CONTRIBUTION TO THE KNOWLEDGE OF THE FOSSIL MAMMALIAN FAUNA OF JAVA.

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INSTITUTO DE GEOLOGÍA
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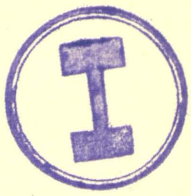

PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKS-UNIVERSITEIT TE UTRECHT, OP GEZAG VAN DEN RECTOR MAGNIFICUS Dr. L. S. ORNSTEIN, HOOGLEERAAR IN DE FACULTEIT DER WIS- EN NATUURKUNDE, VOLGENS BESLUIT VAN DEN SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP VRIJDAG 8 JULI 1932, DES NAMIDDAGS TE 4 UUR

DOOR

FRANCISCUS HENDRICUS VAN DER MAAREL

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Aan mijn vrouw.

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Hoewel mijn dank uitgaat naar allen, die tot de vorming van mijn geest hebben bijgedragen, wil ik mij op deze plaats beperken tot woorden van erkentelijkheid aan U, Hooggeleerde RUTTEN, SCHMUTZER en NIERSTRASZ.

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CONTRIBUTION TO THE KNOWLEDGE OF THE FOSSIL MAMMALIAN FAUNA OF JAVA.

BY

F. H. VAN DER MAAREL.

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INTRODUCTION.

The material, the description and determination of which forms the subject of the present paper, was part of an extensive collection, brought together by the exertions of the Geological Survey („Opsporingsdienst") of the Dutch East Indies, and entrusted to the author for examination. The specimens of this collection had been procured, partly from a new finding spot in the vicinity of Bumiaju (Central Java), partly from Javan localities already known for a long time. A renewed reconnoitring of the latter took place namely, in order to prepare a scheme, which had in view cooperation between the Survey mentioned and the American Museum of Natural History. On that occasion a rather great number of mammalian remains was collected, among which were some very fine specimens. The plan above mentioned was not carried into effect, so that the latter material was also sent to the writer.

The reader may form himself an idea of the extensiveness of the whole collection, if is mentioned that this consisted of four sendings, containing in total 31 cases, partly of considerable size [1]). The first, third and fourth sending consisted exclusively of specimens, obtained from the vicinity of Bumiaju. The second sending (18 cases) contained the material, collected in the other localities.

The packing was so excellent that most of the specimens either had experienced no harm whatever, or had hardly suffered any injury on the long journey. Only one specimen viz., a cranium of *Bibos sondaicus fossilis*, arrived in a very damaged condition. This was, however, not owing to the packing, but a result of the small degree of fossilization of that specimen.

Though in Bandung already much time was spent on the preparation, it appeared that by prolonged preparation a good deal of the specimens described could be brought into a considerable better condition. This work, which required both patience and skill, has aptly been done by Mr J. VAN DIJK, amanuensis of the Geological-Mineralogical Institute of the University of Utrecht.

The collection sent to Utrecht consisted for the greater part of mammalian remains. The cranial and dental remains of *Buffelus*, *Bibos*, *Rhinoceros*, *Hippopotamus*, "*Elephas*", *Stegodon*, "*Mastodon*",

[1]) Beside these 31 cases one more case was received, comprising molluscs from, and samples of rocks of the vertebrate bearing strata, near Bumiaju. The writer intends to examine the rocks, possibly the molluscs too.

and also the proboscidean limb bones have been selected for examination.

In accepting the examination the writer had undertaken to care that the greatest possible number of specimens should be returned before the beginning of the fourth Pacific Science Congress (Bandung 1929). Consequently, the specimens, after having been carefully examined, described, measured and pictured, immediately set out on the return journey, provided or not with a provisional name. It will hardly be necessary to point out that this working method involved difficulties. On the other hand, it yielded an advantage, which is not to be underestimated. The very fact that the fossils were sent back before their determination was definitely ended, gave rise to an absolutely objective description of each specimen, and as a matter of necessity the description had to remain objective, as later on its contents could not be changed any more.

In what follows the reader will find an enumeration of all the specimens described, and of the localities [1]) from whence they have been obtained [2]).

Residency: **Pekalongan.**

Regency: **Brebes.**

District: **Bumiaju.**

Locality: Bumiaju.

a. Excavation 1—4.

Tetralophodon bumiajuensis nov. spec.:
Fr. upper jaw with inj. l. and r. M^3.
Fragment of cranium with l. and r. M^3.
Incisive tusk.
? Fr. pelvis.

Mastodon sp.:
Inj. molar.

? *Mastodon* sp.:
Posterior portion of cranium.

Hippopotamus sp.:
R. horizontal mandibular ramus.
Lower jaw.

---

[1]) See also maps nos. 1 and 2.

[2]) In this list "fr." means fragmentary and "inj." injured. A sign of interrogation in front of the circumscription of a specimen indicates its *possible* belonging to the form under which it is mentioned.

b. Excavation 6.

Stegodon airâwana MARTIN:
Inj. cranium.

Stegodon sp.:
Nine fragments of grinding teeth.

c. Excavation 8.

Tetralophodon bumiajuensis nov. spec.:
Fr. r. mandibular ramus with M_3.
? Two femora (nos. 2 and 6).
? Three ulnae (nos. 1—3).
? Two radii (nos. 1 and 2).
? Tibia (no. 2).

Hippopotamus sp.:
Fr. upper jaw with l. and r. M^1—M^3.
Four detached lower C.

d. Excavation 9.

Hippopotamus sp.:
One detached lower C.

e. Excavation 11.

Stegodon sp.:
Three fragments of grinding teeth.

f. Excavation 13(?).

Hippopotamus sp.:
Fr. lower jaw.

g. Tji Saät.

Genus and species undetermined:
Proboscidean femur (no. 4).

h. Kali Biuk.

? *Archidiskodon planifrons* (FALC. et CAUTL.):
Fr. l. horizontal mandibular ramus with m_3(?).

i. Tji Pangglosoran.

Stegodon airâwana MARTIN:
Fragment of cranium with l. M^3.
Archidiskodon planifrons (FALC. et CAUTL.):
Detached l. M^1.

k. Tji Djedjawai.

Genus and species undetermined:
Proboscidean femur (no. 3).

l. Exact locality unknown.

Stegodon airâwana MARTIN:
Detached fr. l. M^3 and ditto r. M^3.
Detached M_1.

Residency: **Bodjonegoro.**

Regency: **Bodjonegoro.**

District: **Tambakredjo.**

Locality:

a. Mendut near Tinggang.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*:
Detached horn-core.

Stegodon trigonocephalus MARTIN:
Inj. cranium with r. M^3.

b. Lepen Alit near Tinggang.

Stegodon airâwana MARTIN:
Fr. lower jaw with l. and r. M_3.

Genus and species undetermined:
Proboscidean tibia (n°. 1).

c. Tegaron.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium and two detached horn-cores.

Residency: **Rembang.**

Regency: **Blora.**

District: **Randublatung.**

Locality:

a. Sentang Kedung Klampo near Kuwung.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

Elephas ?maximus L. *fossilis*:
Fr. lower jaw with l. and r. M_3.

b. Bondol near Kuwung.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Three fr. crania.

Rhinoceros sondaicus DESM. *fossilis*:
Cranium.

Rhinoceros ?sondaicus DESM. *fossilis*:
Fr. cranium.

Stegodon bondolensis nov. spec.:
Fr. lower jaw with l. and r. M_3.

Genus and species undetermined:
Proboscidean femur (n°. 1).

c. Tegal Sambiduwur near Kuwung.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Two fr. crania.

d. Wedilembut [1]).

Genus and species undetermined:
Proboscidean femur (n°. 5).

Residency: **Madiun.**

Regency: **Ngawi.**

District: **Ngawi.**

Locality:

a. Watualang.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*:
Cranium with both horn-cores preserved. Crushed cranium.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Two fr. crania.

Hippopotamus sp.:
Hinder portion of cranium.

Genus and species undetermined:
Proboscidean humerus (n°. 2).

b. Pitu.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

District: **Dero.**

Locality:

Redjuno.

Genus and species undetermined:
Proboscidean humerus (n°. 1).

---

[1]) On the leaf of the staff-map (1 : 25.000), relating to the matter in question, we only found "Alas Wedilembut". Alas means forest.

Government: **Surakarta.**

Regency: **Sragen.**

District: **Sragen.**

Locality:

Kedung Kendang [1]).

Bibos sondaicus SCHL. et MÜLL. *fossilis*:
Cranium with one horn-core preserved.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

Genus and species undetermined:
Proboscidean femur (n°. 7) and humerus (n°. 3).

First we will occupy ourselves with the new localities NNW. of Bumiaju.

According to ZWIERZYCKI [2]) the first finds were made by Mr. N. DE ZWAAN at Limbangan, who discovered in 1922—'23 some loose specimens in the Kali Glagah and Tji Saät [3]). It lasted till March 1923 before Mr. BUNING of Cheribon announced these finds in the papers. The result was that VAN DER VLERK, at that time palaeontologist of the Geological Survey, by order of that Survey made inquiries on the spot. A brief communication of his experiences will be found in the "Mijningenieur" of 1923 [4]).

The specimens found by VAN DER VLERK, together with the collection presented by DE ZWAAN to the Geological Survey, were sent for examination to STEHLIN in Bale. The results of this investigation were embodied in a paper entitled: "Fossile Säugetiere aus der Gegend von Limbangan (Java)" [5]).

All of STEHLIN's specimens had been obtained from the Kali Biuk and Tji Saät [6]). They were considerably rounded, distinctly indicating river transport. Only a few specimens allowed of determining the species. Noteworthy is that STEHLIN recognized

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[1]) According to the list of localities, which accompanied the second sending, and also to the labels, Kedung Kendang is situated in the residency Madiun. From the staff-map it appeared, however, that a campong of that name does not occur in the residency mentioned. As it does occur in the government Surakarta, and as it is this campong, which VAN ES (1931) mentions as a locality of vertebrate remains, we may be sure that both list and labels contained an erroneous statement.

[2]) De Mijningenieur, Jrg. 7, 1926, p. 229.

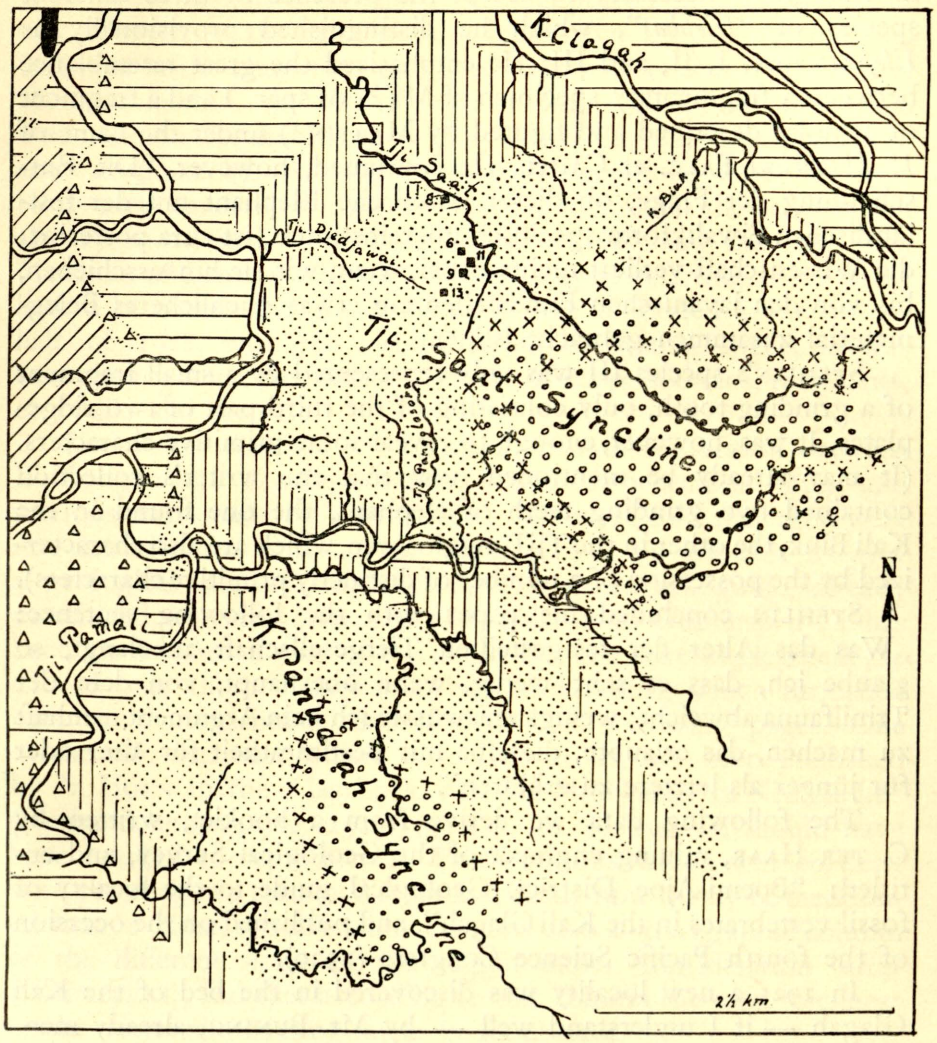
[3]) See for the topographic names map n°. 1.

[4]) Jrg. 4, p. 967.

[5]) Wetensch. Mededeelingen, Dienst v. d. Mijnbouw in Ned.-Indië, n°. 3, 1925.

[6]) I cannot see, therefore, how TER HAAR (1929) came to the assertion that all of STEHLIN's specimens ".....had been collected from the higher strata".

Map n°. 1.



Quaternary.

Upper conglomerate group with tuff beds. } Vertebrate zone.

Lower sandstone-conglomerate group. } Vertebrate zone.

Turritella zone.

Breccia zone.

Limestone-marl zone.

Andesite (pipes and sills).

Excavation.

among the stegodont remains *Stegodon airâwana* MARTIN, and that he thought it necessary to accept the presence of three different species of "*Elephas*", which he distinguished provisionally as *Elephas* spec. I, II, and III. He emphasized the great resemblance between a fragmentary specimen of M^3(?) of spec. I and a fragment of a molar described and figured by MARTIN [1]) under the name of *E. hysudricus* FALC. et CAUTL. He continued, however, "Die Entscheidung der Frage, ob dieser javanische Elephant mit der festländischen Siwalikform specifisch übereinstimmt, ist cura posterior; die Wissenschaft verliert nichts dabei, wenn wir sie hinausschieben, bis von den javanischen Fundstellen ein etwas reichlicheres Belegmaterial zusammen gebracht ist" [2]).

STEHLIN's species III was only represented by a small fragment of a grinding tooth, only consisting of the third part of two ridge-plates. It was, however, enough to reveal some primitive characters. (It may already be mentioned now that the writer's collection contained two grinding teeth of elephant, the one found in the Kali Biuk, the other in the Tji Pangglosoran, which are also characterized by the possession of a number of distinctly primitive characters).

STEHLIN concluded his paper with the following sentence: „Was das Alter der festgestellten Tiergesellschaft anbelangt, so glaube ich, dass es sehr wenig, wenn überhaupt, von dem der Trinilfauna abweicht; wenigstens wüsste ich kein Argument namhaft zu machen, das erlaubte, dieselbe mit Bestimmtheit für älter oder für jünger als letztere zu erklären".

The following data we derive from a booklet, written by C. TER HAAR, mining engineer of the Geological Survey, and entitled: "Boemi-Ajoe District. Geological guide to the locality of fossil vertebrates in the Kali Glagah", and published on the occasion of the fourth Pacific Science Congress (1929).

In 1925 a new locality was discovered in the bed of the Kali Glagah — if I understand well — by Mr. BUNING, already mentioned. As a result of his report a renewed investigation was made by OPPENOORTH, at that time superintendant of the Java party of the Geological Survey. In June 1925 VAN ES [3]), mining engineer of the Geological Survey, had visited the spot, on which occasion he had got the impression that more and better preserved material might be obtainable in excavating the bones. Accordingly OPPENOORTH's investigation had for its object to ascertain whether it

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[1]) Samml. Geol. Reichs-Mus. Leiden, IV, (1887), p. 57, pl. VI, figs. 2—2*a*.

[2]) This quotation has been given, because of the fact that sometimes (ZWIERZYCKI, 1926, p. 229, and 'T HOEN, 1930, p. 29) erroneously is maintained that STEHLIN determined one of his specimens as *E. hysudricus*.

[3]) See L. J. C. VAN ES. The Age of *Pithecanthropus*. The Hague 1931. Dissertation Delft 1931, p. 16.

would be possible to find the bones in situ, and if so, whether excavations would take effect. This appeared indeed to be the case. And it is the specimens, which have been excavated and collected in the years 1925 and 1926, which were sent to the writer for examination. At the same time some geological researches were made in the neighbourhood by the mining engineer TER HAAR and ZWIERZYCKI. All the excavation operations were put to a temporary standstill during the negotiations about the cooperation already mentioned of the Geological Survey and the American Museum of Natural History. When it appeared that these plans had to be abandoned, the operations were continued in the second half of 1928, with the result that an interesting collection was brought together, containing remains of hippopotamus, ruminants, crocodile and tortoise.

The writer received a geological map of the region between Limbangan and Bumiaju, together with two sections. Map and sections were made by ZWIERZYCKI. We were told that they were not intended for publication. Nevertheless, we are able to give a geological map of that region. The geological guide, already mentioned, contains namely a geological map. Our map n°. 1 has been made after a part of the latter. For the sake of clearness the site of only those excavations has been added, which furnished part of the specimens described in the following pages. One of the two sections, which were sent to us, has been published by 'T HOEN in the "Jaarboek van het Mijnwezen in Ned.-Indië" (Verhandelingen), Jrg. 1929, 1930, p. 30, so that we should have been entitled to reproduce it. From reasons which will be dealt with presently, we refrained from it. Already now it may be mentioned that 'T HOEN's publication contains also a stratigraphic column of the different strata of the region under consideration (after ZWIERZYCKI), and that according to this column the total thickness of the vertebrate bearing layers is about 1200 m.

It is easily to see that the section, published by 'T HOEN, is more or less perpendicular to the strike. No mention was made, however, of the exact situation of the section. It will be desirable, therefore, to mention that, according to the unpublished map, received by us, the section is situated in the south-easterly part of both synclines, more particularly going via that place between both synclines, where the lower sandstone-conglomerate group crops out between two strips of the Turritella zone. A superficial comparison between map (TER HAAR) and section (ZWIERZYCKI) will reveal that in the latter respect no perfect accordance exists between the two, the section showing a more simple structure. On the other hand the section shows the presence of a vertical fault

in the southwestern syncline, whereas on the map no fault will be found. VAN ES [1]) remarked that the tectonic structure is not so simple as would appear from the section published. Be that as it may, from the map it will be seen that the following statement holds good.

NNW. of Bumiaju a double syncline occurs with approximately NW.-SE. strike. TER HAAR calls the northeastern syncline: K. Saät Syncline, the southwestern one: K. Panudjah Syncline. At the time of TER HAAR's publication (1929) the exact length of the former (and probably also of the latter) was not known yet. Both synclines are separated by an anticline, in the core of which the clay-marls of the Turritella zone make their appearance. The region is intersected by the Tji Pamali and its tributaries. According to VAN ES (l.c.) the "..... region shows signs of recent upheaval; erosion still has great effect and in the valleys landslips frequently occur".

As to the exact stratigraphy an extensive enumeration has been given in a report of the Geological Survey [2]). In consequence of new determinations by VAN ES and VON KOENIGSWALD, the former was able to make some additions. The list, which follows below, has mainly been composed in combining that of the Geological Survey and that of VAN ES. The mention of *Mastodon perimensis* (one of the provisional determinations of the present writer) has been replaced by *Tetralophodon bumiajuensis*.

Zone	Sediments	Fossils	Appr. thickness in meters
Pliocene. Vertebrate zone.	1. conglomeratic series with sandstone layers.	Scattered remains of vertebrates	250
	2. tuff horizon of grayish white sandstones.		150
	3. sandstone-conglomerate series with argillaceous sandstones, clay and marl, locally with beds of lignite, and mostly bearing lime.	*Tetralophodon bumiajuensis* nov. spec. *Stegodon airâwana* MARTIN. *Hippopotamus* sp. Several species of *Melania* and *Corbicula*, 69 % of which recent species. Some marine molluscs and foraminifera.	200

[1]) L. c. p. 48.

[2]) Jaarb. v. h. Mijnwezen in Ned.-Indië. Algemeen ged., 1930, p. 49.

Zone		Sediments	Fossils	Appr. thickness in meters
Pliocene.	Turritella zone.	blueish-gray and greenish argillaceous marls, subordinate sandy marls. mollusc bed.	Molluscs, 56% of which recent species.	175
	Conglomerate zone.	andesitic sandstones and conglomerates.	In the upper part locally coral reefs.	200–250
Miocene.	Breccia zone.	hard, usually coarse basic andesitic breccia. Intercalations of tuff beds, and –at 300 m. from the base– a horizon of pumice-stone breccia of a thickness of 200 m; locally lava.		1000
	Tuff-sandstone zone.	fine and coarse greenish andesitic sandstones and lime bearing sandstones with intercalations of marl beds. more towards the top the sandstones become more conglomeratic and "breccia-like". a characteristic horizon is formed by a series of light coloured tuff-sandstones and grit with pieces of pumice stone.		?
	Argillaceous marl-limestone zone.	greenish, concretionary Globigerina marls, in the upper part bedded by thin layers of sandstones; more towards the base grayish-green marls with limestones, containing many foraminifera; finally unstratified concretionary argillaceous marls.	*Trybliolepidina rutteni* with several varieties. *Cycloclypeus neglectus*. *Cristellaria* sp. *Operculina* sp. *Operculinella* sp. *Amphistegina* sp. *Gypsina globulus*. *Rotalidae*, *Algae*, and pricks of echinids.	?

Both the author of the report as well as VAN ES agree as to the pliocene age of the series composed by the Vertebrate zone, Turritella zone and Conglomerate zone. I do not know, however, on what grounds the lowest boundary of the Pliocene has been drawn between the Conglomerate zone and the Breccia zone, which are both unfossiliferous. Furthermore, it may be pointed out that in all probability in TER HAAR's map (and therefore also in our map n°. 1) both Conglomerate zone and Turritella zone have been indicated by the same vertical signature. I do not know, however, with which zone the Tuff-sandstone zone has been united.

It will be remembered that in the foregoing part has been stated that according to the original opinion of ZWIERZYCKI the total thickness of the vertebrate bearing layers is about 1200 m. The above list shows that according to more recent opinions, the thickness is but 600 m. As ZWIERZYCKI calculated the thickness from the sections, it is highly probable that the section published by 'T HOEN — and already mentioned in the foregoing pages — does not hold good any more. That is, therefore, the reason why I have refrained from reproducing it.

From the report of the Survey we borrowed what follows.

The Vertebrate zone lies at the K. Glagah conformably on the Turritella zone [1]); an interjacent zone of some tens of meters consists of alternating Turritella layers and vertebrate layers, and begins with conglomeratic, andesitic sandstones, containing lumps of lignite. The latter horizon is better developed (ca. 150 m.) in the Bentarsari basin, and shows there a series of layers of impure lignite, containing 50 % of water, which high percentage should indicate a pliocene age. The lowest vertebrate bearing layers are argillaceous marls and tuffoid sandy marls of andesitic material. In the Turritella zone, thus called on account of the frequence of *Turritella djadjariensis*, 46 species of molluscs (gasteropods and lamellibranchiates) were found, 22 of which, i. e. 48 % are recent. This percentage was, however, not used as an argument for a pliocene age. According to TER HAAR [2]) this fauna has been examined by GERTH, who established the age of the Turritella zone as older Pliocene. In the report stress has been laid upon the fact that the fauna shows resemblance to that of Tjidjurai (Cheribon), examined by MARTIN, and held to be Pliocene by this investigator.

As an argument for the pliocene age of the vertebrate bearing sandstone-conglomerate series the occurrence of *Mastodon peri-*

[1]) According to TER HAAR (1929) this is invariably the case.

[2]) L. c. p. 11.

mensis, *Stegodon airâwana* and *Hippopotamus* sp. [1]) is mentioned. Though in a final chapter we shall return to the age of these beds on the basis of the determination of the mammalian remains, already now it may be pointed out that the cogency of the argument mentioned, cannot be called sufficient. It must not be forgotten that *St. airâwana* is an upper pliocene species according to DUBOIS [2]), a lower pleistocene species according to MARTIN [3]), a middle pleistocene species according to OSBORN [4]), and an upper to youngest pleistocene species according to DIETRICH [5]). As to *Hippopotamus*, it must be borne in mind that according to PILGRIM the youngest horizon in which this genus occurs, is the Boulder Conglomerate zone (uppermost Upper Siwaliks). PILGRIM [6]) regards the Upper Siwaliks as of pliocene age. MATTHEW's [7]) recent investigations on the Siwalik fauna led him, however, to the conclusion that there are no valid reasons for referring the Upper Siwaliks fauna to the Pliocene. Accordingly he reckons the Upper Siwaliks to the lower Pleistocene. Finally it may be mentioned that according to OSBORN [8]) *Mastodon (Anancus) perimensis* is an upper miocene species. I must admit, however, I do not know on what grounds.

VAN ES (l. c.) determined in cooperation with VON KOENIGSWALD, one of the palaeontologists of the Survey, part of a collection of gastropods and lamellibranchiates from the Turritella beds, collected by him and C. A. DE JONGH. The following values were found. Of 34 species determined, 19 or 56 % were still living. In VAN ES's opinion this percentage points decidedly to a pliocene age, which would be confirmed by the fact that 24 species are known to occur in the Miocene, against 33 in the Pliocene. If one compares this percentage of 56 % with the value found by VAN ES and VON KOENIGSWALD for the fauna (76 species) of the Turritella beds of Sangiran (45 %), and with those established by MARTIN [9]) for the rich marine fauna (150 species) of Sonde (53 %), and for the marine fauna (64 species) of Tjidjurai (51 %), one would be

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[1]) The mention of these forms was based on provisional determinations of the writer. It may be repeated that in the writer's present opinion the mastodont of Bumiaju is not identical with *Mastodon (Anancus) perimensis*, but represents a new species *(Tetralophodon bumiajuensis)*.

[2]) Tijdschr. Kon. Ned. Aardr. Gen., ser. 2, XXV, 1908, p. 1257. DUBOIS reckons *St. airâwana* to *St. ganesa, var. javanicus* DUB.

[3]) Unsere palaeozoologische Kenntnis von Java. Leiden 1919, p. 144.

[4]) Proc. Amer. Philos. Soc., LXX, 1931, n°. 2, p. 189.

[5]) Sitz.ber. Ges. Naturf. Fr. Berlin, Jhrg. 1924, 1926, p. 139.

[6]) Rec. Geol. Surv. India, XLIII, 1913, part 4, p. 324.

[7]) Bull. Amer. Mus. Nat. Hist., LVI, 1930, p. 445.

[8]) Proc. Amer. Philos. Soc., LXIV, 1925, p. 27.

[9]) See VAN ES's correlation table.

inclined to believe that the Turritella beds of Bumiaju show the greatest affinity to the Sonde beds. It must not be forgotten, however, that resp. 22 and 21 Bumiaju species were found to occur in Sangiran and Tjidjurai, against but 10 in Sonde. VAN ES, therefore, concluded: "A comparison with Sonde shows a great disparity to exist, but the resemblance to Sangiran and Tjidjurai is very obvious. As Sangiran (.....Lower Pliocene) and Tjidjurai (Middle Pliocene) are different in age, the almost equal affinity to both faunas makes it rather difficult to decide from this point of view to what horizon the Turritella bed of Bumiaju belongs. However, considering the rather high percentage of living species there is more reason to accept a Middle Pliocene age"[1]). In connection with the latter quotation, and with the percentages mentioned above, I should like to point out that the difference between the percentages of Sangiran (45 %) and of Tjidjurai (51 %) is 6 %, and between those of the latter and Bumiaju (56 %) is 5 %. Whilst VAN ES regards the fauna of Sangiran to belong to the Lower Pliocene, he considers the fauna of Bumiaju to be of the same age (Middle Pliocene) as that of Tjidjurai, in spite of a difference of 5 % between Bumiaju and Tjidjurai. Herewith I do not intend to maintain that an equal age of both is to be excluded. It must not be forgotten that the percentage of 56 %, found for the fauna of Bumiaju, is based on but 34 species, whereas in Tjidjurai almost twice as many species have been found.

VAN ES gave also the results of the determination by GERTH of a collection of fresh-water molluscs (*Corbicula*, *Unio*, *Melania*, *Paludina)* from the vertebrate bearing layers of Bumiaju. Of 13 species determined, 9 or 69 % appeared to be still living. From this VAN ES drew the conclusion: "This percentage points to an Upper Pliocene age of the fresh-water beds"[2]). 13 species, however, form too small a number to justify so resolute a conclusion. VAN ES's statement is the more remarkable, because on p. 26 he himself points rightly out that it is ".....necessary to exercise great caution in determining the age of the beds from the ratio of living species when too few Molluscs are present". He even set some examples, one of which is very noteworthy. In Sangiran MARTIN found a percentage of 33 % living species on 21 species; VAN ES was able to determine a ratio of 45 % out of 76 species.

GERTH[3]) advanced another objection against VAN ES's determinations of the age. He remarked namely that VAN ES, in placing

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[1]) L. c. p. 50.

[2]) L. c. p. 52.

[3]) Tijdschr. Kon. Ned. Aardr. Gen., ser. 2, XLIX, n°. 2, 1932, p. 345.

the young tertiary fauna of molluscs with 50—60 % living species [1]) in the Middle Pliocene, started from a supposition, which lacks sufficient ground, as long as we do not know that this percentage is indeed a characteristic of the middle pliocene strata of Java. We may add that MARTIN — without doubt the best connoisseur of the Tertiary of Java — has hitherto refrained from subdividing the Javan Pliocene [2]).

Later on we shall have the opportunity to return to VAN Es's very important paper. For the present we will pay attention for a moment to another argument, mentioned by VAN Es to prove the tertiary age of the vertebrate bearing strata of Bumiaju, viz., their strong folding. The report, already mentioned, of the Geological Survey even speaks of very intense folding. And as — VAN Es remarks — quaternary beds with a steep dip are unknown till now, a tertiary age is most likely. That also this argument has no absolute cogency, may be proved by a quotation, which we borrow from VAN Es himself: "Arguments derived from the dip of the beds are but of relative and local value and are insufficient to serve as a proof for the age of the beds....." [3]).

We shall now proceed with the consideration of the other localities. We may begin to ask ourselves whether detailed stratigraphic and tectonic data of these localities are available. In 1927 the state of affairs was still such that RUTTEN [4]) — after the discussion of the vertebrate bearing layers of Java — had to make the bitter remark, that not only the tectonic structure and the stratigraphy of the Trinil beds was very insufficiently known, but also the startling fact occurred that our knowledge of the geology of the surroundings of Trinil, famous by DUBOIS's discoveries of *Pithecanthropus erectus* and of a very rich fauna of vertebrates, was but very small. And had VAN Es not published the results of his extensive investigations, we should have been compelled to make exactly the same remarks. Just because we had to criticize VAN Es's paper in the foregoing pages, we are the more eager to avail ourselves of the opportunity afforded of throwing light upon the great merits of this work. It is entirely due to VAN Es that at present we dispose of a lot of stratigraphic and tectonic particulars of numerous localities, all embodied in detailed geological maps and sections. Moreover, VAN Es made extensive collections of molluscs from the

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[1]) See the very instructive table given by VAN Es (l. c.).

[2]) See his recent paper: "Wann löste sich das Gebiet des Indischen Archipels von der Tethys?" Leidsche Geol. Meded., IV, 1, 1931.

[3]) L. c. p. 7.

[4]) Voordrachten over de geologie van Ned. Oost-Indië. Groningen 1927.

marine layers, which occur almost everywhere below the vertebrate bearing series. And though GERTH's remark may be true, namely, that only the relative age has been established by the determinations of these fauna by VAN ES (and VON KOENIGSWALD), it must not be forgotten that VAN ES, in publishing so many new data, considerably enriched our knowledge of these marine sediments.

I should like to draw attention to some more merits. On the occasion of the 70th birthday of Professor K. MARTIN a jubilee book was published[1]), which is a sort of reasoned fossil catalogue of the entire East and West Dutch Indies. This work has been brought about by cooparation of a number of Dutch and some foreign investigators. The *Mammalia* have been dealt with by the present writer. The various localities, which I found mentioned in the papers relating to the subject, were united in a small sketch map[2]). If that map be compared with a similar map, occurring in VAN ES's paper, it will be seen that also in this respect VAN ES collected many new data.

Noteworthy furthermore is the way in which VAN ES discussed the problem of the age of the Trinil beds. As will be known, the number of publications, dealing with this problem, is considerable, and the number of opinions is hardly less large. Consequently difficulties are met, if one tries to form a definite opinion from the chaos of assertions and opinions. VAN ES, however, had the original idea to class the arguments, advanced by the various authors, with eleven different headings viz., 1. Orogenic movements, 2. Vulcanism, 3. River terraces, 4. Culture remains, 5. The anatomical features of *Pithecanthropus erectus*, 6. The process of fossilization, 7. Marine molluscs, 8. Fresh-water molluscs, 9. Plant remains, 10. Vertebrates, 11. Climate. In this way an excellent synopsis originated.

After this expatiation, which appeared to us as wholly justified, we return to our starting-point. We shall begin with the localities Watualang, Pitu and Kedung Kendang, all situated near the Solo river[3]). It will be known that the famous localities Trinil and Sonde are also situated on that river.

VAN ES's publication contains a geological map of the Solo river region between Gesi (N. of Sragen) and Ngawi. According

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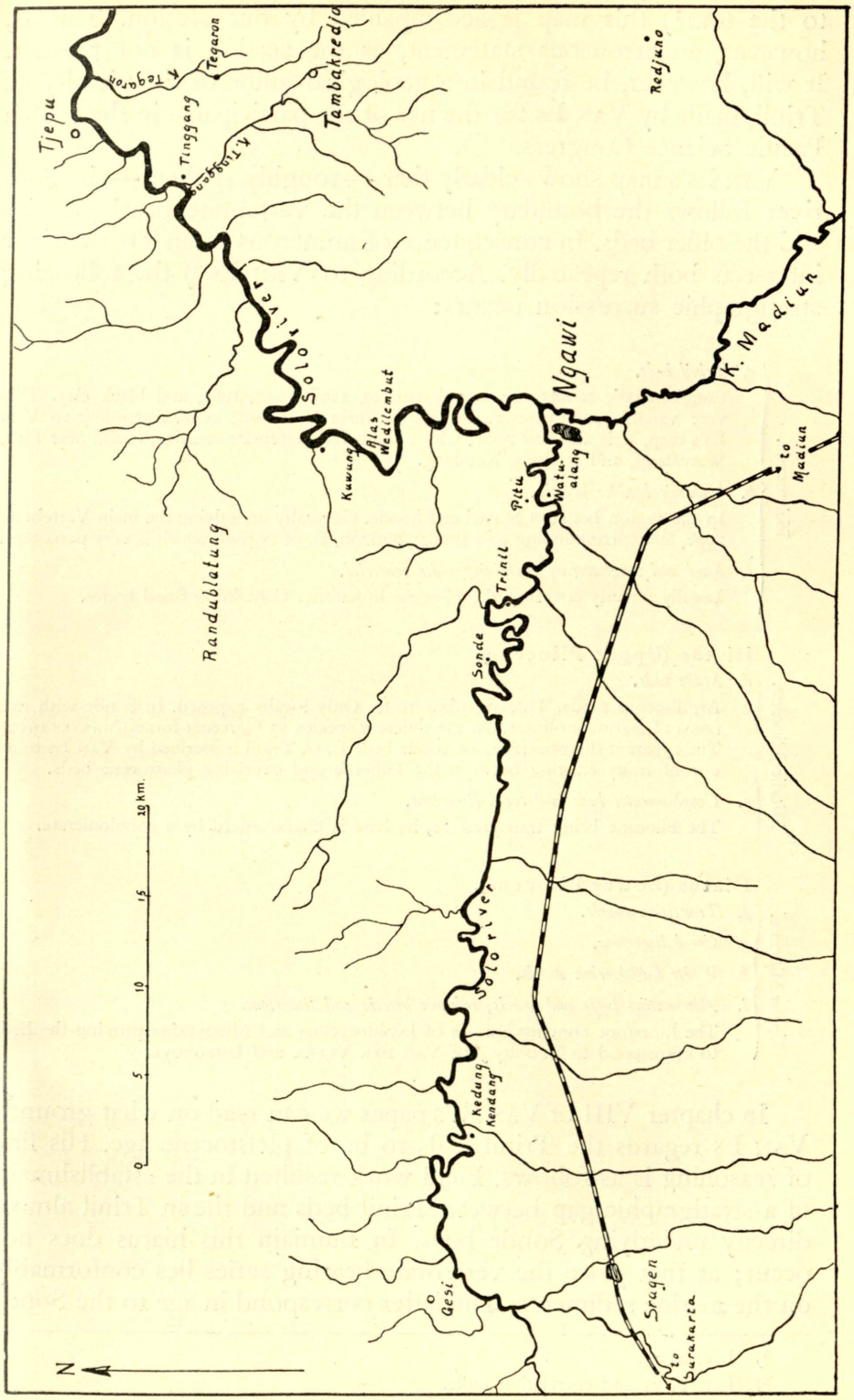
[1]) Leidsche Geol. Meded., V, 1931.

[2]) L. c. p. 471.

[3]) See map n°. 2.

Map n°. 2.


Tjepu
K. Tegaron
Tegaron
Tinggang
K. Tinggang
Tambakredjo
Redjuno
Solo river
Ngawi
K. Madiun
Alas Wedilembut
Kuwung
Randublatung
Pitu
Watu-alang
to Madiun
Trinil
Sonde
Solo river
Kedung Kendang
Gesi
Sragen
to Surakarta
0
5
10
15
20 km.
N

to the text [1]) this map is accompanied by one section. This is, however, an erroneous statement, as the section is not present. It will, however, be found in a geological guide of the vicinity of Trinil, made by VAN ES for the use of the participants in the fourth Pacific Science Congress.

VAN ES's map shows clearly that — roughly spoken — the Solo river follows the boundary between the vertebrate bearing series and the older beds. In consequence of numerous meanders the river intersects both repeatedly. According to VAN ES [2]) the following stratigraphic succession occurs:

Pleistocene.

a. Trinil beds.

Conglomeratic sandstones, conglomerates, sandstones, tuffs, and black clay. This very variable succession represents the main Vertebrate zone. According to VAN ES's map, it is also this zone, which yields the vertebrate remains, found near Pitu, Watualang, and Kedung Kendang.

b. Volcanic boulder breccia.

In the region between Ngawi and Sonde. Generally underlying the main Vertebrate zone, and corresponding to a similar horizon, E. of Ngawi, which is very persistent.

c. Sand and conglomerate containing older material.

Locally directly covering the pliocene limestone. Containing fossil bones.

Hiatus (Upper Pliocene).

Middle Pliocene.

d. Sonde beds.

Argillaceous sands. Thickness but 50 m. Only locally exposed. In Sonde with rich fauna of marine molluscs. On 150 different species 53 % recent forms (MARTIN 1919). The apparent disappearance of Sonde beds E. of Trinil is ascribed by VAN ES to an unconformity existing between the Pliocene and overlying pleistocene beds.

e. Conglomeratic beds and coral limestone.

The Pliocene being transgressive, its base is characterized by a conglomerate.

Hiatus (Lower Pliocene).

Upper Miocene.

f. Transition marls.

g. Coral limestone.

h. White Globigerina marls.

i. Alternating tuffs and marls, volcanic breccia and limestone.

The limestone contains species of Lepidocyclina and Miogypsina proving the beds to correspond to Tertiary *f* of VAN DER VLERK and UMBGROVE.

In chapter VIII of VAN ES's paper we can read on what grounds VAN ES regards the Trinil beds to be of pleistocene age. His line of reasoning is as follows. Field work resulted in the establishment of a stratigraphic gap between Trinil beds and the in Trinil almost directly underlying Sonde beds. In Bumiaju this hiatus does not occur; at that place the vertebrate bearing series lies conformably on the marine sediments. The latter correspond in age to the Sonde

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[1]) L. c. p. 75.

[2]) L. c. p. 75 and correlation table.

beds, each showing a percentage of recent species between 50 and 60 %. (As already mentioned this percentage surely proves the beds to be of pliocene age; their supposed belonging by VAN ES to the Middle Pliocene, however, remaining to be solved). The stratigraphic gap which occurs in Trinil, corresponds to the vertebrate beds of Bumiaju. In Java, therefore, an upper pliocene and a lower pleistocene fauna of vertebrates occur. The vertebrate beds of Bumiaju represent, however, only one facies of the Upper Pliocene. No less than four different facies were found, of which the marine facies, discovered N. of Djombang, is of great importance of course. For sediments of that facies VON KOENIGSWALD found 66 % recent forms on 71 species determined [1]) (Sumberringin layers 2 and 3), while MARTIN established a percentage of 70 % on 50 species determined [2]) (fauna of Kedungwaru).

From the above data VAN ES drew the conclusion that "……if ever a marine fauna of the age of the Trinil beds is discovered in Java, it will show to contain more than 70 % living species of Molluscs" [3]). This high percentage, which is to be expected, would fill the gap between the Upper Pliocene and the post pleistocene beds of Grissee (90 % on 30 species) and Batavia (86 % on 22 species).

A totally different facies of the "Bumiaju beds" is met with in Surakarta (near Sangiran and Baringinan), where freshwater lake-deposits occur. In these beds 16 different forms have been found, 9 of which have been determined hitherto. As only 3 species appeared to be recent, the percentage of living species can never exceed 62½ %, whatever the result of the determination of the remaining forms may be. MARTIN-ICKE and MARTIN determined the fresh-water molluscs, occurring in the Trinil beds: 83 % appeared to be recent species. The Trinil beds therefore are decidedly younger than the fresh-water deposits in Surakarta. Accordingly VAN ES classed the Trinil beds with the Pleistocene. As furthermore the Trinil beds (1) underlie a mighty complex of volcanic sediments (Notopuro beds) in the vicinity of Pandan and (2) occur in the basal part of a complex of at least 500 m. thickness in the Kendeng Hills N. of Djombang, he inferred that they occupy a rather low horizon of the Pleistocene. VAN ES regards the presence of *Mastodon?* sp. [4]), *Stegodon* and *Hippopotamus* as another indication in that direction.

For the present the above will suffice. In our final chapter we shall return to the problem of the age of the Trinil beds.

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[1]) See VAN ES (1931), p. 115.

[2]) See VAN ES (l.c.), p. 117. VAN ES borrows these particulars from a report by MARTIN not yet published. It may be emphasized that MARTIN concludes to a pliocene age.

[3]) L. c. p. 134.

[4]) This form will be dealt with in the sequel.

Before passing on to the consideration of the other localities, it will be desirable to bring forward the following particulars concerning the Trinil beds between Gesi and Ngawi.

According to VAN ES the bones seldom occur as abundantly as in Trinil. The bone beds of a. o. Watualang and Kedung Kendang are mentioned as deposits, that might compete with those of Trinil. VAN ES protests against the opinion of some, that the origin of the bone beds should be a result of the destruction of the existing fauna by volcanic eruptions. He points out that in many cases the bones were found in cross-stratified sandstones, containing rounded pebbles indicating true river deposits. In his opinion the animals died through natural causes; they were swept by flooded rivers to some wirl-pool bend where they sank, or to sandy banks where they finally decomposed. In several cases the bones were already broken and weathered, before they were burried in the sand. Crocodiles often caused accumulation of the bones.

"In other cases the bone-bearing bed consists of black clay, containing fresh-water Molluscs and remains of fishes, crocodiles and turtles [1]). This black clay has been formed in stagnant pools and marshes or even in big lakes. Sometimes nearly complete skeletons of larger Vertebrates occur, owing to the fact that marshes often form the dwelling place of big animals." [2])

That river accumulation, not volcanic activity, was predominant is — according to VAN ES — proved by the fact that the bone beds contain detritus of miocene strata. It is these detrital products which VAN ES holds responsible for the solidification of sandstones and conglomerates.

Then VAN ES discusses the opinion, that the bones should have been washed off from the older beds. Admitting the preponderant influence of erosion, this possibility may not be immediately excluded. Many bones, however, do not show traces of wear. Furthermore, he rightly points out that *Stegodon* tusks and crania with the horn-cores attached, are too brittle in a fossil state to allow of any transport. Moreover, bigger bones and skulls often occur in medium-grained sand, containing only small pebbles, whilst big boulders are absent. Transport of the bones in a fossil state is in such cases highly improbable, as the specific weight increases by the process of fossilization.

As to the tectonic structure of the Trinil beds he mentions that the general dip is 6—10° S., showing the influence of tilting or folding movements. Several transverse faults show, moreover, that the beds did not remain undisturbed.

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[1]) Meant is tortoises.

[2]) L. c. p. 79.

We think it entirely superfluous to occupy ourselves with the geology of the surroundings of Redjuno. From that locality, namely, we are able to mention only one specimen viz., a proboscidean humerus, which did not even allow of determining the genus with sufficient reliability. Those who are interested in the stratigraphy and tectonic structure of the region, I may refer to VAN ES's publication.

As to the localities, which are situated in the districts Randublatung and Tambakredjo, we are forced to be brief, because VAN ES did not make detailed investigations in these regions. On p. 19 VAN ES mentions that he discovered in 1927 an occurrence S. of Randublatung, which appeared to be very rich in vertebrates. As Kuwung is situated SE. of Randublatung, it is highly possible that our specimens from Randublatung have been obtained from that locality. "The beds mainly consist of sandstone and gravel of volcanic origin and overlie the Miocene hills. There is a very pronounced unconformity between the slightly N.-dipping vertebrate beds and the steeply folded Miocene marls."

Still on p. 19 he cursorily deals with the localities in the neighbourhood of Tinggang. In 1926—1927 he collected there a large number of vertebrate remains from gravel beds, mostly containing pebbles of volcanic origin. "Owing to the bad exposures no data were obtainable concerning the relations to the underlying Tertiary beds. In the vertebrate beds in several spots a slight dip to the N. not exceeding 5° was established."

It may be mentioned that it is highly probable that the remains of our collection derived from these localities have been collected by VAN ES, the label of numerous specimens of the second sending bearing the mention: "Collection VAN ES".

We shall now drop the subject of the consideration of the localities, and pass on to a discussion of the few "*Mastodon*" remains which were hitherto found in the Dutch East Indies.

MARTIN [1]) described and figured under the name of *Mastodon* sp. the posterior portion of a grinding tooth, and the distal portion of an incisive tusk. DUBOIS [2]) did not agree with the generic determination. According to this investigator both specimens might rather belong to *Stegodon*. The fragment of the incisor shows a distinct flattening as a result of wear. DUBOIS rightly pointed out that this feature is not an exclusive character of the tusk of mastodonts.

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[1]) Samml. Geol. Reichs-Mus. Leiden, IV, 1888, p. 90, pl. XI, figs. 1—2*a*.

[2]) Nat. Tijdschr. v. Ned.-Ind., LI, 1892, p. 95.

LYDEKKER [1]) recorded from British Borneo a l. M^3 of *Mastodon latidens* CLIFT. [2]) The determination is certainly correct. At present this form is reckoned to the new genus *Stegolophodon* SCHLESINGER (*Prostegodon* MATSUMOTO), which OSBORN reckons to the subfamily of the *Stegodontinae*. But as far as I can see, this is merely a matter of taste.

VAN ES [3]) gave under the name of *Mastodon*? sp. two fine figures of a fragmentary grinding tooth, obtained from Sangiran, and from beds, which he regards to be of lower pleistocene age. In a note on p. 54 he mentions, furthermore, that DUBOIS showed him part of a similar molar, collected from the Kendeng Hills. In the latter's opinion these specimens might represent an atavistical deviation of a *Stegodon* molar. The writer should not like to endorse this statement. Be that as it may, VAN ES's specimen does not in the least resemble the specimens obtained from Bumiaju. As to the latter, these were originally determined as belonging to *Mastodon longirostris* by STEHLIN [4]). As already mentioned, originally the writer identified the form of Bumiaju provisionally with *Mastodon perimensis*.

Some forms of our collection appeared to be specifically identical with still living species (kerabau, banting, Javan rhinoceros and Indian elephant). In this connection I should like to make some remarks.

It is clear that everyone, who has to occupy himself with the examination of a relatively young fauna, will make comparisons with the recent fauna. In doing so, it is of the first importance that not one or some specimens of the recent species be used, but the greatest number possible. STREMME — in determining the greater part of the mammalian remains of the Trinil collection of Mrs. SELENKA — neglected this requirement, and it played tricks on him. As a matter of fact the German museums of Natural History will not contain so great a number of Dutch East Indian specimens as the Dutch museums do. I have not got the impression, however, that STREMME troubled himself sufficiently. Moreover, he apparently did not feel fully the seriousness of the requirement mentioned. Otherwise he would not have ventured to draw such resolute inferences by the help of so small a material for comparison.

As mentioned, the writer was in a far better position. And he has made an eager use of the opportunity afforded. Not because measuring skulls and composing tables of measurements is a plea-

[1]) Proc. Zool. Soc. London, 1885, p. 777, pl. XLVIII, figs. 1—2.

[2]) VON KOENIGSWALD (De Mijningenieur, n°. 11, 1931) pointed out that this specimen has possibly been imported from China!

[3]) L. c. p. 66.

[4]) See De Mijningenieur Jrg. 7, 1926, p. 230. As far as my knowledge goes STEHLIN only received photographs.

sant occupation! On the contrary. This declares in my opinion why in this respect a lot of work remains to be done. The necessity to have the disposition of tables, which show in numbers the individual variation of the cranium of recent species, may appear from the fact that FRANZ TOULA's [1]) tables of cranial measurements of *Dicerorhinus sumatrensis* are repeatedly consulted, in spite of the fact that they contain several miscalculations.

Incidently it may be pointed out that in studying the measurements of the crania of recent forms of *Hippopotamus* we arrived at an unexpected result. *Hippopotamus constrictus* MILLER, namely, appeared to have no right to specific distinction, being identical with *H. amphibius*. One more proof of the correctness of the assertion above mentioned.

As to the measuring of the skulls and the making of the tables of measurements the greatest possible accuracy has been practised. Repeatedly it has occurred that measurements, which distinguished themselves either by a very high or low value, have again been taken. The percent numbers in general have been obtained by the help of an electric calculating machine. All the percent numbers have twice been checked. Nevertheless I do not imagine my tables to be without errors. This is practically an impossibility with a material of several thousands of numbers. Also I fully realise that the material measured, does not suffice to serve as a base for far-reaching conclusions. It will be known that some anthropologists are not wholly satisfied before they dispose of the measurements of some 2000 crania.

Finally some detached remarks.

Of course it has been tried to obtain from Prof. DUBOIS the permission of comparing our specimens with those of his famous collection. Prof. DUBOIS wrote us, however, that he regretted much that he was forced to refuse our request, because his collection was not in a state for demonstration in consequence of its repeated removals.

Most specimens described are strongly fossilized. This especially concerns the specimens from Bumiaju. As to the degree of fossilization of the remaining, some require special mention. The three crania of *Bibos sondaicus fossilis*, and some specimens of *Buffelus bubalus* ?var. *sondaicus fossilis* are but little fossilized. Accordingly it was necessary to harden them. Contrary to the remaining specimens, the specific weight of the specimens mentioned is low. Also they do not show the gray colour of the specimens from Bumiaju, but have a brown appearance. One specimen of our collection is extremely little fossilized. It is the posterior portion of a cranium of *Hippopotamus* sp., and shows a remarkable recent appearance.

[1]) Abh. K.—K. Geol. Reichsanst. Wien, XIX, H. 1, 1902.

It appeared that the photographs of the proboscidean grinding teeth in general considerably gained in clearness, if the dentine material of the teeth was blackened previously. It will be seen that most specimens have been treated in that way.

Last not least the following remark. The present paper is the work of a beginner. The writer has sufficiently realized that palaeontological science will profit more by very accurate descriptions than by phylogenetical speculations of beginners. Consequently very much attention is given to the former. Especially in describing the proboscidean grinding teeth, the writer started from the supposition that it is better to give too much than too little.

I cannot conclude without expressing my sincere thanks to:

Mr. A. C. DE JONG, mining engineer, Intendant of the Geological Survey (Opsporingsdienst) of the Dutch East Indies, to whose intermediary I owe that this fine collection was sent to me for examination.

Prof. Dr. L. M. R. RUTTEN, who had the supervision of this work, and who, though not being a vertebrate palaeontologist, saved me by his clear criticism from faulty reasoning.

Prof. Dr. H. F. NIERSTRASZ, Director of the Zoological Institute of Utrecht, to whose warm recommendation I owe for a good deal that the Geological Survey entrusted me with the determination, for his unremitting attention in my work and for permitting me to measure some fine crania, contained in his Institute.

Prof. Dr. MAX WEBER for several important informations, and for his kindly lending me many separates of his collection.

Prof. Dr. EUG. DUBOIS, for his valuable informations.

Prof. Dr. E. D. VAN OORT, director of the National Museum of Natural History in Leiden for access to his museum, and the permission to measure and photograph specimens under his charge.

Dr. A. L. J. SUNIER, Director of Natura Artis Magistra at Amsterdam, for the opportunity of measuring and photographing the specimens contained in the various museums under his charge.

Prof. Dr. L. A. DE BEAUFORT, Director of the Zoological Institute of the University of Amsterdam and

Dr. H. ENGEL of the same Institute for their willingness to help, showed to me.

Mr. P. TH. N. MOESVELD for revision of the text.

Finally I am greatly indebted to my wife for her real and moral support.

Fam. BOVIDAE.

Subfam. BOVINAE.

Buffelus bubalus (L.) **?var. sondaicus** (SCHL. et MÜLL.) **fossilis.**

Pl. I, figs. 1—4.

Text fig. 1.

Localities: Sentang Kedung Klampo, Bondol near Kuwung, Tegal Sambiduwur, Tegaron, Pitu, Watualang, Kedung Kendang.

Buffalo remains are represented in our collection by eleven fragmentary crania, and two detached horn-cores. They have been obtained from seven different localities.

Number	Locality	District	Regency	Residency
1	Sentang Kedung Klampo	Randublatung	Blora	Rembang
2, 5, 8	Bondol			
3, 6	Tegal Sambiduwur			
11, 12, 13	Tegaron	Tambakredjo	Bodjonegoro	Bodjonegoro.
9	Pitu	Ngawi	Ngawi	Madiun
4, 10	Watualang			
7	Kedung Kendang	Sragen	Sragen	Surakarta

The numbers of the specimens refer to those of table B of cranial measurements.

Unfortunately all the specimens of crania (nos. 1—11) are very incomplete; some only consist of the fronto-parietal region with a short portion of one or both horn-cores. Most are broken off, either in front of the orbit or immediately behind it. In this respect two specimens are somewhat better preserved, the one (no. 2) showing the hinder half of the nasals, the other (no. 3) still having the posterior portion of the left maxillary with some molar teeth. One specimen (no. 2) possesses a zygomatic arch. In only one specimen (no. 3) the orbit is tolerably well preserved. Two crania (nos. 10 and 11) are in too bad a condition to allow of measuring.

All the specimens show a smaller or greater portion of one or both horn-cores. Two crania, one of which is figured in figs. 3 and 4 of pl. I, are in this respect the best preserved, one having

the nearly complete right horn-core, the other being in the possession of both horn-cores. But even of these a smaller or greater portion of the tip is wanting. Nevertheless, the specimens represented fortunately enable us to state the curvature and course of the horn-core of this fossil buffalo, to determine the relation of the complete core to the fronto-occipital region of the cranium, and to realize the enormous span of the horn-cores.

As far as can be gathered from these fragmentary crania they all seem to have belonged to adult individuals of the same species. I think, therefore, it will be best to give a summarized description of all the specimens.

Before commencing with the descriptive part it will be desirable to lay stress upon the fact that — in describing the crania in question — these were supposed to be placed on the anterior premolar teeth and the paroccipital processes.

The occipital surface is in a splendid state of preservation in specimen n°. 1, two views of which are given in figs. 1 and 2 of pl. I. The occipital surface is divided by the occipital crest into two semi-distinct portions, a smooth supra-cristal portion, and a rough infra-cristal portion (i. e. the true occiput) for muscular attachments. The occipital crest is a wide arch, the summit of which is mostly flattened. This crest is sometimes so prominent that it makes the impression as if the upper half of the true occipital surface has sunk into the strong frame of the crest. Above this crest the temporal fossae, which terminate in blunt, round extremities, cut into the occipital surface. The degree of constriction of the occiput will be dealt with below. In specimens 1 and 7 the course of the posterior part of the temporal fossa is the same as in the cranium of the kerabau. In specimens 2, 3, 5, 6 and 8, however, a peculiarity occurs. In these specimens, namely, the posterior parts of the temporal fossae first converge normally backwards; near the occiput, however, they change their direction, strongly diverging backwardly. To this peculiarity we shall have to return later on. The true occipital surface is much more broad than high, the interval between the upper margin of the for. magnum and occipital crest being more than three times contained in the greatest breadth of the occiput. The supra-cristal portion joins the frontals by a gentle curve. There is not the slightest trace of an intercornual ridge, with the only exception of one specimen in which the transition of forehead into occiput is not wholly gradual, but more or less angular. The absence of an intercornual ridge made it impossible to measure with tolerable reliability the height of the occipital surface (see also note 2 on p. 38). Though, therefore, the exact height of the supra-cristal portion cannot be given in mm., never-

theless it is not difficult to state that the interval between occipital crest and for. magnum is nearly equal to the interval between occipital crest and the middle of the curve formed by the gradual transition of forehead to supra-cristal portion of occiput. From the middle of the occipital crest straight downwards runs the vertical crest, affording attachment to the ligamentum nuchae between the occipital muscles. In some specimens this crest is ill-defined, in others very distinctly marked. The occipital condyles are obliquely placed; the for. magnum is subcircular. Its upper border, complete but in few specimens, is either convex or has the form of a flat reversed V. The paroccipital processes are thick, short, with blunt extremities. They are curved backwards and inwards.

The basi-occipital has a relatively great width and its posterior tuberosities are very well developed. The position of the post. nares and of the various foramina on the inferior aspect of the cranium does not differ from those of the living kerabau.

If we now continue to view the upper aspect of the cranium we notice that the frontals are nearly flat or slightly convex across, and also slightly convex from front backwards. Immediately in front of the base of the horn-cores the forehead is contracted, but not much, which is mainly caused by the fact that a strong ridge runs from the middle of the posterior border of the orbit to the antero-inferior angle of the horn-core. The upper border of the orbit is — at least in the few specimens in which the orbit is preserved — considerably oblique to the longitudinal axis of the cranium. The orbit seems to be subcircular; in the only specimen, however, in which the orbit is rather completely preserved, it is to a great extent restored with plaster, so that its proper form cannot be clearly seen. The orbits are closely approximated to the cores.

The supraorbital foramina are in general ill-preserved and often covered and filled with matrix, which could not be removed. There is, however, one specimen (nº. 4), in which the left supraorbital sulcus and foramen are finely preserved. As, moreover, the specimen in question is in the possession of the posterior extremity of the nasals, and of a part of the upper border of the orbit, we are able to give from this specimen the following particulars.

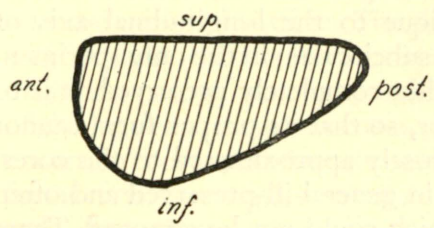
The supraorbital foramen is large and situated at the height of the posterior border of the orbit. The foramen itself is directed obliquely backwards and slightly downwards, the posterior border overhanging it. The supraorbital sulcus leads immediately into the foramen. Its posterior portion is deep and distinctly marked. More frontwards, however, the sulcus gradually dies out, so that its total length cannot be given. In the specimen under consider-

ation the sulcus is separated from the orbit by a broad, but salient ridge. In the remaining specimens this ridge is either absent or much less clearly marked.

From the imperfection of the anterior portion of the face it is impossible to determine the relations of praemaxillaries and the anterior half of nasals and maxillaries mutually, and to the posterior portion of the face. Only can be stated that the nasals are clearly convex across between the supraorbital sulci, and nearly straight longitudinally. In profile view of the cranium the nasals are situated in the elongation of the anterior half of the frontals. In front of the orbits the contraction of the face is considerable.

Now we have still to consider the horn-cores. These are triangular in cross-section. As the upper surface is continuous with the plane of the frontals, and — as has been noticed above — the latter are continued in the supracristal portion of the occipital surface by a gentle curve, it will be clear that the posterior angle of the horn-core is somewhat in advance of the true occipital surface, and still more in advance of the prominent higher part of the occipital crest. The boundary to which the base of the horn extended is clearly marked on the inferior and anterior aspect of the core by a rather sudden decreasing of height and width.

If further on will be spoken of the "horn-core" this will always mean that part of the core that formerly was covered by the horn-sheath. As has been already mentioned the horn-core is triangular in cross-section. The cross-section of the base of the core has a form represented in text fig. 1. The superior surface is flat; in some instances even slightly concave. The angle between superior and anterior surface is remarkably sharp; that between superior and inferior surface much more rounded, and blunted. Anterior and inferior border merge very gradually into one another by a gentle curve.



Text fig. 1. *Buffelus bubalus?* var. *sondaicus fossilis*. Cross-section of left horn-core near base.

The antero-posterior diameter always exceeds the infero-superior diameter throughout the whole length of the core.

From base to tips it becomes gradually more difficult to distinguish anterior- and inferior border. Some two or three dm. from the tip the core shows in cross-section — roughly spoken — the form of an ellips, the upper border of which, however, is far less convex than the lower border, and the posterior angle much more accuminated than the anterior angle.

The cores, which are of very large size and thickness, are set obliquely to the longitudinal axis of the cranium, and are considerably curved backwards in one regular curve.

In the posterior aspect of the cranium they slope slightly downwards from base to tip.

* * *

Both from the description and the figures it will have appeared that the fossil form under consideration must belong to the genus *Buffelus* in its narrowest sense. Now there are only known the following Asiatic forms of *Buffelus* s. str. [1])

Buffelus platyceros (LYD.) [syn. *Buffelus sivalensis* (RÜTIM.)].

Buffelus bubalus (L.) var. *palaeindicus* (FALCONER).

Buffelus palaeokerabau (DUBOIS).

Buffelus bubalus (L.) (Living arni and kerabau).

Buffelus platyceros (LYD.).

Bubalus platyceros, R. Lydekker, Rec. Geol. Survey India, X, 1877, p. 31; Mem. Geol. Survey India, ser. X, I, 1878, p. 127, pl. XVIII; 1880, p. 173; L. Rütimeyer, Abh. schweiz. pal. Ges., V, 1878, Nachträge, p. 186.
Bubalus sivalensis, L. Rütimeyer, Abh. schweiz. pal. Ges., V, 1878, p. 138.
Bos platyceros, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 116.

This species was founded by LYDEKKER in 1877 on the evidence of one fragmentary cranium from the Siwaliks; in 1878 he published an elaborate description of the type specimen, illustrated by drawings of frontal and occipital aspect, and of a cross-section of the horn-core [2]). Mention was, furthermore, made of a detached horn-core, and of a cast of a cranium of the species, also from the Siwaliks, the original of which LYDEKKER presumed to be in the British Museum. This indeed was true, being the fragmentary specimen on which RÜTIMEYER (1878) founded his *Buffelus sivalensis*. The second part of RÜTIMEYER's memoir "Die Rinder der Tertiär Epoche, etc.", 1878, in which part the cranium of *Buffelus sivalensis* RÜTIM. was described [3]), was published after LYDEKKER's memoir

[1]) We may neglect the two fossil Chinese buffalo species which KOKEN (Palaeont. Abh. III, H. 2, 1885, p. 67, Taf. II, figs. 14 and 20; p. 68, Taf. II, figs. 15 and 21) recognized among the detached teeth of bovines in his collection, but which he left specifically undetermined. MATSUMOTO (Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, 2nd ser., [Geology], III, 1915-'18) referred the detached teeth and lower jaws of bovines of his collection from Sze-chuan (China) also to two different species. The one, *Buffelus* sp. a, (p. 19, pl. IX, figs. 4 and 5) was considered as possibly identical with *Buffelus palaeindicus* (FALCONER); the other *Buffelus* sp. b, (p. 20, pl. VIII, figs. 1-5) as perhaps identical with that species of KOKEN, which the latter described on p. 67. Also of these forms the above mentioned may suffice.

[2]) A partly restored view of the type specimen was given by LYDEKKER in 1898.

[3]) See figure in the first part (1877).

on the bovinian remains, contained in the collection of the Indian Museum, Calcutta. RÜTIMEYER could, therefore, append to his study a review of LYDEKKER's results in which he stated among others that *Buffelus platyceros* (LYD.) and *Buffelus sivalensis* were without any doubt identical. Since LYDEKKER's figure and full description were previous to those of RÜTIMEYER, the name *Buffelus platyceros* had the right of priority.

Though there are certainly affinities between *Buffelus platyceros* and our fossil form, the former is readily distinguished by the distinctly oblique position of the horn-cores on the forehead; by the rapid tapering of the horn-cores; by the form of the cores, being "perfectly triangular in section" [1]), with the posterior angle "remarkably sharp" [2]), and by the direction of the cores, being upwards, outwards, and then somewhat inwards.

Buffelus bubalus (L.) var. palaeindicus (FALC.).

Bos palaeindicus, H. Falconer, Catal. of Fossil Vertebr. of Asiatic Soc. of Bengal, 1859, p. 230; Pal. Mem. I, 1868, p. 284, pl. XXII, figs. 1—3.
Bubalus palaeindicus, L. Rütimeyer, Versuch einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 31; Abh. schweiz. pal. Ges. V, 1878, p. 141; R. Lydekker, Mem. Geol. Surv. India, ser. X, I, 1878, p. 132.
Bos bubalis palaeindicus, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 127.
Bubalus buffelus Blum. var. palaeindicus, R. Lydekker, Cat. Foss. Mamm. in the Br. Mus. II, 1885, p. 28.

