NON MARINE MOLLUSCA FROM FOSSIL HORIZONS IN JAVA WITH SPECIAL REFERENCE TO THE TRINIL FAUNA

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With 4 tables, 1 map, 9 plates, and 5 textfigures

CONTENTS

PREFACE

The following report is based in the first place on the important collection of fossil non-marine mollusca made by Prof. Eug. Dubois at Trinil and vicinity (East Java) during excavations in the years 1890 to 1900. It is the very same region where Prof. Dubois discovered the famous remains of his *Pithecanthropus erectus,* a man-like primate. The structure and affinities of this fossil being have not only roused the general interest of naturalists and occupied them for almost the last 40 years, but they appeal also to the imagination of the whole mankind in past, present and future.

The entire Dubois Collection is now preserved at Leiden, as a special part of the collections of the Rijksmuseum van Natuurlijke Historie, under the immediate supervision of the collector.

I take great pleasure in expressing to Prof. Dubois my infinite gratitude for entrusting to me the malacological part of his extraordinary collection.

His benevolent interest during the progress of the work was amply demonstrated by various suggestions and useful advice.

My acknowledgments are also due to the late Dr. J. J. A. Bernsen O. F. M., former assistant of Prof. Dubois, as well as to the present assistant Dr. L. D. Brongersma.

Secondly I had at my disposal a small, but valuable collection excavated in 1907 by Prof. Dr. J. Elbert during an expedition in the neighbourhood of Trinil and at the base of Mount Pandan, some miles east of Trinil in the S. Kendeng Mountains.

The Elbert shells were presented to the Museum of the Senckenbergische Naturforschende Gesellschaft at Frankfort on the Main (Germany). Through the kind intervention of Dr. F. Haas, former curator of Mollusca at the Senckenberg Museum, the authorities of the Society most graciously allowed me to study these specimens along with the Dubois collection. I have to thank Dr. Haas for support on various occasions which has greatly contributed to facilitate my path.

In the third place I was allowed to describe the non-marine mollusca collected by members of the Staff of the Geological Survey of the Netherlands Indies at Bandoeng (Java) during recent explorations in the residencies Bodjonegoro, Soerabaja, Madioen and Kediri (East Java). Part of these samples were sent linea recta to Amsterdam; a still greater part together with an enormous quantity of marine shells were conveyed from the Bandoeng Institute to Prof. L. Rutten of Utrecht for definite distribution among specialists.

He put the Gastropods in the hands of Dr. R. IJzerman and the Bivalves into those of Dr. J. F. van Tuyn and both started with sorting the material and making a few preliminary notes. After some time, unfortunately, Dr. Van Tuyn died and Dr. IJzerman had to give up the subject before a final report could be completed.

At that moment Prof. Rutten allowed me to lift the freshwater shells out of the Bandoeng collection and to implicate them in my survey of the non-marine mollusca of Trinil and vicinity. For his interest and his confidence in my work I have to express to Prof. Rutten my sincere gratitude. To Dr. IJzerman and to the late Dr. Van Tuyn I am very much indebted for their generosity in putting at my disposal such notes and descriptions as originally were to serve their own investigations.

The fourth collection which I could glance over are a number of shells collected by the Trinil Expedition of Mrs. Selenka in the years 1907 and 1908. The malacological collections, after description by Prof. Dr. K. Martin and Mrs H. Martin-Icke, were deposited in the Musea of Berlin and Leiden.

It is this latter set, which, owing to the courtesy of the Director of the Leiden Geological Museum, Prof. Dr. B. G. Escher, and of the curator, Dr. I. M. van der Vlerk, I could consult for comparison. Besides I profited a great deal from the older collections of this institute, containing various species described or identified by Prof. Martin.

Apart from the Selenka shells the Leiden Geological Museum provided me with another collection of Quarternary fossils from about the same region in East Java, only preliminarily investigated by Dr. IJzerman. They were collected during the years 1930 and 1931 by Dr. J. Cosijn and presented to the above mentioned institute. I was allowed to select the freshwater shells only, leaving the marine ones for future workers.

Another lot, which I received from the Geological Museum in Delft was also collected during the Trinil Expedition in 1907 and 1908. These shells can be considered as duplicates of the Selenka collection. They were presented to the Delft institute by Ir. W. F. F. Oppenoorth, mining engineer, who joined the German expedition as a leader of excavations.

I am very much indebted to Prof. J. H. F. Umbgrove, Director, and to Dr. P. Kruizinga, curator of the Geological Museum in Delft, for putting the shells immediately at my disposal as soon as I had made an application.

INTRODUCTION

Our knowledge of localization and composition of the non-marine molluscfauna in the fossilbearing beds in Java has for a long time remained in a very unsatisfactory state. The two principal reasons which may account for this are: 1. the discontinuous and incomplete exploration of the proper fossil loci, and 2. the imperfect state of our knowledge of the recent non-marine molluscan fauna of the island for many years.

A critical comparison of both recent and fossil shells by one and the same author therefore was always an impossibility. The malacologists did not trouble about such shells as existed—let us say—before the European occupation of the colony, and the geologists and palaeontologists generally underestimated the value of the recent fauna, if they considered it at all.

In recent years, however, an appreciable change for the better has supervened, both in the geological field-exploration and in the malacological investigation of the island, and to day we may safely say that each branch of research in its own line has reached a fairly satisfactory state. Little or no attempt, however, has been made to unite the study of extinct and living fauna, or to consider the development of the non-marine shells from fossil layers in the general conception of molluscan evolution.

It goes without saying that from a zoological—better malacological—point of view the question is certainly worth studying. That moreover geologists and palaeontologists will also be interested in the subject was already anticipated by Van Es (1931 [1]), p. 29):

"...... a thorough investigation of the species of *freshwater Molluscs* will lead to important results with regard to a demarcation of Pliocene and Quaternary beds.

The *fresh-water* beds, however, are as yet insufficiently recorded and the determination of the *Molluscs* has been neglected, excepting those of the **Trinil** beds.

A comparative study of the *fresh-water Molluscs* of the Pliocene and Quaternary beds is to be considered as very urgent and should likewise embrace the phylogenetic evolution of some genera and species of *Melania* and *Paludina.*

A better knowledge of these Molluscs is of special interest with regard to those occurring in or alternating with an established marine fauna.

As *marine Molluscs* seem to fail in the Lower Quaternary, the possibility of a stratigraphic division of the Quaternary beds depends for a great deal upon the investigations regarding the *freshwater Molluscs*".

Now the great privilege granted to me by Prof. Dubois in offering his valuable collection of fossil non-marine mollusca from Trinil for further description and discussion, gave me the unique opportunity to venture a comparative and critical study of all the fossil land and freshwater shells recorded from Java.

SYNOPSIS OF THE STRATA YIELDING FOSSIL NON-MARINE MOLLUSCA

Geologically speaking land and freshwater molluscs are of rather modern appearance in the natural history of the island. Apart from some odd species of *Faunus, Thiara* (= *Melania*) and *Neritina* (s.l.) in older deposits (Van der Vlerk, 1931, p. 254—255 and 262) the bulk of the non-marine mollusca does not appear prior to the Middle Pliocene, all previous horizons yielding sea shells only. No freshwater fauna has been described either from the Lower Pliocene, or from older strata.

Of the geological formations containing fossil land and freshwater molluscs some are considered to be of Middle, some of Upper Pliocene, some of Pleistocene age. Moreover a certain number of species, dated as

1) Full bibliographical reference will be found on p. 177 of this paper.

subrecent, is known from prehistoric kitchen middens in a rock shelter in Central Java.

By way of introduction I will begin by bringing up from literature a list of all localities in Java where fossil non-marine shells have been discovered, classified according to their supposed age. Not being a geologist myself I have to rely entirely upon other people's opinion on the chronological sequence of the layers and on the correlation of the contemporaneous horizons [1]). For this purpose I adopt the interpretation of Van Es (1931), because it is, more than any other, based on ample field exploration and on a broad standard of combination and criticism [2]). In doing so I am well aware that from the very beginning certain investigators will disagree with me, first and foremost Prof. Dubois himself in so far as concerns the determination of the age of his classic field of research, the Trinil beds. The facts and discussions which follow in the chapters 4 and 6 will bring out whether his opinion or another should finally be adopted.

In the special case of Trinil it is not unamusing to follow the various authors in their disputations and controversies about the chronological demarcation of the deposits.

Quite a considerable state of affairs was enumerated by Van Es (1931). I wonder if scientists will ever arrive at a definite opinion? Every new paper increases the difficulties, because each zoological, botanical, geological or other special angle from which the problem is approached requires a separate technique and train of thoughts which can never be fully overlapped by any other.

Soemberringin Fauna

The deposit is identified as Middle Pliocene (Van Es, 1931, p. 64 and 116). Not more than 3 genera have been recorded, in two cases even without specific names.

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1) It is a well known fact that stratigraphical arrangement and parallelization of the fossil remains at the various localities is a matter of continuous trouble and confusion, and even in 1919 I find the following complaint of Prof. Martin (1919, p. 33—34): „Das gegenseitige Lagerungsverhältnis ist... nur ganz ausnahmsweise bekannt. Die palaeontologischen Untersuchungen konnten somit nur in den seltensten Fällen mit stratigraphischen in Verband gebracht werden, ein Übelstand, der sich... stets fühlbar machte und die Arbeit selbstredend ungemein erschwerte, denn fast jeder Fundort verlangte infolgedessen eine gesonderte Behandlung und Altersbestimmung".

2) Two recent publications of Von Koenigswald (1934, 1935) proposing a somewhat different view of the stratification of the Javanese Pleistocene can provisionally be left aside, as they do not touch upon malacological matters. Later, in chapter 6, they will receive due acknowledgment.

Isidora spec.
Thiara spec., syn. *Melania* spec.
Viviparus javanicus (v. d. Busch), syn. *Paludina javana* (sic!) v. d. Busch.

As I have not seen the specimens, I cannot judge whether the *Isidora* is related to the Boemiajoe and Trinil shells which nowadays should be transferred to *Ameria,* but I consider it highly probable.

The name *Melania* Lamarck 1799 has to be dropped in favour of *Thiara* Röding 1798. Several authors, moreover, prefer to employ the subgeneric names for a better classification of this large and polymorphous genus.

Paludina should be replaced by the earlier *Viviparus* and *javana* is obviously a misprint for *javanica.*

Boemiajoe Fauna

The whole of the extensive Boemiajoe Fauna is almost unanimously placed in the Pliocene period, though, as is to be expected, the successive strata represent different periods. At one time an encroachment of the sea took place, at another the sea retired again, thus causing different modes and different products of sedimentation (Van Es, 1931, p. 48 and 126).

In a recent paper Oostingh (1935) has published an extensive account of the rich malacological population, its frequency and its distribution in the successive zones. Most of the species are of marine origin and belong to the two oldest deposits: Tapak beds and Kali Bioek beds, both Middle Pliocene, in which freshwater shells are not very frequent. The uppermost horizon, however, the socalled Kali Glagah beds, contain a greater number of lacustrine elements. This layer is dated Upper Pliocene.

In the same paper Oostingh with his usual gift for bibliography deals exhaustively with all previous literature on the Boemiajoe Fauna and this discharges me from further quotation and discussion.

The following list of species is adopted from Dr. Oostingh's paper

Tapak beds (= breccia zone)

No freshwater shells but *Thiara tornatella* (Lea) [syn. *Sermyla tornatella* (Lea)] the environment of which (whether brackish or freshwater) is unknown.

Kali Bioek beds (= Turritella zone)

Theodoxus (Clithon) spec.
Thiara scabra (Müll.), syn. *Thiara tjemoroensis* (Martin).
Thiara tuberculata (Müll.), syn. *Melanoides woodwardi* (Mart.).
Thiara tuberculata tuberculata (Müll.), syn. *Melanoides tuberculata tuberculata* (Müll.).
Thiara tuberculata tegalensis (Oostingh), syn. *Melanoides tuberculata tegalensis* Oostingh.

Thiara granifera (Lam.), syn. *Melanoides junghuhni* (Mart.).
Brotia oppenoorthi Oostingh.
Brotia testudinaria (v. d. Busch), syn. *Sulcospira testudinaria* (v. d. Busch).
Brotia foeda (Lea), syn. *Sulcospira foeda* (Lea).
Viviparus javanicus (v. d. Busch).
Corbicula gerthi Oostingh.
Ganesella martini Oostingh.

Kali Glagah beds (= Vertebrate zone)

Thiara scabra (Müll.).
Thiara scabra (Müll.), syn. *Thiara tjemoroensis* (Martin).
Thiara tuberculata (Müll.), syn. *Melanoides woodwardi* (Mart.).
Thiara tuberculata tuberculata (Müll.), syn. *Melanoides tuberculata tuberculata* (Müll.).
Thiara tuberculata tegalensis (Oostingh), syn. *Melanoides tuberculata tegalensis* Oostingh.
Thiara zollingeri fennemai (Martin), syn. *Melanoides fennemai* (Mart.).
Thiara granifera (Lam.), syn. *Melanoides junghuhni* (Mart.).
Thiara granifera (Lam.), syn. *Melanoides flavida* (Dkr.).
Thiara granifera (Lam.), syn. *Melanoides tjariangensis* (Mart.).
Thiara granifera madiunensis (Martin), syn. *Melanoides madiunensis* (Mart.).
Thiara preangerensis (Mart.), syn. *Melanoides preangerensis* (Mart.).
Thiara fallax (Oostingh), syn. *Melanoides fallax* Oostingh.
Thiara martini (Oostingh), syn. *Melanoides martini* Oostingh.
Brotia oppenoorthi Oostingh.
Brotia testudinaria (v. d. Busch), syn. *Sulcospira testudinaria* (v. d. Busch).
Brotia foeda (Lea), syn. *Sulcospira foeda* (Lea).
Viviparus javanicus (v. d. Busch).
Pila conica (Gray).
Lymnaea javanica (Mouss.).
Gyraulus convexiusculus (Hutton).
Ameria duboisi nov. spec. (cfr. p. 98 of this paper, syn. *Isidora* (*Ameria*?) spec.).
Elongaria orientalis (Lea).
Pseudodon vondembuschianus vandervlerki (Oostingh), syn. *Pseudodon vandervlerki* Oostingh.
Corbicula gerthi Oostingh.
Corbicula pullata (Phil.).
Ganesella martini Oostingh.

At my request Dr. Oostingh kindly forwarded me the 5 (defective) shells of *Ameria* and 3 (incomplete) valves of his *Pseudodon vandervlerki* for examination. A few remarks on their systematic position will be inserted later on in chapter 4 when discussing the genera *Ameria* and *Pseudodon* respectively.

Sangiran Fauna

The freshwater excavations described from Sangiran are classified as Upper Pliocene (Van Es, 1931, p. 61 seq., 128 and 136). The deposit consists of several subordinate layers of which especially the so called *Corbicula*-beds, the volcanic breccia and the black clay contain freshwater fossils.

In the list of species on p. 65 and in the discussion on the preceding page Van Es arrives at a total of 11 species. At the foot of the list, however, and also on p. 64 he mentions a species of *Unio* and a few (how many?) *Melania*'s besides, but he does not include them in the final addition. In another table again, at p. 136, the *Unio* is supplemented indeed, but no *Melania*'s occur other than the forms listed at p. 65, thus making a sum of 12 species.

Isidora spec.
Brotia variabilis (Benson), syn. *Melania soloënsis* Mart.
Brotia testudinaria (v. d. Busch), syn. *Melania testudinaria* v. d. Busch.
Thiara scabra (Müll.), syn. *Melania tjemoroënsis* Mart.
Thiara scabra (Müll.), syn. *Melania granum* v. d. Busch.
Thiara bojolaliensis (Martin), syn. *Melania bojolaliënsis* Mart.
Thiara zollingeri fennemai (Mart.), syn. *Melania fennemai* Mart.
Thiara granifera (Lam.), syn. *Melania kritjanensis* Mart.
Thiara nov. spec., syn. *Melania* nov. spec.
Viviparus javanicus (v. d. Busch), syn. *Paludina javanica* v. d. Busch.
Corbicula exporrecta Mart.
Species of Najad, syn. *Unio* spec.

According to modern taxonomy the *Unio* can no longer be maintained in this genus, but undoubtedly belongs to another. Without having seen specimens I must abstain from further judgment.

With respect to the *Isidora* I must refer to the suggestion already given in the paragraph of the Soemberringin Fauna.

Kali Tjemoro Fauna

The formation mentioned by Martin (1919, p. 139 under c) from the Kali Tjemoro, upstream Tandjong I compute at Upper Pliocene also. It contains the following fossils:

Thiara zollingeri fennemai (Martin), syn. *Melania fennemai* Mart.
Thiara scabra (Müll.), syn. *Melania granum* v. d. Busch.
Thiara scabra (Müll.), syn. *Melania tjemoroënsis* Mart.
Thiara granifera (Lam.), syn. *Melania kritjanensis* Mart.
Viviparus javanicus (v. d. Busch), syn. *Paludina javanica* v. d. Busch.

Baringinan Fauna

The horizon of Baringinan, containing non-marine fossil molluscs, corresponds to the just mentioned Sangiran beds and like these belongs to the Upper Pliocene. It can be divided in a lower bed, containing *Corbicula exporrecta*, and a superposing association of greater importance as such explicitly freshwater genera like *Lymnaea, Planorbis* and *Segmentina* are represented (Van Es, 1931, p. 74, 128 and 136).

Viviparus javanicus (v. d. Busch), syn. *Paludina javanica* v. d. Busch.
Brotia testudinaria (v. d. Busch), syn. *Melania testudinaria* v. d. Busch.
Lymnaea spec.
Isidora spec.
Planorbis spec.
Segmentina spec.
Hydrobia spec.

It is a pity that in the majority of cases a specific name could not be ascertained. Especially would the proper position of the *Planorbis* (whether *Gyraulus* or *Planorbis* s. str.) and the *Hydrobia* contribute to a better knowledge of the formation. No true *Planorbis* or *Hydrobia* is represented in the recent fauna of Java, and it would be important to determine the exact relationship of these fossils.

As regards the generic name *Isidora* I must refer to the remark already made in a previous paragraph.

Boetak Fauna

This is the last horizon of the Upper Pliocene which we have to discuss. It can hardly be designated a „fauna" because only three species are recorded (Van Es, 1931, p. 100 and 128):

Isidora spec.
Thiara spec., syn. *Melania* spec.
Corbicula spec.

Patih Ajam Fauna

With the Patih Ajam Fauna palaeontologists presume to enter a new stratigraphical area, the Pleistocene. From our point of view it is not a very important horizon, only

Viviparus javanicus (v. d. Busch), syn. *Paludina javanica* v. d. Busch and
Thiara div. spec., syn. *Melania* diff. spec.

having been recorded (Van Es, 1931, p. 54 and 128). On his authority I adopt the opinion that "there is hardly any doubt that the beds represent the same horizon as the Trinil beds".

Trinil Fauna

The Trinil Fauna has been subject to frequent discussion and much controversy among scientists, even till in our days. A definite solution is still to be waited for.

Ever since the excavations at Trinil and thereabouts in the last decade of the 19th century the principal interest has centred on the bone remains, especially the mammalian. Compared with the Vertebrates the study of the non-marine mollusca has been more or less neglected, probably because the shells were not considered of high value (Dubois, 1908, p. 1250 and 1253).

With the exception of a few preliminary notes by Dubois and some scanty remarks by Elbert 1908, Alter der Kendeng-Schichten, and 1909 only two short reports on the Gastropods and the Lamellibranchs have been published by Mrs. Martin and Prof. Martin (both in 1911). All later references in literature are based on these papers, no records of new material having been published.

The account of Trinil molluscs presented by Van Es (1931, p. 136) is entirely based on the publications of Martin and Martin-Icke.

Amphidromus palaceus (Mouss.), syn. *Bulimus citrinus* Brug. [1]).
Landouria rotatoria (v. d. Busch), syn. *Helix rotatoria* v. d. Busch.
Lymnaea javanica (Mouss.), syn. *Limneus rubiginosa* Michel.
Gyraulus convexiusculus (Hutt.), syn. *Planorbis tondanensis* Quoy et Gaim.
Ameria duboisi nov. spec., syn. *Physa* spec. (= *Isidora* spec.).
(cfr. p. 98 of this paper).
Brotia testudinaria (v. d. Busch), syn. *Melania testudinaria* v. d. Busch.
Brotia testudinaria forma *scalaroidea* (Mouss.), syn. *Melania infracostata* Mouss. [1]).
Thiara tuberculata (Müll.), syn. *Melania tuberculata* Müll.
Thiara scabra (Müll.), syn. *Melania granum* v. d. Busch.
Thiara zollingeri (Brot), syn. *Melania savinieri* Brot.
Thiara granifera (Lam.), syn. *Melania verrucosa* Hinds.
Thiara spec., syn. *Melania* spec.
Bithynia truncata (Eyd. & Soul.).
Viviparus javanicus (v. d. Busch), syn. *Paludina javanica* v. d. Busch.
Pila conica (Gray), syn. *Ampullaria scutata* Mouss. and *A. ampullacea* L. [1]).
Elongaria orientalis (Lea), syn. *Unio productus* Linn.
Pseudodon vondembuschianus trinilensis (Dubois), syn. *Unio trinilensis*? Dubois.

In the present paper the problem is again touched upon, now as seen by a malacologist. I have reexamined the molluscs of the Selenka Expedition from the Leiden Geological Museum and besides I identified a great quantity of new material from the different collections mentioned in chapter 2 of this paper. Though a certain number of the samples were not excavated in the immediate vicinity of Trinil itself, but at various distances to the West and the East of this village, yet they are implicated in the present research because they supply valuable information to our knowledge of the stratigraphical succession and the chronological order of the different layers. On the accompanying sketch map the reader is informed about the general topography of the region.

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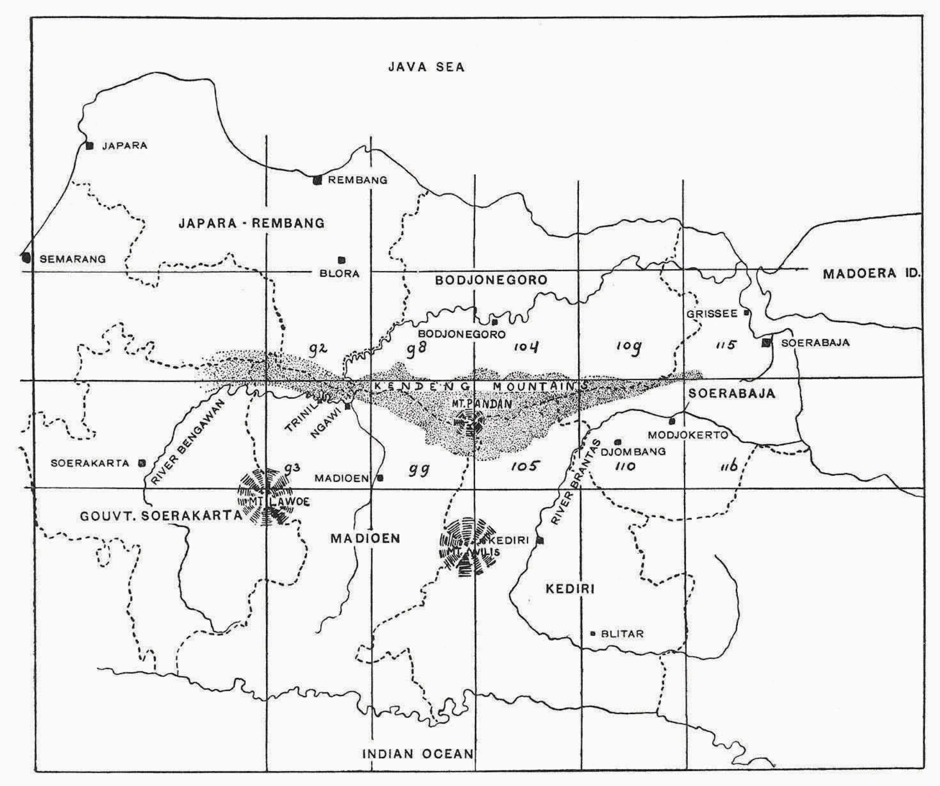
1) It escapes my notice why Van Es (1931, p. 136) records these 3 species from "South of Mt. Pandan". In Mrs Martin's report (1911, p. 51) they were mentioned from Trinil and the labels in the Leiden Geological Museum also bear Trinil as locality.



Sketch map of East Java, showing the Kendeng Region. The numbers refer to the Sheets of the Geological Map.

Notopoera Fauna

A little younger than the Trinil layers are the Notopoero beds in the Kendeng Mountains (Van Es, 1931, p. 102). From a malacological point of view this formation is quite unimportant, only "*Melania*", without further indication being represented (Van Es, l.c., table facing p. 132).

SYSTEMATIC SURVEY OF THE SHELLS

Amphidromus palaceus (Mousson)

1849 Mousson, Land und Süssw. Moll. Java, p. 28 and 108, pl. 3 fig. 1 (*Bulimus palaceus*).
1908 Branca, p. 270 (*Bulimus citrinus*).
1908 Dubois, p. 1249 (eine *Bulimus*).
1908 Martin, p. 14 (*Bulimus citrinus*).
1911 Carthaus, p. 13 (*Bulimus citrinus*).
1911 Martin-Icke, p. 51 (*Bulimus citrinus*).

1919 Martin, p. 69 (*Bulimus citrinus*).
1921 Hilber, p. 150 footnote (*Bulimus citrinus*).
1931 Van Es, p. 136 (*Bulimus citrinus*).
1931 Van der Vlerk, p. 208 (*Bulimus citrinus*).

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 7296. Trinil: 1 spec. (sinistral), height 47 mm, breadth 25 mm, height of aperture (exteriorly) 23 mm.

There is no doubt that this specimen should be inserted as *Amphidromus palaceus*. Its two principal characters (not counting the coloration which is no longer present in this fossil shell) are: the perforated umbilicus and the rather strong striation of the shell causing the suture to appear subcrenulated (Pilsbry, Man. of Conch., vol. 13, 1900, p. 134, pl. 47 figs 1, 2, 4, 5, 6). Martin (1908, p. 15) properly remarked that the condition of preservation of the *Amphidromus* leaves no doubt that the specimen must originate from the immediate vicinity of the place of interment, the shell being so well kept and not showing traces of wear due to transportation.

The real *Bulimus citrinus* Brug. is synonymous with *Amphidromus perversus* (L.), a quite different species.

Amphidromus palaceus occurs in the recent fauna of Java throughout the whole island (West, Middle and East), but not beyond it.

Another, incomplete, *Amphidromus* specimen was found near River Ngetas (Sheet 99 B, No. 18, Collection of the Geological Survey, Bandoeng) in the Kaboeh layers. As it is only a fragment of a sinistral shell (aperture only) further identification unfortunately is not possible.

Chloritis transversalis (Mousson)

1857 Mousson, Journ. de Conch., vol. 6, p. 158, pl. 6 fig. 5 (*Helix transversalis*).
1911 Martin-Icke, p. 46 (*Helix* spec.).

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 7293. Padas Malang: 1 spec., well preserved, only the aperture a little broken. Max. diam. 14, min. diam. 11, height 9 mm.

Collection of the Geological Survey, Bandoeng

Sheet 99 B No. 18. River Ngetas, Kaboeh formation[1]): 2 spec., max. diam. 14 and 13 mm, min. diam. 11 and 10 mm, height 9 and 8 mm respectively.

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1) The names for the subdivisions of the Pliocene and Pleistocene which are in use in this paper are discussed in chapter 6 and on table II and III.

With respect to the specimen of the Selenka Expedition Mrs. Martin rightly remarked (l.c., p. 48) that the finding of a land shell in a deposit of almost exclusively marine species (Sonde formation) must certainly be attributed to accidental washing away. An exact determination of that animal's age therefore is impossible, though it is most probable that the specimen should belong to the Trinil fauna.

From the equivalent of the Trinil beds, the Kaboeh layers, two well preserved shells were disclosed.

In the recent fauna of Java *Chloritis transversalis* is only noted with some doubt. From the islands of Madoera (north of the tailend of Java) and of Bali (east of Java) documentary specimens are present.

The above shells demonstrate the former occurrence of *Chl. transversalis* in Java. In later centuries it emigrated to islands eastward of Java.

Landouria rotatoria (v. d. Busch)

1842 Von dem Busch, in Philippi, Abb. & Beschr., vol. 1, p. 10, pl. 1 fig. 5 (*Helix rotatoria*).
1911 Carthaus, p. 13 (eine kleine *Helix*-Form).
1911 Martin-Icke, p. 50 (*Helix rotatoria*).
1919 Martin, p. 69 (*Helix rotatoria*).
1921 Hilber, p. 150 footnote (*Helix rotatoria*).
1931 Van Es, p. 136 (*Helix rotatoria*).
1931 Van der Vlerk, p. 208 (*Helix rotatoria*).

The single specimen, collected at Trinil by the Selenka Expedition seems to be lost. It is not preserved in the Leiden Geological Museum, and not in the Geological-Palaeontological Museum of Berlin either.

It is the only fossil record of the species. The recent distribution comprises Sebesi, Java, Bali, Lombok, Soembawa, Flores, Timor and the Philippines.

Ellobium aurisjudae (Linné)

1758 Linné, Syst. Nat., Ed. X, p. 728, no. 345 (*Bulla Auris Judae*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 B No. 172. Trench to Kampong[1]) Soekomoeljo, Poetjangan layers, layer II: 1 spec., high 48 mm, broad 20.5 mm.

A typical, well preserved shell, the first fossil *Ellobium* from Java.

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1) The Malay word Kampong means Native village. Goenoeng = Mountain, Kali = River.

Pythia spec.

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 98. Mount Grobogan, Poetjangan layers: 1 incomplete spec.

Cosijn Collection

Locality 54. North of Kampong Soembergondang, Poetjangan layers: 1 incomplete spec.

In both specimens the aperture is missing for the greater part. The first has a damaged spire besides. Therefore I have abstained from further identification.

Gyraulus convexiusculus (Hutton)

1850 Hutton, Journ. As. Soc. Bengal (2) vol. 18, p. 657 (*Planorbis convexiusculus*).
1911 Martin-Icke, p. 50 (*Planorbis tondanensis* Quoy et Gaimard em. Mousson).
1919 Martin, p. 69 (*Planorbis tondanensis*).
1931 Van Es, p. 136 (*Planorbis tondanensis*) and perhaps p. 74 (*Planorbis* spec.).
1931 Van der Vlerk, p. 208 (*Planorbis tondanensis*).
1935 Oostingh, p. 117.

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 7299. Trinil: 1 spec., max. diam. 4, min. 3, height 1 mm.

I have reexamined the little ram's horn shell which Mrs Martin recorded from Trinil as *Planorbis tondanensis* in the conception of Mousson. In the first place it belongs to the group of small, fragile species nowadays put together as *Gyraulus*. Secondly Mousson's opinion of *Planorbis tondanensis* is covered in modern taxonomy by *Gyraulus convexiusculus*. The true *tondanensis* shows a different mode of coiling and possesses a wider terminal volution [1]). A good figure of *tondanensis* was published by Kobelt (Abh. Senck. Naturf. Ges., vol. 24, 1897, pl. 11 fig. 3).

Gyraulus convexiusculus is a common species in the recent fauna of Java. A few remarks on its variability may be found in two publications of Van Benthem Jutting (Treubia, vol. 13, 1931, p. 5 ff.) and Rensch (Trop. Binnengew., vol. 5, 1934, p. 209 ff.).

The oldest record in Java belongs to the Kali Glagah beds (Boemiajoe Fauna) estimated Upper Pliocene (Oostingh, l.c.).

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1) Mousson (Land und Süssw. Moll. Java, 1849, p. 44) noticed these differences: "...in der Figur (of *tondanensis* Quoy & Gaimard, Voy. Astrolabe, vol. 2, 1832, pl. 58 fig. 39) hingegen, erscheint die äusserste Windung im Verhältnis zu den früheren etwas grösser als in unserer Art" etc., and "Auf der Unterseite sind die Windungen etwas flacher convex als auf der Oberseite, daher der gerundete Rücken etwas, doch wenig, näher an jener Seite liegt", but he did no attach adequate value to them.

In our days the distribution of the species reaches from Mesopotamia, Persia, Afghanistan, India, the Malay Peninsula, Japan, China and the Philippines to Poeloe Weh, Sumatra, Java, Bali, Lombok, Soembawa, Soemba, Celebes and Boeroe.

Lymnaea javanica (Mousson) (Plate IV figs. 1—5).

1849 Mousson, Land und Süssw. Moll. Java, p. 42, pl. 5 fig. 1 (*Limnaeus succineus* var. *javanica*).
1908 Branca, p. 272 (*Limnäus*).
1908 Dubois, p. 1249 (*Limnaeus*).
1908 Elbert (Nieuwste Onderzoekingen), p. 129 (*Limnaeus*).
1911 Martin-Icke, p. 50 (*Limnaeus rubiginosus*).
1919 Martin, p. 69 (*Limnaea rubiginosa*).
1931 Van Es, p. 74 (*Lymnaea*) and p. 136 (*Limneus rubiginosa*).
1931 Van der Vlerk, p. 208 (*Limnaea rubiginosa*).
1935 Oostingh, p. 117.

Material examined:

Dubois Collection

No. 9769. Trinil: 2 spec., slender, high 17, 16 mm, broad 10, 10 mm.
No. 9771. „ : 9 spec., slender, high 24, 21, 21, 20, 19, 17, 16, 16, 15 mm, broad 14, 12, 11, 12, 11, 9, 9, 8, 8 mm.

Selenka Collection (Leiden Geological Museum)

St. No. 7297. Trinil: 1 spec., high 17, broad 11 mm.
St. No. 7298. „ : 5 spec., high 24, 20, 16, 15, 14 mm, broad 13, 11, 9, 8, 8 mm.
Both samples of the same slender form.

Collection of the Geological Survey, Bandoeng

Sheet 105 A No. 38. River Senantok, Kaboeh layers: 1 spec., a little damaged by pressure, not measured; slender form.
Sheet 110 A No. 98. Mount Grobogan, Poetjangan layers: 3 spec., all incomplete, one belongs to slender form, others inflated.

Cosijn Collection

Locality 60. North of Kaboeh, Poetjangan layers: 1 spec., high 12, broad 8 mm.

It is curious that most of the fossil shells are of the slender type. It can be designated as *Lymnaea javanica typica*, because it answers best to the description and figure in the original diagnosis of Mousson.

A similar slender form was recorded by Oostingh from the Kali Glagah beds in the Boemiajoe Fauna which is credited a little older than the Trinil formation. Oostingh brings his best preserved specimens (the others are immature or caducous) to *Lymnaea javanica angustior* Marts., a variety quite close to the typical form.

Of the two inflated specimens from Mt. Grobogan (Sheet 110 A No. 98) it is difficult to say with which of the many—not always clearly defined—varieties of *Lymnaea javanica* they should be united. In the ms. notes of Dr. IJzerman I find a suggestion to the var. *subteres* Marts. (Conch. Mitt., vol. 1, Heft 5 and 6, 1881, pl. 16 figs. 6—7), but there is also a certain resemblance to the var. *intumescens* Marts. (ibid., pl. 16 figs. 2—4).

