting with low concentric folds. Hinge line straight, without teeth or with an obsolete tooth in front of the apex. Ligament long and narrow. Interior nacreous with bluish-white to greenish lustre. Muscle scars and pallial lines little impressed, hardly palpable.

Of the soft parts almost nothing is known. Still less are we informed on the functions of the animals, as breathing, feeding, reproduction, sense perceptions etc.

Distribution: Annam, Cambodia, Cochin China, Siam, Sumatra, Borneo, Java.

In Java there is only one species:

***Pilsbryconcha exilis* (LEA, 1839) (fig. 8). Native name: Keong tutut.**

- 1839 LEA, Trans Americ. Philos. Soc. 6, p. 81, pl. 22, fig. 68 (*Anodonta*).
 1849 MOUSSON, Land & Süßw. Moll. Java, p. 98, pl. 19, fig. 2, 3 (*Anodonta polita*).
 1850 MOUSSON, Zeitschr. f. Malak. 7, p. 46 (*Anodonta polita — exilis*).
 1860 ZOLLINGER, Naturk. Tijdschr. Ned. Indië, 21, p. 319 [*Anodonta exilis (polita)*].
 1867 MARTENS, Malak. Blätt. 14, p. 12 (*Anodonta*).
 1875 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. I¹, p. 171, pl. 56, fig. 7-8 (*Anodonta*).
 1890 BOETTGER, Ber. Senckenb. naturf. Ges. p. 163 (*Anodonta polita*).
 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 308 (*Anodonta*).
 1914 HAAS, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 296, pl. 36, fig. 3-4, pl. 37, fig. 1-3.
 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 266.
 1914 SIMPSON, Descr. Catal. Naiades, p. 241.
 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 87.
 1935 PARAVICINI, Arch. Moll. Kunde, 67, p. 175.
 1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 159.

Shell elongate-oval to tongue-shaped. Much compressed laterally. Rounded in front, angular or pointed behind. Yellowish-brown or greenish-brown, thin and transparent, in fresh specimens somewhat glossy. Epidermis fibrous on front and hind parts, more smooth in the central part of the shell.

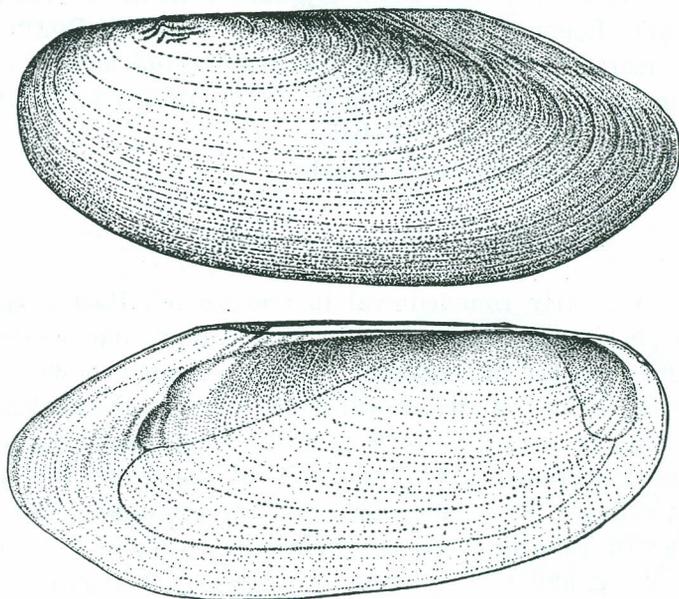


Fig. 8. *Pilsbryconcha exilis* (LEA). Exterior and interior of left valve. Somewhat reduced. ABDULKADIR del.

Dorsal and ventral margins almost parallel or slightly diverging. Along the dorsal side the two valves are much compressed. Ventral margin merging into the posterior one almost imperceptibly. The transition of the dorsal margin to the posterior one is generally marked by a more or less oblique angle. Apex at $\frac{1}{5}$ to $\frac{1}{4}$ of the total shell length.

Umbones almost flat or very little projecting. In adult shells generally eroded, in fresh and young shells they are plicated near the apex with a few coarse, concentric, slightly double looped undulations. Ligament long and narrow, reaching from the apex to the angle separating dorsal and posterior sides.

Interior smooth and beautifully iridescent. Muscle scars in the upper half of the shell. Pallial line not sinuous.

There are no hinge teeth. A low crest of shell substance runs parallel to the ligament and serves as its support.

Dimensions: length up to 108 mm, height up to 48 mm, diam. up to 23 mm.

Distribution: Siam, Cambodia, Cochin China, Sumatra, Borneo, Java.

Habitat in Java: In lakes, marshes and rivers, always in fresh water.

West Java: Tji Durian in N. Bantam; environs of Djakarta (MARTENS, 1867); Antjol, near Djakarta; from a marsh near Djakarta; beach E of harbour canal of Pasar Ikan, Djakarta; Lenteng Agung, between Djakarta and Bogor; Bekasi River, near Bekasi (BOETTGER, 1890); Tjitarum, near Krawang; Lasarang, between Indramaju and Karang-haur; Palimanan, near Cheribon (PARAVICINI, 1935); Lake Leles.

Central Java: Brebes, in Pekalongan.

East Java: Kali Mas, near Surabaya.

Genus *Physunio* SIMPSON, 1900.

Shell irregularly rounded-oval to trapezoidal. Rather low in front, but higher behind the umbones, forming a wing-like angle where the dorsal margin touches the posterior side. Epidermis yellowish or greenish.

Umbonal region inflated, towards the margins the shell is more compressed. Umbones with a pattern of nodules and undulations. This sculpture is generally eroded in adult shells. From the umbo one or more faint ridges run obliquely back- and downwards to the lower posterior margin.

Hinge with 2 cardinals (in adult shells often coalescent) and 2 laterals in the left valve, and 1 cardinal and 1 lateral in the right valve. In adult shells an auxiliary lateral lamella can be present above the others in both valves.

Of the anatomy very little is known. Only the Siamese species *Physunio gravidus* (LEA) was examined by HAAS (1914, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 275, fig. 12-13). Of the Javanese species no soft parts were available.

Distribution: Assam, Cambodia, Cochin China, Siam, Sumatra, Java.

In Java only one species:

***Physunio eximius* (LEA, 1856) (fig. 9).**

1856 LEA, Proc. Acad. Nat. Sci. Philadelphia, 8, p. 93 (*Unio*).

1858 LEA, Journ. Acad. Nat. Sci. Philadelphia, 3, p. 294, pl. 25, fig. 8 (*Unio*).

1914 HAAS, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. II², p. 285, pl. 34, fig. 6-8.

1914 SIMPSON, Descr. Catal. Naiades, p. 1067.

1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 160.

Shell irregularly oblong, or trapezoidal, with low front part, but higher, even wing-like, behind the umbones. Central part of the shell rather inflated, towards the margins more compressed. Apex in about $\frac{1}{3}$ to $\frac{1}{4}$ of the shell length.

Light brown to greenish, with a darker brown to brownish-black periostracum. From the top to the posterior side 2 to 3 greenish rays diverge to the posterior slope. The lowermost ray in some specimens coincides with a faint keel or ridge. Growth lines coarse and irregular, hence the exterior of the shell is uneven and fibrous. Young shells thin and transparent, old ones thicker and less transparent.

Dorsal side in front of the apex straight or somewhat concave, making a more or less distinct angle with the anterior side. Behind the apex the dorsal side goes up obliquely forming a distinct "wing" with the posterior side. Basal margin rounded; in

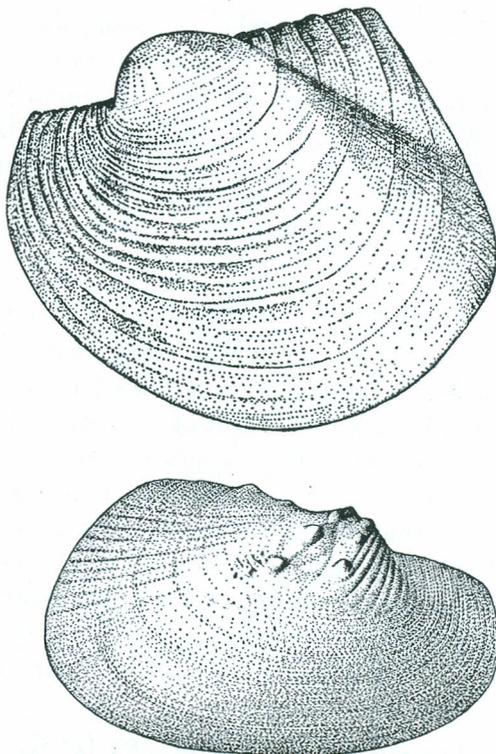


Fig. 9. *Physunio eximius* (LEA). Left valve of adult shell. Author del. Right valve of juvenile shell. Both figures about nat. size. ABDULKADIR del.

old and stretched shells straight, or even a little concave. Anterior margin evenly rounded, posterior one rather steep.

Umbones in young specimens with two radiating rows of 3 to 4 coarse nodules. Anteriorly and posteriorly of these each valve has a few undulating ridges radiating from the apex. Ligament long and narrow, stretching from the apex to the wing between dorsal and posterior margins. The ligament is supported by a narrow ridge.

Interior nacreous, white to bluish white. Muscle scars shallow, lying in the upper half of the shell. They are connected by a pallial line without sinus.

Left valve with two cardinals, almost in one line with each other and mostly fused to one ridge in adult specimens. Behind the apex the left valve possesses two laterals. Right valve with two cardinals and two laterals. The superior lateral in this valve is much weaker than the lower one.

Dimensions: length up to 78 mm, height up to 52 mm, diam. up to 43 mm.

Distribution: Cambodia, Siam, Java.

Habitat in Java: *Physunio eximius* was found in rivers. There is no other information of the relevant quality of its habitat.

West Java: environs of Djakarta (HAAS, 1914).

Central Java: Sonde to Padas Malang, near Trinil; River Bengawan, near Trinil; River Soko, right tributary of River Solo; near Trinil (VAN BENTHEM JUTTING, 1937).

Doubtful species of *Unionidae*.

Unio dimotus LEA was mentioned by MARTENS (1897, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 308) from Java. It is, however, not a Javanese species, but an inhabitant of Sumatra. MODELL (1931, Trop. Binnengew. 1, p. 682) considers it as a subspecies of *Contradens ascia* (HANLEY).

As *Contradens ascia dimotus* has never been found in Java again, it is possible that either MARTENS had a shell from Sumatra before him which had been erroneously labelled "Java", or — as seems more probable — that he mistook a specimen of the polymorph Javanese species *Contradens contradens* for a shell of *C. dimotus*, the two species being so closely related that it is often difficult to separate them.

The species which SOWERBY (1867, in: REEVE, Conch. Icon. 17, pl. 11, fig. 33) described as *Anodon Javona* is presumably *Pilsbryoconcha exilis*, as HAAS (1914) suggested in his monograph in the Conchylien Cabinet.

The figure of SOWERBY agrees very well with the Javanese species, but in his description he gave "Japan" as a habitat. Could this confusion be inspired by the printer's error "Javona" which could stand for either "Javana" or "Japona"?