Under the name of *Bos palaeindicus* this form was founded by FALCONER (1859) on some crania. A complete description, however, was not given, but only short notices. A frontal view [3]) of an extraordinarily well-preserved cranium together with a side view of an imperfect specimen will be found in pl. XXII of the first part of the "Palaeontological Memoirs", which figure has been copied from one of the unpublished plates of the "F. A. S.", where — as LYDEKKER (1878) states — other imperfect crania have also been figured. In 1868 RÜTIMEYER gave a description of a cast of a cranium of the present form, which he had seen in various museums. A figure could not be given. RÜTIMEYER considered the form as closely allied to the living arni, only distinguished by ". . . . mächtigere, weniger nach abwärts und rückwärts gerichtete Hörner und breitere und flachere Stirn . . . ." [4]).

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[1]) LYDEKKER 1898, p. 117.

[2]) LYDEKKER 1878, p. 129. See also RÜTIMEYER 1878, p. 140.

[3]) Concerning this figure RÜTIMEYER (1878, note on p. 142) observed:
„Die schöne Abbildung....., combinirt aus mehreren derselben Species — keineswegs, wie MURCHISON angibt — demselben Individuum angehörigen Fragmenten, ist, obschon nach einem Entwurf von FALCONER's Hand, doch dem Arni zu ähnlich gehalten. Der Schädel von *Bubalus palaeindicus* ist in beiden Geschlechtern nach hinten breiter."

[4]) p. 32.

In 1878 our knowledge of this form was considerably enriched by publications both of LYDEKKER and RÜTIMEYER. LYDEKKER fully described and figured a cranium (frontal and occipital aspect) from the Narbada valley, while mention was made and dimensions were given of some other specimens, two of which had been found in the topmost clay beds of the Siwaliks near Bubhor (Punjab). Besides this locality LYDEKKER mentioned the following localities, from which remains of this fossil buffalo were obtained: greater portion of the central Narbada Valley, Jamna Valley, Godavari and Perim-Ganga Valleys, and Madras (?) [1].

RÜTIMEYER (1878) discussed four crania in the British Museum, all obtained from the Narbada Valley. Again he laid stress upon the very close relationship between the fossil form and the living arni, and doubted whether the fossil form had a sufficient right to specific distinction. He maintained, however, FALCONER's name " . . . . um einmal der palaeontologischen Sitte zu folgen, und zweitens eine weitere Verständigung über die fossile Form des Arni nicht durch Auslöschen eines Namens zu erschweren" [2]. In his review of LYDEKKER's work he is wholly convinced of the specific identity of LYDEKKER's specimens with those in the British Museum.

Contrary to RÜTIMEYER, LYDEKKER (1878) considered the differences between the fossil Indian form and the living arni important enough to distinguish between the two, so that FALCONER's name was maintained unchanged. In 1885 LYDEKKER had partly revised his opinion stating that the fossil Indian form cannot be but regarded as more than a large variety of the living buffalo (*Buffelus bubalus* L.). In his book "Wild oxen, sheep and goats of all lands", 1898, he stuck to his opinion, while the Punjab specimen was regarded as probably belonging to the same race. In that work we can also find the following summary of the characters: "Very close to the typical race, but of larger dimensions, with a more convex forehead, and the horns apparently always directed to a great extent outwardly. In the horn-cores themselves the transverse section is also somewhat different, tending to become quadrangular, instead of being strictly triangular." [3]

We shall return to this species further on. Already now, however, I may call attention to the fact that the specimen which RÜTIMEYER mentioned in 1868 was said to be distinguished from the arni a. o. by a "breitere und flachere Stirn", whereas LYDEKKER (1898)

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[1] In 1898 LYDEKKER mentioned as localities, outside the Siwalik Hills: Narbada-, Godavari- and Pem Ganga Valley.

[2] p. 141.

[3] p. 127.

mentions as one of the distinguishing characters the "more convex forehead" of the present variety. This proves — in my opinion — that both forms of forehead may occur in the fossil race, which in no wise surprises me as I could state exactly the same in about thirty crania of the recent Javanese kerabau.

Buffelus palaeokerabau (Dubois).

Bubalus buffelus, E. Dubois, Nat. Tijdschr. Ned. Indië, LI, 1892, p. 94.
Bubalus palaeokerabau, E. Dubois, Tijdschr. Kon. Nederl. Aardr. Gen., ser. 2, XXV, 1908, p. 1263.
non: Buffelus palaeokerabau, H. Stremme, Pithecanthropus-Schichten, 1911, p. 124, pl. XVIII, figs. 5—6; pl. XIX, fig. 8; pl. XX, figs. 7—9, 12—14.

This fossil Javanese form was originally considered by Dubois (1892) as identical with *Buffelus palaeindicus*, which form he regarded as the ancestor of the kerabau and specifically identical with the latter. In 1908 he had changed his opinion as may appear from the following quotation: "Den Buffel des Kendeng hielt ich früher für *Bubalus palaeindicus*. Der fossilen javanischen Art kommt aber weder die längliche Form des Schädels der Narbadá-Art, noch die fast gerade Streckung und quere Richtung und der nahezu vierkantige Querschnitt von deren Hornzapfen zu. Die Schädelform ist kurz wie diejenige der lebenden javanischen Art, und an den Hornzapfen ist die frontale Fläche eben, mit scharfen Unten- und scharfen Obenrand, während ihre orbitale und ihre temporale Fläche abgerundet sind; und indem sie auch durch eine sehr stumpfe Kante sich von einander abgrenzen, kann der Durchschnitt des Hornzapfes von dreieckig fast halbkreisförmig werden. In der Form des Hornzapfes nähert der Kendengbuffel sich etwas dem siwalischen *B. platyceros* und unterscheidet sich von der lebenden Kerabauart, übrigens sind die Schädel der beiden javanischen Arten einander sehr ähnlich; die lebende stammt wahrscheinlich von der fossilen Art ab, wie der Name *Bubalus palaeokerabau* n. sp. andeuten soll." [1])

In what precedes all has been quoted that Dubois hitherto has written about this new species. Figures have not been given.

The collection of the Trinil-expedition of Mrs. Selenka contained buffalo remains, which have been described by Stremme. Three crania have been found, one of which but relatively little damaged. Especially of this cranium Stremme gave a detailed description, together with measurements and figures. Stremme too arrived at the conclusion that the relationship between the fossil Javanese form of the German Trinil collection and the recent kerabau is a very close one. He noticed, however, some differences

[1]) p. 1263.

by which the fossil form seemed to be distinguished viz., ". . . durch einen längeren Gesichtsteil im Verhältnis zum Hirnteil, durch eine stärker ansteigende Stirn; durch deren Crista und Furchen, ... durch schmalere Prämaxillen . . . ." [1]). Besides, he did not see hitherto a specimen of kerabau of the same size. He did, however, not exclude the possibility that more ample materials of the recent kerabau, than he had at his disposal, should reveal that these differences in reality did not exist.

STREMME united in a table the cranial measurements of his fossil form, of the kerabau, arni, "*Buffelus palaeindicus*" and *Buffelus platyceros*; he calculated, moreover, a number of relations, and drew some more inferences from them. At last he arrived at the conclusion that his fossil form belonged without doubt to DUBOIS's *B. palaeokerabau.*

As a matter of fact, in determining the fossil form of our collection, we shall still have to pay constant attention to STREMME's work. I should like, however, to observe already now that it will have appeared from what precedes that DUBOIS mentioned only one difference between *Buffelus palaeokerabau* and the living kerabau viz., a different form of the horn-core in cross-section. STREMME enumerated also a number of differences between the fossil form and the kerabau. He did not notice, however, any difference in form of the horn-core in cross-section. And nevertheless he considered his form as belonging *without doubt* to *Buffelus palaeokerabau.* In my opinion the possibility that DUBOIS's and STREMME's form of buffalo are identical is great, both authors emphasizing the very close relationship to the kerabau. On the other hand, however, STREMME's argumentation cannot be regarded as sufficient to make the identity probable enough. To *prove it*, will be, of course, an impossibility in consequence of the absence of any figure of DUBOIS's specimens.

Buffelus bubalus (L.)

Bos bubalis, Linnaeus, Syst. Nat., ed. 12, I, 1766, p. 99.
Bubalus sondaicus, L. Rütimeyer, Vers. einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 38, text fig. 4.
Bubalus indicus var. sondaica, L. Rütimeyer, Vers. einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 173.
Bos bubalus var. sondaica, Schlegel and S. Müller, Verh. over de nat. gesch. der Nederl. Overzeesche Bezittingen etc., Zoologie, 1839—1844, p. 205—208, pl. XL and XLI.
For more extensive synonymy see: R. Lydekker, Wild oxen, sheep and goats, 1898, p. 118.

Of this wide spread recent species there are two races, which deserve our interest viz., the wild buffalo of India, the arni, and the buffalo of the Malayan Islands, the kerabau. Of the form first

[1]) p. 125.

mentioned an extraordinary fine cranium of an adult individual is contained in the National Museum of Natural History at Leyden. Its measurements will be found in table B of cranial measurements, together with those of two more crania of the arni, borrowed from LYDEKKER (1878) and STREMME (1911). The Leyden Museum is, furthermore, in the possession of a buffalo cranium, labelled "*Bos bubalus, Arni*", while in the collection of "Natura Artis Magistra" at Amsterdam two skulls are preserved, which also are regarded as specimens of the arni. These three crania, however, are deviating in many points from the skull of the arni, so that I strongly doubt the correctness of the determination. That is also the reason why the measurements of these specimens have not been given. Above we observed that both DUBOIS and STREMME arrived at the conclusion that in Java a fossil form of buffalo occurred, closely related to the kerabau. As this race, therefore, is of the uttermost importance, it will be dealt with extensively in the sequel.

Often the kerabau will be found named as "*Buffelus* (*Bubalus*) *sondaicus* RÜTIMEYER". And indeed, RÜTIMEYER (1868, p. 38) figured[1]) an occipital aspect of the cranium of a male kerabau with the subscription "*Bubalus sondaicus*". On p. 173, however, we can read in the explanation of plates and text figures that fig. 4 in the text represents "*Bubalus indicus*, var. *sondaica*". And it was SCHLEGEL and MÜLLER (1839—1844, p. 205), who for the first time distinguished the present form as a variety (var. *sondaica*) of *Buffelus bubalus* (syn. *Bos bubalus*, *Bubalus indicus*). From RÜTIMEYER's text it appears that he wholly agreed with MÜLLER and SCHLEGEL. Those who are sufficiently acquainted with the studies of RÜTIMEYER on the *Bovidae*, will have noticed that this author, who knew this family as nobody else did, drew the limits of the "species" very widely. In my opinion, therefore, the subscription of text fig. 4 must be considered as an error, and the kerabau must be called *Buffelus bubalus* (L.) var. *sondaicus* (SCHLEGEL et MÜLLER).

It will be known that the kerabau occurs in abundance as a domesticated animal in the Malayan Islands. It is, furthermore, a fact that here and there, e. g. in the uttermost SE. and SW. of Java[2]), the kerabau is met with in a wild state. Whether, however, they reverted to this state from domesticity or whether they are indigenous inhabitants of the island is a moot point. The first supposition is generally accepted, but it has certainly not been proved. STREMME (1911) stated as his opinion that the occurrence of the fossil *B. palaeokerabau* in Java made it probable that the

[1]) Text fig. 4.

[2]) See: J. MERKENS, Bijdrage tot de kennis van den karbouw en de karbouwenteelt in Nederlandsch Oost-Indië. Dissert. Utrecht, 1927.

kerabau — as CUVIER already believed — belonged to the original fauna of the island. MERKENS (1927) too, doubted — on historical grounds — the original domesticity of *all* wild specimens of kerabau.

STREMME, in determining his fossil form as *B. palaeokerabau*, had for direct comparison at his disposal but one cranium of kerabau. In this respect the present writer was in a far better position, the musea of "Natura Artis Magistra" containing not less than twenty six crania, and the National Museum of Nat. Hist. six specimens.

The being in use of M^3 was taken as a criterium of adultness. That I was right in doing so, is proved by what follows. MERKENS (1927), on p. 106 mentions that the fourth pair of permanent teeth, that is to say the lower canini, protrude, when the animal is 5½ to 6 years old. My friend Mr. P. VAN RIJN, veterinary surgeon, was so kind as to make an investigation of the relationship between the protruding of the C and the entering in use of the permanent upper molars. In one of the musea of "Natura Artis Magistra" he found a cranium with the undoubtedly corresponding lower jaw. In this specimen the C was already in use, whereas the M^3 was still untouched by wear. This single example would, of course, not afford great evidence, were it not that the length of the horn cores proved in a convincing manner the adultness of all the specimens, of which measurements are given in table B. From this table appears, first, that the shortest horn-core, which was measured, has a length of 273 mm. and secondly that in those specimens in which the horns were still present, and in which they could be removed, the difference in length between horn and horn-core is very considerable. From MERKENS (1927) we derive, furthermore, the following data. At the age of one year the length of the horn is about 50 mm., in the second year 100 mm., in the third 150 mm. As will be seen from table B, the length of the horn of the specimen with the shortest horn-core is 460 mm. Even if the rapidity of the growth of the horns should increase after the third year of the animal — which appears to me as not very probable — we may be sure that a length of the horn of 460 mm. will not be reached before the seventh year. And — as we have seen above — the kerabau reaches the adult state in his sixth year.

Of the thirty-two crania two specimens had to be excluded as being not fully grown. Two specimens, furthermore, showed such strong deviations from the normal type, that I esteemed it advisable to exclude these specimens too. There remained, therefore, the measurements of twenty-eight specimens, to which have been added the measurements of three more crania viz., those of one specimen, given by STREMME, and those of two frontlets of enormous

size, contained in the Buitenzorg Museum [1]). Of course it would have been better, if we had been able to compare our fossil form with crania of the *wild* kerabau. But even in the Dutch East Indies it will be very difficult to obtain a sufficient number of crania of the wild kerabau. We may be sure, therefore, that most, if not all the crania, which have been measured by the writer, belonged to domesticated animals.

Fortunately for us, however, the kerabau does not interbreed with the Indian or European cattle [2]), which excludes the possibility of crania of hybrids being among the specimens measured. Castration of the males, however, occurs on a rather large scale [3]), so that we may be sure, that among the twenty-eight specimens — besides males and females — a number of oxen will be represented. Three specimens from Leyden are, according to the label, males. But in the first place it is in general desirable to accept such data of museum specimens with some degree of reserve, and in the second place these specimens may represent bulls as well as oxen.

Originally it was thought that our table should considerably gain in value, if we should be able to exclude the oxen, and if we could distinguish between the crania of cows and bulls. MERKENS (1927) tried to detect cranial differences between cows, bulls and oxen. For that purpose he took twenty-one measurements of four adult specimens of each; expressed each measurement in % of the total length of the cranium, and calculated the average of each measurement for cows, bulls and oxen. After comparison of these averages he arrived at the conclusion that in some respects differences exist between the crania of cows, bulls and oxen. Though everyone will be inclined to distrust conclusions based on such few materials, it cannot be denied — after examination of all the numbers given by MERKENS — that in general his conclusions seem to be not devoid of foundation. One conclusion, however, must be rejected as being totally wrong. The average length in mm. of the cranium of cows, bulls and oxen appeared to be respectively 480, 479 and 489. MERKENS considered a difference of 1 mm. too small to be of any value regarding the small number of specimens measured [4]). He did, however, attach value to a difference of 10 mm. Now it

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[1]) My sincere thanks are due to Dr. K. W. DAMMERMANN who was so kind as to send me — at my request — the measurements of these specimens. The one (Buit. Mus. n°. 760) has been obtained from Sumba, the other (Buit. Mus. n°. 761) from Sumbawa. The measurements of the former have been published by DAMMERMANN in "Treubia", vol. X, 1928.

[2]) See: MERKENS (1927), p. 8.

[3]) Loc. cit. p. 154.

[4]) Even if MERKENS had measured 400 specimens of cows, bulls and oxen each, instead of 4, a difference of 1 mm. would be in my opinion of not the slightest importance.

appears that the total length of two of the four of MERKENS's crania of oxen differ not less than 60 mm., which totally invalidates his conclusion.

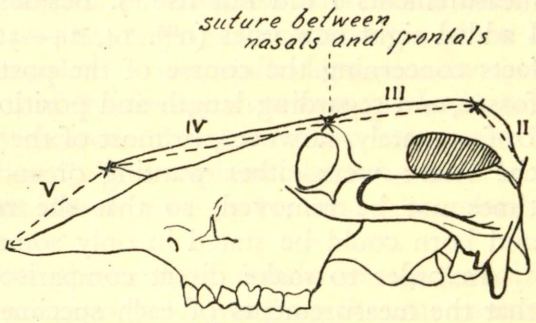
The present writer took partly entirely different measurements than MERKENS, so that not all of MERKENS's conclusions could be tested by the help of our more ample materials. Those conclusions we were able to test, are:

a. Bulls have in relation to cows a longer forehead, and a shorter nasal part. Oxen are intermediate in this respect.

b. The breadth of the praemaxillaries is greatest in cows, smallest in bulls. Also in this respect oxen are intermediate.

c. The breadth of the base of the horn is greatest in oxen, smallest in cows.

In order to be able to express the difference in length of the forehead and the nasal part into % of the total length, MERKENS took (IV+V)−(II+III). (See for the meaning of the Roman numerals text fig. 2). As none of these four measurements had been taken by me, I used (1—7)−7, which expresses an almost identical difference. The meaning of the Arabian numerals will be found in my own table B. As, furthermore, by far in most of the crania of the kerabau measured, the horns were wanting, I used instead of the breadth of the horn, that of the horn-core, against which no objections can be raised.



Text fig. 2.

In table A will be found all necessary measurements (in % of the total length). In the 4th, 5th and 6th horizontal row the smallest and greatest number have been heavy printed.

I have tried to indicate, on the base of the characteristics, given by MERKENS, which of the crania are males, and which are females. Table A shows clearly, that the number of contradictions at which we arrive then, is so great, that we are certainly justified to draw the following conclusions:

1. The differences, which MERKENS believed to exist between the crania of oxen, cows and bulls, appear in reality not to exist, if tested on more extensive materials.

2. Consequently, it is impossible to distinguish in our own table between oxen, bulls and cows.

3. This negative result proves that the (almost certain) presence of measurements of oxen in our table, need not trouble us; the differences — if indeed present — being still smaller than the small differences which MERKENS believed to exist.

Besides the cranial measurements of 31 crania of the kerabau and of 3 crania of the arni, all already mentioned above, table B contains the measurements of 9 specimens of our own fossil form, of 2 specimens of "*Buffelus palaeokerabau*", borrowed from STREMME, of 3 specimens of *Buffelus bubalus*, var. *palaeindicus* derived from LYDEKKER, and — for the sake of completeness — of one specimen of *Buffelus platyceros*, also borrowed from LYDEKKER.

As far as the condition of the specimens measured by the writer allowed, thirty measurements have been taken. As to the choice of the measurements I had to join STREMME [1]), who in his turn for the greater part followed LYDEKKER. Two of STREMME's measurements I did not use [2]). Besides STREMME's measurements I added eight new ones (nos. 14, 24—30), in order to invest some facts concerning the course of the posterior part of the temporal fossae, and regarding length and position of horns and horn-cores. Unfortunately, however, in most of the recent specimens measured the horns were either wanting or — if present — could sometimes not be removed, so that the relation between horn-core and horn could be stated in only some cases.

In order to make direct comparison possible, it is necessary that the measurements of each specimen be expressed in % of a certain measurement as unit. Usually as unit is taken the total length of the cranium. We do not dispose, however, of this measurement in our fossil crania, being all very fragmentary. For that reason the smallest breadth of the forehead has been chosen as unit in table C. In order to facilitate a review of the numerous percent numbers of table C, the maximum and minimum values of each measurement for the various forms have been united in table D. Table E contains a series of relations between certain measurements. In this respect my choice was wholly fixed, as I had to join STREMME. Only the relations 1 : 20 and 19 : 7 have

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[1]) In STREMME's table of measurements on p. 126 a lapsus calami occurs in the circumscription of measurement IV and XII viz., "Orbitalkamm" instead of "Occipitalkamm".

[2]) II. "Entfernung zwischen dem Hinterhauptskamm und dem Scheitel". From the description of our own fossil form it will appear that the transition of the frontals into the supracristal portion of the occiput is often very gradual, so that the "Scheitel" is not sharply defined. The same occurs in the cranium of the kerabau.
XXIII. "Entfernung vom Occipitalkamm zum Vorderrande der Orbita". As the crista occipitalis is a wide arch, I could not know which point of this crest STREMME meant.

been added. For the sake of an easy review the various minima and maxima of table E have been collected in table F.

As is seen from table C, in all the specimens of the kerabau the interval between the extremities of the temporal fossae (measurement 13) is not only exceeded by the "greatest" width between the temporal fossae (measurement 14), but also by the interval between the extremities of the occipital condyles (measurement 11). That m. 13 is exceeded by m. 14 is caused by the fact that the convex posterior portion of the temporal fossa of either side converge backwards. That, furthermore, m. 11 exceeds m. 13 proves that the temporal fossae cut deeply into the supra-cristal portion of the occipital surface, a fact which already RÜTIMEYER (1868, p. 33) strongly emphasized. The percent numbers in table C show also in a convincing manner that the individual variation is in this respect extraordinarily great. In my own notices, made of the recent specimens of kerabau which I saw in Amsterdam and Leyden, I read: "The manner in which the temporal fossa terminates is very variable. In some cases the temporal fossa and the plane of the occiput are — roughly spoken — perpendicular to one another; in others the posterior end of the fossa curves very gradually, and the boundary can hardly be seen. Between these extremes are a great number of transitions". This explains also why in table F the relation 4 : 13 varies from 1.82—3.87, and the relation 10 : 13 from 1.87—3.14.

As to the specimens of the arni, *B. bubalus* var. *palaeindicus* and of "*B. palaeokerabau*" m. 14 is only known from the arni cranium of which measurements have been given by the author. In this specimen m. 14 exceeds also m. 13, but only with 4 %. For the rest the arni crania show — as in the kerabau — a considerable variation in the difference between m. 13 and 11, being in spec. a 1, in spec. b 0 and in spec. c 24. Of spec. A and B of the Siwalik variety *palaeindicus* m. 11 and 13 are known. Apparently the temporal fossae do not cut so deeply into the occipital surface, m. 11 being — in contradiction to the kerabau crania — *smaller* than m. 13. The relation 4 : 13 is for spec. A of the variety in question but 1.66 which is distinctly smaller than the smallest value which was found for the kerabau. Also in the relation 10 : 13 the fossil Siwalik variety shows a tendency to smaller values. The only cranium of "*B. palaeokerabau*" of which m. 11 and 13 are known, shows in this respect no difference from the kerabau cranium.

Coming now to our own fossil specimens we notice that in the five specimens, in which m. 11 and 13 can be compared, m. 11 is *smaller* than m. 13, in two specimens even considerably smaller. In this respect, therefore, they are distinguished from the kerabau,

and in accordance with var. *B. palaeindicus*. This is also demonstrated by the relation 4 : 13 of table F, varying in our fossil specimens from 1.33—1.53 and being 1.66 in the only specimen of *B. palaeindicus*, for which the relation 4 : 13 could be calculated. One would perhaps be inclined to infer from the numbers quoted that the degree of constriction of the occiput by the temporal fossae is in our fossil form still smaller than in *B. palaeindicus*. It must not be forgotten, however, that of only one skull of the fossil variety the relation 4 : 13 is known. Moreover, the relation 10 : 13 differs but slightly in both forms.

The percent numbers of m. 13 and 14 of table C show, furthermore, clearly the remarkable feature, already mentioned in the description of our fossil specimens. In spec. 1 and 7 namely m. 14 exceeds m. 13, the course of the posterior portion of the temporal fossae being the same as in the kerabau crania. In spec. 2, 3, 5, 6 and 8, however, m. 13 is larger than m. 14, which is caused by the fact that near the occiput the temporal fossae change their direction, diverging backwardly. Probably I should have been strongly inclined to attach value to this difference, were it not that in one of two fossil crania of *Bibos* in our collection — without a shade of a doubt belonging to the living species — exactly the same deviation occurred. I must admit, however, that I cannot declare this phenomenon. Of course it cannot be connected with a stronger development of the occipital muscles, as these are attached to the true occipital surface, and not to the supra-cristal portion of the occiput.

Before trying to answer the question whether or not our fossil form is identical with the form described by STREMME under the name of *Buffelus palaeokerabau* DUBOIS, it will be desirable to consider closely the differences which STREMME thought to perceive between his form and the kerabau. As has been already mentioned, STREMME calculated [1]) a number of relations between certain measurements. From these he concluded that his fossil form presented "erhebliche Abweichungen" from the kerabau, a. o. *B. palaeokerabau* should have narrower praemaxillaries and its forehead should be longer in proportion to the interval between orbit and distal end of the praemaxillaries. As to the latter difference STREMME took the relation $\frac{\text{XXIV}}{\text{XXIII}}$. STREMME's XXIV corresponds with our m. 19.

[1]) If STREMME's table of measurements is compared with ours, it will be seen that the former contains not unfrequently errors and miscalculations which do not increase the usefulness of the tables.

We did not use, however, m. XXIII for reasons already pointed out in note 2 on p. 38. Instead of the relation $\frac{XXIV}{XXIII}$ we used 19 : 7. From table F appears that both differences in reality do not exist. Nevertheless there remain other differences. But in the first place they are small, and secondly it is almost certain that they would disappear if still more extensive materials of the kerabau had been available. STREMME hinted already at this possibility. On p. 125 STREMME mentions some more differences viz., a more strongly ascending forehead, the presence of crests and grooves on the forehead and (perhaps) a greater size. As to the difference first mentioned I may add that in the kerabau the forehead appeared to be very variable, in some cases being almost flat, in others very distinctly convex antero-posteriorly. Concerning the second difference I may mention that supraorbital sulci appeared to be either present or absent in the crania of the kerabau. As to the difference in size I may refer to spec. 30 of my table B, which shows a tip to tip interval of the horns of about 3 m. !

Summarizing we can state that the fossil Javanese form, described by STREMME *under the name of Buffelus palaeokerabau* DUBOIS, *appears to be indistinguishable from the recent kerabau. It has, therefore, no right to specific distinctness, and must be called: Buffelus bubalus* (L.) *var. sondaicus fossilis.* [1])

Finally our own fossil form. As far as can be gathered from our fragmentary specimens the resemblances to the cranium of the kerabau is so close that I should not hesitate in classing it with that variety, if not the degree of constriction of the occiput were far too small. In this respect the fossil form of our collection is distinctly separated from the kerabau, and shows resemblance with *B. bubalus* (L.) var. *palaeindicus* (FALCONER). In my opinion, however, this single difference does not suffice to establish a new variety so that I class it provisionally with *Buffelus bubalus* (L.), var. *sondaicus* (SCHLEGEL et MÜLLER) *fossilis*.

[1]) With this I do not intend to maintain that *Buffelus palaeokerabau* does not exist, though — as has been pointed out already above — identity between STREMME's fossil form and that of DUBOIS is not improbable.

Bibos sondaicus (SCHL. et MÜLL.) **fossilis.**

Pl. II, figs. 1—5; pl. III, figs. 1—4.

Localities: Watualang, Kedung Kendang, Mendut near Tinggang.

Of the genus *Bibos* I received three crania and one detached, entirely complete horn-core, obtained from the following localities.

	Locality	District	Regency	Residency
Cranium with two horn-cores and crushed cranium	Watualang	Ngawi	Ngawi	Madiun
Cranium with one horn-core	Kedung-Kendang	Sragen	Sragen	Surakarta
Detached horn-core	Mendut near Tinggang	Tambak-redjo	Bodjone-goro	Bodjone-goro

Though two crania had to be freed from considerable quantities of adherent matrix and restored with glue and plaster, they are in a rather fine state of preservation. The third cranium, however, when unpacked, showed itself to be for the greater part fallen into tiny pieces, so that it was absolutely impossible to restore it. What remained was the left maxilla together with a portion of the orbit, the greater portion of the right horn-core and a smaller piece of the left core. The maxilla contained five grinding teeth (P^3—M^3), all finely preserved.

The two crania of which views are given in figs. 1—2, 4—5 of pl. II and figs. 1—3 of pl. III agree so much in nearly every feature that their belonging to the same species cannot be doubted. The remains of the crushed cranium and also the detached horn-core show no characters by which they are distinguished from the better preserved specimens.

As will be seen from the figures, one cranium only possesses one horn-core, the other both. The specimen with one horn-core is in general better preserved. In the specimen with two horn-cores the nasals are for the greater part wanting, the occipital surface is injured; the pterygoid-sphenoid region very much damaged, and what remained of it covered with plaster in order to give the very desired support to this cranium which was broken into two behind the orbits.

As RÜTIMEYER already gave such an excellent account of the skull of the living banting, *Bibos sondaicus*, and of the great differences

which are connected to sex and age, it will be unnecessary to explain why the two figured crania and the figured, detached horn-core all belonged to male individuals. The two fragmentary cores belonging to the crushed cranium also indicate the skull of a male. There are, however, differences in age. From the curvature of the cores we may be sure that the cranium with two horn-cores is that of a mature male individual, while the cranium with one core, and the detached core belonged to old males. The molars prove this assertion to be true. In both crania all the molars are in use, but the degree of wear is greater in the cranium with one horn-core. Though of the cores of the crushed cranium a considerable part of the distal end is wanting, the curvature of the remaining part proves the cranium to belong to a younger individual. And the degree of wear of the molars supports this statement, for, though the M^3 is already in use, the remaining premolars are but little worn.

As the resemblance between the two figured crania on the one side, and those of the living mature male Javan banting on the other side, is very close, it will be best to commence by comparing the two together. If, however, differences occur between the two fossil crania, they will be mentioned separately.

For direct comparison I had at my disposal only one cranium, but a very fine one, namely that of an old male, contained in the Museum of the Zoological Institute of the University of Utrecht, and kindly lent to me by its director, Prof. NIERSTRASZ. The fossil specimens could, moreover, be compared with the descriptions and figures of some fine crania of the banting [1]), preserved in the National Museum of Natural History at Leyden, and with my own sketches and notices of these crania and of two more specimens contained in the museums of "Natura Artis Magistra" at Amsterdam.

Below the comparison between the fossil specimens and the crania of mature male individuals of the Javan *Bibos sondaicus* will be made in this way, that respectively upper-, hind-, side-, and lower aspect of the cranium and the horn-cores will be dealt with, each preceded by an enumeration of resemblances and differences which the present writer could state in the recent specimens. (N. B. The crania are supposed to rest upon paroccipital processes and cheek teeth.)

Upper (frontal) aspect.

This aspect shows but small individual variations. As has been already pointed out by RÜTIMEYER and clearly shown by the

[1]) SCHLEGEL and MÜLLER, Verh. Nat. Gesch. der Ned. Overzeesche Bezittingen (Zoölogie), 1839—1844, p. 197, pl. XXV—XXIX, and RÜTIMEYER, Denkschr. schweiz. Ges. XXII, 1868, p. 77, text figs. 10—13.

figures, given by SCHLEGEL, the whole skull becomes, from mature to old, broader in reference to its length, with the orbits very prominent, masseter crista and malar process very well developed. Nasals broad and short. I should like to add that the supraorbital sulci and foramina may show considerable variations concerning length and convergence of sulci, position and number of the supraorbital foramina. I am, therefore, convinced, that no specific value whatever may be attached to position and number of supraorbital foramina, and to length and position of the supraorbital sulcus.

Concerning the prominence of the orbit, the shortness of the nasals and their relation to the frontals, there is a very close resemblance between the fossil specimens and the recent crania. The masseter crista and the malar process are, however, less developed than in general is the case in the crania of the living species.

As will be seen from the figures the two fossil specimens show slight, mutual variations concerning the length of the supraorbital sulcus, and the number and position of the supraorbital foramina. But these variations by no means exceed the boundaries of variation found in the crania of the Javanese banting.

Hind (occipital) aspect.

The crania of mature male individuals of *Bibos sondaicus* showed that the transition of the plane of the frontals in that of the occiput is in some specimens gradual, in others rather abrupt. The latter is caused by the fact that the forehead — in profile view of the cranium — instead of being flat, and situated in the elongation of the nasals, is slightly concave and rising strongly to the vertex cranii, producing a ridge, called by RÜTIMEYER "Frontalwulst" and identical with LYDEKKER's "intercornual ridge". The feature above described appears to be connected with a rich development of bone-tubercles on the posterior half of the forehead.

From the above it will be clear that the relation between height of supra- and infracristal portion of the occiput has but little value.

As mentioned by RÜTIMEYER, the true occipital surface becomes gradually broader, so that in an old male the lower portion of the occiput ". . . . beidseits weit über den Hornansatz hinausragt . . . ."[1]). This is also the case in both fossil specimens. In the specimen with one horn-core the interval between the posterior border of the meatus auditivus externus osseus of either side exceeds with some 7 cm. the interval between the bases of the horn-cores, and in the specimen with two horn-cores the difference between both measurements is about 8 cm.

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[1]) p. 84.

There is a difference — though not essential — between the fossil specimen with one horn-core, and that with both cores regarding the degree of constriction of the supracristal portion of the occiput by the posterior extremities of the temporal fossae, being in the "two horned" specimen very considerable, and in the "one horned" cranium far less pronounced. It will be seen, however, from table H of cranial measurements that in this respect there occurs a considerable amount of individual variation in the crania of the Javan *Bibos sondaicus*. This is caused by the fact that in some specimens the curved walls of the temporal fossae gradually converge backwards, whereas in other crania the extremities of the temporal fossae change their direction near the occipital surface, so that the utmost ends of the temporal fossae *diverge* strongly backwards. It will be clear that in the latter crania m. 25 (of table G and H) will show relatively great values. But in none of the six recent crania m. 25 exceeds m. 26 (greatest interval between temporal fossae in the prae-occipital region). The "two horned" fossil cranium does not show divergence of the utmost ends of the temporal fossae, so that in this specimen the constriction of the occiput is very considerable and m. 25 distinctly smaller than m. 26. In the "one horned" specimen, however, this divergence occurs in such a strong degree, that not only the constriction of the occiput is far less pronounced, but m. 26 is even slightly exceeded by m. 25. But of course this small deviation does not afford any reason for specific distinction.

In both fossil specimens the tips of the paroccipital processes are wanting. In position, and curvature of the remaining portion, however, they show no differences from those of the crania of the recent form.

The occipital condyles also are similar in shape and position to those of the Javan banting.

In the crania of *Bibos sondaicus*, and also — according to RÜTIMEYER — in those of *Bibos frontalis* there runs, from the indentations by the temporal fossae on either side, a crista obliquely upwards meeting in the middle of the breadth of the supracristal portion of the occiput and some cm. above the middle of the occipital crest. In examining six complete crania of the living Javan banting it was revealed that also in this respect some variation may occur. In some crania these cristae originate there, where occipital crista and posterior extremities of the temporal fossae meet; in other specimens they begin about 2 cm. higher, namely at the upper angle of the indentations of the occiput by the temporal fossae. In some specimens the point where both cristae meet is situated very near to the vertex of the cranium,

in others some cm. below it. In other words at times both cristae converge rapidly, at other times they enclose a greater angle. In our fossil specimens these cristae are but poorly developed, they meet about 3 cm. above the middle of the occipital crest and about 4 cm. below the vertex cranii. Exactly as in the crania of the banting, in or immediately above the point of meeting the supracristal portion of the occiput bulges up, causing the "intercornual ridge" to show in the upper aspect of the cranium a convex outline in its middle third.

Side aspect.

Viewed from the side all the crania of mature male specimens of *Bibos sondaicus* which I examined were very much alike. The only difference which may occur, and which has already been mentioned in noticing the frontal aspect, is the sometimes abnormally strong development of the posterior portion of the forehead causing the plane of the frontals to slope stronger than that of the nasals. For the rest, however, the relation between frontals, nasals, lacrymals, maxillae, and intermaxillae, the shape and position of the orbits, the development of masseter crista and malar process is in all the specimens I saw, very much alike. Also in this respect both fossil crania are perfectly in accordance with the skulls of the Javan banting, with the only exception, already mentioned, that masseter crista and malar process are not so strongly developed as seems to be the rule in the crania of the banting.

Lower aspect.

Here also we may be short. Both fossil specimens show the same relations of the bones of the bottom of the cranium as in the banting. For dimensions, and comparisons with those of the banting, I may refer to tables G and H.

Horn-cores.

In but one specimen of cranium of the Javan banting (E) the horns could be removed from the cores. It revealed that the core by no means fills the sheath of the horn to its top, but that a distinct difference in length exists between horn and horn-core. As, especially in old male individuals, the curvature of the horn is strongest in its distal third, the core will always show a smaller degree of curvature than the horn which belongs to it. That explains why I ventured to refer the "one horned" fossil specimen to an old individual, although the curvature of the core is not so extremely pronounced. I shall not try to give an account of the various forms of the horns of the crania which I saw. Their degree of curvature

is — as was clearly pointed out by RÜTIMEYER — a function of age. I am not wholly certain, but I believe that the distance from tip of horn to tip of nasals, which, as will be seen from tables G and H, may vary considerably, is not only dependent upon age, but is also liable to common individual variation. For the sake of completeness I will try to describe the form and curvature of the horn-cores of both fossil crania, and of the detached core.

a. "One horned" specimen.

Near its base the core is directed outwards, downwards and somewhat backwards. This downward slope decreases gradually so that the core in the middle third of its course is — roughly spoken — horizontal. Then the core rises upwards in one regular curve, its tip directed slightly inwards.

If the cranium is placed on paroccipital processes and cheek teeth, and viewed in side aspect, the distal third of the horn-cores slopes distinctly backwards. The lowest point of the inferior surface of the core is at the level of the lower angle of the occipital condyles. At the base the horn-core is in cross-section approximately an ellips; its longest axis forms the antero-posterior diameter; inferiorly it is far more flattened than superiorly. The core maintains the flattened lower border throughout its proximal half; more distally it gradually disappears, and the core becomes conical. The surface of the core is deeply grooved and chanelled.

The place to which the base of the former horn extended is on lower and posterior surface of the core marked by a sudden decrease of height and breadth.

b. The detached horn-core.

This core resembles the one, described above, in nearly every feature. It is only larger and thicker, and its tip is more directed inwards. It apparently belonged to a still older male. Without difficulty it can be identified as a left core.

c. "Two horned" specimen.

The differences between the cores of this specimen and the one described first are:

1. In its proximal third it is directed somewhat more backwards and less downwards.

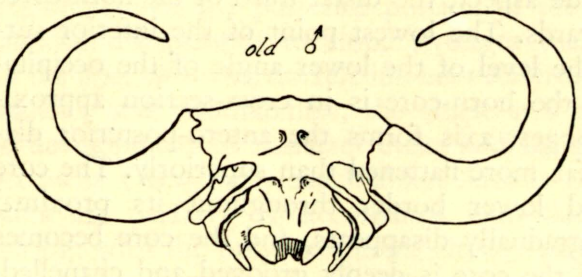
2. Its tip is directed straight upwards and not inwards (which proves its belonging to a less old individual).

3. Placed in the position above mentioned, and viewed in side aspect, the distal third of the horn-core stands nearly perpendicular.

4. The lowest point of the inferior surface is at the level of the upper border of the for. magnum.

The cores belonging to the crushed cranium are already mentioned, and are in too imperfect a condition to make a detailed description possible.

The form of the cores in cross-section of our fossil specimens is entirely similar to that of the Javan banting. Also concerning the course of the cores there is in general a close resemblance between the fossil form and *Bibos sondaicus*. In the "one horned" and "two horned" specimen, however, the maximum span of the horn-cores, in proportion to the total length of the cranium, is distinctly greater than in the five recent crania which the writer measured (See table H). That this is a point of minor importance is in my opinion proved by the fact that the detached fossil horn-core is considerably less spread out, showing almost exactly the same degree of curvature as the horns of the type specimen of the cranium of an old male (Compare fig. 4 pl. III, and text fig. 3).



Text fig. 3. Hind aspect of old male type cranium of *Bibos sondaicus* (recent). After SCHEGEL and MÜLLER. $^1/_{11}$ nat. size.

As I could not state any essential, structural difference between the molars and premolars of the fossil specimens and those of the recent Javan banting, it will suffice to refer to fig. 3 of pl. II, in which an upper view of the dentition has been given. In the "two horned" specimen are preserved: left M^1-M^3, a fragment of the left P^4, and right M^2-M^3. In the one horned specimen: P^2-M^3 of either side. Of left M^2 and right M^1 the outer wall of the molar has been lost. In the crushed cranium: left P^3-M^3.

Below we shall have to compare our fossil form with the following South Asiatic and Malayan species:

Bibos frontalis (LAMB.)

Bibos gaurus (H. SM.)

Bibos palaeogaurus (FALC.)

Bibos geron MATS.

Bibos protocavifrons DUB.

Bibos palaeosondaicus DUB.

Bibos sondaicus (SCHLEG. ET MÜLL.)

The comparison between the fossil form of our collection with the Javan *Bibos sondaicus* has already been made in what precedes, but there are still some varieties of *Bibos sondaicus* which need discussion.

Bibos frontalis (LAMB.) (1) and Bibos gaurus (H. SM.) (2).

(1) Bos frontalis, Lambert, Trans. Linn. Soc. VII, 1804, p. 57 and 302.
Bos gavaeus, Colebrooke, As. Researches VIII, 1805, p. 488.
Gavaeus frontalis, Hodgson, Journ. As. Soc. Bengal XVI, 1847, p. 706.
Bos (Bibos) gavaeus, L. Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 105.
Bos (Bibos) frontalis, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 31.
(2) Bos gaurus, H. Smith, in Griffith's Animal Kingdom IV, 1827, p. 399.
Bibos cavifrons, Hodgson, Journ. As. Soc. Bengal VI, 1837, p. 745.
Bos (Bibos) gaurus, Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 88; Lydekker, Wild oxen, sheep and goats, 1898, p. 23.
Gavaeus gaurus, Blyth. Journ. As. Soc. Bengal XXIX, 1860, p. 282.
See for more extensive synonymy of these two species: Lydekker, Wild oxen, sheep and goats, 1898, p. 23 and 31, from which the above data have mainly been derived.

We may immediately exclude *Bibos frontalis*, the gayal, and *Bibos gaurus*, the gaur from our comparison. These recent South Asiatic species are readily distinguished from the recent Javan banting — and therefore also from our fossil form whose striking resemblances to the former has been repeatedly emphasized in the foregoing part — by a number of features of which I shall mention the following ones. In both species the cranium is less elongated[1]). In the Mus. of Nat. Hist. at Leyden one cranium of gayal is preserved. It belongs, however, to an individual not fully grown for which reason I thought it better not to give the measurements. The relation between the smallest breadth of the forehead and the condylo-basal length in this specimen is 221 : 421, whereas from table G of cranial measurements may be seen that in all the specimens of the Javan banting the same relation is decidedly smaller. It must not be forgotten that the relation between the smallest breadth of forehead and condylo-basal length is smaller than may be expected in the cranium of an adult individual, as the cranium becomes broader in proportion to its length. This smaller width in reference to the total length coincides with a triangular form, far more pronounced than in the banting head.

Another difference is that the horns are but very slightly curved, with no inward bending. Of the gaur I have not seen the cranium. But this species is much better known. That its skull is less elongated in comparison to that of the banting can be clearly seen from the

[1]) LYDEKKER (1898), p. 37.

table of measurements given by RÜTIMEYER [1]), who described some crania of the species in question in an excellent way. Another difference is afforded by the high intercornual ridge on the vertex, causing the forehead to be deeply concave [2]), and the occipital surface higher than broad [3]). The horns, compared with those of the Javan banting, are shorter and more massive; towards the base becoming lower and broader [3]). For the rest, however, the course of the horns strongly reminds of the banting.

Bibos palaeogaurus (FALC.).

Bos (Bibos) palaeogaurus, L. Rütimeyer, Abh. schweiz. pal. Ges. V, 1878, p. 154.
Bos palaeogaurus, R. Lydekker, Cat. Foss. Mamm. Br. Mus. part. II, 1885, p. 23.

RÜTIMEYER mentions under the present name a fragment of a cranium from the Narbada and preserved in the British Museum. RÜTIMEYER should have named the species without any reserve *Bibos gaurus*, had he not thought it useful to give in general fossils new names. "Dennoch" — he continues — ", da ich keinen Unterschied von dem lebenden Bos Gaurus entdecken konnte, würde ich auf einen Namen verzichtet haben, wenn derselbe nicht, freilich ohne Nachweis, dass er diesem Fossil gewidmet war, in den Manuscripten FALCONER's vorgefunden hätte". LYDEKKER stated as his opinion, that the specimen is perhaps insufficient for specific determination.

Bibos geron MATS.

Bibos geron, Matsumoto, Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, 2nd ser. (Geology), III, 1915—1918, p. 21; pl. IX, figs. 1—3, pl. X, figs. 1—3.
Bibos [4]) geron, W. D. Matthew and Walter Granger, Bull. Amer. Mus. Nat. Hist. XLVIII, 1923, p. 594; text figs. 26—27.
Bibos geron, O. Zdansky, Palaeontologia Sinica, Ser. C, V, 1928, fasc. 4, p. 111.

This species has been based by MATSUMOTO upon parts of upper and lower jaw, secured from Sze-chuan, China. Fossil remains of *Bibos*, however, were already known from China long before MATSUMOTO described the present species. Both KOKEN [5]) and SCHLOSSER [6]) namely referred cheek teeth of their collections to the genus *Bibos*, but apparently thought it advisable not to establish new species on such materials. MATSUMOTO stated as his opinion that the species under consideration might possibly be not identical with KOKEN's and SCHLOSSER's species, though both are undoubtedly closely allied.

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[1]) RÜTIMEYER (1868), p. 101.

[2]) See the fine figures of a male cranium given by RÜTIMEYER, loc. cit. pl. II.

[3]) Loc. cit. p. 97.

[4]) In the heading mentioned as *Bibos geron*; in the subscription of the text figures, however, as *Bibos* (?) *geron*.

[5]) KOKEN (1885), Pal. Abh., III, 2. p. 64, pl. II, figs. 16—17; text fig. 1.

[6]) SCHLOSSER (1903), Abh. Ak. München, M. Ph. Kl., XXII, 1. p. 159.

W. GRANGER, palaeontologist of the Third Asiatic Expedition, obtained also from Sze-chuan a fine collection in which the genus *Bibos* was represented by "a series of skulls, skeletons, upper and lower jaws, etc." [1]), which were all referred to MATSUMOTO's new species by MATTHEW and GRANGER. Of a complete skull, selected as neo-type, figures of side-, upper- and lower aspect were given. No detailed description, however. Nevertheless it is not difficult to see that *Bibos geron* is specifically distinct from our fossil form. The totally different outline of the forehead in side aspect of the cranium, the different course of the horn-cores, especially in their proximal portion, the greater breadth of the cranium in reference to its length present positive indications in this respect. Among the numerous remains from Chou-K'ou-Tien, extensively described and figured by ZDANSKY under the name of *Bibos geron*, the cranium was only represented by a damaged horn-core and a fragment of ditto.

Bibos protocavifrons DUB. (1) and Bibos palaeosondaicus DUB. (2).

(1) Bibos protocavifrons, Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2de ser. XXV, 1908, p. 1262.
(2) Bibos palaeosondaicus, Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2de ser. XXV, 1908, p. 1262.
? Bibos palaeosondaicus, Stremme in: Die Pithecanthropus-Schichten auf Java, 1911, p. 136, pl. XVIII, figs. 7—8; pl. XIX, figs. 7, 9—11; pl. XX, figs. 10—11; text fig. 10.

DUBOIS's collections of fossil mammals from the Kendeng Hills in Java contained, besides *Leptobos*, ". . . . mehrere Formen von *Bibos* . . . ., von welchen die meisten sich, mehr oder weniger nahe, dem lebenden Banteng anschliessen" [2]). These forms he united into a new species, *Bibos palaeosondaicus*. Other forms showed transitions from the latter to the Javan fossil species of *Leptobos*, whereas one form occurred which, in having a very high intercornual ridge and concave forehead, strongly resembled the gaur. Whence the name *Bibos protocavifrons* [3]).

Above has been repeated all that DUBOIS has mentioned on these new species. It is clear that our own fossil form does not belong to *Bibos protocavifrons*. Furthermore, it is not improbable that our form is identical with *Bibos palaeosondaicus*. But as little as we were able to prove the identity of the fossil *Buffelus* of our collection with *Buffelus palaeokerabau* DUBOIS, as little will it be possible to identify with sufficient certainty our form of *Bibos* with *Bibos palaeosondaicus* DUBOIS.

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[1]) MATTHEW and GRANGER (1923), p. 594.
[2]) DUBOIS (1908), p. 1262.
[3]) *B. cavifrons* syn. with *B. gaurus*.

STREMME, however, apparently esteemed the few sentences, which DUBOIS dedicated to *Bibos palaeosondaicus*, sufficient enough to consider a form of *Bibos*, obtained by the Trinil expedition of Mrs. SELENKA, as belonging *without doubt* to that species. According to STREMME, DUBOIS, in naming his form *Bibos palaeosondaicus*, followed the same custom as RÜTIMEYER did, when the latter gave the fossil specimen of *Bibos gaurus* the name of *Bibos palaeogaurus*. I do not know how STREMME came to this conception. Apparently, others have not interpreted DUBOIS in this way, the absence of any recent species among the mammalian remains of the Kendeng beds being used by some as an argument against a relatively young age of these beds.

STREMME's determination is mainly based on the hinder portion of a cranium. Therefore, he could take only the following five measurements:

1. Stirnbreite unterhalb der Hornzapfen . . . . . 222 mm.
2. Schmalste Stelle der Scheitelbeine. . . . . 95 „
3. Gröszte Hinterhauptsbreite. . . . . 205 „
4. Höhe des oberen Hinterhauptsbeines . . . . . 114 „
5. Entfernung der Stirnmitte zum oberen Rande des Foramen magnums . . . . . 205 „

He compared these measurements with the corresponding ones taken from 2 crania of the Javan banting and from 3 specimens of the Bornean banting; calculated, furthermore, six different relations from which he concluded: ". . . . alle Proportionen zeigen das schmalere und engere Hinterhaupt des fossilen *Bibos* gegenüber den rezenten. [1])".

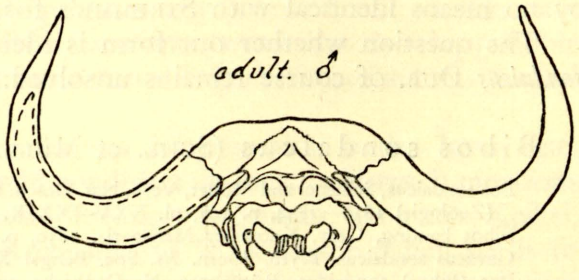
STREMME considering the fossil cranium as that of an old male will probably have compared it — though nowhere it is mentioned — with crania of adult male individuals of the Javan and Bornean banting. This taken for granted, it is extremely probable that one of the two crania, which STREMME considered as belonging to the Javan banting, in reality belongs to the Balian ox [2]). STREMME namely mentions that in the referred cranium the horn-cores are "fast gerade", while SCHLEGEL and MÜLLER, and later on RÜTIMEYER, pointed out, that in the adult male of the Javan banting the horns are bent very strongly. In a cranium of the adult male Balian ox, which I found (without horns) in the Nat. Museum of Nat. Hist. at Leyden, the horn-cores are nearly straight. This appears not to

[1]) STREMME (1911), p. 138.

[2]) Which is generally considered as the domesticated Javan banting.

be an exception as 'T HOEN [1]) gave a photograph of a living specimen of the adult male Balian ox, in which the horns are also but slightly curved.

As to the measurements taken by STREMME, the following remarks may be made. What STREMME meant by m. 1, 2 and 3 is clear; they agree with m. 3, 25 and 24 of my own table G. The meaning of m. 4 and 5, however, is not clear at all. We may even say that STREMME did *not* mean by m. 4 the height of the supraoccipitale. It will be known that in all Artiodactyla it is not the supraoccipitale which bounds the for. magnum superiorly, but the median united exoccipitalia [2]). That this is also the case in the cranium of *Bibos sondaicus* may be clearly seen in text fig. 4, which represents the hinder aspect of the type cranium of the adult Javan banting. The figure of STREMME's fossil specimen shows, however, distinctly the absence of the suture between supraoccipitale and exoccipitalia, so that STREMME certainly cannot have measured the height of the supraoccipitale. Originally, I supposed that STREMME in reality might have meant by m. 4 the interval between upper border of the for. magnum and crista occipitalis. This interval, however, appears — according to the figure, the exact scale of which can be ascertained without any difficulty — not to be 114 mm., but at most 100 mm.



Text fig. 4. Hind aspect of adult male type cranium of *Bibos sondaicus* (recent). After SCHLEGEL and MÜLLER. $^1/_{11}$ nat. size.

The circumscription of m. 5 is very indistinct. What exactly is meant by "Stirnmitte"? The highest point of the curve, formed by the more or less abrupt transition of forehead into occiput in the median line of the cranium? Probably not, for the distance between this point and the upper border of the for. magnum is — according to STREMME's figure — at most 176 mm., instead of 205 mm. We go, therefore, not too far, if we conclude that STREMME's m. 4 and 5 are entirely worthless.

In spite of all these objections it cannot be denied that STREMME's fossil specimen possesses indeed a higher and narrower occiput

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[1]) 'T HOEN, Buffel en Rund, 1921, fig. 5.

[2]) See e. g. MAX WEBER, Die Säugetiere I, 1927, p. 56.

than in the adult male cranium of the Javan *Bibos sondaicus* appears to exist. It must, however, strongly be doubted whether STREMME had a right to consider his fossil form so closely related to the recent Javan banting. For, beside the difference above mentioned, STREMME's specimen is — in my opinion — very decidedly distinguished from adult crania of the Javan banting by totally different form and course of the horn-cores. As STREMME himself observes, the horn-cores taper rather rapidly, and are but slightly curved. In all typical adult male crania of the recent Javan species, however, the horns are very strongly bent, and the horn-cores taper gradually [1]). The above will suffice to show, I believe, that our fossil form is by no means identical with STREMME's fossil specimen.

The question whether our form is identical with *Bibos palaeosondaicus* DUB. of course remains unsolved.

Bibos sondaicus (SCHL. et MÜLL.).

Bos sondaicus, Schlegel and Müller, Verh. Nat. Gesch. der Ned. Overzeesche Bezittingen (Zoölogie) 1839—1844, p. 197, pl. XXV—XXIX.
Bibos banting, Gray, Knowsley Menagerie, 1850, p. 48.
Gavaeus sondaicus, Blyth, Journ. As. Soc. Bengal XXIX, 1860, p. 296.
Bos (Bibos) sondaicus, Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 77; Lydekker, Wild oxen, sheep and goats, 1898, p. 36.

LYDEKKER distinguished in 1898 the following races:

a. Javan race, *Bos (Bibos) sondaicus typicus.*

b. Burmese race, *Bos (Bibos) sondaicus birmanicus.*

c. Manipur race, *Bos (Bibos) sondaicus*, var.

The two latter races, being founded on differences in coloration of the skin, are of no interest here.

In LYDEKKER's publication of 1898 mention was already made, and frontlets were figured of the Bornean banting, which seemed to be distinguished in having the horns less spread out and directed more upwardly. At that time LYDEKKER did not know, however, whether this difference should prove to be constant. In 1912 [2]) he returned to the Bornean form, the British Museum having obtained new specimens both of Javan and Bornean banting. From these specimens it appeared that the difference noticed above is indeed constant and, moreover, that the Bornean banting is characterized by the flatness of the forehead and the straight intercornual ridge. In LYDEKKER's opinion these differences fully justified the right to racial distinction. This race received the name of *Bos (Bibos) sondaicus lowi.* The museums of Natura Artis Magistra contain two crania of adult male individuals of the race in question.

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[1]) See text fig. 4, where the place of the horn-core is indicated with a dotted line.

[2]) LYDEKKER, Proc. Zool. Soc. of London, 1912, p. 902, text figs. 123—125.

In the National Museum of Natural History, furthermore, a cranium of the Bornean banting is preserved, which is according to the label that of a female. From the course and curvature of the horns we may be sure, however, that the latter specimen represents the cranium of an old male individual.

In a relatively recent publication 'T HOEN [1]) mentions the occurrence on the island Mojo, N. of Sumbawa, of the Balian ox, which has there reverted from domesticity. He regards the wild Bornean form as probably identical with the form of Mojo. There appears, therefore, to exist still a great amount of doubt as to the origin of the Bornean banting.

In 1909 LYDEKKER [2]) provisionally founded still another race of banting, namely *Bos (Bibos) sondaicus porteri.* But also this possible variety cannot interest us, as it seems only distinguished by a flecked skin.

The race which deserves our full attention is the Javan one. This form occurs in a wild condition in Java. 'T HOEN [3]) mentions the Southern part of Bantam, Preanger Regencies, Banjumas, Kediri, Pasuruan, and Besuki. According to 'T HOEN the Balian ox is in fact the domesticated Javan banting. Originally this tamed race only occurred in Bali, but to-day it is also found in Lombok. It has even been imported in Celebes, Sumbawa, Sumba, and New-Guinea.

The cranium of *Bibos sondaicus (typicus)* is well known. SCHLEGEL and MÜLLER published, beside descriptions, extraordinary fine drawings of the crania of male and female at different age. It was these crania, preserved in the Nat. Mus. of Nat. Hist. at Leyden, which served RÜTIMEYER [4]) as a basis for his masterly studies on the cranium of *Bibos sondaicus* and allied forms. Among the type specimens crania of an adult and an old male are represented.

In table G are united, beside the measurements of these two type specimens, and of our fossil specimens, those of the two crania of old males, contained in the museums of Natura Artis Magistra, and those of the skull of an old male in the possession of the Zoological Institute at Utrecht.

It will be known that the wild Javan banting interbreeds freely with the European and Indian cattle. Furthermore, it will be remembered that higher up mention was made of the occurrence of the domesticated banting in several islands of the Malayan Archipelago. Consequently it is highly possible that among

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[1]) Loc. cit. p. 5.

[2]) LYDEKKER, Proc. Zool. Soc. of London, 1909, p. 669, text fig. 217.

[3]) Loc. cit. p. 4.

[4]) RÜTIMEYER, Versuch einer natürlichen Geschichte des Rindes, N. Denkschr. schweiz. Ges. 1867—1868.

museum specimens, labelled as *Bibos sondaicus*, crania of the domesticated form, and of hybrids are contained. In this connection I think it desirable to lay stress upon the fact, that the five crania of male individuals, of which the measurements are given in table G, without any doubt belonged to wild specimens of the Javan banting. As to the crania D and E no explanation is needed; concerning specimens A, B and C it will suffice to mention that they show every essential feature which the type crania exhibit. Originally, the present writer intended to give in table G also the measurements of a rather large number of frontlets, which he found in the various museums, and which were regarded as belonging to the Javan banting. After all, their measurements have not been added for fear that in frontlets alone the presence of the domesticated form, and of hybrids could perhaps not always be detected. Besides the measurements of the five crania above mentioned, table G contains those of the three male crania of the Bornean banting already noticed on p. 54 and 55. They will, however, not be used in the below, the Bornean banting perhaps not being, as we saw higher up, an originally wild form. Perhaps that at some time or other, the measurements given — together with those of a much greater number of crania — will provide sufficient data to solve this problem. Though I myself did not want measurements of the crania of females, I added the measurements of the type cranium of the adult female, which may be of use to others.

As far as the materials allowed, forty-one [1]) different measurements have been taken. As to the choice of the measurements, I partly joined RÜTIMEYER who measured also the type specimens. [2]) In order to avoid confusions it will be very desirable to explain what is meant in m. 2 and 19—21 with "vertex cranii". Text fig. 5 shows some ways in which the transition of forehead into occiput in the median line of the cranium may take place; point *a*, that is to say the middle of the uppermost curve, marks the place which has been taken as vertex crania.

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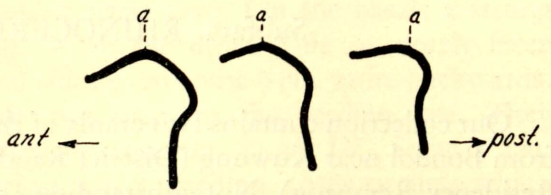
[1]) M. 20, 22 and 24 have been taken in the recent crania, after the fossil specimens were already returned to Bandung.

[2]) RÜTIMEYER's table of cranial measurements (1868, p. 86) does not contain the absolute values, all the measurements being expressed in % of "Länge der Schädelbasis vom vorderen Rand For. magnum bis Intermaxilla". In the text, however, some measurements are given in mm., so that it is not difficult to calculate the absolute values of the remaining measurements. If RÜTIMEYER's measurements be compared with the corresponding ones of my table G, it will be seen that they differ in general. As a rule these differences do not exceed 1—3 mm., which is easy to explain. In a few cases the difference is, however, greater. (I took the trouble to verify these measurements !) Furthermore, I may draw attention to the fact that in the circumscription of m. 13 of RÜTIMEYER's table a lapsus calami occurs. M. 13 does not represent "Höhe des Occiput vom untern Rand For. magn. bis Crista Occipit." but very probably the interval between the lower border of for. magnum to highest point of forehead.

In table H the various measurements have been expressed in % of the condylo-basal length of the cranium, while in table I the relations between certain measurements are given.

If we have a close look at table H — in which the maximum and minimum values for the crania of the Javan banting have been heavy printed — we notice that also the various percentage numbers reveal the great resemblances of our fossil cranium to those of adult specimens of the Javan banting. There remain still differences, but everyone will have expected them, being the measurements of but five recent crania available for comparison. From table H also distinctly appears the greater maximum span of the horn-cores (m. 13), and the greater values of those measurements, which bear upon m. 13, in the fossil crania. I should have been inclined perhaps to accept specific distinction on these grounds, were it not — as has already been stated — that the form of the detached horn-core of our collection is in perfect accordance with that of the type cranium of the old male of the Javan banting.



Text fig. 5.

At last, what does table I reveal? The notorious fact that nearly all the values found for the fossil form are situated between the (heavy printed) maximum and minimum values, found for but five recent crania! That the relation 19 : 25 is so small in our specimen *a* is caused by the fact that m. 25 (width of occiput between extremities of temporal fossae) is in that specimen abnormally great.

For the rest, however, the accordance is remarkably great, so that in my opinion the fossil specimen may not be regarded as a distinct form, but specifically identical with the recent Javan banting, *Bibos sondaicus* (SCHLEGEL et MÜLLER).

Fam. RHINOCEROTIDAE.

Subfam. RHINOCERINAE.

Our collection contains two crania of rhinoceroses, both obtained from Bondol near Kuwung (District Randublatung, Regency Blora, Residency Rembang). Notwithstanding the fact that one specimen is ill-preserved, we may say that these new founds enrich our knowledge of the fossil rhinoceroses of Java not inconsiderably, as will appear in the sequel.

We shall begin with the description of the finest specimen.

Rhinoceros sondaicus DESM. **fossilis.**

Pl. IV, figs. 1—3; pl. V, figs. 1—4.

Locality: Bondol near Kuwung.

State of preservation.

The middle portion of right zygomatic arch is wanting; the left arch is remarkably well preserved. The praemaxillaries have been totally lost; the processes of the maxillaries with which they are connected too. The absence of the praemaxillaries need not surprise us, as in museum specimens of recent rhinoceroses they are often wanting. The pterygoid processes are injured; the paroccipital processes broken off near their base. The palate is considerably damaged, both in front and in back. The petrosal of either side has been lost, their former presence being now indicated by a hole on either side of the basioccipitale. (In museum specimens I often found the petrosals detached in the brain case). The thin wall, which separates the left orbit from nasal cavity has been destroyed. The vomer is also totally absent. Of the cheek teeth only the crown of the left P^1 is wanting. The teeth are on the whole more or less injured. The degree of injury will be mentioned later on, when describing them in detail.

Description of the cranium (Pl. IV, figs. 1—3; pl. V, fig. 1).

(The cranium is supposed to rest on posterior molars and postglenoid processes.)

Brachycephalic, with strong, frontal depression and moderately high occiput, which slopes backwards [1]). Postglenoid and post-tympanic processes of the squamosal ankylosed below the meatus auditorius externus. Frontals smooth, rugosities totally absent, proving that the specimen in question was not provided with (a) frontal horn(s). Nasals rather pointed, separated by a groove extending from tips to vertex of nasal arch. On the nasals a strong rugosity occurs, extending — on the upper side — nearly from tips to vertex; on the lateral sides even some 6 cm. more backwards. Cristae fronto-parietales do not meet in the median line. They are sharper than would appear from fig. 3, pl. IV. Some 5 cm. in front of the occipital crest a low median crista occurs, which extends about 5 cm. frontwards, dying out gradually. If one compares the specimen in question with a sufficient number of equally aged crania of the living *Rhinoceros sondaicus*, it will be revealed that the eye cannot perceive any essential structural difference. In my opinion, therefore, it would be a waste of words to describe the cranium under consideration more detailed. Of course we shall have to return to it, in discussing the tables of measurements.

Description of premolar and molar dentition (Pl. V, figs. 2—4).

As to the names, given below to the various components of premolars and molars, see the appendix at p. 77.

In order to be able to give the inner aspect of the cheekteeth a photograph has been taken (fig. 4, pl. V) from the image, produced by a mirror placed obliquely between both rows of teeth.

P^1 (preantepenultimate premolar).

Left: Crown totally broken off, only the fangs are preserved.

Right: Antero-external angle damaged. Subtriangular shape. Ground down to the base of the crown, presenting a disc of dentine. Palatinally and posteriorly of the middle a very small and shallow pit occurs, surrounded by an edge of enamel. This pit represents the remainder of the medisinus.

P^2 (antepenultimate premolar).

Left: The enamel of the ectoloph has been lost. Quadriform. Deuterocone almost isolated. No crochet. Postfossette oval-shaped; in its antero-external angle a very incipient enamel fold. Though the enamel of the ectoloph has been lost, still it can be seen, that the protocone presents on the outer surface of the tooth an ill-defined rib, which dies out towards

[1]) Here and in the following pages the direction of the slope is interpreted in the manner of the geologists!

the base of the crown. In general the outer surface is clearly convex with a concavity between protocone and tritocone. A small protostyle probably was present, the indications therefore are, however, not absolutely conclusive.
The buccal extremity of the medisinus is triangular and its bottom is situated considerably below the entrance to the medisinus.
Anterior cingulum is present. Interior cingulum totally absent.

Right: Preservation and structure as in the left one, with the only exception, that the postfossette does not show an incipient enamel fold in its antero-external angle.

P^3 (penultimate premolar).