The recent distribution of the species comprises Sumatra, Banka, Java, Bali, Lombok, Soembawa, Flores, Soemba, Rotti, Semaoe, Timor, Borneo, Celebes and Boeroe.

In a fossil state it occurs since the Upper Pliocene.

Ameria duboisi nov. spec. (Plate IV figs. 6—9)

Shell oval to pear-shaped, with small apex and large ultimate whorl. Sculpture consisting of fine growth lines of irregular strength becoming a little more conspicuous just below the suture. Opaque, a little shining. No colour, no epidermis. Aperture oblique.

Whorls 4—4$^{1}/_{2}$, in some specimens rather inflated and forming a conspicuous "shoulder". In others the shoulder is less distinct, so as to fade away almost entirely in one or two specimens. Suture well defined, but not deep. Aperture oblong, rounded at the base and more pointed to the top. Height of the mouth generally more than half the height of the entire shell. Lip not continuous, sharp, not reflected, only a little deflected outwardly at the base. No siphonal canal, no umbilicus. Columella with a small fold.

Dimensions (in mm):

	a (type)	b	c	d	e	f	g	h	i	j	k	l	m
height	14	*19*	13	12	*22*	19	16	15	*13*	*10*	18	*17*	*14*
breadth	9	12	8	7	13	11	10	9	*9*	*10*	11	11	9

The numbers in italics indicate that the measurements do not give the size of the shell accurately, owing to malformation or incompleteness of the fossil.

Material examined (in the same sequence as the table of dimensions):

Dubois Collection

No. 9769. Trinil (a, b): 2 spec., a is the type; of the other spec. the apex is missing.

Selenka Collection (Leiden Geological Museum)

St. No. 7300. Trinil (c): 1 spec.

Collection of the Geological Survey, Bandoeng

Sheet 105 B No. 68. River Brangkal, Poetjangan layers (d): 1 spec.
Sheet 105 B No. 71. River Klotok, Poetjangan layers (e): 1 spec.
Sheet 110 A No. 98. Mount Grobogan, Poetjangan layers (f, g, h, i): 4 spec.
Sheet 110 A No. 100. River Soemberringin, Poetjangan layers: (j) 1 spec.

Cosijn Collection

Locality 52. N. E. of Soemberringin, Poetjangan layers (k, l): 2 spec.
Locality 60. North of Kaboeh, Poetjangan layers (m): 1 spec.

In the figures mentioned above the higher or lower degree of shell volume does not stand out satisfactorily. For that purpose I drew up diagrammatic outlines (fig. 1) in order to distinguish the shells with depressed apex and well developed "shoulder" (nos. a, b, c) from the one with a trifle more flattened shoulder (l) and from such specimens which still show this design, albeit still more slender (m and i). In increasing degree of slenderness there follow the nos. k, d, f, g, h, j, and e. This last shell is very robust. It has

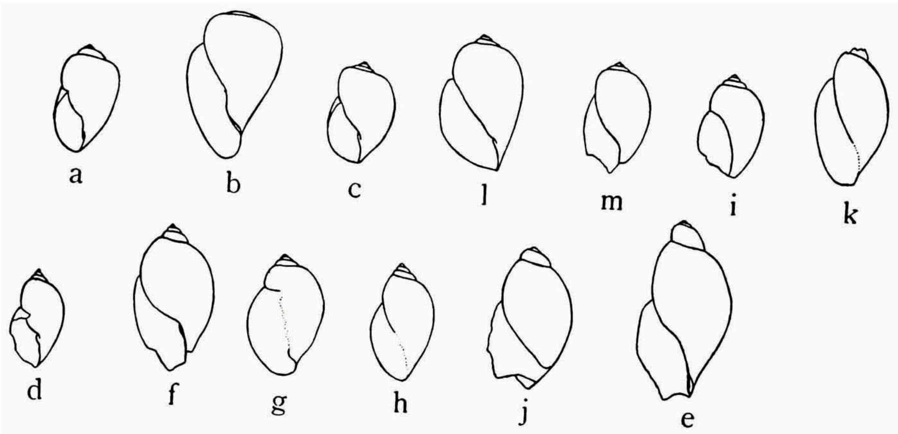

Fig. 1. Diagrams of outline of *Ameria duboisi* specimens. Arranged according to their degree of slenderness. The letters a, b, c, etc., correspond with those in the table of measurements and in the order of the examined material. Natural size.

been damaged a little by pressure, causing it to appear particularly high, in fact abnormally high.

Arranged according to their occurrence in the different formations the specimens can be grouped as follows:

Trinil deposits (Kaboeh layers) a, b, c.

Poetjangan layers d—m.

From this classification there is some evidence that in the oldest horizon (Poetjangan) only evenly curved shells with little or no shoulder occurred. The younger layer, the Trinil deposit, produced conspicuously shouldered specimens, a, b, c. Numbers l, m, and i are more or less intermediate between the two forms.

It is interesting to note that from the 5 *Ameria* excavated at Boemiajoe (Oostingh, 1935, p. 118) which Dr. Oostingh kindly sent me on loan, 4 shells belong to the pattern of our g or h (5th specimen is so small, hardly one mm long, that no further opinion as to the form can be given). It is almost impossible to render a correct impression of the Boemiajoe shells by photo's or drawings as they are partly damaged, partly filled up with hardened sand, so as to hide pieces of the aperture. The dimensions which will follow here should be understood with due reserve, no accurate figures being possible.

	Loc. 194	Loc. 199
height	13 mm	11, 11, 10 mm
breadth	7 mm	7, 7, 7 mm

These specimens were found in the uppermost horizon of the Boemiajoe formation, the so called Kali Glagah beds and this period must be estimated equivalent with the Upper Kalibèng layers in East Java. Phaenotypically they can be ranged without difficulty in the beginning of the evolutionary series, corresponding with their relatively high age. I do not hesitate to name these species *Ameria duboisi* also. They are the oldest *Ameria* known from Java.

From a zoogeographical point of view *Ameria duboisi* can positively be credited the most interesting member of the fossil Trinil Fauna. Not only is it one of the four extinct species[1]) of the formation under discussion, it is moreover a representative of a genus (*Ameria*) and even of a whole family (Isidoridae) no longer indigenous in Java.

In other islands of the Netherlands East Indies, however, the family is abundantly represented nowadays. It comprises three genera with about 30 species, occurring in Sumatra, Celebes, several of the Lesser Sunda Islands and of the Moluccas, and in New Guinea (Van Benthem Jutting, Treubia, vol. 7, Suppl. 1927, p. 15 seq.) and it has been always more or less a puzzle why the family is absent from the recent fauna of Java.

A similar case of another member of the family Isidoridae occurring in fossil deposits, the modern fauna of the region not yielding a single representative is described by Annandale (Rec. Geol. Surv. India, vol. 51, 1920, p. 50—64) for *Bullinus prinsepii* (Sow.) from the Intertrappean (late Cretaceous) beds in the Central Provinces of India.

When considering both the recent and the fossil records of members of the family Isidoridae we see that its distribution extends nearly uninterruptedly from Africa through Asia Minor, Mesopotamia (all recent) to India

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1) The other three are: *Corbicula gerthi* and *C. exporrecta,* and *Polymesoda tegalensis.* Besides there are 3 extinct subspecies: *Thiara granifera madiunensis, Th. zollingeri fennemai* and *Pseudodon vondembuschianus trinilensis.*

(fossil). Then Burma and Malacca are passed (at least no species has been discovered), but thence the chain is ranging almost continuously via Sumatra (recent), Java (fossil), Celebes [1]), the Philippines, some of the Moluccas and some of the Lesser Sunda Islands to New Guinea, Australia, New Zealand, Tasmania, Fiji Islands, Tonga Islands, New Caledonia and the Sandwich Islands (all recent).

In the island of Java fossil shells of *Ameria* (and *Isidora* ?) were found at various localities:

1908 Dubois, p. 1249 (eine *Isidora*).
1911 Martin-Icke, p. 50 (*Physa* spec.).
1919 Martin, p. 69 (*Bulinus* spec. (*Isidora*) and *Physa* spec.).
1931 Van Es, p. 64, 65, 74, 100, 116, 136 (*Isidora* spec.).
1931 Van der Vlerk, p. 208 (*Bulinus* spec., and *Physa* spec.).
1935 Oostingh, p. 118 (*Isidora* (*Ameria* ?) spec.).

Of these six quotations Dubois (1908) and Martin-Icke (1911) are based on actual material from the Trinil deposits, Martin (1919) and Van der Vlerk (1931) only adopting the same references again for their synopses of Javanese fossil shells.

Both Van Es (1931) and Oostingh (1935) dealt with shells of a somewhat older age.

I have only examined the specimens of the Dubois, Selenka and Oostingh collections, not those of the deposits described by Van Es. It remains to be seen whether the species of *Isidora* mentioned by Van Es should be attributed to *Ameria* also.

The case of *Ameria* is again a fine evidence of the extension of the freshwater fauna in eastward direction during the growth of the Javanese continent in the Neogene.

Theodoxus corona (Linné)

1758 Linné, Syst. Nat., Ed. X, p. 777, no. 629 (*Nerita corona*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N. F.), vol. 1, p. 273, pl. 40 figs. 657—659 (*Neritina* (*Clithon*) *brevispina* Lam.).
1911 Martin-Icke, p. 49 (*Neritina* (*Clithon*) *brevispina* Lam.).
1919 Martin, p. 101 (*Neritina brevispina* Lamk.).
1931 Van der Vlerk, p. 262 (*Neritina brevispina* Lamk.).

Material examined:

Dubois Collection:

No. 1246. Padas Malang: 1 spec.
No. 1352. Sonde: 1 spec.

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 257 and 258. Bengawan Solo, South of mouth of River Alastoewa, near Sonde, Upper Kalibèng layers: 1 + 17 spec.

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1) In Borneo no Isidoridae have come to our knowledge so far.

Sheet 93 B No. 260. Bengawan Solo near Bangoenredjo Kidoel, Upper Kalibèng layers: 2 spec.
Sheet 116 A No. 216. North of Kampong Klagenblandong, Poetjangan layers, layer II: 1 spec.

In several specimens of sample 258 part of the shell ornamentation, minute triangles, has been preserved. Five also show traces of black spiral bands and in two the cicatrices of broken spines are visible.

In the recent fauna this is a very common species in almost all the islands of the Malay Archipelago.

The fossil occurrence dates back as far as the Kalibèng layers (Sonde formation).

Theodoxus flavovirens (v. d. Busch)

1843 Von dem Busch, in Philippi, Abb. & Beschr., vol. 1, p. 26, pl. 1 fig. 6 (*Neritina*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 105 B No. 49. Kali Bèng, Poetjangan layers: 1 spec.
Sheet 110 B No. 158. Banjoebanger, Poetjangan layers, layer I: 1 spec.

Both specimens, though not quite complete, are fairly well preserved, showing reminescences of the original ornamentation of black-lined triangles.

In the recent fauna the species is widely distributed in most of the islands of the Indo-Australian Archipelago.

In a fossil state it has been recorded since the Upper Kalibèng layers.

Theodoxus ualanensis (Lesson)

1830 Lesson, Voy. Coq. Zool., vol. 2, p. 379 (*Neritina oualaniensis*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 258. Bengawan Solo, South of mouth of River Alastoewa (near Djetis, Poetjangan layers: 1 spec.

Cosijn Collection

Locality 36. Saddle Kedoengwaroe anticlinal, N.W. of Klagenblandong, North of Djetis, Poetjangan layers: 1 spec.

Both specimens are 6.5 mm high and resp. $6^1/_2$ and 6 mm broad. The ornamentation is well preserved, consisting of closely set black, vertical lines on a cream ground, crossed by 4 spiral bands of triangular spots on the ultimate whorl. On account of these little triangles the shell belongs to the variety *polydelta* Marts.

The recent distribution of the species comprises the area between India and the Pacific Isles, and between South Japan and North Australia.

Our two fossil shells belong to the Sonde Fauna and to the Djetis Fauna. The species is already recorded in the fossil fauna of Java since the Lower Miocene (Van der Vlerk, 1931, p. 262).

Neritina communis (Quoy & Gaimard)

1834 Quoy & Gaimard, Voy. Astrolabe, Zool., vol. 3, p. 195, pl. 65 figs. 12—14 (*Nerita*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 98. River Grobogan, Poetjangan layers: 1 spec., high 16.6, broad 16.4 mm.

Cosijn Collection

Locality 4. Kedoengwaroe anticlinal, North of Klagenblandong, North of Perning, Poetjangan layers: 1 spec., high 19, broad 19.3 mm.

It is the first fossil record of the species. In the recent fauna *Neritina communis* is very common in the whole Malay Archipelago, including the Philippines and New Guinea.

Neritina pulligera (Linné)

1767 Linné, Syst. Nat., Ed. XII, p. 1253 (*Nerita*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 117. River Kedoengkerang, Poetjangan layers: 1 spec.

Cosijn Collection

Locality 34. Saddle of Kedoengwaroe anticlinal, North of Klagenblandong, North of Perning, Poetjangan layers: 1 spec., juv.

Two immature specimens, high resp. 9.5 and 6.6 mm, broad resp. 11.2 and 9.8 mm.

These are the first fossil records of the species. In the recent fauna *Neritina pulligera* is abundant in the whole Indo Aústralian Archipelago.

It is remarkable that until now so very few fossil species of Neritinidae have been excavated in Java. Compared with the recent number of 25 (Van Benthem Jutting, Treubia, vol. 11, 1929, p. 86—87), *Septaria* not included, the 9 fossil species (from all geological formations combined, cfr. Van der Vlerk, 1931, p. 262) indeed make a poor figure.

Stenothyra ventricosa (Quoy & Gaimard)

1834 Quoy & Gaimard, Voy. Astrolabe, Zool., vol. 3, p. 173, pl. 58 figs. 6—8 (*Paludina*).

Material examined:

Dubois Collection

No. 736. Bapang A 87: 8 spec.,
high 2.75, 2.35, 2.3, 2.3, 2.15, 2.1, 2.1, 1.9 mm,
broad 1.65, 1.45, 1.35, 1.3, 1.3, 1.3, 1.25, 1.15 mm.
No. 9665. Tjenklik near Solo C 126: numerous spec., dimensions of the 10 largest:
high 2.8, 2.8, 2.8, 2.6, 2.5, 2.5, 2.5, 2.4, 2.4, 2.35 mm,
broad 1.7, 1.65, 1.55, 1.6, 1.5, 1.5, 1.5, 1.4, 1.4, 1.4 mm.
No. 9677. Bogo: numerous spec.
No. 9678. Bogo: 8 spec.
No. 9680. Bogo: numerous spec.

In the recent fauna the species is recorded from Java, Soembawa, Soemba and Celebes (Martens, in: Weber, Erg. Reise Niederl. Ost Indien, vol. 4, 1897, p. 210—211; Schepman, Notes Leyden Mus., vol. 15, 1893, p. 155; Rensch, Zool. Jahrb. (Syst.), vol. 65, 1934, p. 399—400). During renewed investigations in Verlaten Island, one of the islands of the Krakatoa-group between Sumatra and Java, Dammerman discovered in December 1933 four living specimens, measuring 2,6, 2.2, 2.2, 2.1 mm high, and 1.7, 1.6, 1.6, 1.5 mm broad.

In most cases the species was found in brackish water, only the type habitat, Lake Tondano in North Celebes, is entirely fresh water.

Fossil specimens have never been mentioned before, so the shells of the Dubois Collection are the oldest *Stenothyra ventricosa* which have come to our knowledge. The entire samples, on cursory examination, look like river rejectamenta from a quiet corner, containing numerous immature shells of *Viviparus* and various *Thiara*. However, a few specimens of *Cylichna* and a Pyramidellid in the Tjenklik sample suggest that we have to do with an estuarine or brackish water deposit.

Bithynia truncata (Eydoux & Souleyet)

1852 Eydoux & Souleyet, Voy. Bonite, Zool., vol. 2, p. 548, pl. 31 figs. 22—24 (*Paludina truncata*).
1911 Martin-Icke, p. 50.
1919 Martin, p. 97.
1931 Van Es, p. 136.
1931 Van der Vlerk, p. 256.

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 11116. Trinil: 3 spec., high 9, 7, 7 mm,
broad 6, 5, 5 mm.

The specimens collected by the Selenka Expedition are the only fossil *Bithynia* from Java. In the recent fauna the species is not abundant either. It occurs throughout the whole island, from W to E, but never in great numbers at a time.

Beyond Java the species occurs in India, Sumatra, Lombok, Soembawa, Soemba and Celebes.

In the Table facing p. 657 Elbert (1908, Alter der Kendeng-Schichten) mentioned a few times "Hydrobiiden" from what he designated as "Lower Kendeng beds". It cannot be ascertained which species he meant. In the samples from the Senckenberg Museum no Hydrobiidae could be discovered.

Pila conica (Gray) (Plate IV figs. 10, 11)

1828 Gray in Wood, Index Test. Suppl., pl. 7 fig. 22 (*Ampullaria conica*).
1908 Branca, p. 270 (*Ampullaria ampullacea*).
1908 Dubois, p. 1249 (eine *Ampullaria*).
1908 Elbert (Nieuwste Onderzoekingen), p. 129 (*Ampullaceae*).
1908 Martin, p. 14 (*Ampullaria ampullacea*).
1909 Elbert, p. 517 (Ampularien).
1911 Carthaus, p. 13 (*Ampullaria ampullacea*).
1911 Martin-Icke, p. 50 (*Ampullaria (Pachylabra) scutata*), p. 51 (*Ampullaria ampullacea*).
1919 Martin, p. 98 (*Ampullaria scutata* and *A. ampullacea*).
1931 Van Es, p. 136 (*Ampullaria scutata* and *A. ampullacea*).
1931 Van der Vlerk, p. 256 (*Ampullaria ampullacea* and *A. scutata*).
1932 Van Benthem Jutting, p. 103 seq.
1935 Oostingh, p. 41.

Material examined:

Dubois Collection

No. 1574. Trinil: 1 spec., high 30, broad 26 mm.
No. 9774. id.: 1 spec., high 31, broad 26 mm.
No. 1502. id.: 1 operculum, high 22, broad 14 mm.
No. 9765. id. 1899: 6 opercula, high 30, 30, 22, 22, 20, 20 mm,
broad 20, 18, 16, 15, 13, 12 mm.
No. 9766. id.: 5 opercula, high 26, 24, 22, 20 mm,
broad 16, 16, 15, 12 mm and fragm.

Selenka Collection (Leiden Geological Museum)

St. No. 11126. Trinil ?: 2 opercula, not measured, partly imbedded in tuff.
St. No. 11127. Trinil: 1 spec., high 32, broad 28 mm.

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 85. Path to River Soendo, Poetjangan layers: 1 spec., partly damaged, not measured.

Sheet 110 A No. 95. River Klatjem, Poetjangan layers: 4 spec., 1 adult, 3 juv. The adult shell and the smallest young one incomplete, not measured. Others: high 18?, 15 mm, broad 16, 14 mm.

Sheet 110 A No. 98. Mount Grobogan, Poetjangan layers: 4 spec., 3 adult, 1 juv. One of the adults too much damaged. Dimensions of the other shells:
high 35, 28, 15 mm,
broad 26, 25, 14 mm.

Sheet 110 A No. 100. River Soemberringin, Poetjangan layers: 1 spec. (cast), not measured.

Cosijn Collection

Locality 1. North of Kaboeh, Poetjangan layers: 1 spec., h. 29, br. 24 ? mm.

Locality 6. Saddle of Kedoengwaroe anticlinal, N. E. of Perning, Poetjangan layers: 1 spec., h. 30, br. 28 mm.

Locality 37. S. limb. of Kedoengwaroe anticlinal, near Klagenblandong, N. of Perning, Poetjangan layers: 1 spec., h. 28, br. 24 mm.

Locality 52. N. E. of Soemberringin, Poetjangan layers: 1 spec., h. 27, br. 21 mm.

Locality 60. N. of Kaboeh, Poetjangan layers: 1 spec., h. 30, br. 28 mm.

Locality 78. S. limb of Kedoengwaroe anticlinal, E. of road Komlagi-Sima, Poetjangan layers: 1 spec., h. 25?, br. 20 mm.

It is a well known fact that the discrimination of *Pila conica* and *P. ampullacea* is not easy in certain cases (cfr. Rensch, 1934, Trop. Binnengew., vol. 5, p. 218) especially in immature specimens. Yet I did not experience difficulties in this question with the fossil shells of Java, but more so in distinguishing certain forms of *Pila conica* from *P. polita* (Desh.).

In three samples (Sheet 110 A No. 95 and 98 and Cosijn Collection Loc. 52) I hesitated whether one of the shells, resp. the only shell should be credited to *Pila polita*, the spire being uncommonly elevated for the usual *P. conica*. I suppose, however, that a malformation, due to post mortal pression, is responsible for this unfamiliar physiognomy and in my opinion they belong to *P. conica* anyhow.

It is remarkable that single opercula of *P. conica* are relatively common in the samples, more frequent at least than of any other species. They are found washed together without the corresponding shells. The same phenomenon is observed in recent *Pila* (*conica, polita*). After the animal's death, when shell and operculum have parted, both fall victim to waves and stream separately. At that moment a mechanical sorting of the drift-material sets in: the shells offering more points of attachment than the lids, and, being of a different specific weight, soon loose sight of the opercula.

In our regions similar instances are noted of *Bithynia tentaculata*, both recent and fossil (Tesch, 1929, Meded. Rijks Geol. Dienst, Serie A, no. 3, p. 6 [1]); Van Benthem Jutting, 1931, Vakbl. v. Biologen, vol. 13, p. 5; Trusheim, 1931, Senckenbergiana, vol. 13, p. 153—159). I guess that the phenomenon may be a general one though I never saw it recorded before in tropical regions.

So far as we know it is only observed in species with a calcareous operculum. Probably horny opercula are apt to decay too quickly.

In the recent fauna of Java *Pila conica* is very frequent in stagnant water: marshes, pools, watered rice fields, lakes. Under similar conditions it

1) Tesch (l.c., p. 8) mentioned the same for *Lithoglyphus naticoides* (Fér.).

occurs in the Malay Peninsula, Sumatra, Banka, Bali, Lombok, Soembawa, Borneo, Celebes and Saleyer.

In a fossil state the specimens from the Boemiajoe deposits (Oostingh, l.c.) form the oldest record available.

Viviparus javanicus (v. d. Busch)

1844 Von dem Busch, in Philippi, Abb. & Beschr., vol. 1, p. 114, pl. 1 figs. 11—12 (*Paludina javanica*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N. F.), vol. 1, p. 249, pl. 37 figs. 601—604 (*Paludina* (s. str.) *javanica*).
1908 Branca, p. 270 (*Paludina javanica*).
1908 Dubois, p. 1249 (eine *Paludina*).
1908 Elbert (Nieuwste Onderzoekingen), p. 129 (*Paludinae*).
1908 Elbert (Alter der Kendeng-Schichten), p. 656 (Paludinen) and p. 657 (Paludinen).
1908 Martin, p. 14 (*Paludina javanica*).
1909 Elbert, p. 517 (Paludinen).
1911 Carthaus, p. 13 (*Paludina javanica*).
1911 Martin-Icke, p. 50 (*Paludina javanica*).
1919 Martin, p. 98 (*Paludina javanica* var.).
1931 Van Es, on several pages (*Paludina javanica*).
1931 Van der Vlerk, p. 256 (*Paludina javanica*).
1935 Oostingh, p. 39.

Material examined:

Dubois Collection

No. 736. Bapang A 87: 3 spec. juv.
No. 1576. Kedoeng Nojo near Tritik B 124: 1 spec.
No. 1585. id. id. id. id. B 124: 13 spec.
No. 1585. Gedoeng Djoerit E 21: 34 spec., most of them badly preserved, almost casts.
No. 1671. Kedoeng Nojo near Tritik B 124: 24 spec., rather worn.
No. 1683. id. id. id. id. B 124: 38 spec., some of the shells show spiral sculpture, others bear a faint carina at the periphery.
No. 9646. Tjenklik near Solo C 126: 8 spec., juv.
No. 9753. Kedoeng Nojo near Tritik B 124: 11 spec. some with spiral sculpture.
No. 9759—9761. id. id. id. id. E 21: numerous spec., some with spiral sculpture, no traces of keel.
No. 9760. id. id. id. id. E 21: numerous spec., some with spiral sculpture, no keel, 10 spec. measured: high 35, 31, 30, 30, 29, 23, 22, 22, 21, 21 mm,
broad 29, 28, 26, 24, 24, 20, 19, 16, 17, 16 mm.
No. 9764. id. id. id. id. 2 spec.
No. 9770. Trinil: 1 spec.
No. 9774. id. 1 spec.
No. 9776. Tjenklik near Solo: 2 spec., partly in stone.

Elbert Collection

Mount Singokerto near Tritik in Pandan ("Untere Kendengschichten"): numerous spec., rather badly preserved, most of them are more casts than shell substance.

Selenka Collection (Leiden Geological Museum)

St. No. 11122. Trinil: 1 spec., without apex.
St. No. 11123. id. 2 spec., one adult, one juv.

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 260. Bengawan Solo near Bangoenredjo Kidoel, Upper Kalibèng layers: 1 spec.

Sheet 99 B No. 19. River Kedoengloemboe, downstream St. 26 B, Kaboeh layers: 31 spec., many rather worn, 5 spec. with spiral sculpture.

Sheet 105 A No. 35. River Tritik, Kaboeh layers: 10 spec., some slender, a few with spiral sculpture.

Sheet 105 A No. 38. River Senantok, Kaboeh layers: 5 spec., severely damaged.

Sheet 105 B No. 67. River Bèng, near trolley, Poetjangan layers: 1 spec.

Sheet 105 B No. 71. River Klotok, tributary of R. Bangle, St. 58 Dj., Poetjangan layers: 33 spec., five of which laterally compressed.

Sheet 105 B No. 73. River Bangle, Poetjangan layers: 2 spec.

Sheet 110 A No. 81. River Gembajang, Poetjangan layers: 2 spec.

Sheet 110 A No. 89. River Marmojo, Poetjangan layers: 1 spec., apex missing.

Sheet 110 A No. 95. River Klatjem, Poetjangan layers: 1 spec.

Sheet 110 A No. 98. River Grobogan, Poetjangan layers: 13 spec., some very heavy, some very slender.

Sheet 110 A No. 100. River Soemberringin, Poetjangan layers: 4 spec.

Sheet 110 A No. 101. Path to River Soemberringin, Poetjangan layers: 1 spec., apex missing.

Sheet 110 A No. 104. River Kedoengglingang, Poetjangan layers, layer I: 1 spec.

Sheet 110 A No. 126. Trench near Moenoengkerep, Poetjangan layers, layer II: 1 spec.

Cosijn Collection

Locality 1. North of Kaboeh, Poetjangan layers: 6 spec., semiadult.

Locality 52. N. E. of Soemberringin, Poetjangan layers: 2 spec., id.

Locality 59. North of Kaboeh, Poetjangan layers: 1 spec. without apex.

Locality 60. id. id. id. id. id. 3 spec., one adult, two semiadult.

Collection of the Geological Museum, Delft

No. K. A. 2235—2236. Trinil, argillaceous layers covering the Vertebrate beds, Pit II: 2 spec.

Most of the samples belong to the Poetjangan and Trinil (syn. Kaboeh) formation, only Sheet 93 B No. 260 must be located in the Upper Pliocene.

The shells show a remarkable high degree of variation: slender and stout, ponderous and fragile, plain and sculptured specimens being represented, sometimes even in one and the same sample.

If we compare recent shells of *Viviparus javanicus* of Java we meet quite similar diversity in shape and texture.

Various forms have been indicated by subspecific or varietal names, although nearly to nothing is known about the factors (whether chemical, physical, nutrimental, geographical, or other) inducing the animal's polymorphism.

So long as we are not better informed on the nature of the factors controlling the phaenotypical configuration I consider it vain effort to loose oneself in speculations on nomenclature of subordinate rank on so unsubstantial grounds. It is of common knowledge among malacologists that certain species (the labile ones) are much more liable to form modifications of size, colour, etc., than others (the stabile ones). This involves that certain factors which in stabile species would provide sufficient evidence for separating related animals, do not deserve equal valuation in species with an unstable disposition.

In my opinion *Viviparus javanicus* is such an unstable animal. Whether the phenomenon has any evolutionary significance I do not venture to decide. I only give my observations as checked from numerous recent and fossil specimens. So much is certain that during the centuries from the Upper Pliocene up to our days the species persisted uninterruptedly in producing an abundant diversity of modifications.

Viviparus javanicus makes its appearance in the Pliocene era in a few sparse disconnected localities where freshwater fauna could settle, safeguarded against marine transgressions.

With the approach of the Quarternary epoch and during this era the island of Java more and more assumed its present configuration, at the same time enabling the non-marine fauna to expand its quarters and to migrate into new settlements.

Thus *Viviparus javanicus* through its wide spread occurrence is far from an appropriate guide fossil. Yet this same ubiquity causes it to be a safe indication for the discrimination of a freshwater horizon as it is not or hardly wanting in any one.

A species of *Paludina* is also recorded from the prehistoric deposits in Sampoeng Cave, near Ponorogo, Central Java (Van Es, 1929, p. 336). As I pointed out before (Van Benthem Jutting, 1932, p. 104) I did not actually see these specimens, but there can hardly be any doubt that they belong to *Viviparus javanicus*.

In the recent fauna of Java the species is extraordinarily frequent in the most various inland waters. Only rapidly running waters and high mountain regions are avoided. Under similar conditions *Viviparus javanicus* is recorded from Sumatra, Bali, Lombok, Soembawa, Borneo, Celebes, Saleyer and the Philippines.

Faunus ater (Linné)

1758 Linné, Syst. Nat., ed. X, p. 746, no. 441 (*Strombus*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 142. River Djegrek, Poetjangan layers, layer III: 2 spec., one imperfect, high 44.5, broad 18.7 mm, one with incomplete spire, high 39.6, broad 12 mm.

Although the base of the aperture is missing in both species, so that nothing can be said of the condition of the curve in the outer lip in this part of the shell, yet I do not think that there can rise any doubt against this identification.

Faunus ater is a common species in the recent Indo-Australian fauna, brackish as well as freshwater, more so in the Eastern part of the Archipelago than in the Western.

This is the first fossil record of the species.

In several papers on Quarternary and Upper Tertiary fossils of Java various species of *Melania* are recorded. In many cases, however, they were only identified as far as the genus, the disconcerting diversity of species having kept back the authors from specific nomination. It goes without saying that at present this arrear cannot be worked up.

Brotia testudinaria (v. d. Busch)

1842 Von dem Busch, in Philippi, Abb. & Beschr. vol. 1, p. 3, pl. 1 fig. 14 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N. F.) vol. 1, p. 234 and 236, pl. 36 figs. 558, 558a, 559, 561 (*Melania* (*Pachychilus*) *testudinaria*).
1908 Branca, p. 270 (*Melania testudinaria* var.).
1908 Martin, p. 14 (*Melania testudinaria* var.).
1911 Carthaus, p. 13 (*Melania*).
1911 Martin-Icke, p. 50 (*Melania* (*Pachychilus*) *testudinaria* var.).
1919 Martin, p. 96 (*Melania*).
1929 Van Es, p. 336 (as *Melania* only; the specimen figured in photo 6 is *Brotia testudinaria*).
1931 Van Es, p. 65, 74, 136 (*Melania*).
1931 Van der Vlerk, p. 255 (*Melania*).
1932 Van Benthem Jutting, p. 103 (*Melania*).
1935 Oostingh, p. 29 (*Sulcospira*).

Material examined:

Dubois Collection

No. 1585. Kedoeng Nojo near Tritik B 124: 2 spec., forma *angulifera*; 15 spec., forma *striatula*.
No. 9775. id. id. id. id.: 2 spec., forma *angulifera*; 4 spec., forma *striatula*.

Selenka Collection (Leiden Geological Museum)

St. No. 10961. Trinil: 3 spec., forma *striatula-subangulifera*.
St. No. 10962. id. 9 spec., forma *striatula-subangulifera*.
St. No. 11028. id. 2 spec., forma *angulifera*.

Leiden Geological Museum

St. No. 10954. Sonde: 4 spec., forma *typica* (figured by Martin, 1905, l.c.).
St. No. 10957. id. : 1 spec., with broken and afterwards regenerated spire.
St. No. 10958. id. : 1 spec., with colour remains, forma *typica*.
St. No. 10959. id. : 12 spec., forma *typica*.

St. No. 10960. id. : 18 spec., forma *typica*.
St. No. 10963. id. : several spec., forma *typica*.
St. No. 11025. Mount Gombel near Tjandi, Semarang: 1 spec., with colour remains.

Collection of the Geological Suivey, Bandoeng

Sheet 93 B No. 260. Bengawan Solo, near Bangoenredjo Kidoel, Upper Kalibèng layers: 1 spec. forma *typica*, with colour remains.

Sheet 93 B. Trinil, Ingr. 1, block c, layer II, 23. VIII. 1932: 3 spec., forma *angulifera*.

Sheet 93 B. Same locality, layer III, 28. X. 1932: several spec., forma *angulifera*.

Sheet 99 B No. 18. River Ngetas, near Kampong Kedoeng Broeboes, Kaboeh layers: numerous spec., partly in stone, all forma *angulifera*, largest 53.8 mm high.

Sheet 105 A No. 35. River Tritik, Kaboeh layers: 5 spec., forma *striatula*.

Sheet 105 A No. 37. River Senantok, Kaboeh layers: 2 spec., forma *typica*.

Sheet 105 B No. 67. Trolley near River Bèng, Poetjangan layers: 2 spec., forma *typica*.

Sheet 105 B No. 73. River Bangle, Poetjangan layers: 3 fragm., forma *typica*.

Sheet 110 A No. 100. River Soemberringin, Poetjangan layers: 1 spec., forma *typica*.

Sheet 110 B No. 116. River Kedoengkerang, Poetjangan layers: 1 spec., forma *typica*.

Sheet 110 B No. 188. River Bantengan, Poetjangan layers, layer III: 1 spec., forma *angulifera*.

Sheet 110 B No. 199. North of Kampong Lokardowo, Kaboeh layers: 1 spec., forma *angulifera*.

Sheet 116 A No. 216. North of Kampong Klagenblandong, Poetjangan layers, layer II: 2 fragm., forma *typica*.

Sheet 116 A No. 218. Same locality, same formation, layer II: 3 spec., forma *angulifara*.

Sheet 116 A No. 221. River Soemberdjo, Poetjangan layers, layer II: 1 spec., forma *typica*.

Sheet 116 A No. 227. East of Kampong Semboeng, Poetjangan layers, layer II: 1 fragm., forma *angulifera*.

Sheet 116 A No. 228. River Klagen, Poetjangan layers, layer III: 1 spec., forma *angulifera*.

Cosijn Collection

Locality 4. North of Klagenblandong, Poetjangan layers: 2 spec., forma *typica*.

Locality 6. North of Soemberdja, N.N.E. of Perning, Poetjangan layers: 1 spec., forma *angulifera*.

Locality 38. North of Klagenblandong, Poetjangan layers: 1 spec., forma *angulifera*.