The shell which MOUSSON (1848, Mitt. naturf. Ges. Zürich, 1, p. 269 and 1849, Land & Süßsw. Moll. Java, p. 95, pl. 17, fig. 1, afterwards quoted by ZOLLINGER, 1860, Naturk. Tijdschr. Ned. Indië, 21, p. 319) mentioned and figured as *Unio tumidus* RETZ. is undoubtedly a representative of this European species. The entire form and texture, the muscle scars, the hinge teeth and the double-looped umbonal sculpture all point to this conclusion. The supposition of HAAS (1914, in: MART.-CHEMN. N. Syst. Conch. Cab. Bd. IX, Abt. II², p. 234), afterwards repeated by me (1937, Zool. Meded. 20, p. 58 footnote) that the shell might represent *Rectidens sumatrensis* (DKR) can therefore be abandoned.

Although MOUSSON mentioned "mehrere Exemplare" (several specimens) there are only two shells in his collection in Zürich. Their dimensions are: length 84, 82 mm, height 42, 40 mm, diam. 29, 28 mm.

MOUSSON's confidence in the trustworthiness of his correspondent ZOLLINGER was so strong that he blindly adopted ZOLLINGER's presumption that the mussels came from Java. In my opinion, however, there must have slipped in a mistake in the labelling of the locality and we must once and for all expunge MOUSSON's *Unio tumidus* from the fauna of Java.

It is curious that some notion of doubt had entered MOUSSON's mind in later years when compiling the catalogue of his collection in 1889 (40 years after the publication of his book!). This doubt was not directed towards the locality, but towards the specific name. He doggedly kept to the erroneous habitat "Java", but on the label he changed the specific name in *U. subtumidus* MSS. As this is only a collection name it has no further consequences in nomenclature.

Another uncertain species mentioned by MOUSSON in 1848 and 1849 is his *Unio ligula* (see also MARTENS, 1867, Malak. Blätt. 14, p. 14).

Fortunately the shell is still present in the MOUSSON collection so that I can now give an opinion on its affinities. The measurements are length 54, height 27.5 (not 37.5 as MOUSSON mentioned p. 94) and diam. 15.5 mm. It is accompanied by a label scribbled by CHARPENTIER: "U. marginalis Lam., reçu pour tel du Musée de Vienne; c'est probablement une variété de votre modiolaeformis? Java. Rapporté par HÜGEL".

As MOUSSON had already suggested, the shell is without doubt a semiadult shell of *Lamellidens marginalis* (LAM.), a species inhabiting India, but not Java. Some erroneous labelling must have caused the confusion.

Hence *Unio ligula* MOUSSON has to be expelled from the fauna of Java also.

The third problematic species mentioned by MOUSSON in 1848 and 1849 is *Unio evanescens* MOUSSON (afterwards quoted by ZOLLINGER, 1860, *Natuurk. Tijdschr. Ned. Indië*, 21, p. 319 from Java; by MARTENS, 1867, *Malak. Blätt.* 14, p. 14 from Surabaya; by MARTENS, 1897, in: WEBER, *Erg. Reise Nied. Ost Indien*, 4, p. 308 from Java and by LESCHKE, 1914, *Mitt. naturh. Mus. Hamburg*, 31, p. 267 from Java and Surabaya).

I could compare the two specimens (in his book, 1849, MOUSSON referred only to one specimen) in the MOUSSON collection at Zürich. Their dimensions are length 72, 65 mm, height 38, 35 mm, diam. 25, 22 mm. The larger one was figured in MOUSSON's book pl. 17 (not pl. 10!), fig. 2. The umbones are somewhat inflated, the umbonal sculpture consists of long, undulating ridges.

In the catalogue of his collection which was compiled in 1889 (40 years after his book!) MOUSSON added an ? to the locality Java. From the label in the box we can also conclude that he had changed his mind as it has: "U. marginalis Lam. (evanescens Mss) Java (Zolling 46)."

In my opinion the two shells are unmistakably *Lamellidens marginalis* (LAM.), a species not native in Java, but in India. Therefore some regrettable confusion in the labelling must have slipped in, and we must definitely exclude *Unio evanescens* from the fauna of Java.

The shell which PARAVICINI (1935, *Arch. Moll. Kunde*, 67, p. 175) recorded as *Lamellidens evanescens* MOUSS. from Palimanan, near Cheribon, and which is now preserved in the Basle Museum of Natural History (length 64, height 33, diam. 27 mm) is, in my opinion, *Elongaria orientalis* (LEA).

In spite of intensive searching in the MOUSSON collection I have not been able to discover *Margaritana fragilis* MOUSSON, mentioned in 1849 (*Zeitschr. f. Malak.* 6, p. 186) from Java and not published anywhere later. From the description one might conclude that it is a form of *Pseudodon vondenbuschianus*, but for the present it remains a myth.

Familia CORBICULIDAE

Shell small (genus *Corbicula*) or large (genera *Polymesoda* and *Batissa*), rounded-triangular to oval, strong. Exteriorly greenish-brown

or yellowish-brown (*Polymesoda* and *Corbicula*) or blackish (*Batissa*) by the strong, somewhat fibrous periostracum. Concentrically striated or ribbed. Interior white, pink or violet.

Hinge with three cardinal teeth in each valve, and one or two laterals before and behind the umbo. In *Batissa* and *Corbicula* the lateral teeth are transversely grooved, in *Polymesoda* they are smooth.

The two adductor muscles are connected by a pallial line with a shallow sinus, or without sinus. Ligament strong, exterior.

Animal with strong foot. Mantle closed on the dorsal side and in the posterior part where it forms two siphonal openings. The basal side of the mantle is open.

Siphonal openings not, or little prolonged into tubes. There are two pairs of gills, the outer pair is smaller than the inner one.

Of the reproduction very little is known; only in *Corbicula* some observations have been made. They will be discussed when dealing with this genus.

Distribution: tropical and subtropical regions of all continents. In fresh and brackish water. In Java the genera *Polymesoda* and *Batissa* inhabit fresh and brackish water. *Corbicula* is more restricted to fresh water habitats, although it can stand a slight amount of salt water without difficulty.

Key to the genera living in Java:

1. Shell large, more than 5 cm length 2.
- Shell small, under 5 cm length **Corbicula**
2. Lateral teeth transversely grooved, umbonal region little inflated **Batissa**
- Lateral teeth smooth, umbonal region much inflated . . **Polymesoda**

Genus **Polymesoda** RAFINESQUE, 1820.

Shell large, strong and inflated; orbicular to irregularly oval, concentrically striated or even irregularly ribbed. Covered by a yellowish-green or greenish-brown periostracum which is fibrous and deciduous. In some species one or two faint keels arch obliquely backwards over the shell from the umbo to the lower posterior part. Not transparent and without lustre. Umbonal region generally inflated, apices in the groove between the umbones.

In front of the umbones the dorsal side is straight and falls down quickly; behind the umbones it is more or less convex, curving down gradually. Anterior side evenly rounded. Posterior side rounded or rostrated, or obtusely angular. Base rounded. Ligament exterior, strong.

Interior white, chalky or somewhat porcelainous, but never so shining as in *Batissa* or *Corbicula*. Adductor muscle scars connected by a pallial line with shallow sinus, or with a narrow, tongue-shaped sinus.

Hinge with three diverging cardinals in each valve. The cardinals are occasionally bifid. Lateral teeth lamelliform; in the left valve one lateral before and behind the umbo; in the right valve there are two before and behind the umbo. All laterals are smooth (fig. 12).

Animal with short siphons and strong foot. Mantle closed on the dorsal side and on the posterior side, leaving only the siphonal openings free. The ventral side of the mantle is open. There are two gills on either side of the body; the innermost gills are broader and longer than the exterior ones.

Distribution: tropical and subtropical regions of America, Asia, North Australia and in various Pacific islands. In fresh and brackish water in the lowlands.

The genus has been recorded from tertiary layers in the Greater Sunda Islands (VAN DER VLERK, 1931, Leidsche Geol. Meded. 5, Feestbundel MARTIN, p. 281; OOSTINGH, 1935, Wetensch. Meded. no. 26, Dienst Mijnb. Ned. Indië, p. 168; VAN BENTHEM JUTTING, 1937, Zool. Meded. 20, p. 141).

The taxonomy of the species of *Polymesoda*, at least of the Oriental ones, is in a state of tremendous confusion. In this region there is an almost infinite diversity of "forms", causing contradictory identifications and the creation of new names based on unstable characters. Nobody has a satisfactory notion of the anatomical relationship of the various forms, and not either of the responses of the shells at different growth stages to environmental effects.

Consequently the classification of the Javanese *Polymesoda* as will be attempted below, is a questionable one, quite unsatisfactory for the authoress who realizes that the results are deficient, and equally confusing for the naturalist who tries to identify his specimens.

Parting from the material three different species can be distinguished in Java:

1. Shell orbicular, or nearly so 2.
- Shell with distinct posterior prolongation, almost rostrate. **expansa**
2. Umbo much inflated and incurved to anterior side. From umbo to postero-ventral side a distinct groove over the shell . . **bengalensis**
- Umbo little inflated and not so incurved to anterior side. No groove from umbo to postero-ventral side **erosa**

***Polymesoda bengalensis* (LAMARCK, 1818) (fig. 10).**

- 1818 LAMARCK, *Hist. Nat. Anim. s. Vert.* 5, p. 554 (sign. 36) (*Cyrena*).
 1852 DUNKER, *Zeitschr. f. Malak.* 9, p. 51 (*Cyrena eximia*).
 1854a DESHAYES, *Proc. Zool. Soc. London*, p. 18 (*Cyrena impressa* and *C. sinuosa*).
 1854b DESHAYES, *Catal. Brit. Mus. Conch.* II, p. 235 (*Cyrena eximia*), p. 249 (*Cyrena impressa*).
 1857 PFEIFFER, *Novit. Conch.* 1, p. 88, pl. 24 (*Cyrena eximia*).
 1876 SOWERBY, in: REEVE, *Conch. Icon.* 20, pl. 7, fig. 23 (*Cyrena*).
 1879 CLESSIN, in: MART.-CHEMN. *N. Syst. Conch. Cab.* 9, Abt. III, p. 107, pl. 13, fig. 1-2, pl. 17, fig. 4, 6 (*Cyrena bengalensis*), p. 228, pl. 45, fig. 1 (*Cyrena sinuosa*), p. 235 (*Cyrena eximia*).
 1897 MARTENS, in: WEBER, *Erg. Reise Nied. Ost Indien*, 4, p. 93 (*Cyrena impressa*), p. 98 (*Cyrena eximia*).
 1914 LESCHKE, *Mitt. naturh. Mus. Hamburg*, 31, p. 267-268 (*Cyrena eximia, impressa, sinuosa*).
 1929 VAN BENTHEM JUTTING, *Treubia*, 11, p. 87 (*Cyrena eximia*), p. 88 (*Cyrena impressa* and *C. sinuosa*).
 1932 PRASHAD, *Siboga Exp. Monogr.* 53-c, p. 175 (*Geloina*).
 1941 VAN BENTHEM JUTTING, *Arch. néerl. Zool.* 5, p. 321 (*Polymesoda eximia*).