Left: Ectoloph is totally broken off. Contrary to the P^2, the deuterocone is not isolated, but has been united with the protocone, forming the protoloph. From the metaloph a thick blunt crochet projects into the medisinus.
The antero-external angle of the postfossette is occupied by an enamel fold, which — though small — can be clearly seen.
Anterior cingulum is present. Also internal cingulum, which extends from the middle of the deuterocone to the middle of the tetartocone, and consists of a single row of very small tubercles. This row is strongly curved, concave upwards. The entrance to the medisinus is on the same level with the middle of the internal cingulum. Both are situated some 12 mm. above the base of the internal side of the crown. In the succeeding teeth this distance decreases gradually, so that in the M^2 the entrance to the medisinus is almost at the base of the crown.

Right: The state of preservation is better than that of the left one, only the anterior half of the ectoloph being damaged. The crochet is still more blunt; an enamel fold in the antero-external angle of the postfossette is absent.

P^4 (ultimate premolar).

Left: Ectoloph considerably injured. Structure of the present tooth strongly resembles that of P^3. The enamel fold in the postfossette, however, is now very distinct, while lingually of the crochet (which is not so blunt as in the P^3) another faint secondary enamel fold occurs. Interior cingulum as in P^3.

Right: The only tooth which is not damaged. The ectoloph is perfectly preserved, fortunately allowing us to study the outer surface of the tooth. The ectoloph shows a very strong protostyle, separated by the parastyle fold from the protocone, which manifests itself on the outer surface by a distinct rib (protocone style). The latter style, which dies out towards the base of the crown, is well-defined in front, but posteriorly it passes gradually into the outer surface of the ectoloph. Outer surface and posterior surface of the tooth are almost perpendicular to one another, forming a sharp edge, which therefore may be called the tritostyle. The crochet is double. The buccal one is lobe-shaped, the palatinal one sharp triangular. The secondary enamel fold in the postfossette is as distinctly developed as in the left P^4. Internal cingulum as in the left P^4.

M^1 (antepenultimate molar).

Left: Ectoloph for the greater part broken off. The protoloph shows a distinct swelling in its protocone portion. The single crochet is strong, broad and blunt, and approaches the protocone very closely, being separated by a space of about 1 mm. breadth. The metaloph is very oblique with regard to the ectoloph. Already in the P^2 the metaloph is oblique, but the degree of obliqueness increases in the succeeding teeth, culminating in the M^2. The postfossette, without a secondary enamel fold, is clearly ovalshaped, its longest axis almost parallel to the oblique metaloph. The ectoloph, though strongly injured, shows still a rather strong metastyle. Internal cingulum is wanting. Only a very small tubercle is situated near the entrance to the medisinus.

Right: Ectoloph totally broken off. The structure is exceedingly like that of the M^1.

M^2 (penultimate molar).

Left: Ectoloph considerably injured. The worn protoloph is in its top everywhere of equal breadth. More towards the base of the crown the protoloph shows the same swelling of its protocone portion as in the foregoing M^1. The crochet is sharper than in the M^1 and does not approach so close the protoloph. The medisinus is in general wider. The postfossette is triangular, posteriorly bounded by a finely crenulated, posterior cingulum. Internal cingulum is totally absent.

Right: The structure resembles that of the left one down to the smallest detail. The state of preservation is better in so far as only the antero-external portion of the ectoloph has been broken off. A distinct metastyle is developed. The outer side of the metacone is clearly concave, especially in its upper portion, which is, moreover, strongly inclined outwards.

M^3 (ultimate molar).

Left: Strongly damaged. The enamel of the outer surface of inner- and front side of the protoloph has been lost, while the crochet also is considerably injured. It will therefore be better to study the structure of the M^3 in the right molar.

Right: The top of the united ectoloph and metaloph, and of the crochet is somewhat damaged. The base of the crown is subtriangular. Parastyle is present, but moderately developed. Behind the parastyle another rather ill-defined rib occurs, namely the manifestation of the paracone on the outer surface. The crochet is sharp and elongated. Internal cingulum is absent. The postero-external angle of the outer surface of the tooth ends in a sharp tubercle, closely attached to the outer surface, and representing a vestige of the posterior cingulum.

Summary of the structure of premolars and molars.

Brachyodont. P^4 and P^3 are completely molarized. The metamorphosis of the P^2 into the molar pattern is not so progressed in so far as the deuterocone is still distinctly isolated. The P^1 is far too much worn to show its former structure.

Though the ectoloph of most teeth is to a smaller or greater extent damaged, we may be sure, from the evidence of the undamaged right P^3, that the outer surface of the teeth is marked by two vertical ribs viz., a strong parastyle (protostyle of premolars) and a distinct paracone style (protocone style of premolars), in front separated by the parastyle (protostyle) fold. Backwards the paracone (protocone) style passes more or less gradually into the outer surface of the tooth. The edge where outer- and posterior surface meet is sharp and may perhaps be called a metastyle (in premolars tritostyle). The M^2 is certainly provided with a metastyle. Protoloph and metaloph are oblique in regard to the direction of the tooth row. The metaloph is always more oblique than the protoloph, while the degree of obliqueness of the metaloph increases gradually in the teeth more backwards.

Crista and antecrochet are totally absent. A crochet is distinctly developed from the P^3 up to and including the M^3. In the right P^4 the crochet is distinctly double.

In the antero-external angle of the postfossette of the left P^2 and P^3, and of the left and right P^4 a secondary enamel fold occurs. In both P^4 this fold is most distinct. It is totally wanting in the postfossette of M^1 and M^2.

An outer cingulum never occurs. Inner cingulum is present in P^3 and P^4 of either side, and consists of a curved row of small tubercles. In the molars the inner cingulum is sometimes present in the form of a single incipient tubercle in the entrance to the medisinus. An anterior cingulum is always present (except perhaps in P^1). It runs from the antero-internal angle of the protoloph (at a level equal to the inner cingulum, if this is present) in the direction of the outer surface of the tooth, thereby bending strongly upwards, and forming a valley, which probably may be called praesinus [1]). A posterior cingulum is distinctly visible in both M^2, whereas it is represented in the M^3 in the form of a tubercle.

The posterior side of the protocone (deuterocone in premolars) and the anterior side of the hypocone (tetartocone in premolars) are both either straight, slightly concave or slightly convex in profile view of the molar. Both converge strongly downwards, so that the palatinal portion of the medisinus becomes gradually narrower towards the base of the crown. The buccal extremity of the medisinus is wide or narrow depending upon the development of the crochet and the degree of wear of the tooth.

From the slightly worn M^3, we may infer that the specimen described above, belonged to an adult, though not old individual. The second specimen, however, the description of which will follow now, certainly belonged to a very old individual, as will be seen below.

Rhinoceros ?sondaicus DESM. fossilis.

Text fig. 6.

Locality: Bondol near Kuwung.

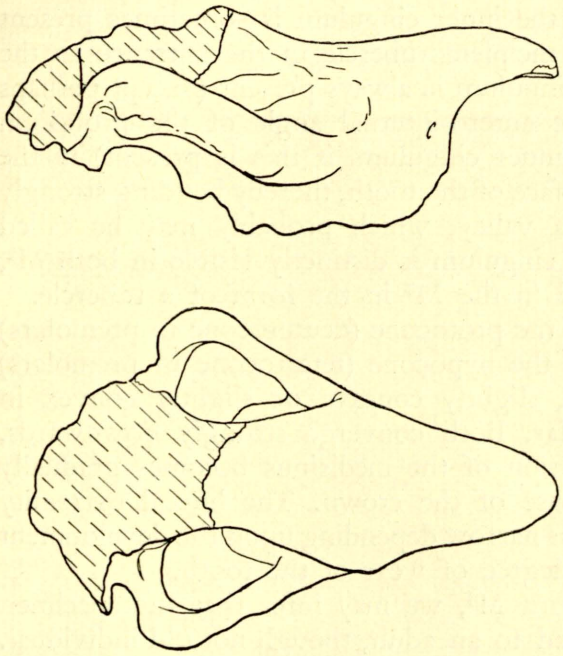
The second specimen is very much injured. Some deformation is not impossible.

State of preservation of the cranium.

The whole of the occipital and parietal region of the cranium is very much damaged. The brain case is totally uncovered, and has

[1]) See appendix.

been filled for a good deal with plaster. As both petrosals, and a portion of the basioccipitale have been lost, the bottom of the brain case presents a shapeless hole. The upper surface of the nasals is so much injured, that it cannot be seen whether or not a rugosity for a nasal horn occurred. Both zygomatic arches are remarkably well preserved; locally, however, restored with plaster. Praemaxillaries and the processes of the maxillaries, with which they are attached, have been lost. Both postglenoid processes have been broken off for the greater part. This is also the case with the right paroccipital process, whereas of the left corresponding process only the base can be seen. The tips of both pterygoid processes are absent. The palate is injured both in front and in back. The nasal cavity is for the greater part filled with matrix, which could not be removed, without running the risk to demolish the whole of the cranium. Of the right occipital condyle the greater part of the surface of the lower side is preserved, so that the total length of the cranium could be estimated with a tolerable degree of certainty.



Text fig. 6. Upper and side aspect of damaged cranium of *Rhinoceros ?sondaicus fossilis*. $^1/_9$ nat. size.

Description of the cranium.

Brachycephalic. Strong depression of frontal region. Union of posttympanic and postglenoid process below the meatus auditorius externus. No rugosities can be detected on the frontals, indicating the absence of frontal horn(s). Due to the injury of the nasals we cannot detect whether a nasal horn was present.

State of preservation of premolar and molar dentition.

Of the right tooth row remains of P^3—M^3 are present; of the left tooth row still less has been preserved viz., only remains of

M^1—M^3. These remains show that the degree of wear is very great; M^3 is ground down to a level only about 8 mm. above the bottom of the palatinal extremity of the medisinus. We may, therefore, be sure, that the cranium under consideration belonged to a very old individual.

The state of preservation of these premolars and molars being, in general, very bad, it will be of no interest to describe them detailed.

The little, which these poor remains still exhibit of the structure of the cheekteeth, seems to show that by no single character the cheekteeth in question differ from those of the foregoing specimen.

Before commencing to explain how we came to the conclusion that the well preserved rhinoceros cranium of our collection was indistinguishable from that of the living *Rhinoceros sondaicus*, we will make a comparison between the two specimens described.

As far as the bad state of preservation of the one allows of comparison, there appears to be an absolute accordance regarding essential characters. Both show:

1. a strong frontal depression;
2. union of postglenoid and posttympanic processes below the meatus auditorius externus;
3. no frontal horn(s);
4. brachycephaly.

Above it was seen, furthermore, that the remains of the cheekteeth of the ill-preserved specimen did not show any character by which the teeth could be distinguished from those of the well preserved cranium.

As, furthermore, both specimens have been found in the same locality, it is very probable that both belong to the same species. On the other hand, however, it cannot be denied that four of the ten measurements, which could be taken[1]) from the fragmentary specimen, show — if expressed in % of a certain measurement as unit — rather great differences with the corresponding maximum or minimum values found for 16 adult crania of *Rhinoceros sondaicus*. Though I certainly do not neglect the fact that more ample materials of the recent species would reveal a still greater individual variation, I thought it better to consider the identity between both fossil specimens as not totally proved. This may account for the addition of a sign of interrogation to the name under which the fragmentary cranium has been described.

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[1]) See table L of cranial measurements.

As has already been emphasized on page 59, the resemblance between the well preserved cranium and that of the recent *Rhinoceros sondaicus* is extremely close. Hereafter will, furthermore, be pointed out that also concerning the various measurements a nearly complete accordance appears to exist. Moreover it will be shown that also the permanent cheekteeth dentition resembles that of the recent species down to the smallest detail. We shall, therefore, be wholly justified if the fossil specimen in question be compared only with the recent and fossil Malayan forms of the genus *Rhinoceros* s. s., and with the only Asiatic form which shows distinct affinities to *Rh. sondaicus* namely, *Rh. sivalensis* FALC. et CAUTL. In this manner the following species remain:

Rhinoceros kendengindicus DUBOIS.

Rhinoceros sivasondaicus DUBOIS.

Rhinoceros sivalensis FALC. et CAUTL.

Rhinoceros sondaicus DESM. *fossilis.*

Rhinoceros sondaicus DESM.

Rhinoceros kendengindicus DUBOIS.

Rhinoceros kendengindicus, Eug. Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2nd ser., XXV, 1908, p. 1259.

Our knowledge of this fossil Javan form must be called absolutely insufficient. DUBOIS only mentioning — after shortly dealing with *Rh. sivasondaicus* —: "Die zweite Form von Rhinoceros schliesst sich dem nur auf dem Kontinente lebenden R. *indicus* an, ist von diesem aber in untergeordneten Punkten verschieden. Das hintere Joch der oberen Molaren ist relativ breiter, die Nasenknochen sind schmaler und scharfrändiger. Ich unterscheide diese zweite Art als *Rhinoceros kendengindicus* n. sp." [1]). Though this is very little, yet it suffices in the present case to exclude *Rh. kendengindicus* from the comparison. There are certainly a number of resemblances between the crania of *Rh. unicornis* L. (*Rh. indicus* CUV.) and of *Rh. sondaicus*, and therefore also between those of *Rh. kendengindicus* and our own fossil form. The cheekteeth of the latter, however, are readily distinguished from those of *Rh. unicornis* (and therefore also from *Rh. kendengindicus*) by the absence of crista and medifossette, the latter formed by the union of crochet and crista [2]).

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[1]) p. 1259.

[2]) See e. g. W. H. FLOWER, On some cranial and dental characters of the existing species of rhinoceroses. Proc. Zool. Soc. of London, 1876.

Rhinoceros sivasondaicus DUBOIS.

Rhinoceros javanicus, Eug. Dubois, Nat. Tijdschr. v. N.-I., LI, 1892, p. 94.
Rhinoceros sivasondaicus, Eug. Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2nd ser., XXV, 1908, p. 1258.
non Rhinoceros sivasondaicus, H. Stremme in: Die Pithecanthropus-Schichten auf Java, 1911, p. 89, pl. XVII, fig. 8; pl. XVIII, figs. 1—2.

Originally DUBOIS (1892) mentioned the occurrence of *Rh. javanicus* CUV. (*Rh. sondaicus* DESM.) in the fossil state in Java. In 1908 he apparently redetermined this form as *Rh. sivasondaicus* n. sp. As this species is of extreme importance to us, we shall quote all that DUBOIS mentioned about it. *Rhinoceros sivasondaicus* ". . . . ist ein sehr naher Verwandter des R. *sondaicus*, der jetzt lebend in Java, aber auch auf dem Festlande vorkommt. Diese lebende Art is sicher von R. *sivalensis* wenig verschieden, und LYDEKKER betrachtete deshalb letztere als ihre Stammform. Es ist nun sehr merkwürdig, dass die Kendeng-Form den geringen Abstand, welche noch jene beiden trennt, überbrückt. Gerade die wenigen Unterschiede die LYDEKKER angibt sind in der Kendeng-Form noch geringer geworden. Namentlich vermittelt die fossile Art von Java in dem Verhältnisse zwischen Länge und Breite der oberen Molaren den Uebergang jener beiden. Ich nenne sie deshalb *Rhinoceros sivasondaicus* n. sp. Jedenfalls war diese eine mit der heutigen doch nicht identische Art. Von R. *sivalensis* unterscheidet sie sich auch durch den Besitz eines zwar sehr kleinen medialen Unterkieferincisiven, von R. *karnuliensis* durch das Fehlen des Cingulum an der Innenfläche der Vorderjoche und des Höckerchens in dem Quertal der oberen Molaren" (l. c. p. 1258).

In dealing with *Rh. sivalensis* we shall return to the dental difference above mentioned.

The Trinil collection of Mrs. SELENKA contained of rhinoceros remains, besides some detached upper and lower cheekteeth and limb bones, a fine, well preserved cranium. All the remains were reckoned by STREMME to *Rh. sivasondaicus* DUB., mainly from the fact, that he thought to notice some differences between the cheek-teeth of his fossil form and those of *Rh. sondaicus*. Though STREMME stated that his material did not enable him to detect a transition between *Rh. sondaicus* and *Rh. sivalensis*, yet he came to the conclusion that his form was specifically identical with *Rh. sivasondaicus* DUBOIS. And again we may repeat what we observed already concerning STREMME's identification of his fossil forms of *Buffelus* and *Bibos* with resp. *Buffelus palaeokerabau* DUBOIS and *Bibos palaeosondaicus* DUBOIS, namely: the probability is great that STREMME's form is identical with DUBOIS's form, but STREMME had certainly no right to accept this identity as if it had been wholly proved.

Hereafter we shall have the opportunity to deal with STREMME's determination more detailed.

Rhinoceros sivalensis FALC. et CAUTL.

Rhinoceros indicus fossilis, Baker and Durand, Journ. Asiatic Soc. of Bengal, IV, 1836, p. 486, pl. XV, figs. 1—3; pl. XIX, figs. 7—8.
Rhinoceros sivalensis, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis, pl. LXXIII, figs. 2—3*a*; pl. LXXIV, fig. 5; pl. LXXV, fig. 5.
Rhinoceros sivalensis, R. Lydekker, Mem. Geol. Surv. India, ser. X, I, part 2, 1876, p. 8, pl. IV, fig. 2; pl. V, fig. 5.
Rhinoceros sivalensis, R. Lydekker, Mem. Geol. Surv. India, ser. X, II, part 1, 1881, p. 28, pl. V, figs. 1, 3—6; pl. X, fig. 4.

The literature relating to this Siwalik species is more extensive than would appear from the above, where only has been mentioned what will be needed in the below. Furthermore stress must be laid upon the fact that of each of the papers quoted only the figures of those specimens have been mentioned which appear to belong with certainty to the present species.

The name *Rh. sivalensis* appears to have been first applied to a number of specimens figured in the F.A.S. a.o. comprising a damaged, but still rather fine, adult cranium, in which both sets of cheekteeth have been preserved.

In 1836 BAKER and DURAND published a paper in which they described and figured a.o. a well preserved cranium, an occiput and several upper cheekteeth. Though all the specimens were assigned to one species (*Rh. indicus fossilis*), the authors hinted at the possibility of there being a second species. LYDEKKER twice referred to some of BAKER and DURAND's specimens viz., in 1876 and 1881. He redetermined the cranium and two M^3 as certainly belonging to the present species. A M^2, which he in 1876 also reckoned to *Rh. sivalensis*, was in 1881 considered as possibly belonging to *Rh. palaeindicus*. Another of BAKER and DURAND's specimens, namely a symphysial part of the mandible, was thought probably to belong to *Rh. platyrhinus*. Furthermore, LYDEKKER pointed out the resemblance between still another specimen, namely the occiput already mentioned and the hinder portion of the cranium described and figured by him under the name of *Rh. sivalensis*, var. *gajensis* LYD.[1])

We see, therefore, that among BAKER and DURAND's material of the fossil *Rhinoceros indicus* not only a number of different species are contained, but even two different genera.

I thought it desirable to mention these details to make what follows comprehensible. BAKER and DURAND's paper contains a

[1]) This form was again redetermined as *Aceratherium gajense* PILG. by PILGRIM (Mem. Geol. Surv. Ind., new ser. IV, 1912). MATSUMOTO (Science Rep. Tôhoku Imp. Univ. Sendai, Japan, 2nd ser. (Geology), V, (1918—1921) rightly pointed out that according to the law of priority the name of the species must be *Acer. gajense* (LYD.).

lot of measurements among others of the cranium and occiput, both already mentioned, and of about twenty specimens of upper premolars and molars. From the above it will be clear that the measurements of the cranium may safely be used. Those of the occiput and cheekteeth [1]), however, cannot.

Apparently STREMME was not acquainted with these particulars, his tables containing, besides the measurements of BAKER and DURAND's cranium of *Rh. sivalensis*, also those of the occiput and of one tooth row [2]).

Except the cranial measurements of BAKER and DURAND's specimen and a few dental measurements which will be dealt with in the sequel, we do not dispose of more material of numbers.

A comparison between the cranium of our own fossil form with that of *Rh. sivalensis* will be made together with the discussion of the crania of the recent *Rh. sondaicus*. At this moment we shall pay attention to the differences between upper M of *Rh. sivalensis* and *Rh. sondaicus*. LYDEKKER [3]) stated: "Between the true molars of these two species, taking into consideration the small variation which I have noticed in those of the fossil, I am totally unable to discover more than one point in their plan of structure which can be taken as affording any certain indication of distinction. This point is a difference in the relative dimensions of the molars of the two species."

"Taking little worn teeth, we shall find that in *R. sivalensis* the greatest length of the anterior surface, measuring to the second "costa" [4]) of the "buttress" is exactly equal to the greatest length of the external surface; whereas in *R. javanicus* the former measurement is greater than the latter."

To illustrate this relationship, LYDEKKER gave the dimensions of:

a. M^2 of *Rh. sivalensis*, drawn in fig. 2, pl. V, 1881;

b. M^2 of *Rh. sivalensis*, drawn in fig. 5, pl. V, 1876;

c. two M^2 of *Rh. sondaicus*.

Specimen *a*, however, was later on reckoned by LYDEKKER [5]) to *Rh. sivalensis*, var. *intermedius* [6]). Though by doing so, one of

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[1]) N. B. — BAKER and DURAND's table of measurements of the cheekteeth does not indicate which of the specimens of the table have been figured.

[2]) One would perhaps be inclined to suppose that this tooth row belongs to the cranium in question. This is, however, not the case as may appear from BAKER and DURAND's text.

[3]) 1881, p. 31.

[4]) Paracone style.

[5]) Mem. Geol. Surv. Ind., ser. X, III, part 1, 1884, p. 5.

[6]) PILGRIM redetermined this tooth as belonging to *Acer. gajense*, var. *intermedium* (See Rec. Geol. Surv. Ind., XL, 1910, part 3, p. 200).

the two specimens of *Rh. sivalensis*, of which LYDEKKER gave the measurements, must be omitted, yet we may attach value to the difference mentioned, because LYDEKKER stated that in all the specimens he could procure, this relationship appeared to be constant.

In this connection I wish to observe that the structure of a rhinoceros molar is such that the length of the anterior surface decreases towards the top of the crown, while the length of the external surface increases towards the top. Consequently in a molar of *Rh. sivalensis* it will depend upon the stage of wear whether "the greatest length of the anterior surface" will be equal to or greater than "the greatest length of the external surface". It will, therefore, be clear, I believe, that the distinguishing character, which LYDEKKER discovered, will be very difficult to handle.

Now it will be remembered that the only character, which DUBOIS mentions of *Rh. sivasondaicus*, is that its molars are intermediate in this respect. I may add, that if afterwards, *Rh. sivasondaicus* should turn out to be a distinct species, we shall certainly have to admire DUBOIS for his not overlooking such a very subtle detail. As already stated, STREMME did not succeed in using this character. As to the teeth of my own fossil form they are in this respect indistinguishable from those of *Rh. sondaicus*.

Rhinoceros sondaicus DESM. fossilis.

Rhinoceros sp., G. Busk, Proc. Zool. Soc. London, 1869, p. 409, text figs. 1—4.
? Rhinoceros sondaicus Cuv. in: R. Lydekker, Cat. Foss. Mamm. in the Br. Mus. part III, 1886, p. 129.

BUSK described and figured a left and right fossilized M^2 of rhinoceros belonging to a species "not distinguishable by its dental characters from R. *sondaicus*" [1]). They were obtained from Sarawak (Borneo). Exact locality unknown. LYDEKKER provisionally referred to *Rh. sondaicus* two M^1 or M^2 of opposite sides, and three lower cheekteeth, from a depth of sixty feet in a cavern deposit at Sarawak. The upper molars were said to present all the characters of those of R. *sondaicus*.

Rhinoceros sondaicus DESM.

Rhinoceros sondaicus, Desmarest, Mammalogie, 1822, p. 399.
Rhinoceros javanicus, F. Cuvier, Hist. nat. des Mammifères, III, liv. 45, 1824, p. 2.

Of this recent species the present writer was able to examine and measure thirteen crania of adult and old individuals, being in

[1]) p. 415.

all thirteen specimens the M^3 to a smaller or greater extent abraded by wear. The National Museum of Natural History at Leyden contained five specimens; the museums of Natura Artis Magistra six, and the Zoological Institute of the University of Utrecht two. In one specimen (nº. 10 of table K) the lower jaw could not be removed without demolishing the specimen. That is the reason why length and breadth of the cheekteeth of this specimen have not been given in table N. In cranium n°. 4 only left M^2 and M^3 were present. Cranium nº. 6 wanted left P^1—M^2. Furthermore from table N will be noticed that in four specimens P^1 of either side is absent. In nearly all cases, there are, however, clear indications that this loss has taken place after the death of the animal.

Before proceeding with a discussion of the individual variation which exists both in cranium, and permanent upper cheekteeth dentition, it will be desirable to call attention to the various tables of measurements.

Table K contains, besides the measurements of the thirteen crania, already mentioned, those of:

one cranium [1]) of *Rh. sondaicus*, borrowed from FRANZ TOULA, Das Nashorn von Hundsheim, Abh. K. K. Geol. Reichsanstalt, XIX, 1902, table;

two crania of the same species, borrowed from CUVIER, Recherches sur les ossements fossiles, 1822, p. 37;

one cranium of *Rh. sivalensis*, derived from BAKER and DURAND, 1836, p. 502;

one cranium of *Rh. sivasondaicus*, derived from STREMME, 1911, p. 90 and 94;

the two fossil specimens of our own collection.

As to the measurements themselves we followed for the greater part STREMME who in his turn partly joined TOULA.

In table L all the values are expressed in % of measurement 13. The total length of the cranium could not be used as unit, because of three crania the total length was unknown. Maxima and minima have been heavy printed for *Rh. sondaicus*.

Table M contains a number of relations of certain measurements. As to the choice of the measurements we followed STREMME as

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[1]) At the time that TOULA measured this specimen, it was preserved in the Nat. Mus. of Nat. Hist. at Leyden. Apparently it has been exchanged later on.

far as possible. For *Rh. sondaicus* the greatest and smallest number of each horizontal row have been heavy printed.

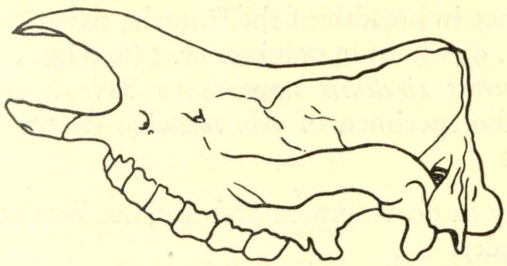
In table N the length, breadth (both measured at the base of the crown) and the relation length : breadth of each cheektooth have been united. Why this table does not contain — in contradiction to STREMME's table — measurements of premolars and molars of *Rh. sivalensis* will be clear, I believe, after what has been stated in the foregoing part. Originally we added to table N also the measurements of two cheekteeth sets which will be found mentioned on p. 39 of CUVIER's paper quoted. When it appeared, however, that in P^2—M^2 of one of these rows the relation $\frac{\text{length}}{\text{breadth}}$ not inconsiderably exceeded the highest value found in the corresponding teeth of twelve foregoing crania it was thought better to exclude them from our table.

As will be seen we have given all dental measurements in mm. STREMME, however, in tenths of mm. In my opinion this is absolutely superfluous. For, though the structure of a rhinoceros tooth certainly permits exact measuring of the breadth, it surely does not allow of measuring the exact length of the tooth. Moreover it must not be forgotten that length as well as breadth of corresponding teeth of opposite sides may differ distinctly.

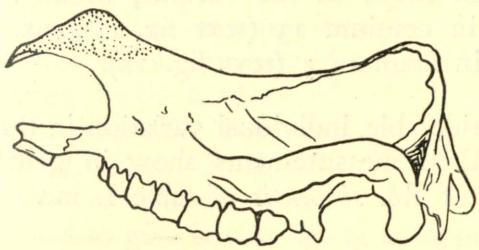
In table O, at last, the breadth and length have been expressed in % of resp. the breadth and length of the fourth premolar. Both in table N and O maxima and minima found for the teeth of *Rh. sondaicus* have been heavy printed.

We shall now return to the measurements of the sixteen crania of *Rhinoceros sondaicus*. Both from table L and M it will be seen that even such a relatively small number of specimens already may show a considerable individual variation. Especially concerning some points there appears to exist noticeable differences between the crania of the present species. In this respect we may bring forward:

a. The great differences in degree of depression of the frontal region; smallest in cranium n°. 5 (text fig. 7), greatest in cranium n°. 8 (text fig. 8). Both text figures show, moreover, clearly that a feeble frontal depression coincides with slightly curved nasals. Table L exhibits, furthermore, decidedly that whereas the difference between the greatest and smallest value, found for m. 6 in 16 crania of *Rh. sondaicus* is 18 %, the greatest value is exceeded by no less than 22 % by the only cranium of *Rh. sivalensis*.



Text fig. 7.



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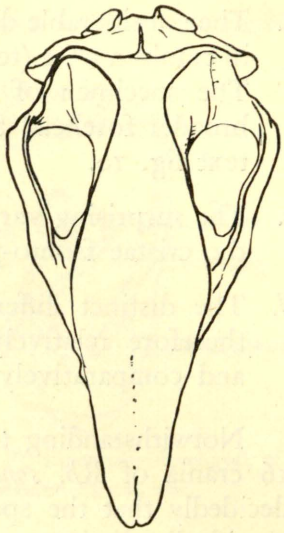
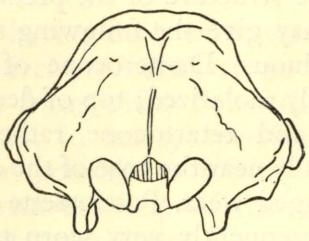
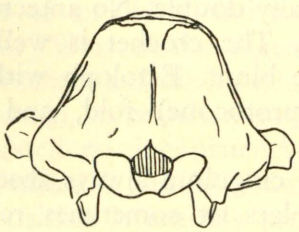


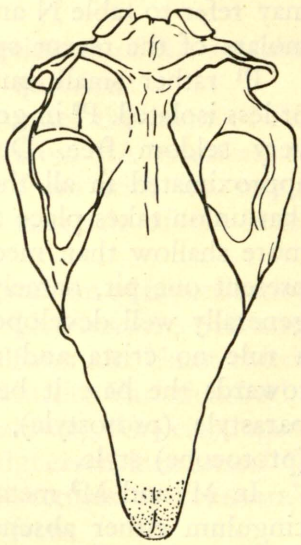
Text fig. 9.



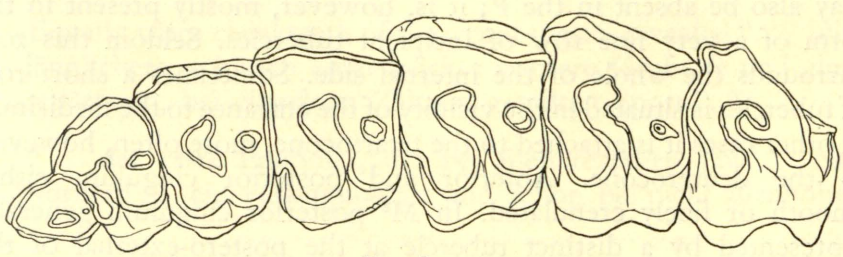
Text fig. 11.



Text fig. 12.



Text fig. 10.



Text fig. 13.

Text figs. 7—13. *Rhinoceros sondaicus* (recent). Text figs. 7—12 of approximate equal size ($^1/_9$ nat. size). Text fig. 13 ($^1/_2$ nat. size).

b. The considerable difference in breadth of the frontals, narrowest in cranium nº. 2 (text fig. 9), widest in cranium nº. 1 (text fig. 10). The specimen of *Rhinoceros sivalensis* appears to have a still broader forehead than the specimen of *Rh. sondaicus* drawn in text fig. 10.

c. The surprising variability in development and distance between the cristae fronto-parietales.

d. The distinct differences in shape of the occiput; broad and therefore relatively low in cranium 13 (text fig. 11), narrow and comparatively high in cranium 3 (text fig. 12).

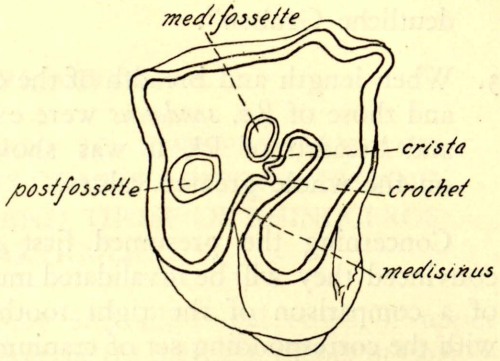
Notwithstanding the considerable, individual variation in these 16 crania of *Rh. sondaicus*, their measurements show in general decidedly that the specimen of *Rh. sivalensis* of table L must be specifically distinct.

As to the individual variation of the dental measurements I may refer to table N and O. Of the structure of the premolars and molars of the recent species we may give the following summary.

P^1 rather small, but not deciduous. Deuterocone of P^2 more or less isolated. P^3 in general entirely molarized; top of deuterocone very seldom free. Deuterocone and tetartocone rather closely approximated in all the P, especially near the base of the crown, so that union takes place after prolonged wear. Postfossette distinctly more shallow than medisinus; consequently very worn teeth only present one pit, namely the buccal part of the medisinus. Crochet generally well developed, occasionally double. No antecrochet. As a rule no crista and medifossette. The crochet is well defined, towards the base it becomes more blunt. Ectoloph with distinct parastyle (protostyle), paracone (protocone) fold, and paracone (protocone) style.

In M^2 and M^3 metastyle. Outer cingulum always absent; inner cingulum either absent in the molars or sometimes represented by a small tubercle at the entrance to the medisinus. Inner cingulum may also be absent in the P; it is, however, mostly present in the form of a very fine row of incipient tubercles. Seldom this row surrounds the whole of the internal side. Sometimes a short row of tubercles is situated in the vicinity of the entrance to the medisinus, in other cases it is attached to the tetartocone, more often, however, to the deuterocone. Anterior and posterior cingulum either smooth or finely crenulated. In M^3 posterior cingulum generally represented by a distinct tubercle at the postero-external of the crown. An incipient secondary enamel fold in the postfossette of the premolars may occasionally occur.

Lastly I will bring to the attention the following noticeable peculiarity. The right P^3 of cranium n°. 2 appeared to be in the possession of a well developed crista which had regularly united with the crochet, forming a medifossette. It is remarkable that none of the other teeth of the cranium in question show any trace of a crista. By the kindness of the director of the Nat. Mus. of Nat. Hist., Prof. Dr. E. D. VAN OORT, I am enabled to give in text fig. 14 an upper view of the specimen, made after a photograph, taken for me in Leyden.



Text fig. 14. Right P^3, abnormally developed, of *Rhinoceros sondaicus*. $^4/_5$ nat. size.

After having dealt with cranium and cheekteeth of *Rh. sondaicus* so extensively, we shall try to answer the question:

Is the form, which STREMME described under the name of *Rh. sivasondaicus*, in reality specifically distinct from *Rh. sondaicus*, or will it be possible to identify STREMME's form with the recent species with the help of the more ample materials of the latter we had at our disposal?

After a detailed comparison of the fossil cranium of his collection with that of an old ♂ and a young ♀ of *Rh. sondaicus*, STREMME concluded: "Weist so die allgemeine Schädelform nur Unterschiede von der rezenten auf, die innerhalb der individuellen Variationsbreite liegen können, so bestehen doch in der Bezahnung Abweichungen, die die Aufstellung einer neuen Art gerechtfertigt erscheinen lassen" [1]). My own tables L and M show that the correctness of STREMME's first supposition is entirely proved by the facts.

The differences in the dentition which STREMME noticed are:

1. Equally worn cheekteeth of the recent species revealed ". . . . eine länglichere, schwach eingedrückte vordere Grube [2]) und einen schärferen, bei einzelnen Zähnen geteilten Sporn". [3])

2. " . . . der erste Prämolar, der bei allen rezenten Java . . . Nashörnern . . . ein verkümmerter und schon bei nicht allzuhohem

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[1]) p. 91.
[2]) Meant is "prefossette".
[3]) p. 91.

Alter abgekauter Zahn war, ist hier bei der abgekauten Zahnreihe des fossilen Nashorns noch relativ stattlich und zeigt zwei deutliche Gruben".

3. When length and breadth of the cheekteeth of STREMME's form and those of *Rh. sondaicus* were expressed in % of resp. length and breadth of P^4, it was shown that STREMME's form gave on the whole greater values.

Concerning the presumed first and second difference, I am convinced they will be invalidated much more rapidly with the help of a comparison of the right toothrow of STREMME's specimen with the corresponding set of cranium 5 of *Rh. sondaicus* and drawn (after a photograph) in text fig. 13, than by means of a lot of words.

As to the third difference I may refer to my own table O. Though I immediately admit that still the breadth of P^1, P^3 and M^1 of "*Rh. sivasondaicus*" show the greatest values, we may be absolutely sure that also these differences would disappear, if but we had been able to collect the measurements of some more crania of the recent *Rh. sondaicus*.

As, moreover, the other rhinoceros remains, which STREMME described, do not afford any reason for specific distinction I conclude:

The fossil form described by STREMME *under the name of Rh. sivasondaicus* DUB. *is specifically indistinguishable from the recent Rh. sondaicus, and must therefore be called Rhinoceros sondaicus* DESM. *fossilis.*

At last our own fossil cranium (specimen *a* of the tables).

Both from the tables and from comparison of the description of the specimen in question with our enumeration of cranial and dental characters and peculiarities of *Rh. sondaicus* appears —without leaving a shade of doubt — that also our form is specifically identical with the recent *Rh. sondaicus*, and consequently also with STREMME's specimen.

APPENDIX.

ON THE TERMS APPLIED TO THE PRIMARY AND SECONDARY ELEMENTS OF UPPER PREMOLARS AND MOLARS IN GENERAL AND THOSE OF RHINOCEROS IN PARTICULAR.

The terminology of primary and additional cusps of upper premolars and molars, based upon the tritubercular theory of COPE—OSBORN, was originally as follows:

Primary cusps	Protocone	for	Antero-internal	cusp
	Hypocone	„	Postero- „	„
	Paracone	„	Antero-external	„
	Metacone	„	Postero- „	„
Additional cusps	Protoconule	„	Antero-intermediate	„
	Metaconule	„	Postero- „	„

SCOTT's [1]) investigations, however, lead him to the conclusion that the cusps of the premolars were not homologous with the corresponding ones of the molars. Accordingly he proposed a series of new names, which are for the primary cusps of upper premolars as follows:

Primary cusps	Protocone	analogous	with	paracone	of molars
	Deuterocone	„	„	protocone	„ „
	Tritocone	„	„	metacone	„ „
	Tetartocone	„	„	hypocone	„ „

As regards the upper premolars OSBORN accepted in full SCOTT's interpretation.

SCOTT was convinced that the conules of the premolars were not homologous with those of the molars. ("In position these conules correspond to the proto- and metaconules of the molars, but are obviously not homologous with them") [2]). He

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[1]) The Evolution of the Premolar Teeth in Mammals. Proc. Acad. Nat. Sci., Philadelphia, 1893, p. 405—444.

[2]) Loc. cit. p. 413.

committed, therefore, an incompleteness in not proposing new names for the conules of the premolars. OSBORN, too, failed to do so.

I should not have been at all surprised if OSBORN had not accepted SCOTT's new names for the primary cusps of the upper premolars. This assertion will be sufficiently explained by the following quotation. OSBORN [1]) in dealing with the subject of nomenclature observes: ". . . . the system of terms was originally based upon the actual homologies of the primary elements of the trigon and trigonid, but in extending it to the other parts of the crown and to the secondary cusps it was found that we must apply similar terms to some of the later elements in the upper and lower teeth, which are merely analogous to each other . . . ., *otherwise the terms soon multiply, so as to become a burden rather than a convenience*" [2]).

Perhaps the present writer should not have ventured to draw attention to these points, were it not that OSBORN had been inconsistent in another point. At the same time that OSBORN introduced the terms proto-, para-, meta- and hypocone for the primary cusps of the upper premolars and molars, he proposed namely some new names for the peripheral pillars, which occur in the upper cheek teeth of all ungulates. In view of the rhinoceros premolar and molar there are two pillars which may interest us, namely those which OSBORN gave the names of parastyle and metastyle, the prefixes (para-, meta-, etc.) being applied ". . . according to their proximity to the cones . . . ." [3]). One should expect that OSBORN after acceptance of SCOTT's terms "proto-, deutero-, trito- and tetartocone" for the primary cusps of the upper premolars, should have named the antero-external and postero-external pillar of the premolar resp. protostyle and tritostyle, instead of parastyle and metastyle. He did not, however. See e. g. figs. 116 and 192 in OSBORN's work "Evolution of Mammalian Molar Teeth".

Some subsequent investigators — I may mention ZDANSKY [4]) and COOPER [5]) — apparently met with the same inconsistency, for they use the term protostyle for the antero-external pillar of the premolars. It is, however, an enigma to me, why COOPER —

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[1]) Evolution of Mammalian Molar Teeth. Biological Studies and Addresses, vol. I, 1907, p. 69.

[2]) The italics are ours.

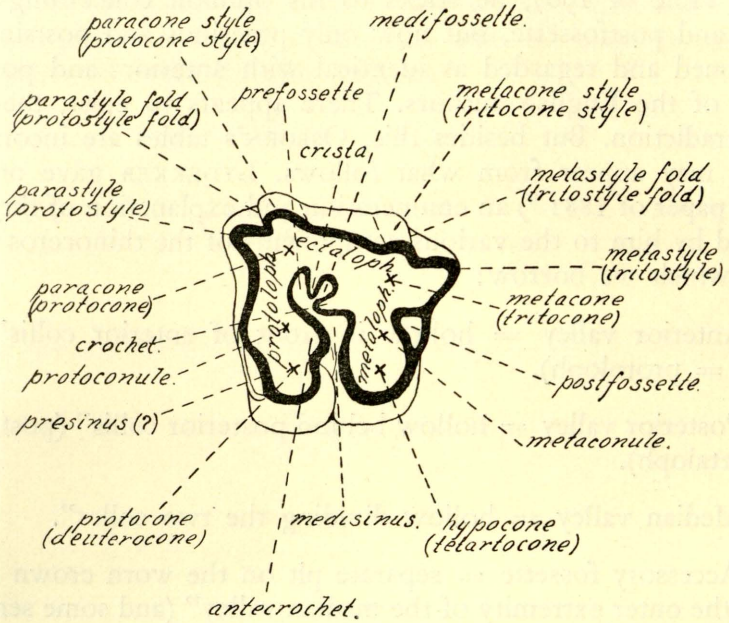
[3]) OSBORN (1907), p. 70.

[4]) OTTO ZDANSKY, Die Säugetiere der Quartärfauna von Chou-k'ou-tien. Palaeontologia Sinica, Ser. C, V, fasc. 4, 1928.

[5]) C. F. COOPER, On the skull and dentition of the Paraceratherium bugtiense. Phil. Trans. Royal Soc. of London, Ser. B, vol. 212, 1923—1924.

in whose specimens of premolars also the postero-external pillar was developed — does speak of protostyle, and not of tritostyle instead of metastyle [1]).

Turning now to the rhinoceros premolar and molar of the upper jaw, we have only some remarks to add. After what preceded



Text fig. 15. Diagram of a hypothetic left upper cheek tooth of rhinoceros showing the terms applied to the various components of upper premolars and molars. (The terms which only refer to premolars are placed in parenthesis.)

it will need no explanation why we used, in describing the premolars of *Rhinoceros sondaicus fossilis*, the terms protostyle fold and protocone style. As to the greater part of the remaining terms I may refer to text fig. 15. It will only be desirable to pay attention to OSBORN's terms praesinus, medisinus and postsinus. As far as my knowledge goes OSBORN gave twice viz., in 1898 [2]) and 1907 [3]), a table in order to show the parallelisation between his terms and those of former authors. Of course hereafter only the terms applied to the rhinoceros tooth will interest us. His table of 1898 contains the terms medisinus and postsinus, which he regarded as identical with resp. anterior and posterior valley of the English authors

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[1]) See e. g. COOPER, p. 382.

[2]) The extinct Rhinoceroses. Mem. Amer. Mus. Nat. Hist. I, pt. 3, 1898.

[3]) Loc. cit.

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[BOYD DAWKINS (1867), BUSK (1877), LYDEKKER (1881) [1]), FOOTE (1874)]. According to the same table the authors above mentioned should not have used terms identical with OSBORN's prae-, medi- and postfossette. Without any further explanation OSBORN speaks, furthermore, dealing in the text [2]) with the rhinoceros molar of "the three inner valleys ... presinus, medisinus and postsinus". In his table of 1907, he sticks to his opinion concerning prae-, medi- and postfossette, but now only praesinus and postsinus are mentioned and regarded as identical with anterior- and posterior valley of the English authors. There appears to exist, therefore, a contradiction. But besides this, OSBORN's tables are incomplete, which may appear from what follows. LYDEKKER gave on p. 8 of his paper of 1881 [3]) an enumeration and explanation of the terms applied by him to the various components of the rhinoceros molar, from which we borrow:

"Anterior valley = hollow in front of anterior collis" (ant. collis = protoloph).

"Posterior valley = hollow behind posterior collis" (post. collis = metaloph).

"Median valley = hollow dividing the two colles".

"Accessory fossette = separate pit on the worn crown cut off from the outer extremity of the median valley" (and some sentences further) "caused by the union of the crochet and combing-plate" (combing-plate = crista).

Furthermore, it may be mentioned that LYDEKKER did not distinguish rigorously between the term valley and fossette, which appears from this quotation: "When worn down" the "tooth .... would present two fossettes on the crown (formed by the outer part of the median valley and by the posterior valley)" [4]). With these data it is not difficult to introduce the following corrections:

medisinus = median valley,

postfossette = posterior valley,

medifossette = accessory fossette.

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[1]) OSBORN mentions 1882, but apparently meant 1881 as I do not know a publication of LYDEKKER on rhinoceroses of 1882.

[2]) OSBORN, 1898, p. 105.

[3]) Siwalik Rhinocerotidae, Mem. Geol. Surv. of India, ser. X, II, part 1, 1881.

[4]) Loc. cit. p. 16.

OSBORN [1]) meant by postsinus the vestige of the primitive valley, which may occur in the third upper molar of some species between the ectoloph and the posterior surface of the metaloph. This pit, therefore, is apparently considered as not homologous with the postfossette of the remaining premolars and molars. I cannot, however, see the reason. What OSBORN meant by the praesinus of the rhinoceros molar I have not succeeded in detecting. I believe, however, that it is identical with the anterior valley of LYDEKKER and other English authors.

[1]) See OSBORN 1898, p. 142.

Fam. HIPPOPOTAMIDAE.

The genus *Hippopotamus* is represented in our collection by a number of remains which all — with the exception of one specimen— have been excavated NNW. of Bumiaju at the base of the vertebrate beds. The exact locality of each specimen will be mentioned in dealing with each remain separately. After the description of all the specimens we shall draw a comparison between the remains of our collection and the fossil specimens which hitherto have been found in SE. Asia, and Java.

Hippopotamus sp.

Right horizontal ramus of the mandible.

Pl. VI, figs. 1 and 2; Pl. XIX, fig. 1.

Locality: Bumiaju, Excavation 1—4 at K. Glagah [1]).

State of preservation.

At the back broken off some cm. behind the posterior extremity of M_3. All the I are lost; three alveoli in the anterior border of the ramus mark distinctly the presence of three I in this half of the mandible. C is partly preserved, being broken off about 4 cm. above its alveolar margin. P_1 is lost; a dark coloured spot in front of the P_2 indicates, however, its alveolus filled with matrix. For the rest the whole dentition is present. M_1 is slightly damaged on its postero-internal angle. The posterior half of M_3 is for the greater part wanting.

Cheek teeth dentition.

The premolars, except P_1 which probably was one-fanged, consist of a single cone, supported by two fangs. P_2, which is hardly worn, points strongly forward, so that — whereas the fangs of P_2 and P_3 are closely approximated — the interval between the top of P_2 and the middle of the worn summit of P_3 is not less than 4 cm. In P_2 and P_3 a relatively slightly developed cingulum occurs on the anterior and internal side, but not on the external

[1]) See sketch map n°. 1.

and posterior side. In the succeeding P_4 also on the posterior side the cingulum is distinctly developed.

M_1 is very much worn. Internal and external cingulum are totally wanting. The cingulum is only present on the anterior side. On the posterior side it occurred probably too, but must have disappeared by the process of trituration. The degree of wear of M_2 is also considerable. In front the dentine islets of protoconid and metaconid [1]), and in back those of hypoconid and entaconid, have wholly become confluent, while even a narrow connection already occurs between the dentine of anterior and posterior lobe. M_2 shows a well developed cingulum on its anterior and posterior side; internal and external side are — just as in M_3 — devoid of a cingulum. M_3, the posterior extremity of which is lost, shows a thick anterior cingulum and an undamaged, worn, anterior lobe, clearly consisting of two rather regular trefoils, which are already united for the greater part. These trefoils are formed by the fact that each cone is pinched in by vertical grooves on its anterior and posterior face. Of the second lobe only the enamel of the front side of hypoconid and entaconid has been preserved. These remnants show, however, that hypoconid and entaconid also present trefoils after wear.

The enamel of molars and premolars is smooth and does not show striations or other sculptures.

The mandibular toothrow is approximately straight from M_3 up to and including P_3. Its frontmost portion, however, formed by P_2 and P_1, is considerably curved outwards.

Horizontal ramus.

The horizontal ramus shows the typical form of the corresponding part of a hippopotamus mandible and need no detailed description. It will suffice to refer to the measurements and to figs. 1 and 2 of pl. VI in which upper and front aspect are given, and to fig. 1 of pl. XIX in which a side view is represented. Stress may be laid, however, upon the occurrence of three I. The alveoli of I_1 and I_2 are of subequal size, that of I_3 is smaller than either of the others. The lower alveolar margin of I_2 is situated somewhat above the alveolar border of I_1 and distinctly above that of I_3. C is too much injured, to fix its form in cross-section. Its enamel shows regular longitudinal striations.

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[1]) OSBORN in his well-known work „Evolution of Mammalian Molar Teeth" nowhere deals with the hippopotamus cheek teeth separately, so that there exists some uncertainty in respect of the terminology of some of the cusps. I have applied the term metaconid (and not paraconid) to the antero-internal cusp from the evidence of the terms occurring in OSBORN's text fig. 152 in which are represented some lower teeth of a primitive artiodactyl.

The M_3 of the specimen in question having been fully in use, we may be sure that it belonged to an adult individual.

Lower Jaw.

Pl. VII, figs. 1 and 2; Pl. XVIII, fig. 3; Pl. XIX, fig. 2.

Locality: Bumiaju, Excavation 1—4 at K. Glagah.

State of preservation.

The left half of the present specimen is in general better preserved than the right one. Of the left half the anterior and posterior surface of the ramus are injured, the top of the coronoid process is broken off, while — which is very unfortunate — the descending plate of the ramus, so peculiar to the present genus, is for the greater part lost. As will be known this descending plate apparently furnishes specific characters [1]). Of the right half the anterior border of the ramus is damaged and the greater part of the lower posterior moiety of the ramus has disappeared. The coronoid process, however, is remarkably well preserved.

The left C, apart from small injuries, is complete. The right C is broken off about 3—5 cm. above its alveolar margin. As a result of the considerable injuries of the front border of the mandible a good deal of the alveolar portion of both canines have been laid open on their anterior face. Left and right P_1 are wanting. Just as in the foregoing specimen the alveole of P_1 is filled with matrix and is indicated by a dark coloured, circular spot in front of P_2. In all probability P_1 was therefore one-fanged. Of the left P_2 only the posterior fang is preserved while the alveolus of the anterior fang is again marked by a dark coloured, circular spot in the bone material. The right P_2 is broken off close to the base of its crown; the two fangs and the enamel of the posterior side of the crown are present. The top of the left P_3 is injured; the right P_3 has disappeared. The left P_4 is undamaged; the right P_4 injured on its external border. M_1, M_2 and M_3 of either side are present, all injured to some extent, but, in general, well preserved. I, in situ, do not occur. To this mandible belongs, however, a detached I which is represented in pl. XVIII, fig. 3.

Cheek teeth dentition.

The resemblance between the premolars of the present lower jaw with those of the foregoing specimen is so close that a description would be a needless repetition.

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[1]) See FALCONER, Palaeontological Memoirs, I, 1868, p. 135.

All three molars are considerably abraded by wear; M_1, of course, most of all. The structure of the molars is very similar to those of the specimen just described. They show the typical pattern of a worn hippopotamus molar. M_1, M_2 and M_3 possess a strong anterior and posterior cingulum; both M_3 show the common feature of a strong posterior talon, consisting of three to four cusps. External and internal cingulum are either totally wanting or very slightly indicated. If we have a close look at the grinding surface of the left M_3, we can state that, whereas the worn metaconid, protoconid and hypoconid present a more or less regular trefoil-shaped dentine islet, the entaconid is not, or hardly pinched in by vertical grooves on its posterior and anterior face. The same feature will be seen in the right M_3 and in the left and right M_2. (M_1 is too much damaged).

The enamel of the molars is smooth and without striations or other sculptures. Each toothrow is in its posterior half approximately straight; its anterior half is clearly curved outwards.

The degree of wear of the cheek teeth is somewhat less than of the foregoing specimen. As M_3, however, has been fully in use, the mandible in question certainly belonged to an adult individual.

The detached I, which is broken off 126 mm. from its top, is compressed in cross-section, greatest and smallest diameter being resp. 24 and 18 mm. The same shape in cross-section is maintained throughout the posterior half; towards the top a very gradual tapering occurs. The whole tooth is, furthermore, slightly bent. Its top is obliquely truncated on the convex surface. The thin enamel is smooth. As we do not know, whether in the present fossil form the incisors were abraded on the external or internal surface, it is impossible to decide whether the incisor under consideration must be reckoned to be a right or a left I.

As has been already mentioned the anterior surface of the mandible is considerably damaged, especially the upper third. It will, furthermore, be remembered that the former place of P_1 of either side is marked by a dark coloured spot, representing the alveole filled with matrix. It will be clear, that if the anterior surface of the mandible exhibits dark coloured spots with a regular form, these represent either foramina or alveoli of incisors, filled with matrix. The right half of the anterior surface showed indeed dark coloured spots in a light coloured material. A microscope section revealed that the light coloured material consisted of calcined bone, the dark coloured material of a tuffoid substance. As the damaged, anterior surface of the mandible was very irregular, it was very difficult to decide whether the dark coloured spots were regular

in shape or not. The regular outline of these spots was, however, splendidly revealed by grinding a plane to the upper portion of the right half of the mandible [1]). The result can be seen in Pl. XIX, fig. 2. If this figure be compared with fig. 2 of pl. VI it will easily be seen that the three uppermost spots represent the alveoli of I_1, I_2 and I_3, while the lower spot marks the place of a foramen mentale. In consequence of the grinding and the inward slope of the grinded plane, the three uppermost spots cannot be taken as representing the real outline of the incisors at the alveolar margin. They do show, however, the mutual position of the incisors, revealing that also in this respect there is a great resemblance between the present lower jaw and the specimen described above.

C are pearshaped in cross-section; the top of the pear is directed backwards and inwards. The left canine, which is nearly complete, shows the usual strong curvature; it is obliquely truncated on its posterior surface over a considerable distance. Due to the injury of the ramus the "fang" of both C can be seen, the posterior surface of the fang of the left canine exhibits a shallow broad groove. The posterior surface of the right canine is in too damaged a condition to show this feature. As in the foregoing specimen the enamel of the canines is provided with fine regular, longitudinal striations.

The lower jaw itself does not present peculiarities which need description. Its form may be easily judged from the figures. In what follows we shall have an opportunity of reverting to the relations between certain of its measurements.

Fragmentary lower jaw.

Pl. XX. fig. 2.

Locality: Bumiaju, Excavation 13(?) [2]).

State of preservation.

Very damaged specimen, on either side broken off some cm. behind the posterior extremity of M_3. The left half still possesses a portion of the descending plate, expecially a good deal of its anterior border. The upper surface of the anterior half of both horizontal rami and the whole front border of the mandible are

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[1]) Fig. 2 of pl. VII shows the original state in which the specimen was received.

[2]) The specimen in question was contained in one of the cases (n°. 17) of the fourth sending. Though it did not occur on the list of specification, we may be sure that it has been secured in one of the excavations near Bumiaju, as the case referred to contained only specimens of various excavations near that village. Furthermore it is not improbable that the specimen under consideration, which showed the number 13, has been found in excavation 13.

very considerably injured. Due to this fact both C, all the I, P_1—P_4 of either side are wanting. Even no remains of the alveoli of the incisors can be seen.

Of the cheek teeth dentition only fragmentary left and right M_1, left and right M_2, (right one injured) and right M_3 are preserved.

The whole fragment, furthermore, has been subjected to a crushing force, which fact is clearly shown by the unusual oblique position of the left ramus with reference to the right one. M_3 having been in use the mandible in question belonged to an adult specimen.

If the remaining molars be compared with those of the foregoing specimens it will be seen that there are no essential differences in structure. Only the manner of wear is somewhat different. Both M_1 are in too damaged a condition and too incomplete to show much of their structure. Both M_2 and the M_3 show a strong anterior and posterior cingulum while — as in the molars of the foregoing specimens — external and internal cingulum are practically absent. Just as in the molars of the mandible described just before, the entaconid presents a simple structure, its anterior and posterior face not being pinched in and, therefore, not presenting a trefoil-shaped dentine islet.

Fragmentary upper jaw.

Pl. VI, fig. 3 and 4.

Locality: Bumiaju, Excavation 8.

The present specimen consists of the detached corresponding parts of left and right maxillary, each containing M^1—M^3.

In both fragments the structure and the degree of wear of the cheek teeth are exactly the same. The state of fossilization and the colour are also strikingly alike. The cheek teeth of the one fragment being furthermore almost exactly the reflected image of the other, we may be sure that both fragments belong to one another. It was, indeed, possible to match both fragments with a tolerable degree of certainty.

The preservation of the teeth is splendid. The degree of wear is considerable, M^1 being ground down near to the bottom of its transverse valleys. The four cusps of M^3 are abraded by wear into distinct trefoils. The trefoil-shaped dentine islets of protocone and paracone in front, and those of hypocone [1]) and metacone in back,

[1]) Perhaps this cusp ought to be called: metaconule, for OSBORN (Evolution of Mammalian Molar Teeth, 1907, p. 173) mentions: „In all Artiodactyls the metaconule is very large, often replacing completely the cingulum-hypocone". See also the note on p. 83.

have, however, not yet become confluent. The structure of M^1, M^2 and M^3 is very similar and relatively simple.

Each tooth consists of four cusps, the inner ones are wider than the outer ones, the longitudinal valley being consequently situated buccally of the longitudinal median line of the tooth. Each cusp wears into a rather regular trefoil, anterior and posterior face of each cusp being pinched in by vertical grooves. A cingulum surrounds the whole of the crown. It is especially strongly developed on the anterior and posterior surface, giving rise, in M^2 and M^3, to something which may be called resp. front and back talon. Inner and outer cingulum are on the whole crenulated; they obstruct the entrances to the transverse valley. The enamel is in general smooth and not sculptured.

Detached lower canines.

spec. a. Locality: Bumiaju, Excavation 9, Pl. V, fig. 5.

spec. b—e. „ „ „ 8.

The pearshaped cross-section of spec. a and b, together with the fact that they are truncated of the concave side, show that they represent lower canines. Specimen a is figured, being the one which is best preserved. Its left side shows but a very slight curvature across, whereas the right side is strongly convex in the same direction. The left C of the lower jaw described on page 84 has its *outer* side strongly curved proving that spec. a represents a right C. All the specimens are strongly curved; the top is obliquely truncated and the enamel provided with fine, regular, longitudinal striations, which are parallel to the curvature of the tooth. Spec. b is a left lower C. It differs from spec. a in having on its inner side a shallow, broad, longitudinal groove which occupies the middle portion of the inner face along the whole length of the tooth. Spec. a shows a similar groove on its posterior surface. Whether this groove is also present in spec. b cannot be ascertained as the whole posterior surface has been restored with plaster.

Spec. c—e are longitudinal halves of lower C. They need no detailed description, as their resemblance to the foregoing specimens is very close.

The measurements of spec. a are:

Length along outer curve	285 mm.
Greatest transverse diameter at base . .	37 mm.
Smallest ditto	24 mm.

Hinder portion of cranium.

Pl. XVIII, figs. 1—2; Pl. XIX, fig. 3.

Locality: Watualang [1]).

This specimen represents that part of the cranium situated behind a plane which contains the (broken) tips of both zygomatic processes of the squamosal and which intersects the frontals at a distance of 14 cm. from the occipital crest.

The preservation of the present fragment is exceedingly fine. Only the left petrosal has fallen out and the right paroccipital process has broken off.

The degree of fossilization is notoriously small; the holes between the spongiosa of the bone are unfilled and the surface of the bone has a very recent appearance. Of our whole collection in the specimen under consideration the process of fossilization has least progressed. Of course, this need not to be regarded as an indication of a young age. Fossilization does not depend upon mere time.

The occipital surface is comparatively broad and low. Regarded in hind aspect, the occipital crest is strongly and regularly convex. The sagittal crest is thin in its anterior extremity, that is to say, at the point where the cristae fronto-parietales meet. From that point the sagittal crest becomes gradually wider towards the occipital crest, thus exhibiting a very gradual transition into the latter. Both cristae fronto-parietales are thin, sharp ridges. The braincase is narrow, the curvature of the parietals being from above downwards but slight. As will be seen from Pl. XVIII, fig. 2, the frontals extend far backwards, so that only a narrow space remains between the cristae fronto-parietales and the suture between frontals and parietals. Pl. XVIII, fig. 1 shows that if the occiput is placed vertically, the upper surface of the braincase slopes distinctly forwards.

The specimen in question probably belonged to an immature individual, as the various bones are not yet ankylosed, but separated from one another by clearly visible sutures.

We shall have to compare our fossil specimens with the following species:

Hippopotamus sivalensis.

Hippopotamus (Hexaprotodon) sivalensis, H. Falconer and P. T. Cautley, Asiat Researches, XIX, 1839, p. 39 (reprinted in Pal. Mem. I, 1868, p. 130); Fauna Antiqua

[1]) District Ngawi, Regency Ngawi, Residency Madiun.

Sivalensis, 1845, pl. LIX—LXI, pl. LXII, figs. 1—10, pl. LXIII—LXVI (name and figures); Pal. Mem. I, 1868, p. 142.
Hippopotamus sivalensis, R. Lydekker, Mem. Geol. Surv. India, ser. X, III, 1884, p. 37; Cat. Foss. Mamm. Br. Mus., II, 1885, p. 297; G. E. Pilgrim, Rec. Geol. Surv. India, XL, 1910, p. 202 and 203, Rec. Geol. Surv. India, XLIII, 1913, p. 324.
Hexaprotodon sivalensis, W. D. Matthew, Bull. Am. Mus. Nat. Hist., LVI, 1930, p. 557.

This species was founded by FALCONER and CAUTLEY on the evidence of an almost complete cranium from the Siwaliks. It was figured in the Fauna Antiqua Sivalensis (pl. LIX, figs. 1—1*b*), together with numerous specimens of crania, lower jaws, vertebrae, limbbones, etc., apparently all obtained from the Siwalik Hills. The name *Hexaprotodon* was originally applied in a sub-generic sense, but was — according to LYDEKKER — adopted as a generic term by OWEN. LYDEKKER pointed out in 1884 that among the material of *H. sivalensis*, preserved in the British Museum, probably two different varieties were represented, which he provisionally distinguished as var. *latidens* and var. *augustidens*, only on the ground of the different breadth of the upper true molars. The type specimen of *H. sivalensis* was reckoned by LYDEKKER to var. *latidens*. There existed some more cranial differences between both varieties, but two other crania, which showed transitional characters concerning the latter differences, prevented LYDEKKER from considering var. *augustidens* as a distinct species. From the catalogue of the Br. Mus. in which — as will be known — LYDEKKER gave his last, definite opinion it is not difficult to infer that he thought it better to cancel both varieties.

Besides extensive references to specimens of the Br. Mus. LYDEKKER shortly described and figured in his paper of 1884 a fragmentary lower jaw from the Punjab, which he had originally considered as possibly belonging to *H. iravaticus* [1]). Subsequent examination of the original specimens on which the latter form was founded, convinced him that the lower jaw under consideration was too large and had too short a symphysis to belong to *H. iravaticus*. LYDEKKER thought it, however, not improbable that it would be identical with the form which he had provisionally termed *H. sivalensis*, var. *augustidens*.

In a faunal list given by PILGRIM in 1910, the latter variety is said to occur in the Middle and Upper Siwaliks of the Salt Range (near Asnot and Dhok Pathán), and *H. iravaticus* in the Middle Siwaliks of Yenangyaung (Burma) and Asnot. In a subsequent paper PILGRIM (1913) recorded only the latter form from the Dhok Pathán Zone (mid Middle Siwaliks), and not a single mention is made of *H. sivalensis*, var. *augustidens*.

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[1]) Rec. Geol. Surv. India, XV, p. 32.

MATTHEW, who in the winter of 1926—1927 had the opportunity of making a critical re-examination of the type collections of the Siwalik fauna preserved in the Indian Museum in Calcutta and in the British Museum in London, records only *H. iravaticus* from the Middle Siwaliks [1]) and *H. sivalensis* from the Upper Siwaliks [2]). He apparently does not accept any variety of the latter species.

As to the specific characters of the present form we may quote the summary which LYDEKKER gave in 1885 viz.,

"This species is somewhat smaller than the existing *H. amphibius*, and has three incisors in both jaws, those of the mandible being of subequal size; the groove in the upper canine is much deeper than in *H. amphibius*, and the mandibular symphysis relatively longer." [3])

As will be known, LYDEKKER included in the genus *Hippopotamus* both *Hexaprotodon* and *Tetraprotodon* FALC. et CAUTL. His reasons were that "*Tetraprotodon*" *palaeindicus*, appeared in reality to be in its lower jaw a *Hexaprotodon* while, moreover, an instance of unilateral hexaprotodontism in *H. amphibius* [4]) was known. MATTHEW remarked that the only character he could find to separate *Hexaprotodon* is the presence of six subequal incisors. This being the state of affair, it is, of course, merely a matter of taste whether or not one will use the term *Hexaprotodon*.

Hippopotamus iravaticus.

Hippopotamus (Hexaprotodon) iravaticus, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis. 1845, pl. LVII, figs. 10—11, pl. LXXXIII, fig. 12 (name and figures); Pal. Mem. I, 1868, p. 142; Pal. Mem. II, 1868, p. 406.