Collection of the Geological Museum, Delft

No. K. A. 2232. Trinil, Kendeng layers, Pit I, layer 17: 6 fragm., forma *striatula*.

I followed Oostingh (l.c.) in his careful discrimination of forms and varieties of this polymorphous species.

In the recent fauna of Java *Brotia testudinaria* is also very abundant, though not in the least so variable as in prehistoric centuries. The specimens from Sampoeng Cave (Van Benthem Jutting, l.c.) look more like recent shells than like fossil ones.

Whether *Brotia foeda* (Lea) should be united with the present species as suggested by Rensch (Trop. Binnengew., vol. 5, 1934, p. 242 seq.) I do not regard as sufficiently settled.

Beyond Java *B. testudinaria* is recorded from Bawean Id., where Dr. K. W. Dammerman collected specimens in a streamlet close to the South coast, May 1928.

In a fossil state the species occurs since the Middle Pliocene (Kali Bioek beds, Boemiajoe formation).

Brotia testudinaria (v. d. Busch) forma **scalaroidea** (Mousson)

1849 Mousson, Land & Süssw. Moll. Java, p. 66 (*Melania destudinaria* (sic!) forma *scalaroidea*).
1908 Branca, p. 270 (*Melania infracostata*).
1908 Martin, p. 14 (*Melania infracostata*).
1911 Carthaus, p. 13 (*Melania infracostata*).
1911 Martin-Icke, p. 51 (*Melania (Melanoides) infracostata*).
1919 Martin, p. 96 (*Melania infracostata*).
1931 Van Es, p. 136 (*Melania infracostata*).
1931 Van der Vlerk, p. 254 (*Melania infracostata*).
1935 Oostingh, p. 30 (*Sulcospira testudinaria* fa. *scalaroidea*).

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 10966. Trinil: 1 spec., base a little damaged.

The shell identified as *Melania infracostata* after collections of the Selenka Expedition is certainly not that species, but a scalariform *Brotia testudinaria*. The real *infracostata* was described by Mousson as a valid species (l.c., p. 65), but was afterwards given varietal rank by Nevill (Handlist Moll. Indian Mus., vol. 2, 1885, p. 253). He was followed by various authors, but recently Rensch (Trop. Binnengew., vol. 5, 1934, p. 241 and 243) recommended to restore it in its ancient position.

Scalariform *Brotia testudinaria* are apparently not rare in fossil strata of Java. Oostingh described and figured various degrees of this malformation from the Boemiajoe deposits. And though the form was originally created after a recent shell, yet they are far from common in our contemporary fauna.

Brotia variabilis (Benson)

1836 Benson, Journ. As. Soc. Bengal, vol. 5, p. 746 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 234 and 237, pl. 36 figs. 563—564 (*Melania (Melanoides) soloensis*).
1919 Martin, p. 96 (*Melania soloensis*).
1931 Van Es, p. 65, 136 (*Melania soloensis*).
1931 Van der Vlerk, p. 255 (*Melania soloensis*).

Material examined:

Dubois Collection

No. 1585. Kedoeng Nojo near Tritik B 124: 1 spec., high 30.3, broad 14.3 mm.
No. 9760. id. id. id. id. E 21: 1 spec., high 28.7, broad 14.- mm.

Leiden Geological Museum

St. No. 10969. Ngrawan, Soerakarta: 7 spec. (s.n. *Melania soloensis* Martin).

Collection of the Geological Survey, Bandoeng

Sheet 99 B No. 19. River Kedoengloembo, Kaboeh layers: 3 spec., very incomplete, only two last whorls preserved.

The specimens described by Martin (l.c.) as *Melania soloensis* are doubtlessly *Brotia variabilis* (Benson). They bear strong resemblance to immature recent shells of this species from Deli, East Coast of Sumatra.

The two fossils from Kedoeng Nojo are a little different from Martin's shells in so far as their spiral sculpture is preponderant, the vertical plicae being less pronounced.

In the recent fauna the species is very common in India and Burma, Sumatra and West Java. From the central and east section of this island, however, I never heard of any recent record. So these fossil shells prove that in prehistoric centuries the distribution of *Brotia variabilis* in Java must have been more extensive than it is in our days.

In a fossil state it occurred in Java with certainty since the Kaboeh formation. The specimens from Ngrawan are of uncertain geological age. According to Van Es (1931, p. 65) who mentioned shells from the Sangiran Fauna, the species was already present in the Upper Pliocene. His reference to the Boemiajoe deposits (l.c., p. 52 and p. 65 column 6 of table) were afterwards called in question by Oostingh (1935, p. 212).

Thiara (Tiaropsis) winteri (v. d. Busch)

1842 Von dem Busch, in Philippi, Abb. & Beschr., vol. 1, p. 1, pl. 1 figs. 1—2 (*Melania*).

Material examined:

Dubois Collection

No. 9772. Kedoeng Nojo near Tritik: 1 spec., high 17 mm.

Collection of the Geological Survey, Bandoeng

Sheet 105 B No. 67. Trolley near River Bèng, Poetjangan layers: 5 spec., varying between 26.7 and 30 mm height.

Sheet 105 B No. 68. River Brangkal, Poetjangan layers: 2 spec., resp. 28.3 and 31.7 mm height.

Sheet 110 A No. 80. River Gembajang, Poetjangan layers: 1 spec., high 32.8 mm, spira and aperture incomplete.

Sheet 110 A No. 86. Path to River Soendo, Poetjangan layers: 1 spec., high 27 mm, spira and apex as preceding.

Sheet 110 A No. 95. River Klatjem, Poetjangan layers: 1 spec., high 26.5 mm.
Sheet 110 A No. 132. River Pandogan, Poetjangan layers: 2 spec., resp. 31.8 and 31.2 mm.
Sheet 110 A No. 137. N.W. of Kampong Moenoengkerep, 14. IV. 1933, Poetjangan layers: 34 spec., most in bad condition, 5 spec. measured, varying between 28 and 31.4 mm height.
Sheet 110 A No. 143. River Kedoengtjeleng, Poetjangan layers, layer III: 1 spec., 25 mm high, aperture incomplete.
Sheet 110 B No. 188. River Bantengan, Poetjangan layers, layer III: 1 spec., 22.3 mm high.
Sheet 116 A No. 216 North of Kampong Klagenblandong, Poetjangan layers, layer II: 4 spec., one too bad for measuring, others resp. 20, 29 and 32 mm high.
Sheet 116 A No. 217. Same locality, same formation: 1 spec., high 26.7 mm.
Sheet 116 A No. 218. Same locality, same formation: 1 spec., high 31 mm, base incomplete.
Sheet 116 A No. 227. East of Kampong Semboeng, Poetjangan layers, layer II: 1 spec., high 33 mm, base incomplete.
Sheet 116 A No. 228. River Klagen, Poetjangan layers, layers III: 1 spec., high 29 mm.
Sheet 116 A No. 236. River Klagen, Poetjangan layers: 1 spec., bad, not measured.

Cosijn Collection

Locality 4. North of Klagenblandong, Poetjangan layers: 22 spec., varying between 42.3 and 25 mm high.
Locality 5. North of Klagenblandong, Poetjangan layers: 1 spec., high 25.4 mm.
Locality 6. North of Soemberdja, N.N.E. of Perning, Poetjangan layers: 1 spec., spire incomplete.
Locality 29. North of Gondang, N. W. of Djetis, Poetjangan layers: 1 spec., high 17.8 mm.
Locality 30. East of Djoewet, N. of Wringinanom, Poetjangan layers: 1 spec., spire incomplete.
Locality 31. North of Soemberdja, N.N.E. of Perning, Poetjangan layers: 1 spec., high 27.3 mm.
Locality 34. North of Klagenblandong, Poetjangan layers: 1 spec., high 27.7 mm (fine specimen).
Locality 37. North of Klagenblandong, Poetjangan layers: 1 spec., high 28 mm.
Locality 39. North of Klagenblandong, Poetjangan layers: 1 spec., high 31 mm.
Locality 118. Near Bantengan, N.E. of Koepang, Poetjangan layers: 1 spec., too bad to be measured.
Locality 133. Probably West of Kedoengpalang, N.W. of Djetis, Poetjangan layers: 1 spec. base incomplete.

The species is very common in the Kendeng region, perhaps even more abundant in prehistoric times than at the present day. Among the fossil shells now before me none reaches the dimensions of the recent representatives, 48 mm height as indicated by Brot (Melaniaceen, in: Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874, p. 301) and 50 mm as occurring in the collections of the Zoological Museum at Amsterdam. The spines are variable, so in number as in projection, sometimes sharp, sometimes blunt, just as in recent *Th. winteri* shells. The species has not been recorded beyond Java. In a fossil state it is found in the Poetjangan and Kaboeh layers.

Thiara (Tiaropsis) rudis (Lea)

1850 Lea, Proc. Zool. London, p. 186 (*Melania*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 B No. 185. S. of Kampong Sidorojol, Poetjangan layers, layer III: 1 spec., high 22, broad 9.7 mm.

Sheet 116 A No. 216 North of Kampong Klagenblandong, Poetjangan layers, layer II: 15 spec., high 21.4, 20.-, 18.3, 17.8, 17.4, 16.8, 16.-, 15.5, 14.5, 13.7, 12.3, 12.3, 12.-, 11.2, 10.8 mm, broad 8.3, 8.2, 7.8, 7.8, 6.5, 7.5, 7.-, 6.-, 6.5, 5.6, 5.8, 5.5, 6.5, 4.5, 4.4 mm.

Cosijn Collection

Locality 5. North of Kampong Klagenblandong, North of Perning, Poetjangan layers: 1 spec., high 20, broad 7.7 mm.

Locality 33. North of Soemberdja, N.E. of Perning, Poetjangan layers: 1 spec., high 24, broad 10.5 mm.

Locality 34. North of Kampong Klagenblandong, North of Perning, Poetjangan layers: 1 spec., high 17.5, broad 7 mm, apex missing.

Locality 36. N.W. of Kampong Klagenblandong, N. of Djetis, Poetjangan layers: 2 spec., one too bad for measuring, other high 21.5, broad 9.3 mm.

Locality 71. S.E. of Tjendara and Simo, Poetjangan layers: 1 spec., high 24.5, broad 9.6 mm.

Locality 74. Same locality, same formation: 1 spec., high 14.5 , broad 5.6 mm.

The specimens of sample 116 A No. 216 are very well preserved. As is evident from the measurements there is a great deal of variation in degree of slenderness. Furthermore the spinosity is varying considerably, some are armed like certain forms of *Th. scabra,* others on the contrary are hardly spinous at all, but coarsely granulated, with only few sparse, blunt spikes. All the fossil shells possess a relatively small aperture, as is proper to paratypes of *Melania fortitudinis* Fulton in the Amsterdam Museum. The slender forms, referred to above, resemble *Melania rudis* var. *cylindrica* Schepman (Bijdr. t. d. Dierk., afl. 20, 1915, p. 27, fig. 6).

Recent specimens of *Thiara broti* (Dohrn) from Ceylon, *Th. rudis* (Lea) from Phu Yen and Ceram, *Th. rudis* var. *cylindrica* (Schepman) from Ceram, *Th. fortitudinis* (Fulton) from Java and *Th. drilliiformis* (Martens) from the same island now before me fully confirm Rensch's opinion (Zool. Jahrb. (Syst.), vol. 65, 1934, p. 408) that all these "species" are but modifications of one single species: *Th. rudis.* Even *Th. armillata* (Lea), recorded from Soemba by Schepman (Notes Leyden Mus., vol. 14, 1892, p. 157), afterwards quoted by me (Treubia, vol. 10, 1928, p. 156) should be incorporated in *Th. rudis.*

In the recent fauna *Thiara rudis* has a wide distribution, being recorded from Ceylon, Burma, Sumatra, Java, Bali, Soemba, Ambon, Ceram, Halmaheira, Batjan, and the Philippines. In a fossil state it is only found in the Poetjangan layers.

Thiara (Tiaropsis) zollingeri (Brot)

1868 Brot, Matér. pour servir à l'étude Fam. Mélan., vol. 2, p. 42, pl. 2 fig. 4 (*Melania*).
1908 Branca, p. 270 (*Melania sarrinieri* sic!).
1908 Martin, p. 14 (*Melania savinieri* sic!).
1911 Carthaus, p. 13 (*Melania savinieri* sic!).
1911 Martin-Icke, p. 50 (*Melania* (*Plotia*) *savinieri* sic!).
1919 Martin, p. 96 (*Melania Savinieri* sic!).
1931 Van Es, p. 136 (*Melania savinieri* sic!).
1931 Van der Vlerk, p. 255 (*Melania savinieri* sic!).
1935 Oostingh, p. 18 and 19, pl. 1 figs. 17—20 (*Melanoides* (*Melanoides*) *fennemai* forma b and c).

Material examined:

Dubois Collection

No. 736. Bapang A 87: numerous spec., largest shell 11.6 mm.
No. 1471. Java (no exact locality): 8 spec., largest shell 20.5 mm.
No. 1503. Tjenklik near Solo C 129: numerous spec., largest shell 13.5 mm.
No. 1504a. id. id. id. C 129: 10 spec., largest shell 12.5 mm.
No. 1504b. id. id. id. C 129: 9 spec., largest shell 12.5 mm.
No. 1505. id. id. id. C 129: 2 spec., largest shell 9.8 mm.
No. 9680. Bogo: 12 spec., semiadult.
No. 9818. Without locality C 133: numerous spec. largest shell 16 mm.

Selenka Expedition (Leiden Geological Museum)

St. No. 10983. Trinil: 1 spec., high 15.7 mm (s.n. *savinieri*)
St. No. 10984. Trinil: 1 spec., high 13 mm, base and top incomplete (s.n. *savinieri*)

Cosijn Collection

Without locality: 1 spec., high 16.8 mm.
Locality 5. North of Klagenblandong, North of Perning, Poetjangan layers: 1 spec., high 16.7 mm.

Collection of the Geological Museum, Delft.

No. K.A. 2232. Trinil, Kendeng layers, Pit I, layer 17: 11 spec., largest shell 14.3 mm high.

The two specimens from the Selenka Expedition, persistently called *savinieri* in stead of *savinierei* by all authors, must be classified as *Thiara zollingeri*, a common species in the recent fauna of Sumatra, Java, and Borneo.

Thiara zollingeri and *Th.savinierei* are synonymous, *zollingeri* has 16 years priority over *savinierei* (Brot, in: Morlet, Journ. de Conch., vol. 32, 1884, p. 330, pl. 7 fig. 2). It is hardly to be accepted that the superficial, uncharacteristic diagnosis of *savinierei* should be attributed to Brot, who, as a rule, gave exact descriptions and critical remarks.

In the Monograph of *Melania* in Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874, p. 111, Brot compared *M. zollingeri* to *M. cancellata* Benson from continental Asia and it is true that No. 10983 of the Selenka Collection approaches fig. 7b on plate 9 in the just mentioned Monograph, but less so the nos. 7, 7 a and 7 c. I must abstain from further comparison as I have no typical material of *M. cancellata* at my disposal.

Rensch is certainly right in uniting with *zollingeri* the "species" *bockii* Brot, *subcancellata* Boettger and *sykesi* Bullen (Trop. Binnengew., vol. 5, 1934, p. 233).

Much the same could be said in favour of including also *Melania fennemai* Martin in this synonymy. The typical form of this species is distinct enough, but modifications in various directions have come to light in later years, a fact which Martin could not notice as he had only one single shell (the type) before him.

Oostingh (l.c.) supplemented the original diagnosis of *fennemai* on account of abundant material from Upper Pliocene deposits near Boemiajoe. He directed the attention to the elaborate variability of *M. fennemai* and denoted the forms b an c subordinate of the typical *fennemai*.

In my opinion, however, these two forms, with their wide variation capacity, should be regarded as the elementary form whence *M. fennemai* has developed as a derived, higher specialized unit.

Transitions to real *fennemai* exist, but are not frequent. For this reason and also because I do not know of a similar form in the recent fauna I have kept *fennemai* as a subspecies of *Thiara zollingeri*.

The nominal form, *Th. zollingeri,* is known in a fossil state since the Upper Pliocene (Kali Glagah layers at Boemiajoe).

Thiara (Tiaropsis) zollingeri fennemai (Martin)

1905 Martin, Foss. Java. Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 234 and 239, pl. 36 fig. 571 (*Melania* (*Striatella*) *fennemai*).
1919 Martin, p. 96 (*Melania Fennemai*).
1931 Van Es, p. 65 and 136 (*Melania fennemai*).
1931 Van der Vlerk, p. 254 (*Melania fennemai*).
1935 Oostingh, p. 17, pl. 1 figs. 12—16 (*Melanoides* (*Melanoides*) *fennemai*).

Material examined:

Dubois Collection

No. 736. Bapang A 67: 18 spec., largest shell 15.4 mm high.

No. 1503. Tjenklik near Solo C 129: 4 spec., largest shell 10.5 mm high.
No. 1504b. id. id. id. C 129: 5 spec., largest shell 15.- mm high.
No. 1505. id. id. id. C 129: 4 spec., largest shell 19.5 mm high.
No. 9646. id. id. id. C 126: numerous spec., largest shell 14.8 mm high.
No. 9665. id. id. id. C 126: numerous spec., largest shell 10.- mm high.
No. 9677. Bogo: 4 spec.
No. 9678. id. 5 spec.
No. 9695. Trinil, coll. 1900 No. 12: 5 spec., most incomplete, largest complete shell 10.5 mm high.
No. 9760. Kedoeng Nojo near Tritik E 21: 2 spec., both very incomplete.
No. 9818. Without locality C 133: 5 spec., largest spec. 15.- mm high.

Leiden Geological Museum

St. No. 10976. River Tjemoro, Soerakarta: 1 spec. (type of *Melania fennemai* Martin).

The considerations which have led me to maintain *fennemai* as a subspecies of *zollingeri* have been discussed already under the previous heading. A detailed supplementary description of *fennemai*, accompanied by figures, was given by Oostingh (1935).

In the samples 736, 9646, 9665 there are specimens possessing a complete spire from the very beginning. The sculpture of this initial part elucidates precisely why for all reasons *M. fennemai* deserves a subspecific rank under *Th. zollingeri* and is not a separate species.

This form is only known as a fossil. It has been recorded in the Upper Pliocene (Boemiajoe) and Middle Pleistocene (Kaboeh) formations. The palaeontological age of Martin's type specimen is probably Upper Pliocene (see p. 90 of this paper). Van Es (1931, p. 65) mentioned its occurrence in the Sangiran Fauna and consequently located it also in the Upper Pliocene.

Thiara (Plotia) scabra (Müller)

1774 Müller, Hist. Verm., vol. 2, p. 136 (*Buccinum*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 235 and 240, pl. 36 figs. 572—573 (*Melania (Plotia) scabra*); p. 235 and 241, pl. 36 figs. 575—576 (*Melania (Tarebia) tjemoroensis*); p. 321 (*Melania (Plotia) granum*).
1908 Branca, p. 270 (*Melania granum*).
1908 Martin, p. 14 (*Melania granum*).
1911 Carthaus, p. 13 (*Melania granum*).
1911 Martin-Icke, p. 50 (*Melania (Plotia) granum*).
1919 Martin, p. 96 (*Melania scabra, M. granum* and *M. tjemoroensis*).
1931 Van Es, p. 65 and 136 (*Melania granum* and *M. tjemoroensis*).
1931 Van der Vlerk, p. 254 (*Melania granum*) and p. 255 (*Melania scabra* and. *M. tjemoroensis*).
1935 Oostingh, p. 10 (*Thiara scabra*) and p. 12 (*Thiara tjemoroensis*).

Material examined:

Dubois Collection

No. 1503. Tjenklik near Solo: 2 spec.
No. 9646. id. id. id. C 126: 5 spec., juv.
No. 9665. id. id. id. C 126: several immature spec.
No. 9677. Bogo: 4 spec. juv.
No. 9763. Kedoeng Nojo near Tritik: 10 spec., mostly incomplete.
No. 9772. id. id. id. id. 2 spec.

Selenka Collection (Leiden Geological Museum)

St. No. 10980. Trinil: 1 spec., 15 mm high (s.n. *M. granum*, vide Martin-Icke, l.c.).
St. No. 11038. id. 1 spec., apex missing, not measured.

Leiden Geological Museum

St. No. 10977. Sonde: 2 spec., resp. 21.5 and 22 mm high (figured by Martin, 1905).
St. No. 10978. id. 2 spec. resp. 20 and 18 mm high, base of first shell incomplete.
St. No. 10979. id. ?: 3 spec., resp. 8, 8 and 9 mm high.
St. No. 10981. River Tjemoro, Soerakarta: 1 spec., 8.5 mm high.
St. No. 10987. Ngrawan, Soerakarta: 1 spec. (s.n. *tjemoroensis*, figured by Martin, pl. 36 fig. 575).

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 256. Bengawan Solo, S. E. of Sonde, Upper Kalibèng layers: 12 spec., most incomplete, only 2 spec. measured, high 11.5, broad 6 mm, high 11.4, broad 5.7 mm.
Sheet 93 B No. 260. Bengawan Solo, near Bangoenredjo Kidoel, Upper Kalibèng layers: 3 spec., high 11.8 mm, broad 6 mm, others incomplete.
Sheet 99 B No. 18. River Ngetas, Kaboeh layers: 1 spec., without spire.
Sheet 105 A No. 35. River Tritik, Kaboeh layers: 20 spec., four too bad for measuring, others: high 18.5, 17.8, 17.-, 15.5, 15.-, 14.7, 14.5, 14.5, 14.5, 13.7, 12.8, 11.5, 11.5, 11.-, 10.5, 10.5 mm.
Sheet 105 D No. 70. Small arm of River Kedoengtimbo, Poetjangan layers: 3 spec., resp. 17, 16 and 11.5 mm high, two first with incomplete bases.
Sheet 105 B No. 73. River Bangle, Poetjangan layers: 1 spec., spire and base damaged.
Sheet 116 A No. 236. River Klagen, Poetjangan layers: 3 spec., 18 and 15.2 mm high, third too bad to be measured.

Collection of the Geological Museum, Delft.

No. K.A. 2232. Trinil, Kendeng layers, Pit I, layer 17: 1 spec.

The shells of sample 105 A No. 35 are relatively broad, all the other on the contrary rather slender. All are ornated with strong vertical ribs, varying in number and in strength. The ribs form a sort of shoulder between the suture and the periphery. In some cases each rib is tapering to a blunt spike.

Each of the samples 105 B No. 73 and 93 B No. 260 contains a fragmentary shell of much larger proportions than the average fossil *scabra*.

Oostingh (1935, p. 12) drew already attention to the fact that Martin obviously did not hit upon the idea that his *Melania tjemoroensis* might be related to *Thiara scabra.* He even put it in a different subgenus, and compared it to *M. armillata,* which, as we have seen, is a synonym of *Th. rudis.*

The recent distribution is very wide: Mauritius, Seychelles, India and Burma, Andaman Ids., Philippines, Indo Australian Archipelago, New Guinea and Pelew Ids. (fide Rensch, Trop. Binnengew., vol. 5, 1934, p. 239).

In a fossil state it is recorded in Java since the Upper Pliocene.

As to its environment the species is not very particular. It ranges from sea level up till circa 2000 m (fide Rensch, l.c., p. 238), in stagnant or in running water, often in brackish estuaries or in hot springs. With *Th. tuberculata* it is the most common recent Thiarid in the Netherlands East Indies, and it is astonishing that it is relatively so scarce in the Kalibèng, Poetjangan and Kaboeh layers.

Thiara (Sermyla) tornatella (Lea)

1850 Lea, Proc. Zool. Soc. London, p. 185 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 245, pl. 37 figs. 591, 591a, 592, 593 (*Melania* (*Sermyla*) *tornatella*).
1911 Martin-Icke, p. 49 (*Melania* (*Sermyla*) *tornatella* Bea (sic!)).
1919 Martin, p. 97 (*Melania tornatella*).
1931 Van der Vlerk, p. 255 (*Melania tornatella*).
1935 Oostingh, p. 26 (*Sermyla tornatella*).

Material examined:

Dubois Collection

No. 722. Sonde to Padas Malang, C. 130: 1 spec., high 16 mm.

Leiden Geological Museum

St. No. 11014. Sonde: 3 spec. (figured by Martin).
St. No. 11015. id. 9 spec.
St. No. 11016. id. 7 spec.

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 257. Bengawan Solo, South of mouth of River Alastoewa near Sonde, Upper Kalibèng layers: 1 spec., high 14.3 mm, base incomplete.

Sheet 93 B No. 258. Same locality, same formation: 26 spec., 4 too bad to be measured, height of others: 19.-, 18.3, 18.2, 17.5, 17.-, 16.4, 15.2, 15.-, 14.8, 14.6, 14.3, 14.-, 14.-, 13.8, 13.7, 13.-, 13.-, 12.-, 11.4, 11.-, 10.4, 10.- mm.

Sheet 110 A No. 120. River Batjang, Poetjangan layers: 1 spec., high 15.8 mm, apex missing.

In some specimens of the sample No. 258 the two different sculpture patterns on each individual shell are clearly visible. The 3—5 initial whorls bear strong revolving ridges, crossing the vertical ribs and causing a peculiar granulation in this part of the shell. Later whorls, however, possess the spiral ridges and the vertical ribs separately, the spiral ones below the periphery of each whorl, the closely-set undulating vertical ribs above this periphery. The shells are variable in the ratio height: breadth, slender and stout shells occuring.

All the samples belong to the so called Sonde formation, only the last is younger and estimated oldest Pleistocene.

In his Monograph of the Fossils of Java Martin himself united already his *Melania herklotsi* (Tertiärsch. Java, 1879, p. 88, pl. 14 figs. 19, 19a) with the present species.

In the recent fauna *Thiara tornatella* is recorded from the Philippines and the Aroe Islands (fide Oostingh), and in the Buitenzorg Museum are preserved specimens from Soekaboemi (West Java) from the collection of the late Major Ouwens. The latter locality however needs confirmation.

Rensch (Zool. Jahrb. (Syst.), vol. 65, 1934, p. 410) united the species with *Th. riqueti*. Judging from the material at my disposal I cannot follow his opinion. The two shells of his fig. 5 both belong to *riqueti*, the real *tornatella* being more spindle-shaped, with each whorl wrapping round its preceding with a sort of collar. These features I found to be constant in all specimens.

Thiara (Sermyla) riqueti (Grateloup)

1840 Grateloup, Actes Soc. Linn. Bordeaux, vol. 11, p. 433, pl. 3 fig. 28 (*Melania*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 117. River Kedoengkerang, Poetjangan layers: 12 spec., rather small, largest 11.5 mm high.

Sheet 116 A No. 216. North of Kampong Klagenblandong, Poetjangan layers, layer II: 17 spec., one too bad to be measured, others high: 22,-, 17.5, 17.-, 15.5, 15.4, 15.3, 15.-, 14.7, 14.6, 14.5, 14.-, 13.-, 12.9, 12.9, 12.2, 9.8 mm.

Cosijn Collection

Locality 5. North of Klagenblandong, North of Perning, Poetjangan layers: 1 spec., high 17 mm.

Locality 34. Same locality, same formation: 6 spec., resp. 14.6, 14.-, 13.7 and 12.8 mm high and two too bad to be measured.

The sculpture of this species resembles that of the preceding, only the vertical ribs are less numerous. Furthermore the whole shell is more slender, and each following whorl is not fixed so step-like, or collar-like to its predecessor as in *Th. tornatella*. In this way the profile of the shell, which is often convex and spindle-shaped in *tornatella,* becomes more stretched and dagger-like in *riqueti.*

Thiara riqueti was mentioned by Brot (Melaniaceen, in: Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874, p. 333) from " Philippinen (Cuming); Java? (Dkr.); Bombay (Gratel.); Quilon, Travancore, Cochin (Hanley) (Die beiden ersten Angaben, Philippinen und Java, sind zweifelhaft)". Martens, in: Weber, Erg. Reise Niederl. Ost Indien, vol. 4, 1897, p. 74, recorded it from Makassar in Celebes, Muntok in Banka and Singkawang in Borneo, and Rensch (Zool. Jahrb. (Syst.), vol. 65, 1934, p. 411) added Laboean Hadji in Lombok.

Degner (Treubia, vol. 10, 1928, p. 381) mentioned the species in his account of Sumatran mollusks, referring to the list in Martens' just quoted paper, p. 305, column I. On looking up the said passage, however, we find that this author expressly wrote: "*riqueti* Banka", thus obviously referring to the same record as on page 74 of his paper. Therefore Sumatra must be dropped from the distribution-area of *Th. riqueti* so long as no actual specimens from this island are obtained. It was probably on Degner's authority that Rensch (l.c.) included Sumatra in the geographical distribution of this species, no other reference of this kind having come to my notice.

I have never seen recent specimens from Java. The *Melania* mentioned under this name by Mousson (Land & Süssw. Moll. Java, 1849, p. 76) was not our species, but *Thiara semicostata* (Phil.) (cfr. Brot, l.c., p. 308; Martens, l.c., p. 73). In a fossil state the species has been excavated from the Poetjangan formation.

Thiara (Tarebia) granifera (Lamarck)

1822 Lamarck, Hist. Anim. s. Vert., vol. 6, pt. 2, no. 13 (*Melania*).
1879 Martin, Tertiärsch. Java, p. 89, pl. 14 fig. 20 (*Melania Junghuhni*).
1887[1]) Martin, Palaeont. Erg. Tiefbohr. Java, Samml. Geol. Reichsmus. Leiden (1), vol. 3, p. 158 and 324 (*Melania semigranosa*); p. 159 and 338 (*Melania granifera*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 235 (*Melania (Tarebia) tjariangensis, verrucosa, kritjanensis, semigranosa, junghuhni*), p. 243, pl. 36 figs. 581—583 (*Melania (Tarebia) tjariangensis*), p. 244, pl. 36 figs. 587—588 (*Melania (Tarebia) kritjanensis*).
1908 Branca, p. 270 (*Melania verrucosa*).
1908 Martin, p. 14 (*Melania verrucosa*).
1911 Carthaus, p. 13 (*Melania verrucosa*).
1911 Martin-Icke, p. 50 (*Melania (Tarebia) verrucosa*).
1919 Martin, p. 96 (*Melania tjariangensis, verrucosa* and *kritjanensis*), p. 97 (*Melania semigranosa* and *Junghuhni*).
1931 Van Es, p. 65, 136 (*Melania kritjanensis*) and p. 136 (*Melania verrucosa*).

1) The title page of this volume bears the date 1883—1887. It was obviously edited at once in one volume, and not, as one would expect, in parts between 1883 and 1887. In the preface Martin admitted that the manuscript was concluded in 1887. Therefore this year must be considered the year of publishing.

1931 Van der Vlerk, p. 254 (*Melania junghuhni* and *kritjanensis*) and p. 255 (*Melania semigranosa, tjariangensis* and *verrucosa*).
1935 Oostingh, p. 19 (*Melanoides* (*Tarebia*) *junghuhni*), p. 22 (*Melanoides* (*Tarebia*) *tjariangensis*), p. 24 (*Melanoides* (*Tarebia*) *flavida*) and p. 25 (*Melanoides* (*Tarebia*) *martini*).

Material examined:

Dubois Collection

No. 318. Trinil: 14 spec., badly preserved.
No. 736. Bapang A 87: several spec., with nodules rather pointed and in undulating rows.
No. 1503. Tjenklik near Solo C 129: numerous spec., typical *granifera.*
No. 1504a. id. id. id. C 129: 9 spec., typical *granifera.*
No. 1504b. id. id. id. C 129: 27 spec., typical *granifera.*
No. 1505. id. id. id.: 15 spec., containing a few very broad shells.
No. 1585. Kedoeng Nojo near Tritik B 124: several spec., partly in breccia, typical *granifera.*
No. 5023. Golan: 5 spec., badly preserved.
No. 9646. Tjenklik near Solo C 126: several spec., partly in andesitic tufa, nodules rather pointed, in undulating rows.
No. 9665. Tjenklik near Solo C 126: as preceding sample, many immature shells.
No. 9677. Bogo: numerous spec., partly *verrucosa* form.
No. 9678. id. 19 spec., partly *verrucosa* form.
No. 9680. id. numerous spec., partly *verrucosa* form.
No. 9695. Trinil No. 12 Coll. 1900: several small shells, nodules rather pointed.
No. 9760. Kedoeng Nojo near Tritik E 21: several spec., partly in breccia, mostly typical *granifera,* a few approaching *verrucosa.* Three spec. measured:
high 25.-, 19.6, 19.6 mm,
broad 8.-, 7.5, 7.- mm.
No. 9763. Kedoeng Nojo near Tritik: several spec., partly very slender, *verrucosa* form.
No. 9772. id. id. id. id. numerous spec., partly very slender, *verrucosa* form.
No. 9775. id. id. id. id. 7 spec., partly in stone.
No. 9776. Tjenklik near Solo: several spec., in andesitic tufa, mostly small, slender spec.

Selenka Collection (Leiden Geological Museum)

St. No. 11004. Trinil: 3 spec., high resp. 17.-, 15.6 and 14.- mm, broad resp. 6.8, 5.8 and 6.- mm (s.n. *verrucosa*).
St. No. 11005. Trinil: 13 spec. (s.n. *verrucosa*).

Leiden Geological Museum

St. No. 11006. Demak Grobogan, Semarang (recent ?): 1 spec., high 16.3, broad 6.2 mm (s.n. *verrucosa*).
St. No. 11009. Ngrawan in Bojolali: 2 spec. (s.n. *kritjanensis*).
St. No. 10996. Sonde: 1 spec. (figured by Martin, pl. 36 fig. 583, s.n. *tjariangensis*).
St. No. 10997. id. 2 spec. (s.n. *tjariangensis*).
St. No. 11011. Mountains in West Banjoemas, Tjilatjap: 1 spec. (type of *Melania junghuhni* Martin).

Collection of the Geological Survey, Bandoeng

Sheet 93 B. Trinil, Ingr. 1, block c, layer II, 16 and 23. VIII. 1932: 24 and numerous spec., all rather slender forms, approaching *verrucosa.*

Sheet 93 B. Trinil, Ingr. 1, block c, layer III, 28. X. 1932: several spec., same form as preceding.

Sheet 93 B No. 256. Bengawan Solo, S.E. of Sonde, river terraces ?: numerous spec., many with broken spire.

Sheet 93 B No. 260. Bengawan Solo, near Bangoenredjo Kidoel, Upper Kalibèng layers: 9 spec., with pointed nodules, approaching *Th. lateritia.*

Sheet 99 B No. 19. River Kedoengloemboe, Kaboeh layers: 3 spec., slender, like *verrucosa.*

Sheet 105 A No. 26. River Grendjengan, near Soekoen, Poetjangan layers: 4 spec., imperfect.

Sheet 105 A No. 35. River Tritik, Kaboeh layers: numerous spec., some resembling *verrucosa*, some *granospira.*

Sheet 105 B No. 42. River Garoetan, East of Losari, Upper Kalibèng layers: 1 spec.

Sheet 105 B No. 54. River Garoetan, Poetjangan layers: 1 spec., rather rolled, probably this species.

Sheet 105 B No. 67. Trolley near River Bèng, Poetjangan layers: 3 spec.