Shell almost orbicular, white, under a yellowish-brown, fibrous epidermis which easily peels off. The shell is concentrically striated; occasionally the striae become somewhat rib-like on the anterior side. Little shining, not transparent. Ligament exterior strong.

Umbones large and inflated, much incurved. Apices in the groove between the umbones. Dorsal margin in front of the umbo straight, behind

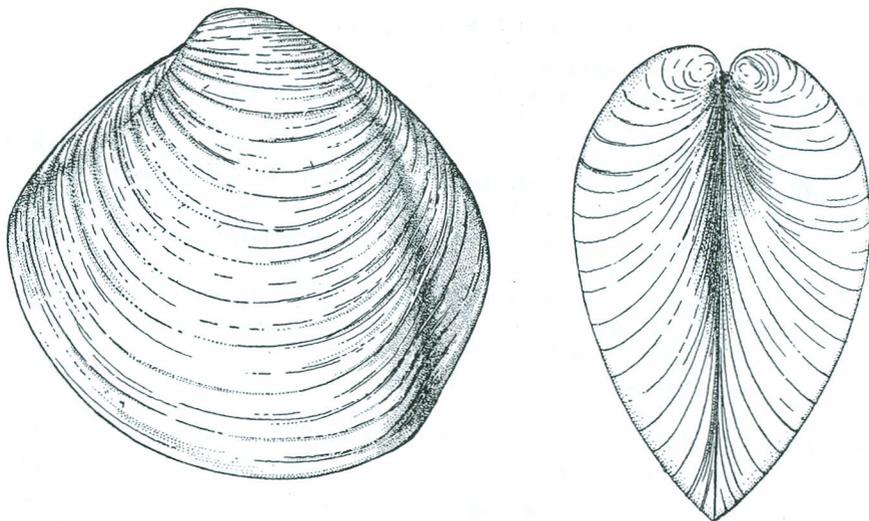


Fig. 10. *Polymesoda bengalensis* (LAM.). Left valve, and closed shell from anterior side. Slightly reduced. J. MASTRO del.

it slightly convex. Anterior margin rounded. Posterior margin obtuse, angular at the transition to dorsal and basal margin. Basal margin rounded. From the umbones a distinct groove stretches obliquely along the postero-dorsal side of each valve to the angle where basal and posterior margins meet.

Interior of shell white, chalky or porcelainous. Adductor muscle scars connected by a pallial line with shallow sinus. Hinge teeth strong. The central and posterior cardinals of the right valve, and the central and anterior cardinals of the left valve are bifid. Laterals not serrated.

Nothing is known of the anatomy or physiology of this species.

Dimensions: length up to 85 mm, height up to 85 mm, diam. up to 52 mm.

Distribution: India, various islands of the Malay Archipelago, including Java and some islands in the Bay of Djakarta: Amsterdam, Rotterdam and Middelburg Islands. Also Nusa Kambangan and Celebes.

No complete account of the distribution can be given before the taxonomic confusion of *Polymesoda* in the Oriental region has been elucidated.

Habitat in Java: The few records which we have, correspond to localities with fresh water.

West Java: River Panimbang, near Pardana, Bantam (DESHAYES, 1854a).

Central Java: River Progo, near Magelang (DESHAYES, 1854b).

Polymesoda erosa (SOLANDER, 1786) (fig. 11).

- 1786 SOLANDER, Portland Catalogue, p. 71, 186 (*Venus*).
 1818 LAMARCK, Hist. Nat. Anim. s. Vert. 5, p. 554 (sign. 36) (*Cyrena zeylanica*).
 1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 269 (*Cyrena ceylonica*).
 1849 MOUSSON, Land & Süßw. Moll. Java, p. 89, pl. 13 (*Cyrena ceylonica* var. *major*).
 1860 ZOLLINGER, Naturk. Tijdschr. Ned. Indië, 21, p. 319 (*Cyrena ceylonica*).
 1876 SOWERBY, in: REEVE, Conch. Icon. Vol. 20, pl. 19, fig. 111 (*Cyrena ceylonica*).
 1879 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 102, pl. 17, fig. 1, 2, pl. 18, fig. 1, 2 (*Cyrena ceylonica*).
 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 94 (*Cyrena moussoni*).
 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 268 (*Cyrena moussoni*).
 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 88 (*Cyrena moussoni*).
 1932 PRASHAD, Siboga Exp. Monogr. 53-c, p. 174 (*Geloina*).

Shell almost orbicular, white under a yellowish-green periostracum which becomes more brownish towards the margin. This periostracum is fibrous and easily peels off. The shell is concentrically striated. Towards the base the striae are coarser, somewhat rib-like. The entire shell is little shining and not transparent.

Umboes moderately inflated, less inflated than in *Polymesoda bengalensis*. Ligament exterior, strong.

Dorsal margin in front of the umbo straight; behind it slightly convex. Anterior margin rounded; posterior margin rounded or obtuse. Basal margin rounded. The distinct oblique postero-dorsal groove of *P. bengalensis* is generally missing in *P. erosa*. Yet a faint, hardly palpable, depression may occur in old shells.

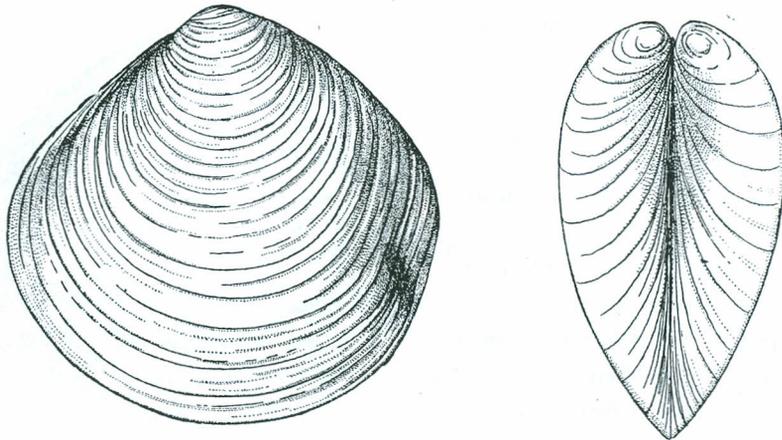


Fig. 11. *Polymesoda eximia* (SOL.). Left valve, and closed shell from anterior side. Slightly reduced. J. MASTRO del.

Interior of the shell white, chalky or porcelainous. Scars of the adductor muscles connected by a pallial line with shallow sinus. Hinge teeth strong. The central and posterior cardinals of the right valve, and the central and anterior cardinals of the left valve are bifid. All the laterals are smooth.

Of anatomy and functions no more is known than the characters mentioned under the genus.

Distribution: various islands of the Malay Archipelago including the Philippines and New Guinea; in fresh and brackish water.

The confusion with other species renders the preparing of an exact account of the distribution impossible.

Dimensions: length up to 75 mm, height up to 75 mm, diam. up to 40 mm.

Habitat in Java: in rivers and estuaries.

West Java: Panimbang River near Pardana (MOUSSON, 1849); Tjiandjur and Tjikalong (MARTENS, 1897).

Central Java: Kedungwuni, near Pekalongan; Tjilatjap.
East Java: Kali Wlingi, SE Kediri.

***Polymesoda expansa* (MOUSSON, 1849) (fig. 12).**

- 1849 MOUSSON, Land & Süßw. Moll. Java, p. 89, pl. 14 (*Cyrena*).
1854 DESHAYES, Catal. Conch. Brit. Mus. II, p. 243 (*Cyrena*).
1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 (*Cyrena*).
1879 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 105, pl. 15, fig. 1, 2 (*Cyrena*).
1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 95 (*Cyrena*).
1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 268 (*Cyrena*).
1929 VAN BENTHEM JUTTING, Treubia, 11, p. 87 (*Cyrena*).
1932 PRASHAD, Siboga Exped. Monogr. 53-c, p. 176 (*Geloima*).

Shell rotund-oval, with conspicuous posterior prolongation. White, under a fibrous, light yellowish-green or straw-coloured epidermis, somewhat darker to the anterior and posterior margins. The shell is concentrically striated, little shining and not transparent. Ligament exterior, strong.

Umboes moderately inflated. Dorsal margin in front of the umbo straight, behind it also straight or slightly convex. Anterior margin rounded. Posterior margin obtuse and indistinctly angular at the transition to the dorsal and basal margins. Basal margin rounded, generally somewhat flexuous at the point where a shell fold from the umbo to the base reaches the basal margin. This fold is not homologous with the groove in *Polymesoda bengalensis*.

Interior of shell white, chalky or porcelainous. Scars of adductor muscles connected by a pallial line with a shallow sinus. Hinge teeth well

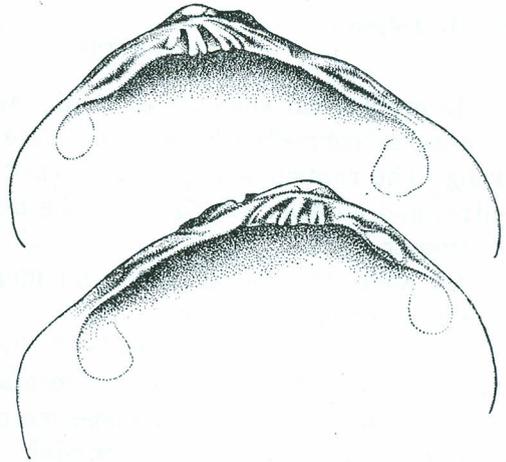
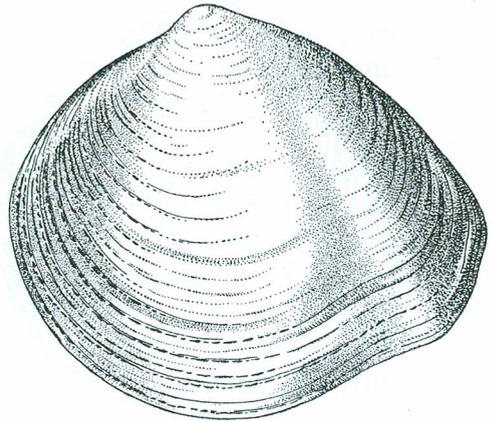


Fig. 12. *Polymesoda expansa* (MOUSS.). Exterior of left valve. Hinge of right and left valves. Slightly reduced. J. MASTRO del.

developed, but less strong than in the two other Javanese species. The middle and posterior cardinals of the right valve, and the middle and anterior cardinals of the left valve are bifid. All the laterals are smooth.

No data are available on the anatomy of the soft parts and on the functions of the animal.

Dimensions: length up to 100 mm, height up to 100 mm, diam. up to 60 mm.

Distribution: various islands in the Malay Archipelago, Sumatra, Java, Borneo, Celebes, Batjan, Karakelang, and several islands in the Bay of Djakarta: Middelburg, Onrust, Rotterdam, Schiedam, Kerkhof.

Habitat in Java: There are no exact localities known from Java. The only record is: East Java (MOUSSON, 1849) .

Whether *Cyrena lata* MOUSSON (1848, Mitt. naturf. Ges. Zürich, 1, 269) is the same species is not certain.

Genus *Batissa* GRAY, 1852.