Hippopotamus iravaticus, R. Lydekker, Cat. Foss. Mamm. Br. Mus., II, 1885, p. 309; G. E. Pilgrim, Rec. Geol. Surv. India, XL, 1910, p. 196 and 203; Rec. Geol. Surv. India, XLIII, 1913, p. 285 and 300.

Hexaprotodon iravaticus, H. Falconer, Journ. Ac. Nat. Sci. Philad., ser. 2, I, 1849, p. 237; W. D. Matthew, Bull. Am. Mus. Nat. Hist., LVI, 1930, p. 557.

The present form was founded by FALCONER and CAUTLEY on the evidence of two specimens of the symphysis, obtained from Burma. They will be found figured in pl. LVII of the Fauna Antiqua Sivalensis. In fig. 12 of pl. LXXXIII of that work the distal end of a radius is figured under the name of *Hippopotamus* (*Hexaprotodon*) *iravaticus*. According to LYDEKKER this specimen has also been derived from Burma. Finally FALCONER reckoned to the species

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[1]) p. 449.

[2]) p. 444.

[3]) p. 297.

[4]) From the evidence of *H.palaeindicus*, the lower I_2 of which is about to disappear, LYDEKKER concluded that also in *H. amphibius* it is the second incisor which is wanting. But here LYDEKKER was wrong as subsequent investigations showed that the very young milk dentition still possesses the third upper and lower incisor, and that it is I_3 which disappears (See MAX WEBER, Die Säugetiere, II, 1928, p. 546).

in question the distal end of a radius and femur which he supposed to have come from Ava (Burma)[1]). As has already been stated under the heading of *H. sivalensis*, according to PILGRIM the present form occurs in the Middle Siwaliks of Burma and of the vicinity of Asnot (Hasnot). The occurrence in the Asnot beds, however, appears to be open to a certain degree of doubt, PILGRIM (1913) stating on p. 300 "... the ... species seems to have been found in the Hasnot beds, ..."[2]). Without determining the species, PILGRIM (1913) mentioned, furthermost, the abundant occurrence of hippopotamus remains in the Tatrot beds (lowermost Upper Siwaliks) of the Salt Range. According to MATTHEW[3]) the latter material is probably comparable with *H. iravaticus*.

With the exception of a note published in Pal. Mem. II (p. 406), in which it is stated that "*H. iravaticus* is a size larger than *H. liberiensis*," neither FALCONER nor CAUTLEY left any further information concerning the species in question.

In 1884 LYDEKKER pointed out the differences which he believed to see between *H. iravaticus* and *H. sivalensis*, and which he considered important enough "... as to leave little doubt of the specific distinctness of the small Irawadi hippopotamus ...". In the Catalogue of the Br. Mus. he gave the following summary:

"This species is slightly larger than the existing *H. liberiensis*, and has three mandibular incisors; the cranium being unknown. The outer lower incisor is laterally compressed, and the mandibular symphysis apparently relatively longer than in any of the foregoing species (*H. sivalensis*, *H. palaeindicus*, and *H. namadicus*). Other specimens are required to indicate its full affinities." [4])

It remains with us to mention that according to LYDEKKER [5]) the type specimen (F.A.S., pl. LVII, fig. 10) belonged to a sub-adult specimen, P_2 being half protruded. The second specimen of the symphysis is in my opinion entirely worthless, being too fragmentary and figured on too small a scale.

Hippopotamus namadicus.

Hippopotamus (Hexaprotodon) namadicus, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis, 1845, pl. LVII, fig. 12, pl. LVIII, figs. 1—3 (name and figures); Pal. Mem. II, 1868, p. 406.

Hippopotamus namadicus, R. Lydekker, Mem. Geol. Surv. India, ser. X, III, 1884, p. 43; Cat. Foss. Mamm. Br. Mus., II, 1885, p. 294.

Hexaprotodon namadicus, W. D. Matthew, Bull. Am. Mus. Nat. Hist., LVI, 1930, p. 557.

Neither the present species has ever been described by FALCONER

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[1]) See Pal. Mem. I, p. 142.

[2]) The Asnot beds belong to the Dhok Pathán Zone (middlemost Middle Siwaliks).

[3]) 1930, p. 557.

[4]) 1885, p. 309.

[5]) 1884, p. 42.

and CAUTLEY. FALCONER [1]) mentioned only that it was larger than *H. amphibius* or *H. sivalensis*, and that it had wellmarked specific characters. In the F.A.S. are figured under the present specific name four fragmentary specimens of the mandible which show considerable variation in size. In 1884 LYDEKKER mentioned the following specific characters. [2]):

"The incisors are three in number on either side; the second being smaller than either of the others, and its alveolus placed slightly above the level of those of the other two; this character is more marked in some specimens than in others . . ." The mandibles figured in the F.A.S. ". . . are readily distinguished from the mandible of *H. sivalensis* by the more abrupt angle at the inferior border of the anterior extremity, and by the relatively shorter symphysis." One would be inclined to infer from LYDEKKER's words in the Catalogue of the Br. Mus. that a year afterwards he did not attach much value neither to the mutual position of the lower incisors nor to the relatively smaller I_2 and to the abruptness of the angle formed by inferior and posterior border of the horizontal ramus, as may appear from the following quotation: [3])

"This species is somewhat smaller than the last" (*H. palaeindicus*, which he considered as fully equal in size to *H. amphibius*) "and distinguished by having three small and subequal-sized mandibular incisors. The mandibular symphysis is slightly longer than in the last species." As appears from my own observations of twenty three lower jaws of *H. amphibius*, the characters, the specific value of which LYDEKKER apparently doubted, are indeed subject to too strong an individual variation to be very reliable.

Remains which can certainly be referred to the present form have been obtained only from the Narbada (Nerbudda) River beds.

Hippopotamus palaeindicus.

Hippopotamus (Tetraprotodon) palaeindicus, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis, 1845, pl. LVII, fig. 5.

? Hippopotamus (Tetraprotodon) palaeindicus, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis, 1845, pl. LVII, figs. 1—4, 6—9, pl. LVIII, figs. 4—10, pl. LXII, figs. 11—12. H. Falconer, Pal. Mem. I, 1868. p. 147.

Tetraprotodon palaeindicus, H. Falconer, Journ. As. Nat. Sci. Philad., ser. 2, I, 1849, p. 236.

Hippopotamus palaeindicus, R. Lydekker, Mem. Geol. Surv. India, ser. X, III, 1884, p. 44; Cat. Foss. Mamm, Br. Mus., II, 1885, p. 293; W. D. Matthew, Bull. Amer. Mus. Nat. Hist., LVI, 1930, p. 556.

With the exception of the four specimens of the mandible, which FALCONER and CAUTLEY reckoned to the foregoing species,

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[1]) Pal. Mem. II, p. 406.

[2]) p. 43.

[3]) p. 294.

they considered all other hippopotamus remains of the Narbada deposits as belonging to *H. palaeindicus*. Among the latter remains there is only one symphysial part of the lower jaw which still possesses the lower incisors. It is represented in pl. LVII, fig. 5 of the F.A.S. and must be taken — as LYDEKKER pointed out — as the type. The remaining specimens comprise fragmentary crania (in which the praemaxillaries are wanting), vertebrae and limbbones. I wholly agree with LYDEKKER, who stated that there is apparently not the slightest reason for assigning these specimens to *H. palaeindicus*, as FALCONER and CAUTLEY did, and not to the other Narbada form *H. namadicus*. The same holds good with regard to a damaged cranium from the Narbada and noticed by FALCONER in the Catalogue of the Museum of the Asiatic Society of Bengal [1]).

FALCONER and CAUTLEY never published any detailed description of the species. It was again LYDEKKER, who supplied this want. This author pointed out [2]), that the restoration of the type mandible in the F.A.S. as simply tetraprotodont is most probably incorrect. He figured namely a symphysis of a hippopotamus mandible obtained from the Narbada, which resembled the type specimen in every feature except that between the two large incisors, occurring in each half of the type specimen, a very minute teeth was wedged, evidently corresponding with I_2. Had this specimen been the only instance of hexaprotodontism of "*Tetraprotodon*" *palaeindicus*, the present writer should certainly not have been convinced of the hexaprotodont character of the present form. For, as will be seen in dealing with twenty three skulls of the recent *H. amphibius*, the lower jaw of this form shows in some cases notorious abnormities [3]). LYDEKKER mentioned, however, that the British Museum after FALCONER's death acquired two similar mandibles from the Narbada, which exhibited a precisely similar arrangement of the incisors. As, moreover, the young milk dentition of *H. amphibius* is characterized by the presence of upper and lower I_3, there cannot remain any doubt with regard to the invalidity of the term "*Tetraprotodon*".

In the Catalogue of the Br. Mus. LYDEKKER gives the following specific characters of this Narbada form: [4])

"This species is fully equal in size to the existing *H. amphibius*. The number of upper incisors is unknown; but there are three in the mandible, the middle one being very small, and perhaps dis-

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[1]) See Pal. Mem. I, 1868, p. 146.

[2]) 1884, p. 45.

[3]) See note on p. 104.

[4]) 1885, p. 293.

appearing in the adult; the other two are large, and equal in size. The mandibular symphysis is extremely short."

Like *H. namadicus*, the present species is only certainly known from the Narbada (Nerbudda) River beds.

Hippopotamus sivajavanicus.

Hexaprotodon sivajavanicus, Eug. Dubois, Tijdschr. Kon. Ned. Aardr. Gen., ser. 2, XXV, 1908, p. 1264.
Hippopotamus sivajavanicus, W. Soergel, Palaeontographica, Suppl. IV, Abt. III, Lief. 1, 1914, p. 2.

DUBOIS reckoned the fossil hippopotamus remains of his collection to a new species of which he gave a very short notice, which will be entirely quoted below:

"Es ist ... ein *Hexaprotodon*, wie die fossilen Flusspferde des indischen Festlandes. Sie entfernt sich jedoch weit von den beiden Narbadá-Arten: *Hexaprotodon namadicus* und *H. palaeindicus*, durch die Länge der Unterkiefersymphyse und die relative Grösse der Incisiven, nähert sich in diesen Punkten sowie in der Schädelform sehr beträchtlich H. *sivalensis*, von der sie sich, ausser durch ihre etwas geringere Grösse, durch die im Verhältnis zur Länge grössere Höhe zwischen den Gaumen- und Nasenbeinen, durch den relativ breiteren Oberkiefer, und besonders auch durch die nicht geradlinige Lage der Austretungsstellen der unteren Incisiven unterscheidet. Sie steht der Siwalikform deutlich sehr nahe, und während sich die Narbadáformen in der überwiegenden Entwickelung des lateralen Incisiven als Endzweige des *Hexaprotodon*-Stammes zu erkennen geben, stand *Hexaprotodon sivajavanicus* n. sp., sogar noch *H. sivalensis* etwas übertreffend in dem relativ stärkeren medialen Incisivus, dem Stamme des afrikanischen Flusspferdes sicher noch näher."

SOERGEL determined a collection of fossil mammalian remains collected by J. ELBERT in the Kendeng beds of Java. Though he gave the results of all the determinations, only the stegodonts were fully described and figured. Hippopotamus was represented in ELBERT's collection by two lower jaws and one cranium (all the three without incisors and canines, for the greater part also without molar teeth); furthermore by one specimen of M_3, fragments of C and I, some limbbones and vertebrae. Apparently SOERGEL determined all these remains as belonging to *Hippopotamus sivajavanicus*. Of course, SOERGEL's determinations are of not the slightest value to us; they have only been mentioned here for the sake of completeness.

Hippopotamus sp.

From Java. H. Stremme in: Die Pithecanthropus-Schichten auf Java, 1911, p. 104.
H. G. Stehlin, Wet. Med. Dienst Mijnb. Ned. Ind., 1925, p. 3.
J. Cosijn, Verh. Geol. Mijnb. Gen. v. Ned. en Kol., Geol. ser. IX, 1931, p. 119.
Non M. Schlosser, Abh. Math. Phys. Kl. K. Bayer, Ak. Wis., XXII, 1903, p. 95, (from China).

The collection obtained by the Trinil Expedition of Mrs. SELENKA contained four upper true molars, partly damaged, two right astragali of hippopotamus and a detached tooth, considered as possibly representing an incisor of the present genus. The specimens were described and well figured by STREMME. They did, however, not enable him to determine the species.

STEHLIN who determined a collection of fossil mammalian remains obtained from Kali Biuk and Kali Saat (vicinity of Bumiaju), mentions some fragmentary limbbones and a portion of the pelvis as belonging to Hippopotamus. Interesting is that the distal end of a radio-cubitus indicated the presence of a dwarf individual, whereas the other specimens pointed to individuals of the size of small specimens of *H. amphibius*. Whether or not the dwarf individual belonged to another species STEHLIN could not determine.

COSIJN detected a new findspot of fossil vertebrate remains N. of Djetis and Perning (Central Java). UMBGROVE, to whom the specimens were sent for determination, recognized among them a mandible with teeth of *Hippopotamus* sp.

SCHLOSSER described and figured a deformed, injured molar tooth from Shansi, which he considered to belong to *Hippopotamus*. RINGSTRÖM[1]) redetermined this specimen, however, as *Sinotherium* sp.

From what precedes it will have appeared conclusively, I believe, that very small differences exist in general between the Siwalik hippopotamus species mutually and between the latter and the Javan fossil form *H. sivajavanicus Dub.* If ever it was necessary to determine the degree of the individual variation of a recent species of the genus, it was now. In doing so the writer met, however, with rather great difficulties, as will be seen from what follows.

Besides the dwarf species *Choeropsis liberiensis* (MORTON) of Liberia there have been recorded three recent hippopotamus species:

1. *Hippopotamus amphibius* LINNAEUS, Syst. Nat., I, 1758, 10th ed., p. 74 (Nile).

Syn: *Hippopotamus typus* DUVERNOY, l'Institut, XIV, 1846, p. 333 (Senegal and Abyssinia).

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[1]) Palaeontologia Sinica, ser. C, I, fasc. 4, 1924, p. 145.

2. *Hippopotamus australis* DUVERNOY, l'Institut, XIV, 1846, p. 333 (Cape region).

(Previously described, but not named by DESMOULINS, Journ. Physiol. Exp. et Path., V, 1825, p. 354).

3. *Hippopotamus constrictus* MILLER, Smiths. Misc. Coll. LIV, no. 7, 1910, p. 1 (Angola).

H. australis from the Cape is founded upon differences in the bony cranium, but also upon a number of differences in the skeleton; *H. constrictus*, however, is founded only upon differences in the bony cranium.

Hippopotamus appeared to be well represented in the Dutch collections. The writer measured only skulls in which at least the first true molar was in use. Nevertheless he found not less than 23 skulls, viz., 2 in the Zoological Institute of the University of Utrecht, 7 specimens in the museums of Natura Artis Magistra in Amsterdam, and 14 specimens in the Nat. Mus. of Nat. Hist. in Leyden. The two Utrecht specimens were labelled *H. amphibius*; the localities from where they are obtained were unknown. All Amsterdam specimens were unlabelled. With the exception of one unlabelled specimen, all Leyden specimens were labelled *H. amphibius*. From table P it will be seen that of most of the latter the locality is known. As localities are mentioned: Congo, Mozambique, Cape, Nile, Zambezi and Zanzibar. With regard to the last locality I strongly doubt the correctness of the statement for it occurs as highly improbable to me that in this relatively small island near Africa's E. coast hippopotami should occur, these being surely bound to large rivers. Furthermore it must be borne in mind that in a museum, so old and venerable as the Leyden Nat. Mus. of Nat. Hist., the data of the labels are perhaps not in all cases reliable. For all these reasons I thought it advisable to start from the supposition that of all recent specimens measured the localities were unknown, so that I should be obliged to determine all. And this seemed to be an easy task by the help of the data which the literature provides.

We shall begin with *H. constrictus*. The U. S. National Museum contained two skulls of hippopotamus, one from the Zambezi river, the other from Angola, which differed — according to MILLER — noticeably from each other in important details of form. Originally MILLER could not determine the exact value of these differences as no sufficient material was available to get an idea of the variation in individuals from one locality. Later on this want was supplied by eight skulls from British East Africa, secured by the Smithsonian African Expedition. According to

MILLER the latter specimens showed conclusively that individual variation is not "unusually great ..." [1]) so that he was convinced that the Zambezian and Angolan specimen represented distinct species. As, furthermore, the skulls from British East Africa agreed in all essential characters with the Zambezian skull, they were for the present assumed to represent true *Hippopotamus amphibius* of the upper Nile. The Angolan species was named *H. constrictus* because of the deep rostral constriction.

The type skull of *H. constrictus* is that of an immature male (M^3 not fully in place); no. 34787, U. S. Nat. Mus. MILLER gave the following diagnosis: "Skull in general like that of *Hippopotamus amphibius*, but rostral constriction deeper, dorsal surface of cranium more flattened, difference in level between anterior border of maxillary and of premaxillary more pronounced, and mandibular symphysis much shorter, its median length less than one-third length of mandible; teeth smaller than in *Hippopotamus amphibius*, the transverse diameter of m^2 [2]) scarcely more than one-half that of palate." MILLER mentioned more differences but apparently did not esteem them important enough to add them to his diagnosis. Furthermore, he gave the measurements of the Angolan specimen of *H. constrictus* and of the adult male Zambezian skull, already mentioned, and calculated a number of relations between certain measurements in order to show most of the differences mentioned in numbers. His paper is illustrated by fine figures of the two specimens of which he gave the measurements.

Without doubting the exactness of MILLER's assertion concerning the variation which he noticed in the eight skulls from British East Africa, we may say that MILLER's foundation of a new species would have been far more convincing, if he had given the measurements of all these skulls so that the reader might have formed a notion of the range of variation. For it appears to me as not improbable that MILLER will have selected among the nine skulls of *H. amphibius* which he had at his disposal, the one showing the greatest differences from the Angolan specimens. Premising the correctness of this supposition, MILLER gave too favourable an idea of the differences which in general exist between the Angolan specimen and the skulls of *H. amphibius*. But apart from this, MILLER in some cases flattered the differences too much. E.g. he says: "... depth at level of anterior border of orbit contained about 4 times in condylobasal length, instead of $3\frac{1}{2}$ times, as in *H. amphibius*; rostral constriction very pronounced, its least breadth contained

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[1]) p. 1.

[2]) Meant is M^1, which appears from the text and also from pl. II where a palate view of both specimens is given.

nearly 7 times instead of about 5 times in condylobasal length ..." [1]). If one calculates, however, these relations it appears that for the relation first mentioned the values are resp. 3,81 and 3,51 (instead of 4 and 3 ½) and for the second relation resp. 6,27 and 5,07 (instead of 7 and 5). Furthermore, I cannot see how MILLER came to put in his diagnosis "... the transverse diameter of M^1 [2]) scarcely more than one-half that of palate ..." If one calculates namely the relation between width of palate at anterior lobe of M^1 and width of first upper molar, one finds for the Angolan skull 1,65 and for the Zambezian skull 1,67. Of course this difference is too small to be of any signification.

As MILLER compared the measurements of an immature specimen (namely the Angolan skull in which M^3 was not fully in place) with those of a mature skull (the Zambezian one) I was justified in using not only the measurements of the skulls in which M^3 has been in use, but also those with worn M^2. In this way there remained 16 skulls. The measurements of these specimens, together with those of MILLER's specimen and those of 7 crania [3]) in which only the first true molar has been in use, will be found in table P. Of each skull the measurements mentioned by MILLER have been taken. I joined MILLER also with regard to the circumscription of each measurement. Only there where the possibility of a wrong interpretation was not excluded, I added a short explanation between quadrangular parenthesis. In order to be able to settle the question whether *H. constrictus* was represented among the skulls above mentioned, and if so, which skulls had to be assigned to that species, we united in table Q the results of a number of calculations.

The relations 1 : 7, 1 : 3, 4 : 2, 13 : 12 and 15 : 12 are those selected by MILLER. I added:

1 : 11 and 1 : 6 in order to express in numbers a difference which exists between MILLER's Angolan and Zambezian skull and which MILLER described as: "... occipital region and dorsal surface of orbits much less elevated above level of median portion of frontals than in *H. amphibius* ..." [4]).

9 : 10 in order to show the difference described by MILLER as "... the vertical diameter of orbit not conspicuously greater than transverse diameter ..." (in Angolan specimen, contrary to Zambezian skull where vertical diameter distinctly exceeds the horizontal diameter).

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[1]) p. 1.

[2]) See note on p. 98.

[3]) The measurements of these crania are given, as I expect that they may be of use to others.

[4]) p. 2.

5 : 6 and 15 : 14. These relations have only be added in order to dispose of some data with respect to the variability of these relations in a recent species. In judging the question whether *H. constrictus* is represented in the material measured by us, it is better not to use the values found for these two relations, as MILLER did not mention a single word about the difference which the two skulls, measured by him, showed in these respects.

When making table Q we asked ourselves: Which specimens show typical "constrictus"characters and which typical "amphibius" features. We used therefore only those values, which lay outside the interval restricted by the values of resp. MILLER's Angolan and Zambezian skull. In spite of the fact that in doing so we accepted individual variation in only one direction, we came to remarkable results.

It will be seen that only specimen no. 13 (and perhaps no. 7) paramountly show constrictus characters, whereas the other ones mostly show typical constrictus as well as typical amphibius characters [1]). The occurrence of such a large number of intermediate skulls, proves, however, that *H. constrictus* MILLER has no right to specific distinction and that it is identical with *H. amphibius*. The reader who has taken the trouble to study the tables, which demonstrate the individual variation of kerabau, banting and Javan rhinoceros, will not be astonished by this result.

Finally it may be remarked that "... the difference in level between anterior border of maxillary and of premaxillary ..." which difference MILLER mentioned in his diagnosis and which can hardly be expressed in numbers, also appeared to be of no value as a specific character.

We shall still have to occupy ourselves with the question whether perhaps *H. australis* of the Cape region is present among the material measured by us. Therefore it will be necessary to consider the original literature, which deals with that form.

DESMOULINS started from the opinion, that when the dentition of two forms shows no structural differences "... la figure, la proportion et la direction de leur usure peuvent servir à exprimer d'une manière abréviative et générale l'ensemble des différences de deux animaux comparés, et par conséquent, à déterminer leur espèce" [2]).

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[1]) The reader will have noticed that, if one considers table Q as a whole, the number of constrictus characters distinctly exceeds that of the amphibius features. This is easy to explain (1) if we take into consideration the fact, that MILLER had at his disposal only one skull of *H. constrictus*, but nine specimens of *H. amphibius*, and (2) if we suppose that MILLER selected that skull of *H. amphibius* which showed the greatest differences from the skull of *H. constrictus*.

[2]) p. 355.

The difference in use of the canines of a specimen of the Cape and of one of Senegal it was, which led him to make further investigations. The result was, that he believed to see sufficient essential differences (in cranium as well as in skeleton) to justify specific distinction. Only the cranial differences may be of interest to us.

The Senegal skeleton was that of an adult individual, M_3 being worn, whereas the Cape skeleton belonged to an immature individual, as it is stated that M_3 was not yet in use. It will be permitted, therefore, to make use of the same 16 recent crania in what follows.

DESMOULINS mentions a.o. the following differences:

a. Worn surface of canines almost vertical in Senegal form, about 25° more oblique in Cape form.

b. Point of $\overline{C}$ a "pouce" [1]) below alveolar border of $\underline{C}$ in Senegal form; in Cape form a "pouce" above it.

c. Hind border of for. infraorbitalis above the middle of P^3 [2]) in Senegal form; Cape form above front border of P^4 [2]).

DUVERNOY compared the skull of a skeleton obtained from Abyssinia with those of two skeletons from Senegal and with that of a skeleton from the Cape. It is highly probable that this material contained the two skeletons, which DESMOULINS had at his disposal. DUVERNOY concluded that the forms of Abyssinia and Senegal were identical, but specifically distinct from the form of the Cape. The one mentioned first was named *H. typus*, the second *H. australis*. The former ought, however, to be named of course *H. amphibius*.

Of the differences mentioned by DUVERNOY I give the following ones:

d. The greater length of the teeth row (P^2—M^3 at alveolus) in Abyssinia form, compared with Cape form.

e. The smaller length of the cranium in proportion to its width in *H. amphibius* of Senegal and Abyssinia.

f. The circular or even ovalshaped form of the orbit with its longer diameter vertical in the latter species instead of horizontal as in *H. australis*.

With the differences above mentioned, we shall try to answer the question formulated at the beginning.

We may commence by observing that the difference mentioned under *a.* is of no value, as a great number of intermediate conditions

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[1]) 27 mm.

[2]) DESMOULINS does not mention P^3 and P^4, but the 5th and 4th molar. Apparently he numbered the cheek teeth from back to front.

occur. Furthermore may be remarked that in composing table R, we proceeded in the same way as in table Q.

Table R shows convincingly that also the remaining 5 differences are of no value as species-characters. Only one specimen (n°. 6) has exclusively "australis" characters. But that this also is of no signification may appear from comparison with table Q, which reveals that spec. 5 also possesses typical constrictus- and amphibius characters. Thus the impression is strongly made, that the skull of *H. australis* in reality cannot be distinguished from that of *H. amphibius*. With this remark I do not intend to say that *H. australis* is not a distinct species. Therefore I should have been obliged to implicate in my considerations also the differences of the skeleton, which DESMOULINS mentions. But this would have led me too far.

In order to avoid confusions, I will lay stress upon the fact that I do not imagine that I proved rigorously the entire accordance of the crania of *H. amphibius* and *H. australis*. I only made it more or less probable.

As may appear from what follows we took all this trouble in order to get data, on the one side with regard to the relation between length of the symphysis and width of lower jaw across canines, on the other side in respect to the relation between length and breadth of the occiput. For assurance of those, who esteem the possibility not excluded of *H. australis* being represented among the recent material measured, we may add that neither DESMOULINS nor DUVERNOY did mention any difference, which concerned the above relations.

In table S all the measurements are given, which LYDEKKER gave of the mandible remains of *H. sivalensis*, *H. iravaticus* and *H. palaeindicus*. Moreover to this table are added the corresponding measurements of the mandible remains of our own collection. With the data of this table, combined with the conclusions, which we can draw from table Q, we shall try to determine whether or not the three mandibles of our own collection belong to one species and if so, whether this species is identical with one of the S. E. Asiatic fossil forms. Also we shall have to ask the question whether these continental fossil forms really belong to four different species.

Comparison of measurements and descriptions of the Javan specimens show that there is not the slightest reason for accepting the presence of more than one species.

As to the right of the continental forms to specific distinction the following observation may be made. From the discussion of the continental forms it will have appeared what large value was placed on the relative length of the symphysis. In table Q we may notice the degree of variation of the relation between the length of the

symphysis (m. 15) and the interval between outer surface of canines (m. 14) in 18 skulls of (very probably) one recent species. If we had had at our disposal more recent material for comparison, the minimum and maximum values of relation 15 : 14 would undoubtedly differ still more. It is, however not probable that the difference would be very much greater. [1])

Returning now to table S, we notice that on the basis of the length of the symphysis both Narbada forms, *H. namadicus* and *H. palaeindicus*, certainly cannot be distinguished [2]).

I cannot see, therefore, why LYDEKKER [3]) stated that the mandibular symphysis of *H. namadicus* is ... "slightly longer ..." than that of *H. palaeindicus*. Nevertheless there is no doubt that both forms are specifically distinct, as the incisives afford ample reasons to separate the two.

The value found for the relation 1 : 2 for the type specimen of *H. iravaticus* (which is also the only specimen of which measurements are known) shows that this species is certainly not identical with one of the Narbada species. The specific distinction between *H. iravaticus* and *H. sivalensis* appears less convincing from the values of the relation 1 : 2. It does, however, appear from the comparison of the absolute values in *H. iravaticus*, measurement 1 distinctly exceeding m. 2, and the reverse being the case in *H. sivalensis*. The decidedly smaller size of *H. iravaticus*, together with its lateral compressed outer incisor, give some more differences, which certainly justify specific distinction.

The values of the relation 1 : 2, together with the absolute values of measurements 1 and 2, show that specific identity of *H. namadicus* and *H. sivalensis* may be considered as improbable.

Thus we arrive at the conclusion that on the ground of the material hitherto found, 4 different continental species of hippopotamus have indeed to be distinguished.

And now the question: Is our own fossil form identical with one of the continental species?

It will be clear — and moreover it will appear from table S — that the Javan form is certainly not specifically identical, neither with *H. palaeindicus* nor with *H. iravaticus*.

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[1]) One must not forget, that these 18 specimens are certainly partly derived from very separate localities. As a matter of fact we may expect, therefore, a larger range of variation than should have been found if we had had at our disposal 18 skulls of the *same* locality.

[2]) N.B. Measurement 2 of table S is not identical with measurement 14 of table P. In the first case I had to follow LYDEKKER, in the second case MILLER.

[3]) 1885, p. 294.

Consideration of the values of the relation 1 : 2 and of the absolute values of measurements 1 and 2 reveal, that the affinity of the Javan form to the Narbada form *H. namadicus* is far more close than to *H. sivalensis*. On the other hand, however, I immediately admit that the values of m. 5—13 of the Javan form in general fairly agree with the corresponding ones of the small variety of *H. sivalensis*. With a view to the fact, however, that we do not dispose of these values in *H. namadicus*, too much value cannot be attached to this agreement.

From table S it will be seen that in all the specimens of *H.namadicus* and *H. sivalensis* of which LYDEKKER gave the measurements the diameter of I_2 is smallest in comparison with those of I_1 and I_3, whereas in our own specimen II, the diameter of the alveolus of I_3 is smallest. However, this need not be an argument against identity with one of the two forms mentioned. First it appeared that the relation between the diameter of I_1 and I_2 in *H. amphibius* may vary considerably [1]); secondly in fig. 4 of pl. LXII of the F.A.S. a front aspect of the anterior portion of a lower jaw of *H. sivalensis* is represented, showing I_3 which is in cross-section smaller than I_2 and the latter slightly smaller than I_3. Therefore it exhibits a similar condition as our specimen II. The above mentioned Siwalik specimen deserves also in another respect our full attention. From fig. 2 of pl. VI, it will have been seen that the alveoli of the incisors of specimen II are remarkably shallow. Remarkably because of the fact that in all recent hippopotamus mandibles which the writer saw and in which the incisors could be removed, the alveoli appeared to extend almost throughout the whole length of the symphysis. In the figure of the Siwalik specimen referred, however, the alveolus of right I_2 (which is the only incisor which is wanting) appears to be, as in our specimen II, very shallow. As to *H. sivalensis*, however, this appears to be not a constant character. In fig. 4*a* of pl. LXII of the same work there is namely represented the front aspect of a vertical section through the anterior portion of lower jaw, and that section — which is very distinctly situated behind the anterior margin of the mandible — shows distinctly sections through the six incisors. As far as can be seen from those figures in the F.A.S., which represent mandibles of *H. namadicus*,

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[1]) For the sake of completeness may be mentioned here, that the writer did not see any skull, in which the diameter of I_2 was equal to or greater than that of I_1. At the same time I may draw attention to two peculiarities which I noticed in studying the recent crania. In the lower jaw of specimen 6 of table P only one incisor occurs in each half of the jaw, while in the upper, quite normally, four incisors are developed. In the lower jaw of specimen 5 of table P there occur two alveoli between the outer incisors, but considerably above the level of these teeth. The peculiarity is, that the diameter of the right alveolus is 39 mm. and of the left one 11 mm. In this specimen the upper jaw is also normal.

the alveoli of the incisors are much deeper than those of our own specimen II. But for reasons which will appear from the above I dare not attach any value to this difference. We arrive, therefore, at the conclusion that the mandibles of our own collection in one important detail, namely in the relation between measurements 1 and 2 correspond with those of *H. namadicus*, while on the other hand affinities to *H. sivalensis* cannot be denied.

Before occupying ourselves with the question whether our fossil form exhibits affinities to *H. sivajavanicus* DUB., it will be desirable to direct our attention for a moment to the two remaining specimens of our collection viz., the portion of the palate with M^1—M^3 of either side, and the posterior portion of the cranium. Beforehand we may expect that these specimens will be of little use in our effort to determine the species. First it will be known that no sufficient distinction can be drawn between the different species of hippopotamus from the structure of the molars; secondly we saw that only of *H. sivalensis* the cranium is known.

In the table below will be found (a) the measurements of the molar teeth of the referred palate of our collection, (b) those of the type form and of an aberrant form of *H. sivalensis*, (c) those of *Hippopotamus* sp. described and figured by STREMME and obtained from Java.

	Our own specimen				H. sivalensis Lydekker 1884, p. 39								Hippopotamus sp. Stremme 1911, p. 104.			
					type form ("var. latidens")				aberrant form ("var. augustidens")							
	left		right		A		B		a		b		left		right	
	l	b	l	b	l	b	l	b	l	b	l	b	l	b	l	b
M^1	35	35	33	35	—	—	34	44	46	38	45	41	—	—	38	37
M^2	40	41	38	41	47	54	42	53	53	44	54	47	39	38	48	48
M^3	41	41	40	42	46	52	48	50	53	—	—	—	—	—	—	—

The molar teeth of our own specimen have been measured at the base of the crown, and at the outer side of the teeth. STREMME mentions that he took his measurements at the base of the crown. LYDEKKER does not notice where he took the measurements of *H. sivalensis*. Like the molars measured by STREMME, those of our specimen are quadrangular at the base of the crown and seem to differ in this respect from *H. sivalensis*.

In the F.A.S. four hind aspects of hippopotamus crania are figured namely three of *H. sivalensis* and one of "*H. palaeindicus*". As already noticed LYDEKKER pointed out that the cranium remains, which FALCONER assigned to the latter species, may partly belong to *H. namadicus*. The values of the relation between height (from lower border of for. magnum to occ. crest) and breadth in these four specimens [1]) will be found below, together with the measurements and the corresponding relation of our own specimen.

	Our own specimen	H. silvalensis F.A.S. pl. LX			H. namadicus or palaeindicus F.A.S., pl. LVII, fig. 1c.
		fig. 2b	fig. 3c	fig. 4c	
1 Interval between lower border of for. magnum and occipital crest.	142	—	—	—	—
2 Breadth of occiput	236	—	—	—	—
2 : 1	1.66	1.30	1.33	1.28	1.61

With a view to the fact that the variability which we noticed in this respect in 18 skulls of *H. amphibius* (see table Q), we may say that our own specimen shows more affinities to the skull of *H.* "*namadicus-palaeindicus*" than to that of *H. sivalensis*.

Both upper molars as occiput should therefore point in the direction of a species, distinct from *H. sivalensis*.

At last the question: Can our specimen be assigned to *H. sivajavanicus* DUB? Of the differences which DUBOIS mentioned the following ones may interest us.

H. sivajavanicus differs widely from both Narbada species by

a. length of symphysis.

b. relative size of incisors.

Concerning these points it shows affinities to *H. sivalensis* from which species it is especially distinguished by:

α in having the alveoli of the lower incisors not situated in a straight line, and furthermore by:

β relatively stronger I_2.

Concerning difference *a* it will be remembered that in this respect our specimens are in perfect accordance with *H. namadicus*.

[1]) taken from the figures.

As to the size of the incisors (difference *b*) a closer affinity to *H. sivalensis* can hardly be detected. To difference *a* I do not attach much value. Finally it may be remarked that I_2 of specimen II of our collection is indeed more strongly developed with regard to I_1 than is often the case in *H. sivalensis*. (See table S). It will, however, be remembered that an identical development occasionally appeared to exist in the latter species.

We conclude that we are not justified in classing our fossil form with *H. sivajavanicus* Dub.

If we summarize the results, we may say that the teeth of the palate as well as the occiput — though of course totally insufficient for specific determination — seem to point in the direction of a form distinct from *H. sivalensis*. As to the other remains, we noticed the greatest affinities to *H. namadicus*. In my opinion, however, the specimens, which I had at my disposal, do not allow of answering the question whether they belong to *H. namadicus* or not. Better preserved Javan specimens are needed to show full affinities. I therefore thought it better to leave our specimens provisionally specifically undetermined, and to describe them under the heading of *Hippopotamus* sp.

Fam. BUNOMASTODONTIDAE.

Subfam. TETRALOPHODONTINAE.

Tetralophodon bumiajuensis nov. spec.

Fragmentary right mandibular ramus with M_3 *in situ*.

Pl. VIII, fig. 2; pl. IX, fig. 3.

Text figs. 17—18.

Locality: Bumiaju, Excavation 8.

Description of ramus. (Pl. VIII, fig. 2).

The horizontal ramus is broken off some 3 cm. in front of the anterior extremity of the molar so that nothing of the mandibular symphysis has been preserved. There is not the slightest indication of the presence of lower incisors.

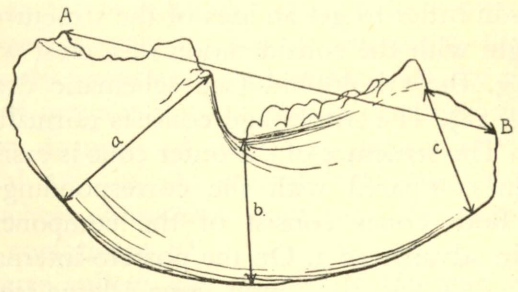
The upper portion of the coronoid process and the upper part of the ascending ramus are lost. The lower border of the horizontal ramus is slightly but clearly convex, and sweeps round by a bold curve into the posterior border of the ascending ramus. Inner- and outer surface of the horizontal ramus are slightly convex antero-posteriorly, and converge frontwards. Below the anterior extremity of the molar the greatest width of the horizontal ramus is, however, still considerable. The outer side of the horizontal ramus is strongly convex from above downwards. The inner side is in the same direction but slightly convex in its upper portion; towards the lower border the convexity increases. The outer side presents a circular foramen mentale (diameter 13 mm.) situated some 7 cm. below and about 2 cm. in advance of the anterior extremity of the molar. The inner-upper side of the ascending ramus shows the base of the orifice of the dental canal, still filled with matrix.

The alveolar margin of the molar and the lower border of the horizontal ramus converge but slightly posteriorly. Consequently the difference in height between the horizontal ramus at the front side of the molar and at the posterior extremity of the latter is small.

MEASUREMENTS OF RAMUS.

(See text fig. 17).

Length of AB	450	mm.
Length of a	195	„
Length of b (height of hor. ramus immediately behind M_3)	133	„
Length of c (height of hor. ramus immediately in front of M_3)	ca 140	„
Greatest width of cross-section perpendicular to outer side of hor. ramus and containing c	103	„
Greatest width of similar cross-section, but containing b	122	„
Greatest width of hor. ramus below middle of M_3	135	„



Text fig. 17.

Description of the molar. (Pl. IX, fig. 3).

Extraordinary fine specimen. Only the enamel of the outer cone of the pentalophid is somewhat damaged.

The tooth carries five transverse ridge-crests, a fore- and aft talon. The bases of proto-, meta-, and tritolophid are of approximate equal width; from the tritolophid, however, the transverse diameter of the crown decreases gradually. The posterior extremity of the tooth is rounded off. At the anterior extremity a large disc of pressure occurs which can distinctly be seen in fig. 3 of pl. IX. Posteriorly any such a feature is totally absent. The tooth under consideration is certainly a third molar, as may be determined from its size, form, number of ridge-crests and from the absence of any indication of a pressure-effect behind.

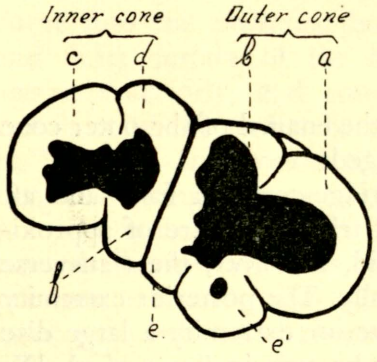
The specimen is rather considerably abraded by wear; inner- and outer cones of the protolophid, up to and including tetartolophid, present dentine-islets. The dentine-islet of the outer cone of the

protolophid and of the metalophid is in direct connection with that of the inner cone. The cones of pentalophid — though touched by attrition — have their thick enamel not yet perforated, the hind talon, which is much lower, is untouched.

Both grinding surface and base of the crown are distinctly concave superiorly. The plane of wear, however, is not only concave longitudinally, but also in the direction of the greatest diameter of the transverse lophs. The grinding surface slopes obliquely from the inside, which is higher, to the outside, which is lower, thereby presenting the characteristic "*Mastodon* position" of the grinding surface. The molar is slightly bent, as viewed in plan; the outer side is concave, the inner side convex.

The ridge-crests are not perpendicular to the longitudinal axis of the crown, the inner cones being in advance of the outer ones, which causes a slightly alternative arrangement of inner- and outer cones.

Protolophid and metalophid being too much ground down, it will be necessary — in order to get an idea of the structure of the ridge-crests — to begin with the consideration of a crest which is not so much worn e.g. the tritolophid (see schematic drawing of this crest in text fig. 18). The tritolophid consists normally of an outer- and inner cone. The structure of the outer cone is easily understood, especially when compared with the corresponding cone of the tetartolophid. Both cones consist of the components a and b; b is distinctly in advance of a. On the postero-internal angle of the outer cone a large trefoil conule (e) occurs. Furthermore, it is probable that the component e^1, which is closely attached to e, represents another trefoil conelet. It will be clear, that the outer cone of the tritolophid, if more ground down, would present a distinct trefoil-shaped dentine-islet, similar to the one shown already by the outer cone of the metalophid.



Text fig. 18.
Diagram of tritolophid of r. M_3.

The outer cone of the tetartolophid resembles closely that of the tritolophid, described above. The only difference is that in the fourth crest the separation between the components e and e^1 is considerably less distinct.

The outer cone of the pentalophid — though injured — presents clearly the components a and b, while the component e (? plus e^1) occurs at the base of the postero-internal angle of

the component b in the form of a faint rudiment of a trefoil conule.

The structure of the inner cone of the tritolophid is not so clear. Without doubt also the inner cone consists of two components (c and d), comparable with the components a and b of the outer cone (see the inner cone of the pentalophid). It seems, furthermore, that a trefoil conule (f) occurs on its postero-internal angle. This component f is certainly present in the inner cone of the metalophid, while its presence is also indicated in the corresponding cone of the tetartolophid. The inner cone of the pentalophid has lost component f. On its antero-internal angle, however, a low, but distinct trefoil conule occurs. The foregoing description will render it perfectly clear to the reader that the inner cone possesses a tendency to form an imperfectly trefoil-shaped dentine-islet, which, however, will never be so regular as that of the outer cones (e.g. compare inner- and outer dentine-islet of metalophid).

The cleft which separates inner- and outer cone of each crest is not parallel to the longitudinal axis of the crown, but axis and each cleft intersect anteriorly. This is caused by the fact that the cleft runs from the middle of component e of the preceding crest to the middle of component d of the succeeding loph.

The greatest diameter of the inner cone is at right angles to the longitudinal axis of the crown with the exception of the tetartolophid, where component d of the inner cone is somewhat in advance of component c [1]).

The transverse valleys are completely blocked, mainly by the large component e. The bases of the — relatively wide — inner- and outer extremities of the transverse valleys are each occupied by an — on the whole — thick, blunt, accessory tubercle.

The accessory tubercles, occupying the outer mouths of the valleys between proto-, meta-, and tritolophid are already abraded or touched by attrition. Cement is present in very small quantities. There are, however, some faint indications which seem to point out that cement has been lost, so that we must take into consideration the possibility that the real amount of cement has been greater.

The enamel is thick and near the basis of the crown provided with a wavy and finely grooved rugosity, more or less parallel to the base of the crown.

Remains to describe the fore- and the hind talon.

The anterior talon is only slightly developed, due to the great pressure, which the tooth under consideration exerted on the

[1]) This is perhaps an indication that component d is united with an internal trefoil conule as would have occurred in the inner cone of the pentalophid after prolonged wear.

preceding r. M_2. The fore talon apparently consisted of two low tubercles, the one situated in front of component a of the outer cone, the other placed in front of component d of the inner cone of the protolophid.

The hind talon consists of 3 conelets and is distinguished from the pentalophid by its much lower elevation. Noteworthy, however, is the arrangement of these three conelets. Two of them are arranged in a transverse line parallel to the direction of the greatest diameter of the ridge-crests; the third conule is situated behind the interval of the two, first mentioned. The couple, which is arranged in a transverse line, in this respect resembles closely a true crest, which impression is strengthened by the fact that the inner conelet of that couple presents a division into two. There is no doubt, that OSBORN would have spoken in the present case of a hexalophid plus posterior talon (cingulum), which is of course merely a matter of taste.

The molar under consideration being a third molar and carrying five ridge-crests and a hind-talon, two conelets of which show the apparent potency to form another crest, evidently belongs to a tetralophodont mastodont. Its determination, however, will be dealt with at the end of the descriptions of the mastodont remains.

MEASUREMENTS IN mm. OF R. M_3.

(Total length [1]) 180 mm.)

	Fore talon + 1	2	3	4	5	Hind talon
Length at the base of the crown.	66	66	66	63	51	35 [2])
Interval between lingual extremities of transverse valleys.	35	37	36	38	28	21 [3])
Height of the unworn or slightly worn ridge-crest	—	—	—	—	—	25

[1]) Measured along median line of tooth.

[2]) In this case the total length of the two foremost conelets.

[3]) Lingual width of the total hind talon.

Fragmentary upper jaw with injured l. and r. M^3 *in situ.* [1])

Pl. IX, figs. 1—2.

Text fig. 19.

Locality: Bumiaju, Excavation 1—4 at K. Glagah [2]).

Fragment of the upper jaw, containing on either side a fragmentary tooth, which is inferred to be the third molar from its size, form, and number of ridge-crests. The greater part of the l. M^3 is lost; only fragments of the inner cone of proto- and metaloph are preserved. The dentine-material of its fangs can easily be distinguished from that of the bone of the palate, enabling us to get an idea of the position of this molar in the upper jaw and of its total length. Left and right molar are approximated behind and divergent in front, (width of the palate anteriorly 84 mm., posteriorly 73 mm.). The surface of the palate is damaged.

The r. M^3, though not inconsiderably injured, is much better preserved. Therefore, it will be sufficient only to give of this specimen a detailed description.

This molar presents a regular form, as viewed in plan. Inner- and outer side are approximately straight and converge posteriorly; the tooth therefore becomes narrower towards its posterior extremity. The hind talon and the outer cone of the protoloph are totally wanting; the last crest and the fore talon are for the greater part broken off. The inner cone of proto- and metaloph is injured.

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[1]) According to the first of the original lists of specification (dated Bandung, 27 December 1927, n°. 11567) case n°. 1 of the first consignment contained (literal translation):

Of Mastodon skull:

1 upper jaw, 1 portion of a lower jaw;

1 incisive tusk (length 83 cm.), 1 connection (bridge) from upper jaw to occiput.

Originally the writer believed that the meaning of the foregoing statement was that all these remains belonged to the same skull. He had, however, to alter his opinion after case n°. 1 had been unpacked. On that occasion it was revealed that the "portion of the lower jaw" in reality represented a portion of the upper jaw, containing fragments of l. and r. M^3. As the "upper jaw" (represented in fig. 1 of pl. VIII and fig. 2 of pl. X) also contains r. and l. M^3, it was — for this reason alone already — impossible that the two specimens belonged to the same individual. This being so, there was in the writer's opinion no reason to believe that the remaining two specimens belonged to one another and to one of the two specimens mentioned.

After the investigation of the two latter specimens was ended, they were immediately sent back to Bandung. The other two (tusk and zygomatic arch), however, remained provisionally in Utrecht. In a letter (dated Bandung, June 4th 1929, n°. H 498) was asked for these specimens, because they were needed "for completion and mounting of the skull". From this appears that in Bandung one is convinced of the belonging of tusk and zygomatic arch to the specimen of the upper jaw. That is the reason why we ventured to describe the tusk in the following pages under the same name as the other specimens mentioned.

If we are rightly informed, a reconstruction of the skull has been made in Bandung. For that purpose undoubtedly the specimens will have been needed, which have subsequently been found. (See p. 128.)

[2]) See sketch map n°. 1.

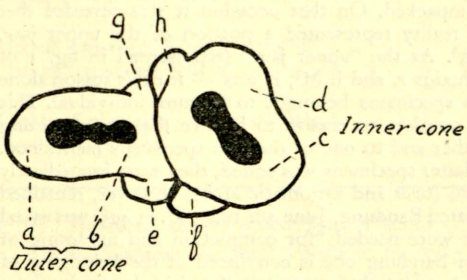
The degree of wear is moderate. The remnant of the inner cone of the protoloph and the outer and inner cones of the metaloph present dentine-islets. The outer cone of the tritoloph is flattened and not yet perforated; the inner cone is just perforated by attrition. Inner- and outer cones of the tetartoloph are only slightly touched by wear. The grinding surface slopes obliquely from the inside, which is lower, to the outside, which is higher (the tooth is supposed to be in the natural position).

A convexity of the plane of wear could not be ascertained. In my opinion the tooth carried five ridge-crests, a fore- and aft talon. As to the presence of five crests plus an anterior talon the reader will immediately be convinced after examination of the fig. 1 of pl. IX. But also the former presence of a posterior talon is absolutely certain. The disc of dentine-material namely, which occurs behind the fragments of enamel belonging to the front side of the pentaloph, is undoubtedly too extensive for one crest.

The crests are rather tall and comparatively narrow antero-posteriorly. They are clearly inclined forward. The relatively wide transverse valleys are in general obstructed at their extremities by low, blunt, accessory tubercles. In the middle they are totally blocked by trefoil conules, as will be seen in what follows.

It will be desirable again to pay our attention in the first place to the structure of one crest, e.g. the tritoloph. (Text fig. 19 presents a schematic drawing of this crest, only the degree of wear is supposed to be somewhat greater).

It will be seen that this crest — like the other crests — is normally composed of an inner and an outer cone, each subdivided into two components (resp. c and d; a and b). The components a and b of the outer cone are arranged in a line which is nearly perpendicular to the longitudinal axis of the crown. The greatest diameter of the inner cone is, however, distinctly oblique to the same axis, the component d being in advance of component c. Both on the postero-internal and the antero-internal angle of the inner cone a well-defined trefoil conule occurs (f and h); f is slightly more developed than h; f is attached to the component c, while h is fastened to the component d. The postero-internal angle of the outer cone also presents a trefoil conule (e), while a very ill-defined



Text fig. 19.
Diagram of tritoloph of r. M^3.

trefoil conelet (g) occurs on its antero-internal angle. But these two trefoil conules are attached to the innermost component (b) of the cone.

Having fixed the detailed structure of the tritoloph we shall continue with the consideration of the resemblances and differences between the tritoloph and the other crests.

As has been already mentioned, the pentaloph is present in the form of fragments of the enamel of its front side. But even these poor remnants show clearly that the inner cone was also composed of the components c and d, the latter being distinctly in advance of the former. The presence of a component h is not indicated.

The structure of the tetartoloph corresponds in general with that of the tritoloph. The components e and h, however, do not occur. Furthermore, it will be seen that the subdivision of inner- and outer cone is less conspicious, when the cones are unworn or but little worn.

The difference between the second and third crest is small. In the inner cone of the metaloph the component h is probably wanting, while component f is strongly developed. The whole presents a rather regular trefoil-shaped dentine-islet, one lobus being formed by component d, the third by the trefoil conule f. In the outer cone of the metaloph the component g is present in the form of a faint rudiment of a trefoil conule; the component e also occurs, but its development is still smaller (compared with that of component e in the tritoloph).

So much being lost of protoloph and fore talon, their detailed structure cannot be ascertained.

It will be clear that the inner cone of trito- and tetartoloph should present, if ground down enough, a rather regular trefoil-shaped dentine-islet, like that of the inner column of ridge 2. The outer cones also show a tendency to form trefoil-shaped dentine-islets, due to the presence of the components e and g. But as these components are on the whole but very slightly developed a well-defined trefoil-shaped dentine-islet will never occur in the outer half of the tooth.

The clefts separating inner- and outer cones of trito- and tetartoloph run from the middle of the front side of component f in the direction of the middle of component e of the foregoing crest; consequently longitudinal axis of the crown and cleft are not parallel, but converge posteriorly. The cleft, which separates inner- and outer cones of the metaloph, is almost parallel to the longitudinal axis of the crown.

The inner- and outer extremities of the transverse valleys are occupied by low, thick, and blunt accessory tubercles. Those occupy-

ing the outer extremities are much more strongly developed than those in the inner mouths. The valleys contain now a small amount of cement, but I am convinced, from several indications, that the quantity of cement was originally greater.

There is a wavy and finely grooved rugosity parallel to and near the base of the crown.

MEASUREMENTS IN mm. OF R. M^3.

(Estimated total length 170 mm.)

	Fore talon + 1	2	3	4	5	Hind talon
Length at the base of the crown.	—	74	69	64	—	—
Interval between buccal extremities of transverse valleys	—	ca 34	33	33	—	—
Height of unworn or slightly worn ridge-crest	—	—	—	55	—	—

Fragment of cranium with l. and r. M^3 *in situ*.

Pl. VIII, fig. 1; pl. X, figs. 2—3.

Text figs. 20—21.

Locality: Bumiaju, Excavation 1—4 at the K. Glagah.

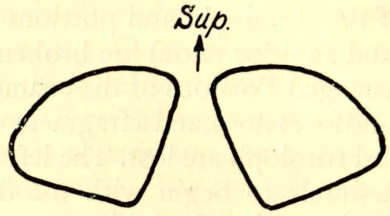
Description of the fragment of the cranium. (Pl. VIII, fig. 1; Pl. X, fig. 2; Text fig. 20).

Fragment of the cranium containing the M^3 of either side, very considerably worn. The fragment consists of both incisive sheaths, the well-preserved palate, the anterior surroundings of the posterior nares, the greater portion of both maxillaries together with the zygomatic processes of either side.

The palate is considerably concave across. The molars are approximated behind and divergent in front. In palatal view of the cranium the vertical surfaces of both maxillaries converge strongly towards the posterior nares, enclosing an angle of about 50°. The incisive sheaths are injured and in front broken off. Their outer sides are almost parallel to one another, and thus parallel to the longitudinal axis of the cranium. The inner sides converge posteriorly; an open space, which becomes narrower backwards, separates both sheaths in the median line. In cross-section each sheath presents rudely the form of a sector of a circle. The radii are formed by lower and inner side of each sheath, upper and outer side constitute

the bow of the circle. The angle which is enclosed between the two radii is approximately 90°. The inner sides converge superiorly.

From the antero-internal extremity of each molar a curved crista runs forward, passing gradually in the edge formed by the sudden transition of the lower side of the incisive sheath to its inner side. In the lateral aspect of the cranium it will be seen that the lower border of the incisive sheath is but slightly curved, while the above mentioned crista is clearly concave. The acute angle enclosed between the lower border of the incisive sheath and the lengthening of the alveolar margin of the molar is about 22°.



Text fig. 20.

Noteworthy, furthermore, is that the posterior extremity of the incisive sheath is situated only some 4 cm. above the alveolar margin.

In upper view of the cranium the interalveolar fossa presents approximately the form of an ovalshaped disk, which is considerably concave in the transverse direction of the cranium, and less concave in the longitudinal direction.

MEASUREMENTS OF THE FRAGMENT OF THE CRANIUM.

Transverse diameter of the anterior (broken) extremity of left incisive sheath	ca 100	mm.
Height of ditto	ca 100	„
Width of palate at front side of M^3	120	„
Ditto at back side of M^3	105	„
Interval between anterior margin of posterior nares and middle of line connecting alveolar margins of both M^3 anteriorly	245	„
Interval between the outer sides of the incisive sheaths in front	255	„
Ditto behind	265	„
Estimated length of interalveolar fossa	260	„
Greatest depth of ditto	60	„
Greatest width of ditto	120	„

Description of the molars. (Pl. X, fig. 3; text fig. 21.)

Both teeth are very much ground down. The grinding surface of both slopes obliquely from the inside, which is lower, to the

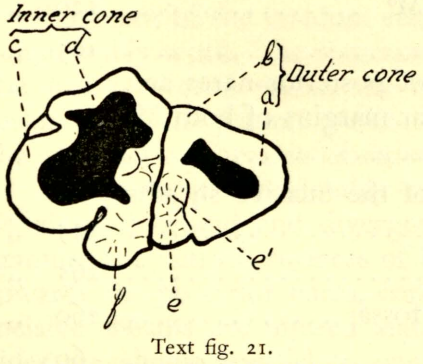
outside, which is higher. (The molars are supposed to be in the natural position). The plane of wear is almost flat.

The left molar is slightly injured. The enamel of the inner side of the metaloph, and portions of the anterior side of the protoloph (and anterior talon) are broken off. The right molar is slightly more damaged. Portions of the enamel of the anterior side of the protoloph (and fore talon), and a fragment of the enamel of the inner side of proto- and tritoloph are lost. The left molar, being best preserved, it will be desirable to begin with the detailed description of this specimen.

It carries five ridge-crests and a hind-talon, while a narrow ledge of enamel, closely attached to the front side of the protoloph indicates, the presence of an anterior talon.

The ridge-formula may therefore be represented as follows: $\times 5 \times$. As will be seen from the figure, there cannot be any doubt that the tooth represents the third of the true molar series. The degree of wear is so considerable, that not only the dentine-islets of the inner and outer cones of the first three crests have been united, but also the dentine masses of these crests mutually. The direction of the greatest diameter of each crest is almost perpendicular to the longitudinal axis of the crown. It will be clear that none of the first three ridge-crests is suitable to allow of studying the structure of this molar so that it will be necessary to have a close look at tetarto- and pentaloph. We will describe these crests again with the help of a schematic drawing of one ridge viz., that of the pentaloph represented in text fig. 21.

Outer and inner cone of the last mentioned crest are each composed of two components (resp. a and b; c and d). It will be noticed that neither the direction of the greatest diameter of the inner cone, nor that of the outer cone is at right angles to the longitudinal axis of the crown. In both the innermost cone is in advance of the outermost one; in the inner cone, however, in a far stronger degree than in the outer one. The same can be seen in the tetartoloph. On the postero-internal angle of the outer cone two small trefoil conules (e and e^1) occur, closely attached to one another. The outer cone of the tetartoloph does not present the two components e and e^1, but only one thick trefoil conelet, while it is possible that a smaller trefoil conule occurs on its antero-internal angle. The structure of



Text fig. 21.
Diagram of pentaloph of l. M^3.

the inner cone of the pentaloph is somewhat irregular. But after comparison with the corresponding cone of the M^3 of the right side [1]), the structure of which is more simple, it is not difficult to interpret its peculiarities. As has been mentioned above, component d is very much in advance of component c. On its postero-internal angle, and attached to component c, a thick trefoil conule (f) occurs. It is not certain, whether or not a small trefoil conule is present on its antero-internal angle. The crest is already too much ground down to give clear indications on this point. The resemblance in structure of the inner cone of the tetartoloph with that of the pentaloph is close. The equivalent of the component f seems to be less developed in the tetartoloph.

The hind talon consists of two thick and blunt conelets; the outer one is situated immediately behind the component e of the fifth ridge-crest, the inner one is closely attached to the hind side of the component f. The outer tubercle is slightly stronger developed. The posterior extremity of the narrow cleft, which separates both tubercles of the hind talon, is occupied by a very faint rudiment of another tubercle.

Cement is present in very small quantities. It must be borne in mind, however, that the molar is very considerably ground down so that the possibility of finding cement has become very small, even if the amount of cement was originally greater.

Most crests being ground down below the level of the base of the valleys it is rather difficult to form an idea of the form and shape of the crests in lateral aspect of the molar. They seem to have been rather tall. The cleft which separates outer- and inner cone of the pentaloph forms a small angle with the longitudinal axis of the crown. Cleft and axis converge posteriorly. The corresponding cleft of the tetartoloph and the axis of the crown converge also posteriorly, but the angle between both directions is considerably greater. The extremities of the transverse valleys are in general occupied by accessory tubercles, of which those of the outer extremities are most strongly developed. The base of the sides of the crown is provided with a wavy, finely grooved rugosity.

The differences between left and right M^3 are small. The only difference worth mentioning concerns the hind talon. The structure of the posterior talon of the l. M^3 has already been dealt with. That of the r. M^3 differs in having in the first place a slightly better developed tubercle between its main components, and in the second place by the presence of still another tubercle externally of the left principal conelet (apply magnifying lens to fig. 1 of pl. VIII).

[1]) The reader will be able to make this comparison by applying the magnifying lens to fig. 1 of pl. VIII.

MEASUREMENTS IN mm. OF R. AND L. M^3.

(Total length of each 165).

	Fore talon + 1	2	3	4	5	Hind talon	
Length at the base of the crown . .	69	ca 69	66	65	53	29	l. M^3
	ca 68	69	65	62	52	30	r. M^3
Interval between the buccal extremities of the transverse valleys . . .	35	32	32	28	27	12	l. M^3
	35	35	32	32	25	10	r. M^3
Height of the unworn or slighty worn ridge-crest	—	—	—	—	—	24	l. M^3
	—	—	—	—	—	25	r. M^3

Upper incisor.

Pl. X, fig. 1.

Locality: Bumiaju, Excavation 1—4 at K. Glagah.

In a note on p. 113 mention has already been made of this specimen. I may repeat here that there is a possibility of its belonging to the same individual as the fragment of the cranium represented in fig. 1 of pl. VIII and fig. 2 of pl. X.

Measured in a straight line the specimen under consideration has a length of 830 mm. It is slightly curved in one plane. The distal 14 cm. show a flattening of the convex side. At the base it is circular in cross-section (diameter 65 mm.), and it remains circular as far as 14 cm. from the top. At that distance the diameter is 50 mm., so that the tooth tapers very gradually. The surface of the tooth is provided with very shallow, longitudinal grooves of about 1 cm. width, separated by edges consequently of small elevation. The grooves are not exactly parallel to the longitudinal direction of the tooth, presenting a distinct screw-shaped twist. Towards the top they become indistinct. Not the slightest indication of the presence of an enamel band could be perceived.

Before passing on to the determination of the specimens described in the foregoing part I think it desirable to mention two more specimens, namely a portion of the cranium and a very damaged molar, both obtained from excavation 1—4 at K. Glagah. The molar undoubtedly belongs to *Mastodon*; it does, however, not allow of determining the species. As in excavation 1—4 determinable remains of only one species of *Mastodon* have been found, it is very probable the tooth in question belongs to that species. Never-

theless I thought it better to describe it under the heading "*Mastodon* sp.".

As to the fragment of the cranium, I may mention that, as far as my knowledge goes, excavations 1—4 have not yielded remains of *Stegodon* and *Elephas*. There exists, therefore, a great possibility that the fragment under consideration belongs to *Mastodon*, and in that case probably to the same species as the other remains. I thought it advisable, however, to describe the fragment in question under the heading "?*Mastodon* sp.".

Mastodon sp.

Locality: Bumiaju, Excavation 1—4 at K. Glagah.

Very much injured and deformed molar, imbedded in a mass of andesitic-tuf. With some difficulty 5 ridge-crests may be recognized so that it is probable that the specimen in question respresents a third molar. Only two cones are well preserved. These are unworn and show each an indistinct division into two at the top. The remaining cones are present in the form of remnants of enamel and dentine. In upper view the molar is considerably bent, but this is certainly due to the same crushing force, which caused the destruction of the various cones. Whether the specimen respresents an upper or lower molar could not be determined. It may be observed that the specimen under consideration does not present a single character by which it may be distinguished from the molars described in the foregoing paragraph.

? Mastodon sp.

Locality: Bumiaju, Excavation 1—4 at K. Glagah.

Fragment of the cranium, comprising the surroundings of the occipital foramen and of the posterior nares, both cavitates glenoidales, left- and right proc. zygomaticus of the squamosal.

The occipital foramen is subcircular. Both occipital condyles are perfectly preserved, they are egg-shaped, slightly accuminated below. Some 5 cm. above the foramen magnum the lower part of a median depression of the occiput occurs, still filled with matrix.

Left- and right cavitas glenoidalis are separated from the occipital surface by a distinct furrow. The latter is accentuated by the fact that the base of the occipital surface is situated below the level of the cavitas glenoidalis.

At least I may emphasize the fact that it is absolutely impossible that the specimen in question and the fragmentary cranium, represented in fig. 1 of pl. VIII and fig. 2 of pl. X, belong to the same individual.

MEASUREMENTS.

Transverse diameter of for. magnum	62	mm.
Longitudinal diameter of ditto	54	„
Transverse diameter of occipital condyle	63	„
Longitudinal diameter of ditto	95	„
Interval between outer surfaces of zygomatic processes	560	„

Discussion of the determination.

First of all we shall have to ask ourselves: Do the three determinable remains belong to one and the same species? It will be desirable to divide the question into two, and, as only the molars allow of comparison, the circumscription of these questions runs as follows:

1°. Do the l. and r. M^3 of the fragment of the cranium present characters by which they can be distinguished from the r. M^3 of the fragmentary upper jaw, or are distinguishing characters absent?

2°. If so, does the r. M_3 of the fragmentary right mandibular ramus show distinguishing features from the molars of the foregoing specimen or not?

For the sake of brevity and comfort we shall call in the following considerations:

A. the l. and r. M^3 of the fragment of the cranium;

B. the r. M^3 of the fragmentary upper jaw;

C. the r. M_3 of the fragmentary right mandibular ramus.

If the descriptions and figures of A and B be compared, it will be evident that A and B have the same structural characters viz.,

a. Both have precisely the same form and probably the same size.

b. The ridge-crest formula of A is $\times 5 \times$, while — as was noticed above — that of B is in all probability also $\times 5 \times$.

c. The extremities of the valleys of both A and B are occupied by accessory tubercles.

d. In A and B the valleys are in the middle blocked by trefoil conules, as well as by the distinctly oblique position of the inner cone in respect to the direction of the transverse crests.

e. The base of the crown of either is provided with a wavy and finely grooved rugosity.

f. The height of the crests is probably the same in either.

g. In either trefoil conules may occur as a rule on front and back side of inner and outer cones. In general the trefoil conelets of the inner cone are more strongly developed than those of the outer one.

h. The clefts separating outer- and inner cone of each crest are in both molars as a rule not parallel to the longitudinal axis of the crown.

i. Though the amount of cement in A and B is at present small, we have seen above, that the amount in B was certainly greater, while we must take into account the possibility, that the quantity of cement in A was also greater.

I have no doubt that the reader — after perusual of the foregoing enumeration — will be convinced of the extremely close resemblance between A and B. There will be therefore no hesitation in referring the two specimens to the same species, so that we may continue answering the second question.