Sheet 105 D No. 70. Small arm of River Kedoengtimbo, Poetjangan layers: several spec., most rather slender, but also a few broad shells with pointed nodules, approaching *Th. lateritia.*

Sheet 110 A No. 135. Trench to Moenoengkerep, Poetjangan layers: 1 spec.

Sheet 110 A No. 144. Near Kampong Soemberringin, Kaboeh layers: numerous spec.

Sheet 110 B No. 199. North of Kampong Lokardowo, 21. XI. 1933, Kaboeh layers: numerous small spec., in breccia, mostly badly preserved.

Sheet 116 A No. 236. River Klagen, Poetjangan layers: several spec., mostly slender.

Cosijn Collection

Locality 51. Near Soemberringin, East of Kaboeh, Poetjangan layers: numerous spec., in general slender shells, 8 very slender ones measured:

high 20.5, 18.8, 18.5, 18.5, 18.-, 17.3, 16.4, 14.- mm,

broad 7.5, 6.5, 6.8, 5.8 [1]), 6.4, 6.-, 6.-, 5.- mm, others typical *granifera*, a few like *flavida*, a few like *semicostata.*

Collection of the Geological Museum, Delft.

No. K.A. 2232. Trinil, Kendeng layers, Pit I, layer 17: numerous spec., some approaching *verrucosa.*

More than any other *Thiara* is *Th. granifera* subject to an endless splitting into species of more or less doubtful value. This may serve as a proof for its unrivalled power of modification, combined with its wide dispersal, both in horizontal direction (recent) and in vertical sense (fossil).

Without large series of material from the entire area of distribution (India and Burma, Malay Archipelago, New Guinea and the Philippines, from sea level up till circa 1500 m.) it is impossible to understand the diversity of form and sculpture of *Thiara granifera.* Never two shells are identical and instead of minutely selecting certain details of minor or doubtful diagnostic significance it is more advisable not to stress every trifle modification, but to consider the value of such variations in a wider scope. This

1) A little abnormal.

infers also a better correspondence between fossil horizons and a connection with the present day position of the species[1]).

In the material which I could examine there are slender, granulate shells, approaching *Th. verrucosa;* others are broad, with oblique or undulating rows of nodules, or with hardly any granulation at all. Some have a shallow suture, in others it is nearly step-like, or channelled. The nodules can be blunt, on a squarish base, or pointed, on a round base. The latter form is Martin's *Melania kritjanensis.* Well preserved shells of this type are almost prickly in appearance. The same sculpture is found in *Th. lateritia* (Lea), in the conception of Brot (Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874, p. 319). *Melania junghuhni* Martin is a very coarse *Th. granifera.*

Contrary to what I remarked in *Th. scabra* and *Th. tuberculata* the frequence of the fossil specimens of *Thiara granifera* and their variation seems to rival the conditions in their present day successors.

The oldest fossil record is that of *Melania junghuhni* in Western Banjoemas. This locality was credited Miocene by Martin.

Thiara (Tarebia) granifera madiunensis (Martin)

1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 234 and 237, pl. 36 fig. 562 (*Melania (Sulcospira) bodjaensis*); p. 235 and 242, pl. 36 figs. 578—580 (*Melania (Tarebia) madiunensis*).
1911 Martin-Icke, p. 48 and 49 (*Melania (Tarebia) madiunensis*).
1919 Martin, p. 96 (*Melania bodjaensis* and *M. madiunensis*).
1931 Van der Vlerk, p. 254 (*Melania bodjaensis* and *M. madiunensis*).
1935 Oostingh, p. 21 (*Melanoides (Tarebia) madiunensis*).

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 10993. Doekoe Pengkal: 4 spec. (s.n. *madiunensis*).

Leiden Geological Museum

St. No. ?. Watoeloemboeng in Bodja, Semarang: 1 spec. (type of *bodjaensis*).
St. Nos. 10991, 10992, 10994. Sonde: 10 spec. (s.n. *madiunensis*).

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 255. Bengawan Solo, downstream Sonde, Upper Kalibèng layers: 3 spec.

Sheet 93 B No. 257. Bengawan Solo, South of mouth of River Alastoewa, Upper Kalibèng layers: 4 spec.

Sheet 93 B No. 258. Same locality, same formation: 30 spec.,

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1) Cfr. Rensch, Zool. Jahrb. (Syst.), vol. 65, 1934, p. 404 and id., Trop. Binnengew., vol. 5, 1934, p. 230. To the synonyms discussed there may be added furthermore *Melania (Tarebia) tjibodasensis* Leschke (Mitt. Zool. Mus. Hamburg, vol. 31, 1914, p. 219, fig. 12).

high 19.6, 19.-, 17.3, 17.-, 16.5, 15.3, 15.-, 14.6, 14.4, 14.-, 13.-, 12.5, 12.3, 12.-, 11.6 mm,
broad 9-, 9.-, 7.5, 8.-, 7.5, 7.-, 7.2, 7.5, 7.3, 6.8, 6.8, 5.6, 5.6, 5.5, 5.5 mm.
The others are too bad to be measured.

Sheet 105 B No. 48. River Bèng, Poetjangan layers: 3 spec., rather badly preserved.

The only characteristics mentioned by Martin to justify the creation of *Th. madiunensis* were the fine pattern of rectangular nodules and the, as a rule, peculiar habitus. The latter, though very peculiar indeed, is difficultly put into words, but satisfactorily exhibited in the figs. 578—580 of Martin's paper.

The rectangular form of the nodules is especially conspicuous in large shells.

The reason why I keep this species of Martin as a subspecies of *granifera,* while I inserted quite a number of his other creations as synonyms into that species, is, that I did not succeed in finding among recent *granifera*-material one single shell, comparable to *madiunensis,* whereas all Martin's other forms: *junghuhni, kritjanensis, tjariangensis* are represented in the recent fauna.

In conferring *madiunensis* a subspecific rank under *granifera* I acknowledge at the one side that it belongs to the "Rassenkreis" of *Th. granifera* and at the same time that I consider it sufficiently distinct to maintain it as a separate form.

Judging from the excavation records all *Th. granifera madiunensis* descend from the Sonde horizon and consequently are of one and the same age. The species may perhaps be regarded as a local or temporal (or both?) modification of *Th. granifera.*

At first sight it does not look very convincing to unite *Melania bodjaensis* under *Th. granifera madiunensis.* Closer examination however elucidates: 1. that the species is certainly no *Sulcospira* and 2. that there occur on the least eroded parts of the poorly preserved type-specimen squarish, flat granules of much the same form as in shells of *Thiara granifera madiunensis* which are better off. Part of the bases of the ultimate whorl of the type specimen and of one shell from sample 105 B No. 48 still show remnants of spiral ridges, as is marked in Martin's figure. I could compare the type of *bodjaensis* with a few rather weathered shells from sample 93 B No. 258 and I was struck by their similarity. Therefore I do not hesitate to bring *Melania bodjaensis* to *Thiara granifera madiunensis.*

Thiara (Stenomelania) rustica (Mousson)

1857 Mousson, Journ. de Conch., vol. 6, p. 160 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. (N.F.), vol. 1, p. 234 and p. 235, pl. 36 figs. 556, 557 (*Melania* (s. str.) *sondeiana*).

1911 Martin-Icke, p. 47 (*Melania* (s. str.) *sondeiana*).
1919 Martin, p. 96 (*Melania sondeiana*).
1931 Van der Vlerk, p. 255 (*Melania sondeiana*).

Material examined:

Selenka Collection (Leiden Geological Museum)

St. No. 10953. Padas Malang: 1 spec., high 33.5 mm, and 1 fragm. (s.n. *sondeiana*).

Leiden Geological Museum

St. No. 10951. Sonde: 2 spec. (types of *sondeiana*, figured by Martin).
St. No. 10952. id.: 8 spec. (s.n. *sondeiana*) one too much damaged to be measured, others high 36,7, 36.5, 36.2, 33.9, 29.1, 28.2, 23.7 mm.

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 255. Bengawan Solo, downstream Sonde, Upper Kalibèng layers: 1 spec., incomplete.
Sheet 93 B No. 257. Bengawan Solo, South of mouth of River Alastoewa, near Sonde, Upper Kalibèng layers: 5 spec., three incomplete, others high resp. 50.4, and 39.8 mm.
Sheet 93 B No. 258. Same locality, same formation: 2 spec., incomplete.
Sheet 93 B No. 259. West of Sonde, near bridge Bengawan Solo, Upper Kalibèng layers: 34 spec., of which 19 are too bad to be measured, others high: 51.7, 48.5, 47.-, 42.6, 40.8, 40.8, 40.5, 39.5, 38.8, 37.3, 35.5, 33.4, 31.1, 29.7, 29.5 mm.

On some shells of the last sample (nos. 6, 10, 12 and 13 of the measured specimens) traces of the colour pattern are still discernable, not occupying the entire height of the shell, but only close to the periphery. It consists of brown flammules, sometimes vertical, sometimes zigzagging. In some shells the flammules are of equal strength, in others broad and small ones alternate. One of the coloured specimens is also provided with fine vertical ribs in the oldest part of the spire, about 15 per whorl.

In the discussion following the diagnosis of *Melania sondeiana* Martin suggested already its affinity to *M. rustica* (and to two other recent species besides). As points of divergence he mentioned the more slender and tapering form of the shell ("ist schlanker und schärfer zugespitzt") in *rustica*, referring to plate 17 fig. 2 in Brot's Monograph of *Melania* (Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874). These arguments however are not very sound: in the first place there are among the very shells which Martin had before him several individuals of similar shape and profile as *rustica* and secondly, as Martin himself must have been fully aware, these characters can only be employed with the utmost care in such a polymorph genus as *Thiara*. In recent *Th. rustica* of the Zoological Museum at Amsterdam the outward appearance is also very variable.

In the recent fauna *Th. rustica* is found in Sumatra, Java, Bali, Soembawa, and Flores (Rensch, Zool. Jahrb. (Syst.), vol. 65, 1934, p. 414).

The fossil shells all come from the Sonde deposits.

Thiara (Stenomelania) semicancellata (v. d. Busch)

1844 Von dem Busch, in: Philippi, Abb. & Beschr., vol. 1, p. 159, pl. 3 fig. 2 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. (N.F.), vol. 1, p. 234 and 235, pl. 35 fig. 555 (*Melania* (s. str.) *gendinganensis*).
1919 Martin, p. 96 (*Melania gendinganensis*).
1931 Van der Vlerk, p. 254 (*Melania gendinganensis*).

Material examined:

Leiden Geological Museum

St. No. 10950. Sonde: 1 spec. (type of *gendinganensis*, figured by Martin).

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 257. Bengawan Solo, South of mouth of River Alastoewa, near Sonde, Upper Kalibèng layers: 1 spec., juv., high 23.7, broad 7.5 mm.

Sheet 93 B No. 258. Same locality, same formation: 2 spec., high 43.5, broad 14 mm, other incomplete.

The type specimen of *gendinganensis*, the only one which served Martin for his diagnosis, is high 35.8, broad 12 mm. The concave profile of the spire renders it a curious aspect and is of the same nature as in recent shells of *Th. semicancellata*. Martin was well aware of the affinity of his *gendinganensis* with *semicancellata*. The comparison with *Th. sobria* was less fortunate. As principal points of discrimination with *Th. semicancellata* Martin drew attention to the difference in sculpture.

Von dem Busch described the sculpture of his species as follows: "supremis lineis transversis impressis (circa 8) plicisque longitudinalibus decussatus, inferioribus laeviusculis, ultimo convexiuscula", and a more extensive statement was given by Brot (in: Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 1, Abt. 24, 1874, p. 118 seq.). This author, a.o., mentioned that: "Diese Art ...... variirt aber bedeutend in der Skulptur, die Längsfurchen sind meistens auf der ganzen Schale gleich stark entwickelt, ich besitze aber ein Exemplar, an welchen sie nur an der Basis und unter der Naht existieren. Die Querfalten sind nach den Individuen sehr verschieden entwickelt, und erstrecken sich mehr oder weniger auf die letzten Windungen, können aber beinahe gänzlich fehlen, namentlich auf den ersten Umgängen ...... Der letzte Umgang ist beinahe immer merklich kantig an der Peripherie".

A set of 4 recent shells from Java in our Museum, collected by the famous Java-explorer Franz Junghuhn fully demonstrates this variation in sculpture. There is one individual possessing the spiral striae only below the periphery. Vertical plicae are present on two shells, absent in the two others. The two younger, semiadult shells, are angular at the periphery, the adults are rounded. Very characteristic is the building of the tapering spire which is awl-like and wound in a narrow screw, quickly increasing in height. The whorls bear close set spiral lines, sometimes crossed by small vertical folds.

The type of *gendinganensis*, though on the whole well preserved, carries little or no trace of sculpture; only the 6 ridges encircling the umbilical area, already mentioned by Martin, are discernable.

Of the three fossils collected by the Geological Survey, only the fragmentary shell of Stat. 258 presents faint spiral striae on the younger whorls. The immature specimen of Stat. 257 possesses 8 grooves in the umbilical region, the adult of Stat. 258 is too much worn in this part of the shell to allow discrimination of any sculpture at all.

In the recent fauna the species in only known from Java. In a fossil state it occurs in the Sonde deposits and besides it was already mentioned (with reservations) from Quarternary strata in South Celebes (Martin, Tijdschr. Kon. Ned. Aardr. Gen. (2), vol. 7, 1890, p. 277).

Thiara (Melanoides) tuberculata (Müller)

1774 Müller, Hist. Verm., vol. 2, p. 191 (*Nerita*).
1887 Martin, Palaeont. Erg. Tiefbohr. Java, Samml. Geol. Reichsmus. Leiden (1), vol. 3, p. 157 and 324 (*Melania*).
1905 Martin, Foss. Java, Samml. Geol. Reichsmus. Leiden (N.F.), vol. 1, p. 234 and 238 (*Melania (Striatella) tuberculata*); p. 234 and 239, pl. 36 figs. 567—570 (*Melania (Striatella) Woodwardi*).
1911 Martin-Icke, p. 50 (*Melania (Striatella) tuberculata*).
1919 Martin, p. 96 (*Melania tuberculata* and *M. woodwardi*).
1931 Van Es, p. 52 and 136 (*Melania tuberculata*).
1931 Van der Vlerk, p. 255 (*Melania tuberculata* and *M. woodwardi*).
1931 Van Benthem Jutting, p. 103 (*Melania tuberculata*).
1935 Oostingh, p. 13 (*Melanoides (Melanoides) tuberculata*) and p. 17 (*Melanoides (Melanoides) woodwardi*).

Material examined:

Leiden Geological Museum

St. No. 10967. Ngembak: 3 spec. (s.n. *tuberculata*).
St. No. 10970. Sonde: 1 spec. (s.n. *tuberculata*).
St. No. 10971. id.: 2 spec. (s.n. *tuberculata*).
St. No. 10973. id.: 4 spec. (s.n. *woodwardi*).
St. No. 10974. id.: 10 spec. (s.n. *woodwardi*).
St. No. 10975. id.: 21 spec. (s.n. *woodwardi*).

Collection of the Geological Survey, Bandoeng

Sheet 93 B. River Grendjingan, Ingr. VIII, layer III, 21. X. 1931: 14 spec., high 28.2, 28.-, 25.7, 25.-, 24.8, 24.4, 22.8, 22.6, 22.3, 22.2, 21.8, 20.-, 19.5, 18.- mm.

Sheet 99 B No. 18. River Ngetas, Kaboeh layers: 4 spec., very little sculptured, highest spec. 23.5 mm.

Sheet 105 B No. 54. River Garoetan, Poetjangan layers: 3 spec., resp. 19, 20 and 21 mm high. Initial whorls missing.

Sheet 110 A No. 145. Near Kampong Soemberringin, Kaboeh layers: 12 spec., very little sculptured, partly damaged. Highest complete spec. 25 mm.

Sheet 110 B No. 156. Trench B, North of Kampong Soembergajam, Poetjangan layers, layer I: 1 spec., high 29.2 mm.

Sheet 110 B No. 188. River Bantengan, Poetjangan layers, layer III: 1 spec., 25 mm high.

Cosijn Collection

Locality unknown: 1 spec. high 19.5 mm.

In our days the species is very abundant in the whole Indo-Australian Archipelago and beyond it, ranging from the Mediterranean and East Africa, Mesopotamia, India, Burma, China, via the Malay Archipelago to Queensland. It is found at sealevel, but also in hilly country up to circa 1100 m and locally even to 2000 m (crater lake Segara Anak in Lombok). They have a predilection for running water, though stagnant waters are not avoided. Even in hot springs the species flourishes and samples were collected in the hot sodium-containing travertine springs of Koeripan (close to Buitenzorg, West Java) (vide Rensch, Trop. Binnengew., vol. 5, 1934, p. 229) and in the iodine-containing springs and lakes between Soerabaja and Pasoeroean (East Java) (coll. Miss Dr. A. G. Vorstman, in Zoological Museum, Amsterdam).

Fossil *Th. tuberculata* have been recorded ever since the Upper Miocene. It is remarkable that this species which is so extremely common, both in the recent fauna and in older deposits (cfr. Oostingh, 1935, p. 13 seq.) was not found in exceptionally great numbers in the Kendeng region. Whether this condition represents the normal circumstances during the Plio-Pleistocene period I am unable to decide, though I venture to suppose that the frequency must have been considerably higher during the Kalibèng and Poetjangan formations.

Several shells still show some traces of red-brown flames. Those of the Geological Survey are in various grades intermediate between the forms *plicifera* Mousson and *virgulata* Quoy & Gaimard, according to the greater or lesser development of the vertical ribs on the spire.

Among the material which I received for comparison from the Leiden Geological Museum there are 3 shells from Demak Grobogan, Semarang, Central Java (St. No. 10968) which approach *Th. crepidinata* Reeve. This species is a close relation of *Th. tuberculata* and, in my opinion, should be classified as a form (or subspecies?) of the latter.

Melania woodwardi Martin was created by this author for fossil shells, which, compared with *M. tuberculata,* possess less convex whorls, less pronounced sculpture on the younger whorls and are without a spiral groove along the suture.

Judging from the type and paratypes, now in the Leiden Geological Museum, *M. woodwardi* in itself is a very variable species, even more than the diagnosis would make suppose. The same is asserted by Oostingh (l.c.) on account of shells from the Boemiajoe deposits.

In sample 110 A No. 145 there are a few shells which for the greater part are devoid of any sculpture at all. Their surface is smooth and shining. Only on the top the specific *tuberculata*-sculpture is demonstrated, thus assigning their proper systematic place. It cannot enough be recommended to employ this part of the shell as a character of supreme taxonomic value.

In the recent fauna there occur slender and broad, sculptured and smooth specimens, strongly constricted ones and shells with less convex whorls. I do not see sufficient reason to maintain *M. woodwardi* as a separate species or subspecies.

The oldest records in Java are the shells from Ngembak. Martin estimated these layers to be Upper Miocene. In the paragraph on *Corbicula exporrecta* hereafter a short notice will be found why these deposits are probably younger.

Two scalariform Melaniids were excavated at Mount Bareng, North of Kaboeh (Cosijn Collection, Locality 1) and at Bengawan Solo, near Bangoenredjo Kidoel (Sheet 93 B No. 260, Collection of the Geological Survey, Bandoeng). Unfortunately I was not able to bring them to a definite specific position.

Corbicula pullata (Philippi) (Plate IV figs. 12—15).

1850 Philippi, Abb. & Beschr., vol. 3, p. 110 (*Cyrena pullata*).
?1908 Dubois, p. 1249 (eine noch zu bestimmende *Corbicula*). — Either this species or the next.
?1911 Carthaus, p. 13 (*Corbicula*). — Identification left at that.
1935 Oostingh, p. 170.

Material examined:

No. 1576. Kedoeng Nojo near Tritik B 124: 6 entire spec. and 37 single valves. Largest valve high 20 mm, sag. diam. 20 mm.
No. 1684. Kedoeng Nojo near Tritik ?: 6 entire spec. and 57 single valves.
No. 9751—9758. Kedoeng Nojo near Tritik B 124: a few entire spec. and numerous single valves.
No. 9768. Trinil: 1 single valve.
No. 9783. No locality: 1 single valve.
No. 9817. id. id. 2 single valves.

Elbert Collection

Sonde, in the vicinity of the waterfall. Lying wall („Liegendes") of the Kendeng layers: piece of marl with several imbedded valves.

Collection of the Geological Survey, Bandoeng

Sheet 99 B No. 18. River Ngetas, 23 July 1934, Kaboeh layers: 15 single valves.

Shells of *Corbicula pullata* are plentiful at Kedoeng Nojo, a small native village East of Tritik, in a zone of Kaboeh layers. The material is very homogeneous, consisting of middle-sized valves of about 15 mm length in vertical and in sagittal direction, only rarely reaching 20 mm, as the specimen mentioned above in sample No. 1576 of the Dubois Collection. There are few entire shells; the majority are single valves imbedded in a coarse-grained yellowish-brown sandstone.

Corbicula pullata is already recorded in the late Pliocene, the Kali Glagah beds at Boemiajoe (Oostingh, l.c.) where several specimens were found.

In the recent fauna it is still an inhabitant of Java, especially of the Eastern part. Beyond this island *Corbicula pullata* is found in Sumatra and Borneo.

Corbicula gerthi Oostingh (Plate V figs. 1—7).

? 1908 Dubois, p. 1249 (eine noch zu bestimmende *Corbicula*). — Either this species or the preceding.
? 1911 Carthaus, p. 13 (*Corbicula*). — Identification left at that.
1911 Martin, p. 53 (*Corbicula*). — Probably this species.
1919 Martin, p. 65 (*Corbicula* spec. indet.). — Same remark as in preceding reference.
1931 Van der Vlerk, p. 281 (*Corbicula* spec.). — Same remark as in preceding reference.
1935 Oostingh, p. 169, pl. 16 figs. 141—143.

Material examined:

Dubois Collection

No. 736. Bapang A 87: 20 single valves.
No. 1503. Without locality: 10 single valves.
No. 1504 a and b. Tjenklik near Solo C 129: 9 single valves.
No. 1505. Tjenklik near Solo C 129: 6 single valves.
No. 1680. Trinil: several single valves:
No. 9635. Tjenklik near Solo C 128: several single valves.
No. 9646. id. id. id. C 126: several single valves.
No. 9676. Bogo: 4 single valves.
No. 9680. id. 8 single valves.
No. 9682. id. some single valves, in stone.
No. 9695. Trinil No. 12 Coll. 1900: several single valves.

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 256 River Solo, East of Sonde, River terraces?: several single valves.

From Martin's remarks on the unidentified *Corbicula* collected by the Selenka Expedition it can be easily understood that he had before him shells of the above species, characterized by "die Höhe der Schale, die aufgetriebenen und weit hervorstehenden Wirbel, sowie den ausgesprochen dreiseitigen Umriss".

Unfortunately I cannot verify this presumption as none of the actual specimens is present in the Leiden Geological Museum.

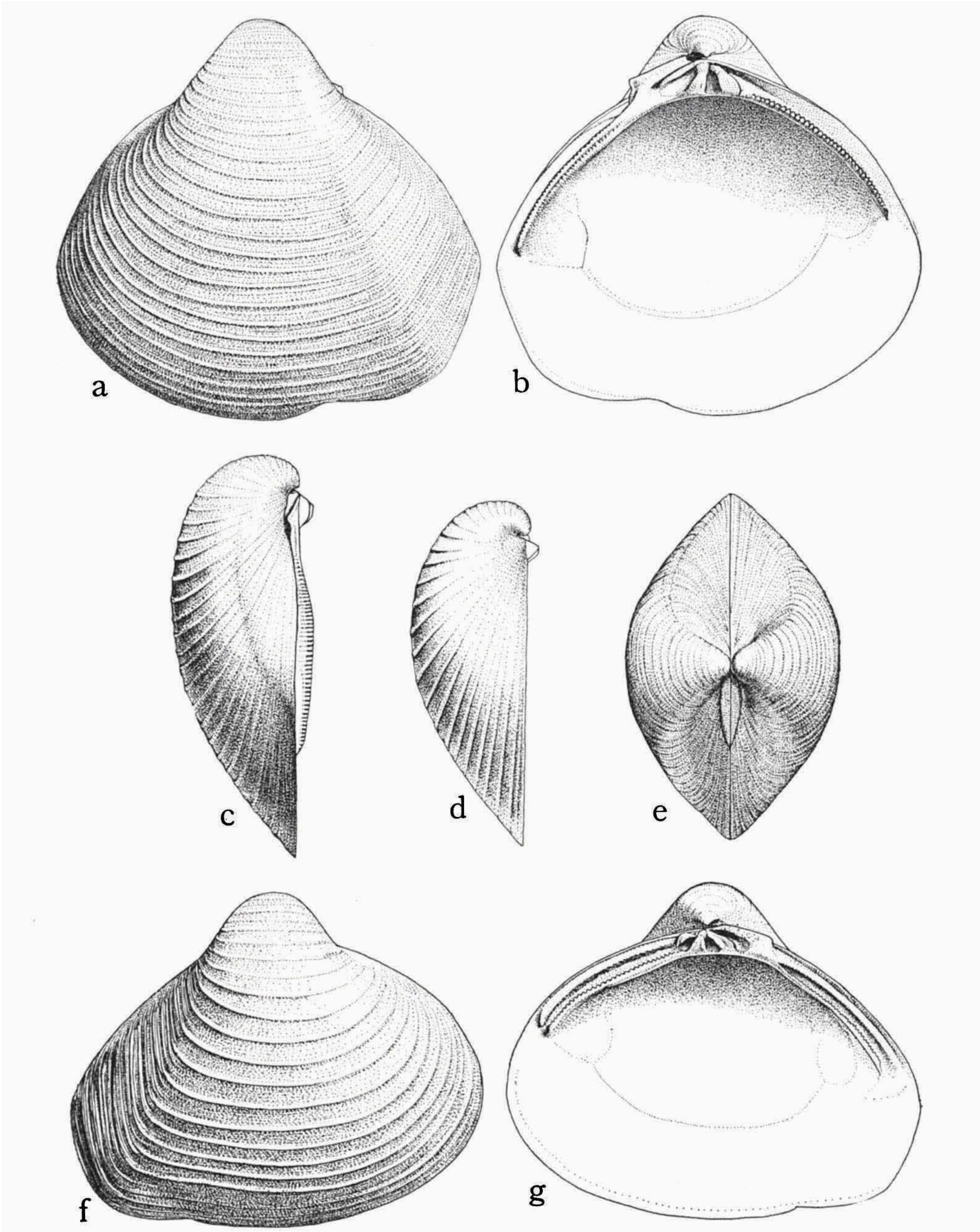

Fig. 2. *Corbicula gerthi* Oostingh. a, b, c, left valve from exterior, interior, and profile; d, f, g, right valve from profile, exterior, and interior; e, closed shell from top. × about 2½.

At Boemiajoe, whence it has been described for first time by Oostingh, *Corbicula gerthi* occurred in the Kali Bioek beds and Kali Glagah beds (Middle and Upper Pliocene). The specimens which I have now before me

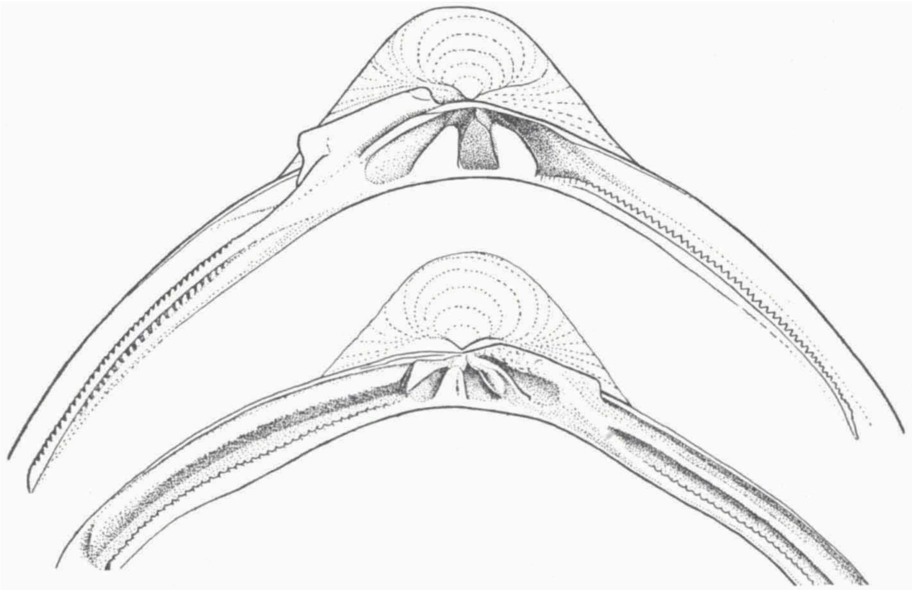

Fig. 3. *Corbicula gerthi* Oostingh. Hinge of left and right valves. × about 5.

belong to a younger formation; those collected in the terraces of the River Solo (Sheet 93 B No. 256) belong to a recent secondary deposit of fossil material and therefore have little value for chronological evidence.

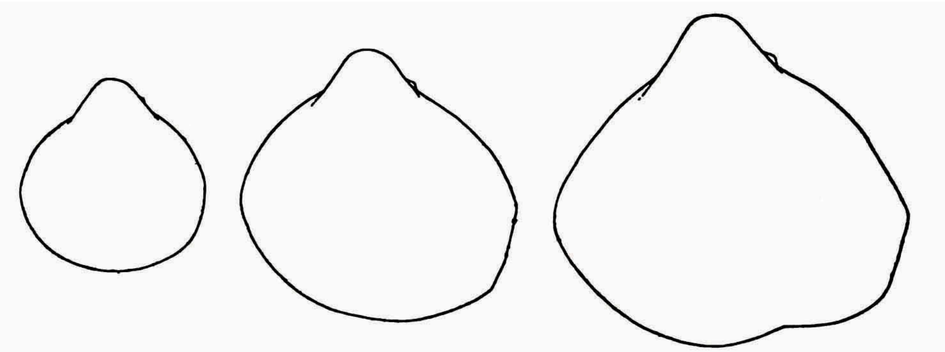

Fig 4. *Corbicula gerthi* Oostingh. Outlines of 3 left valves of different age. × about 2½.

Like the Boemiajoe shells our *Corbicula gerthi* from the Kendeng mountains are variable in outline and in interior capacity. Traits of resemblance with *Corbicula exporrecta* Martin will be discussed under this species.

Corbicula exporrecta Martin

1887 Martin, Palaeont. Erg. Tiefbohr. Java, Samml. Geol. Reichsmus. Leiden (1), vol. 3, p. 222, pl. 11 fig. 220.
1919 Martin, p. 65.
1931 Van Es, p. 61, 62, 64, 65, 73, and 136.
1931 Van der Vlerk, p. 281.

Material examined:

Dubois Collection

No. 1680. Trinil: 5 single valves, vert. diam. 18, 16, 12, 12, 10 mm,
sag. diam. 16, 14, 12, 11, 9 mm; the two larger are right valves, the others are left valves.

The Trinil specimens are somewhat smaller than the shells measured by Martin. Of his material I could compare 2 paratypical valves, a left one of 16 mm sag. diam., and 21 mm vert. diam., and a right, incomplete one.

The shells of the Dubois Collection are much better preserved than the fossils from Ngembak and therefore the opportunity was seized to reproduce here a few new and more detailed drawings, after Trinil specimens.

The umbo is very much incurved, like the beak of a bird of prey. Considering the size of the very solid valves the interior is rather shallow, caused by deposition of shell substance against the inside wall. This character increases with advancing age. The exterior of the shells never shows a faint concavity at a short distance of the posterior side and parallel with it, as in *Corbicula gerthi.*

Young stages of *C. gerthi* sometimes resemble *C. exporrecta*, so long as they are rounded-triangular and convex, with prominent beaks, three features which are transformed afterwards when *C. gerthi* becomes more and more stretched, with obtuse posterior angle, and diminishing convexity. The umbones of full-grown *C. gerthi* are still projecting as if not quite in harmony with the rest of the shell, thus rendering it a very peculiar aspect. (figs. 2 and 4). A certain convergence of *C. exporrecta* and certain forms of *C. gerthi* was already referred to by Oostingh (l.c., p. 169).

Martin's specimens were excavated from what were supposed to be Miocene layers at Ngembak (Residency of Rembang). The two quotations in Martin (1919) and Van der Vlerk (1931) both bear upon the same individuals.

Van Es could dispose of additional material from Sangiran and Baringinan (vide chapter 3 of this paper). In both localities *C. exporrecta* formed part of a younger deposit,viz., the Upper Pliocene. The specimens of Martin's original locality were even supposed to be of Pleistocene age (Van Es, l.c., p. 61 and table p. 136).

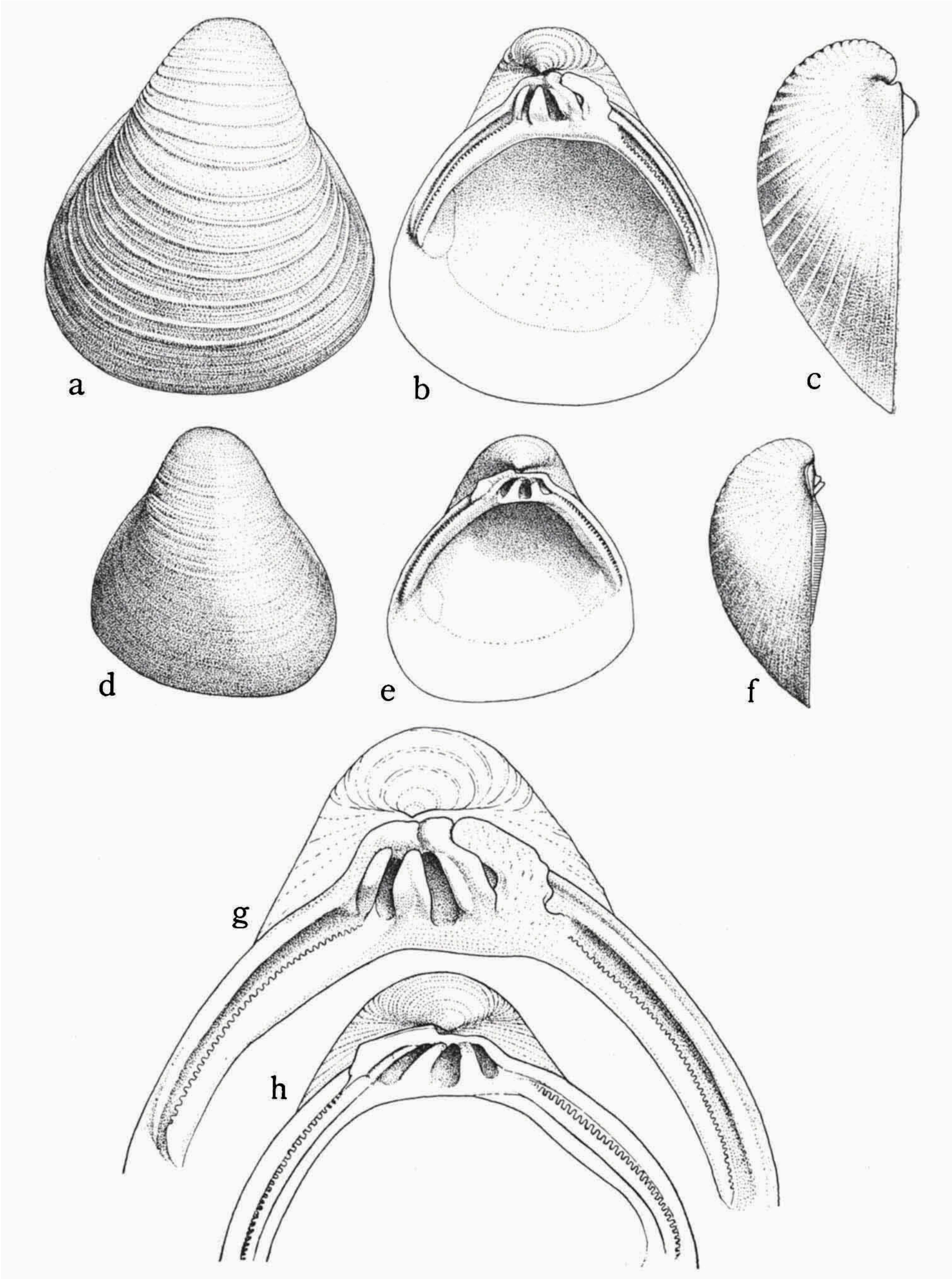

Fig. 5. *Corbicula exporrecta* Martin. a, b, c, right valve from exterior, interior, and profile; d, e, f, left valve from exterior, interior, and profile; g, hinge of right valve; h, hinge of left valve. a—f, × about 2½; g and h, × about 5.