Shell large and thick, rounded-oval to rounded-trigonal. Exteriorly coated with a fibrous, blackish-green periostracum, covering a white or violet shell. Concentrically striated or irregularly ribbed; some irregular violet stripes diverge from the top to back and base. Not transparent.

Dorsal side straight or somewhat concave before the top, and somewhat convex behind it. Anterior side merging almost evenly in the basal margin. Along the posterior side there can be one or two obtuse angles. Ligament exterior, strong, black.

Interior of shell white, pink or violet. From the umbo one or two thickened, but not sharp ridges stretch obliquely downwards in each valve. They flatten away towards the margin. The two adductor muscle scars are connected by a pallial line without sinus.

Hinge with three cardinals in each valve, the central ones can be bifid. In the left valve with one lateral before and behind the umbo, in the right valve with two laterals before and behind the umbo. The upper flanks of the left laterals and of the lower right laterals are transversely grooved (fig. 13).

Animal with strong foot and short siphons. Mantle closed along the dorsal side, but open on the ventral side. Of the gills the exterior ones are shorter and narrower than the interior ones.

Distribution: Malay Archipelago, Philippines, New Guinea, NW Australia, various Pacific Islands. In fresh and brackish, often running water.

In Java only one species:

Batissa violacea (LAMARCK, 1818) (fig. 13).

- 1818 LAMARCK, Hist. Nat. Anim. s. Vert. 5, p. 553 (sign. 36) (*Cyrena*).
- 1834 LEA, Trans. Americ. Phil. Soc. Philadelphia (N.S.) 5, p. 108, pl. 17, fig. 52 (*Cyrena jayensis*).
- 1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 269 (*Cyrena violacea*).
- 1849 MOUSSON, Land & Süßsw. Moll. Java, p. 88, pl. 15, fig. 1 (*Cyrena violacea* var. *javanica*).
- 1850 PHILIPPI, Abb. & Beschr. Cyrena, p. 107, pl. 3, fig. 1 (*Cyrena rotundata* non *C. rotundata* LEA), p. 108, pl. 3, fig. 2 (*Cyrena violacea*).
- 1854 DESHAYES, Catal. Conch. Brit. Mus. II, p. 235 (*Batissa rotundata* non *B. rotundata* LEA), p. 238 (*Batissa violacea* inclus. var. *suborbicularis* MOUSSON, nom. nud.).
- 1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 [*Cyrena rotundata* (*violacea* sec. MSS)].
- 1862 PRIME, Ann. Lyc. Nat. Hist. New York, 7, p. 115 (*Batissa sphaericula*).
- 1879 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 207, pl. 33, fig. 3-4 (*Batissa jayensis* inclus. *B. violacea* var. *javanica*), p. 208, pl. 33, fig. 5 (*Batissa violacea*).
- 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 102 (*B. jayensis*), p. 103 (*B. javanica*), p. 104, pl. 5, fig. 3, 6-9 (*B. violacea* inclus. var. *celebensis*, *macassarica*, *discoidea* and *extensa*).
- 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 268 (*B. javanica* and *B. jayensis*).
- 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 88 (*B. javanica* and *B. jayensis*).

Shell large and thick, rounded-oval or rounded. The top is situated in the middle or anteriorly of it. Dorsal side straight or somewhat concave in front of the apex, and generally convex behind it. Anterior side merging almost evenly in the basal margin. The transition from dorsal to posterior, and from posterior to basal margins is rounded in young shells, but obtusely angular in full-grown ones. Concentrically striated or irregularly ribbed. These ribs are most developed on the anterior side. Shell white, or pink, or violet under a dark, fibrous, somewhat shining epidermis. From the umbo a few irregular violet stripes diverge to back and base. Ligament exterior, strong, brownish-black.

Interior of shell white, pink or violet, with porcelainous lustre. The two adductor scars are connected by a pallial line without sinus.

Hinge plate strong and broad. In each valve there are three cardinals; the central one can be bifid. The left valve bears 2 laterals which are transversely grooved on their dorsal side; the right valve has 4 laterals (2 in front of the umbo and 2 behind it) of which the lower ones are transversely grooved on their dorsal sides.

Dimensions: The largest specimen which I have seen is 150 mm long and 105 mm high, with a diameter of 55 mm, but generally the shells are smaller.

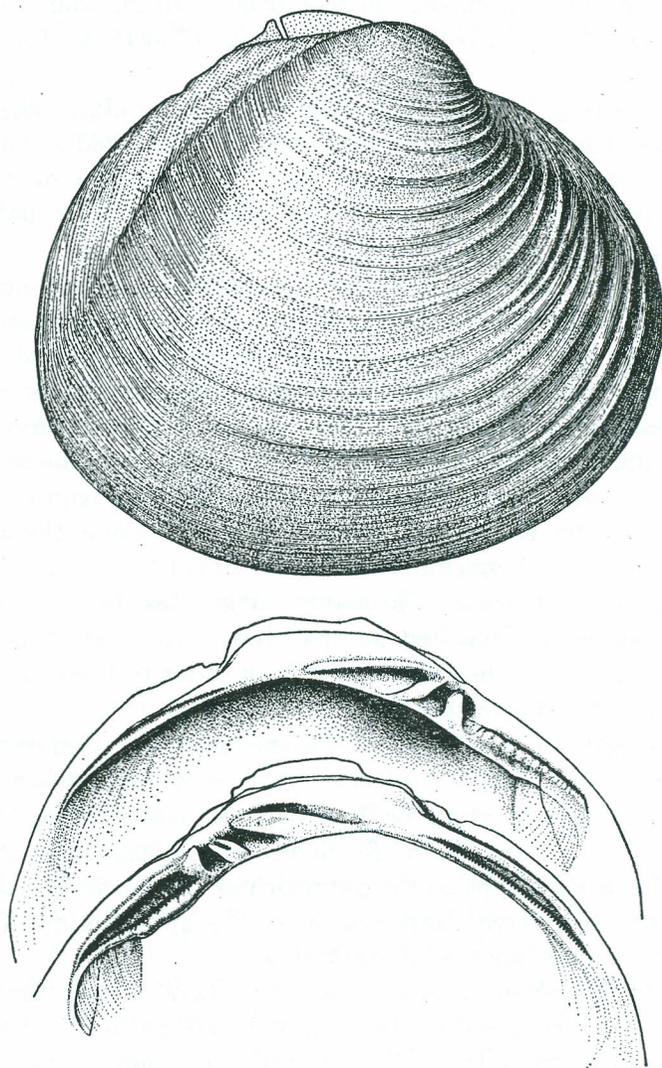


Fig. 13. *Batissa violacea* (LAM.). Exterior of right valve. Hinge of left and right valves. Somewhat reduced. ABDULKADIR del.

Distribution: various islands of the Indo-Australian Archipelago, including Java. In fresh and slightly brackish water of rivers and estuaries, on and in the bottom among sand and mud.

Habitat in Java: There are only few exact localities recorded from Java, and still more scanty are the observations on the environmental conditions of *Batissa violacea*.

West Java: River Panimbang, near Pardana, in Bantam (MOUSSON, 1849); Batavia (CLESSIN, 1879); Pelabuanratu (MARTENS, 1897); Tjiandjur.

As the species is so very variable local forms have often been described under different names. Whether these must be regarded as subspecies or as ecological modifications is not certain. Comparison of extensive series from many localities and of various ages might eventually solve this question.

A curious fact is that one rarely gets in hand young and semi-adult specimens of *Batissa violacea*. Therefore the developmental stages are imperfectly known. Judging from the samples of Java which I could examine it is my impression that young stages are invariably orbicular or nearly so, i.e. length and height of the shell are almost similar. With increasing age this rotund form can either be maintained, the adult shell then being also suborbicular, but mostly the adult form acquires a more elongate-oval shape by adding more shell-substance along the posterior side than along the basal margin.

This elongate modification probably originates in waters where sediments are regularly deposited so that the *Batissa* animals have to compensate by prolonging their sagittal axis in order to keep the siphonal openings at level with the bottom surface.

From the original descriptions of *Batissa violacea* (LAMARCK, 1818), *B. jayensis* (LEA, 1834) and *B. violacea* var. *javanica* (MOUSSON, 1849)¹⁾ it is evident that all are more or less oval to oval-elongate. The discrimination of the var. *javanica* of *B. violacea* by MOUSSON on account of the stronger concentric ridges on the anterior part of the shell was already considered of not very great importance by the author himself. It is a common feature in most species of *Batissa*.

Whether *Batissa jayensis* is indigenous in Java is very problematic. All later references are based on the original designation by LEA (1834) who received a shell from Dr J. C. JAY with the doubtful locality "Batavia?" DESHAYES (1854, p. 237) and MARTENS (1897, p. 103) recorded the species from Sumatra, and SOWERBY (1878, in: REEVE, Conch. Icon. 20, pl. 6, fig. 19) from Waigiori (possibly Waigeu?).

Batissa keraudreni (LESSON) and *B. violacea* (LAM.) var. *macassarica* MARTS were recorded from Pleistocene layers in Java (VAN BENTHEM

¹⁾ The location of *Batissa rotundata* (LEA, 1834) is unknown. The erroneous designation "Java" for this species is due to PHILLIPPI, 1850. Instead of the true *B. rotundata* he classified as such a form of *B. violacea* (fide MARTENS, 1897, p. 104).

JUTTING, 1937, Zool. Meded. 20, p. 137). Both species are still persisting in recent years.

Batissa keraudreni is now included as a modification in *B. violacea* (LAM.) (RIECH, 1937, Arch. Naturgesch. (N.F.) 6, p. 87).

Corbicula MEGERLE VON MÜHLFELDT, 1811.

Shell rather small, almost symmetrical, rounded-triangular to irregularly oval, generally strong, and little or not transparent. Umbones inflated in most species. Exteriorly covered by a strong, somewhat fibrous, periostracum of yellowish-brown or greenish-brown colour. Striated or ribbed concentrically. Ligament exterior, strong.

Interior white, pink or violet, with porcelainous lustre. In each valve the two impressions of the adductor muscles are connected by a pallial line with a shallow sinus, or without sinus at all (fig. 14).

Hinge with three cardinals in each valve. The left valve has one lateral tooth before and behind the umbo, the right valve possesses two laterals in front and behind the umbo. The cardinals are smooth, the lamelliform laterals transversely serrated on the sides facing the laterals of the opposite valve.

Foot trapezoidal to triangular. Mantle flaps separate, except on the dorsal side where they are entire, and in the siphonal region where they are partly fused forming the ingestion and egestion openings. At a little distance from and parallel to their free margins the mantle flaps bear a row of minute papillae on their inner surface.

The upper (anal) siphon is smaller than the lower (branchial) one. The edges of the siphonal orifices are somewhat darker than the rest of the mantle edges, and are provided with distinct, conical papillae. These siphonal papillae are larger than those along the free mantle edge.

On each side of the body there is a pair of gills. The outermost gills are smaller than the inner pair, both in length and in width.

As far as the soft parts have been investigated the animals are of separate sex. The eggs, after leaving the gonad, are not liberated into the water, but are deposited in the interlamellar spaces of the two inner gills. Here the larvae undergo their first developmental stages.