It will perhaps be desirable first to lay stress upon the fact, that in the dentition of the *Bunomastodontidae* constant differences occur between the corresponding molars of the upper and lower jaw. These differences are:

1. Lower molars are always narrower and longer than the corresponding upper ones. The M_3 is often laterally bent (outer side concave, inner side convex).

2. In upper molars the transverse crests are as a rule at right angles to the longitudinal axis of the crown, while in lower molars the longest diameter of the crests is oblique to the axis, the inner cone being in advance of the outer one.

3. The valleys of the lower molars are relatively wider than those of the upper ones.

Furthermore it will be known, that inner (resp. outer) cone of an upper molar is comparable with the outer (resp. inner) cone of the corresponding lower molar.

These constant differences must be taken into consideration, comparing the lower third molar (C) with A and B.

If the descriptions and figures of these molars be compared, it will be observed, that the resemblance of C with A and B is also very close. The resemblances are:

a. The ridge-crest formula of A, C and (very probably) B is $\times 5 \times$.

b. The innermost component of the outer cone of C is distinctly in advance of its outermost component. The same can be seen in the inner column of A and B.

c. The diameter of the inner cone of the first three crests of C is perpendicular to the longitudinal axis of the crown. The greatest diameter of the inner cone of the succeeding two crests is slightly oblique to this direction. Precisely the same can be seen in the outer cones of A and B.

d. In all the three trefoil conules may occur on front and aft side of both outer- and inner cones. The trefoil conules of the outer cones of C and those of the inner cones of B are most strongly developed.

e. The transverse valleys of A, B, and C are in the middle blocked by the trefoil conules.

f. The extremities of the valleys of A, B, and C are occupied by accessory tubercles.

g. The height of the crests is in all the three probably the same.

h. In all the three the cleft, separating outer- and inner cones of each crest is not parallel to the longitudinal axis of the crown.

i. The base of the crown of A, B, and C is provided with a wavy finely grooved rugosity.

j. The enamel is in all the three of approximately equal thickness.

We see therefore — making allowance that C is a lower M_3, A and B upper M^3 — that the accordance of the characters of C with those of A and B is so extremely close that C certainly may be reckoned to the same species.

If we summarize the essential structural characters of the third molar of our species, we come to the following list:

1. Ridge-crest formula $\times 5 \times$. There exists the apparent potency of forming a sixth crest in the lower M_3.
2. Rather tall crests, clearly divided in outer- and inner cone.
3. The clefts separating outer and inner cone of each ridge-crest are on the whole not parallel to the longitudinal axis of the crown.

4. The innermost component of the outer cones of the M_3 and of the inner cones of the M^3 is much in advance of the outermost component.
5. The greatest diameter of the inner cones of the M_3 and of the outer cones of the M^3 is perpendicular (sometimes nearly perpendicular) to the longitudinal axis of the crown.
6. Trefoil conules may occur on the postero-internal angle of both inner- and outer cones.
7. The trefoil conules of the outer cones of the M_3 and of the inner cones of the M^3 are generally more strongly developed than those of the cones of the other side.
8. The transverse valleys are blocked in the middle. In the M_3 mainly by the large trefoil conules, which occurs in the postero-internal angle of the outer cones; in the M^3 both by the trefoil conule, which occurs on the postero-internal angle of the inner cone, and by the oblique position of the inner cones in respect to the direction of the transverse crests.
9. The extremities of the valleys are occupied by accessory tubercles.
10. Thick enamel, near the base of the crown provided with a wavy, finely grooved rugosity.
11. Cement is present.

Below a list will be found containing the names of the twenty seven species of "*Mastodon*" of East and South Asia which are known to the writer. As far as possible we have tried to give each species the generic name under which it has been mentioned by OSBORN. For that purpose we had to peruse a rather great number of OSBORN's publications on the present subject, as at the time this was written (March 1932) OSBORN's announced memoir on "The Evolution of the Proboscidea" had not yet been published. Of only two forms viz., "*Mastodon*" *lydekkeri* and "*Mastodon*" *pandionis* the systematic position remains uncertain. That is the reason why these forms have not been placed under the heading of one of the subfamilies.

The list below-mentioned does not pretend to completeness as far as the quoted literature is concerned. As a rule only those papers are mentioned, which either contain the descriptions of the type specimens, or which supply the reader with sufficient data. The mention of two papers behind the name of a species means that in the first paper the species has only been curtly mentioned, but that in the second it has been fully described and figured.

Having adopted OSBORN's classification [1]) all the forms of *Stegolophodon* SCHLESINGER (syn. *Prostegodon* MATSUMOTO) were reckoned to the *Stegodontinae* (subfam. of the *Elephantidae*). At present in the genus *Stegolophodon* the following forms are united: *Stegolophodon stegodontoides* (PILGR.), *cautleyi* (LYD.), *cautleyi progressus* OSB., *nathotensis* OSB., and *latidens* (CLIFT). It will be unnecessary, I believe, to prove that our species certainly does not belong to *Stegolophodon.*

Subfam. Longirostrinae.

Hemimastodon crepusculi Pilgrim 1908, Rec. Geol. Surv. Ind., XXXVII, p. 157. 1912, Mem. Geol. Surv. Ind., New Ser., IV, 2, p. 17.
Hemimastodon annectens Matsumoto 1924, Journ. Geol. Soc. Tôkyô, XXXI, p. 405. 1926, Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan. Sec. Ser. X, 1, p. 4.
Trilophodon macrognathus (Pilgrim) 1913, Rec. Geol. Surv. Ind., XLIII, p. 309. (Very short description).
Trilophodon angustidens (Cuv.) var. palaeindicus (Lydekker) 1884, Mem. Geol. Surv. Ind., Ser. X, III, 1, p. 19.
Trilophodon angustidens (Cuv.) var. chinjiensis (Pilgrim) 1913, Rec. Geol. Surv. Ind., XLIII, p. 316 (Name only).
Trilophodon sendaicus Matsumoto 1924, Journ. Geol. Soc. Tôkyô, XXXI, p. 408. 1926, Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan. Sec. Ser., X, 1, p. 4.

Subfam. Tetralophodontinae.

Tetralophodon (Lydekkeria) falconeri (Lydekker) 1877, Rec. Geol. Surv. Ind., X, p. 83. 1880, Mem. Geol. Surv. Ind., Ser. X, I, 5, p. 202.
Tetralophodon (Lydekkeria) sinensis (Koken) 1885, Palaeont. Abh. III, 2, p. 6. (See Osborn, Am. Mus. Nov. n°. 154, 1924, p. 2.
Tetralophodon punjabiensis (Lydekker) 1886, Cat. Foss. Mamm. Br. Mus., IV, p. 60.

Subfam. Serridentinae.

Serridentinus mongoliensis Osborn 1924, Am. Mus. Nov., n°. 148, p. 1.
Serridentinus browni Osborn 1926, Am. Mus. Nov., n°. 238, p. 4.
Serridentinus hasnotensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 2.
Serridentinus metachinjiensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 4.
Serridentinus chinjiensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 5.
Serridentinus prochinjiensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 6.
Serridentinus florescens Osborn 1929, Am. Mus. Nov., n°. 393, p. 6.

Subfam. Rhynchorostrinae.

Rhynchotherium chinjiensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 8.

Subfam. Brevirostrinae.

Synconolophus dhokpathanensis Osborn 1929, Am. Mus. Nov. n°. 393, p. 10.
Synconolophus ptychodus Osborn 1929, Am. Mus. Nov., n°. 393, p. 12.
Synconolophus propathanensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 12.
Synconolophus corrugatus (Pilgrim) 1913, Rec. Geol. Surv. Ind., XLIII, p. 293.
Synconolophus hasnoti (Pilgrim) 1913, Rec. Geol. Surv. Ind., XLIII, p. 293.
Anancus perimensis (Falconer et Cautley) 1845, Fauna Antiqua Sivalensis.
Pentalophodon sivalensis (Cautley) 1836, Journ. As. Soc. Bengal., V, p. 294.

Subfam. Amebelodontinae.

Platybelodon grangeri Osborn 1929, Nat. Hist. XXIX, n°. 1, p. 13. 1931, Am. Mus. Nov. n°. 470, p. 6.

Mastodon pandionis Falconer 1868, Pal. Mem. I, p. 124. (See furthermore Lydekker, Cat. Foss. Mamm. Br. Mus., IV, p. 37.
Mastodon lydekkeri Schlosser 1903, Abh. math. physik. Kl. K. Bayr. Ak. Wis., XXII, Abt. 1, 1903, p. 46.

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[1]) See the excellent summary given by DIETRICH in N. Jhrb. f. Min. etc. I, 1927, B, p. 311.

We shall begin with excluding those species from which our Javan form can be easily distinguished.

Hemimastodon.

Immediately distinguished in having three-crested third molars.

Trilophodon.

As has been already mentioned, the M_3 of the Javan form shows a distinct tendency to hexalophodontism. Consequently all true forms of *Trilophodon* may be excluded from comparison.

Serridentinus.

In 1923 [1]) OSBORN gave the following diagnosis of the present genus ".... clearly distinguished from *Trilophodon* by the serrate crests ascending on the outer cones of the lower molars and on the inner cones of the upper molars; true trefoils [2]), i.e. intermediate conules in the center of the valleys, observed in all the species of *Trilophodon*, are wanting." (It will be noticed that the second part of the quotation yields another character by which the Javan form is distinguished from *Trilophodon*). In 1925 [3]) OSBORN mentioned as a characteristic of the grinding teeth: ".... serrate outer and inner borders....". I cannot see the connection with the foregoing quotation.

There cannot be any doubt that the Javan form does not belong to the genus *Serridentinus*. In the first place the grinding teeth of our species show no "serrate crests", and secondly all the species of the genus in question are apparently trilophodont. In none of the forms, of which the third molar is known, these carry more than four crests [4]), while in the remaining species the known M_2 bears three crests.

Synconolophus.

May also immediately be excluded. The molars of this genus present a peculiar structure, which is easy to recognize, and which OSBORN [5]) aptly described as follows: "....*Synconolophus* is readily distinguished by the multiplication of the cones and conules which finally render the molar a bewildering complex, of a warped, choerodont, ptychoid pattern."

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1) Am. Mus. Nov. n°. 99, 1923, p. 2.

2) This in contradiction to crests with double trefoils. In that case the trefoils are not exactly situated in the centre of the valleys.

3) Proc. Am. Philos. Soc. Philad., LXIV, 1925, p. 23.

4) Only M^3 of *Serridentinus browni* with rudiment of pentaloph.

5) Am. Mus. Nov. n°. 393, 1929, p. 10.

Rhynchotherium.

The M_3 of the only S. E. Asiatic species of that genus carries four crests, which excludes this form.

Platybelodon.

This remarkable genus with its short and broad shovel-tusks (I_2) is represented by one S. E. Asiatic pliocene species from Central Asia, namely, *Platybelodon grangeri*. Though several grinding teeth of that species have been found, no mention has been made of their structure. Nevertheless, we may be sure that our form is not identical with that species which may appear from what follows. Our own specimens described in the foregoing pages, were sent back to Bandung some years ago. It appears that since that time new specimens have been found, VON KOENIGSWALD [1]) mentioning that, besides bones and teeth, fragments of two crania and of three lower jaws have been obtained. Of course, VON KOENIGSWALD, palaeontologist of the Geological Survey of the Dutch East Indies, will not have failed to compare our specimens thoroughly with the remains subsequently found. From his paper (l. c.) it is not difficult to infer that in his opinion remains of only one species have been procured from BUMIAJU. The new material enabled him to state that the lower jaw of the species is devoid of lower incisors. This fact proves the distinctness from *Platybelodon grangeri* (which was a priori to be expected).

Mastodon lydekkeri.

Of this species but very little is known. SCHLOSSER described and figured under the present name a fragment of a M^3 consisting of last crest plus posterior talon. It suffices, however, to point out that *Mastodon lydekkeri* exceeds our species considerably in size and that its molars apparently do not possess trefoil conules, thus showing another, very essential difference.

Tetralophodon (subgenus *Lydekkeria*).

The distinctions of the subgenus in question from the true *Tetralophodon* stage are according to OSBORN [2]) as follows: "(1) second upper and lower molars subtetralophodont to tetralophodont; (2) molars with single central trefoils instead of double trefoils; (3) third upper and lower molars apparently with four and a half to five crests instead of five and a half to six crests; (4) molars extremely short-crowned or brachyodont....". From this quo-

[1]) De Mijningenieur n°. 11, Nov. 1931, p. 201.

[2]) Am. Mus. Nov. n°. 154, 1924, p. 2.

tation follows that our form certainly does not belong to the subgenus *Lydekkeria*, so that two more species are excluded.

Of the twenty seven species there still remain four forms with which we shall have to compare the Javan species.

The remaining forms are:

Anancus perimensis (FALCONER et CAUTLEY).

Mastodon pandionis FALCONER.

Pentalophodon sivalensis (CAUTLEY).

Tetralophodon punjabiensis (LYDEKKER).

Anancus perimensis.

Before the specimens of our collection were sent back to Bandung most of them were provisionally named by the writer. So the "*Mastodon*" of our collection received the provisional name of *Mastodon perimensis*. In the writer's opinion this identification, however, cannot hold good. There are certainly resemblances between the molars of the two forms, but on the other hand there are enough differences to justify distinction. LYDEKKER [1]) reckons but a few specimens to the species in question; only four grinding teeth have been figured viz., one l. M^2, two r. M^2 and one r. M_3. If one compares the figures of these teeth one is inclined to believe that two different species have been united under the name of *M. perimensis*. Two specimens of M^2 appear to show a more complex pattern of the crown than the remaining teeth. The former are in this respect also distinguished from our species. As to the specimens with a more simple structure, these differ in having more distinctly alternate inner and outer cones, and only trefoil conules on one cone of each crest. The figured M_3 shows a considerably greater amount of cement. To this difference, however, I do not attach much value, first because the amount of cement may have been greater in our own specimen, and secondly because the quantity of cement may be very variable in the grinding teeth of one and the same species.

Mastodon pandionis.

LYDEKKER described under the present name both specimens from Sind and Dhok Pathan. PILGRIM [2]) showed that the Dhok Pathan specimens belonged to a distinct species for which he proposed the name *Tetrabelodon corrugatus*. OSBORN [3]) changed the generic name in *Synconolophus*. The type of *Mastodon pandionis* is a first upper molar, the locality of which is not precisely known,

[1]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 58.

[2]) Rec. Geol. Surv. Ind., XLIII, 1913, p. 293.

[3]) Am. Mus. Nov., n°. 393, 1929, p. 10.

but which LYDEKKER considers — according to PILGRIM "with a fair show of probability" — to have come from Sind. This specimen will be found represented in Pal. Mem. I, pl. XXXIV, figs. 6—7; also (and far more distinct) in Mem. Geol. Surv. India, Ser. X, III, 1, 1884, pl. V, figs. 1—1*a*. Comparison of this figure with those of our specimens will reveal that the latter are distinguished by a series of differences, of which I may bring forward the absence of a strong outer cingulum in the lower grinding teeth.

Pentalophodon sivalensis.

PILGRIM (l. c. p. 293) separated under the name of *Mastodon hasnoti* the Middle Siwaliks specimens, which LYDEKKER had referred to *M. sivalensis*, from the typical *M. sivalensis* of the Upper Siwaliks. OSBORN (l. c. p. 10) changed the generic name of "*Mastodon*" *hasnoti* in *Synconolophus*. The intermediate molars of the typical *M. sivalensis* have five crests, the third molar is *in general* hexalophodont. LYDEKKER namely called attention to a M^3 (represented in fig. 1 of pl. XXXIV of the F. A. S.) which is pentalophodont. All known M_3, however, carry six crests. As to the number of crests there is, therefore a distinct affinity of our form to *Pentalophodon sivalensis* of the upper Siwaliks. Nevertheless I do not believe that the two forms are identical. One of the distinguishing features of *P. sivalensis* is the alternate arrangement of outer and inner cones, both in upper and lower grinding teeth. And it will be immediately admitted that alternate arrangement of the cones — though slightly present in our M_3 as a result of the oblique position of the crests — is totally absent in the M^3.

Remains to consider:

Tetralophodon punjabiensis.

It lasted until 1886 before LYDEKKER separated this form from *M. perimensis* (and *M. cautleyi*). LYDEKKER [1]) mentions four grinding teeth, one of which is a l. M^3, and represented by the same author in Mem. Geol. Surv. Ind., Ser. X, I, 5, 1880, pl. XLII. This specimen is readily distinguished from our upper third molar by a number of differences of which I mention (1) the considerably greater size (2) the presence of a crenulated inner cingulum, and (3) a totally different posterior talon.

Concluding that the Javan form is not identical with one of the twenty seven species of S. and E. Asia, we are wholly entitled to consider the Javan form as a distinct species for which we propose the name of *Tetralophodon bumiajuensis.*

[1]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 60.

We may add that the structure of the molars of *T. bumiajuensis* resembles very closely that of the teeth of *Tetralophodon longirostris* [1]); by the absence of lower incisors our form is, however, readily distinguished from the latter species.

[1]) It may be repeated that STEHLIN, to whom photographs (very probably of the grinding teeth of our specimens) were sent, determined the species as probably identical with *Mastodon longirostris*. (See: De Mijningenieur 1926, p. 230.)

Fam. ELEPHANTIDAE.

Subfam. STEGODONTINAE.

Stegodon airâwana MARTIN.

Fragmentary l. M^3.

Pl. XV, figs. 1—2.

Locality: Bumiaju [1]).

An imperfect cheek tooth of which the base of the crown is convex antero-posteriorly, thereby showing that it belongs to the upper jaw. The tooth is implanted in a fragment of the maxillary, which enables us to state with absolute certainty that the tooth is from the left side of the upper jaw. It is namely at the right side of the tooth that portions of the palate have been preserved. The tooth becomes gradually narrower from front to back. It is this characteristic shape of the crown, together with the absence of any disc of pressure on the posterior aspect, which show conclusively that the tooth represents the last of the true molar series. It is, therefore, a l. M^3.

The anterior part of the crown and of the fangs being broken off, it is impossible to estimate the exact number of ridge-crests which are lost. As will be seen below, I have no doubt in referring this molar to *Stegodon airâwana* MART. The ridge-crest formula of the M^3 of this species is in most cases $\times 12 \times$. The tooth under consideration carries a posterior talon plus 9 ridge-crests, so that probably 3 ridge-crests plus an anterior talon have been lost. To avoid confusions, I call the first ridge-crest of the molar in question ridge-crest $3 + 1$; the second ridge-crest $3 + 2$, et. seq.

The greater part of ridge-crest $3 + 1$ is broken off; the inner half of ridge-crest $3 + 2$ and the outer cusp of ridge-crests $3 + 4$, $3 + 5$, $3 + 6$, are somewhat damaged.

Degree of wear:

Ridge-crest $3 + 2$ up to and including ridge-crest $3 + 5$ present dentine-islets; the greater part of the cusps of ridge-crest $3 + 6$

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[1]) Exact locality unknown.

is perforated; the mammillae of ridge-crest 3 + 7 and the big median cusp of ridge-crest 3 + 8 are flattened. Ridge-crest 3 + 9 and the very low hind talon are untouched.

Besides small, regular undulations, the enamel of each ridge-crest shows a certain number of constrictions (6—8) which disappear near the base. The ridge-crests are somewhat bent, but as the figure gives a far better idea of the form of the dentine-islets than any description may do, I think it unnecessary to enter into details.

In order to show the proper form of the tall and rather slender ridge-crests in side aspect, the cement occurring in the palatinal extremities of the valleys between ridge-crests 3 + 4, 3 + 5, 3 + 6, 3 + 7 and 3 + 8 has been removed. A considerable amount of cement is present. The last three valleys are completely filled; the last two ridge-crests and the hind talon are for the greater part covered by cement. The number of cusps, borne by the unworn ridge-crests cannot be clearly ascertained. The penultimate ridge-crest, however, appears to carry 7 cusps; the median cusp is the highest.

The enamel consists of two layers. "Stufenbildung" is moderately developed. The enamel of the buccal and palatinal side of the ridge-crest only consists of one layer, namely the inner one. Owing to this peculiarity the hind and aft side of each ridge-crest is blackish, while the outer and inner side possess the yellow whitish colour of the inner layer. One would perhaps be inclined to believe that the absence of the outer layer on buccal and palatinal side does not represent the original state, but that it might be a result of subsequent transport of the specimen. This is, however, highly improbable, which may appear from the fact that the surface of inner and outer side is provided with distinct, parallel wrinkled, horizontal lines.

The grinding surface as well as the base of the crown are spirally twisted. (See for the former fig. 2 of pl. XV). That is the reason why the position of the grinding surface could not be used in the present case to determine to which side of the upper jaw the molar belongs. In order to be able to show this feature in numbers, we placed the median plane of the tooth vertically, and measured the slope of the top of each worn ridge-crest, and also the slope of the base of each ridge-crest. It will be clear, that the numbers, obtained in this manner, are only approximately right, and have only relative value, as we do not exactly know the position of the present specimen in the upper jaw.

	3 + 1	3 + 2	3 + 3	3 + 4	3 + 5	3 + 6	3 + 7	3 + 8	3 + 9	Hind talon
Slope of the base . . .	b	− 9°	− 7°	− 5°	− 4°	− 2°	− 2°	− 1°	− 0°	—
Slope of the top . . .	b	− 16°	− 13°	− 5°	− 1°	+ 2°	+ 4°	u	u	—

b = broken. — = slope from the inside outwards } if the fangs are above and the
u = unworn. + = „ „ „ outside inwards } crown below.

There cannot be a shade of a doubt that the specimen under consideration belongs to *St. airâwana*. First, it shows all the essential characters of the permanent upper molars of that species, and secondly its measurements agree closely with those of the upper third molars given by JANENSCH. The latter will be easily verified by the help of table T.

Fragmentary r. M^3.

Locality: Bumiaju [1]).

The resemblance of this molar with the foregoing specimen is so close, that there is no doubt, that the tooth in question is a third upper molar of the same species.

This tooth also is implanted in a fragment of the maxillary. As in the foregoing specimen a portion of the palate is present, enabling us to classify the present specimen without any difficulty as a r. M^3. But suppose a fragment of the palate had been absent, we had still been able to determine this specimen as a molar belonging to the right half of the maxilla. For its spirally twisted grinding surface is the reflected image of the plane of wear of the l. M^3, just described.

Both molars agree in almost every feature: form of the dentine-islets, degree of "Stufenbildung", thickness of the enamel, shape of the crown, colour, and state of fossilization. Consequently it seems almost sure, that the l. M^3 already described and the present r. M^3 belong to the same individual. The only difference is the degree of wear, the l. M^3 being somewhat more ground down than the r. M^3. But this cannot be used of course as an argument against the assertion above stated, for it occurs frequently that the cheek teeth of left and right side of the jaw present a different degree of wear.

[1]) Exact locality unknown.

In the present specimen ten ridge-crests plus a posterior talon are preserved so that probably two ridge-crests plus an anterior talon have been broken off. Of ridge-crest 2 + 1 only the enamel of a portion of its posterior side is present; the palatinal portion of ridge-crest 2 + 2 and the outer cusps of ridge-crest 2 + 4 are damaged.

Degree of wear.

Ridge-crests 2 + 2, 2 + 3 and 2 + 4 present dentine-islets; the cusps of ridge-crest 2 + 5 are perforated; the mammillae of ridge-crest 2 + 6 flattened; the median cusps of ridge-crest 2 + 7 just touched by wear. Ridge-crests 2 + 8, 2 + 9, 2 + 10 and the very low hind talon are untouched and covered by a thick coat of cement; only the sides of these ridge-crests and the summits of some of their cusps are partly free from, or project above the cement.

Ridge-crest 2 + 7 carries 6 cusps. The succeeding ridge-crests, being for the greater part concealed by cement, do not allow of ascertaining the number of cusps, borne by each. Ridge-crest 2 + 2 requires more consideration. It presents namely a deep constriction, somewhat palatinally of the median line. This median constriction is flanked on either side by a less distinct lateral constriction. This ridge-crest is therefore divided into four. The outer lateral constriction, as well as the median one, cannot be perceived in the succeeding ridge-crests. The inner lateral constriction, however, is more or less distinct from ridge-crest 2 + 2 up to and including ridge-crest 2 + 7.

The buccal half of the anterior portion of the present specimen shows a peculiar divergency. The transverse valley between ridge-crests 2 + 1 and 2 + 2 is namely blocked by a rudiment of a ridge-crest.

The measurements of the molar in question are given in table T.

The degree of twisting of the grinding surface and of the base of the crown has been expressed in the same manner as in the foregoing specimen. The various values will be found in the table below.

	2+1	2+2	2+3	2+4	2+5	2+6	2+7	2+8	2+9	2+10	Hind talon
Slope of the base . . .	b	b	− 7°	− 6°	− 4°	− 3°	− 2°	0°	+ 2°	+ 2°	—
Slope of the top . . .	b	− 12°	− 8°	− 5°	− 2°	0°	u	u	u	u	—

b = broken. — = slope from the inside outwards } if the fangs are above and the
u = unworn. + = „ „ „ outside inwards } crown below.

Fragment of the cranium with l. M^3 *in situ.*

Pl. XIII, figs. 1—2.

Locality: Tji Pangglosoran [1]).

Description of the fragment.

It consists of that part of the cranium situated between a plane, extending from the front side of the outer narial aperture to the inner nares, and a plane, beginning at the front side of the M^3 and intersecting the incisive sheaths at a distance of about 15 cm. below the outer narial aperture. It contains the M^3 of the left side, and the fangs of the corresponding molar of the right side.

The postero-external part of the left premaxillary is lost. Only the posterior part of the inter-alveolar fossa has been preserved, presenting a divergence of its side walls frontwards. The anterior portion of the right canalis infraorbitalis is well preserved. Its front is subcircular (diameter 4 cm.). Behind it is ovalshaped (7 × 4 cm.).

The palate is considerably injured. Its hindmost part, which is undamaged, is concave in cross-section. Though of the r. M^3 only the fangs are present, it is easily stated that both molars are approximated in front and divergent behind (interval in front 6 cm.; behind 10 cm.).

Description of the l. M^3. (Pl. XIII, figs. 1—2.)

Very fine specimen. The tooth carries 11 ridge-crests, while it is possible that a fore- and aft talon are present. The relatively great width of the foremost dentine-islet namely, may be an indication of the presence of an anterior talon, the dentine of which has now been united with that of the first ridge-crest. This foremost dentine-islet is only at its buccal- and posterior side bounded by an edge of enamel.

The last four ridge-crests were absolutely concealed by a thick coat of cement. In order to be able to show the profile view of these ridge-crests, the cement covering their palatinal sides has been removed. At the same time it was shown that behind the last ridge-crest a considerable amount of cement is present, which possibly conceals a posterior talon.

If this be true, the ridge-crests formula may be represented as follows: × 11 ×.

Degree of wear:

The plane of wear as well as the base of the crown are clearly convex. Ridge-crests 1, 2, 3 and 4 present dentine-islets; the cusps

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[1]) See sketch map n°. 1.

of ridge-crests 5 and 6 are perforated; the median cusps of ridge-crest 7 flattened. The succeeding ridge-crests are concealed by cement, only two median cusps of ridge-crest 8 project through the cement. The worn summit of ridge-crests 2, 4 and 6 is concave in the palatinal-buccal direction. The worn summit of ridge-crest 5 is flat, that of ridge-crest 3 convex. As a result the top of the buccal extremity of the worn ridge-crest 3 is some 7 mm. lower than that of the corresponding part of ridge-crests 2 and 4.

The palatinal portion of ridge-crests 1 and 2 is wanting. Two inner cusps of ridge-crest 5 are damaged. Ridge-crest 2 presents, besides small crenulations, three constrictions of the enamel viz., one constriction in the median line of the molar and two lateral constrictions, resp. buccally and palatinally of the median one. Both lateral constrictions can be followed up to ridge-crest 4. The enamel of the posterior side of ridge-crest 1 shows only a median- and a buccal inlet. We may be sure that the median constriction of ridge-crests 1 and 2 indicates the presence of a longitudinal median cleft, manifestating itself in ridge-crests 3 and 4 by a distinct division of these ridge-crests into two parts, the buccal half being so much in advance of the palatinal half that inner- and outer halfs of ridge-crests 3 and 4 alternate. Ridge-crest 5 is straight. Its palatinal extremity is not developed, so that its width is three quarters of that of the preceding ridge-crest. Ridge-crest 6 extends nearly straight across the crown; ridge-crest 7 and probably ridge-crests 8, 9, 10 and 11 too. The number of cusps, borne by ridge-crests 6 and 7, is resp. ten and eleven. Ridge-crests 2, 3, 4 and 5 are clearly chevron-shaped, the valleys between them are consequently V shaped. The succeeding ridge-crests present more the form of a wall, which fact is accompanied by an increase of the height.

The enamel consists of two layers. This could clearly be perceived in the remnants of the enamel of the r. M^3 which is broken off partly near, partly below the base of the crown. The worn ridge-crests present a moderately developed "Stufenbildung".

The separation between crown and fangs is distinct. Inner- and outer side of the tooth converge posteriorly, thereby showing the characteristic shape of a third molar. As has been already mentioned, the amount of cement is considerable. The coat of cement, which covers the last four ridge-crests, does not present furrows, extending in transverse direction straight across the crown, so that the position of the posterior ridge-crests is entirely hidden by the cement.

The measurements of the l. M^3 will be found in table T.

The fragment itself does not present enough characters by which it can be distinguished; the molar, however, does. The structure of the anterior half of the crown is — as was mentioned above —

considerably irregular. On the other hand, however, the posterior half of the molar in question resembles, down to the smallest detail, the l. M^3 of *St. airâwana* described on p. 132.

Both molars present (comparing the hinder half of the specimens):

a. the same wall-shaped ridge-crests;

b. the same relation between height and width of each ridge-crest;

c. the same thick coat of cement, covering the ridge-crests totally;

d. the same edge-shaped thickening at the base of each ridge-crest;

e. the same curvature of the base of the crown and of the upper surface of the coat of enamel.

In brief, the resemblance is so extremely close, that I have not the slightest doubt in referring the fragment described above also to *Stegodon airâwana*.

Detached right M_1.

Pl. XV, figs. 3—4.

Locality: Bumiaju [1]).

This almost complete, finely preserved tooth having grinding surface and base of the crown concave antero-posteriorly, shows itself to belong to the lower jaw. The right side being concave proves, furthermore, the tooth to belong to the right ramus of the mandible.

At the front the tooth is damaged, but the course of the fangs shows decidedly that only the anterior side of the first ridge-crest (plus perhaps a fore talon) are wanting. The lingual side of ridge-crest 3 and the greater part of the inner moiety of ridge-crest 4 are also broken off. Only the upper portion (1-3 cm.) of the fangs is present. The tooth is slightly narrower in front than behind.

Degree of wear:

Ridge-crests 1, 2 and 3 present dentine-islets; the conelets of ridge-crest 4 are perforated; the cusps of ridge-crest 5 are only flattened; the median cusps of ridge-crest 6 are just touched by wear; ridge-crest 7 and the much lower hind talon are untouched.

The ridge-crests are tall, slender, chevron-shaped. The last five ridge-crests slope backwardly. Ridge-crests 1 and 2 are so much worn down, that it is difficult to determine whether or not they slope backwards. The unworn ridge-crest is the highest in the

[1]) Exact locality unknown.

middle. Ridge-crest 5 consists of a big cusp on lingual and buccal side and between these two five smaller ones. The clefts, which separate the two lateral cusps from the median portion of the ridge-crest, are much more distinct than those separating the five smaller cusps mutually. We see, therefore, that this ridge-crest is divided into three. The same may be seen in all preceding and following ridge-crests. Ridge-crests 1 and 2 not only present two constrictions, which mark a lingual and a buccal cleft, but show also a constriction in the median line. The latter constriction is almost as distinct as the two lateral ones, lingually and buccally of it. Probably it indicates the presence of a median, longitudinal cleft in the first two ridge-crests. While we can easily follow the two lateral, longitudinal clefts in the ridge-crests situated more backwards, this is not the case with the median cleft. In the third ridge-crest there is perhaps still a slight indication for its presence, but it is totally absent in the following ridge-crests.

The structure of ridge-crests 6 and 7 is on the whole similar to that of ridge-crest 5. The buccal extremity of the transverse valley between ridge-crests 6 and 7 is for the greater part blocked by a tall (2 cm.), rather sharp, accessory tubercle, which is closely attached to the outer cusp of the seventh ridge-crest.

The hind talon is much lower than the last ridge-crest and placed more to the inner side of the tooth. It consists of a large median tubercle, flanked by two smaller tubercles on the inner side and four on the outer side.

The outer extremity of each transverse valley — with the exception of the valley between penultimate and ultimate ridge-crests, which is occupied by the large accessory tubercle, already mentioned — possesses a small incipient tubercle. The inner mouths of the valleys are free from tubercles.

Ridge-crests 1 and 2 are nearly straight; ridge-crests 3, 4, 5 and 6 are slightly bent, the portion inwards of the buccal cleft being in advance of the portion right of it. Ridge-crest 7 is almost straight.

The transverse valleys are narrow. The first and second valleys have but little cement; in the succeeding valleys the amount of cement increases gradually, so that the valleys between ridge-crests 5, 6 and 7 and the space between the last ridge-crest and the hind talon are completely filled.

The enamel is moderately thick and composed of two layers. "Stufenbilding" is rather well developed. The enamel of each ridge-crest presents, besides the two or three constrictions, small regular crenulations. The degree of crenulation of the enamel agrees exactly with that of the enamel of the cheek teeth of *Stegodon airâwana*.

I have no doubt to refer the tooth under consideration to *Stegodon airâwana* because this lower tooth resembles in almost every essential character a r. M_2 of that species figured by JANENSCH in "Die Pithecanthropus-Schichten auf Java", pl. XXII, fig. 4. Both specimens show the same form, the same degree of crenulation of the enamel and of "Stufenbildung", the presence of small accessory tubercles in the outer extremities of the valleys, the presence of a bigger accessory tubercle "auszen neben dem letzten Joch" [1] [2].

It now only remains to consider the serial position of the tooth in question. It will be remembered that its ridge-crest formula is either 7× or ×7×. Furthermore, it will be known that cheek teeth of *St. airâwana* have been described by MARTIN [3], JANENSCH [4], SOERGEL [5], DIETRICH [6] and STEHLIN [7]. It is especially by JANENSCH'S excellent investigations that our knowledge of the present form has been considerably enriched. JANENSCH gave the following ridge-crests formulae:

$$m\ \frac{?5\times\quad\times7\times}{}\qquad M\ \frac{\times7\times\quad\times9\times\quad\times11\text{—}12\times}{\times13\times}$$

In 1917 JANENSCH and DIETRICH extensively described the occurrence of the second upper premolar (P^2) in a specimen of the upper jaw of *St. airâwana*. SCHLESINGER [8] showed, however, that this supposed premolar in reality represents the first upper milk molar (m^1). DIETRICH [9] agreed with SCHLESINGER'S redetermination. The referred tooth carries three ridge-crests. Among SOERGEL'S material a r. M_3 was represented, which this author described and figured under the name of *St.* cf. *airâwana*. I have no doubt that this specimen really belongs to *St. airâwana*. Though 9½ ridge-crests and a posterior talon had been preserved, SOERGEL did not hesitate to estimate the ridge-crest formula at × 11 ×,

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[1] JANENSCH, "Die Pithecanthropus-Schichten auf Java", p. 181.

[2] The occurrence of a bigger accessory tubercle in (or near) the outer mouth of the valley between ultimate and penultimate ridge-crest seems to be rather constant in the $M_{1\text{-}2}$ of *Stegodon airâwana*. Besides the example above mentioned, this peculiarity will be found in a r. M_2 of *St. airâwana*, figured by MARTIN in: Verh. Kon. Akad. v. Wetensch. Amsterdam, XXVIII, 1890, pl. II, fig. 3, and in a M_1?, figured by the same author in: Samml. Geol. Reichs-Museums Leiden, IV, 1884—1889, pl. VI, fig. 1. The latter specimen was originally referred by MARTIN with some diffidence to *St. trigonocephalus*; later on, however (Verh. Kon. Akad. v. Wetensch., XXVIII, 1890, p. 10) to *St. airâwana*.

[3] Verh. Kon. Akad. v. Wetensch., XXVIII, 1890, p. 10.

[4] Loc. cit.

[5] Palaeontographica, Suppl. IV, Abt. III, Lief. 1, 1914, p. 4.

[6] In cooperation with JANENSCH. Sitz.-Ber. Ges. Naturf. Fr. zu Berlin, Jhrg. 1916, 1917, p. 126.

[7] Wetensch. Med. n°. 3, 1925, p. 5.

[8] Geologica Hungarica, T II, fasc. 1, 1922, p. 48, note 1.

[9] See Neues Jahrb. f. Min. etc., II, 1923, p. 275.

because the course of the fangs showed that about one ridge-crest plus an anterior talon were wanting. In all probability the number of ridge-crests in the lower third molar of the present species may, therefore, vary from 11 to 13. These are, however, the only additions to JANENSCH's ridge-crest formulae, afforded by the investigations subsequent to those of JANENSCH.

It will be clear that the specimen of our collection either represents m_3 or M_1. Of the last lower milk molar but very little is known. JANENSCH (l. c. p. 8) considered a fragment, consisting of three ridge-crests, as representing a portion of m_3 of *St. airâwana*. Both determination of the species and serial position appear to me to be right. STEHLIN (loc. cit. p. 5) described and figured the greater part of a lower cheek tooth which he determined as M_1 of *St. airâwana*. He gave the length of the last three ridge-crests viz., (from front to back) 73, 72 and 62 mm. In my opinion this specimen does not represent a M_1, as STEHLIN believed, but certainly a M_2. The correctness of this assertion may be seen from comparison of the measurements above stated with those of table U. From the same table it will be seen that the present specimen of our collection cannot but represent a M_1. It is, therefore, the first specimen of M_1 which has hitherto been described.

Fragmentary lower jaw with l. and r. M_3 *in situ*.

Pl. XII, fig. 1; pl. XIV, figs. 2—3.

Text figs. 22—23.

Locality: Lepen Alit near Tinggang [1]).

Description of lower jaw. (Pl. XIV, figs. 2—3; text fig. 22.)

Very fine specimen, containing on either side the posterior part of the totally worn M_2 and the whole of the partly worn M_3.

Horizontal ramus of either side and mandibular symphysis are perfectly preserved. The ascending ramus of the left side is broken off near the neck of the condyle, while the top of the coronoid process has been lost. The ascending ramus of the right side possesses a greater portion of the coronoid process than that of the left side. For the rest, however, the right ascending ramus is broken off some 13 cm. lower than the left one. The mandible is broken into two in the mandibular symphysis, but both parts match exactly.

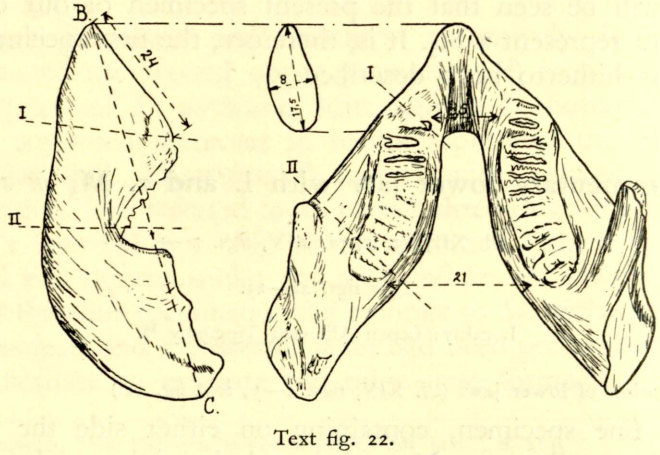
The lower border of the horizontal ramus is nearly straight, that of the ascending ramus strongly curved (portion of the cir-

[1]) District Tambakredjo, Regency Bodjonegoro, Residency Bodjonegoro.

cumference of a circle with a radius of about 25 cm.). Alveolar border and lower border of the horizontal ramus converge strongly backwards. As a result the difference between greatest and smallest height is considerable, and the height of the ramus at the base of coronoid process is small. Inner and outer surface of the horizontal ramus converge strongly frontwards, the ramus becoming considerably narrower towards the symphysis.

The mandibular symphysis presents a spout-like, rather narrow termination. Diastemal ridge and upper border of the symphysis pass into each other uninterrupted. The diastema slopes obliquely frontwards at an acute angle of about 25° with the inferior border of the ramus. Diastema and alveolar margin intersect at an obtuse angle of about 105°.

The anterior border of the upper portion of the coronoid process is perpendicular to the lower border of the ramus. The upper portion of the internal surface of the left ascending ramus presents the oval-shaped orifice of the dental canal.



Text fig. 22.

MEASUREMENTS OF LOWER JAW IN cm.

See text fig. 22.

In plane I $<$ greatest height = 20; greatest width = 8.2

In plane II $<$ greatest height = 12; greatest width = 18.3

Lenght of B C = 70

Both plane I and II are perpendicular to outer and lower surface of horizontal ramus.

It will be sufficient to give a detailed description of the l. M_3 and of the remains of the l. M_2 only, the corresponding molars of left and right side being very similar.

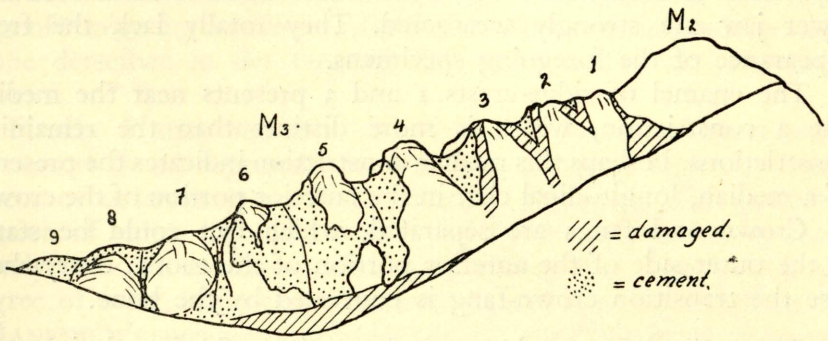
Description of the remains of the left M_2. (Pl. XII, fig. 1.)

Only the last two ridge-crests, absolutely ground down, are present. The whole consists of an oblong fragment of dentine, in the middle with two edges of enamel: remnants of resp. posterior side of the penultimate, and anterior side of the ultimate ridge-crest. Both edges are separated by a very narrow cleft, filled with cement. There is no clear indication of a hind talon.

Description of the left M_3. (Pl. XII, fig. 1; text fig. 23.)

Fine specimen. Only the inner side of the first three ridge-crests and the outer side of the fore talon are somewhat damaged. Ridge-crest formula $\times 11 \times$. This cannot be seen from the figures because the photographs were taken before in the left ramus "bone" material had been removed in order to expose the whole tooth. It was then revealed, that besides the ten ridge-crests plus anterior talon which can be seen in the figures, another ridge-crest plus a very small and low posterior talon are present.

The tooth is considerably laterally bent; inner side convex, outer side concave. The plane of wear is very slightly concave antero-posteriorly. A slope of the grinding surface inwards or



Text fig. 23. St. airâwana.
Lingual aspect of l. M_3 and of posterior portion of l. M_2. $^4/_9$ nat. size.

outwards could not be stated. That part of the surface of the crown which is not touched by wear, slopes obliquely from the outside inwards.

Degree of wear:

The anterior portion of the tooth is so much worn down that the dentine-islets of the first ridge-crest and of the fore talon are

united, presenting an irregularly shaped disk of dentine. A narrow cleft, filled with matrix, separates M_3 and remaining portion of M_2. An inlet of the enamel near the buccal side of the ridge-crest marks the presence of the fore talon. Ridge-crests 2 and 3 present dentine-islets; the cusps of ridge-crests 4 and 5 are perforated, some cusps of ridge-crest 6 are touched by wear, the cusps of ridge-crest 7 and of all succeeding ridge-crests are untouched.

The amount of cement is considerable. The last four ridge-crests plus the hind talon are totally covered by a thick coat of cement; furrows, extending straight across the crown indicate the presence of these ridge-crests. Some cusps of ridge-crest 7 project above the cement, but others are still hidden, so that the number of cusps of this ridge-crest cannot be ascertained. Ridge-crest 6 carries seven cusps; ridge-crest 5 ditto; ridge-crest 4 eight. The narrow, deep valleys between the worn ridge-crests are for the greater part still filled with cement.

The ridge-crests extend straight across the crown. Only ridge-crest 2 presents a slight curvature. The ridge-crests are more or less perpendicular to the curved sides of the tooth, consequently they converge outwards. They are tall and narrow, but still clearly chevron-shaped, the valleys are consequently V shaped. The enamel consists of two layers and consequently "Stufenbildung" is present. Compared with the specimens described in the foregoing pages the "Stufenbildung" makes the impression of being less distinct. This impression is made, however, by the fact that the molars of this lower jaw are strongly weathered. They totally lack the fresh appearance of the foregoing specimens.

The enamel of ridge-crests 1 and 3 presents near the median line a constriction, which is more distinct than the remaining constrictions. Perhaps this median constriction indicates the presence of a median, longitudinal cleft in the anterior portion of the crown.

Crown and fangs are separated, which fact could be stated at the outer side of the anterior portion of the tooth; everywhere else the transition crown-fang is concealed by the bone.

The main difference between the molars of left and right side of the lower jaw in question is that the r. M_2 presents, besides the two edges of enamel, already mentioned in describing the l. M_2, portions of two other edges of enamel namely of the posterior side of the antepenultimate ridge-crest and of the anterior side of the penultimate ridge-crest.

The measurements of l. and r. M_3 will be found in table V.

As to the identification of the present specimen I do not believe that the reader will be convinced at first glance of the correctness

of the determination. Neither to me the specimen under consideration made originally the impression of belonging to *St. airâwana*. I was, however, misled by its weathered appearance, which not only affects the distinction of the "Stufenbildung", but also troubles the degree of crenulation of the enamel. Only by blackening the dentine material of the worn ridge-crests, it was possible to produce a figure which enables the reader to form a notion of the structure and of the degree of crenulation of the enamel. The figure shows, especially when the magnifying lens is applied to it, that the degree of crenulation of the enamel is not so small as it seems to be at first sight. Moreover, it must be borne in mind that the plane of wear and the upper, unworn surface of the tooth are placed very obliquely to one another, consequently the two frontmost ridge-crests are worn down almost to the bottom of the transverse valleys. And as a matter of fact the degree of crenulation becomes smaller towards the base of the ridge-crests.

Neither ridge-crest formula ($\times 11 \times$) nor measurements [1]) afford any reason to suppose that the specimen might belong to a species distinct from *St. airâwana*. Furthermore, I may call attention to the remarkable likeness of the present lower jaw with the specimens of lower jaw of *St. airâwana*, described and figured by JANENSCH (l. c.) and SOERGEL (l. c.). Our specimen exhibits decidedly those characters which appeared to be constant, viz., ". . . . die nach vorn sich kräftig und ziemlich geradlinig verschmälernde Form des Umrisses in der Ansicht von oben, die langgezogene, sehr flach bogenförmige untere Kontur der Mandibeläste und die sehr geringe Höhe derselben in der Gegend des Vorderrandes des Kronfortsatzes . . . ." [2]).

Finally I may mention the following peculiar coincidence. JANENSCH (l. c.) represents in text figs. 4 and 5 upper and side aspect of a lower jaw of *St. airâwana*, containing the posterior portion of either M_2 and l. and r. M_3. In this respect it resembles closely our own specimen, which only differs by a slightly stronger degree of wear, indicating somewhat higher age. The third molar of JANENSCH's specimen resembles very closely those of our specimen as may a. o. appear from table V where specimens B represent l. and r. M_3 of the referred lower jaw of JANENSCH's collection. The peculiarity is that JANENSCH [3]) observes of the molars of his specimen: "Die Zähne . . . machen den Eindruck, als ob sie von der Verwitterung oberflächlich angegriffen wären. Auch der Schmelz ist an den vorderen Jochen auffallend rauh und in seinen Konturen

[1]) See table V.

[2]) JANENSCH, l. c., p. 158.

[3]) L. c., p. 183.

ziemlich unklar und verwaschen". There exists, therefore, also in this respect a remarkable resemblance between both specimens. I do not intend of course to say that the latter resemblance affords an argument for specific identity. I only mentioned it to prove that by weathering the original structure of the ridge-crests of the teeth of *St. airâwana* may be troubled considerably.

In short, in my opinion there remains not the slightest reason to regard this lower jaw of our collection as belonging to a species distinct from *St. airâwana*.

Injured cranium.

Pl. XX, fig. 1.

Locality: Bumiaju, Excavation 6.

Case n°. 17 of the fourth consignment contained a number of specimens obtained from different excavations. According to the original list of specification the present case contained also remains from excavation 6, viz., "1 cranium of a fossil elephant together with 1 detached tusk and detached cheek teeth in a small case . . ."[1]). From this quotation one would be inclined to believe that the detached cheek teeth (nine fragments) belonged to the same individual as the cranium; the more so, if be added, that the detached tusk really appeared to belong to it. Originally the present writer believed this indeed. He had, however, to alter his opinion. From the measurements given on p. 148 it will namely be seen that the cranium in question belonged to an immature individual[2]). On p. 165 it will be seen that among the detached grinding teeth, above mentioned, two fragments occur which are worn, and which represent the hinder portion of (in all probability) the third molar. As would already appear from what precedes, we may be sure that in the cranium in question by no means the third molar was in use. The cranium itself proves this assertion to be true. For though it lacks grinding teeth it was not difficult to infer, that on either side a small molar of about 11.5—12 cm. was in use. From the tables given by JANENSCH it appears that it was in all probability the first true molar. We are, therefore, wholly justified in regarding the

[1]) Literal translation.

[2]) In this connection the following comparison may be drawn. The fine specimen of a young cranium of *St. airâwana* of JANENSCH's collection appears to have a total length (from vertex cranii to tip of premaxillaries) of about 480 cm. In our specimen this interval amounts to 700 cm. In JANENSCH's specimen the last milkmolar is moderately worn. Our specimen being of larger size certainly belonged to a less young individual. On the other hand, however, its size shows that it certainly did not belong to a mature individual.

detached cheek teeth and the cranium as not belonging to the same individual.

We shall now describe the cranium in question.

Injured specimen. No deformation. As already mentioned probably the M^1 of either side was in use, but both are completely hammered down to the margin of the alveoli. The maxillaries are considerably injured. Behind both molars, mentioned above, and on either side of the posterior nares a hole occurs, which is now filled for the greater part with plaster. These holes represent the places of left and right succeeding molar, which was certainly not yet in use, and the crown of which was surely still partly concealed by the bone.

Though grinding teeth are wanting we were able to determine the *Stegodon* nature of the present specimen with absolute certainty. After a careful examination, namely, small remnants of the enamel have been found belonging to the posterior part of the succeeding molar, mentioned above. And the enamel appearing to consist of two layers, we may be sure, that the cranium under consideration does not belong either to *Mastodon* or to *Elephas*.

The left incisive sheath has been partly lost; the right one is better preserved. The detached tusk was broken into three; the parts, however, matched exactly, and after being glued together, revealed that its proximal end fitted close to the portion contained in the right incisive sheath. The incisor is almost straight in lateral view of the cranium, but distinctly bent outwards, if regarded in the upper aspect. Near the top it is compressed, the cross-section being an ellips, the longest diameter of which is parallel to the median plane of the cranium. More backwards the tusk becomes gradually circular in cross-section.

The forehead is convex across. Consequently, the vertex cranii presents a distinct, convex curvature, as seen from the aspect of the occiput. In upper view of the cranium the vertex cranii is convex backwards with a distinct depression in the middle.

The preservation of the lower half of the occiput is bad. There is a shapeless hole, indicating the position of the foramen magnum and the median depression above it.

The walls of the outer nasal aperture are damaged so that a hole has been formed, the dimensions of which are certainly greater than those of the original nasal orifice.

Both zygomatic arches are wanting. The preservation of the left side of the cranium is somewhat better than that of the right side so that we shall describe the former. The temporal fossa is rather deeply concave from front backwards. As a result the temporal contraction of the forehead is distinct. The crista spheno-frontalis

can be followed from above over a distance of some 13 cm. In upper view of the cranium the arcus supraciliaris manifests itself by a slight curve, concave outwards. If we draw on either side a tangent to the upper margin of the orbita and to that of the temporal fossa, both lines are approximated behind and divergent in front. The degree of divergence is, however, small.

The interalveolar fossa is deep and presents the form of an elongated oval, accuminated at both ends. The inner nares are oval-shaped, with longest diameter in the median plane of the cranium. The palate is narrow.

MEASUREMENTS OF THE CRANIUM IN cm.

Total length (from vertex cranii to anterior extremity of premaxillaries)	70
Smallest breadth of forehead	36
Interval between posterior extremity of interalveolar fossa and vertex cranii	32
Interval between tips of postorbitary process of either side	49
Estimated interval between outer sides of each incisive sheath, near the infra-orbital canal	ca 28
Length of inter-alveolar fossa	38
Greatest depth of ditto	7.5
Greatest breadth of ditto	11
Length of exposed portion of right tusk	41
Dimensions of ditto, 5 cm. from tip	3.2 × 2.6
Dimensions of ditto, immediately in front of premaxillary	6 × 6
Breadth of palate	4.5
Dimensions of posterior narial orifice	11 × 5.3

If fig. 1 of pl. XX, in which the upper aspect of the present cranium is represented, be compared with the corresponding aspect of the young cranium of JANENSCH's collection [1]) it will be stated that besides a number of resemblances also some differences occur. And the question is: Are these differences essential or are they the result of different age and (or) individual variation? Of some differences it is not difficult to see that they are invalid. I mean the different form of the interalveolar fossa and the different curvature of the incisor, which is in our specimen outwards, and in

[1]) Die Pithecanthropus-Schichten auf Java, 1911, pl. XXI, fig. 1.

that of JANENSCH inwards. JANENSCH [1]) describes the course of the tusk as follows: "Bemerkenswert ist, dasz der dem Schädel ansitzende rechte Stoszzahn bei schwacher gegen die Mediane konkaver Krümmung mit seiner Spitze über die Mitte nach links hinausgewachsen ist. Würde der .... linke Stoszzahn die gleiche Stellung wie der rechte gehabt haben, so müszten sie sich gekreuzt haben". I am, however, convinced that JANENSCH's specimen represents in this respect a deviation. For it will be known that even in those forms in which the tusks are curved inwards in old individuals (e. g. *Mammonteus primigenius* BLUMENB.) the course of the tusks of younger specimens is such that the animal can use them (e. g. for uprooting food).

As to the different form of the interalveolar fossa, it may be observed that this is strongly affected, of course, by the development of the incisors.

As to the remaining differences, however, it was necessary to study a sufficient number of crania of one species in order to get an idea of the influence of age and the range of variation. As far as my knowledge goes there is not one species of *Stegodon* of which a sufficient number of crania has been described. Consequently I had to turn to a recent species viz., to *Elephas maximus* L., of which the National Museum of Natural History in Leyden possesses a fine collection, consisting of about twenty crania of most different age. Unfortunately time failed to take a great number of measurements of these specimens so that I am not able to illustrate the range of variation in the same manner as I did for kerabau, banting and *Rhinoceros sondaicus* [2]). Notwithstanding this hasty examination it was not difficult to notice a.o. two prominent facts.

a. The relation between height and smallest breadth of the forehead may vary considerably viz., from about 0.87 to about 1.26. In determining the minimum and maximum value of this relation no use has been made of the measurements of very young crania. Furthermore, in measuring the height of the forehead the median projection of the nasals is not included. It appeared that the great difference between maximum and minimum values is not only caused by differences in the relative height of the forehead, but also by a different degree of contraction of the forehead by the temporal fossae.

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[1]) L. c., p. 152.

[2]) After the publication of the present paper, I hope, however, to have the opportunity of making a detailed study of the cranium of *E. maximus*. Then I intend to point out why in my opinion *St. airâwana* and *St. trigonocephalus* are not identical, in spite of the fact that this has been asserted from authoritative side, namely by DUBOIS (Tijdschr. Kon. Ned. Aardr. Gen., sec. ser., XXV, 1908, p. 1257) and by DIETRICH (Sitz. ber. Ges. naturf. Fr., Berlin, 1917, p. 126, note 2).

b. The posterior outline of the cranium, as seen in upper aspect, appeared to be remarkably constant. The depression in the middle may vary a little, but in all specimens examined, it is decidedly present.

Provided with this knowledge we return to the comparison of our specimen with the young cranium of *St. airâwana* of JANENSCH's collection. One of the most striking peculiarities of the latter specimen is its very high forehead, which is relatively little contracted by the temporal fossae. In these respects our specimen differs not inconsiderably, even if one is mindful of (1) the strongly damaged outer narial orifice of our specimen, causing its forehead to seem less high than it is in reality, and (2) the injury of left and right postorbitary process of JANENSCH's specimen by which the impression is made of a smaller degree of contraction of the forehead than really exists. JANENSCH describes the forehead of his specimen as follows: "Die Stirn ist flach und sehr hoch. Ihre Höhe, vom Oberrand der Nasenöffnung an gerechnet, beträgt 20 cm., ebensoviel wie die geringste Breite, die etwa unter der halben Höhe liegt. Dabei ist noch zu berücksichtigen, dasz der von oben in die Nasenöffnung vorragende mediane Vorsprung nicht erhalten und deshalb nicht in den Betrag der Stirnhöhe einberechnet ist. Die Stirn verbreitert sich von ihrer schmalsten Stelle an nach oben zu langsam und gleichmäszig" [1]). If one calculates, however, the relation between height and smallest breadth of the forehead by the help of the excellent figures of JANENSCH's specimen it will be seen that this is not 1.00, but approximately $\frac{62}{70} = 0.81$. In our specimen the same relation will be about 0.61. If we accept that the range of variation in *St. airâwana* is not considerably smaller than in *E. maximus* (and why should it?) the different values for the relation mentioned does not afford a reason for specific distinction. The more so as our specimen presents a conformity with the cranium of *St. airâwana* to which I am inclined to attach much value, after what I have seen in *E. maximus*. I mean the form of the posterior outline of the cranium as seen in frontal aspect. A still younger cranium of *St. airâwana* of JANENSCH's collection in which the posterior portion of the forehead was excellently well preserved, showed a distinct depression of the outline mentioned. The same feature is clearly exhibited in our specimen. In this respect both crania differ essentially from the cranium of *St. trigonocephalus* MARTIN.

As, furthermore, the side aspect of our specimen presents —

[1]) L. c. p. 152.

as far as it has been preserved — no distinguishing characters from the cranium of *St. airâwana*, there remains in my opinion not the slightest reason to distinguish between the two.

Stegodon trigonocephalus MARTIN.

Damaged, mature cranium with r. M^3 *in situ.*

Pl. XI, figs. 1—2; pl. XII, figs. 2—3.

Locality: Mendut near Tinggang [1]).

Description of the cranium. (Pl. XI, figs. 1—2.)

Injured and slightly deformed specimen. Both zygomatic arches are wanting; the occiput is very much damaged; the upper part of the right incisive sheath has been lost; the outer nasal aperture is so considerably injured that it is now in open communication with both incisive alveoli.

The right side of the cranium is considerably better preserved than the left one. At the left side all is broken off, which — in frontal aspect of the cranium — is situated buccally of the line, connecting the outer side of the left incisive sheath with the innermost point of the upper part of the temporal fossa of the same side.

Only the right molar is present, which is inferred to be the M^3 from the characteristic shape of the crown, and from the absence of any other tooth behind.

As has been already mentioned, the occiput is very much damaged: the foramen magnum has become a big, formless hole, condyli are absent.

We shall describe the right lateral side, as being best preserved. The temporal fossa is distinctly separated from the orbita by the crista spheno-frontalis, running from the postorbitary process of the frontal to near the zygomatic process of the squamosal, and presenting — in lateral view of the cranium — a very slightly curved line, convex frontwards.

There is an abrupt transition of the upper part of the temporal fossa into the forehead. The upper border of the former is nearly parallel to the alveolar margin of the molar; anterior and posterior border are almost perpendicular to the upper border, the lower border is formed by the crista spheno-frontalis. Roughly spoken the temporal fossa presents, therefore, the form of a rectangular trapezium; it is deeply concave transversely with a slight longitudinal convexity in the middle.

[1]) District Tambakredjo, Regency Bodjonegoro, Residency Bodjonegoro.

The infra-orbital canal, which is rather well preserved, is oval-shaped. The posterior lower angle of the orbit presents a hole, which for the greater part is filled with matrix, and indicating the position of for. opticum plus for. rotundum. In anterior aspect of the cranium nothing can be seen of the orbit, the arcus supraciliaris not contracting the upper surface.

The forehead is low and considerably convex across. Forehead and upper surface of the premaxillaries are very markedly oblique to one another, as seen in side aspect. The forehead is contracted by the temporal fossae. The cranium broadens decidedly towards the occipital surface. Stress may be laid upon the fact that in frontal aspect the posterior outline of the cranium presents an uninterrupted, strongly convex line without any depression in the middle.

The outer nasal aperture is — as already mentioned — very much damaged. Only parts of the right wall, of the right half of the posterior wall, and of the right side of the median projection of the nasal of that side have been preserved. As, moreover, the interalveolar fossa is complete, we are able to form an idea of the shape and the dimensions of the outer nares.

The palate is slightly concave transversely. Though only of the left M^3 the fangs are present, it can easily be seen, that the molars were approximated in front and divergent behind. The interalveolar fossa is well preserved. Those parts of the incisive sheaths bordering it, are perpendicular to its bottom. The middle portion of the right wall of the fossa even slopes from the left to the right, probably a result of some deformation. Near the nasal aperture the interalveolar fossa is shallow, more frontwards the depth increases quickly, still more frontwards the fossa becomes again more shallow. The side walls diverge frontwards. Some 20 cm. from the tips of the premaxillaries the alveolar fossa ends abruptly in a lobe on either side of the median line. The suture between both premaxillaries presents a very slight curvature, and is situated somewhat left of the median line, illustrating some deformation.

MEASUREMENTS OF THE CRANIUM IN cm.

Total length (from vertex cranii to anterior extremity of premaxillaries	105
Smallest breadth of forehead	49
Height of forehead (median projection of nasals not included)	24
Interval between tips of postorbital process of either side	64
Breadth of forehead at occipital surface	93

Length of interalveolar fossa	39
Interval between anterior extremity of temporal fossa and tip of premaxillaries	18
Greatest depth of interalveolar fossa	12
Greatest breadth of ditto	18
Interval between outer surfaces of both incisive sheaths near infraorbital canal	ca 47
Ditto at anterior extremities	ca 50
Height of outer nares	ca 11
Breadth of ditto	ca 30
Dimensions infraorbital canal	7 × 5
Interval between posterior upper angle of right temporal fossa and posterior extremity of alveolar margin of molar of same side	67
Dimensions of inner nares	14 × 7
Width of palate at front side of molars	7.5
Ditto at posterior side	11.5

Description of the r. M³. (Pl. XII, figs. 2—3.)

Rather injured and damaged specimen [1]). The tooth, having its anterior ridge-crests very much worn down and damaged, it is difficult to ascertain the ridge-crest formula. In order to determine whether or not a hind talon is present, some cement of the hindmost part of the tooth has been removed. It was revealed, that a posterior talon is absent. There is no reason to consider the last ridge-crest to be a hind talon, as it does not distinguish itself from the preceding ridge-crests. The presence of ten ridge-crests can easily be ascertained. Ridge-crest 10 from behind, however, does certainly not represent the foremost part of the tooth, for it is still preceded by a disk of tooth material. The transverse diameter (length) of this disk is considerably smaller than that of the remnants of the foregoing ridge-crest. The well-preserved lower part of the palatinal side of the ridge-crest, last mentioned, passes namely uninterrupted into an undamaged plane, forming the front side of the palatinal portion of the ridge-crest in question. In this manner the impression is made as if the ridge-crest under consideration really represents

[1]) I regret that the figure of the molar is so defective, not at all giving a fair idea of its structure. The cranium was, however, so heavy and the situation in the old building, in which the Utrecht Institute of Geology and Mineralogy was settled at that time, such, that it was impossible to find a place which allowed of a better exposure.

the foremost ridge-crest and the disk of tooth material in front of it the remnants of the posterior part of a preceding molar. If this be true, we might expect to find a narrow cleft, separating both molars. Though I looked out for it with the utmost care, I did not find anything of it, not even the slightest indication. Hence it follows, that the disk in question belongs to the molar we are about to describe.

The disk seems to be too broad for one ridge-crest and too narrow for two, representing, therefore, probably the remnants of one ridge-crest plus an anterior talon, so that the ridge-crest formula is probably $\times 11$.

As has been already mentioned the tooth is considerably injured. The preservation of anterior talon and of first ridge-crest has already been dealt with; of the enamel of ridge-crest 2 only some very small pieces of the posterior side have been preserved; ridge-crest 3 shows a small portion of the enamel of the anterior side, and the greater part of the enamel of the posterior side. Inner and outer side of ridge-crest 4 have been lost; inner side of ridge-crest 5 too; inner and outer side of ridge-crest 6 are considerably injured, the inner cusps of ridge-crests 7, 8 and 9 are more or less damaged.

Degree of wear:

Anterior talon and the first three ridge-crests are ground down to the bottom; ridge-crests 4, 5 and 6 present dentine-islets; the cusps of ridge-crest 7 are perforated and some perforations are united. The median cusps of ridge-crest 8 are flattened; the succeeding ridge-crests were still concealed by cement.

The grinding surface is considerably spirally twisted, the top of ridge-crest 7 sloping obliquely from the outside inwards, the top of ridge-crest 6 being almost horizontal, and that of ridge-crests 4 and 5 sloping obliquely from the inside outwards.

Inner- and outer side of the tooth converge backwards, thereby showing the characteristic shape of a third molar. Both grinding surface and base of the crown are clearly convex. They intersect at an acute angle of about 20°.

The ridge-crests are tall, chevron-shaped, consequently the valleys between them are V shaped. The remnant of ridge-crest 3 and the three succeeding ridge-crests present a constriction of the enamel somewhat (ca 10 mm.) palatinally of the median line. Ridge-crests 4, 5 and 6 possess, moreover, another constriction, on either side of the median one. The succeeding ridge-crests, not being worn enough or being covered by cement, the presence of constrictions cannot be ascertained.