To these scarce data the shells of the Dubois Collection form a welcome addition. In horizontal direction the distribution of *Corbicula exporrecta* stretches from Sangiran and Baringinan near Solo in the West to Trinil in the East. Vertically it has been recorded from Upper Pliocene (if not Miocene?) layers till the age of the Trinil Fauna. Its palaeontological history started in the West of the region in the Upper Pliocene some miles from the prehistoric shore line of Java. With the gradual displacement of this line in eastward direction, according to the continuous increase of the country, more and more room was created for freshwater basins and freshwater animals, so that the species could swarm into the new territory. Scores of centuries later, during the Pleistocene, we find *Corbicula exporrecta* again, this time in the Trinil beds.

As was already stated in the beginning of the discussion the Trinil shells are much better preserved and of more modern appearance than the valves of Ngembak. Judging from their state of fossilization I am inclined to consider the Ngembak specimens oldest Pleistocene, if not of Pliocene age.

Batissa keraudreni (Lesson) (Plate XI, Plate XII figs. 1, 2).

1830 Lesson, Voy. Coq., Zool., vol. 2, p. 429, pl. 11 fig. 3 (*Cyrena* (*Cyprina*) *Keraudrenia*).

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 99 B No. 7. River Ngesong, Poetjangan layers: 1 spec. long 72, high 62, diam. (2) 43 mm, approaching *B. ponderosa* Prime in form 1).

Sheet 105 B No. 64. River Soemberpoele (Tributary of River Bèng), Poetjangan layers: 2 hinge fragments, 1 right, 1 left.

Sheet 105 B No. 66. River Setri (Tributary of River Bèng), Poetjangan layers: umbo and hinge of left valve.

Sheet 105 B No. 67. Trolley near River Bèng, 19. VI. 1931, Poetjangan layers: right hinge fragment.

Sheet 105 B No. 68. River Brangkal, Poetjangan layers: right valve, long 109, high 95, diam. (1) 31 mm.

Sheet 105 B No. 72. River Watoegaleng (Tributary of River Bèng), Poetjangan layers: 5 spec., partly as casts, long 107, 100, 95 mm,
high 83, 80, 79 mm,
diam. (2) 49, 47, 43 mm. The two others are too bad to be measured.

Sheet 110 A No. 78. River Soedo (Tributary of River Bèng), 14. X. 1932, Poetjangan layers: many fragm.

Sheet 110 A No. 106 a. River Toepak, 19. IX. 1933, Poetjangan layers, layer I: 1 spec., long 108, high 88, diam. (2) 59 mm, and 1 right valve too much damaged to be measured.

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1) In this and in following checks diam. (2) means: diameter of the entire shell, with closed valves; diam. (1) means: diameter of one valve.

Sheet 110 A No. 115. River Banger (Tributary of River Bèng), Poetjangan layers: 1 spec., long 105, high 83, diam. (2) 51 mm.

Sheet 110 A No. 116. River Kedoengkerang, Poetjangan layers: 4 spec., mostly casts, not measured.

Sheet 110 A No. 117. River Kedoengkerang, 4. IV. 1933, Poetjangan layers: 1 right valve, very much damaged, and one smaller fragment.

Sheet 110 A No. 118. River Marmojo, 5. IV. 1933, Poetjangan layers: 1 spec., long 86, high 69, diam. (2) 44 mm, 1 right valve, damaged, and 1 fragm.

Sheet 110 A No. 119. Path Bringin-Wadoeng, 17. III. 1928, Poetjangan layers: 3 spec. and 2 left valves. One of the entire specimens and one of the single valves too much damaged to be measured. Dimensions of the others:

long 140, 137, 106 mm,
high 107, 100, 89 mm,
diam. (2) 55, 59, diam. (1) 28 mm. The first and second approach *B. gigantea* Prime.

Sheet 110 A No. 132. River Pandogan, 19. IX. 1933, Poetjangan layers: fragment of right valve.

Sheet 110 A No. 135 b. Trench near Moenoengkerep, 18. I. 1928, Poetjangan layers: 5 spec. and 2 odd valves. One of the entire spec. and one valve cannot be measured. Others:

long 144, 137, 116, ?, 144 mm,
high 102, 95, 83, 87, 102 mm,
diam. (2) 62, 61, 62, 65, diam. (1) 35 mm.

The first, second and fourth shell approach *B. gigantea* Prime.

Sheet 110 A No. 138. North of Desa Sloemboeng, 18. I. 1928, Poetjangan layers: 3 spec., in such a bad condition, that measuring is impossible.

Sheet 110 B No. 152. River Tegaldoekoeh, Poetjangan layers: umbo and hinge of left valve.

Sheet 110 B No. 169. River Soembergajam, 23. IX. 1933, Poetjangan layers: 1 spec. (forma *gigantea*), partly as cast, not measured.

Sheet 110 B No. 184. South of Kampong Sidorojol, Poetjangan layers: 3 spec., partly as casts, not measured. One right valve, high 114, diam. (1) 37 mm, posterior part broken.

Sheet 110 B No. 187. River Bantengan, 16. XI. 1933, Poetjangan layers: 1 spec., long 103, high 92, diam. (2) 52 mm. and 1 fragm.

Sheet 110 B No. 194. Forestborder West of Bangeran, Poetjangan layers: 1 spec. long 111, high 93, diam. (2) 62 mm.

Sheet 110 B No. 199. North of Kampong Lokardowo, Kaboeh layers [1]): 2 right hinge fragments (doubtful).

Sheet 110 B No. 285. River Soemberdadi, 21. III. 1934, formation not ascertained: 2½ spec., and some fragm., all too bad to be measured.

Sheet 116 A No. 221. River Soemberdjo, Poetjangan layers: 1 fragm., with umbo and hinge.

Sheet 116 A No. 236. River Klagen, 24. XI. 1933, Poetjangan layers: 1 left valve, long 91, high 78, diam. (1) 27 mm.

The taxonomy of the genus *Batissa* is in a most deplorable state of confusion. The two monographs of Sowerby (in: Reeve, Conch. Icon., vol. 20, 1878, *Cyrena*) and Clessin (in: Martini & Chemnitz, N. Syst. Conch.

1) This in the only record from the Kaboeh formation, all other specimens being excavated from Poetjangan layers.

Cab., Bd. 9, Abt. 3, 1879) are nearly sixty years old and it is not hazardous to suggest that a considerable number of their "species" can be united or suppressed. However, I must abstain from further comment as I have not compared all the species, nor seen the type specimens.

The greater part of the Java fossils belong to a more or less orbicular and inflated type as represented in the samples 7 (Plate XII figs. 1 and 2), 68, 72, 115, 118, 187, 194, 236. The ratio length: height in these shells varies between 1.119 and 1.289.

Only very large, old specimens, as contained in the samples 119, 135 b (Plate XI fig. 2) and 169, have become more elongate with increasing age. The transverse diameter of these specimens, however, has not increased in the same measure and therefore their entire habitus is relatively more compressed laterally. Their ratio length: height lies between 1.308 and 1.442.

Fortunately the umbonal parts have been well preserved in most of the shells and they show that the beaks are placed rather obliquely, well in front of the middle, though as a rule they are tumid and not projecting very much. The beaks are curved forward and inward, so as to reach each other almost in the median line.

The specimen of sample 7 covers the figure of *Batissa ponderosa* Prime (Ann. Lyc. Nat. Hist., New York, vol. 8, 1866, p. 231) almost completely. The latter surpasses our fossil but for some lines of increment.

The majority of the extinct *Batissa* can be united with the figure of *Batissa keraudreni* in Sowerby-Reeve (l.c., pl. 2 fig. 6) which is 121 mm long and 102 mm high. Its length: height ratio thus amounts to 1.186 and comes under the variation-width of our fossil shells.

The specimens indicated as forma *gigantea* in the analysis of the samples are in my opinion nothing but uncommonly luxuriant stages of *keraudreni*. This instance is not a solitary one: similar cases of gigantic individuals are known in other species of *Batissa*. Mörch (Journ. de Conch., vol. 20, 1872, p. 326) recorded a *Batissa similis* Prime from the Nicobar Islands being 128 mm long and 102 mm high and in the Zoological Museum at Amsterdam a *Batissa violacea* Lam. of 127 mm length and 103 mm height from Java is preserved.

Batissa gigantea Prime as figured by Sowerby (in: Reeve, l.c., pl. 1 fig. 1) measures 145 by 107 mm, giving a length: height ratio of 1.355.

The recent fauna of Java contains two species of *Batissa*, viz., *B. javanica* Mouss. and *B. jayensis* Lea. The former is doubtless a variety of *B. violacea* and is often referred to as *B. violacea* var. *javanica*. The other *Batissa* has a more orbicular outline and is more inflated. This species is related to our fossil *keraudreni*. *B. jayensis* is recorded from Java and Sumatra (Martens, in: Weber, Erg. Reise Niederl. Ost Indien, vol. 4, 1897, p. 102) and from Waigeoe (Sowerby, in: Reeve, l.c., pl. 6 fig. 19). *B. keraudreni* is found in the Philippines and also in Waigeoe. This confluence of the two areas of distribution, together with the conformity in the exterior of the animals led me to the supposition, that both *jayensis* and *keraudreni* might belong to one and the same "Rassenkreis".

The *keraudreni* form which inhabited Java in the past has wandered to Waigeoe and the Philippines since that time. It does not longer occur in Java, but has been replaced by a smaller descendant, *B. jayensis*.

Batissa-species are inhabitants of freshwater, though brackish water is not wholly avoided. Many questions, however, are still unsolved and we hardly know anything about the biology, ecology and propagation of the members of this genus.

Batissa violacea Lamarck var. **macassarica** Martens (Plates IX and X).

1897 Martens, in: Weber, Erg. Reise Niederl. Ost Indien, vol. 4, p. 105, pl. 5 fig. 8.

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 110 A No. 132. River Pandogan, 19. IX. 1933, Poetjangan layers: 5 single valves (3 of which more or less damaged), 2 left and 1 right hinge fragm. and 1 odd fragm., long 93, 75, 57, 51 mm,
high 73, 58, 46, 42 mm,
diam. (1) 24, 21, 14, 14 mm.

Sheet 110 B No. 187. River Bantengan, 16. XI. 1933, Poetjangan layers: 4 single valves (3 of which are badly broken). Other long 101, high 84, diam. (1) 27 mm.

Sheet 116 A No. 216. North of Kampong Klagenblandong, Poetjangan layers, layer II: 3 fragm.

Sheet 116 A No. 235. River Retjo, Poetjangan layers: 1 cast (doubtful) and 1 valve in stone, long 86, high 62 mm, diam. not measured.

Sheet 116 A No. 236 River Klagen, 24. XI. 1933, Poetjangan layers: 10 single valves (4 of which too much damaged to be measured). Others:
long 84, 63, 46, 35, 22, 22 mm,
high 70, 60, 42, 34, 20, 20 mm,
diam. (1) 23, 18, 16, 12, 8, 8 mm.

The recent *Batissa violacea* is a very polymorph animal and a considerable number of "species" haunting the literature, should probably be dropped as synonyms before *violacea*.

Not only the ratio of sagittal, transverse, and vertical dimensions varies a great deal, but also the relative length of the lateral teeth, the position, inflation, and curving of the umbonal part of the shell can differ considerably.

In the nominal species the umbones (if not eroded) are not inflated.

They are placed in front of the middle and are gradually and evenly curved in frontal direction.

Several local varieties or forms have been described, not always of irreproachable value. Of these *B. violacea* var. *macassarica,* originally recorded from Makassar, South Celebes, approaches our fossil shell closely. Judging from the figures and the (not very satisfactory) description *B. veneriformis* (Sowerby, in: Reeve, Conch. Icon., vol. 20, 1878, pl. 4 fig. 11) syn. *B. fuscata* (Prime, Proc. Zool. Soc. London, 1860, p. 319) is a related species, but unfortunately I could not test my opinion by comparing the actual specimens. The papuan *B. angulata* Reinhardt (Sitz. Ber. Ges. naturf. Freunde Berlin, 1886, p. 62) of which I could examine a shell in the Rijksmuseum van Natuurlijke Historie at Leiden, is certainly also a form of *B. violacea,* though not identical with our Java fossils.

In the 5 samples now before me there exists also a great deal of variation. The young specimens of sample 236 (Plate IX figs. 3—5) are relatively short in sagittal direction when compared with the smallest valve of sample 132 (Plate IX fig. 1). The former as such might be classified in Martens' group of the Rotundatae. The older valves of the same sample, however, are more stretched, and from the growth lines on the exterior of the largest valve we can follow the increase of the sagittal axis according to age, and the gradual transition of the rotund to the elliptical state.

These shells of sample 236 approach recent *B. angulata.* Here also we can observe an augmentation of the ratio length: height in favour of the length during growth, the young being orbicular (circa 36 × 32 mm), the mature shell elliptical (80 × 64 mm).

The specimens of the other samples are elliptical from the very beginning. One incomplete valve of sample 132 is a pure *violacea.* All the rest have inflated umbones, even to such an extent that this part of the shell resembles a kind of small inflated bonnet, grafted artificially on a for the rest not particularly inflated shell.

All the samples of the Geological Survey of Bandoeng were collected in the Poetjangan horizon in the East part of the Kendeng region. Probably they lived close to the prehistoric shore line in tidal or in brackish water.

Polymedosa tegalensis Oostingh (Plate XII figs. 3—6).

1935 Oostingh, p. 168, pl. 15 fig. 137.

Material examined:

Collection of the Geological Survey, Bandoeng

Sheet 93 B No. 258. River Bengawan, South of mouth of River Alastoewa, 20. VIII. 1932, Upper Kalibèng layers: 1 right valve, long 60.2, high 55.8, diam. (1) 18 mm.

Sheet 99 B No. 9. West of Kampong Ngronan, Poetjangan layers: 1 spec., long 85, high 83, diam. (2) 59 mm.

Sheet 105 B No. 72. River Watoegaleng (Tributary of River Bangle), Poetjangan layers: 2 spec., hardly more than casts, rather heavy, though not in the same measure as the shell of Sheet 116 A No. 221 (see hereafter). Dimensions: long 85, high 83, diam. (2) 50 mm; long ?, high 78, diam. (2) 50 mm.

Sheet 110 B No. 178. North of Kampong Gondang, Poetjangan layers, layer II: 1 right valve, damaged. Thinner (by natural condition and by corrosion) than the shell of Sheet 116 A No. 221 (see hereafter).

Sheet 116 A No. 214. River Retjo, Poetjangan layers, layer II: 1 fragm.

Sheet 116 A No. 216. North of Kampong Klagenblandong, Poetjangan layers, layer II: 1 fragm.

Sheet 116 A No. 221. River Soemberdjo, 24. XI. 1933, Poetjangan layers, layer II: 1 spec., very large and vaulted shell. Dimensions: long 110, high 100, diam. (2) 80 mm.

Polymesoda tegalensis is undoubtedly related to the recent Javanese species *P. bengalensis* (Lam.) in its modern systematic conception (Prashad, Siboga Exped., Monogr. LIII c, 1932, p. 175). Perhaps it is only an extinct representative, but with the present very unsatisfactory taxonomic conditions in the genus *Polymesoda* it is almost impossible to get the specific limits clearly defined.

The hinge and shell texture are remarkably thick, especially in our last sample (Plate XII figs. 3—4), which agrees very well with Oostingh's description and figure. Both are for instance unquestionably much thicker than recent *Polymesoda* of analogous dimensions (Mörch, Journ. de Conch., vol. 20, 1872, p. 326, *Cyrena* (*Geloina*) *galatheae*).

Oostingh's specimen was excavated from the Kali Bioek beds at Boemiajoe (Central Java) which are dated Middle Pliocene.

Cyrena (s. str.) *rustica* Martin (Palaeont. Erg. Tiefbohr. Java, Samml. Geol. Reichsmus. Leiden (1), vol. 3, 1883—1887, p. 222, pl. 11 fig. 221) was originally described from Miocene layers at Ngembak (Residency of Rembang). Afterwards fossil specimens were also recorded from Madoera Id. and other localities and from younger deposits (Martin, 1919, p. 65 and p. 116; Van der Vlerk, 1931, p. 281; Van Es, 1931, p. 45, 97, 116 and 120). After examination of the type specimen in the Geological Museum at Leiden I am quite convinced that we have to do with a fossil specimen of *Polymesoda erosa* (Sol.). The shell is identical with a recent *P.erosa* of approximately the same size collected by the Siboga Expedition at Stat. 164, East of Misool Id. (Prashad, l.c., p. 174).

Little is known about the habitat of *Polymesoda*. Martens, in: Weber, Erg. Reise Niederl. Ost Indien, vol. 4, 1897, p. 90, found them "hauptsächlich im Küstenland, zunächst dem Meere, oft im Brackwasser, doch nicht immer", but renewed investigations in the field would not be out of place.

Elongaria orientalis (Lea) (Plate V fig. 8, Plate VI).

1840 Lea, Proc. Americ. Philos. Soc., vol. 1, p. 285 (*Unio orientalis*).
? 1908 Branca, p. 270 (zwei Arten von *Unio*).—One of these probably our species.
1908 Dubois, p. 1249 (zwei Arten von Flussmuscheln, eine grosse und eine kleine).— The latter is *Elongaria orientalis*, the former *Pseudodon*.
? 1908 Elbert (Nieuwste Onderzoekingen), p. 129 (Uniones).—No further identification possible.
? 1908 Elbert (Alter der Kendeng-Schichten), p. 656 and table facing p. 657 (Unionen).—Same remark as in preceding reference.
1908 Elbert (Alter der Kendeng-Schichten), table facing, p. 657 (*Unio productus*).
1909 Elbert, p. 517 (*Unio productus*).
? 1911 Carthaus, p. 13 (*Unio*).—Identification left at that.
? 1911 Dozy, p. 35 (*Unio*).—Same remark as in preceding reference.
1911 Martin, p. 52—53 (*Unio productus* and *U. productus* var. *normalis*).
1919 Martin, p. 61 (*Unio productus* var. *normalis*).
? 1921 Hilber, p. 151 (zwei Muschelarten).—Further identification impossible.
? 1929 Van Es, p. 336 (*Unio*).—Further identification impossible. Compare also Van Benthem Jutting, 1932.
? 1931 Van Es, p. 64, 65, 136 (*Unio* spec.).—No further identification possible.
1931 Van Es, p. 136 (*Unio productus*).
1931 Van der Vlerk, p. 274 (*Unio productus* prior *normalis*).—This version is erroneous: *normalis* is not a prior.
1932 Van Benthem Jutting, p. 103.
1935 Oostingh, p. 162, pl. 15 figs. 134—136.

Material examined:

Dubois Collection

No. 736. Bapang: some fragm.

No. 1505. Tjenklik near Solo C 129: ½ spec. and a few fragm.

No. 1670. Kedoeng Nojo near Tritik B. 124: 3 spec. and 6 odd valves, some with posterior end stretched, some declining.

No. 9635. Tjenklik near Solo C 128: ½ spec. and some fragm.

No. 9695. Trinil No. 12 Coll. 1900: ½ spec., tailend missing, umbonal region well preserved.

No. 9719. Trinil No. B 34: 12 single valves of ordinary texture and 6 very heavy ones, caused by depositing shell substance in the interior, so as to make the dwelling cavity more shallow (cfr. also sample 35 of Bandoeng Collection).

No. 9774. Trinil: 2 odd valves, rather well preserved. Smaller one with strong cardinal teeth; posterior end declining. Larger one with posterior end turned upwards.

No. 9783. Without locality: large piece of stone with more than a dozen single valves, all with rounded side outward. Structure disappeared in most shells, only one valve vaguely shows the 2 ridges running obliquely backwards from the umbo. In all specimens the posterior side is curved downward.

Elbert Collection

Mount Singokerto near Tritik in Pandan: numerous spec. and single valves, nearly all imbedded in sandstone, in most cases rather badly preserved. The two forms, with declined and with raised posterior end, occur side by side.

Trinil, lapilli layer in the upper bonebearing bed: 3 spec. and 1 single valve, all rather badly preserved, hinge part generally missing, posterior end of shell upcurved.

Trinil. No. 15: 1 spec. with tailend upcurved.

Collection of the Geological Survey, Bandoeng

Sheet 93 B. Trinil, layer II, 20. VIII. 1932: 1 valve, without tailend, 1 valve with stretched posterior part.

Sheet 93 B. Trinil, layer II, 16. VIII. 1932: ½ spec. without tail.

Sheet 93 B. id. id. id., 28. X. 1932: 1 spec. and 8 single valves, with stretched posterior parts.

Sheet 99 B No. 18. River Ngetas, Kaboeh layers: 2 spec. and 4 odd valves, all more or less damaged.

Sheet 99 B No. 18. River Ngetas, near Kampong Kedoeng Broeboes, 23. VII. 1934, Kaboeh layers: 2 spec. and 8 fragm.

Sheet 99 B No. 19. River Kedoengloemboe, downstream point 26 B, 20. V. 1931, Kaboeh layers: many fragm., some imbedded in stone, posterior part stretched.

Sheet 99 B No. 20. River Kedoengloemboe, Kaboeh layers: 4 fragm., in stone, three of them with stretched posterior end, one with hind part sloping downward.

Sheet 99 B No. 22. River Gedeh, Kaboeh layers: fragm. of 3 single valves, imbedded in stone.

Sheet 105 A No. 35. River Tritik, Kaboeh layers: many fragm. partly free, partly in stone. In all the posterior end is wanting. Several valves peculiarly thickened, caused by depositing shell substance in the interior, so as to make the dwelling cavity more shallow (cfr. No. 9719 of Dubois Collection).

Sheet 105 A No. 41. River Bogo, Kaboeh layers: many fragments, partly in stone, partly free, sometimes only as casts. Tailend stretched in the better preserved valves.

Sheet 116 A No. 327. Kampong Bandjaran, 6. VI. 1934, Kaboeh layers: numerous fragm. in fine grey sand stone.

Selenka Collection (Leiden Geological Museum)

St. No. 5391. Bonebearing bed, Trinil: 4 single valves, damaged.

St. No. 5392. Lowest sheets of the pit at Trinil: 4 single valves, damaged.

Collection of the Geological Museum, Delft.

No. K.A. 2230—2231. Principal bonebearing bed, Trinil, pit 1: 2 single valves, in stone.

No. K.A. 2234. Above the principal bonebearing bed, Trinil, pit 1: 1 spec. partly in stone.

It is a great pity that so many of the *Elongaria* shells are defective. In most cases the posterior part is missing. Therefore it is difficult to give exact figures of the dimensions. There is some variation in size, adult and middle sized shells averaging (sagittal axis from 40 to 60 mm), but no remains of young individuals (under 25 mm sagittal axis) were found.

It is supposed that the extraordinarily thickened shells of the samples No. 9719 (Dubois Collection) (Plate III A) and Sheet 105 A No. 35 (Collection of the Geological Survey, Bandoeng) may represent very old individuals.

Special attention is drawn to the fact that among all the fossil specimens examined and recorded here never one valve showed that shallow constriction in the inflated portion of the shell, just in front of the middle[1]),

1) ...... "Dickenmaximum etwa in der Schalenmitte gelegen, vor ihm eine leichte Einschnürung."

which is so characteristic in recent *Elongaria orientalis* (cfr. Haas, in: Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 9, Abt. 2, II, 1913, p. 169, pl. 17 fig.3, lower sketch). It is not noticeable either in pl. 15 fig. 135 of Oostingh's paper (1935) dealing with *Elongaria orientalis* from the Kali Glagah beds in the Boemiajoe deposits.

In the *Elongaria* shells excavated from prehistoric kitchen middens in Sampoeng Cave (Van Benthem Jutting, 1932, fig. 4 A), however, the shallow curve in the flanks is very evident.

Judging from the abundance of material *Elongaria orientalis* must have been a very common Najad in the provinces South of the Kendeng Mountains between Tjenklik in the West and Bandjaran near Soerabaja in the East during the Kaboeh period.

Als we have seen already in the detailed account there can be distinguished two types of shells: one with a stretched and slightly uplifted posterior end, in which the ventral side is horizontal or a little convex (forma *normalis* Mousson [1]) (Plate VI figs. 5 and 6), the other with a curved and descending tailend and a conspicuously concave base-line (forma *arcuata* Mousson [1]) (Plate VI figs. 3, 4, 7—12). In the samples both types occur side by side, but it is not likely that they did so in nature during the animal's life. Though the two forms cannot be regarded as taxonomic units representing different lines of specific evolution, yet they should be understood as ecologically and perhaps physiologically independant trains. They are the expression of certain environmental influences prevailing in the habitat of the animals. The two forms must be regarded as so called "Reaktionsformen", a kind of extremely labile modifications induced by factors of the milieu and with no more than phaenotypical systematic significance.

In the *Elongaria* of Boemiajoe (Oostingh, l.c.) and in those of Sampoeng Cave (Van Benthem Jutting, l.c.) the two forms are also represented.

Similar cases are reported in European waters for Najads of the genus *Unio* (Modell, Arch. Moll. Kunde, vol. 56, 1924, p. 17—54 and Geyer, Unsere Land- und Süsswasser Moll., Ed. III, 1927, p. 181—182). In this part of the world experience has taught that the typical form (forma *typica)* is characteristic for slowly running alcaline waters with a muddy, or sandy bottom, not too putrified and not too weak, and with moderate vegetation.

The other is a lacustrine modification (forma *lacustris*), common in shallow ponds with little vegetation and a muddy bottom which is regularly agitated by the waves through wind action. The bottom surface is constantly

1) Mousson, Land & Süssw. Moll. Java, 1849, p. 93, pl. 17 figs 3—5.

stirred up and the fauna, i.c. the Najads, must try to keep out of such sand movements as could be fatal. This continuous danger induces the animals to seek as strong a foothold as possible and to burrow so deep as to leave only the beak-like posterior end lying flush with the bottom surface.

It remains to be seen whether we are entitled to apply the interpretation of these ecological modifications founded on European species of *Unio,* equally on tropical Najads belonging to a quite different family.

There is no reason, however, to mistrust the general tendency of the phenomenon, even though our knowledge of the life-history of recent *Elongaria orientalis* is lamentably small [1]) and that of fossil *E. orientalis* is still worse.

Judging from the abundance of material which passed through my hands it can be concluded that part of the Javanese fossil *Elongaria orientalis* must have lived in ponds and lakes (forma *arcuata)* and another part in streams (forma *normalis*).

That both types were found side by side in several samples is no argument against this hypothesis, but can be explained by accidental accumulation of animals from different habitats, caused by subsidence or great floods, or by reworking of the deposits after the death of the mussels. In this instance the thanatocoenosis is not identical with the biocoenosis.

The oldest *Elongaria* specimens recorded from Java are those found in the Kali Glagah formation of the Boemiajoe Fauna (Oostingh, l.c.). They are estimated Upper Pliocene.

Afterwards the species migrated to East Java according to the increase of continent on this side of the island. Here *Elongaria orientalis* appeared more or less explosion-like in numerous localities, especially during the Lower Pleistocene and the Trinil formation.

Again later, in prehistoric times, we meet the species in great number among kitchen middens in a rock shelter near Ponorogo, East Java (Van Benthem Jutting, l.c.).

The recent distribution of this Najad comprises the entire island of Java, with an obvious preference for the Eastern part.

Rectidens sumatrensis (Dunker)

1852 Dunker, Zeitschr. f. Malak., vol. 9, p. 52 (*Unio sumatrensis*).
1932 Van Benthem Jutting, p. 103.

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1) Mousson (Land & Süssw. Moll. Java, 1849, p. 94) recorded the forma *arcuata* from Lake Segaran, District of Probolinggo, East Java, at 1200 feet altitude.

Material examined:

Dubois Collection

No. ?. Without locality: 1 spec., almost cast, and 1 hinge fragm.

Collection of the Geological Survey, Bandoeng

Sheet 93 B. Trinil, Ingr. II, T. II, layer 2: 1 entire spec., almost exclusively a cast, long 80, high 34, diam. (2) 26 mm.

Sheet 93 B. Trinil, Ingr. II, T. II, layer 2, 19. VIII. 1932: ½ spec., only anterior part.

Sheet 93 B. Trinil, Ingr. II, T. II, layer 2, 20. VIII. 1932: 1 entire spec. and 2 single valves. Dimensions of entire spec. long 65, high 31, diam. (2) 17 mm. Single valves not measured, because one incomplete, other partly hidden in rock.

Sheet 93 B. Trinil, Ingr. VIII, River Grendjingan, layer 3, 21. X. 1932: one valve, very heavy, long 79, high 36, diam. (1) 12 mm.

Compared with the preceding species *Rectidens sumatrensis* is only scarce in the material which I had at my disposal and we may safely conclude that it was equally less abundant in nature during the Pleistocene.

It is remarkable that a similar ratio in the frequency of *Elongaria orientalis* and *Rectidens sumatrensis* is observed in the refuse of the meals of primitive inhabitants of the Sampoeng Cave near Ponorogo [1]) (Van Benthem Jutting, l.c.) and even under natural conditions in the recent fauna of Java.

All the above mentioned Pleistocene and Holocene specimens belong to a type with stretched posterior part and with convex ventral side. The form with declining posterior end and with concave base, conformable to the condition in various shells of *Elongaria orientalis,* is not represented in the *Rectidens sumatrensis* on hand.

That such a modification is not an impossibility was demonstrated by Haas (Martini & Chemnitz, N. Syst. Conch. Cab., Bd. 9, Abt. 2, II, 1914, p. 234, pl. 28 fig. 6) in a recent specimen from the environs of Batavia (West Java). Yet the phenomenon is never so manifest as in *Elongaria orientalis.*

Pseudodon vondembuschianus trinilensis (Dubois)
(Plates VII and VIII)

[1840 Lea, Proc. Americ. Philos. Soc., vol. 1, p. 288 (*Margaritana vondembuschiana*)].
1908 Dubois, p. 1249, pl. 39, fig. b (*Unio trinilensis*).
? 1908 Branca, p. 270 (zwei Arten von *Unio*).—One of them probably our species.
? 1908 Elbert (Nieuwste Onderzoekingen), p. 129 (Uniones).—No further identification possible.

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1) Of course the kitchen middens form only an artificial "fauna". With due reserve, however, they can serve as a proof in favour of our hypothesis, because if really the two species, *Rectidens* and *Elongaria,* should have occurred in nature in equal number, the primitive cavedwelling people would certainly have preferred the large sized *Rectidens* to the smaller *Elongaria,* the former being the more efficient provisions of the two.

? 1908 Elbert, (Alter der Kendengschichten), p. 656 and table facing p. 657 (Unionen). Same remark as in preceding reference.
1909 Elbert, p. 517 (*Unio trinilensis*).
? 1911 Carthaus, p. 13 (*Unio*). —Identification left at that.
? 1911 Dozy, p. 35 (*Unio*).—Same remark as in preceding reference.
1911 Martin, p. 52 (*Unio trinilensis*).
1919 Martin, p. 61 (*Unio trinilensis*).
? 1921 Hilber, p. 151 (zwei Muschelarten).—Further identification impossible.
[1929 Van Es, p. 336 (*Unio*).—Further identification impossible. Compare also Van Benthem Jutting, 1932, p. 103; the *Pseudodon* from Sampoeng Cave certainly belongs to the recent form.]
? 1931 Van Es, p. 64, 65, 136 (*Unio* spec.).—No further identification possible.
1931 Van Es, p. 136 (*Unio trinilensis*).
1931 Van der Vlerk, p. 274 (*Unio trinilensis*).
[1932 Van Benthem Jutting, p. 103 (*Pseudodon zollingeri*, the recent form].
[1935 Oostingh, p. 164, fig. 19 a—c (*Pseudodon vandervlerki*; in my opinion another subspecies of *Pseudodon vondembuschianus*].

Material examined:

Dubois Collection

No. 1006. Trinil: many fragm. and 5 complete spec., mostly stretched, only nos. a and b with some inclination to forma *angulosa*.

	a	b	c	d	e
long	117,	99,	108,	110,	109 mm,
broad	71,	63,	64,	68,	66 mm,
diam. (2)	43,	37,	36,	38,	38 mm.

No. 1568. Trinil ?: 1 spec., rather damaged, no definition of outline possible, not measured.

No. 1569. Trinil?: 1 spec., approaching forma *angulosa*. Long 102, broad 65, diam. (2) 39 mm.

No. 1570. Trinil B 34, 39, 47: some fragments, not measured.

No. 1571. Trinil: 1 spec., with right valve rather damaged, left one long 99, broad 60 mm.

No. 1572. Trinil ?: 1 spec., tailend missing, not measured.

No. 1573. Trinil ?: 1 spec., approaching forma *angulosa*. Long 110, broad 70, diam. (2) 43 mm.

No. 1574. Trinil: 1 valve, without tailend, not measured, and 1 spec., somewhat inclining to forma *angulosa*, long 111, broad 69, diam. (2) 32 mm.

No. 1664. Trinil: 1 fragm., not measured.

No. 5234. Trinil C 47: many fragments, 1 single valve and 3 entire spec., all with stretched posterior end, long 107, 97, 96, 102 mm.
broad 68, 61, 58, 69 mm,
diam. (2) 31, 32, diam. (1) 18 mm. In the longest specimen diam. (2) not measured, because damaged by lateral compression.

No. 9709. Trinil C 47: 4 spec. and 1 single valve. Two of the spec. caducous, not measured. Of the measured shells the single valve is of the stretched type, the larger spec. more or less so, and the smaller one decidedly *angulosa*. Dimensions:

long	91,	101, 96 mm,
broad	60,	63, 64 mm,
diam.	(1) 17,	diam. (2) 38, 36 mm.