In many islands of the Indo-Malayan region the soft parts of various species of *Corbicula* are used as food for man or domestic animals (VILLADOLID & ROSARIO, 1930, Philipp. Agric. 19, p. 355-382; BONNE & SANDGROUND, 1939, Geneesk. Tijdschr. Ned. Indië, 79, p. 3016-3034; BONNE, 1941, Natuurwet. Tijdschr. Ned. Indië, 101, p. 176-179; BONNE, BRAS & LIE KIAN

JOE, 1948, Medisch Maandbl. no. 23, p. 456-465). Some recent information was published by THIENEMANN, 1951, Arch. Hydrobiol. Suppl. Bd. 19, p. 535, pl. 30, fig. 3).

BONNE (1941, p. 177) reported that he often saw large heaps of *Corbicula javanica* and *C. rivalis* in the Javanese native market places. The people eat the mussels cooked or made into sajur. Yet it is not a regular food, but they are now and then important in certain districts as a supply of animal protein.

So long as the *Corbicula* are properly cooked there is no danger that the metacercaria stages of the *Echinostoma* parasites (Vermes, Trematoda) infesting the mussels can be transmitted to man. Frequently, however, the boiling process is too short or too imperfect, resulting in a heavy local infection in man.

In other districts the shells are used for burning lime, or the soft parts as bait for fishing.

Distribution: Fresh and brackish water of all continents, especially in tropical and subtropical regions. A few species at high altitudes.

The genus is abundant in the four Greater Sunda Islands and in some of the Lesser Sunda Islands (not in Sumba, Flores and Timor). It is absent from the majority of the Moluccan Islands: Ambon, Ceram, Buru, Banda, Obi, Batjan, Halmahera, Sula Islands, Aru and Kei Islands. In New Guinea and Australia the genus is again represented.

In Java chiefly in fresh water habitats: lakes, ponds, rivers, ditches, canals etc.; occasionally in estuaries where the salinity can be somewhat higher. By their short siphons the animals are obliged to live at a short distance below the bottom surface.

The three Javanese species can be distinguished as follows:

1. Shell finely ribbed, umbones little or moderately inflated 2.
- Shell coarsely ribbed, umbones much inflated *javanica*
2. Interior of shell violet. Umbones little projecting, the transition from dorsal to posterior side forming a "shoulder" behind the top . . . *rivalis*
- Interior of shell cream-colour along the margin, pink or salmon in the umbonal region. Umbones distinctly projecting. No "shoulder" behind the top *pulchella*

Corbicula has been recorded from various tertiary layers in Java and Borneo (VAN DER VLERK, 1931, Leidsche Geol. Meded. 5, Feestbundel MARTIN, p. 281; OOSTINGH, 1935, Wetensch. Meded. no. 26, Dienst Mijnbouw Ned. Indië, p. 141 and 170; VAN BENTHEM JUTTING, 1937, Zool. Meded.

20, p. 131-137). Of these species only *C. pullata* (PHIL.) is also known in the recent state (not from Java); all others are extinct species.

***Corbicula javanica* (MOUSSON, 1849) (fig. 14). Native name: Remis.**

- 1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 269 (*Cyrena orientalis* and *C. fluminea* non MÜLLER).
- 1849 MOUSSON, Land & Süßw. Moll. Java, p. 86, pl. 15, fig. 2 (*Cyrena orientalis* var. *javanica*), p. 87 (*Cyrena fluminea* non MÜLLER).
- 1854 DESHAYES, Catal. Conch. Brit. Mus. II, p. 227 (*moussoni*).
- 1860 PRIME, Proc. Acad. Nat. Sci. Philadelphia, 12, p. 270 (*gracilis* nom. nud.).
- 1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 (*Cyrena orientalis*), p. 320 (*Cyrena fluminea*).
- 1862a PRIME, Journ. de Conch. 10, p. 389, pl. 14, fig. 7 (*gracilis*).
- 1862b PRIME, Proc. Boston Soc. Nat. Hist. 8, p. 274 (*ducalis*).
- 1866 PRIME, Ann. Lyc. Nat. Hist. New York, 8, p. 225, fig. 58 (*ducalis*).
- 1867 PRIME, Ann. Lyc. Nat. Hist. New York, 8, p. 416 (*colonialis*).
- 1869 FRAUENFLED, Verh. Zool. Bot. Ges. Wien, 19, p. 863 (*ovalina*).
- 1879 CLESSIN, in: MART-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 150 and p. 181, pl. 27, fig. 1-2, pl. 31, fig. 20 (*orientalis* var. *javanica*), p. 154, pl. 27, fig. 16-18 (*fluminea* var. *moussonii*), p. 184, pl. 32, fig. 5-6 (*ducalis*), p. 188, pl. 32, fig. 17-18 (*sulcata*), p. 191, pl. 38, fig. 2 (*gracilis*), p. 199 (*colonialis*).
- 1890 BOETTGER, Ber. Senckenb. naturf. Ges. p. 163 (*fluminea*).
- 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 111 (*javanica*), p. 114 (*ducalis*), p. 116 (*sulcata*).
- 1904 BULLEN, Proc. Malac. Soc. London, 6, p. 109, pl. 6, fig. 7-9 (*subrostrata*).
- 1912 SCHEPMAN, Proc. Malac. Soc. London, 10, p. 238 (*ducalis*).
- 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 268-270 (*ducalis*, *gracilis*, *sulcata*, *javanica*, *ovalina*, *subrostrata*).
- 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 88 (*javanica*, *ovalina*, *subrostrata*, *ducalis*, *gracilis*, *sulcata*).
- 1930 PRASHAD, Mem. Indian Mus. 9, p. 194, pl. 24, fig. 1-6 (*javanica*), p. 195, pl. 24, fig. 7-12 (*ducalis*), p. 197, pl. 24, fig. 15-16 (*gracilis*).
- 1934a RENSCH, Zool. Jahrb. (Syst.) 65, p. 418 (*javanica*).
- 1934b RENSCH, Trop. Binnengew. 5, p. 245 (*javanica*), p. 247 (*gracilis*).
- 1935 PARAVICINI, Arch. Moll. Kunde, 67, p. 175 (*ducalis*).
- 1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 160 (*ducalis*).
- 1939 ADAM & LELOUP, Mém. Mus. Roy. Hist. Nat. Belg. (Hors série) 2, fasc. 20, p. 66.
- 1941 BONNE, Natuurwet. Tijdschr. Ned. Indië, 101, p. 176, fig. 1.
- 1941 VAN BENTHEM JUTTING, Arch. néerl. Zool. 5, p. 321 (*ducalis*).
- 1951 THIENEMANN, Arch. Hydrobiol. Suppl. Bd. 19, p. 535.
- 1952 VAAS & SACHLAN, Cort. Gen. Agric. Res. Stat. Bogor, 128, p. 4.

Shell oval to trigonal-oval, with rounded base. Subequilateral in young individuals, more inequilateral with increasing age.

White, pale violet or pinkish under a dark olive-green to yellowish-green, fibrous epidermis. Towards the free margins of the valves the colour is lighter and more shining than in the older parts.

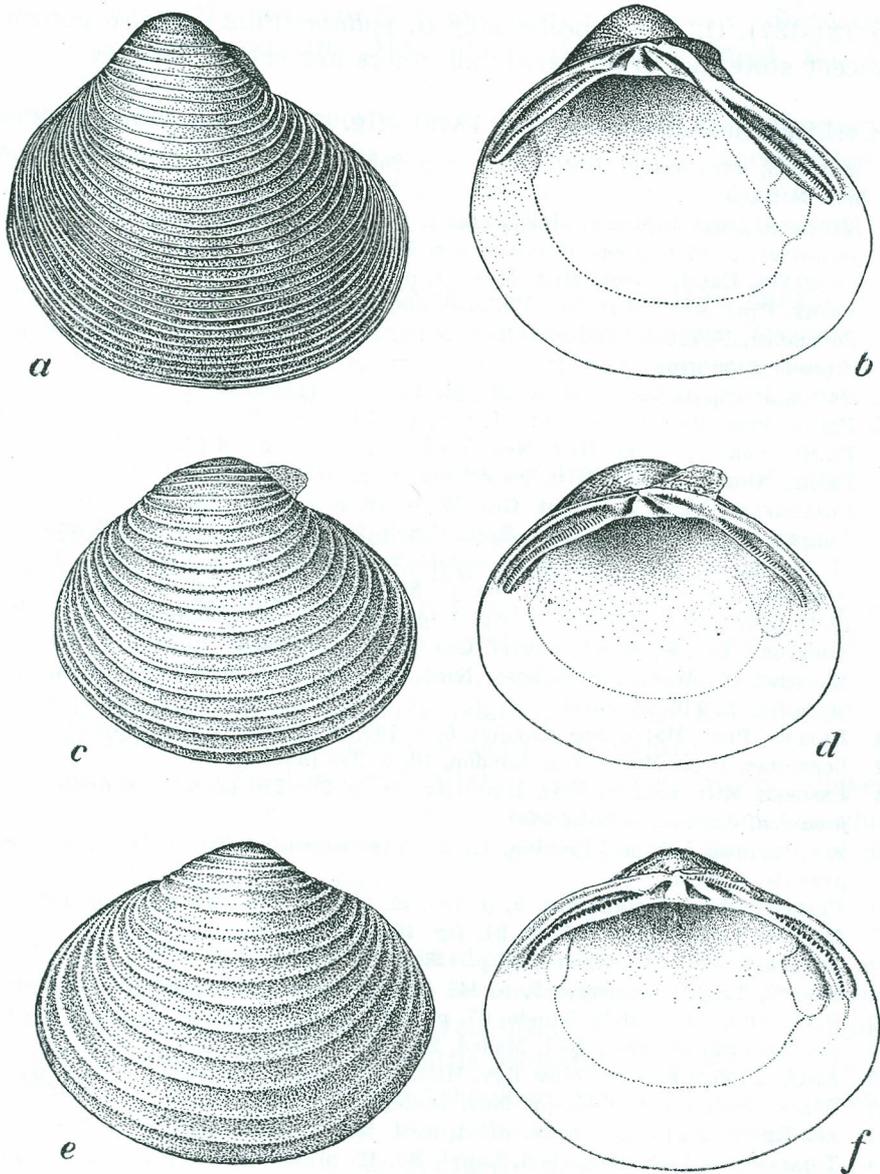


Fig. 14. *Corbicula javanica* (MOUSS.). a. exterior of left valve; b. interior of right valve, both about $1\frac{1}{2}$ times nat. size; c. exterior of left valve; d. interior of right valve, both about 2 times nat. size; e. exterior of right valve; f. interior of some, both about 3 times nat. size. All figures ABDULKADIR del. c. and d. represent what was generally called *Corbicula ducalis* PRIME; e. and f. what was generally called *Corbicula gracilis* PRIME.

Concentrically ribbed with coarse, widely placed ribs, much coarser and more remote than in either *Corbicula rivalis* or *C. pulchella*. On one and the same shell the ribs of the youngest part (shell height 5 mm) are standing closer together than in the later part. In very old shells (length 35 mm and more) the distance between the ribs which is rather wide in the middle part, can diminish again towards the margin. Shell thick, little or not transparent.