Ridge-crests 4 and 6 extend straight across the crown; ridge-crest 5 is slightly concave from behind. Ridge-crests 7, 8 and 9

seem to be convex from behind. Ridge-crest 8 carries six cusps; the palatinal one, which is much damaged, is the biggest. The number of cusps, borne by the succeeding ridge-crests could not be ascertained, because the ridge-crests are for the greater part concealed by cement.

The inner extremities of the valleys between ridge-crests 5, 6, 7 and 8 present a low, blunt, accessory tubercle. A big accessory tubercle is fastened to the front side of the inner cusps of the ultimate ridge. It can clearly be seen in the figure.

The enamel, which is distinctly crenulated, is very thick and consists of two layers. Inner- and outer layer are nearly equally thick. The degree of "Stufenbildung" being in direct proportion to the thickness of the outer layer, might lead us to expect a strong development of "Stufenbildung". That this is less conspicious, is caused by the fact that the molar is considerably weathered.

It will already be understood from what precedes that the amount of cement is considerable.

MEASUREMENTS OF R. M^3 IN mm.

(Total length in straight line ca 254 mm., ditto along convexity 320 mm.).

	Fore talon	1	2	3	4	5	6	7	8	9	10	11
Greatest length at the base of the crown.....	—	—	—	—	97	100	100	96	89c	81c	75c	53c
Breadth at the base of the crown	—	—	25p	—	—	25b	25b	22b	22p	22p	20p	—
Height of unworn or very slightly worn ridge-crest	—	—	—	—	—	—	—	—	57	57c	54c	42c

c = cement included.
p = measured at palatinal side.
b = ditto at buccal side.

As to the specific determination we may make the following remarks. The relation between the height of the forehead (median projection of nasals not included) and smallest breadth of ditto is $\frac{24}{49} = 0.49$. This small value is caused especially by the low forehead. In dealing with the specific determination of the foregoing specimen it was seen that in the young type cranium of *St. airâwana* the same relation amounts to 0.81. Having found, furthermore, that this relation varies already from 0.87 to 1.26 in sixteen crania of the recent *E. maximus*, there should be no reason to consider on this ground our specimen specifically distinct from *St. airâwana*. As already pointed out on page 150 we may, however, in all probability attach much value as a specific character to the form

of the posterior outline of the cranium in front aspect. Though the vertex cranii of our specimen is slightly injured, it was not difficult to see that a median depression of that outline is undoubtedly absent, which distinguishes in my opinion our specimen decidedly from *St. airâwana*, and points in the direction of *St. trigonocephalus* MARTIN. And there are more indications in that direction. In the young type cranium of *St. trigonocephalus* the relation between height and smallest breadth of the forehead is — according to the fine figure given by MARTIN[1]) — about $\frac{41}{70} = 0.59$. In this respect there exists, therefore, a closer resemblance between our specimen and the type specimen of *St. trigonocephalus* than with the type cranium of *St. airâwana*[2]), though it will be hardly necessary, I believe, to point out, that this resemblance alone would be of very little value.

Still another indication is afforded by the cranium. It will be known that MARTIN named *St. trigonocephalus* after the triangular shape of the cranium in front aspect. According to DUBOIS[3]) this form is not original. I have seen both type crania of *St. trigonocephalus*. They are contained in the National Museum of Geology and Mineralogy in Leyden. As far as the young cranium is concerned there is in my opinion not the slightest reason to believe that its triangular form should not represent the original state. In our specimen, being a cranium of an adult animal, the incisive sheaths are much more strongly developed than in MARTIN's young type cranium. Consequently the triangular form has totally been lost in the anterior half of the upper aspect. In the posterior half it is, however, the more distinct. Unfortunately this feature is not clearly shown in figure 1 of pl. XI, which represents the cranium not only as seen from above, but also from the right side. It is, however, very distinctly shown by comparison of two measurements, namely (1) interval between tips of postorbitary process of either side 64 cm., and (2) breadth of forehead at occipital surface 93 cm. In this respect our specimen is even more "*trigonocephalus*-like" than the young type cranium of that species. In the latter specimen, namely, the relation between the measurements is — according to the figure — about $\frac{72}{91} = 0.79$, whereas in our specimen the same relation is $\frac{64}{93} = 0.69$.

[1]) Jaarb. Mijnw. Ned. O.-I., 1887, Wetensch. Ged., pl. III, fig. 1; also in Samml. Geol. Reichs Mus., Leiden, IV, 1884—'89, pl. III, fig. 1.

[2]) See p. 150.

[3]) Tijdschr. Kon. Ned. Aardr. Gen., sec. ser., XXV, 1916, p. 1257.

If, furthermore, the side aspect of our specimen be compared with that of the young cranium of *St. trigonocephalus* [1]), it will be seen — after making allowance of course that there exists a great difference in age, and that the greater part of the occiput of our specimen has been lost — that also on the basis of this comparison no sufficient distinction can be drawn.

We have still to consider the question whether the M^3 of our specimen is apt to strengthen or to weaken our opinion. MARTIN believed to notice a number of structural differences between the grinding teeth of *St. airâwana* and *St. trigonocephalus*. Our knowledge of the teeth of the former species have since been considerably enriched, especially by JANENSCH'S thorough investigations. If one tests the differences, mentioned by MARTIN, by these more ample materials, and also by the experiences gained in the Siwalik stegodonts, it appears that many of them do not hold good. JANENSCH [2]) added some more differences, but concluded at last: "Sicherlich wird man Zahnfragmente beider Arten nicht immer aus einander halten können". In my opinion the differences by which the grinding teeth of *St. trigonocephalus* may be distinguished from those of *St. airâwana* are: (1) thicker enamel, especially of the outer layer, (2) consequently a more distinct "Stufenbildung", (3) generally more strongly indented enamel, and (4) greater size.

In describing the r. M^3 of the present cranium mention has already been made of the thick outer layer of the enamel. At the same time it was pointed out, that its "Stufenbildung" is strongly troubled by the weathering of the crown. The latter fact also affects the impression which the enamel makes to the observer, regarding its degree of crenulation. Nevertheless, we may say that in this respect our M^3 does not show any clear indication, neither in the direction of *St. trigonocephalus*, nor in that of *St. airâwana*.

Finally the size. Comparison between the various measurements of the r. M^3 of the present specimen with the corresponding ones of upper third molars of *St. airâwana* [3]) will reveal that the former distinctly exceeds in size almost all upper third molars of *St. airâwana*.

In my opinion, therefore, not a single essential difference stands in the way of reckoning our specimen to *St. trigonocephalus* MART.

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[1]) Martin (l.c.,), pl. II, fig. 1.

[2]) L. c., p. 189 and 190.

[3]) Which will be found in table T.

Stegodon bondolensis nov. spec.

Fragmentary lower jaw with l. and r. M_3 *in situ.*

Pl. XIV, figs. 1, 4—5.

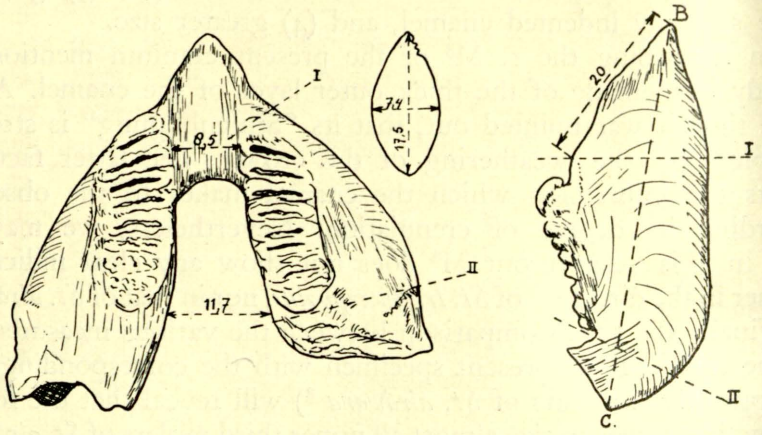
Text figs. 24—25.

Locality: Bondol near Kuwung [1]).

Description of the lower jaw. (Pl. XIV, figs. 4—5; text fig. 24.)

Fine fragment of the mandible, comprising the whole of the horizontal ramus and the lower portion of the ascending ramus of either side; containing on either side a molar which is inferred to be the M_3 from the absence of the indication of any other tooth behind.

The mandible is broken into two in the symphysis, but both parts match exactly. The alveolar border of both molars is damaged. Nevertheless fig. 4 of pl. XIV, shows distinctly that the difference in height of the horizontal ramus respectively at anterior and posterior extremity of the molar is far less pronounced than in the lower jaw of *St. airâwana*, described in the foregoing part.



Text fig. 24.

The diastema descends obliquely forwards at an acute angle of about 35° with the inferior border of the ramus. The mandibular symphysis is produced into a relatively broad, spoutlike termination. Its lower border is damaged. As seen in crown view, and compared with the lower jaw of *St. airâwana*, above mentioned, the distinctly curved outer border of left and right horizontal ramus enclose a considerably greater angle. On the whole the present ramus makes

[2]) District Randublatung, Regency Blora, Residency Rembang.

a more robust impression. The outer surface of the horizontal ramus presents two foramina mentalia, the one situated some 8 cm. below the anterior extremity of the alveolar margin, the other about 8 cm. in advance of the former and nearer to the inferior border of the ramus.

Only the lower portion of the coronoid process has been preserved.

MEASUREMENTS OF LOWER JAW IN cm.

See text fig. 24.

In plane I $<$ greatest height = 16, greatest width = 7.8

In plane II $<$ greatest height = 12, greatest width = 17

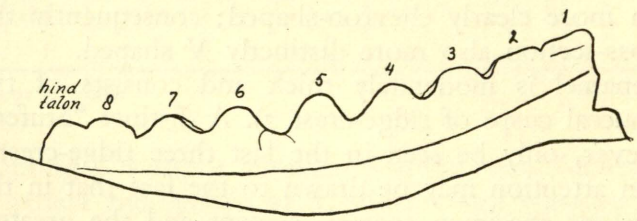
Length of B C = 47.5

Description of l. and r. M_3. (Pl. XIV, fig. 1; text fig. 25.)

Fine specimens. Only the anterior part is damaged. Besides small differences both teeth are very similar so that it will be sufficient to describe one of the two detailed, e. g. the left one.

As the front side of both molars is damaged, it seems — at first sight — impossible to ascertain the true number of ridge-crests carried by each of them. Fortunately, however, in the l. M_3 a small portion of the front surface of the fangs has been preserved. It is situated below the anterior side of the foremost ridge-crest, and proves with absolute certainty, that this ridge-crest is really the first one. That is to say: not a single ridge-crest has been lost. The ridge formula is, therefore, $8\times$.

The tooth is distinctly curved outwards. The base of ridge-crests 1—7 are more or less of the same length; from ridge-crest 8 inner and outer side of the molar converge suddenly backwards.



Text fig. 25. *St. bondolensis.*
Lingual aspect of l. M_3. $^3/_8$ nat. size.

The base of the crown and the grinding surface are strongly concave. The grinding surface slopes obliquely from the outside inwards. The plane of wear and the base of the crown converge

anteriorly, enclosing a very small angle. The separation between crown and fangs is very clear, especially on the inner side of the tooth.

Degree of wear:

All the ridge-crests and the hind talon are abraded by wear. Ridge-crests 1—6 present dentine-islets; the cusps of ridge-crests 7 and 8 are perforated; the cusps of the hind talon are flattened.

The hind talon consists of two thick cusps of which the lingual one is the biggest. Three constrictions of the enamel of ridge-crest 8 mark the presence of four cusps. Ridge-crest 7 possessed five or six, ridge-crest 6 six mammillae. The preceding ridge-crests being too much worn down, it is impossible to estimate the precise number of cusps, borne by each. The first three ridge-crests show clearly, that near the base of the crown the enamel is thrown into vertical corrugations (12—14 a ridge-crest).

The form of the dentine-islet of the second ridge-crest is approximately that of an elongated rectangle, only slightly curved, and but little wider in the middle. The dentine-islet of ridge-crest 3 and of the succeeding worn ridge-crests differ from that of ridge-crest 2 in having inner and outer extremity of the rectangle acuminated. This is — at least partly — caused by the fact, that the grinding surface is not only concave antero-posteriorly, but also in transverse direction.

As a result of the outward curve of the tooth the ridge-crests converge buccally. The elongations of the first and of the last ridge intersect at an angle of about 30° (in r. M_3 ca 32°). To be accurate, it must be added, that this is not quite true. For, as the grinding surface is spirally twisted, intersection will never take place. The twisting of the plane of wear is such, that the slope increases from front to back.

The ridge-crests are, with respect to those of the corresponding molar of *St. airâwana* and of *St. trigonocephalus*, considerably lower and much more clearly chevron-shaped; consequently the valleys are in cross-section also more distinctly V shaped.

The enamel is moderately thick and consists of two layers (see the buccal cusps of ridge-crest 7). A distinct "Stufenbildung" can, however, only be seen in the last three ridge-crests. In this connection attention may be drawn to the fact that in the molars of the present specimen enamel, cement and the greater part of the dentine had the same, irregularly spotted appearance. As a result the crenulation of the enamel was very indistinct, and it was only possible to make it distinctly visible in the photograph by blackening the dentine of the tooth. Another result is, however, that "Stufenbildung" though present, is in general not clearly exhibited.

There is no indication of the presence of a median longitudinal cleft. Cement is present, though in small quantities. The valleys between ridge-crests 1, 2, 3, 4 and 5 possess but little cement. More backwards the amount is somewhat less small, not only the base of the valleys being filled to a greater extent, but also the lingual and buccal sides of the ridge-crests, and the posterior side of the hind talon being covered by a thin coat of cement. Noteworthy is the stronger, local development of cement near the buccal side of ridge-crest 7.

As has been already mentioned, the r. M_3 resembles in almost every feature the l. M_3.

Differences are:

a. The r. M_3 is somewhat less ground down.

b. The r. M_3 does not present the strong, local development of cement near the buccal side of ridge-crest 7.

c. The hind talon of the r. M_3 is less developed, and still totally covered by cement.

MEASUREMENTS OF R. AND L. M_3 IN mm.

Total length of r. M_3 190 mm. } measured along median line of crown.
Ditto „ l. M_3 197 „ }

	1		2		3		4		5		6		7		8		Hind talon	
	molar		molar		molar		molar		molar		molar		molar		molar		molar.	
	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
Greatest length at base of crown	—	—	84	86	83	85	84	86	86c	86c	84c	86c	79c	86c	62c	61c	32c	36c
Breadth at base of crown	—	—	—	ca 19	19	18	21	21	21	20	19	18	20	22	17	19	12c	12c at buccal side
	ca 28	—	26	27	26	26	27	25	27	27	28	27	25	24	21	21	12c	16c at lingual side

c = cement included.

In adopting OSBORN's classification of the *Proboscidea*, the following genera and species of S. and E. Asia must be reckoned to the subfamily of the *Stegodontinae*.

Stegolophodon latidens (Clift) 1828, Trans. Geol. Soc., Ser. 2, II, p. 371.
Stegolophodon stegodontoides (Pilgrim) 1913, Rec. Geol. Surv. Ind., XLIII, p. 294.
Stegolophodon cautleyi (Lydekker) 1886, Mem. Geol. Surv. Ind., Ser. 10, III, p. xiv (of introduction).
Stegolophodon cautleyi progressus Osborn 1929, Am. Mus. Nov., n°. 393, p. 15.
Stegolophodon nathotensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 13.

Stegodon clifti Falconer and Cautley 1846, Fauna Antiqua Sivalensis, pt. 1, p. 47.
Stegodon bombifrons Falconer and Cautley 1846, Fauna Antiqua Sivalensis, pt. 1, p. 46.
Stegodon ganesa [1]) Falconer and Cautley 1846, Fauna Antiqua Sivalensis, pt. 1, p. 45.
Stegodon insignis [1]) Falconer and Cautley 1846, Fauna Antiqua Sivalensis, pt. 1, p. 37.
Stegodon insignis birmanicus Osborn 1929, Am. Mus. Nov., n°. 393, p. 15.
Stegodon orientalis Owen 1870, Quart. Journ. Geol. Soc. London, XXVI, p. 421. (See also: Matthew and Granger, Bull. Am. Mus. Nat. Hist., XLVIII, 1923, p. 567.)
Stegodon orientalis grangeri Osborn 1929, Am. Mus. Nov. n°. 393, p. 16.
Stegodon orientalis shôdoensis Matsumoto 1924, Journ. Geol. Soc. Tôkyô. p. 333. (Preliminary note. Probably not fully described and figured hitherto.)
Stegodon sinensis Owen 1870, Quart. Journ. Geol. Soc. London, XXVI, p. 417. (See also: Matsumoto, Sci. Rep. Tôhoku Imp. Univ. Sendai, Japan, Sec. Ser. (Geol.), III, 1918, p. 7).
Stegodon aurorae [2]) (Matsumoto) 1918, Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), III, p. 52; Ibid XIII, n°. 1, 1929, p. 13 (1).
Stegodon pinjorensis Osborn 1929, Am. Mus. Nov., n°. 393, p. 18.
Stegodon mindanensis Naumann 1890, Zeitschr. D. Geol. Ges., XLII, p. 166; Abh. u. Ber. K. Zool. Anthr. Ethn. Mus. Dresden, 1887, n°. 6, p. 5 (as St. trigonocephalus).
Stegodon airâwana Martin 1890. Verh. Kon. Akad. Wetensch. Amsterdam, XXVIII, p. 4.
Stegodon trigonocephalus Martin 1887, Samml. Geol. Reichs-Mus. Leiden, IV, p. 36. (Also: Jaarb. Mijnw. N. I., 1887, p. 12).

The above list does not pretend to be complete as far as the papers quoted are concerned. For the rest the same remarks hold good which have already been made on p. 125 in connection with the list of species of *Mastodon* of S. and E. Asia.

It will be evident that it will not take us much trouble to exclude from our comparison most of the species above mentioned. As a matter of fact all the species of *Stegolophodon* may be left out of consideration, being all very primitive forms which in my opinion may as well be reckoned to the family of the *Mastodontidae*.

On the other hand, most of the remaining species are considerably more progressive than the form to which the lower jaw in question belongs.

With the exception of *St. clifti* and *St. bombifrons* the remaining forms are readily distinguished by a higher ridge-crest formula of the M_3 or, if this molar has not yet been found, by higher ridge-crests, greater amount of cement, and more cusps a ridge-crest.

There remain, therefore, only the two species already mentioned viz., *St. clifti* and *St. bombifrons*. It is, however, not difficult to dismiss also the former. According to LYDEKKER [3]) the lower third molar of that species carries either seven or eight ridge-crests. In this respect there exists therefore accordance between

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[1]) At present *St. ganesa* is often considered to be the male form of *St. insignis*.

[2]) Originally MATSUMOTO described the present species under the generic name of *Elephas*. In 1929 this author again referred to it as genotypic species of a new genus, namely *Parastegodon* (MATS. 1929). DIETRICH (Neues Jhrb. 1929, III, p. 467) rightly pointed out that "*Parastegodon*" *aurorae* is very closely allied to *St. airâwana*, perhaps still slightly more progressive. The present writer strongly doubts, therefore, the right of *Parastegodon* to generic distinction.

[3]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 79.

our form and the species referred to. Nevertheless there cannot be any doubt of the specific distinction of either, LYDEKKER (l. c.), mentioning that ". . . the plane of wear is the same as in *Mastodon*" i. e. sloping outwards, instead of inwards as in all remaining *Stegodon* species.

The M_3 of *St. bombifrons* carries — according to LYDEKKER [1]) — eight to nine ridge-crests. In general the valleys of the grinding teeth of *St. bombifrons* are completely filled by cement [1]), whereas in the teeth of our specimen cement is present in but small quantities. On the other hand, however, LYDEKKER [2]) reckons to that species a fragmentary lower jaw, containing M_3 of either side, which possess ". . . hardly any cement" [3]). The different amount of cement would, therefore, not give any argument for specific distinction. As, furthermore, the structure of the grinding teeth of Javan and continental form is in several points very close, the writer provisionally named the specimen in question *St. bombifrons*, before it was sent back to Bandung. He overlooked, however, some differences which are now esteemed important enough to separate both forms.

Among the lower third molars, which LYDEKKER reckons to *St. bombifrons*, only two specimens are tolerably perfect. They will be found represented in F. A. S., pl. XXV, figs. 3 and 3a, and pl. XXIX, figs. 7 and 7a. According to the description of the plates the dimensions of the former are 12.9×4.4 inch $= 32.8 \times 11.2$ cm., and of the latter 13.4×4.2 inch $= 34 \times 10.2$ cm. Comparison between these data and the measurements of l. and r. M_3 of our specimen shows that the corresponding molar of *St. bombifrons* is not only considerably larger, but also that the M_3 of the Javan form is much broader in reference to its length than appears to be the case in the M_3 of the continental form.

There seems to be one more difference. JANENSCH [4]) observes: "Bei den Stegodonten der Sivaliks habe ich eine nennenswerte Stufenbildung nicht gefunden". Unfortunately I have not had the opportunity to visit the British Museum, so that I myself could not make comparisons in this respect. The latter remark is added not because I doubt the correctness of JANENSCH's assertion, but because "nennenswert" is a rather elastic conception. As the enamel of the teeth of our specimen, however, is distinctly composed of two layers, and the last three ridge-crests show a distinct "Stufenbildung", also in this respect both forms probably differ.

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[1]) L. c. p. 82.

[2]) L. c. p. 85, n°. M. 2991.

[3]) See description of plates of Fauna Antiqua Sivalensis, pl. XXV, figs. 3 and 3*a*.

[4]) Die Pithecanthropus-Schichten auf Java, 1911, p. 163.

In my opinion we may, therefore, conclude, that the present Javan form is distinct from all other species. I propose the specific name of *bondolensis*, indicating the locality from whence it has been procured.

Stegodon sp.

Pl. XIII, figs. 3—5.

Localities: Bumiaju, Excavations 6 and 11.

Remains to describe twelve fragments of molars, ten of which are unworn, two abraded by wear. On page 146 mention has already been made of nine of them, namely the two worn and seven unworn specimens.

The various fragments carry from one to four ridge-crests. Not a single fragment allows of ascertaining the ridge-crest formula of the tooth, to which it belonged. Owing to the broken condition of the base of the crown of nearly all the fragments, it is only in some cases possible to determine whether the specimen belongs to the upper or to the lower jaw.

Two fragments have been longitudinally and vertically bisected; another specimen and a (half) ridge-crest of one of the specimens vertically bisected have been sawn up in a horizontal direction.

As the ten unworn fragments all carry equally-shaped ridge-crests, and as these ridge-crests carry the same average number of cusps, it is almost sure, that they belong to the same species. A detailed description of all the ten is, therefore, unnecessary; an enumeration of the essential characters will be sufficient.

The ridge-crests are tall, rather narrow and clearly chevron-shaped. They are placed closely together, so that the form of the valleys between them is that of a sharp V. This is clearly shown in those specimens, which have been vertically and longitudinally bisected, and in those fragments which have lost the cement. Most ridge-crests carry from ten to twelve cusps. Of two fragments the cusps are somewhat thicker and blunter, while their average number is eight. The impression is made as if they belong to another species than the remaining unworn specimens. In order to get an answer to the question, whether this impression was right or not, both a specimen with eight cusps a ridge-crest, and a specimen with ten to twelve cusps a ridge-crest were sawn up in a longitudinal-vertical direction. They are represented respectively in figs. 3 and 5 of pl. XIII. These cross-sections reveal, that both fragments are absolutely alike, as far as regards essential characters. Since therefore, the only difference between both fragments in

question, is the number of cusps, there appears to me to be every probability that all unworn specimens belong to the same species.

We will now continue with the enumeration of the characters. The cusps of the ridge-crests are most elevated in the middle, rendering them strongly convex across. Some ridge-crests extend straight across the crown, but most show a slightly S-shaped curvature.

The enamel consists of two layers. The average thickness of the enamel is 6 mm. The ridge-crests, if worn, would have shown therefore "Stufenbildung". Those ridge-crests, which have been horizontally bisected, show that the enamel is considerably crenulated. (See fig. 4 of pl. XIII.)

A large amount of cement is present. Some fragments do not possess cement anymore, but the former presence of a large amount of cement is still clearly indicated.

We have still to consider the two unworn fragments. Both consist of the posterior part of the original tooth, in all probability a third molar, which is inferred from the form and size of the fragments. Both contain the hind talon and the last two ridges. The resemblance between the two specimens is extremely close. The ridge-crests and the hind-talon are distinctly convex backwards. The hind talon consists of six cusps. Ridge-crests and talon are abraded by wear. The enamel consists of two layers. "Stufenbildung" is present and rather well developed. The enamel — at any rate the inner layer — is strongly crenulated.

The amount of cement was — without any doubt — considerable. The ridge-crests are chevron-shaped. Inner and outer side of the fragment converge posteriorly, and pass gradually into the curved posterior side.

It is highly possible that worn and unworn specimens belong to the same species.

I think it advisable to leave all the specimens specifically undetermined, being in too fragmentary a condition.

SOME REMARKS ON THE GENUS ELEPHAS l.s.

Before starting with the description of those specimens of our collection which belong to the genus *Elephas* in its widest sense, we shall have to pay attention to OSBORN's classification of the *Elephantidae*.

In 1925 this author published [1]) a paper entitled: "Final conclusions on the evolution, phylogeny and classification of the Proboscidea" [2]).

In this important paper OSBORN divides the *Elephantidae* in six different "races" (subfamilies) viz.,

a. *Stegodonts*;

b. African Elephants, or *Loxodonts*;

c. Southern Mammoths, or *Archidiskodonts*;

d. North temporate Mammoths, or *Parelephas*;

e. Woolly Mammoths, or *Mammonteus*;

f. True Elephants, or *Elephas* of LINNEAUS.

Already in 1924 [3]) OSBORN had proposed the subdivision of the subfam. *Loxodontinae* in:

Loxodonta F. CUVIER. "Progressive from unknown ancestors to *L. africana* and distinguished by narrow grinding teeth with few ridge-plates and prominent "loxodont sinus" ";

Sivalikia, n. g. "typified by *Loxodonta namadica* FALCONER, type species, and distinguished by broad grinding teeth, numerous ridge-plates, and absence of "loxodont sinus" " [4]);

Pilgrimia, n. g. "typified by *Elephas falconeri* BUSK, type species, ... distinguished by narrow grinding teeth, numerous ridge-plates, "loxodont sinus" vestigial or absent" [5]).

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[1]) Proc. Amer. Phil. Soc. LXIV, 1, 1925.

[2]) It is OSBORN's thirty-sixth communication since 1900 on that subject! (See: OSBORN, Fifty-two years of research, observation and publication. New-York, 1930, p. 86). All these and subsequent preliminary papers will culminate in OSBORN's monograph to be entitled: "The Proboscidea; Evolution, Phylogeny and Classification." (L. c. p. 57).

[3]) Am. Mus. Nov. n°. 152, 1924, p. 2.

[4]) The statement of the absence of a loxodont sinus must be regarded cum grano salis, OSBORN himself mentioning on p. 31 of his referred paper of 1925 ".....absence or rudiment of the "loxodont sinus"....."

[5]) See Neues Jhrb. 1927, IB, p. 313, where DIETRICH raises objections against this subdivision.

OSBORN had, however, to replace his generic name *Sivalikia* by *Palaeoloxodon* MATSUMOTO 1924 [1]), a name a few weeks prior to the former [2]). MATSUMOTO created *Palaeoloxodon* [3]) as a subgenus; OSBORN uses it in a generic sense.

Though OSBORN's before mentioned paper of 1925 has the title of "Final conclusions . . . . ", it appears from subsequent communications of this author, that later on several additions and changes have been made. At this place only those changes may interest us which concern the classification of the *Elephantidae*. The latter are to the effect that all the genera of mammoths, namely, *Mammonteus*, *Parelephas* and *Archidiskodon* are united in the subfamily of the *Mammontinae* [4]).

As far as my knowledge therefore goes, OSBORN's present classification of the *Elephantidae* may be represented as follows:

Fam. *Elephantidae*:

a. Subfam. *Stegodontinae*:

Stegodon FALCONER.

Stegolophodon SCHLESINGER (= *Prostegodon* MATSUMOTO).

b. Subfam. *Loxodontinae*:

Loxodonta F. CUVIER.

Palaeoloxodon MATSUMOTO.

Sivalikia OSBORN.

c. Subfam. *Mammontinae*:

Mammonteus CAMPER (Northern Mammoths).

Parelephas OSBORN (Trogontherian Mammoths).

Archidiskodon POHLIG (Southern Mammoths).

d. Subfam. *Elephantinae*:

Elephas LINNAEUS.

After the description of the specimens of our collection, we shall have the opportunity to see to which genera the various fossil forms of "*Elephas*" of South and East Asia are reckoned.

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[1]) Journ. Geol. Soc. Tôkyô, XXXI, 1924, p. 257 & 260.

[2]) See OSBORN, Am. Mus. Nov. n°. 460, 1931, p. 21.

[3]) The full description of *Palaeoloxodon* is given by MATSUMOTO in Sci. Rep.Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), XIII, 1, 1929, p. 7 (1).

[4]) See OSBORN, Journ. Am. Mus. Nat. Hist. XXX, 3, 1930, p. 230, and Am. Mus. Nov. n°. 393, 1929, p. 18—21.

Subfam. ELEPHANTINAE.

Elephas ?maximus L. fossilis.

Fragmentary lower jaw with l. and r. M_3 *in situ*.

Pl. XVI, figs. 1—3.

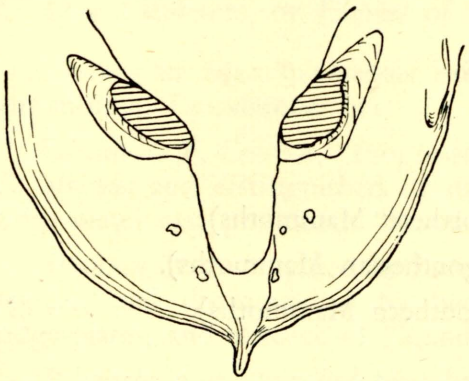
Text figs. 26—27.

Locality: Sentang Kedung Klampo [1]).

Description of the lower jaw (Pl. XVI, figs. 2—3; text figs. 26—27).

Fine specimen of the lower jaw, containing in each ramus the finely preserved M_3. This specimen is broken in the symphysis, but the two parts match exactly. As appears to be the rule in fossil lower jaws of elephants, both condyli have been lost, and both coronoid processes are for the greater part broken off. Of the left process a greater portion has been preserved than of the right one. The hinder side of each ascending rami is furthermore considerably injured.

If the figures of this specimen be compared with the adult lower jaw of *Elephas maximus*, it will be seen that the resemblance between the two is extremely close. The position and number of the various mental foramina may perhaps somewhat differ, but it will be known, that the position and number of the mental foramina may vary considerably. And just the same may be said of the form and shape of the symphysial gutter.



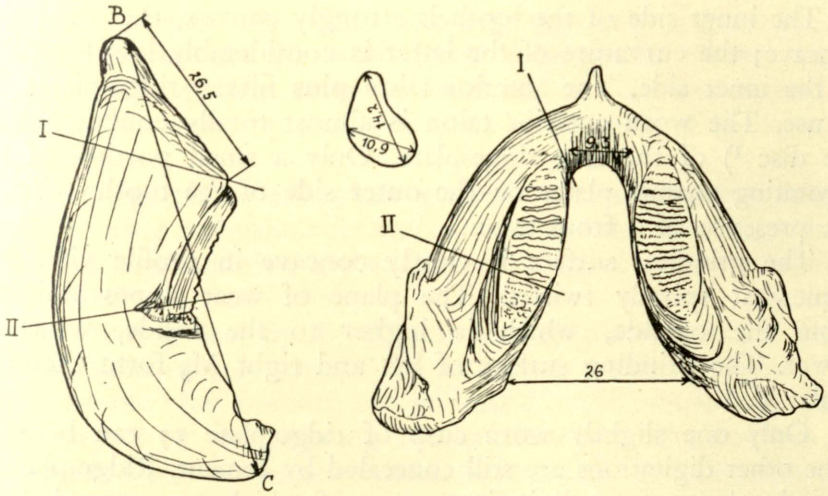
Text fig. 26. Front aspect of mandible of *Elephas ?maximus fossilis*, showing position of mental foramina.

The lower border of the horizontal ramus is in its front portion almost straight; more backwards, however, a slight curvature occurs, passing imperceptibly into the strongly curved, lower border of the ascending ramus. The alveolar border of the molar is clearly concave; the inner alveolar border is more concave than the outer one. Alveolar border and lower border of the horizontal ramus converge posteriorly; the jaw becomes lower from front to back. At the base of the coronoid process the height of the horizontal ramus is,

[1]) Near Kuwung, District Randublatung, Regency Blora, Residency Rembang.

however, still considerable. The diastemal ridge descends obliquely at an acute angle of about 64° with the lower border of the ramus horizontalis.

As seen in upper view, the convexity of the outer side of the horizontal ramus increases strongly towards the symphysial gutter. The angle enclosed by the anterior portion of the outer side of both rami is consequently a very obtuse one. The symphysial gutter is narrow and comparatively short. The front border of the coronoid process is perpendicular to the lower border of the ramus.



Text fig. 27.

MEASUREMENTS OF LOWER JAW IN cm.

See text fig. 27.

In plane I $<$ greatest height = 21, greatest width = 10.5

In plane II $<$ greatest height = 15.4, greatest width = 16.5

Length of BC 62.5

As both M_3 are exceedingly alike, it will be sufficient to describe one of the two in detail, e. g. the left one.

Description of the left M_3 (Pl. XVI, fig. 1).

Very fine specimen. Though the tooth is somewhat injured in front, not a single ridge-plate has been lost. The molar carries twenty-three ridge-plates. If the fore- and hindmost ones are supposed

to be resp. a fore- and aft talon, the ridge-plate formula is × 21 ×. Perhaps, however, the hindmost ridge-plate does not represent the aft talon, because we must take into consideration the possibility that a low posterior talon is still concealed by the "bone" of the jaw. In that case the ridge-plate formula would be × 22 ×.

The relatively narrow crown tapers strongly from ridge-plate 9 towards the posterior extremity. This feature, combined with the high ridge-plate formula makes it sure, that this molar is the last of the true molar series. From ridge-plate 7 the crown also tapers towards the anterior extremity.

The inner side of the tooth is strongly convex, the outer side concave; the curvature of the latter is considerably less than that of the inner side. The anterior talon plus fifteen ridge-plates are in use. The worn anterior talon is almost totally confluent with the disc [1]) of the first ridge-plate. Only a small portion of the separating enamel plates on the outer side of the tooth indicates the presence of a front talon.

The grinding surface is clearly concave in profile view and somewhat spirally twisted. The plane of wear slopes obliquely from the outside, which is higher to the inside, which is lower. The grinding surface of left and right M_3 form therefore a flat V.

Only one slightly worn cusp of ridge-plate 15 can be seen. The other digitations are still concealed by cement. Ridge-plate 14 already shows four digitations, two of which are ground down into distinct annular discs. Ridge-plate 13 presents five annular discs, the middlemost of which is smaller than those immediately buccally and lingually of it. The structure of ridge-plates 12, 11 and 10 resembles closely that of ridge-plate 13. As a result of the increase of the degree of wear towards the anterior extremity of the molar, the three middlemost discs of ridge-plates 11 and 10 have become confluent into a compound oval-shaped disc, while the buccal and lingual discs have also got a more oval shape.

Ridge-plates 12, 11 and 10 are therefore clearly divided into three; the middle portion of each ridge-plate consisting of three digitations. The longitudinal clefts, which cause the triple division, have been lost in the foregoing ridge-plates, which are too much ground down. The buccal longitudinal cleft, however, is still clearly indicated in ridge-plate 9.

Ridge-plate 8 and all foregoing ridge-plates are worn down into transverse discs. The discs of ridge-plates 1 and 2 are rectangular

[1]) disc: a depressed surface of ivory, surrounded by a raised rim of enamel . . . . . (FALCONER, Pal. Mem., II, p. 146).

shaped. Those of ridge-plates 3—8 present the form of a very flat V, the limbs of which converge posteriorly, while each limb is slightly curved, convex frontwards. The lateral extremities generally point frontwards. Anterior and posterior enamel plates of ridge-plates 3—8 each are in general mutually parallel, and no mesial dilatation occurs, except in ridge-plate 7. This is caused by the fact, that the anterior enamel plate of the latter is almost straight in the middle. It may be pointed out, however, that a dilatation, formed in such a manner, often may be observed in the ridge-plates of the molars of *Elephas maximus*.

The enamel is dictinctly "chanelled" [1]), and strongly "crimped" or "plaited" [2]). This crimping especially occurs in the posterior plates of the well worn ridge-plates. Those ridge-plates, which are less worn (10 and 11) only present secondary "flexures" [3]) caused by the confluence of the discs of the separate digitations.

The ridge-plates are close packed, the intervening valleys therefore being comparatively narrow. The anterior five ridge-plates are so much ground down, that the separating valleys have become narrow clefts.

The envelopment by the cement of ridge-plates 1—14 is such, that the sides of this part of the molar are totally concealed, so that in profile view nothing can be seen of their position. As seen in the aspect of the grinding surface, however, the position of ridge-plates 6—10 can be ascertained, as the cement in the intervening valleys is worn down 5—10 mm. below the level of the rim of the discs. It was shown that ridge-plates 6—10 are inclined forwards. In the succeeding ridge-plates the slope gradually increases. As portions of the buccal side of ridge-plates 15—21 project through the coat of cement, it was possible to state that these ridge-plates are distinctly inclined backwards. The ridge-plates diverge, therefore, towards their bases in a fan-shaped manner, which is a common phenomenon in the M_3 of the genus *Elephas*, contrary to the M_2, the ridge-plates of which depart but slightly from parallelism.

As has been already mentioned l. and r. M_3 are very much alike, so that a detailed description of the latter would be of no interest. The only difference is, that instead of fifteen, only thirteen ridge-plates are in use (front talon not included).

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[1]) See: FALCONER, Pal. Mem. II, p. 146 and 147.

[2]) L. c., p. 147.

[3]) L. c. p. 147.

Greatest length of each ridge plate in the level of the grinding surface	r. M_3 / l. M_3
Interval between the middle of two ridge-plates, measured in median line of the grinding surface	r. M_3 / l. M_3

	r. M_3	l. M_3
Total length (measured along median line of tooth).	— [1])	315
Greatest width (cement included)	87	86
Length of grinding surface	205	220

The resemblance between our specimen and some of the mandibles of *E. maximus*, which I saw, is extremely close, both regarding structure and shape of M_3, and form of lower jaw. I should therefore not have hesitated to identify it with that species, were it not, that DUBOIS [2]) mentions that a close resemblance exists between the grinding teeth of *E. maximus* and *E. hysudrindicus*, the fossil Javan form of his collection. Before the cranium of *E. hysudrindicus* had been found DUBOIS accordingly believed that *E. maximus* was represented among the Kendeng fauna. There is, therefore, a possibility that our specimen belongs to DUBOIS's species. On the other hand it must be borne in mind that the M_3 of the mandible of our collection carries at least twenty-one ridge-plates, whereas the third molar of *E. hysudrindicus* possesses — according to DUBOIS — at best nineteen ridge-plates. As moreover DUBOIS did not mention any more structural detail of the teeth of his species, and as we are not able to distinguish our specimen from *E. maximus*, we believe to be wholly justified to class it with the latter species. The addition of a sign of interrogation to the specific name in the heading may indicate the possibility of its belonging to *E. hysudrindicus* DUBOIS.

[1]) Only in the left half of the mandible material has been removed in order to expose the whole length of the molar.

[2]) Tijdschr. Kon. Ned. Aardr. Gen., Sec. Ser., XXV, 1908, p. 1258.

R. AND L. M_3 IN mm.

Fore talon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Hind talon
ca 39	47	56	62	66	72	76	77	72	63	54	46	36	21	—	—	—	—	—	—	—	—	—
ca 35	ca 46	ca 56	61	65	70	75	77	74	68	57	51	42	35	23	—	—	—	—	—	—	—	—
♀	11	12	16	18	18	18	18	17	15	14	11	10	—	—	—	—	—	—	—	—	—	
♀	11	12	16	18	20	20	19	18	17	15	13	11	10	7	—	—	—	—	—	—	—	

Subfam. MAMMONTINAE.

Archidiskodon planifrons FALCONER et CAUTLEY.

Detached l. M^1.

Pl. XVII, figs. 1—2.

Locality: Tji Pangglosoran [1]).

Superb specimen. Only the front talon is damaged. Ridge-plate formula × 7 ×. Slight tendency to × 8 ×, as behind and closely attached to the posterior talon two small, low tubercles occur.

The front talon, all the ridge-plates, and the back talon are in use, though of the posterior talon only the two median cusps are flattened by wear. The grinding surface is slightly convex, and there is a peculiar slew or twist in the wear, the inclination not only diminishing towards the posterior extremity of the tooth, but even becoming in ridge-plates 6 and 7 the reverse of that of the preceding portion of the grinding surface.

The plane of wear being convex proves the tooth to be an upper grinding tooth, and sloping obliquely from left to right [2]) shows that the tooth belongs to the left side of the upper jaw. Its serial position will be considered afterwards.

As seen from above the crown presents — roughly spoken — the form of a rectangle, the posterior extremity of which is rounded off regularly, and the greatest diameter of which is very slightly curved, concave buccally.

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[1]) See sketch map n°. 1.

[2]) The tooth is supposed to be in the natural position.

Crown and fangs are very distinctly separated from one another. The base of the crown is in profile view very slightly convex; this convexity also proves the tooth to be an upper molar. In profile view the tooth shows approximately the form of an isosceles trapezium. The front talon, ridge-plate 1, and the palatinal moiety of ridge-plate 2 are supported by an anterior fang, which curves considerably to the palatinal side. Another anterior fang, supporting the buccal portion of ridge-plates 2 and 3, and which also curves to the palatinal side, is situated buccally of and behind the fang already mentioned. Both are separated by a third fang. The remaining ridge-plates are supported by a coalescence of fangs. All the fangs are closely attached to one another.

The front side of the tooth presents a disc of pressure which is clearly portrayed in pl. XVII, fig. 2. The worn anterior talon, which is for a good deal confluent with the disc of the first ridge-plate is mainly situated in front of the palatinal moiety of ridge-plate 1. The posterior talon carries four digitations, the two median of which are thickest and highest, and flattened by attrition. Ridge-plate 7 also carries four cusps; ridge-plate 6 appears to consist of 5 conelets. In the preceding ridge-plates, the number of digitations borne by each, cannot be estimated, the ridge-plates being too much worn down. The two median digitations of ridge-plate 7 are worn down into irregular annular discs, the palatinal cusp is just perforated, the buccal one only flattened. The worn summit of this ridge-plate slopes very slightly from the inside outwards. This fact already appears from the increase of the degree of wear of this ridge-plate from buccal to palatinal, but could also easily be stated by regarding the molar in question from behind.

From fig. 1 of pl. XVII it will be seen that in ridge-plate 7 the two median digitations are thicker than the buccal and palatinal ones. The structure of ridge-plate 6 resembles that of ridge-plate 7 very closely. There appears only to be one cusp more, while the three palatinal discs have just become confluent. Those two discs of ridge-plate 6, which are comparable with the two median discs of ridge-plate 7, are marked by their relatively great antero-posterior thickness. Their position is such, that the valley between ridge-plates 6 and 5 is partly obstructed. There is a distinct cleft in the middle of ridge-plate 6. Though ridge-plates 5 and 4 are already in a more advanced state of wear, their general structure can easily be understood after comparison with that of the sixth ridge-plate. The posterior enamel plate of ridge-plates 5 and 4 throws out two curved projections, separated from one another by a sharp inlet, indicating the presence of a similar cleft as in ridge-plate 6.

The anterior enamel plate of ridge-plate 5 shows palatinally of the median line of the crown an angular projection, which almost touches the posterior enamel plate of ridge-plate 4. A similar angular projection of the anterior enamel plate is still more distinctly visible in ridge-plate 4. But in the latter it is situated more to the median line of the tooth. Ridge-plates 5 and 4 present therefore an imperfect lozenge shape.

Ridge-plates 3, 2 and 1, though considerably worn down, show in general the same structure as the succeeding ridge-plates. The inlet of the posterior enamel plate near the median line of the crown is still indicated. The angular projection of the anterior enamel plate appears to disappear gradually after advanced wear of the ridge-plates.

The enamel is thick; crimping (folding, plaiting, festooning) is but slightly developed, and disappears near the base of the ridge-plates. The enamel of buccal and palatinal sides of the ridge-plates is rugous, and provided with irregular, anastomosing, vertical grooves.

The wide valleys are filled with cement. The buccal and palatinal sides of the ridge-plates are in general free from cement. Small remnants of cement on these sides reveal, however, that they were probably covered by a thin coat of cement.

See for the discussion of the determination p. 181.

MEASUREMENTS OF L. M^1 IN mm.

(Total length 125 mm.)

	Fore talon	1	2	3	4	5	6	7	Hind talon
Greatest length at base of crown	—	44	50	52	52	52	54	54	45
Breadth at base of crown [1] . . .	—	18 [2]	15	17	17	17	15	15	9
Height of unworn or little worn ridgeplate	—	—	—	—	—	—	—	45 [3]	45

Height of fangs in front 95

Ditto behind 65

[1] Measured at palatinal side.

[2] Breadth of anterior talon included.

[3] Estimated height of ridge-plate 7 if unworn 54 mm.

?Archidiskodon planifrons FALCONER et CAUTLEY.

Fragment of left horizontal mandibular ramus with grinding tooth *in situ*.

Pl. XV, figs. 5—6.

Locality: Kali Biuk [1]).

Description of fragment.

The next specimen for consideration is a fragment of the left horizontal ramus of the mandible containing a small tooth. Lower and inner side of the fragmentary ramus are damaged, thereby denuding the dental canal and a good deal of the lingual side of the fangs of the tooth. Behind the latter, the proximal portion of the alveolus of the succeeding tooth occurs. The fragment, having all edges rounded off, shows clearly its transport by running water.

Description of the molar. (Pl. XV, figs. 5—6.)

In the aspect of the grinding surface, the molar shows rudely the form of an oval, with a contraction some 2 cm. behind the anterior extremity. The degree of wear is such, that in front the molar is ground down below the level of the base of the crown, so that some difficulty is met in estimating the total number of ridge-plates. Still present are: a posterior talon, five more or less complete ridge-plates, and a small fragment of the posterior enamel plate of a sixth ridge-plate. In front of the latter fragment a disc of dentine occurs, the antero-posterior diameter of which is 25 mm. The average width of the worn ridge-plates being 11 mm., in all probability the enamel of two ridge-plates and of the anterior talon has been lost. The ridge-plate formula may therefore approximately be represented as follows: × 7 ×.

The grinding surface is slightly concave and slopes but slightly from the outside to the inside.

Crown and fangs are clearly separated. The posterior talon presents a lingual cusp just perforated, and a buccal, oval-shaped disc. Ridge-plate 7 and all preceding ridge-plates are already so much worn down that the various cusps of each ridge-plate have become confluent into a transverse band. Ridge-plate 7 presents a prominent, curved projection of its anterior enamel plate. Buccally and lingually of this projection the anterior enamel plate is more or less clearly concave. The posterior enamel plate is in its middle portion concave, and towards its buccal and lingual extremity it

[1]) See sketch map n°. 1.

becomes convex. This triangular form of the dentine-islet, whereby the top of the triangle is directed forwards, can easily be recognized in ridge-plates 6, 5 and 4. It will furthermore be seen that towards the base of the crown the projection of the anterior enamel plate gradually disappears.

The relatively wide valleys are V shaped, becoming very narrow clefts if the ridge-plates are ground down. They are in the middle obstructed by the projection of the anterior enamel plate or — if the ridge-plates are more ground down — by the fact, that the two halves of the anterior enamel plate converge frontwards.

The enamel is thick and rather strongly plaited. The plication, however, is coarse. The enamel of inner and outer sides of the ridge-plates is rugous. The valleys are filled with cement. Outer and inner sides are in general devoid of cement, but the buccal side of the crown offers clear indications that cement has been lost, and that the inner and outer sides of the ridge-plates have been covered by a coat of cement.

MEASUREMENTS OF THE TOOTH (PROBABLY m_3) IN mm.

(Total length 104 mm.)

	Fore talon	1	2	3	4	5	6	7	Hind talon
Greatest length at base of crown	—	—	—	ca 42	ca 45	46	46c	46c	ca 31
Interval between the middle of two ridge-plates, measured in the median line of the grinding surface		—	—	—	12	13	14	14	10

c = cement included.

Before pointing out, how we came to the conclusion that the two specimens of our collection belong to *Archidiskodon planifrons*, we shall have to consider how many different forms of "*Elephas*" have hitherto been found in South and East Asia, and to which genera they are reckoned.

FALCONER and CAUTLEY distinguished three forms viz., *E. planifrons*, *E. hysudricus*, *E. namadicus*.

The first is reckoned by OSBORN [1]) to *Archidiskodon*, who followed in doing so POHLIG, the creator of that genus. MATSUMOTO [2]) esteemed it necessary to found on two fragmentary, worn grinding teeth, figured under the name of *E. planifrons* by FALCONER and

[1]) Proc. Am. Phil. Soc., LXIV, 1, 1925, p. 31.

[2]) Jap. Journ. Geol. a. Geogr., V, 1926—'27, p. 214.

CAUTLEY in the F. A. S. (pl. XI, fig. 4, and pl. XIV, fig. 8) not only a new species, but even a new genus, for which he proposed the names of *Leith-Adamsia siwalikiensis*. I wholly agree with DIETRICH [1]) who criticized this redetermination with the words: "Wert Null".

The systematic position of *E. hysudricus* is still somewhat uncertain. POHLIG [2]) has proposed to identify this species with *E.* (*Archidiskodon*) [3]) *meridionalis*. His view has, however, not been generally adopted. OSBORN [4]) reckoned in 1921 the species in question to the *Mammontinae*, but added: "The position of *E. hysudricus* in this phylum is doubtful". The cranium referred to this species by FALCONER is not of the Mammontine type". In 1924 [5]), however, he reckons it — though provided with a sign of interrogation — to the *Elephantinae*. There is indeed a great possibility of its belonging to that subfamily, LYDEKKER [6]) already having expressed as his opinion that *E. hysudricus* might be the direct ancestor of *E. maximus*, and DUBOIS [7]) having mentioned a fossil form from Java which is in his opinion intermediate between *E. hysudricus* and *E. maximus* (*indicus*). The latter species DUBOIS accordingly named *E. hysudrindicus*.

STEHLIN [8]), who determined a collection of fossil vertebrate remains, obtained from the vicinity of Bumiaju, believed to recognize among his material three different species of "*Elephas*". He left them specifically undetermined, but indicated them as spec. I, II and III. STEHLIN's species III might be identical with the form which we identified as *A. planifrons*.

E. namadicus became the subgenotype of MATSUMOTO's new subgenus *Palaeoloxodon* [9]). As already mentioned OSBORN uses *Palaeoloxodon* in a generic sense. Some investigators, among who DIETRICH [10]), consider *Palaeoloxodon namadicus* and *P. antiquus* identical. OSBORN [11]), however, regards them as distinct species. This author [12]) is even inclined to found a new genus (*Hesperoloxodon* = loxodonts of the West) on a form from Italy, described by him under the name of *P. antiquus italicus*.

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[1]) Neues Jhrb., (Ref.) III, 1928, p. 338.
[2]) Sitz. ber. niederrhein. Ges., Feb. 4th, 1884.
[3]) See OSBORN l. c. 1925, p. 31.
[4]) Am. Mus. Nov., n°. 1, 1921, p. 14.
[5]) Am. Mus. Nov., n°. 152, 1924, p. 1.
[6]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 116.
[7]) Tijdschr. Kon. Ned. Aardr. Gen., Sec. Ser., XXV, 1908, p. 1258.
[8]) Wetensch. Meded. Dienst Mijnb. Ned. Ind., n°. 3, 1925, p. 6.
[9]) See Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), XIII, 1, 1929, p. 1.
[10]) See e.g. Neues Jhrb., (Ref.) III, 1929, p. 466.
[11]) L. c. 1925, p. 31.
[12]) Am. Mus. Nov., n°. 460, 1931, p. 21.

MAKIYAMA [1]) distinguished two different subspecies (*namadi* and *naumanni*) of the species under consideration. According to MATSUMOTO, MAKIYAMA laid in doing so ". . . . the corner-stone of further progress in the study of *Elephas namadicus* FALCONER & CAUTLEY in Japan . . . ." [2]). MATSUMOTO added still another new subspecies, *yabei* [3]), and also a new species under the specific name of *tokunagai* [4]). DIETRICH [5]) opposed these determinations strongly. Without agreeing with this author in every respect, there is also in my opinion no sufficient reason to separate these specimens from *P. namadicus*.

Under the name of *E. trongontherii* POHLIG, MAKIYAMA [6]) described and figured two fragmentary grinding teeth from Japan. It is the first record of the occurrence of that species in Japan. OSBORN [7]) reckons this species to his new genus *Parelephas* [8]). In 1926 MATSUMOTO [9]) founded on some detached grinding teeth and on a left mandibular ramus, containing a finely preserved molar, two new forms of *Parelephas*, namely *Parelephas protomammonteus typicus* and *Parelephas protomammonteus proximus*. According to DIETRICH [10]) MATSUMOTO's forms belong partly to *E. antiquus*, partly to a new primitive race of true mammoth for which he proposes the name of *E. primigenius matsumotoi* n. var. In DIETRICH's opinion, furthermore, not only the belonging of the specimens to the left or to the right side is not always rightly determined, but also concerning the serial position misdeterminations occur. As to the latter objections I wholly agree with DIETRICH. As to the redeterminations of this author, however, I wonder, how he has been able to form so definite an opinion by the help of figures alone, the preservation of some specimens being such, that the figure — though exceedingly fine — only gives an absolutely insufficient idea of the structure. Furthermore it must not be forgotten that *Mammonteus primigenius* is a form, which — as far as my knowledge hitherto went — did not range so far South in E. Asia.

In NAUMANN's paper "Ueber Japanische Elephanten der Vorzeit" a short description of a well-preserved grinding tooth of *E. primigenius*

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1) Chikyû- The Globe, I, 1924, p. 381.

2) Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), XIII, 1, 1929, p. 1.

3) L. c. p. 4.

4) L. c. p. 7.

5) Neues Jhrb., (Ref.) III, 1929, p. 466.

6) Jap. Journ. Geol. and Geogr., III, 1924, p. 55.

7) Am. Mus. Nov., n°. 152, 1924, p. 4.

8) According to OSBORN (l. c.) all English authors, namely FALCONER, LEITH ADAMS, and LYDEKKER, confused the teeth and crania of the various species of *Parelephas* with those of the true mammoth, *Mammonteus primigenius*.

9) Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), X, 2, 1926, p. 43 (1).

10) Neues Jhrb., (Ref.) I B, 1927, p. 314.

will be found [1]). NAUMANN himself mentions, however, that the specimen has been possibly obtained from N. Asia.

The occurrence of *E. maximus* (*indicus*) in the fossil state in Japan was for the first time recorded by LEITH-ADAMS [2]). LYDEKKER [3]) doubted strongly the correctness of the determination, and reckoned the specimen to *E. namadicus*. In 1927 MATSUMOTO [4]) stated as his opinion that LEITH-ADAM's determination was right. On the basis of a few differences he distinguished the Japanese form under the new subspecific name of *buski*. To this subspecies MATSUMOTO reckons also a tooth described and figured by NAUMANN (l. c. p. 31, pl. VII) under the name of *E. namadicus* [5]).

Fossil teeth of *E. maximus* have been furthermore recorded by NAUMANN [6]) from Malakka, and by MARTIN (under the name of *E. sumatranus*) from Sumatra [7]), and from Banka [8]).

At last OSBORN [9]) described two new primitive forms of *Elephas*, namely *E. platycephalus* and *E. platycephalus augustidens*.

It will be evident, I believe, that in what precedes no effort has been made to discuss all the papers dealing with the present subject. Only those papers have been used which were necessary for the composition of the following list. The latter contains all fossil forms of *Elephantidae* (exclusive of *Stegodontinae*) of S. and E. Asia, which are known to me, and which have in my opinion right to specific or subspecific distinction.

Subfam. Loxodontinae:
Palaeoloxodon namadicus Falconer et Cautley.

Subfam. Mammontinae:
?? Mammonteus primigenius Blumenb.
Parelephas trogontherii Pohlig.
? Parelephas protomammonteus typicus Matsumoto.
? Parelephas protomammonteus proximus Matsumoto.
Archidiskodon planifrons Falconer et Cautley.

Subfam. Elephantinae:
Elephas hysudricus Falconer et Cautley.
Elephas hysudrindicus Dubois.
Elephas maximus buski Matsumoto.
Elephas maximus L. fossilis.
Elephas platycephalus Osborn.
Elephas platycephalus augustidens Osborn.

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[1]) Palaeontographica, XXVIII, 1882, p. 31.

[2]) Quart. Journ. Geol. Soc. London, XXIV, 1868, p. 496. (Busk, Add. Remarks, id. p. 498).

[3]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 168.

[4]) Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, Sec. Ser. (Geol.), X, 3, 1927, p. 57 (1).

[5]) Already LYDEKKER (l. c. p. 169) was convinced of the specific identity of this tooth with LEITH-ADAM's specimen.

[6]) Abh. u. Ber. K. Zool. etc. Mus. Dresden, 1887, n°. 6, p. 9.

[7]) Samml. Geol. Reichs-Mus. Leiden, III, 1883—'87, p. 5.

[8]) Ibid., IV, 1884—'89, p. 13.

[9]) Am. Mus. Nov., n°. 393, 1929, p. 21 & 22.

It will need no further explanation why the two specimens of our collection, which were determined as belonging to *A. planifrons*, belong indeed to a primitive form. Already for that reason alone we may exclude the greater part of the species occurring in our list. There remain: *A. planifrons*, *E. hysudricus*, *E. platycephalus* and *E. platycephalus augustidens*. Of the dentition of the last two forms but very little is known, OSBORN making only a few remarks on the structure of the M^3, and only figuring the only specimen of molar, namely the unworn type M^3 of the subspecies. From this figure appears that the ridge-plates are higher, narrower and more closely approximated than in our specimens. As far as can be gathered from OSBORN's unworn specimen there seems to be no mesial dilatation of the ridge-plates. Besides these few remarks, however, we shall have to leave these forms out of consideration, the dentition being too little known.

Proceeding with the dentition of *A. planifrons* and *E. hysudricus* we borrow the following ridge-plate formulae (exclusive of talons) from LYDEKKER [1]).

$$A.\ planifrons\ \text{m}\ \frac{3.(5—6).(6—7)}{3.\quad 6.\quad (7—8)}\ \text{M}\ \frac{7.(8—9).(10—12)}{7.(8—9).(10—13)}$$

$$E.\ hysudricus\ \text{m}\ \frac{3.(5—7).(7—11)^{2})}{3.(7—9).(9—11)}\ \text{M}\ \frac{(9—12).(10—12).(13—17)}{(9—12).(12—13).(14—18)}$$

We shall begin with the discussion of the determination of the fine, detached l. M^1.

Being an upper tooth with ridge-plate formula $\times\ 7\ \times$, it will be seen that if it really belongs to one of the two remaining species, it represents either m^2 or m^3 of *E. hysudricus*, or m^3 or M^1 of *E. planifrons* [3]).

There are but a few specimens known of m^2 and m^3 of *E. hysudricus*. They are mentioned by LYDEKKER in his Cat. Foss. Mamm. Br. Mus., IV, 1886; they are figured in the F. A. S., and their dimensions will be found in the "Description of Plates". Borrowing data from these works, we arrive at the following table.

	Length × width of m^2	Length × width of m^3
F.A.S., pl. VI, fig. 2	2.1 × 1.6 inch = 53 × 41 mm.	4.3 × 2.1 inch = 109 × 53 mm.
„ , pl. VI, fig. 3 [4])	2.2 × 1.6 „ = 56 × 41 „	4.3 × 2 „ = 109 × 51 „
„ , pl. VII, fig. 1		

[1]) Cat. Foss. Mamm. Br. Mus., IV, 1886, p. 99 & 116.

[2]) LYDEKKER gives as ridge plate formula of the last upper milkmolar (9—11). He mentions, however, two specimens (nos. 3114 and 16194) which carry but 7 ridge-plates.

[3]) With m^3 is meant the last upper milkmolar (mm^4 of LYDEKKER).

[4]) LYDEKKER (p. 117) mentions erroneously fig. 4.

The dimensions of our specimen are 125 × 53 mm. Supposing it to belong to *E. hysudricus*, it may only represent the ultimate milk-molar. I am, however, convinced, that the molar in question does not belong to that species. Not only that in the aspect of the grinding surface our specimen differs widely from the m^3 of *E. hysudricus* represented in fig. 3 of pl. VI of the F. A. S., but also comparison of the lateral aspect reveals important differences. As the figures, mentioned in the foregoing table, represent milkmolars still fastened in the upper jaw, the latter comparison must be made by the help of the lateral aspect of a lower, detached m_3 of the referred species (F. A. S., pl. VII, fig. 8). It will be seen that the ridge-plates of our specimen are lower, and that the separation between its crown and fangs is much more distinct. So we may exclude *E. hysudricus*.

In the following table the reader will find the dimensions of m^3 and M^1 which LYDEKKER reckons to *A. planifrons*.

	Length × width of m^3	Length × width of M^1
F.A.S., pl. VI, figs. 4-5	4 × 2.4 inch = 102 × 61 mm.	5.5 × 2.7 inch = 140 × 69 mm.
„ pl. XII, fig. 2	3.8 × 2.3 „ = 97 × 58 „	
„ pl. XII, figs. 4-4*a*		— × 2.8 „ = — × 71 „

As already mentioned the dimensions of our specimen are 125 × 53. All the specimens of the foregoing table are therefore wider than our specimen, while the length of the latter is intermediate between those of m^3 and M^1 of the table. Furthermore it will be seen that concerning the relation $\frac{\text{length}}{\text{width}}$ our specimen approaches more closely to the M^1 than to the m^3 of *A. planifrons*. It will be remembered (1) that according to LYDEKKER, the m^3 of the latter species carries six to seven, the M^1 seven ridge-plates, and (2) that our own specimen shows a slight tendency to a transmission of a tooth with seven ridge-plates into one with eight. Supposing its belonging to *A. planifrons*, it is therefore more probable that it represents a M^1 than a m^3.

It cannot be denied, however, that the difference in size between the M^1 of *A. planifrons* represented in figs. 4—5, pl. VI of the F. A. S. and our specimen is considerable. On the other hand LYDEKKER, in dealing with the grinding teeth of the referred species, mentions: "... the relative width and the absolute size of the teeth ... vary very considerably" [1]). This fact is clearly illustrated in

[1]) L. c. p. 99.

the following table, in which I united the dimensions of the various complete M_3 reckoned by LYDEKKER to *A. planifrons*. The dimensions are again borrowed from the F. A. S.

Length × width of M_3	
F.A.S., pl. VIII, fig. 2	8.8 × 3.8 inch = 224 × 97 mm.
„ , pl. XI, fig. 2	11.8 × 3 „ = 300 × 76 „
„ , pl. XI, fig. 8 [1])	12.1 × 3.8 „ = 307 × 97 „
„ , pl. XI, fig. 7	10.2 × 4 „ = 259 × 102 „
„ , pl. XII, figs. 12—12*a*	10 × 3.5 „ = 254 × 89 „

If therefore the various characters of our specimen should appear to be in accordance with those of the molars of *A. planifrons*, its aberrant size and shape may never be used as an argument against specific identity. Now, if the figures of our specimen be compared with those of the molars which LYDEKKER reckons to *A. planifrons*, it will be seen that the former is absolutely indistinguishable. Concerning (1) the relative height of the ridge-plates, (2) the thick enamel, almost quite devoid of plication, (3) the expansion of the ridge-plates in the middle, assuming an imperfect lozenge shape, (4) the distinct separation between crown and fangs, the molar in question resembles so closely those of *A. planifrons*, that in my opinion it may in all probability be classed with that species.

We shall now return to our lower molar, represented in pl. XV, figs. 5—6. Its ridge-plate formula is × 7 ×. Supposing it to belong either to *A. planifrons* or to *E. hysudricus*, it represents either a m_3 or M_1 of the former, or a m_2 or m_3 of the latter.

The data of both following tables have again been derived from LYDEKKER, and from FALCONER and CAUTLEY.

A. planifrons.

Length × width m_3	
F.A.S., pl. XII, figs. 8—8*a*	4.4 × 2.4 inch = 112 × 61 mm.
„ , pl. XII, figs. 10—10*a*	6.7 × 2.6 „ = 170 × 66 „
„ , pl. XI, fig. 6	— × 2.8 „ = — × 71 „

[1]) Figured as M_2.

E. hysudricus.

Length × width m_2	
F.A.S., pl. VII, figs. 7—7*a* [1])	3.1 × 1.5 inch = 79 × 38 mm.
Length × width m_3	
F.A.S., pl. XIIIA, fig. 7	5.4 × 2.3 inch = 137 × 58 mm.
„ , pl. VII, fig. 8	5.5 × 2.2 „ = 140 × 56 „

The dimensions of our specimen being 105 × 46 mm. it will be clear that it may be either a m_3 of *E. hysudricus* or of *A. planifrons*. Of these teeth but very few specimens have been figured in the F. A. S. As furthermore these figures are on far too small a scale, and as the milkmolars of both species are in several characters very much alike, it is extraordinarily difficult to answer the question, whether our specimen belongs to *A. planifrons* or to *E. hysudricus*.

Our specimen presents, however, some characters, which seem to point in the direction of *A. planifrons*. They are:

a. The coarse crenulation of the thick enamel. (In the teeth of *E. hysudricus* the enamel is either very thin, and much plicated, or thicker with slight plication).

b. The relatively low ridge-plates. The estimated height of the last ridge-plate does not exceed 42 mm.

c. The dimensions correspond far better with those of the m_3 of *A. planifrons* than with those of the m_3 of *E. hysudricus*, especially if we take into consideration the fact, that our specimen has lost the greater part of the cement covering its inner and outer side, so that the molar seems to be some mm. narrower than it is in reality.

We conclude therefore: The specimen in question either belongs to *A. planifrons*, or to *E. hysudricus*, but its belonging to the former species is most probable. In that case it represents a last lower milkmolar.

[1]) According to LYDEKKER (l. c. p. 120, n°. 16621) a m_3 (mm4), but in all probability an error, the number of ridge-plates being seven or eight, the dimensions being very small, and FALCONER (Descr. of Plates, p. 8) considering the specimen to be a second milkmolar (m_2).