No. 9710. Trinil: 4 more or less complete spec., 2 single valves and a few fragm. All rather stretched with some inclination to the forma *angulosa* at advanced age.

Dimensions:	long	105, 94, 96 mm,
	broad	65, 59, 64 mm,
	diam. (2)	36, 33, 35 mm.

No. 9711. Trinil C 47: some fragments and 4 entire spec.. Of these no. a has the stretched type, b belongs to forma *angulosa* and c and d are broadly oval, though without inclination to *angulosa*. Dimensions:

	a	b	c	d
long	106,	102,	102,	94 mm,
broad	61,	69,	69,	62 mm,
diam. (2)	33,	43,	42,	35 mm.

The last specimen is the Neotype (Plate VII figs. 1 and 2).

No. 9712. Trinil: 4 spec., two of which in pieces, not measured. All with slight inclination to forma *angulosa*. Dimensions: long 106, broad 65, diam. (2) 39 mm, and long 103, broad 68, diam. (2) 37 mm.

No. 9713. Trinil: 3 spec. and some fragm. One of the spec. too much damaged to be measured. Others: long 102, broad 64, diam. (2) 37 mm, and long 99, broad 65, diam. not measurable, because filled with sandstone.

No. 9714. Trinil: 2 spec. partly in fragm., not measured.

No. 9715. Trinil C 47: 1 spec. and 3 odd valves. The entire spec. and one of the valves (a and b) of the stretched type, the other two valves (c and d) of the *angulosa* form. Dimensions:

	a		b	c	d
long	103,		90,	96,	91 mm,
broad	61,		56,	63,	57 mm,
diam. (2)	33,	diam. (1)	16,	17,	16 mm.

No. 9716. Trinil C 47: 2 spec. and 2 fragm. Of the entire spec. the larger is stretched, without inclination to *angulosa*, the smaller is a little angular. Dimensions: long 117, broad 65, diam. (2) 34 mm, and long 105, broad 65, diam. (2) 34 mm.

No. 9717. Trinil: 3 spec., all a little inclined to *angulosa*,

long	99,	100,	101 mm,
broad	65,	66,	64 mm,
diam. (2)	37,	37,	39 mm.

No. 9718. without locality: some fragments and 2 entire spec., both a little angular, long 104, broad 67, diam. (2) 40 mm, and long 105, broad 67, diam. (2) 40 mm.

No. 9720. without locality: 2 spec., the smaller one a little, the larger decidedly forma *angulosa*, long 108, broad 68, diam. (2) 30 mm, and long 108, broad 70, diam. (2) 32 mm.

No. 9721. Trinil: 2 spec., too much damaged, not measured.

No. 9722. Trinil: 1 spec., of stretched type, long 103, broad 66, diam. (2) 34 mm.

No. 9723. without locality: 4 spec. and 1 fragm. for the greater part of their surface of the stretched type, only in their last growth rings they pass unto the forma *angulosa*. Probably old individuals, with their basal side thickened, so as to make this part of the shell broad[1]). Dimensions:

long	100,	107,	106,	111 mm,
broad	58,	65,	67,	70 mm,
diam. (2)	33,	38,	38,	43 mm.

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1) Attention must be called to specimens from the samples 9723 and 9750. These individuals show a considerable deposition of shell substance along the free basal margin, not as usually in ventral direction, but perpendicularly to it, causing the base line to inflate and broaden. This change in the growth of the base reminds of a similar phenomenon in the European market shells, *Ostrea edulis* and *Mytilus edulis*. Oysters and mussels in this condition are called "dumps" (dutch: dikkers) and are probably produced by unfavourable circumstances in the environment: unsufficient food, physical disturbances, etc. Whether such causes can also account for the nature of the dumpy Trinil Najads I do not venture to decide. At any rate the specimens under consideration are in no way stunted individuals.

No. 9724. Trinil B 24: 2 spec., and 1 single valve, all of the *angulosa* type. One of the spec. too much damaged to be measured. The other very short in sagittal direction. Dimensions: long 95, broad 67, diam. (2) 37 mm, and long 94, broad 58, diam. (1) 17 mm.

No. 9726. Trinil: 5 spec., 2 single valves and a few fragm., all stretched with a faint inclination to forma *angulosa*. One of the spec. and one valve caducous, not measured. Dimensions: long 102, 100, 102, 103, 98 mm,
broad 64, 66, 65, 64, 58 mm,
diam. (2) 35, 37, 37, , diam. (1) 17 mm. Diameter of longest specimen not measured because laterally damaged by pressure.

No. 9727. Trinil B 34: 2 spec., one of which in pieces, not measured. The other long 99, broad 61, diam. (2) 39 mm. This spec. approaches the forma *angulosa*.

No. 9728. Trinil: 1 spec. and 3 single valves. The latter are incomplete and not measured. As far as recognisable all were of the *angulosa* type. Dimensions of the measured spec.: long 89, broad 56, diam. (2) 32 mm.

No. 9729. Trinil B 34: 2 spec., of the stretched type, long 96, broad 59, diam. (2) 38 mm, and long 96, broad 57, diam. (2) 35 mm.

No. 9730. Trinil: 5 spec., all more or less forma *angulosa*,
long 102, 98, 99, 101, 102 mm,
broad 61, 66, 66, 68, 65 mm,
diam. (2) 39, 37, 37, 39, 37 mm.

No. 9731. Trinil: 3 spec. and 1 single valve, all with faint inclination to forma *angulosa*, long 90, 99, 95, 88 mm,
broad 58, 65, 62, 57 mm,
diam. (2) 33, 32, 38, diam. (1) 17 mm.

No. 9732. Trinil: 3 spec., 1 valve and a few fragm. All stretched in the beginning, but becoming a little angular at advanced age, long 103, 105, 94, 91 mm,
broad 65, 67, 60, 61 mm,
diam. (2) 39, 40, 36, mm. In the last specimen diam. (1) not measured because filled with stone.

No. 9733. Trinil B 34: 3 spec., more or less stretched, long 97, 89, 89 mm,
broad 61, 60, 58 mm,
diam. (2) 35, 37, 31 mm.

No. 9734. Trinil C 39: 4 spec., of which no. a is stretched, the others approaching forma *angulosa*.
a b c d
long 108, 116, 97, 98 mm,
broad 70, 70, 65, 64 mm,
diam. (2) 40, 38, 32, 38 mm.

No. 9735. Trinil B 34: 1 cast and several fragments, not measured.

No. 9736. Trinil: 1 spec., without tailend, not measured.

No. 9737. Trinil: 1 spec. and a few fragm. The entire spec. approaches the forma *angulosa*, long 99, broad 64, diam. (2) 34 mm.

No. 9738. Trinil: 2 spec. and 1 single valve. One of the spec. without front part, not measured. The other spec. and the valve show a posterior rostrum. Dimensions: long 111, broad 71, diam. (1) not measured, because filled with stone, and long 114, broad 70, diam. (2) 40 mm.

No. 9739. Trinil: 4 spec. one of which (a) is stretched, the other three (b-d) forma *angulosa*.
a b c d
long 93, 93, 92, 108 mm,
broad 62, 62, 61, 66 mm,
diam. (2) 33, 36, 36, 39 mm.

No. 9740. Trinil: 3 spec., one of which (a) is stretched, the other two (b and c) forma *angulosa*. Besides a few fragm., not measured.

	a	b	c
long	96,	102,	92 mm,
broad	62,	65,	58 mm,
diam. (2)	36,	39,	39 mm.

No. 9741. Trinil:3 spec., one of which (a) forma *angulosa*, the other two of the stretched type (b and c).

	a	b	c
long	91,	99,	91 mm,
broad	62,	63,	59 mm,
diam. (2)	34,	35,	34 mm.

No. 9742. Trinil: 5 spec., rather broad oval. All are inclined to the forma *angulosa*, especially the first. One spec. too much damaged to be measured. Others:

long	100,	101,	112,	82 mm,
broad	65,	62,	72,	61 mm,
diam. (2)	40,	34,	36,	30 mm.

No. 9743. Trinil: 1 spec. and 6 valves and a few fragm., most of the stretched type, some with a faint inclination to forma *angulosa*. The entire spec. too much damaged to be measured. Others:

long	97,	98,	90,	98,	90,	99 mm,
broad	61,	61,	57,	60,	58,	59 mm,
diam. (1)	16,	18,	15,	17,	17,	mm.

Diam. (1) of the last valve not measured because filled with stone.

No. 9744. Trinil: 3 spec. and 2 valves, all of the stretched type. One single valve too much damaged, not measured. Others:

long	104,	106,	69,		103 mm,
broad	67,	67,	43,		67 mm,
diam. (2)	36,	36,	23,	diam. (1)	18 mm.

No. 9745. Trinil: 4 spec., one stretched, three with transitions to forma *angulosa*. One spec. severely damaged, not measured. Others:

long	94,	97,	97 mm,
broad	54,	60,	66 mm,
diam. (2)	32,	36,	mm.

In the last spec. diam. (2) not measured, because filled with sandstone.

No. 9747. Trinil: 5 spec., rather broad-oval. Three are a little approaching forma *angulosa*. Dimensions:

long	80,	103,	103,	98,	104 mm,
broad	52,	61,	63,	63,	68 mm,
diam. (2)	29,	40,	36,	41,	35 mm.

No. 9748. Trinil C 39: 3 spec., partly in fragments, all a little bit *angulosa*. Dimensions:

long	104,	98,	105 mm,
broad	64,	65,	64 mm,
diam. (2)	39,	36,	34 mm.

No. 9749. Trinil: 4 spec., all approaching forma *angulosa*. One too bad to be measured. Others:

long	93,	99,	93 mm,
broad	64,	62,	62 mm,
diam. (2)	38,		33 mm.

Second specimen filled with tuff, no diameter.

No. 9750. Trinil: 4 spec., all forma *angulosa*. No. a is very broad-oval, no. c thickened at the base, like the sample 9723 (cfr. footnote at p. 149). Dimensions:

	a	b	c	d
long	106,	96,	105,	89 mm,
broad	72,	58,	65,	62 mm,
diam. (2)	39,	37,	41,	34 mm.

Nos. 9822—9823. Without locality: 1 fragment.

Elbert Collection

Goenoeng Singokerto near Tritik: 1 spec., a little damaged, not measured. Approaching forma *angulosa.*

Selenka Collection (Leiden Geological Museum)

St. No. 5393. Bonebearing bed, Trinil: left valve, long 101, broad 60, diam. (1) 18 mm. This valve approaches forma *angulosa.*

St. No. 5394. Bonebearing bed, Trinil: right valve, long 99, broad 61, diam. (1) 19 mm.

St. No. 5395. Trinil: 1 spec., long 112, broad 66, diam. (2) 36 mm. With faint inclination to forma *angulosa.*

Collection of the Geological Survey, Bandoeng

Sheet 93 B. Trinil, Ingr. II, T. II, layer 2: Many fragm., 21 incomplete spec. or casts, not measured. Only 2 spec. and 1 single valve measured:

long 99, 93, 96 mm,
broad 63, 61, 59 mm,
diam. (2) 35, 33, mm. In the last spec. diam. (1) not measured.

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 16. VIII. 1932: a few fragm.

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 17. VIII. 1932: 1 fragm.

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 18. VIII. 1932: 3 single valves,

long 106, 109, 102 mm,
broad 59, 60, 60 mm,
diam. (1) 18, 18, 16 mm. The first one is a stretched form, the two others belong to the *angulosa* type

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 19. VIII. 1932: 2 fragm.

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 20. VIII. 1932: 1 spec. and two single valves, long 92, broad 59, diam. (2) 33 mm, and long 100, broad 65, diam. (1) 17 mm. One valve too caducous to be measured. All the shells belong to forma *angulosa.*

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 21. VIII. 1932: 6 valves, mostly incomplete, only one measured, long 91, broad 59, diam. (1) 17 mm. It is a rather stretched form.

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 22. VIII. 1932: 1 spec. and 3 valves. Only two valves are complete enough to be measured: long 100, broad 65, diam. (1) 19 mm, and long 95, broad 60, diam. (1) 19 mm. The first is a stretched shell, the second more inclined to forma *angulosa.*

Sheet 93 B. Trinil, Ingr. I, block b, layer 2, 23. VIII. 1932: 2 spec., rather long in sagittal direction, but also showing the *angulosa* characters: long 110, broad 67, diam. (2) 37 mm, and long 111, broad 70, diam. (2) 37 mm.

Sheet 93 B. Trinil, Ingr. I, Block c, layer 2, 28. X. 1932: many fragm., 12 spec. or casts and 14 single valves, several too much damaged to be measured. Six entire spec. and 9 valves have the following dimensions:

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	
long	120,	112,	116,	111,	114,	102,	103,	96,	94,	102,	109,	108,	92,	107,	104	mm,
broad	64,	64,	71,	69,	75,	63,	63,	65,	59,	62,	73,	66,	64,	69,	66	mm,
diam.	42,	38,	40,			18,	22,	18,					33,			mm.

Diam. of d, e, i, j, k, l, n, and o not given because filled with stone.

Diam. of a, b, c, and m taken from entire spec., diam. of f, g, and h from single valves only.

Sheet 99 B. No. 18. River Ngetas, near Kampong Kedoeng Broeboes, 23. VII. 1934, Kaboeh layers: 1 spec. and 2 single valves, all incomplete, rather small. The 2 valves not measured. The entire spec. is broad 34, diam. (2) 20 mm. Length damaged.

Sheet 105 A No. 35. River Tritik, Kaboeh layers: 2 fragm. not measured.

Collection of the Geological Museum, Delft.

No. K.A. 2224—2225. Principal bonebearing bed, Trinil, pit 1: 1 spec., long 96, broad 59, diam. (2) 36 mm.

No. K.A. 2226—2227. Same locality: div. fragm., not measured.

No. K.A. 2228—2229. Same locality: 2 spec., long 93, broad 56, diam. (2) 34 mm, and long 117, broad 68, diam. (2) 39 mm. All the shells from the Delft Institute are regularly rounded, only the last shell displays some features of the forma *angulosa*.

At the time when Dubois (1908, p. 1249) described his *Unio trinilensis* he remarked that in spite of ample research he had not succeeded in finding a recent equivalent of this large Najad in the fresh- and brackish waters of Java [1]). The short discussion was closed with the following words: "Es ist also nicht unwahrscheinlich, dass hier eine ausgestorbene Art vorliegt; ich bilde sie deshalb nebenstehend ab und nenne sie vorläufig *Unio trinilensis*".

A definite diagnosis never followed, but the figure, the interior of a right valve, is clear enough to recognise the species, and ...... to see at a glance that we have not to do with a *Unio*, but with a *Pseudodon*, and besides that *Unio trinilensis* Dubois belongs to the kinship of *Pseudodon vondembuschianus* (Lea), a regular native of Java [2]).

In order to designate that the large Trinil Najad, though related to the recent *Pseudodon vondembuschianus*, yet is obviously and constantly different from this species in certain points I did employ Dubois' name, reducing it however to subspecific rank.

A detailed description of the fossil *Pseudodon* is following hereafter. As a neotypic specimen I selected the shell which approaches best the figure in the paper of Dubois (cfr. sample 9711, Dubois Collection (Plate VII figs. 1 and 2).

Shell oval to oviform, inaequilateral, solid. Sculpture consisting of numerous lines of growth, coarse and fine ones irregularly alternating. Some specimens display another pattern of sculpture besides: shallow grooves at regular distance radiating from the umbo (Plate VIII), thus creating small, flat ribs, especially in the lower and front parts of the shell.

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1) Evidently Dubois was not acquainted with the recent Najad-fauna of Java, as he did not compare this species or any of the preceding with living species. This is the more curious, because I found large series of recent *Pseudodon, Elongaria, Rectidens, Pilsbryoconcha, Contradens* and *Physunio* among the contemporary mollusks which Dubois collected for comparison in different localities (see list of recent shells at page 158 of this paper).

2) Whether the other recent species *Pseudodon zollingeri* (Mousson) is synonymous with *vondembuschianus* must be left for future investigation. Haas (in: Martini & Chemnitz, N. Syst. Conch.. Cab. Bd. 9, Abt. 2, II, 1913, p. 324 and 326) keeps the two species separate. I for my part am rather inclined to unite them.

It is almost probable that this sculpture is a symptom of weathering, either during the animal's life or—more probably—post mortem. In normal shells these ribs are covered by smooth shell-substance, effacing the pseudo-sculpture, as I could observe in recent *Pseudodon vondembuschianus* from Java of moderate size (length circa 60 mm) where similar ribs are discernable in the interior of the anterior third of the shell when holding it against a very strong light [1]). The occurrence of embryonic sculpture is discussed later when treating the umbo.

Colour and epidermis disappeared. Nacreous lustre variable, according to the degree of preservation. From the umbo backwards the dorsal margin is sometimes horizontal, but generally sloping downwards a little. Its transition into the posterior margin is sometimes marked by an obtuse angle, but more often it is effectuated imperceptibly. The same can be said of the transition of back and basal margins. In strongly angulated shells an obtuse posterior beak is formed (Plate VIII). Basal margin passing evenly into front margin and this into the anterior part of the dorsal side, in front of the umbo. Here is always a shallow concavity, marking the place of the sinulus. Of the dorsal area no trace is left.

Umbones rather prominent, more than in recent specimens of *Pseudodon vondembuschianus*. They are never corroded as is so often the case in the recent representative. In a few instances the umbones are slightly plicated. I am not sure whether this is the persisting embryonic sculpture or a false analogon.

The cartilage pit is rather long, circa 5/9 or ½ of the total length (in recent *P. vondembuschianus* it occupies about 1/3). It is also decidedly broader than in the recent *Pseudodon*. The cardinal tooth is strong in both valves and rather variable in shape. In general it is a trigonal pyramid, but often aberrant oblique forms occur, especially in old individuals. In all cases the teeth are smooth. The ridge lining the ligament is coarse and falls off with square angle to the interior of the shell.

The inside of the shell is evenly rounded, varying in hollowness. Shortly below the umbones the shell is most spacious, more to the base it flattens again. In most of the specimens the pearly lustre in the interior is well preserved. Muscular scars lying in the dorsal half of the shell. The anterior one quite in the "nose", the posterior one at a little more distance from the margin. The anterior scar is deeply excavated, often rough with granular mother-of-pearl deposit. The posterior scar is relatively smooth

1) The same mode of abrasion is observed in dead specimens of, e.g. *Venus* or *Glycymeris*, both recent and fossil. Here also the loss of the surface of the shell produces a reticulation or ribbed structure which is not its normal appearance.

and more shallow. A small number (circa 6) of deeply impressed pits betray the attachment of muscular fibres in the vaulting of the umbo. Pallial line well impressed, not sinuous.

Dimensions of neotypic specimen:

Length 94, breath 62, diameter of the closed valves 35 mm.

The dimensions of the other specimens can be gathered from the detailed account in the beginning of this paragraph.

The differences of *Pseudodon vondembuschianus trinilensis* with the main form can be formulated as follows:

The fossil *Pseudodon vondembuschianus trinilensis* is on the whole more robust and coarser than the recent *P. vondembuschianus,* although the absolute dimensions do not differ very much. The shell texture is thicker, the hinge stronger, the ligament pit longer and broader. The umbones are more jutting and are recurved to the median line and to the front, causing the interior space to be more capaceous.

Recently another extinct *Pseudodon* was described from Java, i.e., *P. vandervlerki* Oostingh, excavated from the Kali Glagah beds at Boemiajoe, Central Java (Oostingh, 1935, p. 164). In the discussion following the diagnosis the author argued why in his opinion this species ought to be classified in the subgenus *Trigonodon* and not in *Pseudodon* s. str. Nevertheless I called the statement in question, the figures being also suspicious. At my request Dr. Oostingh most graciously allowed me to study his new species and sent me on loan the three more of less defectuous shells which served him for his description.

This renewed examination brought to light that *Pseudodon vandervlerki* belongs to the very same subgenus (*Pseudodon* s. str.) as the Trinil Najad and as the recent species *P. vondembuschianus* and *P. zollingeri.* It is doubtlessly related to *P. vondembuschianus* but cannot be united with the recent form on account of some differences. Therefore I propose to call the Boemiajoe specimens *Pseudodon vondembuschianus vandervlerki* (Oostingh) [1]).

As far as can be judged from the three fragments the Boemiajoe shells are distinguished by the following differences:

The valves are large and solid, more solid than those of recent *P. von-*

1) The trigonal tooth erroneously suggesting the subgenus *Trigonodon* is a very variable part of the shell and is inclined to display all sorts of shapes. Yet it is quite different from the genuine *Trigonodon,* as I could compare in a specimen of *Pseudodon (Trigonodon) crebristriatus* (Anthony), kindly lent by Dr. Haas from the Senckenberg Museum.

dembuschianus, but not in the same measure as those of the subspecies *trinilensis.*

The valves are not so much arched as those of the Trinil *Pseudodon* and in this respect the Boemiajoe shells approach the recent form.

The umbones are not so prominent as in the Trinil Najad, but resemble those of the recent main form.

In one specimen (not figured by Oostingh) the umbo of the right valve shows about 6 rather thick horizontal plicae on the exterior. Curiously this structure is not seen on the corresponding right valve.

The cartilage pit is long and broad, and the cardinal teeth strong. These two features point to a greater affinity with the Trinil fossil than with the recent *P. vondembuschianus.*

The Boemiajoe Najad gives the impression to be a kind of intermediate form between the Trinil shell and the recent form. Perhaps it can better be regarded as a combination-type, uniting several fundamental characters whence afterwards the Trinil *Pseudodon* and the recent descendant have evolved in different directions, each along their own line.

The large *Pseudodon vondembuschianus trinilensis* must have been a very common species in the district between Trinil, Kedoeng Broeboes and Tritik, still more abundant than *Elongaria orientalis.* The latter species on the contrary had a much wider distribution, reaching from Tjenklik in the West to Bandjaran, near Soerabaja in the East.

It is remarkable that just as in this species never or rarely young individuals of the fossil *Pseudodon* were excavated. On a total number of 176 entire shells and 67 single valves (fragments not counted) there are only 2 specimens of 80 mm or less sagittal axis (samples 9744 (69 mm) and 9747 (80 mm) Dubois Collection). Nor do the fragments either betray the occurrence of young animals.

For organisms of such respectable dimensions the expansion of the biotope ought to be in agreement [1]) and we must imagine the existance

1) "Grosse Tierarten werden... im allgemeinen einen weiteren Bereich verlangen, während kleine mit einem engen Areal auskommen können" (Hesse, Tiergeographie, 1924, p. 136).

"Eine gewisse Beziehung zwischen der Grösse eines Gebietes und der Mannigfaltigkeit seiner Bevölkerung ist ja zweifellos vorhanden; aber sie lässt sich nicht zahlenmässig auswerten oder sonstwie scharf genug fassen, um für derartige Folgerungen eine genügend sichere Grundlage zu bieten" (ibid., p. 139).

In Europe "for the large mussels the explanation may be that the fishes on which they are dependant need roomy places" (Boycott, Journ. Anim. Ecol., vol. 5, 1936, p. 163), but in Java no conclusion of the kind is entitled, as nothing is known whether or not the propagation of the native Najads takes place by means of a parasitic phase on fishes.

of a vast freshwater lake (or complex of smaller lakes) in the central part of East Java during the Pleistocene epoch.

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

If then such a freshwater basin is to contain scores and scores of large bivalves, living in the littoral zone, each of them requiring its share of food and oxygen, we can take it to be true that this habitat must have been a highly fertile water, well aerated, carrying a sufficient amount of carbonate of lime for direct or indirect use, and a large quantity of plankton.

These and other conditions control the existence of the Najads and they may explain why the large *Pseudodon* is only found in a limited region, whereas the smaller *Elongaria,* which can be credited less exigent, occupied a much larger area.

As we have seen in the detailed account there can be distinguished two types of shells, a broad one and a stretched one, the latter with a rostrum-like tailend, curved downward. The two forms correspond with the shells called *vulgaris* and *angulosa* by Mousson (l.c. p. 96) and very well figured by Haas (l.c., pl. 45 figs. 1 and 2). In the remarks following the description Haas (p. 325) drew attention to the fact that the broad oval form (*vulgaris*) is the normal form, the transformation to the *angulosa* contour only appearing with advancing age. From the growth rings on the shells of *angulosa* specimens it is always evident that these too started as *vulgaris.*

As in the case of *Elongaria orientalis* it is suggested that the two forms, though frequently associated in lots carrying one field label, did not actually occur side by side during the animals' life, but were washed together accidentally from remote habitats.

The two forms can be termed "Reaktionsformen" and are the effect of different environment. These ecological factors though influencing the Najad's individual life, do not modify the species permanently and as such cannot make a claim to genotypical significance.

Similar phenomena have been discussed already in *Elongaria orientalis* and need not be repeated here.

Of all the extinct and recent *Pseudodon vondembuschianus* (subspecies included) recorded from Java the Boemiajoe specimens are the oldest (Upper Pliocene). At that time they seem to have been rather uncommon, but in a following period, in the Kaboeh layers, the species is exceedingly abundant. Next in age are the prehistoric shells from Sampoeng Cave, and in our days *Pseudodon vondembuschianus* occupies the whole island.

It is remarkable that of the six genera of recent Najads inhabiting Java (*Pseudodon, Rectidens, Contradens, Elongaria, Pilsbryoconcha* and *Physunio* [1]) only three are represented in fossil strata (*Pseudodon, Rectidens* and *Elongaria*). This means that these three genera belong to the ancient settlers of the island, whereas *Contradens, Pilsbryoconcha* and *Physunio* evidently arrived much later. *Contradens* at any rate immigrated so early as to be a contemporary of the primitive people inhabiting the rock shelter at Ponorogo in prehistoric centuries (Van Benthem Jutting, 1932). The other two (*Pilsbryoconcha* and *Physunio)* are hitherto only recorded from the recent fauna.

The species of "Unio" recorded from a thin local sheet in the Upper Kalibèng layers (Duyfjes, 1936, p. 140) I have never seen. Therefore it is impossible to identify them more exactly.

In addition to the fossil shells discussed in the preceding pages Prof. Dubois, Dr. Elbert and the geologists of the Geological Survey also collected recent land and freshwater mollusca. Their names and localities are following hereafter. The names of the collectors are abbreviated. Thus Dub. stands for Dubois, Elb. for Elbert, G. S. for Geological Survey, Bandoeng, and G. L. for Geological Institute, Leiden.

Neritina crepidularia Lam. River Miring, on mangrove (Dub.).

Cyclophorus perdix (Brod. & Sow.). Environs of Batavia (Elb.), Trinil (Elb.), Java (Dub.), Bangle? (Dub.).

Cyclophorus rafflesi (Brod. & Sow.). Environs of Batavia (Elb.).

Viviparus javanicus (Von dem Busch). Java (Dub.), Trinil (Dub.), Tjenklik near Solo (Dub.), Bapang (Dub.), Rawah Wadjak (Dub.), Rawah Blawi, near Sidajoe (Dub.), Pandejan (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.), River Solo, near Trinil (G.S.).

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1) Of the Najads mentioned by Mousson (Land & Süssw. Moll. Java, 1849, p. 91—98) under *Unio, Alasmodonta* and *Anodonta* the modern interpretation runs as follows:

Unio evanescens Mouss.—p. 91, pl. XVII (not X) fig. 2: unknown
Unio exilis Dunkr.—p. 92, pl. XVI fig. 3: *Contradens contradens*
Unio mutatus Mouss.—p. 92, pl. XVI fig. 1, 2: *Contradens contradens*
Unio productus Mouss.—p. 93, pl. XVII fig. 3—5: *Elongaria orientalis*
Unio ligula Mouss.—p. 94: unknown
Unio tumidus Retz.—p. 95: probably *Rectidens sumatranus*
Alasmodonta zollingeri Mouss.—p. 96: *Pseudodon zollingeri*
Alasmodonta crispata Mouss.—p. 97: *Pseudodon vondembuschianus*
Alasmodonta vandembuschiana Lea—p. 97: *Pseudodon vondembuschianus*
Anodonta polita Mouss.—p. 98: *Pilsbryoconcha exilis*

Pila conica (Gray). Java (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.).

Bithynia truncata (Eyd. & Soul.). River Soko, right tributary of River Solo (Elb.).

Brotia testudinaria (Von dem Busch). Java (Dub.), River Bengawan near Trinil (Dub.).

Thiara (Plotia) scabra (Müll.). Java (Dub.), River Bengawan near Trinil (Dub.), River Brantas near Modjokerto (Dub.).

Thiara (Tarebia) granifera (Lam.). Java. (Dub.), River Bengawan near Trinil (Dub.), River Brantas near Modjokerto (Dub.).

Thiara (Melanoides) tuberculata (Müll.). Java (Dub.).

Lymnaea javanica (Mouss.). River Soko, right tributary of River Solo (Elb.), Java (Dub.), Rawah Blawi, near Sidajoe (Dub.).

Ena (Coccoderma) thraustus (Mlldff.). Near River Soko, right tributary of River Solo (Elb.).

Opeas gracile (Hutt.). Near River Soko, right tributary of River Solo (Elb.).

Hemiplecta umbilicaris (Le Guill.). Java (Dub.), Trinil (Elb.).

Landouria rotatoria (Von dem Busch). Near River Soko, right tributary of River Solo (Elb.).

Landouria winteriana (Pfr.). Near River Soko, right tributary of River Solo (Elb.).

Landouria ciliocincta (Mlldff.). East of Mt Bareng, North of Kaboeh (Cosijn).

Amphidromus interruptus (Müll.). Toeloeng Agoeng? (Dub.), Java (Dub.), Sonde to Padas Malang (Dub.).

Amphidromus filozonatus Mrts. Java (Dub.).

Amphidromus furcillatus Mouss. Java (Dub.).

Pseudodon vondembuschianus (Lea). Trinil (Dub.), Java (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.).

Rectidens sumatrensis (Dkr.). Java (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.).

Contradens contradens (Lea). River Panowan, near Rembang (G.L.), Java (Dub.), River Trinil and Rawah Wadjak (Dub.), Bangle? (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.), River Solo near Trinil (G.S.).

Elongaria orientalis (Lea). Java (Dub.), River Trinil and Rawah Wadjak (Dub.), River Solo near Trinil (G.S.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.).

Pilsbryoconcha exilis (Lea). Java (Dub.), Environs of Batavia (Elb.).

Physunio eximius (Lea). Java (Dub.), Sonde to Padas Malang (Dub.), Trinil (Dub.), Environs of Batavia (Elb.), River Soko, right tributary of River Solo (Elb.), River Solo near Trinil (G.S.).

Corbicula ducalis Prime. Java (Dub.), Pandejan (Dub.), Toeloeng Agoeng (Dub.), Bangle? (Dub.), Rawah Blawi, near Sidajoe (Dub.), River Solo, near Trinil (Elb.), River Soko, right tributary of River Solo (Elb.), River Solo, near Trinil (G.S.).

Corbicula rivalis (Phil.). Java (Dub.), Trinil (Dub.), River Soko, right tributary of River Solo (Elb.).

ECOLOGICAL VALUATION OF THE DEPOSITS

The zoogeographical reflections which follow are for the greater part of an ecological nature. They will try to give an answer to the question: What can the non-marine neogene shells, excavated at Trinil and adjacent regions [1]) teach us to day about the natural history of the corresponding animals living in the past, or in other words: What is the relation between the thanatocoenosis and the biocoenosis.

Contemporary information being excluded we are obliged to base our discussions and conclusions per analogam on observations of similar events in the present.

This means at the same time that human interference, an important factor influencing our recent mollusc fauna, can be completely left out of consideration for those bygone centuries.

A few remarks on biology and milieu conditions have already been made in the systematic part, in connection with morphological features of the shells.

We will now continue and extend the problem, considering the extinct freshwater fauna as a whole [2]).

Though in general we have to do with a freshwater fauna the dispersal

1) It must be emphasized that Prof. Dubois during his expedition did not purposely pay attention to the frequency of the various species in the field. But it is my experience in Museum work that as a rule the ratio with which species and specimens have been brought together by a good collector (and a prolific collector Dubois certainly has been!) may be considered more or less representative, though not precisely proportional, to the frequency with which the objects occurred in nature.

2) The land shells can better be left out of consideration, because the three species: *Amphidromus palaceus, Chloritis transversalis* and *Landouria rotatoria* are not sufficiently representative, whereas *Ellobium aurisjudae* and *Pythia* spec. are limited to marine and brackish shores.

Brackish water species belonging to the genera *Telescopium, Cerithium* and *Potamides* are found in several localities and in various strata. They will be treated together with the marine shells at another occasion.

of the elements is not homogeneous throughout the region. Local variations occur, just as it is the case in the recent fauna. Several details in the papers of Dubois (1908) p. 1237—1243, Elbert (1908, Nieuwste Onderzoekingen) p. 128—129, Dozy (1911) p. 35, Van Es (1931) p. 79, 101, Duyfjes (1936) different small remarks, support this opinion, and it also evident from table IV in this paper.

These local variations depend for a great deal on casual dispersal of the species and have no other claim than to show that part of the animals had the opportunity to reach a certain spot whereas another part had not, though the latter was undoubtedly equally able to live there had it actually arrived.

In these prehistoric ages when the rivers took their courses at will, not regulated by human intervenience, but freely inundating the country during the west monsoon, damming off old and forming new connections, the entire region must be considered one water system.

Further we have to take into account that diversity in occurrence can also be credited to the difference in milieu factors required by each of the three systematic groups represented: Pulmonates, Prosobranchs and Lamellibranchs.

Even if members of these three groups inhabit a certain water basin in common they occupy different zones and only rarely mix. Thus *Lymnaea, Planorbis, Ameria* and *Pila* prefer the vegetation-zone in stagnant water where they find plenty of food, shelter, and room for depositing their eggs. Because of their air-breathing function they are bound to the upper water sheets. Similar regions may also be favoured by Thiarids, but as a rule these are more frequent on the bottom of waters, between gravel and stones, sometimes in the mud. Thiarids can also tolerate running, even rapid-running water. *Viviparus* and *Bithynia* avoid strong streams and for the rest are bottom- or plant-dwellers.

The Bivalves without exception are bottom-dwellers. The Najads avoid too hard and too soft ground and have an obvious predilection for rivers or open lakes. *Corbicula*, though often found in streams, feels equally well at home in quiet arms between sand and mud.

Mussels with long siphons are better equipped for the struggle for life than those with short ones. Not only can the former with their protrusile respiration tubes regain the surface of the bottom more easily after a sudden or prolonged deluge of sand or mud, but moreover this condition admits them to burrow far deeper in the sand than mussels with short siphons. In this way the long-tubed animals are better protected against sweeping away by unexpected sand transports.

Unfortunately most Najads possess short siphons and in agitated water they have to compensate for the trouble by elongating the posterior part of body and shell. This leads to the remarkable rostrate modifications as described in the systematic part of this paper, genera *Elongaria* and *Pseudodon*.

The variety in distribution is the expression of diverse vital needs of the different groups. These conditions are of a very complex nature, but, in analysis, can be reduced to a number of more simple factors of which food, reproduction, mortality, and competition are the most important, whereas several physical circumstances of the surrounding medium: temperature, chemical composition, pollution, depth, and movement also play a prominent part.