Umbones inflated, reaching high above the dorsal margin and nearly touching each other in the median plane. Posterior side rostrate in adult shells, the margin obtusely angular at the transition to dorsal and basal sides. Dorsal margin sloping down somewhat more quickly in front of the umbo than behind it. Anterior margin rounded, evenly passing into the basal one. Ligament exterior, strong.

Interior of the valves deeply excavated, porcelainous, white, with tinges of dilute pink or violet in the umbonal part, along the hinge teeth and in the siphonal region. The scars of the adductor muscles are connected by a pallial line with shallow sinus.

Both valves have three cardinal teeth; in old shells the cardinals tend to become bifid. In the right valve there are two laterals before and behind the umbo; in the left valve there is one lateral before and behind the umbo.

All the cardinals are smooth. The laterals of the left valve are transversely serrated on both sides. Of the laterals in the right valve the anterior and posterior lower laterals are grooved on their upper side only.

Dimensions: length up to 50 mm, height up to 44 mm, diam. up to 28 mm.

Distribution: Sumatra, Java, various satellite islands of Java (VAN BENTHEM JUTTING, 1941), Bali, Lombok, Sumbawa, Celebes.

Habitat in Java: rivers, lakes, ponds, ditches, sawahs. Mostly in fresh water.

West Java: Tjikoja (MOUSSON, 1849); Tjiliwong, near Djakarta; River Tanabang, near Djakarta; beach E of harbour canal of Pasar Ikan, Djakarta; Tjikini, Djatinegara; River Antjol, E of Djakarta; Tjitarum, near Krawang; Lenteng Agung, near Depok; from river, near Depok; Tjiliwung, near Depok; Tjiawi, irrigation ditch (running water) from sawah; Tjiliwung, near Bogor; ponds in Botanic Gardens, Bogor; irrigation ditches (slokans) in Botanic Gardens, Bogor; pond near Institute for Fishery Research, near Bogor; Lake of Tjigombong; Tjitjurug (PARAYICINI, 1935); Sukabumi; Parungkuda, near Sukabumi; Pelabuan-ratu, sawah ditches near Tjisolak; Udjung Genteng, Sandbay; Estate Tjiliwung, near Puntjakpass; Lake Tjisarua, near Sindanglaja; Sindang-

laja (MARTENS, 1897); Tjipanas; Tjibodas, pond; Tjiandjur, in running water; between Tungenang and Tjiandjur, in running ditch along the road; Lake Tjiburuj (VAAS & SACHLAN, 1952); river in Kampong Tjimahi; River Tjimahi, between Lagador and Kapek; fish ponds on slope of Mt Patuha; sawah near Bandung; rivulet along road from Tjimindi to Leuwigadja; in old swimming-pond near Lembang; Mt Tangkuban Prahur; Pengalengan, in deserted sawah; Tjitere, in fish ponds; Kampong Patrol Daro, W of Leles; environs of Garut; fish ponds at Tjipanas, near Garut; slokans along fish ponds at Sadang, near Garut; Tjisurupan, near Garut; Mt Tjikorai; Situ Bangendit, near Garut; sawahs along the road from Garut to Tasikmalaja; fish ponds near Tasikmalaja; sawah near Tasikmalaja; Malangbong; Tjipelang, near Udjungdjaja; Kadipaten, in irrigation ditch; sawah near Kartawinangun; Cheribon; Bungkirit, near Cheribon; Palimanan, near Cheribon (PARAVICINI, 1935).

Central Java: Tjilatjap; Bagelen; Tegal; near Pekalongan; Demak; Dempet, near Demak; Purwodadi; Magelang; Tuntang River; iron tubes of water-power plant Djelek, in Kali Tuntang, near Salatiga; Rawa Pening, near Ambarawa; Kali Opak, near Parangtritis; Bangle (VAN BENTHEM JUTTING, 1937); Pandejan (VAN BENTHEM JUTTING, 1937); River Solo, near Trinil (VAN BENTHEM JUTTING, 1937); River Soko, right tributary of River Solo (VAN BENTHEM JUTTING, 1937); Kali Besèk, near Sulang; Rembang.

East Java: Lake Ngebel, near Ponorogo (RENSCH, 1934b); Patjitan; near Bay of Prigi; Tulung Agung (VAN BENTHEM JUTTING, 1937); rivulet near Nglirip; Surabaja; Kali Mas, near Surabaja; Rawa Blawi, Sidaju, near Surabaja; fish ponds at Puntèn, near Malang (RENSCH, 1934b); Kali Brantas, near Malang; Southern Mts in Pasuruan; Pasuruan; Ranu Klindungan, between Pasuruan and Probolinggo (RENSCH, 1934b); Kali Djember.

Previous authors have already suggested that *Corbicula javanica*, *C. ducalis* and *C. gracilis* might represent all one species, but none of them took the direct consequences by uniting the three.

After having compared the type and several paratypes of *Corbicula javanica* in the MOUSSON collection at Zürich and after examining paratypes of *Corbicula ducalis* PRIME and *C. gracilis* PRIME, kindly lent by the Museum of Comparative Zoology of Cambridge (Mass.) I am inclined to consider them all synonymous, forming one polymorph species which — for the sake of priority — has to be called *Corbicula javanica* (MOUSSON).

What PRIME, 1862a, introduced as *Corbicula gracilis*, specially stressing the subequilateral shape and the distinct concentric ridges, is nothing but the semiadult form (max. length 20 mm) of *C. javanica*.

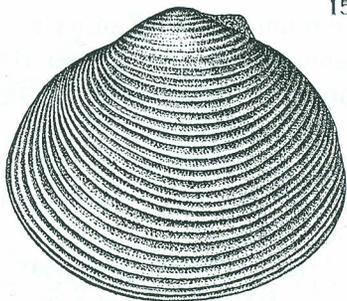
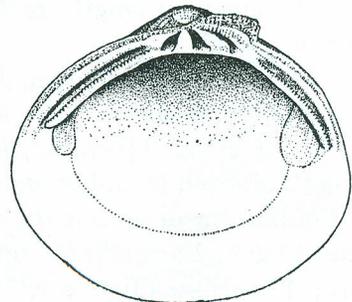
Young shells of *C. javanica* and *C. ducalis* are also subequilateral; it is only with increasing age that they locally can assume a more inequilateral, even rostrate, outline. Moreover the umbones of *C. gracilis* are not distantly ribbed; they are just as narrow as those of juvenile *C. javanica* or *C. ducalis*. On all three forms the ribs are narrow on the initial part of the shell, about 3-4 mm (measured in a curve). After that they become more distant.

The differences between *C. javanica* and *C. ducalis* are equally dubious, the only exact character being the narrower (*javanica*) or wider (*ducalis*) distance between the ribs. This difference, however, cannot be expressed in exact figures, because between 4 ribs in 5 mm, and 7 ribs in 5 mm all transitions are possible. Even on one valve the distance between the ribs (apart from the nepionic part) can vary in different stages of its development.

***Corbicula rivalis* (PHILIPPI, 1850) (fig. 15).**

- 1850 PHILIPPI, Abb. & Beschreib. Cyrena, p. 110, pl. 3, fig. 5 (*Cyrena*).
 1854 DESHAYES, Catal. Conch. Brit. Mus. II, p. 227 (*compressa*), p. 228 (*rivalis*).
 1879 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 159, pl. 27, fig. 15 (*rivalis*), p. 165, pl. 29, fig. 11-12 (*compressa*), p. 180, pl. 31, fig. 16-17 (*javana*).
 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien, 4, p. 118 (*pullata* syn. *javana* CLESSIN), p. 120, pl. 7, fig. 32-33 (*rivalis*).
 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 269-270 (*rivalis*, *pullata* MARTS non PHIL.).
 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 88 (*rivalis*, *pullata* MARTS non PHIL.).
 1930 PRASHAD, Mem. Ind. Mus. 9, p. 197, pl. 24, fig. 15-16.
 1937 VAN BENTHEM JUTTING, Zool. Meded. 20, p. 160.
 1941 BONNE, Natuurwet. Tijdschr. Ned. Indië, 101, p. 177, fig. 1.

Shell trigonal-oval, with rounded base. Epidermis olive to greenish-yellow, darker than in *C. pulchella*, becoming more yellow with increasing size. Top and sides generally darker, with violet hue. Concentrically ribbed with comparatively fine, close set ribs (finer and closer than in *C. javanica*). Be-



15

Fig. 15. *Corbicula rivalis* (PHIL.). Interior of right valve, exterior of left valve; about 3½ times enlarged. ABDULKADIR del.

tween the ribs there are still finer growth lines. Somewhat shining, not or little transparent.

Umbones moderately projecting, not quite so distinct as in *C. pulchella*. They are less inflated than in *C. javanica*. Ligament exterior, short.

Dorsal side somewhat concave before the umbo, more convex, even somewhat "shouldered," behind it. This feature is more evident in young shells than in full-grown ones. Front side merging imperceptibly into basal margin. The transition from the posterior side into the base is obtusely angular in young shells, but more evenly rounded in adult ones.

Interiorly the shell is violet, sometimes even very dark, almost black. In such over-coloured shells even the hinge teeth are violet. Pallial sinus not, or hardly developed.

Left valve with three cardinals in the middle of the hinge plate, and one lateral before and behind the top. Right valve with three cardinals and two laterals in front and behind. All the cardinals are smooth. The laterals of the left valve are transversely grooved on both sides. Of the laterals in the right valve the anterior and posterior lower laterals are grooved on their upper side only.

Dimensions: length up to 25 mm, height up to 21 mm, diam. up to 13 mm.

Distribution: Sumatra, Java, Bawean.

Habitat in Java: lakes and rivers, always in fresh water.

West Java: Tjiliwung, near Djakarta; rivulet in Djakarta; Tjiawi, irrigation ditch (running water) from sawah; irrigation ditches (slokans) in Botanic Gardens, Bogor; brook in Botanic Gardens, Bogor; Tjiliwung, near Bogor; Parangkuda, near Sukabumi; near Ujung Genteng, Sandbay; Tjisarua; Tjiandjur, in old cistern; kali along road in Kampong Tjimahi, beyond Kapek; Tjimatjan, sawahs, ponds and brooklets, all communicating; Kadipaten, irrigation ditch; irrigated rice-field near Bandung; Lembang, near Bandung, in old, dry swimming pool; Mt Tangkuban Prahau; Garut.

Central Java: Wirosari, in Kali Lusi; Purwodadi; Sulang, near Rembang, in Kali Besèk about 8 km from the sea; Trinil (VAN BENTHEM JUTTING, 1937); Kali Soko, right tributary of Kali Solo, near Trinil (VAN BENTHEM JUTTING, 1937).

East Java: brook near Nglirip; along dike of a waduk near Sumber Kepu, NNW of Kertosono; Surabaja; Southern Mts; Banjuwangi.

Like *Corbicula javanica* the present species can act as a second intermediate host of a fluke infection (BONNE, 1941, l.c.; BONNE, BRAS & LIE KIAN JOE, 1948, Medisch Maandbl. no. 23, p. 462).

The shells which CLESSIN (1879, p. 180) described as *Corbicula javana* were classified by MARTENS (1897, p. 118) as *C. pullata* (PHIL.). As this opinion seemed somewhat dubious I asked on loan the original shells of *Corbicula javana* from the State Museum of Natural History in Stuttgart where they are preserved.