PROBOSCIDEAN SKELETON REMAINS.

Besides the cranial and dental remains already described, our collection contains seven femora, three humeri, two tibiae, three ulnae, two radii, and one left half of the pelvis. From the following enumerations it will appear that the bulk of these specimens has been obtained from the vicinity of Bumiaju.

Bumiaju[1]), Excavation 1—4 . .	Pelvis.
„ , Excavation 8 . . .	Femora nos. 2 and 6; tibia no. 2; ulnae nos. 1—3; radii nos. 1 and 2.
Tji Djedjawai[1])	Femur n°. 3.
Tji Saät[1])	Femur n°. 4.
Kedung Kendang[2])	Femur n°. 7; humerus n°. 3.
Watualang[2])	Humerus n°. 2.
Bondol near Kuwung[3]) . . .	Femur n°. 1.
Wedilembut[3])	Femur n°. 5.
Redjuno[4])	Humerus n°. 1.
Lepen Alit near Tinggang[5]) . .	Tibia n°. 1.

Excavations 1—4 and 8 are situated at the base of the vertebrate bearing series. Of proboscidean cranial remains found in excavation 8 our collection contains only one mandibular ramus, namely, the one described in the foregoing pages under the name of *Tetralophodon bumiajuensis* n.sp. From excavations 1—4 the other remains of that species of our collection were obtained. Moreover one badly preserved grinding tooth, and the posterior portion of the cranium of *Mastodon* sp. Neither in these excavations remains of *Stegodon* or "*Elephas*" were found. It is therefore very probable that the proboscidean skeleton remains procured from these excavations belong to *Mastodon*, more particularly to *Tetra-*

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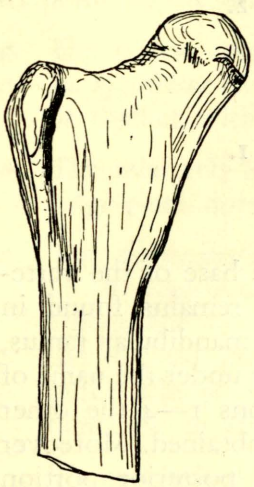
[1]) District Bumiaju, Regency Brebes, Residency Pekalongan.
[2]) District Sragen, Regency Sragen, Government Surakarta.
[3]) District Randublatung, Regency Blora, Residency Rembang.
[4]) District Dero, Regency Ngawi, Residency Madiun.
[5]) District Tambakredjo, Regency Bodjonegoro, Residency Bodjonegoro.

lophodon bumiajuensis. The same cannot be said of the specimens which have been found in the Tji Djedjawai and Tji Saät, both streamlets, which break transversely through the vertebrate bearing strata. For it must be borne in mind that from the vicinity of Bumiaju also *Stegodon* and "*Elephas*" remains have been procured.

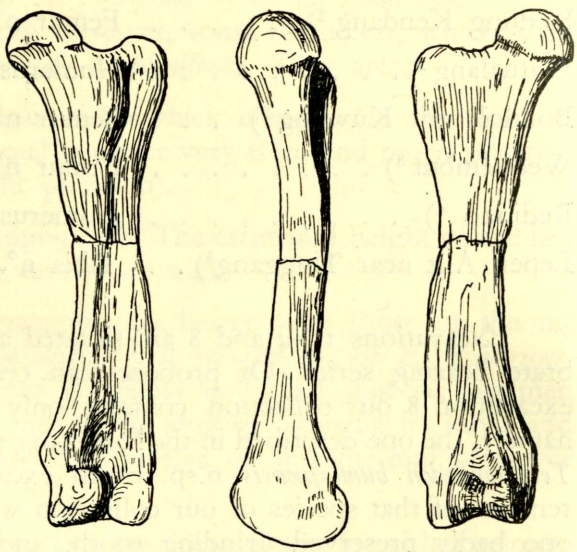
POHLIG [1]) — who studied the proboscidean skeleton remains collected by the Trinil Expedition of Mrs. SELENKA — already pointed out the great lack of a sufficient number of data for comparison, experienced by everyone who is occupied with the determination of skeleton remains. As to proboscidean bones POHLIG's paper supplies this want for a deal. Accordingly we shall use it repeatedly.

We shall begin with the femora, more particularly with their state of preservation.

N°. 1. Text fig. 27. Upper half of left femur of gigantic size. It is very unfortunate that this specimen is not complete, as the remaining portion is perfectly preserved. It is characterized by a low trochanter major.



Text fig. 27.
Hind aspect of upper half of left femur (N°. 1). About $^1/_{13}$ nat. size.



A B C

Text fig. 28. Right femur (N°. 5).
A = Hind aspect; B = Inner aspect; C = Front aspect. About $^1/_{13}$ nat. size.

N°. 2. Pl. XVII, fig. 4. Left femur. Restored with plaster. Front side, distal and proximal extremity injured. Consequently

[1]) "Zur Osteologie von *Stegodon*" in "Die Pithecanthropus-Schichten auf Java" Leipzig 1911.

the fossa intercondyloidea seems wider than it already really is. Smallest width 35 mm.

N°. 3. Right femur. Middle portion of corpus wanting. Great resemblance to N°. 4.

N°. 4. Pl. XVII, figs. 5—7. Right femur. Rather well preserved; considerably restored. Fossa trochanterica better developed than would appear from fig. 7.

N°. 5. Text fig. 28. Right femur. Fine specimen; was broken into two in the middle of the corpus. Both parts have been glued together later on. External epicondylus feebly developed.

N°. 6. Right femur. Badly preserved; proximal and distal extremities broken off.

N°. 7. Probably right femur of elephant. Very badly preserved. Only portion of corpus.

In table W the measurements of our specimens will be found together with those mentioned by POHLIG [1]). It will be remembered that femora nos. 2 and 6 have been found in excavation 8 from which excavation no other remains than of *Mastodon* have been obtained. And the question is whether it is possible to identify nos. 2 and 6 as belonging to *Mastodon* by the help of the data, given by POHLIG. According to that author, the long limb bones of *Mastodon* are (1) thick and short and (2) characterized by the almost total absence of a torsion: "Die hintere Begrenzungsebene der Condylen ist bei *Mastodon* der vorderen des proximalen Femurrandes fast parallel." [2]) From n°. 6 only two measurements could be taken, which are in almost perfect accordance with the corresponding ones of n°. 2. But of course only the latter can be used for comparison. If the relation between total height and smallest breadth of the corpus be calculated, it will be seen that n°. 2 seems to be slightly more slender than POHLIG's specimen of *St. airâwana*. If, however, the relation between total height and smallest girth of corpus be calculated, it will be revealed that in this respect our specimen is intermediate between *St. airâwana* and *M. giganteus*, and distinctly separated from *E. maximus*. In all probability POHLIG attached most importance to the latter relation, as he did not give the value of the smallest breadth of the corpus femoris in the Cambridge specimen of *M. giganteus*. As to the angle of torsion [3]), however, n°. 2 has exactly the same value, which POHLIG mentions of the femur of

[1]) L. c. p. 208—210.

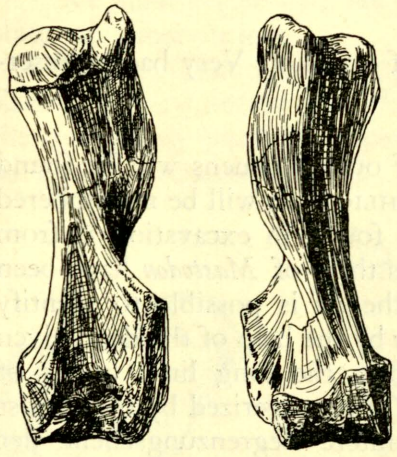
[2]) L.c. p. 210.

[3]) ∠ *a* of table of measurements.

St. airâwana. As to nos. 4 and 5 this angle is even considerably greater; in this respect, therefore, decidedly more "Elephas-like" than *St. airâwana*. Peculiar is, however, that the relation between total height and smallest girth of corpus in nos. 4 and 5 points in the direction of a form which is still more "Mastodon-like" than *M. giganteus*. Conclusion: By the help of POHLIG's data it is not possible to determine our specimens of femora. I repeat, however, that in all probability nos. 2 and 6 belong to *Mastodon*.

We shall now continue with the consideration of the humeri.

N°. 1. Text fig. 29. On the whole very fine specimen. Was above the middle broken into two, but both parts have been glued together. Right specimen.



A B

Text fig. 29. Right humerus (N°. 1). A = Hind aspect; B = Front aspect. About $^1/_{15}$ nat. size.

N°. 2. Considerably smaller than n°. 1. Nevertheless belonging to an adult individual as no separation of the epiphysis can be perceived. Strongly damaged. Caput totally wanting. No essential differences with specimen n°. 1. Right specimen.

N°. 3. As to size intermediate between nos. 1 and 2. Still more damaged than no. 2. A. o. distal extremity wanting. For the rest no differences with n°. 2. Right specimen.

POHLIG's specimens of humeri are so damaged that comparison with our specimen is hardly possible. From table X, in which the measurements of the humeri of our collection and those of POHLIG's best preserved specimen have been united, it will be seen that n°. 1, though not inconsiderably greater, shows in general exactly the same relations as POHLIG's specimen. N°. 1 may therefore belong to *St. airâwana*.

As already mentioned all the ulnae and radii of our collection have been found in excavation 8, and belong therefore in all probability to *Mastodon*. The belonging of ulna n°. 1 to radius n°. 2 and of ulna n°. 2 to radius n°. 1 could be ascertained with absolute reliability.

Ulna n°. 1 plus radius n°. 2. Pl. XVI, figs. 4—7. Very fine specimens of the right side. Only slightly restored. Proc. anconaeus of ulna broken off. Radius but relatively slightly curved.

Ulna n°. 2 plus radius n°. 1. Left specimens. Very close resemblance to foregoing pair. Somewhat less better preserved. Proc. anconaeus wanting. From table Y and Z it will be seen that while the two ulnae are nearly of equal size, radius n°. 1 is somewhat thicker and longer than radius n°. 2.

Ulna n°. 3. Right specimen. No essential differences with n°s. 1 and 2. It wants the distal extremity and the greater portion of the olecranon. The planes of fractures seem to indicate that the epiphyses have been lost, so that the specimen may have belonged to an immature individual.

POHLIG[1]) pointed out that an essential character of the radius of *St. airâvana* is "..... die starke Torsion; stärker ist sie bei *Mastodon*, wo die Längsrichtung der carpalen Gelenkfläche nahezu perpendikulär zu derjenigen der proximalen ist, fast parallel stehen beide bei *E. indicus*, bei *E. africanus* and *E. meridionalis* etwas mehr dem Verhältnis von *Stegodon* angenähert." It appeared, however, that this character is not easy to handle. What must be understood by "Längsrichtung der carpalen Gelenkfläche", the latter being approximately triangular in shape? If we consider the line through top and middle of base of the triangle as representing the longitudinal direction, there occurs indeed but a slight torsion. If, however, the external side of the triangle be taken as longitudinal direction, there exists an angle of about 40° between the latter and the longitudinal direction of the proximal plane of articulation.

As to the ulna POHLIG[1]) observes: "Wie alle anderen langen Knochen, so ist auch die Ulna bei *Stegodon* und *Elephas* schlanker, graciler als bei *Mastodon* ....." From table Z it will be seen immediately that in this respect the two complete ulnae of our collection point decidedly in the direction of *Mastodon*. From which we may infer that our first supposition of what POHLIG meant with "Längsrichtung der carpalen Gelenkfläche" of the radius is right.

At last the tibiae and the pelvis. All the three are very fragmentary. Tibia n°. 1 consists of the proximal portion; n°. 2 is still more fragmentary, proximal as well as distal extremity being wanting. The latter has been found in excavation 8, and belongs therefore probably to *Mastodon*. The fragment has a length of 44 cm., smallest breadth is 7,7 cm. and smallest girth 24 cm.

The left half of the pelvis will be found figured in pl. XVII, fig. 3. The ilium is very much damaged; the ischium has been preserved for the greater part; of the pubis only a small portion is present. Furthermore the border of the acetabulum is damaged. Dimensions of the latter 16 × 14 cm. This specimen, having been found in excavations 1—4, belongs in all probability to *Mastodon*.

[1]) L.c. p. 206.

FINAL CONSIDERATIONS.

Bumiaju.

The following determinations are of interest:

Tetralophodon bumiajuensis nov. spec.

The molars of this species appeared to show very great affinities to *Tetralophodon longirostris*. According to VON KOENIGSWALD [1]), however, the form of Bumiaju is easily distinguished from the European species by the absence of lower incisive tusks.

Stegodon airâwana MARTIN.

The stegodont of the Trinil beds (= Kendeng beds = Pithecanthropus beds).

Archidiskodon planifrons FALC. et CAUTL.

Hitherto this species had not been recorded from the Dutch East Indies.

Hippopotamus spec.

The remains did not allow of determining the species. We were able, however, to show that the Bumiaju form is specifically distinct from the species of DUBOIS's collection viz., *Hippopotamus sivajavanicus* DUB.

The question is: Are these determinations apt to strengthen or to weaken the opinion of an upper pliocene age of the Bumiaju beds? The prevalent opinion is that "*Mastodon*" does not occur in the Pleistocene of Eurasia, whereas it does appear in that of America. This supposition, however, remains to be proved. MATTHEW [2]), namely, in correlating European with American mammal faunas, came to the conclusion that it is either necessary to revise the American succession downward, or the European succession upward. In the latter case "*Mastodon*" should occur, therefore, also in the Pleistocene of Europe. In a quite recent publication OSBORN [3]) does not exclude this possibility either [4]).

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[1]) De Mijningenieur, 11, 1931, p. 200.

[2]) See Bull. Amer. Mus. Nat. Hist., LVI, 1930, p. 439.

[3]) "The Geologic Age of *Pithecanthropus*". Rep. Centenary Meeting Brit. Ass. for the Advancement of Science, London 1931, p. 451. London 1932.

[4]) The correctness of this affirmation may appear from the following quotation: "*Eoanthropus dawsoni* was the companion of *Archidiskodon planifrons* and *Anancus arvernensis*, hence of upper Pliocene or lower Pleistocene age" (l. c. p. 452).

It will be known that PILGRIM [1]) places the Upper Siwaliks in the Pliocene. MATTHEW (l. c.), however, stated as his opinion that he could not find any valid reason for referring the Upper Siwalik fauna to the Pliocene. If, therefore, MATTHEW's assertion should turn out to be correct, "*Mastodon*" [in the form of *Pentalophodon sivalensis* (CAUTL.) [2])] should occur in the Pleistocene of Asia. In the writer's opinion "*Mastodon*" in all probability occurs in the Javan Pleistocene. As already mentioned in the Introduction, in Sangiran a mastodont-like, fragmentary molar has been found by VAN ES in beds, which he regards contemporary with the Trinil beds. Moreover, it was mentioned that a similar grinding tooth had been obtained by DUBOIS from the Trinil beds, but that it might represent in the latter's opinion an atavistical deviation of a *Stegodon* molar. In our opinion, however, this supposition is highly improbable. In what follows it will be seen that some of our determinations give a very strong support in favour of a pleistocene age of the Trinil beds. Consequently "*Mastodon*" in all probability occurs in the Pleistocene of Java [3]).

Turning now to *Stegodon airâwana*, we may be brief. We shall return to that form later on. For the present it will suffice to call to mind that remains of *St. airâwana* are abundant in the Trinil beds, and that VAN ES's researches have shown the Trinil beds to be of younger age than the Bumiaju beds.

As to *Archidiskodon planifrons*, the following remarks may be made. According to PILGRIM (l. c.) this species occurs in the Pinjor horizon (middlemost Upper Siwaliks). In MATTHEW's opinion, therefore, it occurs in the Pleistocene of the Siwalik Hills. It may be added that it is said also to occur in the Narbada deposits, which are generally considered as Lower Pleistocene. It must be borne in mind, however, that our knowledge of the Narbada beds must be called totally insufficient.

Remains to consider *Hippopotamus* spec. According to PILGRIM [4]), *Hippopotamus sivalensis* occurs in the Boulder Conglomerate Zone (uppermost Upper Siwaliks). MATTHEW (l. c.) pointed out that the British Museum specimens of the Upper Siwaliks show two diverse types of fossilization, and that the specimens, which are well fossilized,

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[1]) Rec. Geol. Surv. of India, XLIII, 1913, pl. 26 (table).

[2]) The name of this species is erroneously left out of the faunal list of the Upper Siwaliks, given bij MATTHEW (l. c. p. 443).

[3]) As far as my knowledge goes *Pentalophodon sivalensis* is the only mastodont species which has hitherto been found in the Upper Siwaliks. I cannot see, therefore, how VON KOENIGSWALD (l. c.) came to the assertion that the Bumiaju form resembles certain progressive forms of the Upper Siwaliks so closely, that it is either identical with, or at least closely allied to one of them.

[4]) L. c. p. 324.

may belong to an older horizon, "perhaps Pliocene". As among the specimens of *H. sivalensis* both types of fossilization are represented, there is, therefore, a possibility that this species occurs both in the Pliocene and Pleistocene. *Hippopotamus iravaticus* is, however, an undoubtedly tertiary species. According to PILGRIM [1]) it occurs in the Dhok Pathan Zone (middlemost Middle Siwaliks). PILGRIM places the Middle Siwaliks in the upper Miocene [2]), MATTHEW in the Pliocene. As already pointed out, however, the Bumiaju form is certainly not identical with *H. iravaticus*.

In the Narbada beds *Hippopotamus* is represented by *Hippopotamus* ("*Tetraprotodon*") *palaeindicus*, and *Hippopotamus* ("*Hexaprotodon*") *namadicus*. It will be remembered that we arrived at the conclusion that the Bumiaju form, being hexaprotodont, is certainly distinct from *H. palaeindicus*, but that it shows affinities to *H. namadicus*. It appears, therefore, that neither the *Hippopotamus* remains afford conclusive evidence in favour of an upper pliocene age of the Bumiaju beds. We will return to the problem of their age later on.

Region between Gesi and Ngawi.

(See map n°. 2.)

In this region are situated our localities Pitu, Watualang, and Kedung Kendang. Furthermore the famous locality Trinil. Stratigraphy and tectonic structure are owing to VAN ES well known.

The following determinations are of interest.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*.

Hippopotamus spec. (Hinder portion of cranium).

It will be remembered that the mammalian remains of the rich collection, brought together by the Trinil Expedition of Mrs. SELENKA, have been examined by JANENSCH (*Proboscidea*) and STREMME (the rest). It was the latter who drew his conclusions from the determinations, made by either. One of the first conclusions at which STREMME arrived, was: "So sehen wir hier eine Fauna, die recht beträchtlich von der heutigen verschieden ist und *keine mit ihr gemeinsame Art enthält* [3]); von den gut bestimmbaren Arten ist nicht eine mit einer heutigen identisch" [4]). It has

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[1]) L. c. p. 285.

[2]) That is to say to the Pontian. By some investigators, among who PILGRIM, the Pontian is referred to the Upper Miocene, by most however, to the Lower Pliocene.

[3]) The italics are ours.

[4]) Die Pithecanthropus-Schichten auf Java, p. 143.

been shown that this assertion is not correct. In our opinion there are no valid reasons for distinguishing the forms, reckoned by STREMME resp. to *Buffelus palaeokerabau* DUB. and to *Rhinoceros sivasondaicus* DUB., from the still living species *Buffelus bubalus* var. *sondaicus*, and *Rhinoceros sondaicus*.

Another conclusion of STREMME was that — though he could not find conclusive evidence either in favour of an upper pliocene age, or of a lower pleistocene age — it could not be denied after comparison of the Trinil fauna with upper pliocene European faunas "..... dasz eine gewisse Wahrscheinlichkeit für das oberpliocäne Alter der Kendeng-Fauna spricht." [1]) In his comparison STREMME made use of a faunal list, given by SCHLOSSER, and containing all the genera of some classic faunas, a.o. those of Val d'Arno. The latter fauna, however, formerly regarded as Pliocene, is considered at the present moment by some of the best modern Italian and French authorities as early Pleistocene [2]).

Be that as it may, we do not doubt that STREMME would have come to a pleistocene age, had he — as we — arrived at the conclusion that the Trinil fauna contains at least three still living species viz., *Bibos sondaicus fossilis*, *Buffelus bubalus* var. *sondaicus fossilis*, and *Rhinoceros sondaicus fossilis*.

Vicinity of Kuwung and Tinggang.

(See map n°. 2.)

Our knowledge of the stratigraphy of the vertebrate bearing layers is very insufficient. Regarding the mammalian remains, there seem to be few reasons to accept another age than for the Trinil beds. It may be emphasized that DUBOIS did not accept a different age.

The following determinations are of interest.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*.

Rhinoceros sondaicus DESM. *fossilis*.

Elephas ?maximus L. *fossilis*.

Stegodon airâwana MARTIN.

Stegodon trigonocephalus MARTIN.

Stegodon bondolensis nov. spec.

As to the first three determinations comment will be needless. As already pointed out on p 172, the lower jaw, which we deter-

[1]) L. c. p. 145.

[2]) See MATTHEW, l. c. p. 438.

mined as possibly belonging to the recent *E. maximus*, might perhaps belong to *E. hysudrindicus* DUB., a form, which is said to be intermediate between *E. indicus* (*maximus*) and the Siwalik *E. hysudricus* (Boulder Conglomerate Zone, uppermost Upper Siwaliks). Even if PILGRIM's opinion of the age of the Upper Siwaliks is adopted, we may *E. hysudrindicus* expect only to occur in pleistocene deposits [1]).

Concerning *Stegodon trigonocephalus* we may mention that in the opinion of some this form is specifically indistinct from *St. airâwana*. Though we do not agree with that opinion, we immediately admit that the grinding teeth of both Javan forms show exactly the same height of development.

Since 1914 three different investigators have paid attention to the degree of specialization of the grinding teeth of *St. airâwana*. The first was SOERGEL [2]). He pointed out that in the anterior portion of the teeth of that species the top of the ridge-crests is divided into three by two longitudinal, shallow clefts. As the same phenomenon frequently occurs in *Elephas* teeth, SOERGEL concluded: "In der Dreipfeilerbildung an Proximalende von Stegodontenzähnen haben wir ein fortgeschrittenes, zum speziellen Zahnbau der Gattung *Elephas* überleitendes Merkmal zu erblicken" [3]). SOERGEL pointed out, furthermore, that in the Siwalik stegodonts this feature seems to be absent; consequently they would be older. This difference, together with the greater number of ridge-crests and the thinner enamel, is one of the chief reasons, why SOERGEL regards the Kendeng fauna to be of undoubtedly pleistocene age. The question is, however, not so simple as would appear from the above. From our descriptions and figures of the teeth of *St. airâwana*, it will namely be seen that sometimes the ridge-crests are divided into four, because of the presence of a median, an outer, and an inner constriction. The median constriction indicates the presence of a median, longitudinal cleft. As such a condition is a characteristic of *Mastodon* teeth, its occurrence in *Stegodon* teeth (e. g. those of *St. clifti*) is regarded as a primitive feature. Taken together, we may say that the grinding teeth of *St. airâwana* show in most cases an "*Elephas* character", but in some cases beside it a "*Mastodon* character". Nevertheless it cannot be denied that *St. airâwana* is a progressive species, more specialized than *St. ganesa-insignis*, the species of the Upper Siwaliks, and which

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[1]) The more so, if is added that LYDEKKER already suggested the possibility of a lowermost pleistocene age of the topmost beds of the Siwaliks, and that PILGRIM (l. c. p. 325) refrained from "in the least disputing LYDEKKER's suggestion".

[2]) Palaeontographica, Suppl. IV, Abt. III, Lief. I, 1914.

[3]) L. c. p. 13.

is said also to occur in the Narbada deposits. If therefore — SOERGEL observes — the Narbada stegodont should turn out to be really specifically identical with the form of the Upper Siwaliks, and if indeed should appear that the Narbada deposits are of lower pleistocene age, the Kendeng fauna has to be assigned to the Middle Pleistocene.

The next investigator, who tried to ascertain the age of the Kendeng fauna by the help of the molars of *St. airâwana*, was DIETRICH [1]). His train of thought was as follows. The general progress of the phylogenetic evolution of the dentition of *Stegodon* is: reduction in the region of premolars and (or) milkmolars, addition, i. e. increase of length and of number of ridge-crests, in the region of the molars. Therefore it would be possible to fix in numbers the degree of specialization, if we but disposed of sufficient data to calculate the formula $\frac{\text{length } m^1 \times \text{length } M^3}{\text{length } m^2 \times \text{length } M^2}$ [2]). We lack, however, sufficient data, so that we have to do with the "Längen-Jochzahl-quotient" [3]). After making use of all the measurements available for $M\frac{3}{3}$ — phylogenetic the most active tooth — DIETRICH found the following values:

	M^3	M_3
Stegodon airâwana (+ *trigonocephalus*)	20	21
„ *insignis* (+ *ganesa*) . . .	25	27
„ *clifti* (+ *bombifrons*) . .	29	33

From these values it appears that from *St. clifti* to *St. airâwana* the number of ridge-crests an unit of length increases. But that of course is not new. DIETRICH, however, deduces more from them. He pointed out that according to PILGRIM *St. clifti* and *St. bombifrons* occur in the Dhok Pathan horizon (middlemost Middle Siwaliks) as well as in the Tatrot horizon (lowermost Upper Siwaliks), while *St. ganesa-insignis* occurs in the Boulder Conglomerate Zone (uppermost Upper Siwaliks) and is said to occur in the Narbada deposits. If, therefore, PILGRIM's determination of the age of the various Siwalik horizons is adopted [4]), the difference between the values 33 and 27 (resp. 29 and 25) symbolises a lapse of time, comprising the whole Pliocene. And as the values, which DIETRICH calculated

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[1]) Sitz. ber. Ges. Naturf. Fr. Berlin, 1924, p. 134.

[2]) I cannot see why DIETRICH did not prefer the formula $\frac{\text{length } M^2 \times \text{length } M^3.}{\text{length } m^1 \times \text{length } m^2.}$

[3]) That is to say the relation $\frac{\text{total length.}}{\text{number of ridge-crests.}}$
In our opinion it had been better not to use the quotient, but the product.

[4]) And if the Pontian is reckoned to the Lower Pliocene.

for *St. ganesa-insignis*, are situated almost in the middle between the values found for *St. airâwana* (+ *trigonocephalus*) and *St. clifti* (+ *bombifrons*), he arrived at the conclusion: "Selbst wenn das Entwickelungstempo rascher geworden ist, kommen wir für *Airawana* zu einem sehr viel jüngeren Alter, nämlich zu Jung- bis Jüngstpleistocän" [1]).

We may raise the following objections against DIETRICH's assertions:

1. How little do we know of the movement of evolution!
2. If MATTHEW's views of the age of the various Siwalik horizons are adopted, the difference between DIETRICH's values 33 and 27 (resp. 29 and 25) symbolizes a lapse of time, which reaches at least to the base of the Middle Pleistocene. In that case *St. airâwana* would therefore be still younger than "Jung- bis Jüngstpleistocän".
3. The occurrence of a complex of layers of about 500 m. thickness above deposits, contemporary to the Trinil beds [2]), argues strongly against an upper- to uppermost pleistocene age.

The third author, who has occupied himself — be it indirectly — with the height of development of *St. airâwana*, is OSBORN [3]) (in cooperation with EDWIN H. COLBERT). OSBORN maintains that the grinding teeth of *Elephas* and *Stegodon* can be used as "priceless enamel chronometers" [4]). Therefore it is only necessary to measure very accurately the total enamel length. His method is called ganometric (ganos = enamel). Concerning *Stegodon* grinders the following — roughly estimated — values are mentioned:

Stegodon airâwana, Middle Pleistocene, M^2, 510 mm.

„ *bombifrons*, Lower Pliocene, M^2, 410 „ .

For the present these values do not mean much. It was already long known to us that the enamel of *St. bombifrons* is less plicated than of *St. airâwana*. The difference of 100 mm. has no signification, so long we do not dispose of the value found for the corresponding molar of a species as *St. ganesa-insignis*. And even if we did know, OSBORN will have to prove the correctness of his assertion that the total enamel length can be used as a chronometer.

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[1]) L. c. p. 139.

[2]) See the Introduction.

[3]) Proc. Amer. Philos. Soc., LXX, 1931, p. 187. See also OSBORN's two papers in the Rep. of the Cent. Meeting Br. Ass. London 1931.

[4]) Rep. of the Cent. Meeting Br. Ass. London 1931, 1932, p. 452.

Unfortunately enough in OSBORN's provisional publications on the present subject the technique of the ganometric method is not dealt with. Has use been made of grinders with a certain degree of wear, and has the total length of all the plications been measured at the grinding-surface? Or has in one way or another the height of the various ridge-crests been included? Apparently it has. COLBERT, namely, pointed out: "The measurements thus far assembled are all rough and preliminary; out of the thirty-six teeth studied, only two were unworn; consequently there are large estimated factors in most of the measurements" [1]).

It remains with us to consider *St. bondolensis* nov. spec. On p. 158 it will be seen that this form has been obtained from Bondol near Kuwung, a locality from which also remains of *Buffelus bubalus* ?var. *sondaicus fossilis* and *Rhinoceros sondaicus fossilis* have been procured. This is surprising, as *St. bondolensis* is a rather primitive species, the height of development of which is equal to that of *St. bombifrons*. It will be remembered that the youngest Siwalik horizon in which the latter species occurs, is the Tatrot horizon (lowermost Upper Siwaliks, Lower Pliocene according to PILGRIM, Lower Pleistocene according to MATTHEW). If MATTHEW's views should appear to be correct, the occurrence of *St. bondolensis* together with still living species, would be comprehensible. On the other hand it must not be forgotten that the stratigraphy of the locality mentioned is very badly known. There remains, therefore, a possibility that *St. bondolensis* has been obtained from older strata. Nevertheless the problem remains that the grinders of all the *Stegodon* species, hitherto found in Java, are characterized by enamel, clearly consisting of two layers. Consequently "Stufenbildung" occurs. Why the latter feature is distinctly exhibited only in the teeth of the Javan species is an enigma to me.

To return now to our starting point, we may say that there are several indications, which point in the direction of an older age of the Bumiaju fauna compared with the Trinil fauna [2]) viz.,

1. The Bumiaju fauna does not contain recent forms; the Trinil fauna does.
2. In the Bumiaju beds a very primitive species of *Elephas* (*A. planifrons*) has been found; in the Trinil beds it is absent.

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[1]) Proc. Amer. Philos. Soc., LXX, 1931, p. 191.

[2]) With Trinil fauna I mean the fauna of the Trinil beds between Gesi and Ngawi.

3. The Bumiaju specimens are always well fossilized; in the Trinil specimens the state of fossilization is in some cases far less progressed.

4. The Bumiaju beds are considerably more folded than the Trinil beds.

Stress may be laid upon the fact that each argument alone has but little value. But all together they afford in our opinion strong evidence in favour of an older age of the Bumiaju beds.

It will be noticed that we arrive at the same conclusion to which VAN ES came on geological-stratigraphical grounds [1]). The question is: Do we agree with VAN ES as to the lower pleistocene age of the Trinil beds, and the upper pliocene age of the Bumiaju beds? As already pointed out in the Introduction, VAN ES started from a supposition which lacks sufficient grounds. Nevertheless his assertion may be true. The occurrence of recent species among the Trinil fauna proves in our opinion its pleistocene age. It may therefore be Lower Pleistocene. And in that case the Bumiaju beds have to be placed into the Upper Pliocene. As far as our knowledge goes for the present, the mammalian contents of the latter do not prove it, but neither do they afford sufficient evidence against such a supposition.

We cannot conclude without drawing attention to the following possibility. In a quite recent paper MARTIN [2]) has pointed out that the descriptions of tertiary molluscs from Burma and N. W. India by VREDENBURG and DE COTTER have shown that in these regions tertiary strata occur, which contain both Javan and European species. The discovery is of course of great interest for the correlation of tertiary beds in Europe and Asia. A. o. it enabled MARTIN to emphasize the pliocene age of the marine Sonde beds. He did not let on, however, about the question to which part of the Pliocene the Sonde beds belong. Apparently there is a possibility that the Sonde beds represent (or include) the Upper Pliocene. In that case the Trinil beds — being separated by a stratigraphic gap from the underlying Sonde beds — would belong to the Middle Pleistocene, and the Bumiaju beds — which according to VAN ES are contemporary to the hiatus in Trinil — should be of lower pleistocene age. In my opinion neither the mammalian fauna of the Trinil beds, nor of the Bumiaju layers give sufficient arguments against this supposition.

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[1]) See the Introduction.

[2]) Leidsche Geol. Meded., IV, 1, 1931.

SUMMARY.

1. The Bumiaju fauna is older than the Trinil fauna.

2. The Trinil fauna is certainly of pleistocene age, more particularly either Lower of Middle Pleistocene, but not Upper Pleistocene.

3. Accordingly the Bumiaju fauna is of upper pliocene or lower pleistocene age.

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PLATE I.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*. *

Fig. 1. Occipital view of fragmentary cranium n°. 1*.0.27 nat. size. p. 25.

Fig. 2. Right profile view of ditto, after removal of the right (detached) horn-core. 0.30 nat.size. p. 25.

Fig. 3. Occipital view of fragmentary cranium n°. 8*. 0.10 nat. size. p. 25.

Fig. 4. Front view of ditto. 0.09 nat. size. p. 25.

* See table of measurements B.

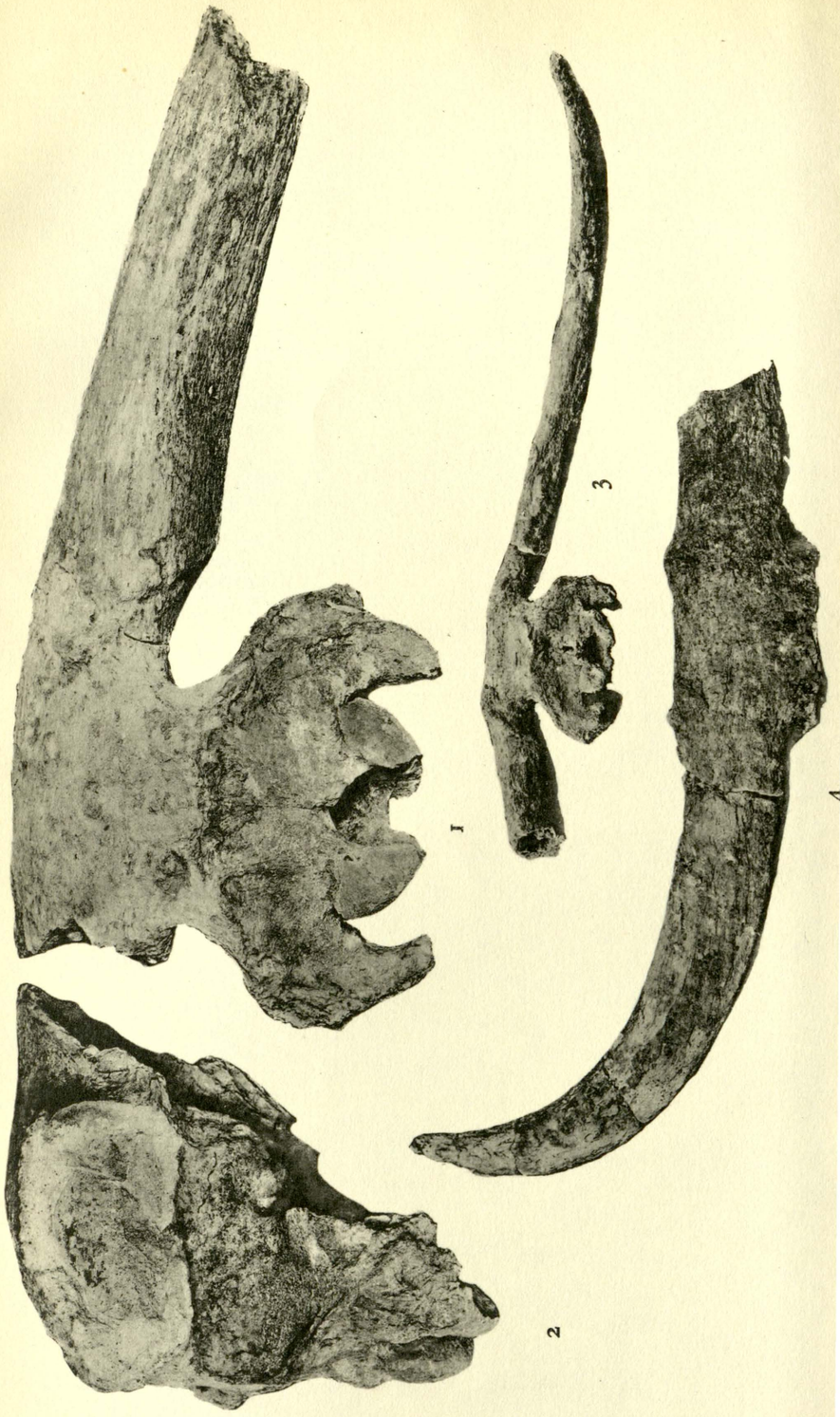


PLATE II.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Fig. 1. Palatal view of "one-horned" ♂ cranium. 0.14 nat. size. p. 42.

Fig. 2. Front view of ditto. 0.16 nat. size. p. 42.

Fig. 3. Right P^2—M^3 of ditto, viewed from the grinding surface. 0.46 nat. size. p. 42.

Fig. 4. Occipital view of ditto. 0.17 nat. size. p. 42.

Fig. 5. Right profile view of ditto. 0.17 nat. size. p. 42.

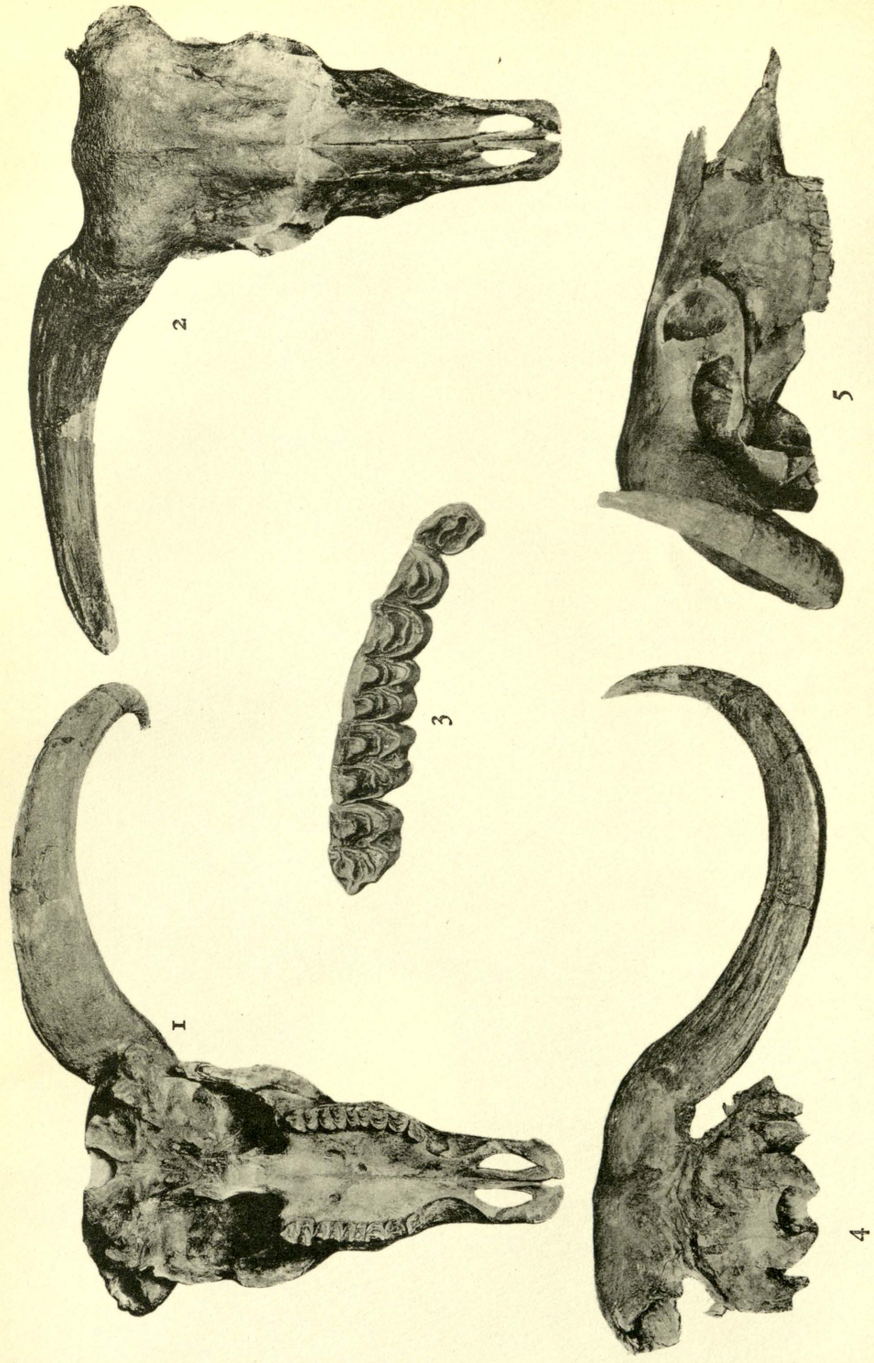


PLATE III.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis.*

Fig. 1. Front view of "two-horned" ♂ cranium. 0.15 nat. size. p. 42.
Fig. 2. Right profile view of ditto. 0.16 nat. size. p. 42.
Fig. 3. Occipital view of ditto. 0.16 nat. size. p. 42.
Fig. 4. Hind view of left detached horn-core of old ♂. 0.24 nat. size. p. 42.



PLATE IV.

Rhinoceros sondaicus DESM. *fossilis.*

Fig. 1. Front view of cranium no. a. *
Fig. 2. Left profile view of ditto.
Fig. 3. Palatal view of ditto.

} 0.21 nat. size. p. 58. (Occipital view in fig. 1, pl. V).

* See table of measurements K.

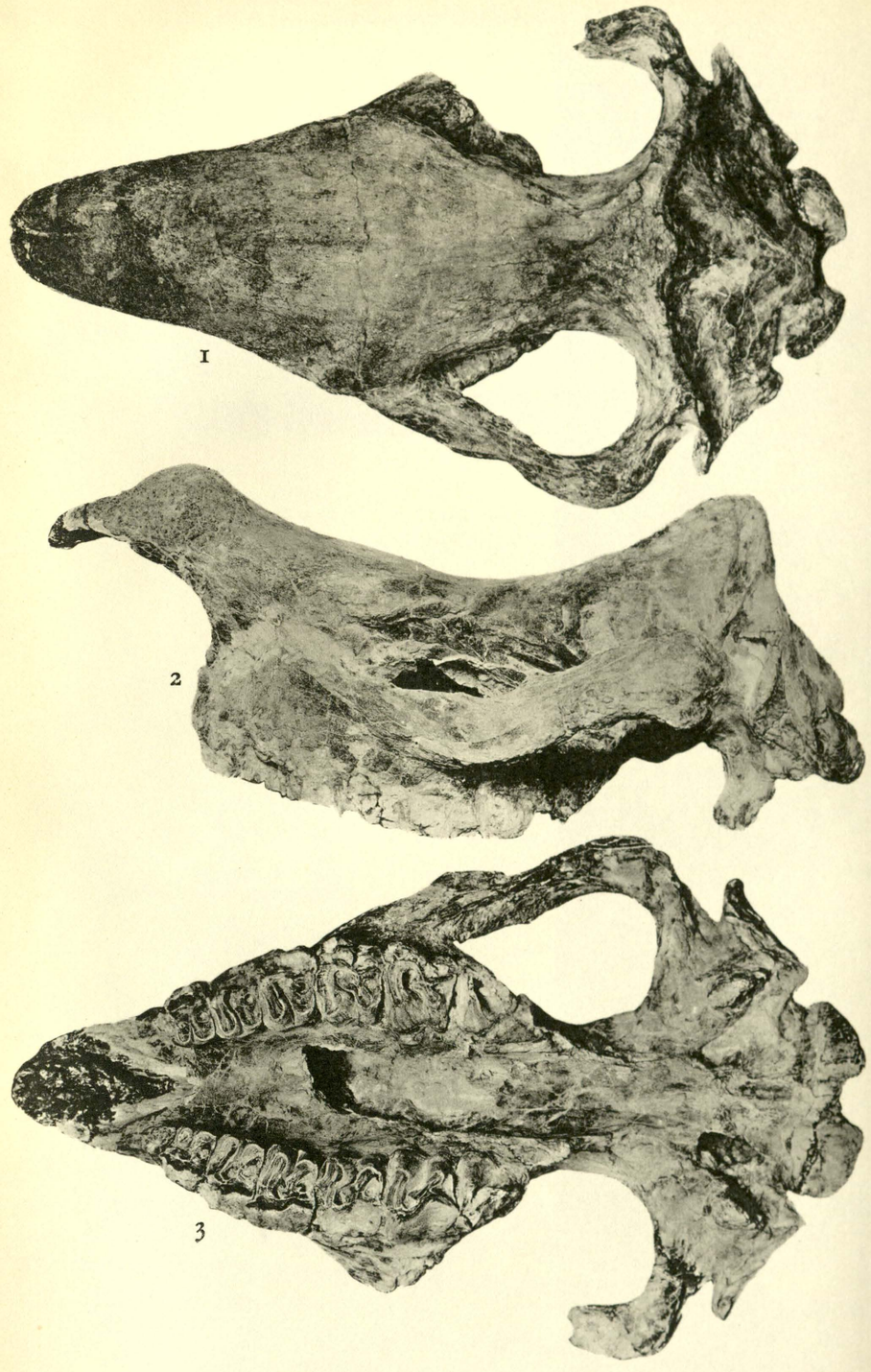


PLATE V.

Rhinoceros sondaicus DESM. *fossilis.*

Fig. 1. Occipital view of cranium no. a. * 0.23 nat. size. p. 58. (The same specimen as of figs. 1—3, pl. IV).

Fig. 2. Outer view of right P^4 of ditto. 0.95 nat. size. p. 61.

Fig. 3. Right P^1—M^3 of ditto, viewed from the grinding surface. 0.60 nat. size. p. 59.

Fig. 4. Reflected image of the inner view of the same tooth row. 0.52 nat. size. p. 59.

Hippopotamus spec.

Fig. 5. Outer view of right detached lower canine (specimen a). 0.50 nat. size. p. 88.

* See table of measurements K.

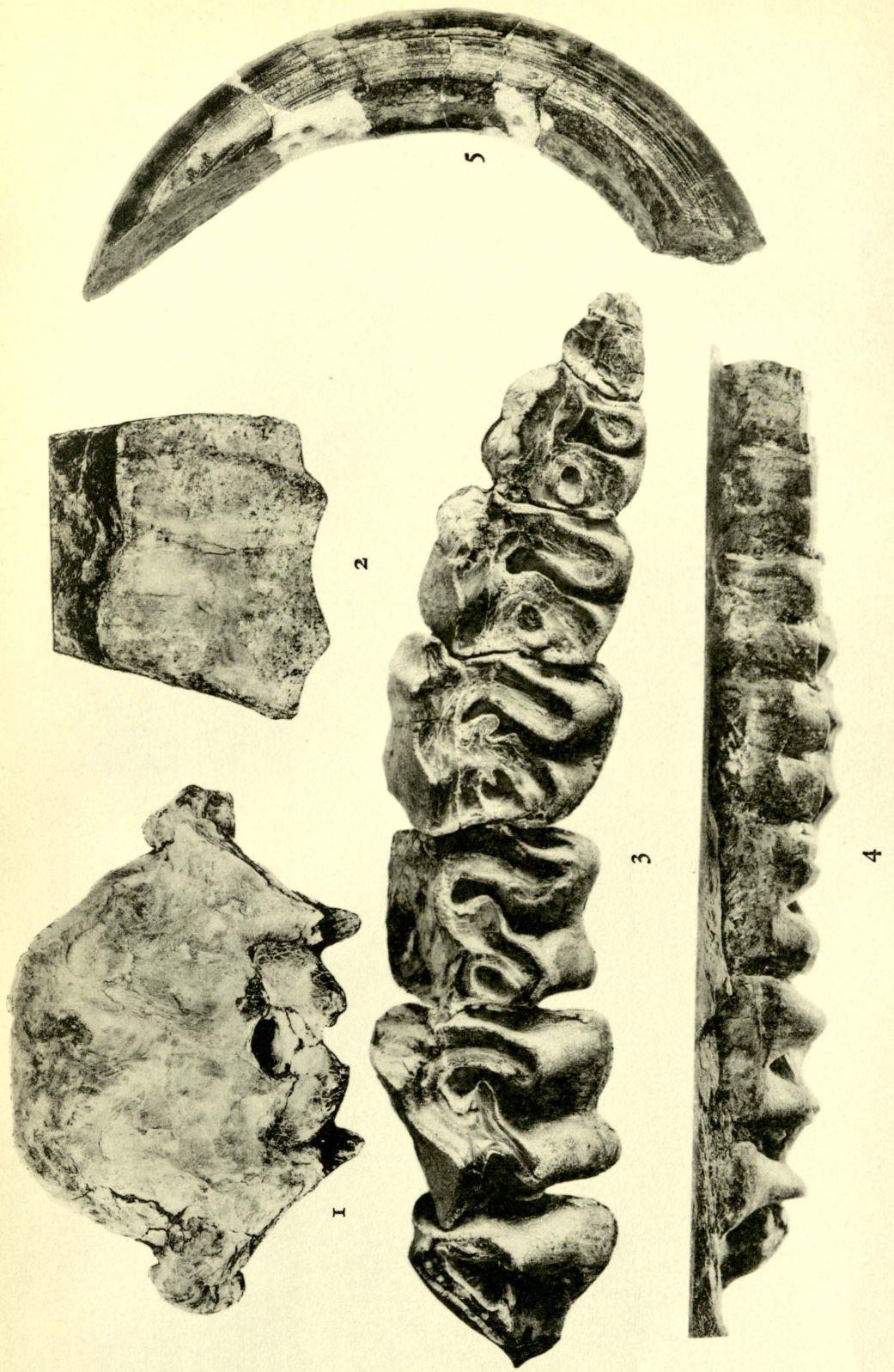


PLATE VI.

Hippopotamus spec.

Fig. 1. Upper view of right horizontal mandibular ramus. 0.51 nat. size. p. 82. (Right profile view in fig. 1, pl. XIX).

Fig. 2. Anterior view of symphysial extremity of ditto. 0.50 nat. size. p. 82.

Fig. 3. Palatal view of fragmentary right upper jaw with M^1—M^3. 0.65 nat. size. p. 87.

Fig. 4. Outer view of ditto. 0.65 nat. size. p. 87.

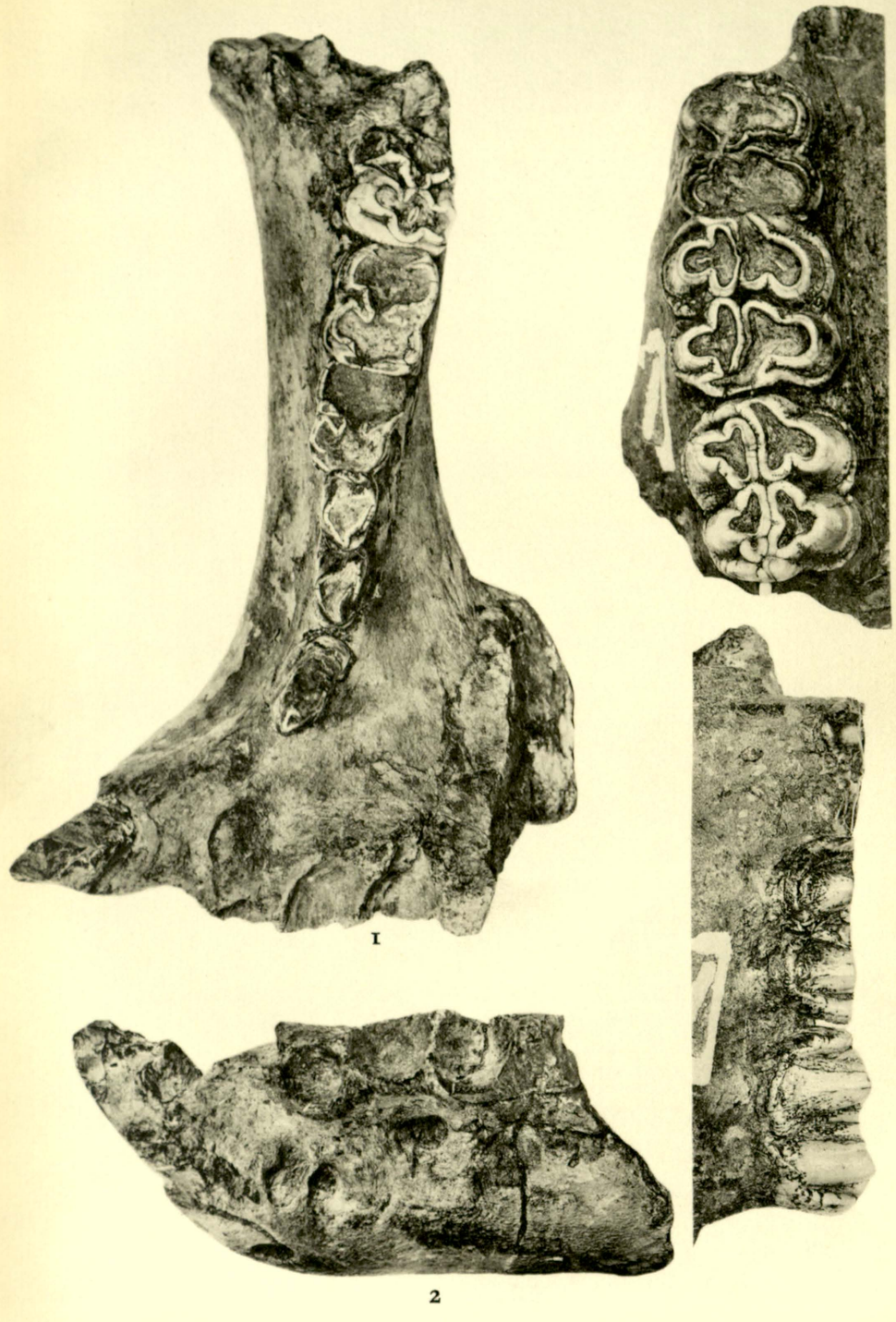
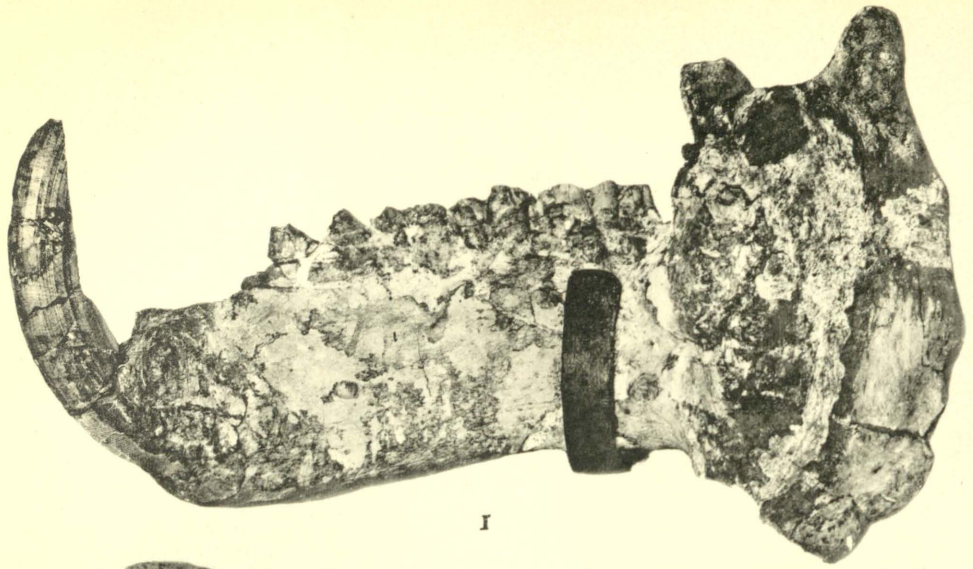


PLATE VII.

Hippopotamus spec.

Fig. 1. Left profile view of fragmentary lower jaw. 0.24 nat. size. p. 82.

Fig. 2. Upper view of ditto. 0.31 nat. size. p. 82. (Anterior view in fig. 2, pl. XIX).



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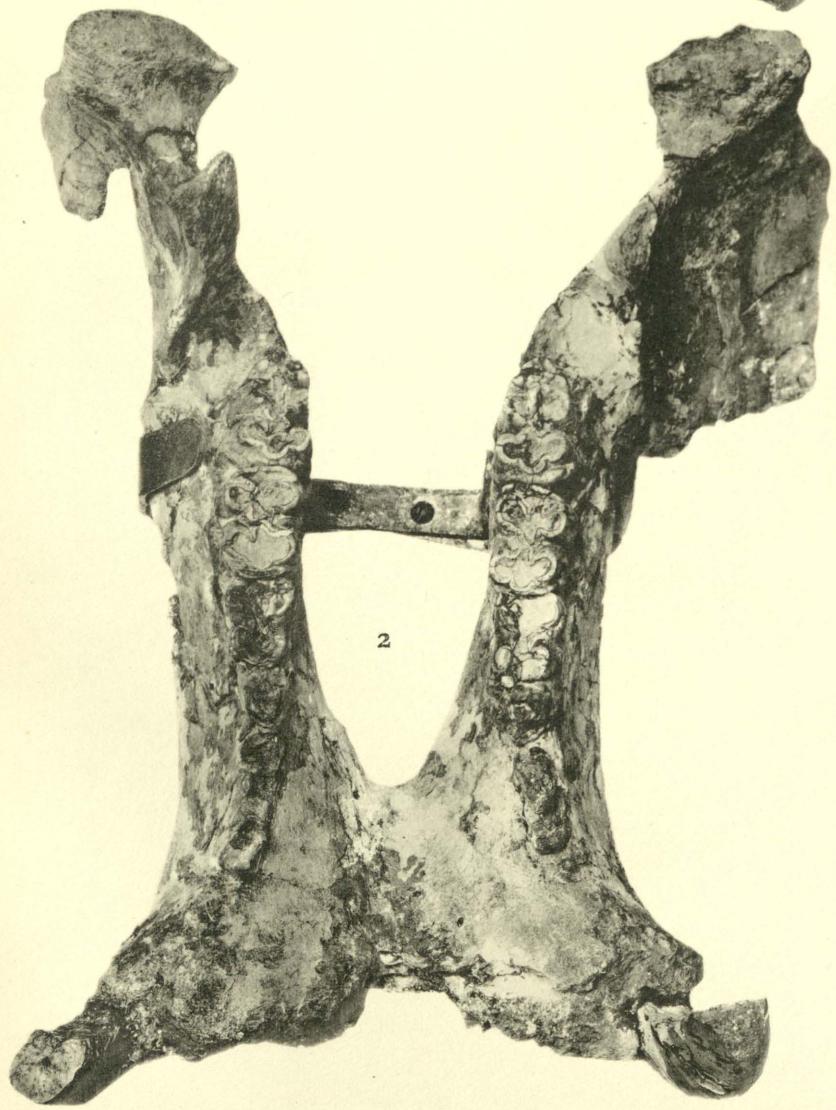

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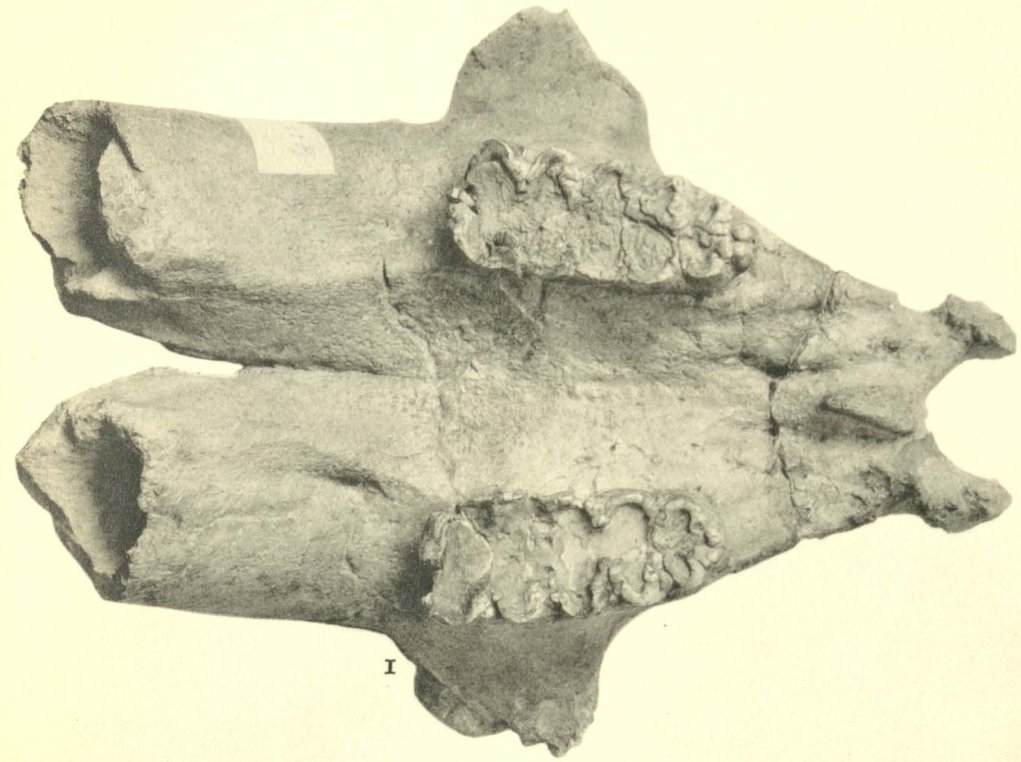
PLATE VIII.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Palatal view of fragment of cranium with l. and r. M^3 in situ. 0.22 nat. size. p. 116. (Left profile view in fig. 2, pl. X).

Fig. 2. Inner view of fragmentary right mandibular ramus with M_3. 0.29 nat. size. p. 108.



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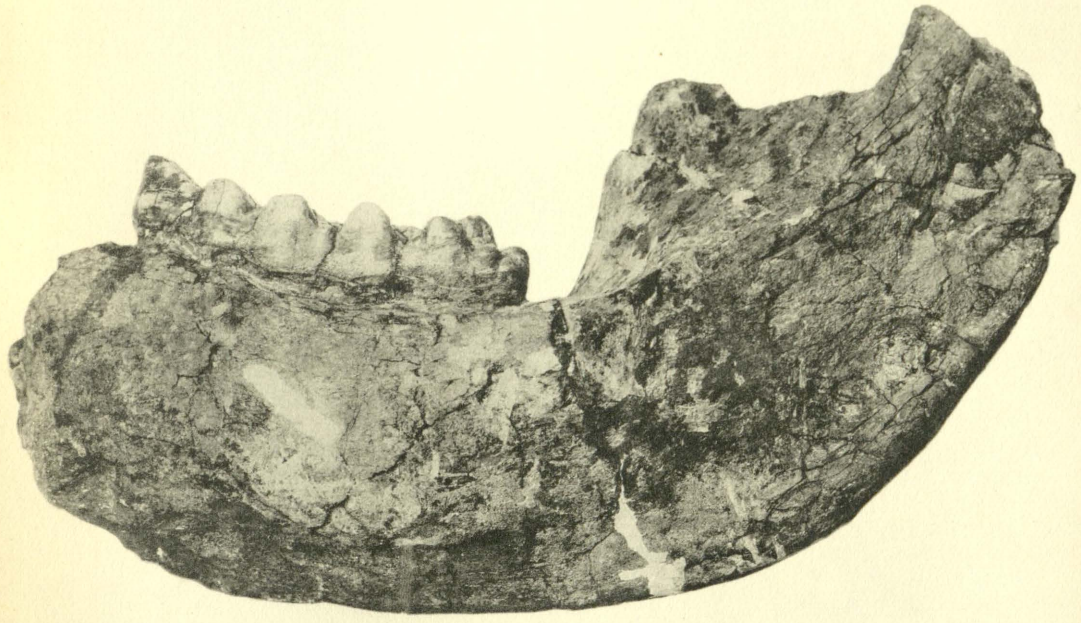

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PLATE IX.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Fragmentary r. M^3, viewed from the grinding surface. 0.81. nat. size. p. 113.

Fig. 2. Outer view of ditto. 0.88 nat. size. p. 113.

Fig. 3. Right M_3 (of ramus portrayed in fig. 2 of pl. VIII), viewed from the grinding surface. 0.53 nat. size. p. 108.