It is far from easy to postulate anything concrete about the available food-quantities in prehistoric ages, but the fact that numerous molluscs have been excavated, which in all probability lived on the spot or in the vicinity, suggest that suitable sources of food for keeping up their lives undoubtedly existed.

The Javanese soil, amply impregnated with volcanic material, is a fertile substratum, not only for land plants, but also for aquatic vegetation.

Mortality, especially infant mortality, is very high in nature, higher than perhaps is realised, although exact figures cannot be given. Careful experimental work, both in the field and in the laboratory, with recent molluscs would certainly be of outstanding importance and would supply valuable information for testing investigations on fossil shells.

Compensation for the loss of so many young animals is attained by producing an immense offspring of which only a very small percentage is allowed to survive and reach maturity.

About the reproduction of the Najads, mentioned in the systematic part of this paper, nothing is known. Whether the larvae are incubated in the maternal gills and whether they have an obligatory parasitic stage on fishes to achieve their life cycle, is completely unknown.

We have already pointed to the fact that so very few young *Elongaria* and *Pseudodon* have been excavated. If this proportion should have been natural, the progeny could not in the least have been sufficient to maintain the population at its previous strength. Hence it is probable that in this case the excavation records do not approximate the real proportions.

The recent Javanese *Corbicula*'s are perhaps ovo-viviparous like their Philippine congeners (Villadolid and Del Rosario, The Philipp. Agriculturist, vol. 19, 1930, p. 355—382) though nothing definite is known about their propagation, nor from the genera *Polymesoda* and *Batissa* either, and still less from the fossil ancestors of these three genera.

Of the other genera, *Viviparus, Brotia,* and *Thiara,* it is probable that the fossil representatives are ovo-viviparous, like their recent descendants. The number of pulli pro female is not exactly known, but is certainly low in comparison with the number of eggs which the females of ovigerous species produce.

Important destruction of animal life in the Kendeng region was caused by temporarily increased volcanic activity, accompanied by huge floods (banjirs), and lava- and mudstreams (lahars). Geological investigations made the volcanoes Lawoe and Wilis responsible for these eruptions and settled their operations at the transition of the Pliocene to the Pleistocene era approximately (Volz, 1907; Dubois, 1908; Carthaus, 1911; Rutten, 1927; Van Es, 1929 and 1931; Von Koenigswald, 1934; Duyfjes, 1936).

The volcanic ejectamenta, now taking place in one direction, then in another, and frequently composed of different material: bombs, lapilli, lava, ashes, buried the mountain flanks and the plain at the base of the mountain at irregular intervals. Water transport afterwards carried the volcanic products down to the plain with such violence that the local animal life, if not already exterminated by the fiery showers, now finally lost its life in the waves.

Once arrived in the lowland the destroying forces were converted into building powers again. Their load of sand, gravel, stones, etc., was deposited, thus establishing at a remote place a new solid ground for new vegetation and new animal life.

The principal cause for fossilization, not of the molluscs only, but equally of the numerous vertebrates, were the mudstreams (lahars), immediately followed by the floods (banjirs) (Carthaus, 1911, p. 14, 16, 19, 20, 27, 28, 30). Dubois (1908, p. 1238) at first supposed "dass die Tuffe in plistocäner Zeit aus Schlammströmen entstanden seien". Afterwards, however, he changed his mind and believed "dass eine Flussablagerung in diesen Tuffen vorliegt".

In their course down the mountain flanks the lahars did not, or hardly, pick up any molluscs. Fossil landshells are too scarce in these layers to allow conclusions about their living state and freshwater shells, especially the larger Bivalves, are absent in mountainous regions. Not the lahars as such (deposited as tuffs, breccia's and conglomerates, comprising the „Hauptknochenschicht") contain fossil freshwater shells, or only occasionally, but the sheets of clay, the sandstones and marls alternating with it (Carthaus, 1911; Duyfjes, 1936). In this respect the molluscs are just the contrary of the vertebrate animals. Quite a number of the latter must have been dragged away by the mudstreams from their actual loci in various altitudes on the slope of the volcanoes.

The destroying activity of the lahars unto the freshwater molluscs in fact only commenced in the plain. Here the mudstreams deposited most of their troublesome cargo and they accomplished their work so rapidly and so intensely that the prevalent freshwater molluscs were taken by surprise and became interred on the very spot where they had lived. We have already drawn attention to the fact that so many of the Bivalves were found imbedded with their valves closed, indicating that they were fossilized in autochthonous situation [1]), without secondary displacement. In this case the thanatocoenosis is equivalent with the biocoenosis.

The very good condition in which species like *Lymnaea*, *Gyraulus*, and *Ameria*, were found is a strong argument in favour of a rapid and undisturbed fossilization (Carthaus, 1911, p. 24, 28, 30). Their fragile shells could never have been preserved so completely would they have been rolled and grated between coarse material.

The freshwater shells of the Kendeng deposits are all characteristic for low lying country (Carthaus, 1911, p. 13). There is not a single trace of a species proper to middle or high altitudes. On the other hand it is true that, at least in our days, *Lymnaea javanica*, *Gyraulus convexiusculus*, *Viviparus javanicus* and several Thiarids can live in the hills in lakes and streamlets at altitudes up to circa 1500 m, in a few cases even higher[2]).

Dubois (1908, p. 1239) called the fauna entirely fluviatile ("der fluviatile Charakter der ganzen Ablagerung steht unzweifelhaft fest"), but that cannot be kept up for the molluscs. In this group there are several species which apparently lived in stagnant water: ponds and swamps (rawahs), viz., *Lymnaea*, *Gyraulus*, *Ameria*, *Pila*, *Viviparus*, *Bithynia* (Carthaus, 1911, p. 14; Van Es, 1931, p. 11). Only the Najads and to a smaller extent *Corbicula* and the Thiarids are inhabitants of running water.

Judging from the freshwater molluscs the opinion of Van Es (1931, p. 127) that "The Pleistocene Trinil beds are characterized as being mainly *denudation* products on account of their content of *detritus* from Miocene and Pliocene beds, mixed with andesitic products *washed down* from the slopes of volcanoes" cannot be maintained.

Moreover this is in contradiction with his statements at p. 79 that "the very rich bone-bed in **Trinil**...... is to be considered as a river

1) Dubois (1908, p. 1240—1241) surmised the same for the vertebrate remains.

2) Cfr. Rensch (Die Geschichte des Sundabogens, 1936, p. 26): „Im Gebiet der Sunda-Inseln — wie auch in den meisten anderen Tropengebieten — sind die Tieflandtiere häufig bis zu Höhen von 800 bis 1000 m, stellenweise auch 1200 m verbreitet. Erst von 1000 m bis 1200 m an beginnt gewöhnlich eine Wandlung der Fauna durch stärkeren Einschlag typisch montaner Elemente."

deposited conglomeratic tuff sandstone...... In many cases the bones were found in cross-stratified sandstones containing rounded pebbles, that are to be considered as true river deposits "(the spacings are mine, T. v. B. J.).

When discussing the frequency of the *Pseudodon* in the systematic part of this paper I touched already incidentally upon the subject of competition. Exact figures, however, cannot be given. Not even in the recent fauna of the tropics attempts to investigate this biologically highly important concurrence have been undertaken. And though from our part of the globe some observations and a few experiments are available, yet there remains a lot of work to be done in this subject.

Thus Boycott in his recent paper on the habitats of freshwater molluscs in Great Britain (Journ. Anim. Ecol., vol. 5, 1936) arrives at the conclusion that "there are facts which suggest competition though they are not conclusive" (p. 126). His experience leads him to admit an interspecific competition, but whether an interindividual one also plays a part, is left to future research.

Though I know of some very impressive exceptions in the Netherlands, whereby numbers of gigantic *Anodonta cygnea* inhabited a small pond, yet as a rule there are sufficient indications that large mussels require spacious water units.

From chapter 4 of this paper it is evident that with the exception of *Ameria* all the genera of non-marine molluscs occurring in the marl zone during the Plio-Pleistocene period have persisted in Java until the present day. Even a good many species of that age and ours are identical and the rest are at least closely related to the modern fauna.

There is not a single species in this mollusc fauna which would suggest a cooler or a drier climate during the Poetjangan and Kaboeh ages, not in the way of latitude on the globe or of altitude above sea level.

Judging from the non-marine mollusca it must therefore be concluded that the temperature and humidity cannot have made serious fluctuations and both functions must have remained almost constant throughout the centuries from the beginning of the Quarternary until the present day.

This opinion is also shared by Van Steenis (Bull. Jard. Bot. Buitenzorg (3), vol. 13, 1935, p. 391—401) and by Merrill (Essays in Botany, in honor of W. A. Setchell, 1936, p. 251—252) with regard to the Malaysian flora. And both statements equally support the view that a serious climatic effect of the Great Ice Age in Malaysia is to be reprobated.

Unless kept within certain limits water movements can be favourable and highly promotive for shell life, so long as they supply food and oxygen and carry away decaying organic products and foul air. In other cases, however, when the pollution of the water by inorganic matter: gravel, sand, and silt amounts to considerable dimensions, the effect of the water movements influences the stock of mollusca in an anything but beneficial way.

The prehistoric streams and lakes were not so obedient as modern ones; great floods during the wet monsoon, volcanic eruptions with all their fatal consequences were perpetually threatening animal life. In fact only in abandoned windings, dead river arms, in lakes and pools where the water was no longer laden with moving material and where plants and weeds had sprung up, the snails and mussels could definitely settle, develop and flourish.

An analysis of a fossil biotope will always be affected with many doubtful points and unsolved questions. It is remarkable that the Mollusca in general have so few relations to other groups of animals, in non-marine even the more so than in marine ones. For fossil representatives the plotting of such points of contact is still more problematic than for recent species and in the preceding pages the possible relations were only rarely mentioned.

The Mollusca are an independent, self contained class of animals and the problems which stir them can but seldom be transmitted to other groups of animals. This involves that conclusions about the geological age and stratigraphical value of the freshwater shells in the Kendeng layers need not coincide with those found by other workers for other systematic classes. Each group has its private mode of evolution which may be highly divergent from the way in other groups. Molluscs are relatively slow and credit a fauna apparently older than it may be in reality.

MALACOLOGICAL EVIDENCE FOR THE DETERMINATION OF THE AGE OF THE BEDS

The expression "Trinil Fauna" or "Trinil beds" is not always employed in the same sense by the different authors. Some of them take it in a narrow sense, restricting it to the fauna of the immediate vicinity of Trinil, others, however, use the designation in a much wider meaning and insert a great many localities beyond the region just mentioned where animal remains of the same age and formation are excavated (e.g., Redjoeno beds, Kendeng beds, Kedoeng Nojo, Bogo, Tritik, Bangle, etc.), all situated in a long West-East lying valley of Central East Java, South of the Kendeng Mountains, the second of three West-East ranging limestone ridges.

TABLE I. Comparison of the principal opinions on the Pliocene and Pleistocene Stratigraphy.

Dubois 1908

recent	actual fauna
Pleistocene	
Pliocene	Trinil or Kendeng Fauna *(Pithecanthropus erectus)*
Pliocene	Sonde

Elbert

recent	actual fauna
Upper Diluv.	
Middle Diluvium	
Lower Diluvium	"Obere Kendeng-Schichten"
Lower Diluvium	"Mittlere Kendeng-Schichten"
Lowest Diluvium	"Untere Kendeng-Schichten" *(Pithecanthropus erectus)*
Pliocene	Sonde

Selenka

recent	actual fauna
Pleistocene	Lapilli resp. laharsandstones alternating with argile layers
Pleistocene	"Hauptknochenschicht" *(Pithecanthropus erectus)*
Pleistocene	Conglomerate breccia
Pliocene	Sonde

Van Es

recent	actual fauna
Upper Pleistocene	Conglomerates Sandstones *(Pithecanthropus erectus)*
Lower Pleistocene	Volcanic breccia
Pliocene	Sonde

Von Koenigswald

recent	actual fauna
Young Pleistocene	Ngandong Fauna
Middle Pleistocene	Trinil Fauna s. str. *(Pithecanthropus erectus)*
Old Pleistocene	Djetis Fauna
Pliocene	Sonde

Geological Survey

recent	actual fauna
Pleistocene	River Terraces
Pleistocene	Notopoero Fauna
Pleistocene	Kaboeh Fauna *(Pithecanthropus erectus)*
Pleistocene	Poetjangan Fauna
Pliocene	Upper Kalibèng (Sonde)
Pliocene	Lower Kalibèng

In table I are tabulated the principal layers mentioned in this paper with the names used by the different authors [1]).

Dubois in 1908 applied the name "Trinilschichten" or "Kendengschichten" to the entire complex of bonebearing layers explored by him between Bapang and Tjenklik near Solo to Bangle. He advocated the opinion that all these deposits should belong to one and the same geological period [2]). He located the deposit in the youngest Pliocene.

One of his arguments in favour of his unitary conception of the Trinil Fauna and of his chronological foundation of it is the inclination of the Trinil layers, through tectonic agency, from North to South of 6—10 or 15°, "which shows the influence of tilting or folding movements. Moreover several transverse faults are present, showing that the beds did not remain undisturbed" (Van Es, 1931, p. 81).

Here Dubois' opinion was evidently based on premisses of Verbeek, that all layers which have undergone a modification in their orography necessarily must belong to the Pliocene or older, no such tectonic disturbances being possible in the Pleistocene.

Modern investigations in the Malay Archipelago, however, have shown that orogenetic movements can also take place in the Pleistocene, and herewith this argument of Dubois is deprived of its authorative validity.

Elbert (Nieuwste Onderzoekingen, 1908, p. 129, and Alter der Kendeng-Schichten, 1908, p. 656 ff.) recognized three separate horizons in the Kendeng region which he called Lower, Middle, and Upper Kendeng beds respectively. He placed the Lower Kendeng deposit in the Lowest Pleistocene and both Middle and Upper Kendeng beds in the Lower Pleistocene. The Lower and Middle Kendeng layers are rich in vertebrate bones and freshwater shells, the *Pithecanthropus* remains were found in the Lower Kendeng layers.

The Selenka Expedition, also visiting chiefly the immediate vicinity of Trinil, made a few series of careful sections in order to ascertain the succession of the different strata. The results, as embodied in the reports of Dr. Carthaus (1911) and Ir. Dozy (1911) demonstrate that we have to do with 3 well definable layers, all belonging to the Pleistocene epoch. From base to top these layers are characterized as follows: 1. Conglomerate tufa (Konglomerattuff), 2. Principal bonebearing bed (Hauptknochenschicht),

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1) In this delicate task I profited a great deal of suggestions and corrections made by Dr. C. H. Oostingh of Bandoeng, to whom I tender here my sincerest thanks.

2) See p. 1244: "Hier muss gleich in den Vordergrund gestellt werden dass alle Fundorten des ganzen Kendeng vollkommen gleichaltrig sind".

3. Lapilli layer, alternating with argillaceous deposits. Local variations, however, occur, especially in zone 3, where lahar sandstones now and then take the place of the lapilli formation if they do not superpose these.

About 20 years after the preceding investigations took place the problem of Trinil was approached again, this time by Van Es (1931). He could dispose of a wealth of new geological and stratigraphical details: modern maps and fresh sections, not only from Trinil and surroundings, but also from several other localities in Java where Vertebrates and Molluscs are found. The deposits containing freshwater shells have been mentioned already in chapter 3 of this paper. The Trinil beds. s. str., being the deposits in the neighbourhood of Trinil, which he placed entirely in the Pleistocene period, are divided into two horizons, a lower one consisting of volcanic boulder breccia and an upper one containing conglomeratic sandstones, tuffs and black clay with rich Vertebrate fauna (*Stegodon*, etc., including *Pithecanthropus erectus*).

Later investigations by Von Koenigswald (1934, 1935) have thrown quite another light on the case of Trinil, and, in his opinion, it is evident now that neither the limited, nor the broad meaning as have been put over against each other in the beginning of this chapter gives a correct impression of what must be considered contemporaneous horizons.

Both in the neighbourhood of Trinil and in the wider surroundings Von Koenigswald distinguishes 3 different strata which until now have always been confounded and which passed in older literature as Trinil layers or Kendeng layers.

Von Koenigswald discriminates the oldest as the Djetis formation. It is classified as Oldest Pleistocene, and occurs along an extensive zone stretching from Trinil Eastward to near Soerabaja. Wellknown localities holding this Djetis Fauna are recorded near the village of Djetis, N.E. of Modjokerto, and along the southern slope of the Kendeng Mountains, especially near Kedoeng Broeboes close to Mount Boetak.

The overlying horizon is the Trinil formation s. str., representing the Middle Pleistocene era. It is excavated at the classic locality Trinil, where it produced the remains of *Pithecanthropus erectus,* and in several other stations lying Eastward, e.g., Mount Pandan and surrounding regions.

Still younger than the Djetis and Trinil faunas just mentioned is the third and last division of the Pleistocene, the Ngandong Fauna. It is only very local and of little importance for our purpose, as it does not carry land and freshwater shells. It is recorded from a number of patches in the valley of the river Solo, North of Ngawi.

It must be emphasized that Von Koenigswald founded his stratification of the Pleistocene on the excavations of mammalian bones only. It remains to be seen whether in the molluscan fauna a similar discrimination is possible.

The restricted sense of the designation "Trinil beds" is certainly to be recommended, but carrying it through will meet with considerable difficulties, especially in old collections and in old records in literature which never took into account such minute details of the deposits and freely mixed up two (perhaps three) zones under the name "Trinil beds" or "Kendeng beds".

In the year 1931 the Netherlands Indies Geological Survey started a renewed mapping of the island of Java, an elaborate task which is still in progress. In course of time extensive districts were explored, a.o., an East-West lying strip of the province of East Java, about 150 km in length, situated in the residencies of Japara-Rembang, Bodjonegoro, Madioen, Kediri and Soerabaja. Attention was paid to both geological and palaeontological evidence, and an enormous quantity of fossils of Neogene origin were excavated. These were forwarded to the Geological Institute at Bandoeng and thence to different specialists.

An account of the results of the new survey has been published by the leader of the field work, Ir. J. Duyfjes (1936) [1]). His clear and efficient demonstration discharges me from the obligation to enter into further remarks on geological and stratigraphical details. I only copy here his table of the stratigraphical and palaeontological sequence of the layers and their supposed parallelization as it displays in concise form the principal results of the investigations (Table II).

In addition to this table Ir. Duyfjes projected a diagrammatic profile showing the succession of the beds and the way in which they wedge out from West to East. This graph was originally accompanying two excavation-reports with field notes (in typescript) of which I could dispose during my work. With a few modifications it is published here with the kind permission of the author (Table III).

On more than one occasion Duyfjes acknowledges that his palaeontological conclusions are chiefly based on mammalian evidence obtained by cooperation with Dr. G. H. R. von Koenigswald, palaeontologist of the Bandoeng Geological Institute. We will see later that the freshwater molluscs in broad outline confirm this assumption.

The mollusca which have been discussed in the systematic part of this paper will be grouped hereafter according to their occurrence in the

1) Preliminary results had already appeared in the Kwartaalverslagen van den Dienst van den Mijnbouw (Quarterly Reviews of the Mining Service) since 1932 onwards.

different sheets of the staffmap and in the different geological phases. The localities are arranged from West to East (Table IV).

Comparing this survey with the tables II and III we are confronted by the malacological side of the problem of Plio-Pleistocene succession in an extensive and almost continuous area in central East Java. So important even are these animals that by the knowledge of their distribution, both in time and in space, we can gather an insight in the evolution of this part of the island of Java during the Neogene period.

In the first place we see that the Lower Kalibèng layers (the Lower Pliocene) never yielded one single land or freshwater mollusc. This corresponds with my remarks on p. 86 of this paper that the non-marine molluscs are a rather young element in the natural history of the island, all horizons previous to the Middle Pliocene yielding sea shells only.

In the Upper Kalibèng layers some 10 non-marine species have been excavated in the vicinity of Sonde, but for the rest of their extent land and freshwater molluscs are altogether absent in these beds[1]).

Besides this horizon is famous for its wealth of marine species, the so-called Sonde fauna, referred to by Martin on different occasions. Whether we have to regard the presence of the non-marine shells [2]) amidst the marine species as accidental, caused by river transport from localities lying upstream, or whether the species have lived in fresh- or brackish water in the immediate vicinity of the Pliocene sea shore [3]) I do not venture to decide.

The superposing Poetjangan layers are of various petrographical composition and of terrestrial or freshwater origin, but never marine [4]). Part of this formation was deposited as sediments of non-volcanic origin, and another part as a volcanic phase, as exhibited in the tables II and III. The transition begins in the Eastern section of Sheet 99, about off the village of Sempol. The volcanic layers are entirely devoid of non-marine shells, the non-volcanic substitute on the contrary abound with such molluscs [5]).

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1) The *Unio*-species mentioned by Duyfjes (1936, p. 140) from the Upper Kalibèng layers I have left out of consideration.

2) The geological estimation of the only landshell (*Chloritis transversalis*) in this deposit is doubtful, cfr. p. 95 of this paper.

3) On account of the presence of Thiarids and *Theodoxus corona* (s.n. *Neritina brevispina*) among the species of marine origin Martin (1908, p. 13) suggested "dass die Sedimente in nächster Nähe einer Flussmündung zum Absatz gelangten".

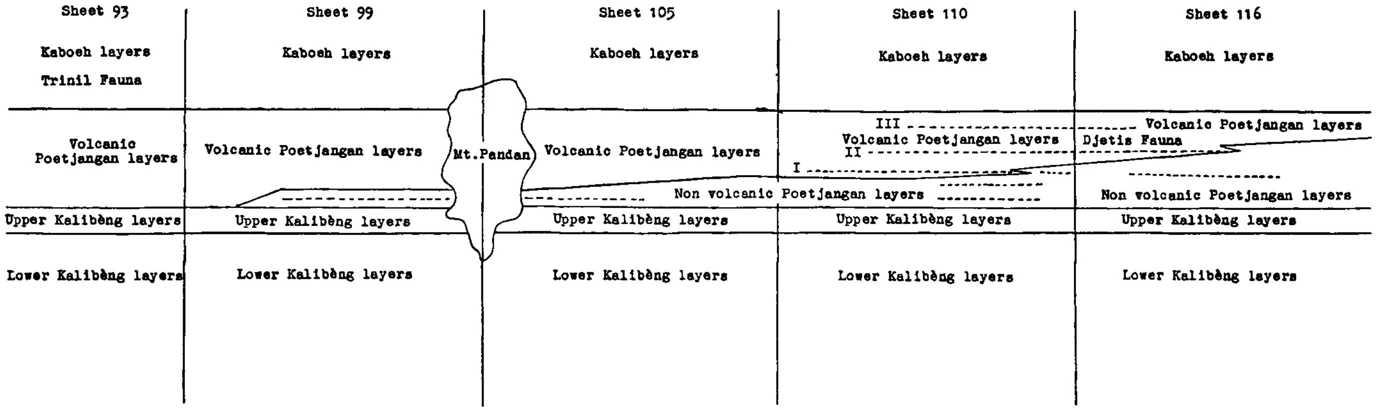
4) "Nowhere in Java exposures have been described showing a marine fauna that might be taken for Pleistocene" (Van Es, 1931, p. 34).

5) Beyond the region of our investigations no non-marine shells of Lower Pleistocene age (Poetjangan) have been excavated.

TABLE II. Parallelization of Stratigraphical and Palaeontological Divisions of Neogene and Pleistocene in the Kendeng Region (after Duyfjes, 1936).

STRATIGRAPHICAL DIVISION			PALAEONTOLOGICAL DIVISION	
Trinil (Sheet 93)	Mt. Boetak (Sheet 99)	Perning (Sheet 110)	Fauna	Age
Alluvium	Alluvium	Alluvium		
Terraces Notopoero layers Kaboeh layers Poetjangan layers (volcanic facies)	- - - - Notopoero layers Kaboeh layers Poetjangan layers (volcanic facies)	- - - - Djombang layers (?) Kaboeh layers Poetjangan layers (volcanic facies) (non volc. facies)	Ngandong Fauna No Vertebrates Trinil Fauna Djetis Fauna	Young Pleistocene Middle Pleistocene (?) Middle Pleistocene Old Pleistocene
Upper Kalibèng layers Lower Kalibèng layers	Upper Kalibèng layers Lower Kalibèng layers	Upper Kalibèng layers Lower Kalibèng layers	Sonde Fauna (Martin) Small Foraminifera	Pliocene (?)
Miocene	Miocene	- - - -	*Lepidocyclina*'s	Miocene (?)

TABLE III. Profile of Neogene and Pleistocene in the Kendeng Region (after Duyfjes, unpublished).



The opinion of Van Es (1931, p. 127) that the volcanic Poetjangan layers are missing in the region of Trinil proper, thus causing a discordance between the Upper Kalibèng layers and the Kaboeh layers, has been recently defeated by Duyfjes (1936, p. 146—147).

The non-volcanic Poetjangan layers contain several Thiarids, *Neritina, Theodoxus, Batissa,* and *Polymesoda,* which might suggest an environment of brackish water, either permanently or incidentally. Yet the presence of such genuine freshwater species like *Lymnaea javanica, Ameria duboisi, Pila conica* and *Viviparus javanicus* demonstrate the lacustrine nature of the habitat.

The geological cause of the difference between the Western and the Eastern part of the Poetjangan layers is not easy to understand. It is not likely that he volcanic mudstreams which descended from Mount Wilis or Mount Lawoe and which filled up the sea at their feet (Duyfjes, 1936, p. 142 and 148) washed away at the same time all the freshwater shells from West to East so thoroughly that not one single shell should have stayed behind in the lahar deposits.

Another suggestion is that the stuffing of the sea arm with volcanic products of the two mountains just mentioned took place so rapidly and assumed such immense proportions in the districts covered by the Sheets 93 and 99 (Duyfjes, 1936, p. 148) that an almost immediate succession of marine to terrestrial condition ensued without the intermediate phase of freshwater. In the Eastern part of the region, however, the sedimentation set in later and has never been so intense. Hence it can be understood that in this section (especially the Sheets 110 and 116) a more gradual transformation from marine to terrestrial habitat, via a freshwater phase took place, albeit with local variations and temporal oscillations.

Intercalated in the volcanic tuffs and sandstones in the districts of Sheet 110 and 116 there have been discovered local horizons of varying thickness (10—15 m) containing a few freshwater shells.

Layer III. *Faunus ater, Brotia testudinaria, Thiara winteri, Th. rudis, Th. tuberculata.*

Layer II. *Ellobium aurisjudae, Theodoxus corona, Viviparus javanicus, Brotia testudinaria, Thiara winteri, Th. rudis, Th. riqueti, Batissa violacea* var. *macassarica, Polymesoda tegalensis.*

Layer I. *Theodoxus flavovirens, Viviparus javanicus, Thiara tuberculata, Batissa keraudreni.*

Most of the non-marine shells in the Sheets 110 and 116 were secured from the non-volcanic Poetjangan beds. It must have been a rich and

TABLE IV.

Survey of the non-marine Molluscs contained in the different layers.

	Sheet 93	Sheet 99	Sheet 105	Sheet 110	Sheet 116
Terraces	*Corbicula gerthi* *Thiara granifera*				
Notopoero					
Kaboeh	*Amphidromus palaceus* *Landouria rotatoria* *Gyraulus convexiusculus* *Lymnaea javanica* *Ameria duboisi* *Stenothyra ventricosa* *Bithynia truncata* *Pila conica* *Viviparus javanicus* *Brotia testudinaria* *Brotia variabilis* *Thiara zollingeri* *Thiara zollingeri fennemai* *Thiara scabra* *Thiara granifera* *Thiara tuberculata* *Corbicula pullata* *Corbicula gerthi* *Corbicula exporrecta* *Elongaria orientalis* *Rectidens sumatrensis* *Pseudodon vondembuschianus trinilensis*	*Chloritis transversalis* *Viviparus javanicus* *Brotia testudinaria* *Brotia variabilis* *Thiara scabra* *Thiara granifera* *Thiara tuberculata* *Corbicula pullata* *Elongaria orientalis* *Pseudodon vondembuschianus trinilensis*	*Lymnaea javanica* *Stenothyra ventricosa* *Viviparus javanicus* *Brotia testudinaria* *Brotia variabilis* *Thiara winteri* *Thiara zollingeri* *Thiara zollingeri fennemai* *Thiara scabra* *Thiara granifera* *Corbicula pullata* *Corbicula gerthi* *Elongaria orientalis* *Pseudodon vondembuschianus trinilensis*	*Viviparus javanicus* *Brotia testudinaria* *Thiara granifera* *Batissa keraudreni* (?)	*Elongaria orientalis*
Poetjangan		*Batissa keraudreni* *Polymesoda tegalensis*	*Brotia testudinaria* *Thiara winteri* *Thiara scabra* *Thiara granifera* *Thiara granifera madiunensis* *Thiara tuberculata* *Batissa keraudreni* *Polymesoda tegalensis* *Theodoxus flavovirens* *Ameria duboisi* *Viviparus javanicus*	III. *Faunus ater*, *Brotia testudinaria*, *Thiara winteri*, *Th. rudis*, *Th. tuberculata* II. *Ellobium aurisjudae*, *Viviparus javanicus*, *Brotia testudinaria*, *Polymesoda tegalensis* I. *Theodoxus flavovirens*, *Viviparus javanicus*, *Thiara tuberculata*, *Batissa keraudreni* *Pythia* spec. *Lymnaea javanica* *Ameria duboisi* *Neritina pulligera* *Pila conica* *Viviparus javanicus* *Brotia testudinaria* *Thiara winteri* *Thiara tornatella* *Thiara riqueti* *Thiara granifera* *Batissa keraudreni* *Batissa violacea* var. *macassarica*	III. *Brotia testudinaria*, *Thiara winteri* II. *Theodoxus corona*, *Brotia testudinaria*, *Thiara winteri*, *Th. rudis*, *Th. riqueti*, *Batissa violacea* var. *macassarica*, *Polymesoda tegalensis* I. .... *Theodoxus ualanensis* *Neritina communis* *Neritina pulligera* *Pila conica* *Brotia testudinaria* *Thiara winteri* *Thiara rudis* *Thiara zollingeri* *Thiara scabra* *Thiara riqueti* *Thiara granifera* *Batissa keraudreni* *Batissa violacea* var. *macassarica*
Upper Kalibèng	*Chloritis transversalis* (?) *Theodoxus corona* *Theodoxus ualanensis* *Brotia testudinaria* *Thiara scabra* *Thiara tornatella* *Thiara granifera* *Thiara granifera madiunensis* *Thiara rustica* *Thiara semicancellata* *Thiara tuberculata* *Corbicula pullata* *Polymesoda tegalensis*				
Lower Kalibèng					

homogeneous population which after centuries of prosperity became suddenly overrun by the ejectamenta of the volcanoes. This catastrophe caused the freshwater fauna to decline in short time. On three occasions it sprung up afterwards again at successive intervals: the above mentioned layers I, II, and III. These interruptions, however, are of local importance only and are but faint reflections of a previous glory.

Throughout the whole area the Poetjangan layers are succeeded by the Kaboeh formation. Here and there these layers have been washed away from the backs of the mountains and mountain ridges which have popped up since, but on their flanks the Kaboeh sheets are still present, in a sloping position.

The Kaboeh layers are composed of sandstones and tuffaceous matter, with local inclusions of conglomerates or clay. Profiles through these layers have been described elaborately in the classic workshop: the bank of the River Bengawan-Solo near Trinil (Dubois, 1908, pl. 39; Oppenoorth, 1911, pl. 2, 3 and 4; Carthaus, 1911, pl. 6 and 7; Dozy, 1911, pl. 10; Van Es, 1929, map; id., 1931, maps; Duyfjes, 1936, figs. 2, 4 and 5).

Though represented throughout the entire region from Trinil Eastward to a point near Soerabaja, where the Kendeng mountains are lost in the plain, the Kaboeh layers produced fossil non-marine shells only in the Western part, up till Sheet 110 [1]).

With regard to the freshwater molluscs of the Poetjangan formation these non-marine Kaboeh layers in my opinion should be considered an altogether new invasion, and not as derivatives from the previous local fauna. They had no connections with the Poetjangan Fauna in the East Kendeng region which was declining gradually and finally became extinct.

Whence the new transgression immigrated I am unable to say for certain, but most probably from the West.

The principal differences between the Poetjangan and the Kaboeh formation are:

1. Absence of *Neritina, Theodoxus, Batissa* [2]) and *Polymesoda* in the Kaboeh layers.
2. Presence of *Gyraulus, Bithynia, Stenothyra, Corbicula* and Najads in the Kaboeh layers.

The opinion of Dubois (1908, p. 1244) to which I referred already in the beginning of this chapter (p. 168), "dass alle Fundorte des ganzen Kendeng

1) In Sheet 116 there is only one isolated record of *Elongaria orientalis*.
2) With one exception: 2 doubtful fragments of *Batissa keraudreni* from Kaboeh layers (Sheet 110 B No. 199).

vollkommen gleichaltrig sind" should be abandoned. It is not even maintained any more by Prof. Dubois himself.

When calculating the percentage of extinct species in a certain formation in relation to the entire number of species in that deposit, a method employed by Martin for ascertaining the exact stratigraphical position of the formation we have to consider the two fauna's, Poetjangan and Kaboeh, separately.

The Poetjangan Fauna in toto contains 23 species (*Batissa violacea* var. *macassarica* and *Pythia* spec. included, but *Thiara granifera madiunensis* not counted). Of these only 2 species (*Ameria duboisi* and *Polymesoda tegalensis*) are extinct, that is 8—9 %.

The Kaboeh Fauna in toto contains 24 species (*Pseudodon vondembuschianus trinilensis* included, but *Thiara zollingeri fennemai* not counted). Of this number 3 species are extinct (*Ameria duboisi, Corbicula gerthi* and *C. exporrecta*; *Pseudodon* not counted), that is 12½ %.

From these figures we see that the two fauna's do not differ largely, and the percentages would suspect them to be of equal age, the Kaboeh Fauna even older than the Poetjangan. This of course is certainly erroneous and the far too small number of species on which the calculation is based should be made responsible for the mistake. It is evident that in such small numbers a fluctuation of only one or two units in any direction would cause a considerable increase or decrease of the percentage and better than by percentage or by the designations of guide fossils the biostratigraphic division of the layer gives an idea of what happened in the secular history of the mollusc-generations.

When trying to parallelize excavations in localities so remote from each other as, e.g., Bapang in the West and Perning in the East, localities situated at circa 150 km distance, a new difficulty is encountered in the absolute and relative value of chronology, altitude, and facies.

At a certain moment of the geological history the West of our field of investigation was already solid earth, elevated at a certain height above sea level and subject to influences like sun, rain, wind, and other powers which modify the earth's physiognomy, whereas at the very same moment the East was still submerged, obeying to forces working below sea level.

With respect to the absolute altitude above the sea, premising that no subsequent tectonic disturbances took place, the Eastern localities are younger than the Western ones of the same niveau.

And when finally comparing the corresponding facies it is evident that one special horizon, e.g., the Kaboeh layers, is older in the West than in the East (and generally lying also at greater altitude).

Therefore it must be recommended to employ the names of formations for corresponding deposits at remote distance with the utmost care. For short distances the danger of comparing not comparable subjects can be left out of account.