The four shells labelled "Java, Dr. BLEEKER 1860" have the following dimensions:

length	28	26.5	25	25	} mm.
height	25.5	24	22	22	
diam.	16	15.5	15.5	14	

No type specimen was indicated by the author, but — judging from the dimensions and from the rather poor figure (pl. 31, fig. 16) — the largest specimen is the holotype.¹⁾

The entire shape and texture, and the dark violet interior of all four shells leave no doubt that they belong to *Corbicula rivalis* (PHILIPPI).

***Corbicula pulchella* (MOUSSON, 1848) (fig 16).**

- 1848 MOUSSON, Mitt. naturf. Ges. Zürich, 1, p. 269 (*Cyrena*).
- 1849 MOUSSON, Land & Süsw. Moll. Java, p. 88, pl. 15, fig. 4 (*Cyrena*).
- 1854 DESHAYES, Catal. Conch. Brit. Mus. II, p. 228.
- 1860 ZOLLINGER, Natuurk. Tijdschr. Ned. Indië, 21, p. 319 (*Cyrena*).
- 1879 CLESSIN, in: MART.-CHEMN. N. Syst. Conch. Cab. 9, Abt. III, p. 181, pl. 30, fig. 7-8.
- 1897 MARTENS, in: WEBER, Erg. Reise Nied. Ost Indien., 4, p. 120.
- 1914 LESCHKE, Mitt. naturh. Mus. Hamburg, 31, p. 269.
- 1929 VAN BENTHEM JUTTING, Treubia, 11, p. 88.
- 1930 PRASHAD, Mem. Ind. Mus. 9, p. 196, pl. 24, fig. 13-14.
- 1934 RENSCH, Trop. Binnengew. 5, p. 246.
- 1935 PARAVICINI, Arch. Moll. Kunde, 67, p. 175.

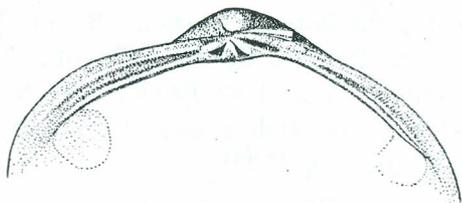
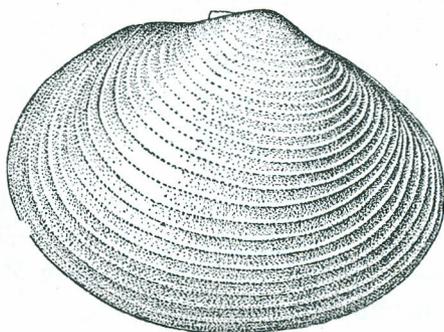


Fig. 16. *Corbicula pulchella* (MOUSS.). Exterior of right valve and hinge part of same; about $3\frac{1}{2}$ times enlarged. ABDULKADIR del.

Shell trigonal - oval, with rounded base. Epidermis greenish-

¹⁾ In the figure, drawn in natural size only 15 concentric ribs are visible. They are rather coarse and have wide interstices. In reality this very shell has 34 fine ribs placed more closely.

brown to straw-colour, lighter than that of *Corbicula rivalis*. Umbones pink or salmon. Concentrically ribbed, with comparatively fine, close-set ribs, finer and closer than in *Corbicula javanica*. Between the ribs there are still finer growth lines.

Shell somewhat shining, not or little transparent. Umbones moderately projecting, somewhat more pointed and prominent than in *C. rivalis*. The umbones are less inflated than in *C. javanica*. Ligament exterior, short.

Dorsal side almost evenly curved before and behind the umbo. Anterior side evenly rounded, posterior side also rounded, or obtusely angular (less angular than in *C. rivalis*).

Interior of the shell pink or salmon in the umbonal region, cream-coloured or dilute pink towards the margin. Pallial sinus not, or hardly, developed.

Left valve with three cardinals in the middle of the hinge plate, and one lateral before and behind the top. Right valve with three cardinals, and with two laterals in front and behind.

All the cardinals are smooth; the laterals of the left valve are transversely grooved on both sides. Of the laterals in the right valve only the upper side of the lower anterior and posterior laterals are grooved.

Dimensions: length up to 14 mm, height up to 11.7 mm, diam. up to 7 mm.

The type specimen, in the MOUSSON collection at Zürich is long 11, high 9.5 and thick 6 mm. This holotype is labelled "Java (ZOLLING '46)". It agrees exactly with the figure in MOUSSON's book (1849).

Distribution: Java.

Habitat in Java: lakes and rivers, always in fresh water.

West Java: environs of Tjikoja (MOUSSON, 1849); Gadok; branch of Tjiliwung, in Botanic Gardens, Bogor (RENSCH, 1934); slokans (irrigation ditches) in Botanic Gardens, Bogor; Pengalengan (PARAVICINI, 1935).

Central Java: Kali Besèk, near Sulang.

East Java: fish ponds at Puntèn, near Malang; Ranu Pakis, near Klakah (RENSCH, 1934).

Familia SPHAERIIDAE.

Shells small, equilateral or inequilateral. Fragile, in most species minutely perforate. Concentrically striated or ribbed, the nepionic part of the shell often differently sculptured, or smooth.

Hinge plate narrow. In each valve one or two cardinals. In the right valve with two lateral teeth in front and behind; in the left valve there is only one in anterior and posterior part.

Animal with the mantle flaps separate. At the posterior end the mantle forms one or two short siphons. There are one or two gills on either side of the body; the inner pair of gills serves as a marsupium for the larvae before they start their own existence.

Hermaphroditic, as far as the species have been studied. Fertilisation takes place by autogamy.

Distribution: all continents, often at considerable altitudes, and also in the polar regions. Always in fresh water.

In Java there is one genus:

Genus *Pisidium* C. PFEIFFER, 1821.

Shell small, oval or obliquely egg-shaped. Anterior side more pointed than the posterior one. Moderately to much inflated. In most species the shell is minutely perforate. Yellowish-brown to greyish-green. Concentrically striated or ribbed. Fragile, transparent and somewhat glossy. Apex behind the middle, umbones moderately to much inflated. Generally the nepionic and the adult parts of the shell are distinctly separated by a ridge. Ligament for the greater part interior, between the two valves.

Right valve with one cardinal which fits in a depression between the two cardinals of the left valve. In the right valve there are two laterals in anterior and posterior part of the hinge. In the left valve there is one lateral in front and behind. On the contiguous surfaces where the laterals of right and left valves articulate, the teeth are finely, transversely serrate. Muscle scars faint, connected by a pallial line without sinus (fig. 17).

In the animal the mantle flaps are not fused; only at the posterior end they form two siphons. In the subgenera *Pisidium* s. str. and *Eupisidium* the anal siphon is well developed, the branchial one, however, is only a narrow slit. In the subgenus *Neopisidium* there is only one siphon. Foot long and narrow.

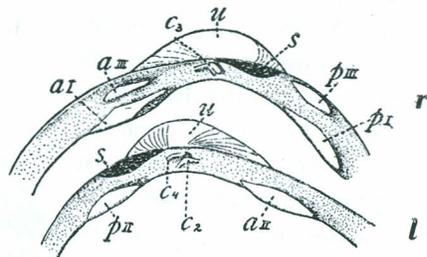


Fig. 17. Hinge of *Pisidium* shell. r. right valve; l. left valve. aI, aII, aIII anterior lateral teeth, c₂, c₃, c₃ cardinal teeth, p^I, p^{II}, p^{III} posterior lateral teeth; s. ligament; u. umbo. After VAN BENTHEM JUTTING.

In the subgenus *Pisidium* s. str. the animals possess two almost equal gills on either side of the body. In *Eupisidium* the inner ones are well developed, but the exterior ones are small (fig. 18); in *Neopisidium* the outer ones have entirely disappeared (fig. 19).

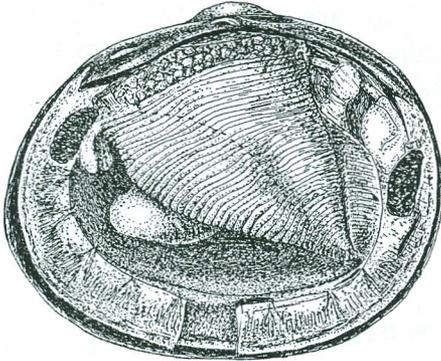


Fig. 18. *Pisidium* (*Eupisidium*) *floresianum* RENSCH. Right valve with animal; about 14 times enlarged. ODHNER del.

The animals are hermaphroditic. Propagation probably always takes place by self-fertilisation. After fertilisation the eggs are not liberated into the water, but deposited in the interior gills. The interior walls of the gills form small cyst-like incubation-pouches in which the larvae never more than 4-6 at a time develop till they reach maturity. In these brood-pouches the embryos are not only protected, but also nourished by the parent. As soon as the young mussels are ripe for being liberated

the brood-pouches burst and the young Pea-shells leave the parent mussel through the siphon.

Distribution: all continents, in fresh water, occurring from the lowlands to high up in the mountains.

Pisidium species can live in almost any water basin, even in oligotrophic ponds which are avoided by other mollusks. Yet it is not so that all species can live in any given habitat; but certain species are plainly adapted for life in special biotopes.

Of the environment in Java where *Pisidium* species were collected very little is known. These details will be mentioned when dealing with each species.

In Java there are three species:

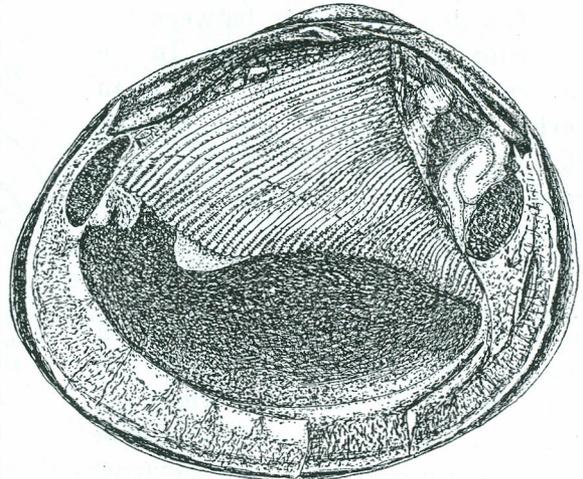


Fig. 19. *Pisidium* (*Neopisidium*) *javanum* VAN BENTHEM JUTTING. Right valve with animal; about 22 times enlarged. ODHNER del.

- 1. Shell inequilateral, posterior limb of cardinal tooth in the right valve not bifid **javanum**
- Shell almost equilateral, posterior limb of cardinal tooth in the right valve bifid 2.
- 2. Hinge plate relatively broad, teeth strong, umbones inflated **sundanum**
- Hinge plate narrow, teeth weaker, umbones little prominent **floresianum**

Pisidium (Eupisidium) floresianum RENSCH, 1934 (fig. 18 and 20).

1931 VAN BENTHEM JUTTING, *Treubia*, 13, p. 13-14, fig. 15a-c (*Sphaerium javanum*).

1934 RENSCH, *Zool. Jahrb. (Syst.)* 65, p. 418-419, fig. 9.

1940 ODHNER, *Nova Guinea (N.S.)* 4, p. 116 and 119-123, fig. 4-7, pl. 12, fig. 3-5, 12, pl. 13, fig. 20-22.

Shell rounded-oval, subequilateral, little inflated, thin, horny-white, with pale brown epidermis. Anterior margin sloping gradually obliquely downward without distinct angle in the region of the lateral teeth and passing with rounded front almost imperceptibly into the ventral margin.

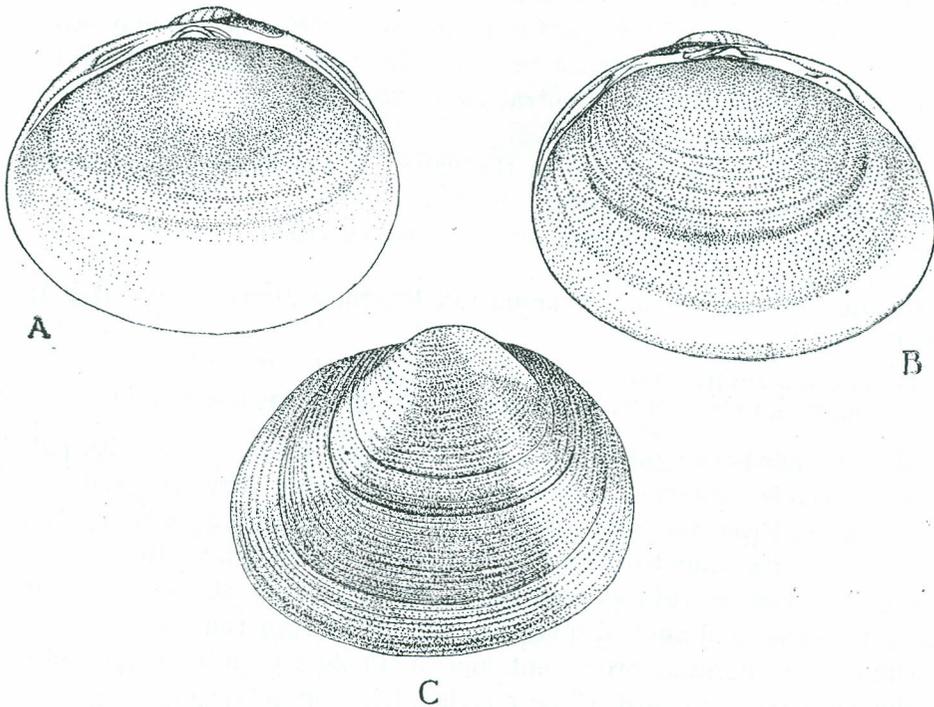


Fig. 20. *Pisidium (Eupisidium) floresianum* RENSCH. a. interior of right valve; b. interior of left valve; c. exterior of same. 10 times enlarged. AEDULKADIR del.

Posterior margin a little shorter and steeper, making a very faint angle near the lateral teeth and from there passing without distinct mark into the ventral margin. Ventral margin rounded. Umbones hardly projecting, not curved inward.

Exterior of the shell very closely striated with concentric striae or delicate ribs, except on the nepionic part which is smooth.

Right valve bears two laterals on each side, the dorsal ones being smallest, the antero-ventral one thickest. There is one cardinal tooth, curved to a nearly right angle, the posterior limb forked.

Left valve has one lateral on each side, and two cardinals in the centre of the hinge plate. Of the latter the postero-dorsal one is a nearly straight ridge, the antero-ventral one short and sharply flexed, with a short anterior limb ending in the middle of the hinge plate. Here it forms a sharp angle with the longer posterior limb which descends to the under edge of the hinge plate, sometimes ending in a small swelling under this tooth. Ligament short, hardly visible exteriorly.

Dimensions: length up to 6.5 mm, height up to 5.5 mm, diam. up to 3.75 mm.

Distribution: Java, Flores, Celebes, New Guinea.

Habitat in Java: With respect to *Pisidium floresianum* the only ecological reference is its occurrence in a marshy pool in the valley of the River Dolog, Dieng Plateau, Central Java, 2000 m alt.

West Java: Bandung.

Central Java: marshy pool in the valley of the River Dolog, Dieng Plateau, 2000 m alt. (VAN BENTHEM JUTTING, 1931).

The animal was amply described by ODHNER (1940).

***Pisidium* (*Neopisidium*) *javanum* VAN BENTHEM JUTTING, 1931 (fig. 19 and 21).**

1931 VAN BENTHEM JUTTING, *Treubia*, 13, p. 12-13, fig. 14a-c.

1940 ODHNER, *Nova Guinea* (N.S.) 4, p. 116, p. 127, pl. 12, fig. 11; text figs. 12, 13.

Shell rounded-triangular, inequilateral, rather thick, white, with pale brown epidermis. Anterior margin at first stretching forward gradually in faint curve. From the lateral teeth onward sloping down more directly and passing with rounded front almost imperceptibly into the ventral margin. Posterior margin shorter and steeper, making obtuse angles in passing to dorsal and ventral margins. Ventral margin rounded.

Umbones moderately prominent, more so in older than in young shells, and slightly curved inward. Closely striated in concentric direction; the striae are often like flat ribs. Only the nepionic part is smooth.

Right valve with two laterals on each side, the dorsal ones being smallest, the antero-ventral one powerful and causing a tooth-like protuberance in this part of the hinge. There is one curved cardinal, rather low in front, but better developed and more prominent towards the posterior side.

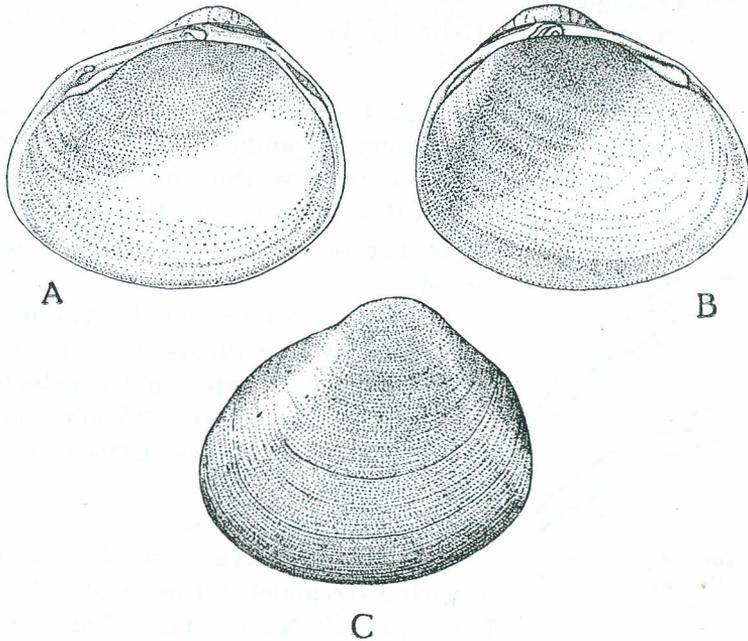


Fig. 21. *Pisidium* (*Neopisidium*) *javanum* VAN BENTHEM JUTTING. a. interior of right valve; b. interior of left valve; exterior of same. 10 times enlarged. ABDULKADIR del.

Left valve with one lateral on each side and two cardinals in the centre. The postero-dorsal one of these is a long, low ridge, the antero-ventral one short, sharply flexed. In some specimens the anterior lateral teeth of both valves emerge rather deeply from the shell margin, causing the hinge plate to be much excavated in front of the cardinals. Ligament short, hardly visible exteriorly.

Dimensions: length up to 4.3 mm, height up to 3.7 mm, diam. 2.4 mm.

Distribution: Java.

Habitat in Java: recorded from the bottom of Lake Tjigombong, in soft mud and fine gravel at 500 m alt., from a marshy pool in the valley of River Dolog, Dieng Plateau, 2000 m alt., and from the splash basin at the foot of the waterfall at Sarangan, 1250 m alt.

West Java: Depok, in drift of River Tjiliwung; Lake Tjigombong.

Central Java: marshy pool in the valley of River Dolog, Dieng Plateau, 2000 m alt.

East Java: Sarangan, on Mt Lawu, near waterfall, 1250 m.
The animal was amply treated by ODHNER (1940).

***Pisidium* (subg.?) *sundanum* RENSCH, 1934 (fig. 22).**

1934 RENSCH, Trop. Binnengew. 5, p. 247-248, fig. 15-16.

1940 ODHNER, Nova Guinea (N.S.) 4, p. 116.

Shell rounded-oval, subequilateral, rather inflated. Whitish, with relatively strong concentric ribs. Umbones prominent. Hinge strong, in the right valve with two laterals on each side, the antero-ventral one thickest. There is one cardinal tooth in this valve, curved to a nearly right angle. The posterior limb of this tooth is forked.

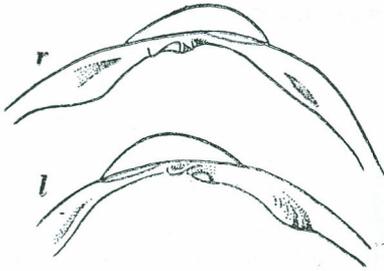


Fig. 22. *Pisidium sundanum*
RENSCH. Hinge of right and left
valves. Author del.

The left valve has one lateral on each side, and two cardinals in the centre. Ligament short, hardly visible exteriorly.

Dimensions: length 3.7 mm, height 3.4 mm, (not 2.3 mm as RENSCH wrote), diam. 3.1 mm.

Distribution: Java.

Habitat in Java: only known from a spring-streamlet ("Quellgraben") near Keleng, on Mt Nukoro near Ngebel, 850 m

alt., Central Java (RENSCH, 1934).

As no soft parts are known the taxonomic position of this species is uncertain.

The shell is somewhat like that of the preceding species, *P. javanum* v. B. JUTTING, but it differs in being more equilateral, more inflated, with stronger concentric ridges, a heavier hinge plate and more projecting umbones.

Dubious species of *Sphaeriidae*.

In 1885 K. MARTIN (Samml. Geol. Reichsmus. Leiden (1) 3, p. 223, pl. 11, fig. 222) described *Sphaerium angulare* from a boring at Blakan Kebon, near Semarang in Central Java. Depth and age of the layer in which the single right valve was found, are unknown. VAN DER VLERK (1931, Leidsche Geol. Meded. 5, Feestbundel MARTIN, p. 281) quoting the original reference, tentatively classified the fossil as Pliocene.

As the occurrence of a *Sphaerium* in tertiary deposits of Java seemed somewhat questionable¹⁾ I asked permission to examine the shell in the Rijksmuseum van Geologie at Leiden. There I could ascertain that the valve has a deep pallial sinus, a feature never occurring in *Sphaerium*. This characteristic, as well as the faint oblique posterior ridge, and the shape and position of the hinge teeth made me decide in favour of a member of the family Tellinidae, and certainly not a *Sphaerium*.

¹⁾ All other fossils from this boring (of equal unknown depth and age) were without exception marine species (genera *Pleurotoma*, *Terebra*, *Murex*, *Nassa*, *Natica*, *Dentalium*, *Tellina*, *Cardium*, *Leda*, *Arca*, *Ostrea* etc.)