The difficulties increase even still more if the parallelization of what are supposed to be identical layers is extended to habitats beyond the Kendeng region, implicating in the discussion other places where non-marine shells have been excavated (see chapter 3 of this paper).

From this point of view it looks more or less artificial to designate one deposit as Pliocene, another as Lower or Middle Pleistocene, etc. The whole process should be regarded as a dynamic course, a secular progress attended with an evolution of the animals, keeping pace with the formation of the island of Java, and without definite demarcations.

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EXPLANATION OF THE PLATES

PLATE IV

Figs. 1—5. *Lymnaea javanica* (Mouss.), Trinil, Dubois Collection, No. 9771. × 1$^1/_3$.

Figs. 6—7. *Ameria duboisi* nov. spec., Trinil, Dubois Collection, No. 9769, type (6) and paratype (7). × 1$^1/_3$.

Fig. 8. *Ameria duboisi* nov. spec., N. E. of Soemberringin, Cosijn Collection, No. 52. × 1$^1/_3$.

Fig. 9. *Ameria duboisi* nov. spec., North of Kaboeh, Cosijn Collection, No. 60. × 1$^1/_3$.

Fig. 10. *Pila conica* (Gray), Trinil, Dubois Collection, No. 1574. × 1$^1/_3$.

Fig. 11. *Pila conica* (Gray), Trinil, Dubois Collection, No. 9774. × 1$^1/_3$.

Fig. 12. *Corbicula pullata* (Phil.), without locality, Dubois Collection, No. 9817. × 1$^1/_3$.

Fig. 13. *Corbicula pullata* (Phil.), River Ngetas, Bandoeng Collection, Sheet 99 B No. 18. × $1^1/_3$.
Fig. 14. *Corbicula pullata* (Phil.), Trinil, Dubois Collection, No. 9768. × $1^1/_3$.
Fig. 15. *Corbicula pullata* (Phil.), Kedoeng Nojo, Dubois Collection, No. 9754. × $1^1/_3$.

PLATE V

Figs. 1—7. *Corbicula gerthi* Oostingh, Trinil, Dubois Collection, No. 1680. Growth series to show the modification of outline and capacity during development. × $1^1/_2$.
Fig. 8. *Elongaria orientalis* (Lea), Trinil, Dubois Collection, No. 9719. Very heavy shell. Nat. size.

PLATE VI

Elongaria orientalis (Lea)

Figs. 1—2. Trinil, Dubois Collection, No. 9719. Very heavy shells. Nat. size.
Figs. 3—6. Kedoeng Nojo near Tritik, Dubois Collection, No. 1670. Nat. size.
Figs. 7—12. Trinil, Dubois Collection, No. 9719. Slightly reduced.

PLATE VII

Pseudodon vondembuschianus trinilensis (Dubois)

Figs. 1—2. Neotype, Trinil, Dubois Collection, No. 9711. × about $^3/_4$.
Fig. 3. Trinil, Dubois Collection, No. 9731. Nat. size.
Fig. 4. Trinil, Dubois Collection, No. 9744. × $1^1/_6$.

PLATE VIII

Pseudodon vondembuschianus trinilensis (Dubois)

Fig. 1. Trinil, Dubois Collection, No. 9711. Slightly enlarged.
Fig. 2. Trinil, Dubois Collection, No. 9724. Nat. size.

PLATE IX

Batissa violacea var. *macassarica* Martens

Figs. 1—2. River Padogan, Bandoeng Collection, Sheet 110 A No. 132. Fig. 1, × $^4/_5$; fig. 2, × $^5/_6$.
Figs. 3—6. River Klagen, Bandoeng Collection, Sheet 116 A No. 236. × about $^8/_9$.

PLATE X

Batissa violacea var. *macassarica* Martens

Fig. 1. River Retjo, Bandoeng Collection, Sheet 116 A No. 235. Nat. size.
Fig. 2. River Bantengan, Bandoeng Collection, Sheet 110 B No. 187. × $^9/_{10}$.

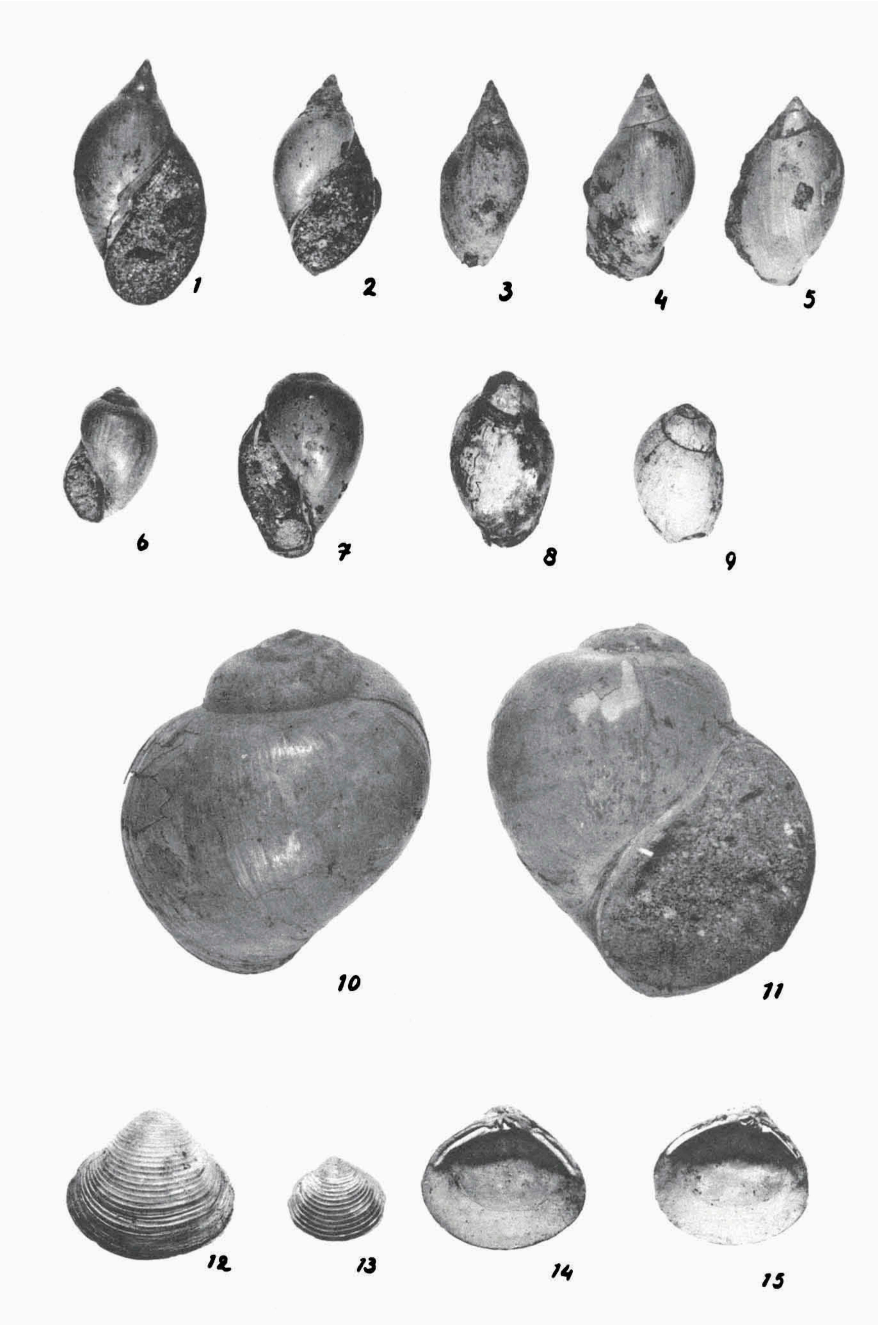
PLATE XI

Batissa keraudreni (Lesson)

Fig. 1. Path Bringin-Wadoeng, Bandoeng Collection, Sheet 110 A No. 119. × about $^4/_5$.
Fig. 2. Trench near Moenoengkerep, Bandoeng Collection, Sheet 110 A No. 135 b. × $^7/_{12}$.

PLATE XII

Figs. 1—2. *Batissa keraudreni* (Lesson), River Ngesong, Bandoeng Collection, Sheet 99B No. 7. × about $^5/_7$.
Figs. 3—4. *Polymesoda tegalensis* Oostingh, River Soemberdjo, Bandoeng Collection, Sheet 116 A No. 221. × about $^3/_5$.
Figs. 5—6. *Polymesoda tegalensis* Oostingh, West of Kampong Ngronan, Bandoeng Collection, Sheet 99 B No. 9. × $^3/_5$.
Fig. 7. Interior of 5, same scale.



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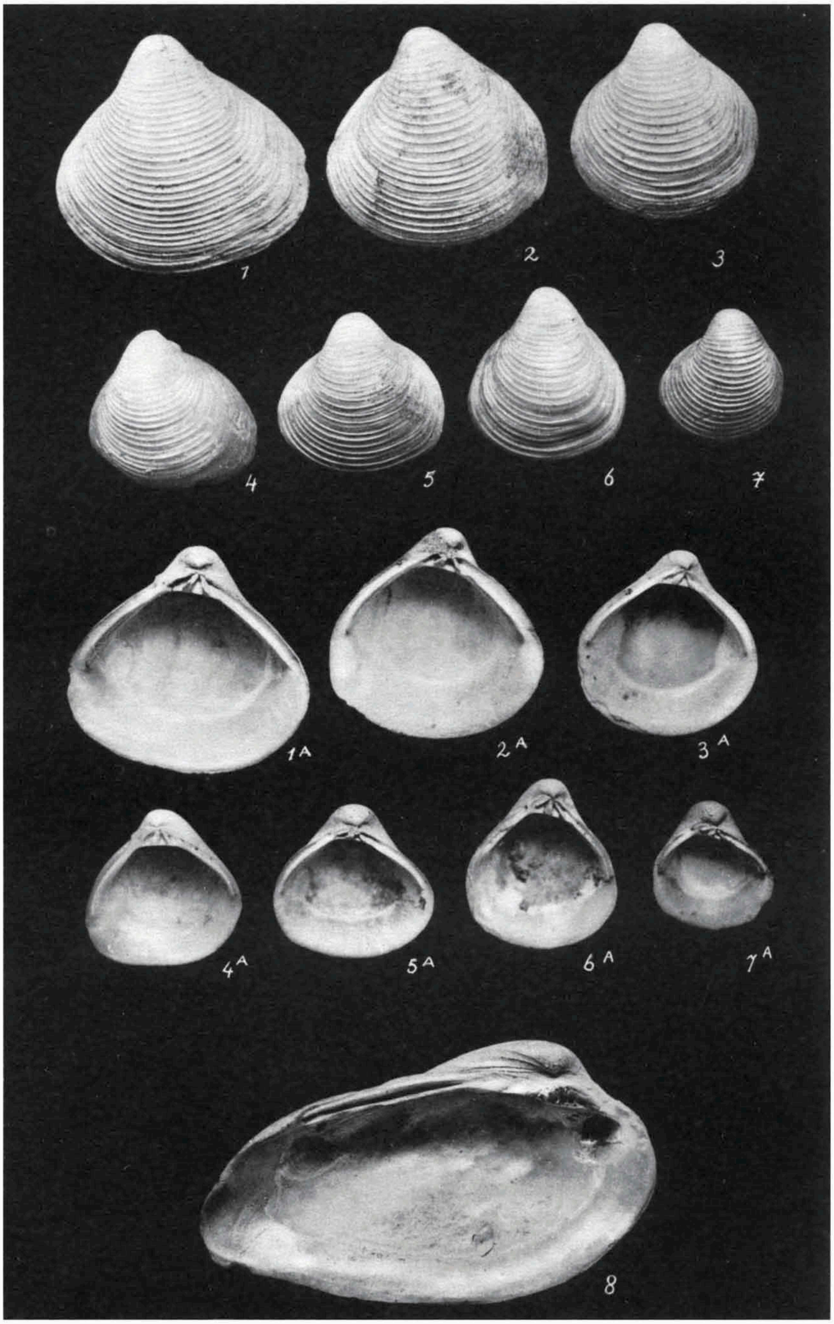

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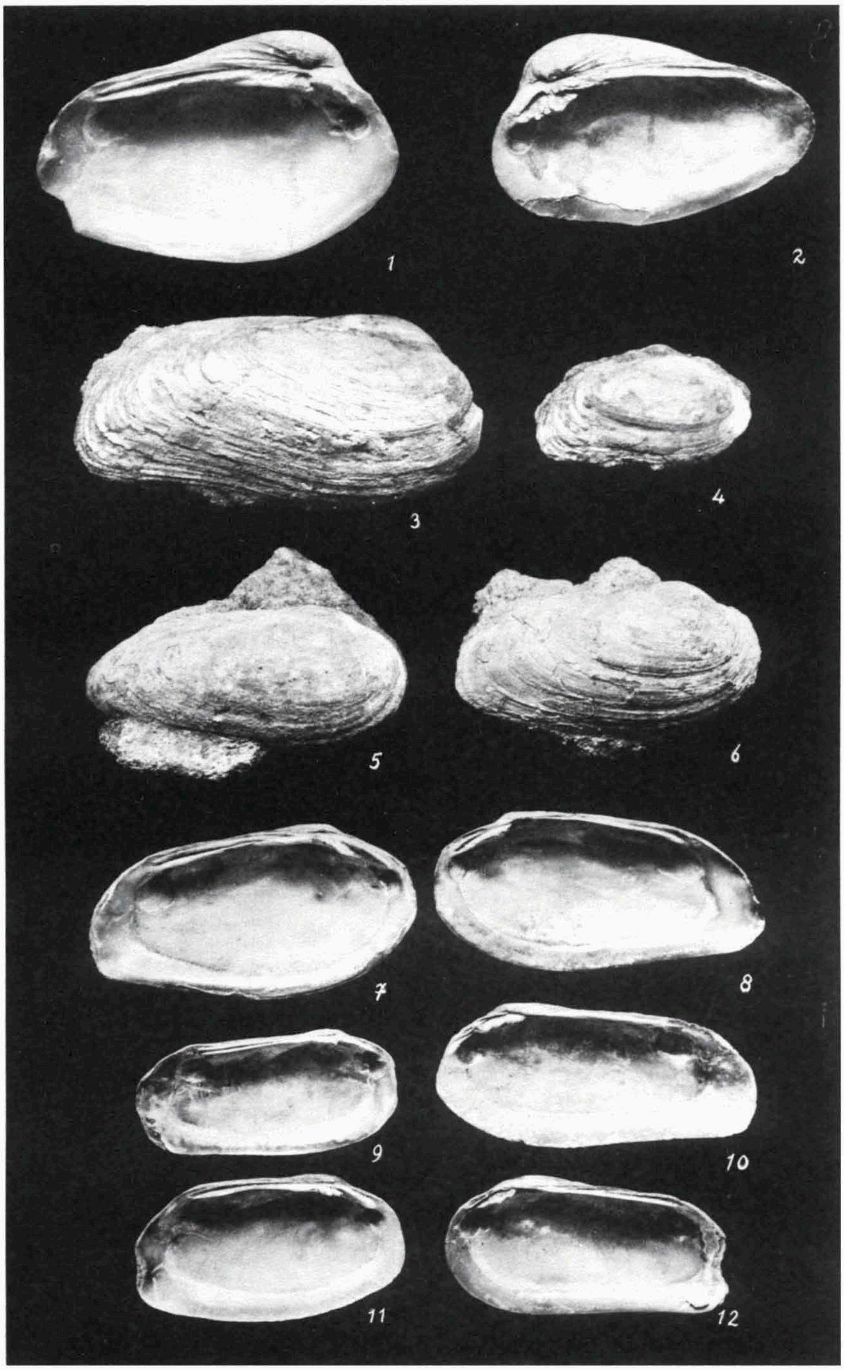

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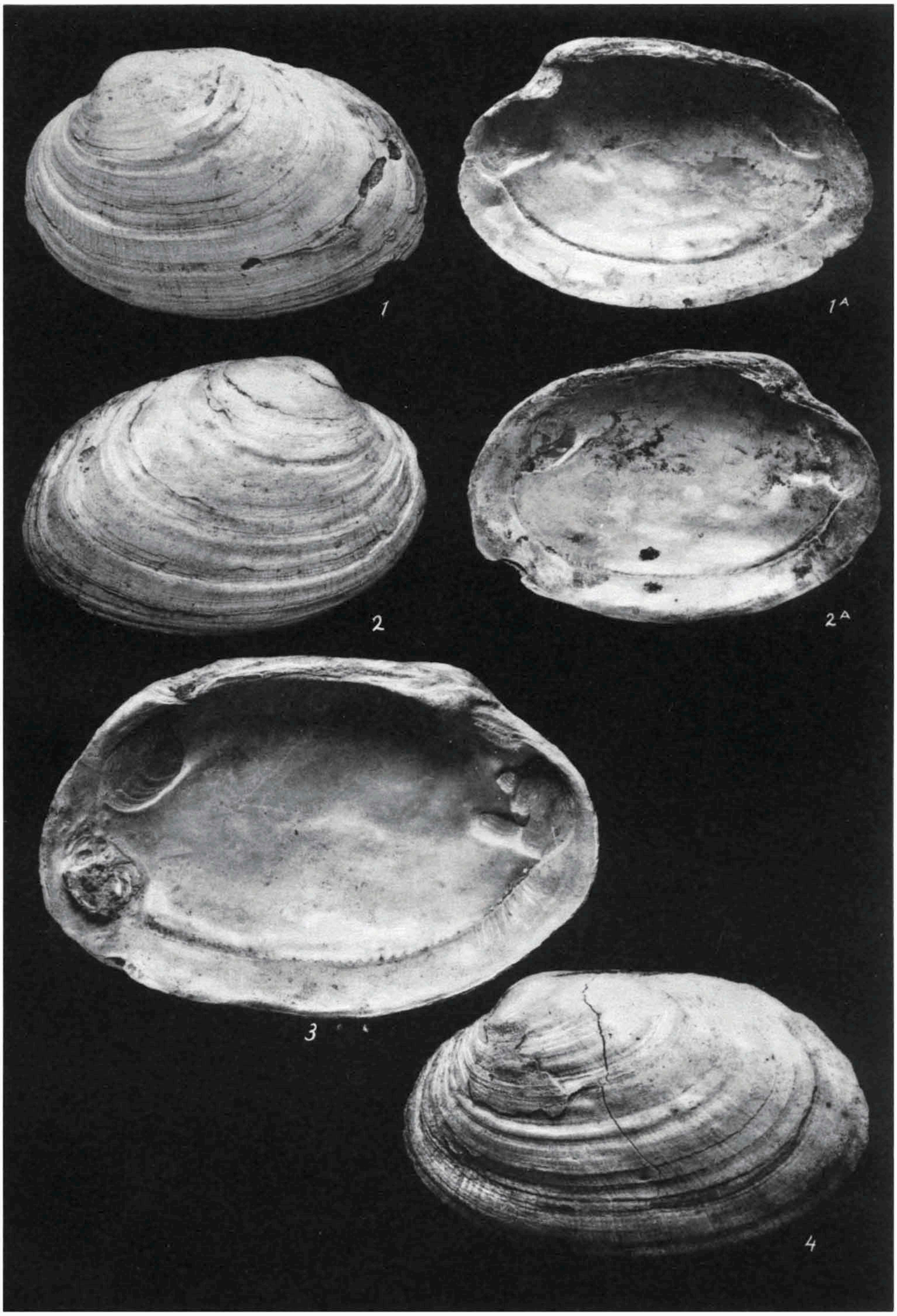

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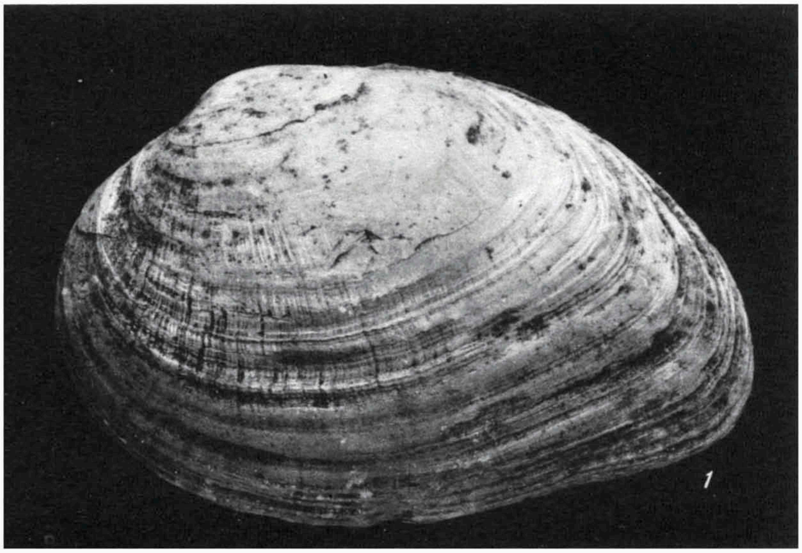

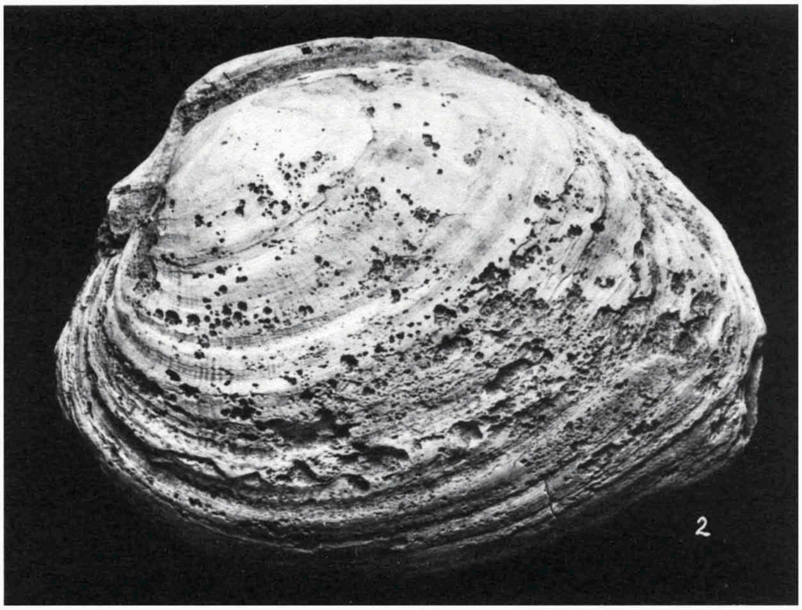

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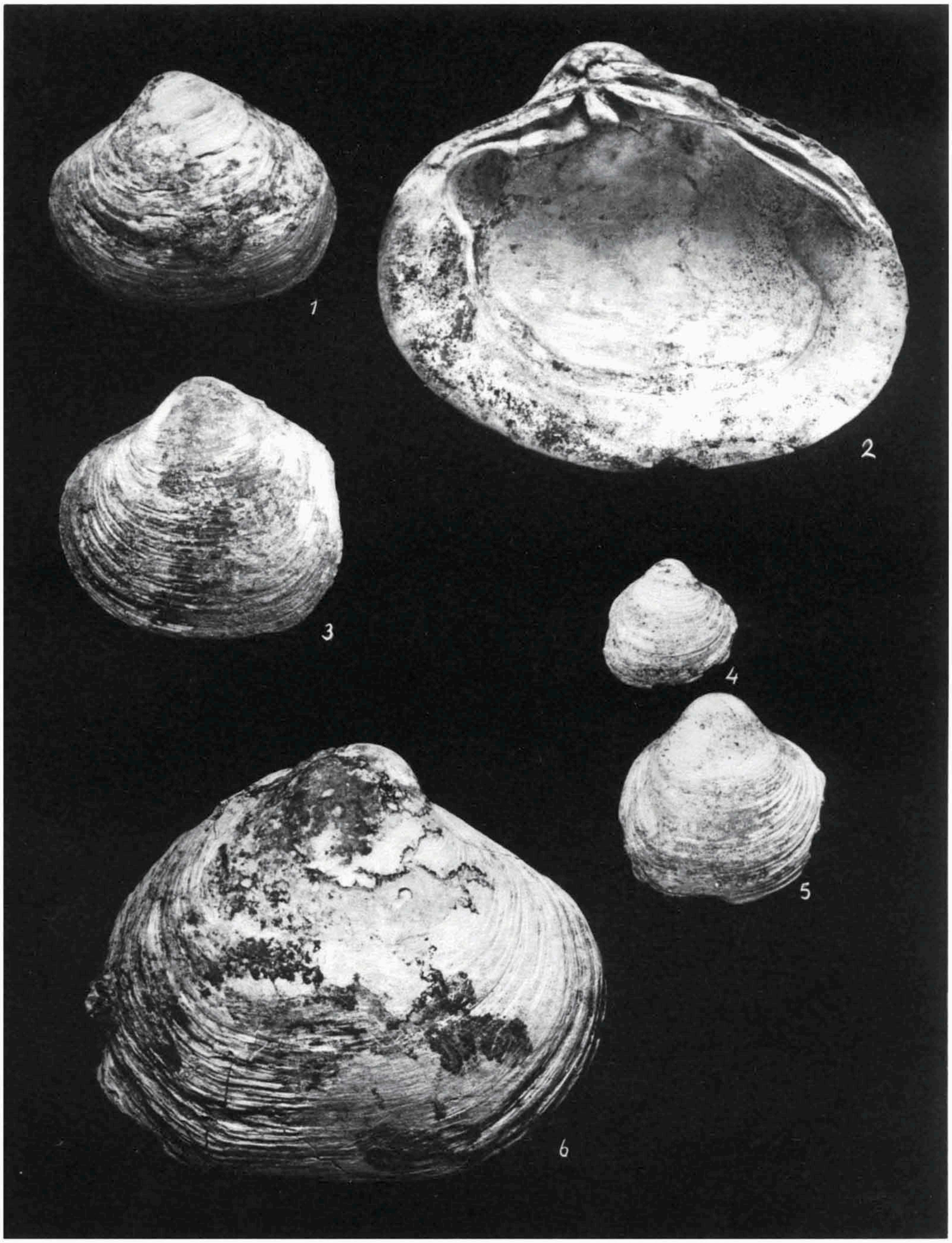

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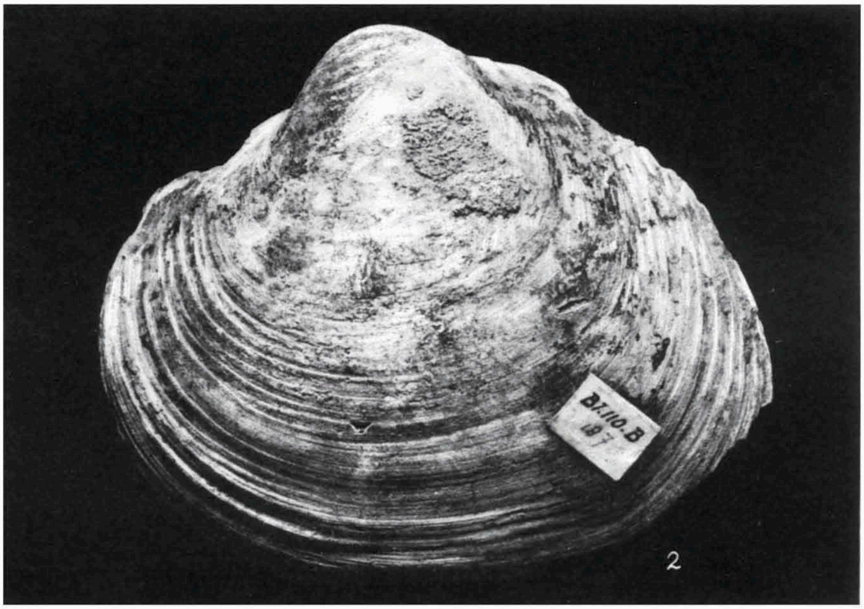

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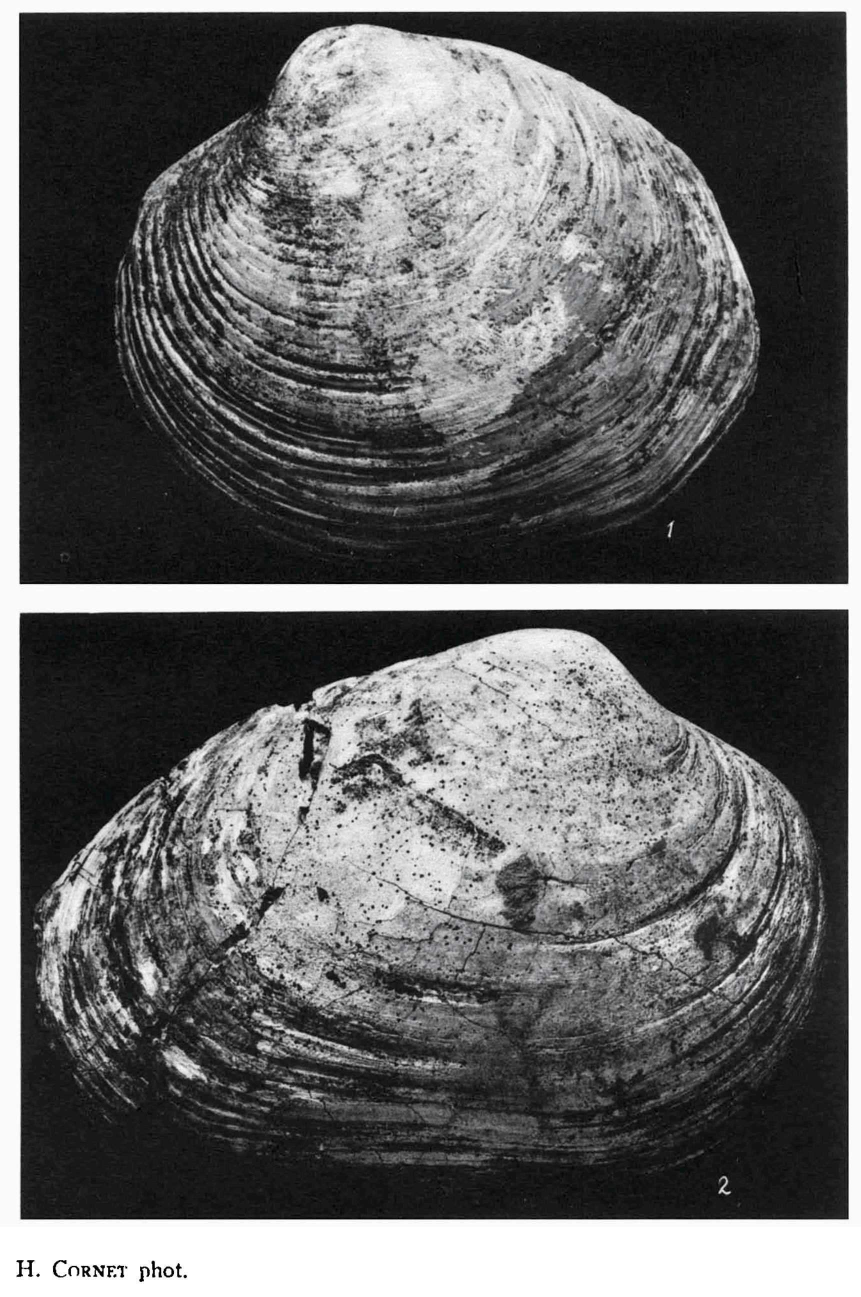

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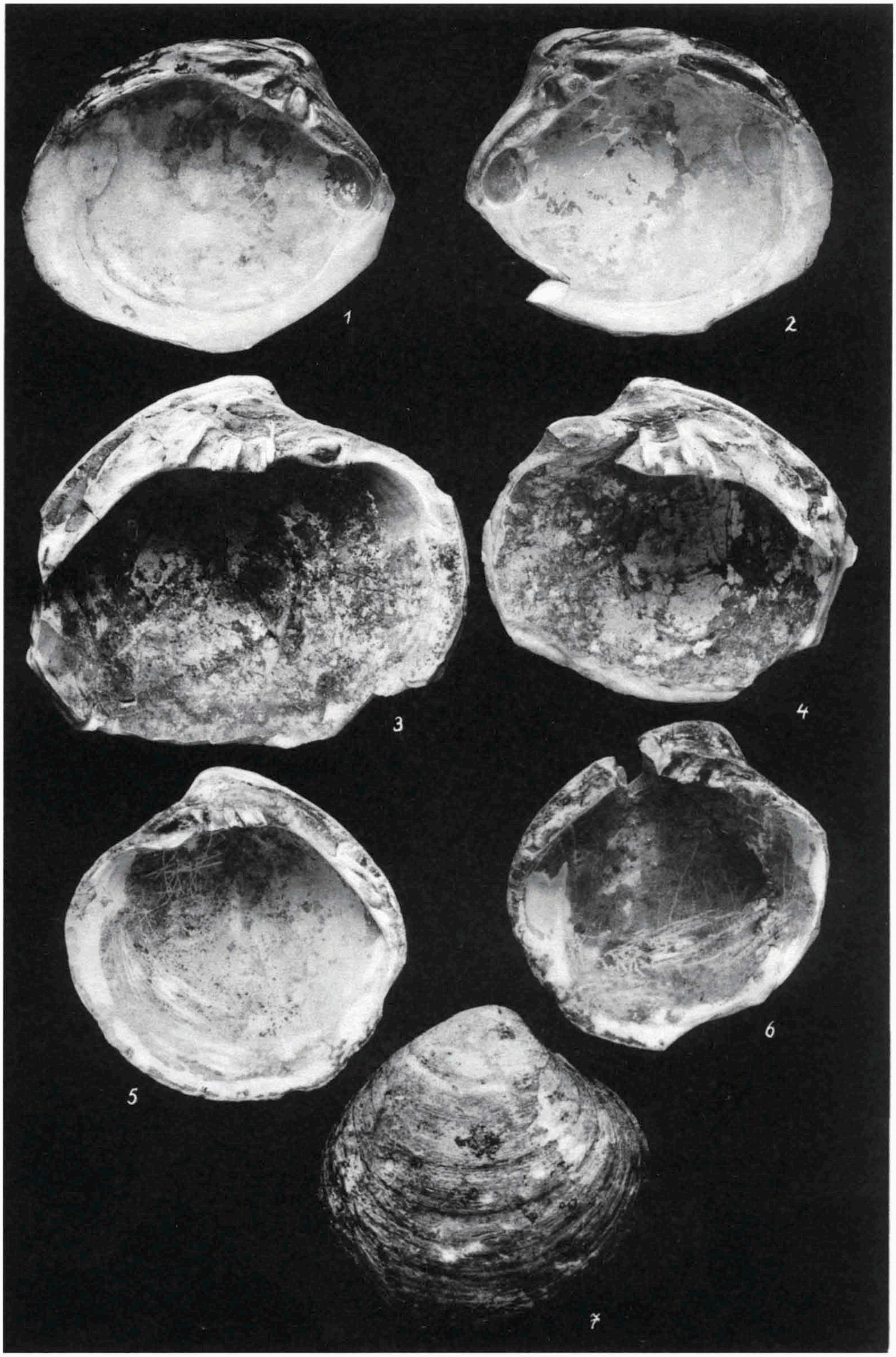

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