1



2



3

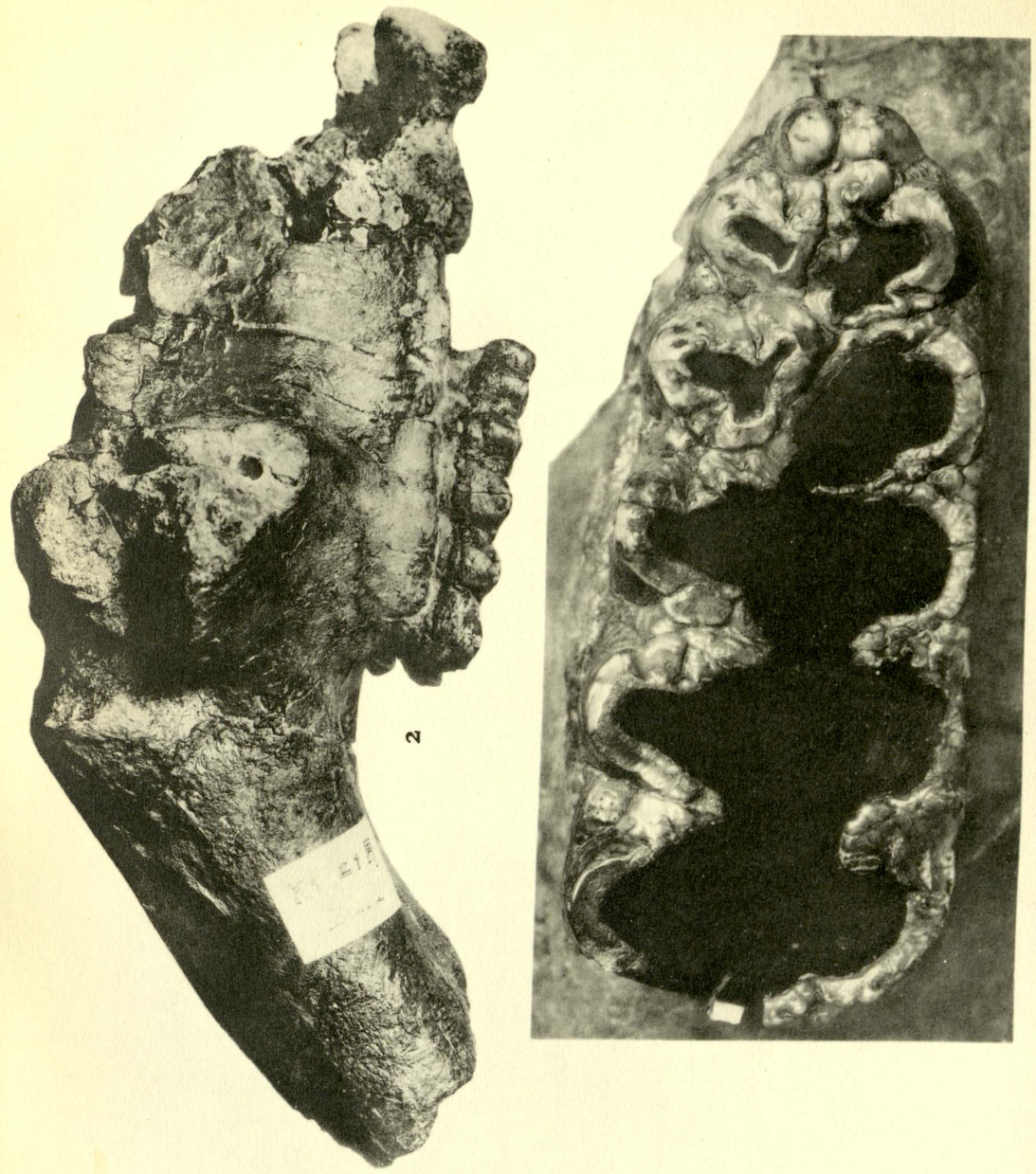
PLATE X.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Detached upper incisive tusk. 0.17 nat. size. p. 120. In all probability belonging to the specimen portrayed in fig. 1, pl. VIII and fig. 2, pl. X.

Fig. 2. Left profile view of fragment of cranium. 0.30 nat. size. p. 116 (palatal view in fig. 1, pl. VIII).

Fig. 3. Left M^3 (of cranium portrayed in fig. 1, pl. VIII and fig. 2, pl. X), viewed from the grinding surface. 0.78 nat. size. p. 117.



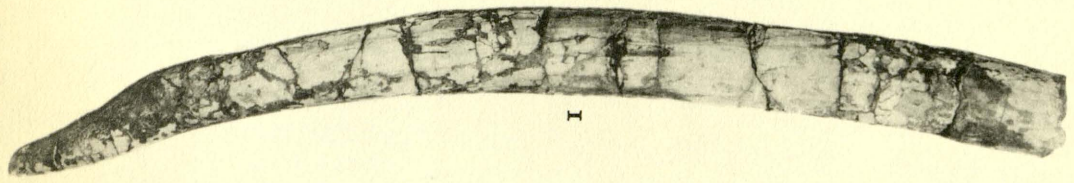
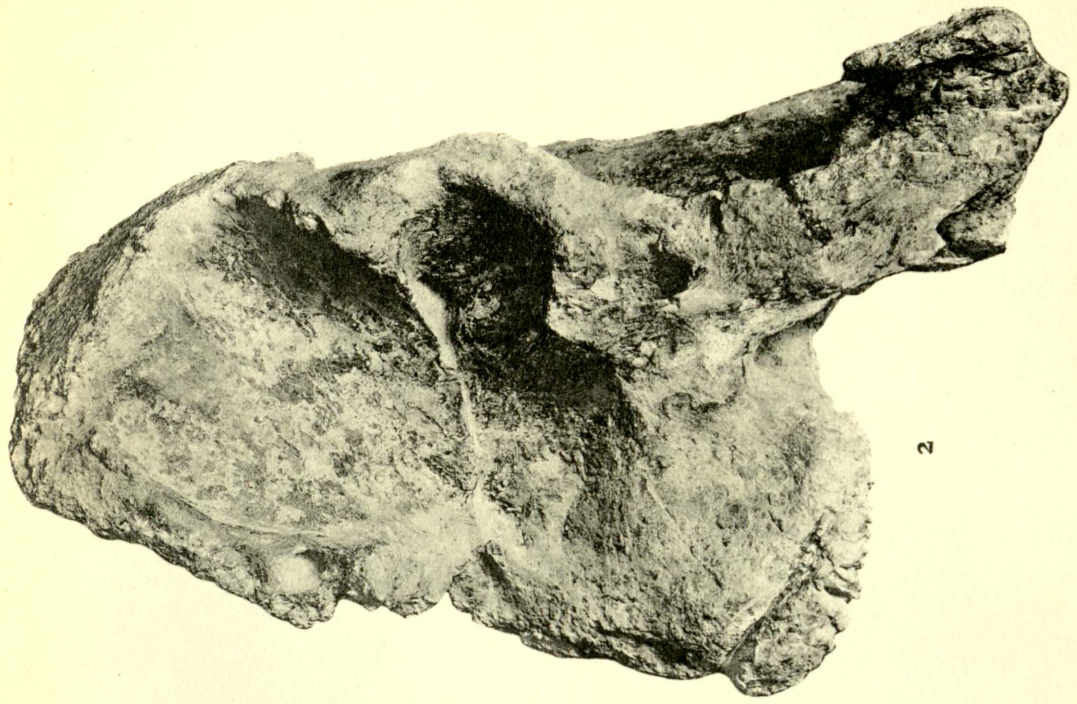


PLATE XI.

Stegodon trigonocephalus MARTIN.

Fig. 1. Damaged mature cranium with r. M^3 in situ, viewed from the upper and partly from the outer side. 0.14 nat. size. p. 151.

Fig. 2. Right profile view of ditto. 0.14 nat. size. p. 151.



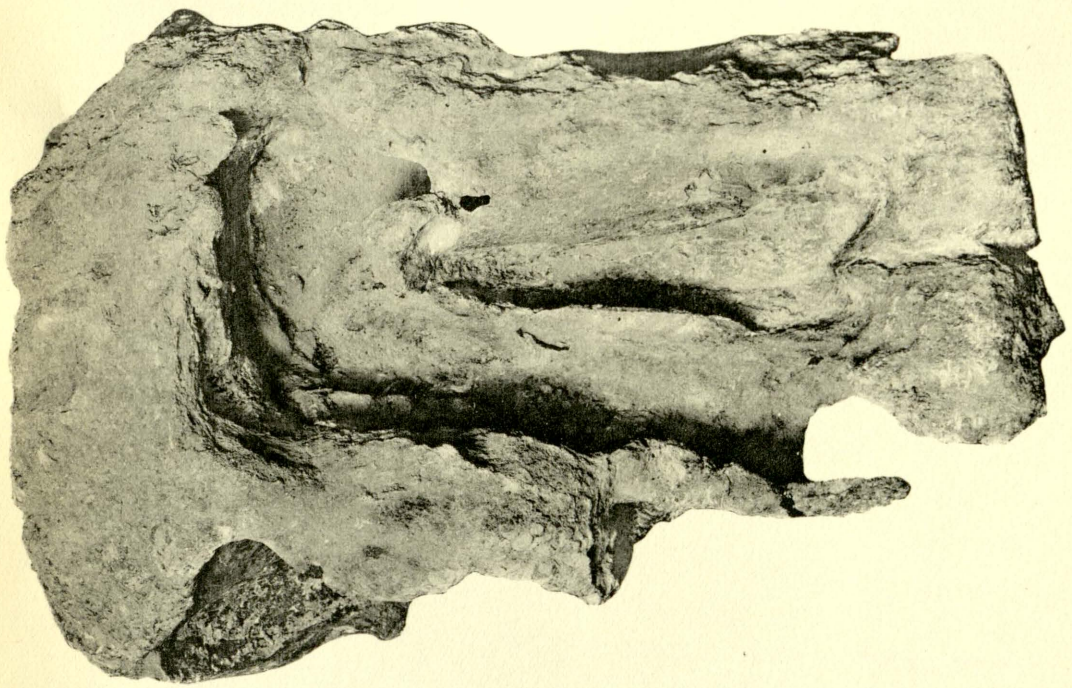


PLATE XII.

Stegodon airâwana MARTIN.

Fig. 1. Left M_3 and posterior extremity of M_2 (of lower jaw portrayed in figs. 2—3, pl. XIV), viewed from the grinding surface. 0.55 nat. size. p. 141.

Stegodon trigonocephalus MARTIN.

Fig. 2. Right M^3 (of cranium portrayed in figs. 1—2, pl. XI), viewed from the grinding surface. 0.63 nat. size. p. 151.

Fig. 3. Outer view of ditto. 0.46 nat. size. p. 151.

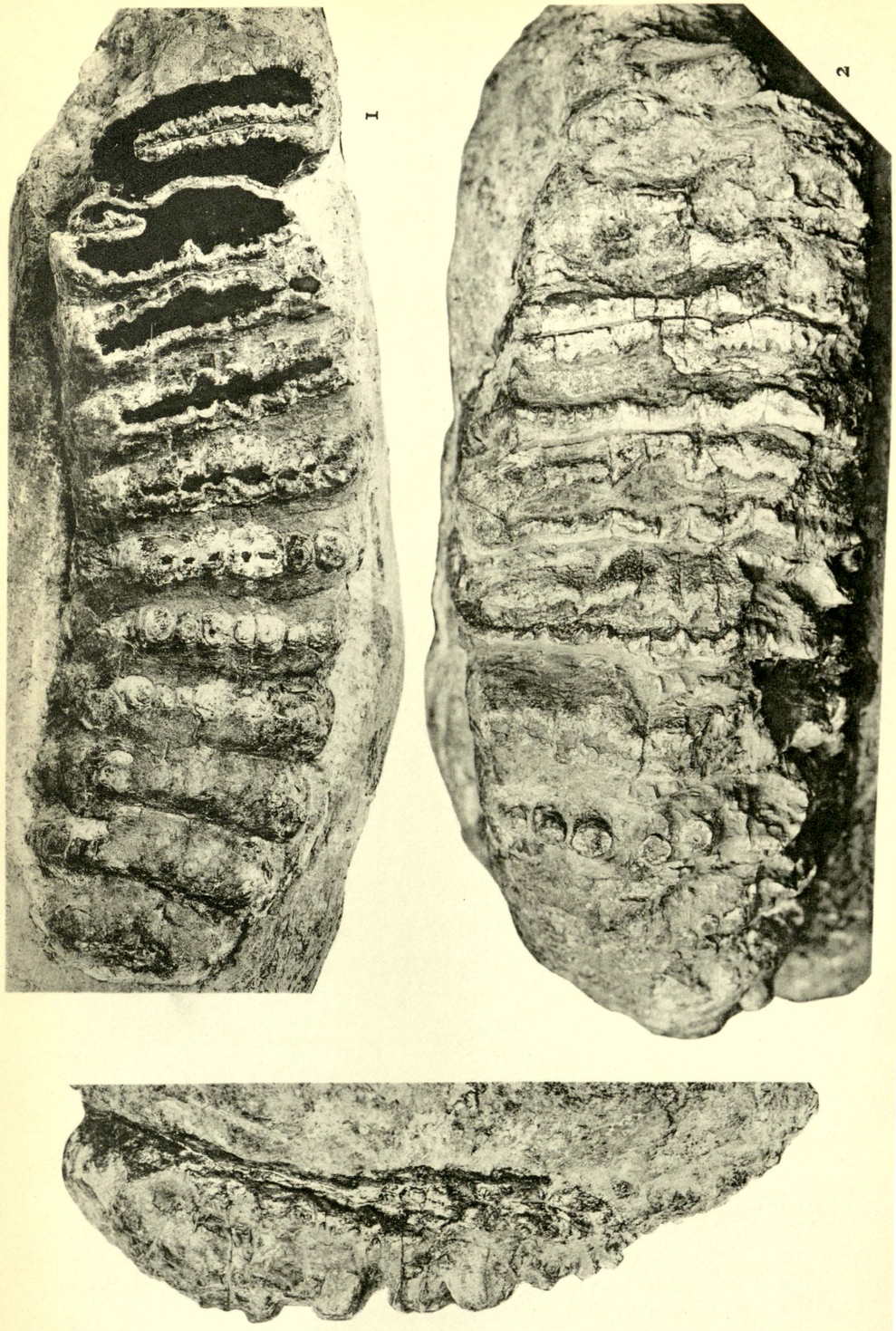


PLATE XIII.

Stegodon airâwana MARTIN.

Fig. 1. Left M^3, viewed from the grinding surface. 0.64 nat. size. p. 142.

Fig. 2. Inner view of ditto. 0.51 nat. size. p. 136.

Stegodon spec.

Figs. 3 and 5. Fragments of (probably) upper grinding teeth, vertically and longitudinally bisected. 0.56 nat. size. p. 164.

Fig. 4. Fragment of grinding tooth, horizontally bisected. 0.56 nat. size. p. 164.

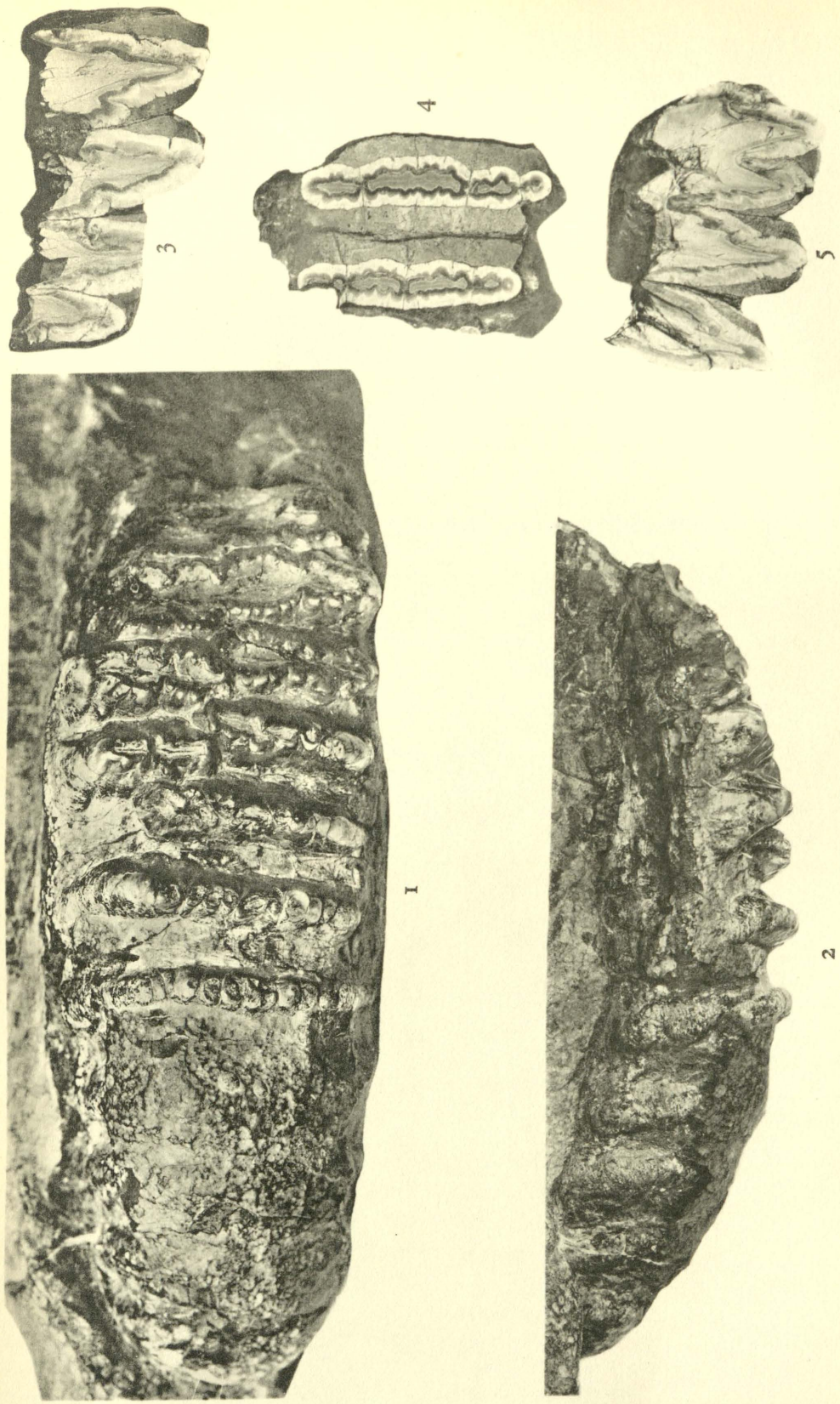


PLATE XIV.

Stegodon bondolensis nov. spec.

Fig. 1. Left M_3 (of lower jaw portrayed in figs. 4—5, pl. XIV), viewed from the grinding surface. 0.63 nat. size. p. 159.

Fig. 4. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.15 nat. size. p. 158.

Fig. 5. Right profile view of ditto. 0.15 nat. size. p. 164.

Stegodon airâwana MARTIN.

Fig. 2. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.10 nat. size. p. 141.

Fig. 3. Left profile view of ditto. 0.10 nat. size. p. 141.

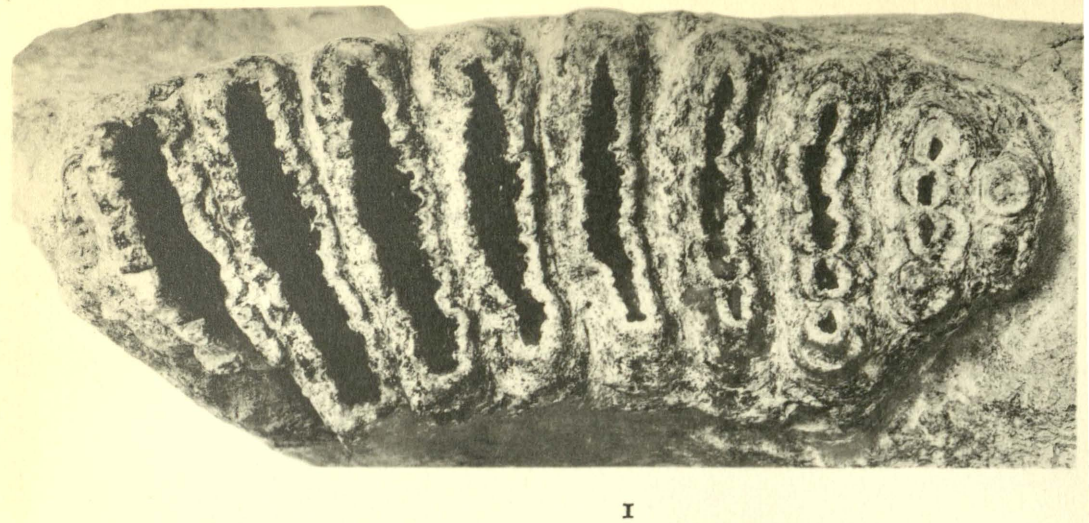


PLATE XV.

Stegodon airâwana MARTIN.

Fig. 1. Left detached M^3, viewed from the grinding surface. 0.50 nat. size. p. 132.

Fig. 2. Inner view of ditto. 0.52 nat. size. p. 132.

Fig. 3. Outer view of right detached M_1. 0.68 nat. size. p. 138.

Fig. 4. The same specimen, viewed from the grinding surface. 0.70 nat. size. p. 138.

? *Archidiskodon planifrons* FALC. et CAUTL.

Fig. 5. Left lower grinding tooth, probably m_3, viewed from the grinding surface. 0.51 nat. size. p. 176.

Fig. 6. Inner view of ditto in fragment of left horizontal mandibular ramus. 0.47 nat. size. p. 176.



PLATE XVI.

Elephas ? maximus L. *fossilis.*

Fig. 1. Left M_3 (of lower jaw portrayed in figs. 2—3, pl. XVI), viewed from the grinding surface. 0.48 nat. size. p. 169.

Fig. 2. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.15 nat. size. p. 168.

Fig. 3. Left profile view of ditto. 0.12 nat. size. p. 168.

? Tetralophodon bumiajuensis nov. spec.

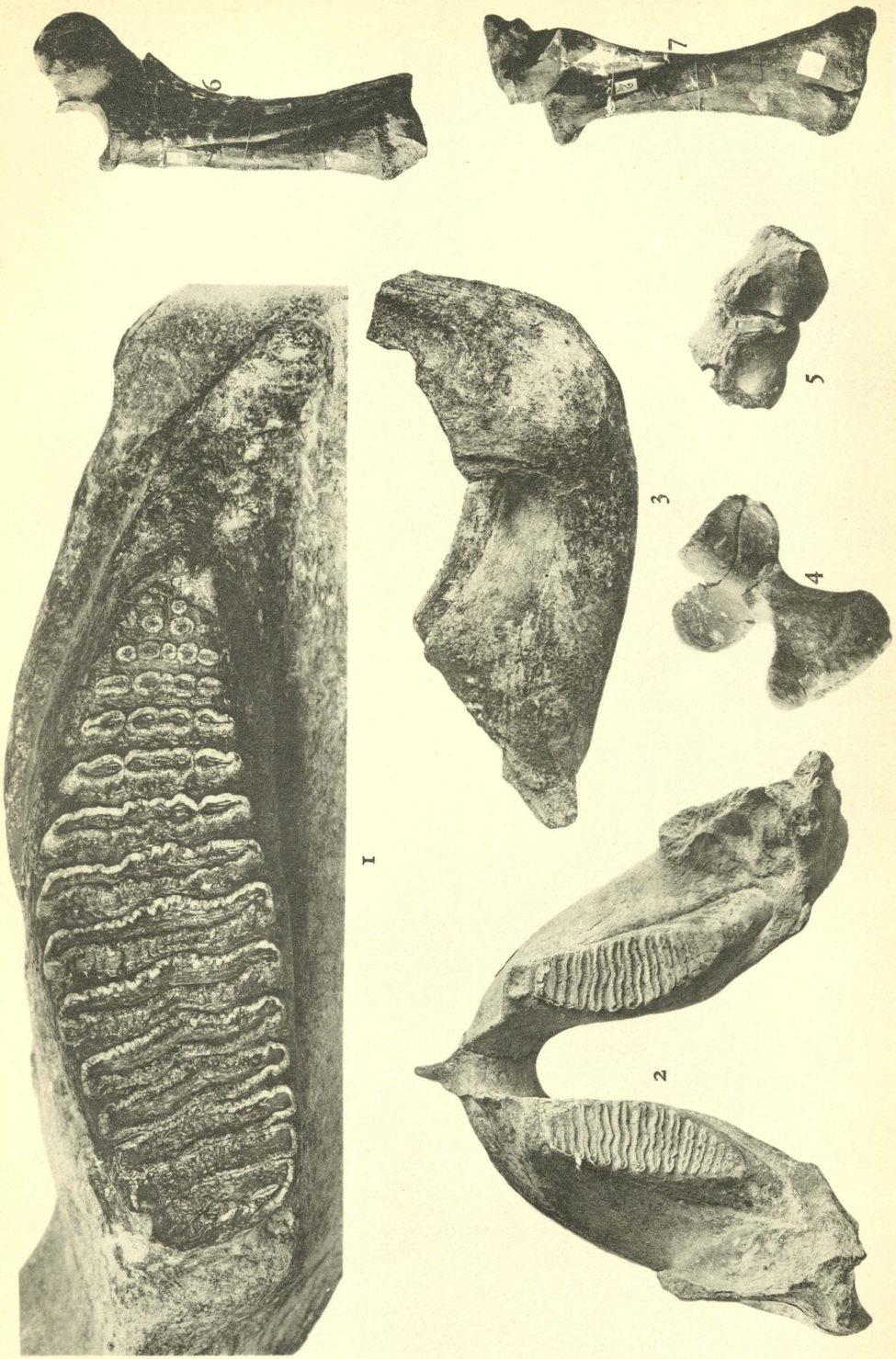
Fig. 4. Proximal surface of articulation of ulna no. 1 * and radius no. 2 *. 0.14 nat. size. p. 188.

Fig. 5. Distal surface of articulation of the same specimens. 0.13 nat. size. p. 188.

Fig. 6. The same specimens viewed from the inner side. 0.10 nat. size. p. 188.

Fig. 7. The same specimens viewed from the front side. 0.10 nat. size. p. 188.

* See tables of measurements Y and Z.



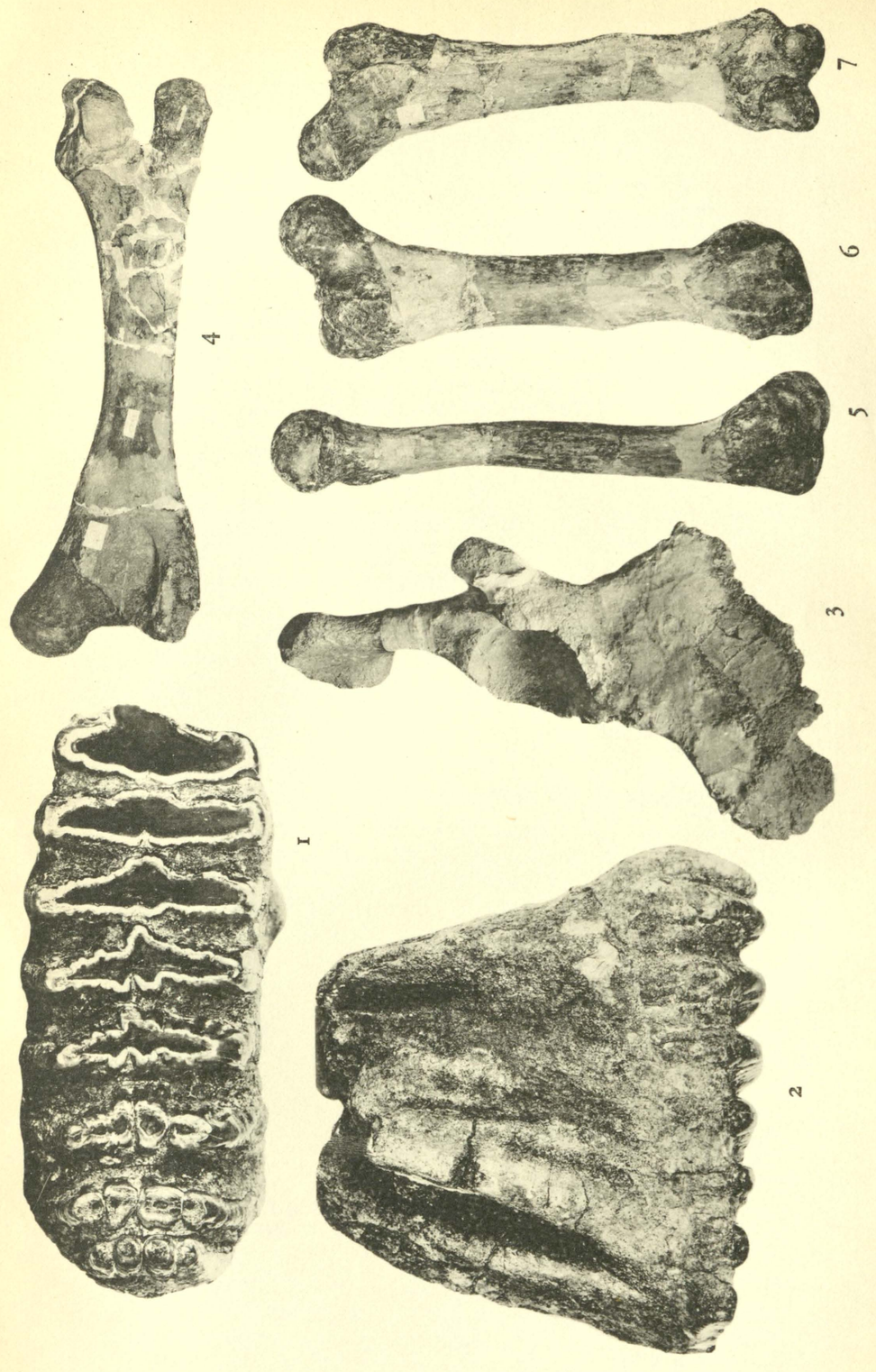


PLATE XVII.

Elephas planifrons Falc. et Cautl.

Fig. 1. Detached left M^1, viewed from the grinding surface. 0.77 nat. size. p. 173.

Fig. 2. Outer view of ditto. 0.65 nat. size. p. 173.

? *Tetralophodon humiajuensis* nov. spec.

Fig. 3. Fragmentary pelvis. 0.13 nat. size. p. 189.

Fig. 4. Left femur (no. 2 *), hind view. 0.11 nat. size. p. 186.

?? *Mastodon* spec.

Fig. 5. Right femur (no. 4*), inner view. 0.12 nat. size. p. 187.

Fig. 6. Front view of ditto. 0.12 nat. size. p. 187.

Fig. 7. Hind view of ditto. 0.11 nat. size. p. 187.

* See table of measurements W.

PLATE XVIII.

Hippopotamus spec.

Fig. 1. Right profile view of posterior portion of cranium. 0.48 nat. size. p. 89.

Fig. 2. Upper view of ditto. 0.45 nat. size. p. 89. (Hind view in fig. 3, pl. XIX).

Fig. 3. Detached lower incisor, probably belonging to the mandible, portrayed in figs. 1—2, pl. VII. 0.69 nat. size. p. 85.



PLATE XIX.

Hippopotamus spec.

Fig. 1. Right profile view of fragmentary lower mandibular ramus. 0.41 nat. size. p. 82. Same specimen as of figs. 1—2, pl. VI.

Fig. 2. Anterior view of right half of symphysial extremity of the specimen, portrayed in figs. 1—2, pl. VII. 0.50 nat. size. p. 84.

Fig. 3. Hind view of posterior portion of cranium. 0.47 nat. size. p. 89. Same specimen as of figs. 1—2, pl. XVIII.

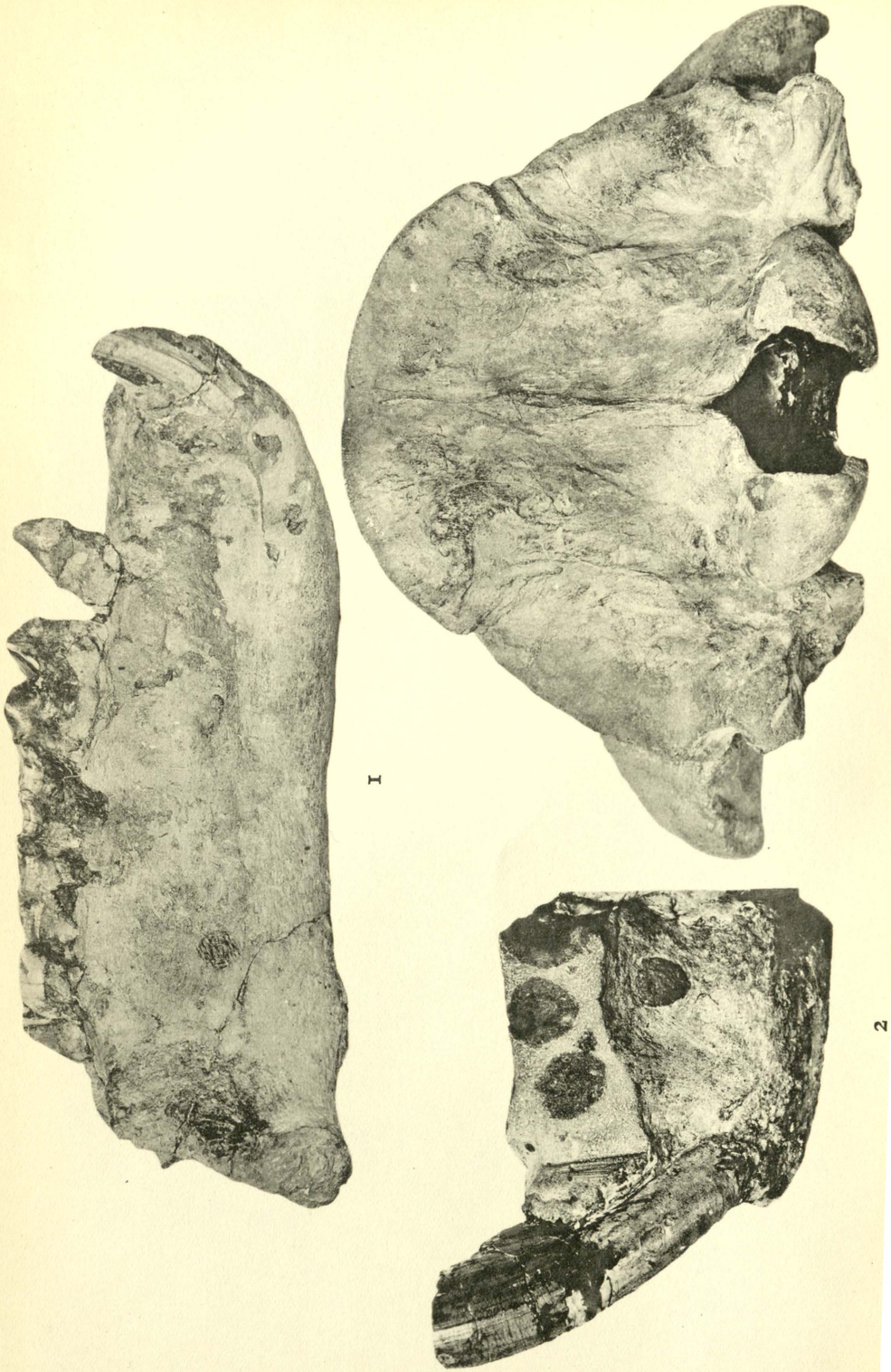


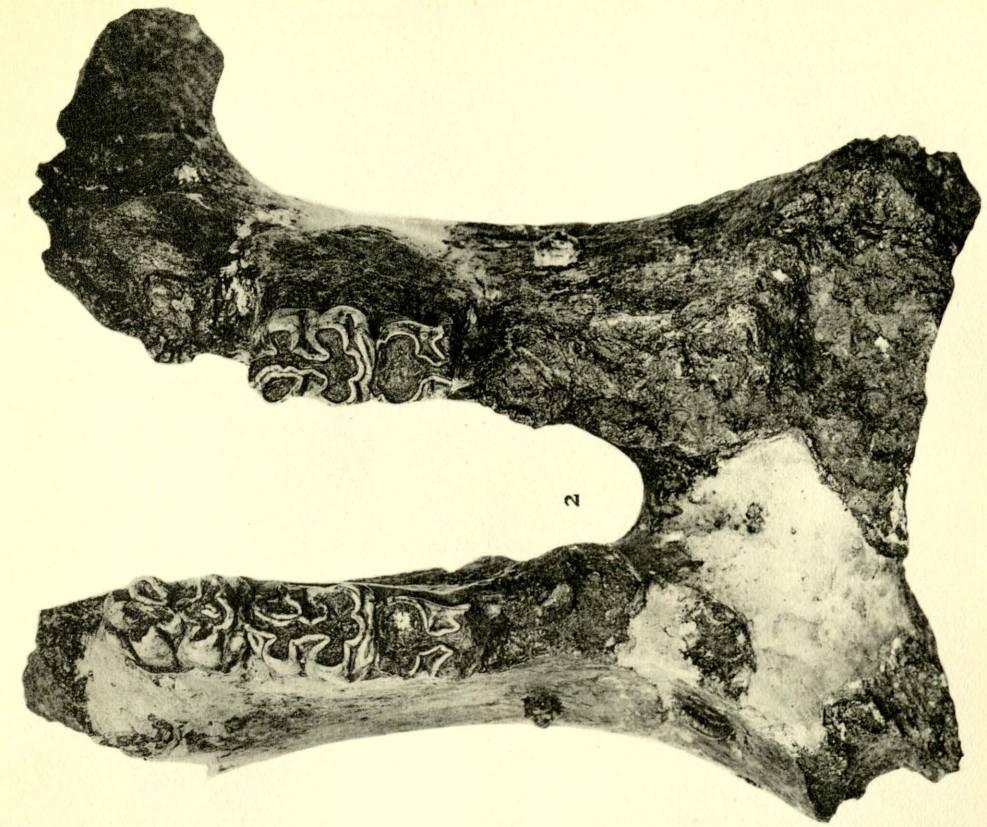
PLATE XX.

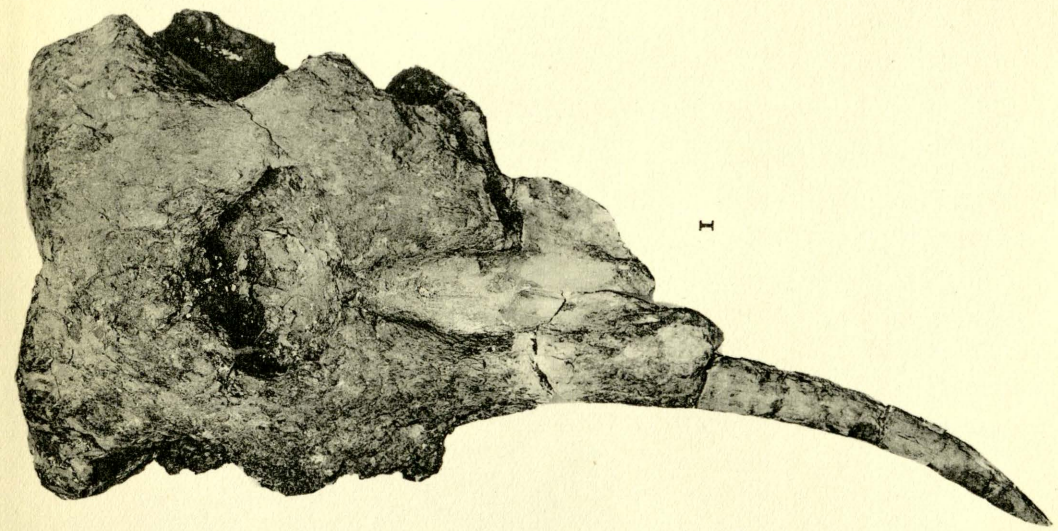
Stegodon airâwana MARTIN.

Fig. 1. Front view of damaged immature cranium. 0.13 nat. size. p. 146.

Hippopotamus spec.

Fig. 2. Upper view of fragmentary lower jaw. 0.42 nat. size. p. 86.





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Contribution to the Knowledge of the Fossil Mammalian Fauna of Java.

BY

F. H. VAN DER MAAREL.

TABLES OF MEASUREMENTS.

TABLES OF MEASUREMENTS.

TABLE **A.**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	42.7	42.6	—	40.9	43.2	40.9	44.0	43.1	41.1	41.3	39.5	40.9	—	—
1–7	57.3	57.4	—	59.1	56.8	59.1	56.0	56.9	58.9	58.7	60.5	59.1	—	—
(1–7)–7	14.6	14.8	—	18.2	13.6	18.2	12.0	13.8	17.8	17.4	21.0 ♀	18.2	—	—
8	21.3	20.4	22.3 ♀	18.9	19.3	19.6	20.3	—	**22.6** ♀	19.3	20.0	21.7 ♀	**17.1** ♂	20.2
21	18.4	20.6	16.5	16.9	17.9	18.7	20.1	20.7	19.9	18.6	18.0	17.6	14.2 ♀	16.0

TABLE **A.**

15	16	17	18	19	20	21	22	23	24	25	♂ 26	♂ 27	♂ 28	29
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
40.6	38.8	40.6	40.2	± 43.7	39.0	40.1	43.4	40.6	± 40.7	41.0	40.0	42.8	41.4	45.6
59.4	61.2	59.4	59.8	56.3	61.0	59.9	56.6	59.4	59.3	59.0	60.0	57.2	58.6	54.4
18.8	**22.4** ♀	18.8	19.6	12.6	22.0	19.8	13.2	18.8	18.6	18.0	20.0 ♀	14.4	17.2	**8.8** ♂
19.4	19.1	19.7	19.3	20.2	19.5	21.1	18.2 ♂	20.6	19.8	19.0	19.5	22.2 ♀	19.6	21.9 ♀
16.5	16.1 ♀	16.8	20.1	14.5 ♀	16.2	17.1	**13.7** ♀	16.1 ♀	16.7	16.5	16.8	—	—	**26.2** ♂

TABLE B.

OUR OWN FOSSIL SPECIMENS OF BUFFELUS

		Nos. of table of measurements Stremme (1911) p. 126.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1	Interval between occipital condyle and front border of premaxillary of the same side	XXII	—	—	—	—	—	—	—	—	—
2	Length from occipital crest to tip of nasals	IV	—	—	—	—	—	—	—	—	—
3	Interval between foramen magnum and suture between nasals and frontals	XXI	—	—	—	—	—	—	—	—	—
4	Width of forehead at superior border of orbits	III	—	ca 242	ca 244	—	—	—	—	—	257
5	Width of ditto at constriction above orbits	XX	ca 230	ca 230	ca 244	—	ca 220	ca 241	ca 237	235	254
6	Interval between supra-orbital foramina [1])	XI	ca 98	ca 90	ca 126	124	—	ca 110	120	114	118
7	Interval between occipital crest and line connecting mid-orbits	XII	—	ca 262	244	—	—	—	—	—	—
8	Width of premaxillaries	XIX	—	—	—	—	—	—	—	—	—
9	Interval between foramen magnum and occipital crest	I	79	86	85	90	—	—	—	ca 88	—
10	Width of occiput through petrosals	V	256	ca 282	ca 268	288	270	—	—	ca 300	—
11	Interval between external angles of occipital condyles	VI	121	124	121	130	—	—	—	ca 129	—
12	Interval between extremities of paroccipital processes	XIII	—	ca 126	144	ca 156	ca 71	—	—	—	—
13	Width of occiput between extremities of temporal fossae	XVII	129	182	159	190	174	161	142	151	—
14	Width between temporal fossae [2]) (horizontally the greatest in the preoccipital region)		137	145	139	147	142	147	158	140	—
15	Length of temporal fossa [3])	VII	—	186	ca 175	—	—	—	—	—	—
16	Interval between front border of horn-core and orbit	VIII	51	61	ca 56	59	ca 73	61	—	49	60
17	Antero-posterior diameter of orbit	IX	—	—	ca 75	—	—	—	—	—	—
18	Transverse diameter of orbit	X	—	—	ca 74	—	—	—	—	—	—
19	Interval between front border of orbit and ditto of premaxillary	XXIV	—	—	—	—	—	—	—	—	—
20	Interval between outer surfaces of zygomatic arches	XIV	—	246	—	—	—	—	—	—	—
21	Antero-posterior diameter of horn-core at base	XV	138	163	167	186	163	178	139	157	192
22	Transverse diameter of ditto	XVI	99	99	108	100	105	110	88	95	118
23	Circumference of horn-core at base	XVIII	390	433	453	470	444	492	365	406	505
24	Length of horn-core along convexity		—	—	—	—	—	—	—	ca 1140	ca 1260
25	Length of horn along convexity		—	—	—	—	—	—	—	—	—
26	Maximum span of horns		—	—	—	—	—	—	—	—	—
27	Maximum span of horn-cores		—	—	—	—	—	—	—	ca 1620	ca 1730
28	Tip-to-tip interval of horns		—	—	—	—	—	—	—	—	—
29	Tip-to-tip interval of horn-cores		—	—	—	—	—	—	—	ca 1510	ca 1570
30	Interval between tip horn and tip nasals		—	—	—	—	—	—	—	—	—

BUFFELUS BUBALUS VAR. SONDAICUS. (KERABAU)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1	Interval between occipital condyle and front border of premaxillary of the same side	550	568	546	528	548	491	518	550	508	543	521	567	508	545	515
2	Length from occipital crest to tip of nasals	441	453	436	418	460	400	422	457	424	452	402	456	399	423	420
3	Interval between foramen magnum and suture between nasals and frontals	273	293	268	264	274	248	262	280	243	267	256	281	258	271	260
4	Width of forehead at superior border of orbits	223	225	—	209	—	212	211	217	215	212	208	226	—	ca 208	205
5	Width of ditto at constriction above orbits	213	215	ca 195	194	203	202	207	200	195	202	199	204	—	204	194
6	Interval between supra-orbital foramina [1])	127	125	110–129	120	125	121	113	127	100	109	105	115	111–124	112	108
7	Interval between occipital crest and line connecting mid-orbits	235	242	—	216	237	201	228	237	209	224	206	232	—	—	209
8	Width of premaxillaries	117	116	122	100	106	96	105	—	115	105	104	123	87	110	100
9	Interval between foramen magnum and occipital crest	74	84	73	72	75	76	73	75	67	70	72	75	74	80	72
10	Width of occiput through petrosals	227	230	—	208	—	—	217	223	205	227	205	242	—	—	213
11	Interval between external angles of occipital condyles	115	119	112	109	114	104	115	120	99	117	114	108	104	101	109
12	Interval between extremities of paroccipital processes	104	95	95	89	88	99	98	—	—	—	—	96	—	—	—
13	Width of occiput between extremities of temporal fossae	81	99	81	75	95	83	96	119	76	92	93	ca 80	ca 72	88	90
14	Width between temporal fossae [2]) (horizontally the greatest in the preoccipital region)	126	135	114	121	129	119	111	131	113	122	115	116	116	125	114
15	Length of temporal fossa [3])	170	172	—	168	—	—	168	168	—	166	157	174	—	—	159
16	Interval between front border of horn-core and orbit	64	52	—	54	57	53	48	55	54	48	44	54	—	51	53
17	Antero-posterior diameter of orbit	65	64	—	62	—	—	59	67	—	64	59	61	—	—	61
18	Transverse diameter of orbit	61	64	—	64	—	—	55	64	—	62	58	59	—	—	55
19	Interval between front border of orbit and ditto of premaxillary	309	320	—	285	309	270	290	306	ca 294	316	290	324	—	—	304
20	Interval between outer surfaces of zygomatic arches	224	221	—	209	—	—	210	216	—	223	202	218	—	—	204
21	Antero-posterior diameter of horn-core at base	101	117	90	89	98	92	104	114	101	101	94	100	72	87	85
22	Transverse diameter of ditto	70	71	67	61	70	62	72	76	68	69	63	66	54	62	58
23	Circumference of horn-core at base	291	308	262	250	283	258	296	227	285	282	265	274	215	249	237
24	Length of horn-core along convexity	445	374	282	360	440	354	488	539	307	384	362	381	358	318	ca 290
25	Length of horn along convexity	904	—	—	—	—	—	—	—	862	—	—	—	—	—	—
26	Maximum span of horns	990	—	—	—	—	—	—	—	980	—	—	—	—	—	—
27	Maximum span of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28	Tip-to-tip interval of horns	565	—	—	—	—	—	—	—	660	—	—	—	—	—	—
29	Tip-to-tip interval of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	Interval between tip horn and tip nasals	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

BUFFELUS BUBALUS VAR. SONDAICUS. (KERABAU) (continued)

		16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	♂ 26.	♂ 27.	♂ 28.
1	Interval between occipital condyle and front border of premaxillary of the same side	502	512	533	490	518	526	512	554	516	527	483	537	536
2	Length from occipital crest to tip of nasals	398	397	441	402	422	427	429	447	409	433	391	436	421
3	Interval between foramen magnum and suture between nasals and frontals	260	263	266	261	255	271	260	279	256	260	249	268	253
4	Width of forehead at superior border of orbits	208	ca 203	205	207	213	214	205	210	196	203	193	218	218
5	Width of ditto at constriction above orbits	197	194	200	197	201	201	192	196	190	195	179	210	203
6	Interval between supra-orbital foramina [1])	114	91	104–115	124	107	100	120	112–119	95	114	101	111	106
7	Interval between occipital crest and line connecting mid-orbits	195	208	214	ca 214	202	211	222	225	ca 210	216	193	230	222
8	Width of premaxillaries	96	101	103	99	101	111	93	114	102	100	94	119	105
9	Interval between foramen magnum and occipital crest	86	75	75	80	77	82	66	84	72	64	67	67	ca 70
10	Width of occiput through petrosals	202	—	222	ca 212	—	223	198	210	—	209	190	207	217
11	Interval between external angles of occipital condyles	109	103	114	111	101	111	119	118	105	102	96	106	105
12	Interval between extremities of paroccipital processes	ca 100	84	104	81	96	90	—	96	—	107	83	—	—
13	Width of occiput between extremities of temporal fossae	ca 80	ca 81	92	85	ca 55	90	ca 63	71	70	ca 84	73	90	92
14	Width between temporal fossae [2]) (horizontally the greatest in the preoccipital region)	117	122	118	125	116	116	126	119	103	122	111	124	127
15	Length of temporal fossa [3])	155	—	158	—	—	159	160	172	—	160	151	171	160
16	Interval between front border of horn-core and orbit	—	50	50	—	47	51	42	54	50	53	47	60	51
17	Antero-posterior diameter of orbit	65	—	62	—	—	66	60	66	—	61	64	58	65
18	Transverse diameter of orbit	56	—	59	—	—	56	56	60	—	54	60	58	60
19	Interval between front border of orbit and ditto of premaxillary	269	276	313	267	ca 291	296	291	309	—	308	273	308	303
20	Interval between outer surfaces of zygomatic arches	199	—	206	—	—	201	208	218	—	212	191	211	215
21	Antero-posterior diameter of horn-core at base	81	86	107	71	84	90	70	89	86	87	81	—	—
22	Transverse diameter of ditto	52	61	68	55	60	64	56	60	66	56	56	—	—
23	Circumference of horn-core at base	235	246	287	208	240	251	205	250	256	240	232	—	—
24	Length of horn-core along convexity	ca 325	311	373	277	325	—	280	ca 380	ca 325	410	273	—	—
25	Length of horn along convexity	—	—	—	—	—	—	—	—	—	985	460	600	792
26	Maximum span of horns	—	—	—	—	—	—	—	—	—	1385	568	785	786
27	Maximum span of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—	—
28	Tip-to-tip interval of horns	—	—	—	—	—	—	—	—	—	1267	425	602	296
29	Tip-to-tip interval of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—	—
30	Interval between tip horn and tip nasals	—	—	—	—	—	—	—	—	—	1020	647	780	775

		Stremme (1911) p. 126.	Buitenzorg Museum n°. 760 from Sumba. Dammermann (1928) p. 312.	Buitenzorg Museum n°. 761 from Sumbawa.	Buffelus bubalus (Arni)			Buffelus bubalus var. palaeindicus			"Buffelus palaeokerabau"		Buffelus platyceros
					a.	b.	c.	A.	B.	C.	α	β	
					Leyden. From Hindostan.	Lydekker (1878) p. 136.	Stremme (1911) p. 126.	Lydekker (1878) p. 136. From Narbada Valley.	Lydekker (1878) p. 137. From Narbada Valley.	Lydekker (1878) p. 140. From uppermost Siwaliks near Bubhor.	Stremme (1911) p. 126. From Trinil.		Lydekker (1878) p. 129. From Siwalik Hills.
		29.	30.	31.									
1	Interval between occipital condyle and front border of premaxillary of the same side	461	—	—	608	—	552	—	—	—	556	—	—
2	Length from occipital crest to tip of nasals	386	—	—	492	533	446	—	—	—	467	—	—
3	Interval between foramen magnum and suture between nasals and frontals	254	—	—	307	—	273	—	—	—	277	—	—
4	Width of forehead at superior border of orbits	201	—	—	247	254	205	295	—	—	214	—	236
5	Width of ditto at constriction above orbits	195	—	—	230	239	203	279	241	234	229	227	213
6	Interval between supra-orbital foramina [1])	94	140	124	118	135	114	165	137	91	109	—	114
7	Interval between occipital crest and line connecting mid-orbits	210	—	—	245	254	240	305	—	—	250	—	—
8	Width of premaxillaries	101	—	—	122	—	112	—	—	—	112	—	—
9	Interval between foramen magnum and occipital crest	75	—	—	101	94	77	107	109	86	100	75	—
10	Width of occiput through petrosals	195	—	—	263	216	176	254	279	224	201	186	—
11	Interval between external angles of occipital condyles	117	—	—	135	130	115	157	130	135	125	—	—
12	Interval between extremities of paroccipital processes	143	—	—	151	127	112	155	—	—	179	—	—
13	Width of occiput between extremities of temporal fossae	87	—	—	133	130	90	178	157	—	106	109	127
14	Width between temporal fossae [2]) (horizontally the greatest in the preoccipital region)	—	—	—	138	—	—	—	—	—	—	—	—
15	Length of temporal fossa [3])	96	—	—	187	178	97	191	—	—	119	—	178
16	Interval between front border of horn-core and orbit	47	53	—	66	61	41	64	—	46	52	—	61
17	Antero-posterior diameter of orbit	65	—	—	79	71	60	76	—	61	65	—	74
18	Transverse diameter of orbit	60	—	—	70	64	58	66	—	—	60	—	—
19	Interval between front border of orbit and ditto of premaxillary	247	—	—	345	—	315	—	—	—	316	—	—
20	Interval between outer surfaces of zygomatic arches	209	—	—	232	254	216	279	—	—	240	—	—
21	Antero-posterior diameter of horn-core at base	121	161	103	171	132	83	185	163	163	141	—	—
22	Transverse diameter of ditto	73	108	71	ca 90	64	60	71	—	76	105	—	84
23	Circumference of horn-core at base	348	439	285	—	330	240	472	—	—	449	—	419
24	Length of horn-core along convexity	—	—	—	—	—	—	—	—	—	—	—	—
25	Length of horn along convexity	—	1700	1138	1130	—	—	—	—	—	—	—	—
26	Maximum span of horns	—	2935	1921	1043	—	—	—	—	—	—	—	—
27	Maximum span of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—
28	Tip-to-tip interval of horns	—	2935	1921	612	—	—	—	—	—	—	—	—
29	Tip-to-tip interval of horn-cores	—	—	—	—	—	—	—	—	—	—	—	—
30	Interval between tip horn and tip nasals	—	—	—	1120	—	—	—	—	—	—	—	—

[1]) If each sulcus contains more than one foramen, two numbers have been given, representing resp. the interval between the frontmost and between the hindmost foramina.

[2]) This measurement does not correspond with Lydekker's measurement "Width of parietals between temporal fossae" (1878, p. 129). As may appear from his text the latter measurement is identical with his measurement "Width of occiput between temporal fossae" (1878, p. 137).

[3]) It is almost certain that Stremme meant something else with the length of the temporal fossa than I, which may appear from what follows. From table C it may be seen that his measurement varies from 157—176 in 18 specimens of the kerabau, measured by the present writer, whereas it is only 98 in Stremme's specimen of kerabau. As this measurement shows also a striking small value in Stremme's specimen of Buffelus palaeokerabau, we may be sure that an error has not been committed. In order to avoid further confusions I may add that I mean with "length of the temporal fossa" the interval between the hindmost point of the temporal fossa and the point where posterior border of orbit and zygomatic arch meet.

TABLE B.

TABLE C.

TABLE C.

		OUR OWN FOSSIL SPECIMENS OF BUFFELUS								BUFFELUS BUBALUS VAR. SONDAICUS (KERABAU)																									Buffelus bubalus (Arni)			Buffelus bubalus var. palacindicus			"Buffelus palaeo-kerabau"		Buffelus platyceros
		1.	2.	3.	5.	6.	7.	8.	9.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	♂ 26.	♂ 27.	♂ 28.	29.	a.	b.	c.	A.	B.	C.	α.	β.	
1	Interval between occipital condyle and front border of premaxillary of the same side	—	—	—	—	—	—	—	—	516	528	560	544	540	486	500	550	521	538	524	556	534	531	510	528	533	497	515	523	533	565	543	541	540	511	528	473	529	—	544	—	—	—	486	—	—
2	Length from occipital crest to tip of nasals	—	—	—	—	—	—	—	—	414	421	447	431	453	396	408	457	435	448	404	447	415	433	404	409	441	408	420	425	447	456	431	444	437	415	415	396	428	446	439	—	—	—	408	—	—
3	Interval between foramen magnum and suture between nasals and frontals	—	—	—	—	—	—	—	—	256	273	275	270	270	246	253	280	249	264	257	275	266	268	264	271	266	265	254	270	271	285	269	267	278	255	249	261	267	—	269	—	—	—	242	—	—
4	Width of forehead at superior border of orbits	—	ca 210	ca 200	—	—	—	—	202	209	209	—	215	—	210	204	217	221	210	209	222	ca 204	211	211	ca 209	205	210	212	213	214	214	206	208	216	208	215	206	215	213	202	211	—	—	187	—	222
5	Width of ditto at constriction above orbits	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
6	Interval between supra-orbital foramina[1])	ca 85	ca 78	ca 103	—	ca 91	101	97	93	119	116	113–132	124	123	120	109	127	103	108	106	113	110	111	116	94	104–115	126	106	100	125	114–121	100	117	113	106	104	96	103	113	112	118	114	78	95	—	107
7	Interval between occipital crest and line connecting mid-orbits	—	ca 228	200	—	—	—	—	—	221	225	—	223	233	199	220	237	214	222	207	227	—	215	198	214	214	ca 217	201	210	231	230	ca 221	222	216	219	219	215	213	213	236	219	—	—	218	—	—
8	Width of premaxillaries	—	—	—	—	—	—	—	—	110	108	125	103	104	95	101	—	118	104	105	121	108	103	97	104	103	101	100	110	97	116	107	103	105	113	103	104	106	—	110	—	—	—	98	—	—
9	Interval between foramen magnum and occipital crest	69	75	70	—	—	—	ca 75	—	69	78	75	74	74	75	71	75	69	69	72	74	78	74	87	77	75	81	77	82	69	86	76	66	75	64	69	77	88	79	76	77	90	74	87	66	—
10	Width of occiput through petrosals	223	ca 245	ca 220	245	—	—	ca 255	—	213	214	—	214	—	—	210	223	210	225	206	237	—	220	205	—	222	ca 215	—	222	206	214	—	214	212	197	214	200	229	181	173	182	232	19[illegible]	176	164	—
11	Interval between external angles of occipital condyles	105	108	99	—	—	—	ca 110	—	108	111	115	112	112	103	111	120	102	116	115	106	99	112	111	106	114	113	100	110	124	120	111	105	107	101	103	120	117	109	113	113	108	11[illegible]	109	—	—
12	Interval between extremities of paroccipital processes	—	ca 110	118	ca 65	—	—	—	—	98	88	97	92	87	98	95	—	—	—	—	94	—	—	ca 102	87	104	82	96	90	—	98	—	110	93	—	—	147	131	106	110	111	—	—	156	—	—
13	Width of occiput between extremities of temporal fossae	112	158	130	158	134	120	129	—	76	92	83	77	94	82	93	119	78	91	93	ca 78	86	93	ca 81	ca 84	92	86	ca 55	90	ca 66	72	74	ca 86	82	86	91	89	116	109	89	128	130	—	93	96	119
14	Width between temporal fossae. (horizontally the greatest in the preoccipital region)	119	126	114	129	122	133	119	—	118	126	117	125	127	118	107	131	116	121	116	114	123	118	119	126	118	127	115	115	131	121	108	125	124	118	125	—	120	—	—	—	—	—	—	—
15	Length of temporal fossa [2])	—	162	ca 143	—	—	—	—	—	160	160	—	173	—	—	162	168	—	164	158	171	—	164	157	—	158	—	—	158	167	176	—	164	169	163	158	98	163	149	96	137	—	—	104	—	167
16	Interval between front border of horn-core and orbit	44	53	ca 46	ca 66	51	—	42	47	60	48	—	56	56	52	46	55	55	48	44	53	50	55	—	52	50	—	47	51	44	55	53	54	53	57	50	48	57	51	40	46	—	39	45	—	57
17	Antero-posterior diameter of orbit	—	—	ca 61	—	—	—	—	—	61	60	—	64	—	—	57	67	—	63	59	60	—	63	66	—	62	—	—	66	63	67	—	63	72	55	64	67	69	59	59	54	—	52	57	—	69
18	Transverse diameter of orbit	—	—	ca 61	—	—	—	—	—	57	60	—	66	—	—	53	64	—	61	58	58	—	57	57	—	59	—	—	56	58	61	—	55	67	55	59	62	61	54	57	47	—	—	52	—	—
19	Interval between front border of orbit and ditto of premaxillary	—	—	—	—	—	—	—	—	290	298	—	294	304	267	280	306	ca 302	313	291	318	—	313	273	285	313	271	ca 290	295	303	315	—	316	305	293	299	253	300	—	310	—	—	—	276	—	—
20	Interval between outer surfaces of zygomatic arches	—	214	—	—	—	—	—	—	210	206	—	215	—	—	203	216	—	221	203	214	—	210	202	—	206	—	—	200	217	222	—	217	213	201	212	214	202	213	213	200	—	—	210	—	—
21	Antero-posterior diameter of horn-core at base	120	142	137	148	148	117	134	151	95	109	92	92	97	91	100	114	104	100	94	98	85	88	82	89	107	72	84	90	73	91	91	89	91	—	—	124	149	110	82	133	135	139	123	—	—
22	Transverse diameter of ditto	86	86	89	95	91	74	81	93	66	66	69	63	69	61	70	76	70	68	63	65	61	60	53	63	68	56	60	64	58	61	69	57	63	—	—	75	ca 78	54	59	51	—	6[illegible]	92	—	79
23	Circumference of horn-core at base	339	377	371	404	408	308	346	398	273	287	269	258	279	235	286	227	292	279	266	269	244	244	239	254	287	284	239	250	214	255	269	246	259	—	—	357	—	276	236	338	—	—	392	—	393
24	Length of horn-core along convexity	—	—	—	—	—	—	—	ca 992	418	348	289	371	433	350	471	339	315	380	364	374	312	ca 299	ca 330	321	373	281	323	—	292	ca 388	ca 342	421	305	—	—	—	—	—	—	—	—	—	—	—	—
25	Length of horn along convexity	—	—	—	—	—	—	—	—	849	—	—	—	—	—	—	—	884	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1010	514	571	780	—	983	—	—	—	—	—	—	—	—	—
26	Maximum span of horns	—	—	—	—	—	—	—	—	930	—	—	—	—	—	—	—	1005	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1421	635	748	774	—	907	—	—	—	—	—	—	—	—	—
27	Maximum span of horn-cores	—	—	—	—	—	—	ca 1379	ca 1362	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28	Tip-to-tip interval of horns	—	—	—	—	—	—	—	—	531	—	—	—	—	—	—	—	677	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1299	475	573	292	—	532	—	—	—	—	—	—	—	—	—
29	Tip-to-tip interval of horn-cores	—	—	—	—	—	—	ca 1285	ca 1236	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	Interval between tip horn and tip nasals	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1046	723	743	764	—	974	—	—	—	—	—	—	—	—	—

[1]) [2]) [3]) See the notes under table B.

TABLE **D.**

	Our own fossil specimens		B. bubalus var. sondaicus (Kerabau)		"Buffelus palaeo-kerabau"		B. bubalus (Arni)		B. bubalus var. palaeindicus		Buffelus platyceros
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	
1	—	—	473	565	486		529	544	—		—
2	—	—	396	457	408		428	446	—		—
3	—	—	246	285	242		267	269	—		—
4	ca 200	ca 210	204	222	187		202	215	211		222
5	200	200	200	200	200	200	200	200	200	200	200
6	ca 78	ca 103	94	132	95		103	113	78	118	107
7	200	ca 228	198	237	218		213	236	219		—
8	—	—	95	125	98		106	110	—		—
9	69	75	64	87	66	87	76	88	74	90	—
10	ca 220	ca 255	197	237	164	176	173	229	182	232	—
11	99	ca 110	99	124	109		109	117	108	115	—
12	ca 65	118	82	147	156		106	131	111		—
13	112	158	ca 55	119	93	96	89	116	128	130	119
14	114	133	107	131	—	—	120		—		—
15[1])	ca 143	162	157	176	—		149	163	137		167
16	42	ca 66	44	60	45		40	57	39	46	57
17	ca 61		55	72	57		59	69	52	54	69
18	ca 61		53	67	52		54	61	47		—
19	—	—	253	318	276		300	310	—		—
20	214		200	222	210		202	213	200		—
21	117	151	72	124	123		82	149	133	139	—
22	74	95	53	76	92		54	ca 78	51	65	79
23	308	408	214	357	392		236	276	338		393
24	ca 970	ca 992	281	539	—		—		—		—
25	—	—	514	1010	—		983		—		—
26	—	—	635	1421	—		907		—		—
27	ca 1362	ca 1379	—	—	—		—		—		—
28	—	—	292	1299	—		532		—		—
29	ca 1236	ca 1285	—	—	—		—		—		—
30	—	—	723	1046	—		974		—		—

[1]) See note 3 under table B.

TABLE **E.**

	Nos. of table of measurements Stremme (1911) p. 127	OUR OWN FOSSIL SPECIMENS OF BUFFELUS						BUFFELUS BUBALUS VAR. SONDAICUS (KERABAU)																								Buffelus bubalus (Arni)			Buffelus bubalus var. palaeindicus		
		1	2	3	4	5	8	1	2	3	4	5	6	7	8	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	a.	b.	c.	A.	B.	C.
1 : 8	XXII : XIX	—	—	—	—	—	—	4.70	4.90	4.48	5.28	5.17	5.11	4.93	—	4.42	5.17	5.01	4.61	5.84	4.95	5.15	5.23	5.07	5.17	4.95	5.13	4.74	5.51	4.86	5.06	5.27	5.14	4.51	5.10	4.56	4.99	—	4.93	—	—	—
1 : 5	XXII : XX	—	—	—	—	—	—	2.58	2.64	2.80	2.72	2.70	2.43	2.50	2.75	2.61	2.69	2.62	2.78	—	2.67	2.65	2.55	2.64	2.67	2.49	2.58	2.62	2.67	2.83	2.72	2.70	2.75	2.56	2.64	2.36	2 64	—	2.72	—	—	—
4 : 13	III : XVII	—	1.33	1.53	—	—	—	2.75	2.27	—	2.79	—	2.55	2.20	1.82	2.83	2.30	2.24	2.83	—	2.36	2.28	2.60	2.51	2.23	2.44	3.87	2.38	3.25	2.96	2.80	2.42	2.64	2.42	2.37	2.31	1.86	1.95	2.28	1.66	—	—
2 : 9	IV : I	—	—	—	—	—	—	5.96	5.39	5.97	5.81	6.13	5.26	5.78	6.09	6.33	6.46	5.58	7.02	5.39	5.29	5.83	4.63	5.29	5.88	5.03	5.48	5.21	6.50	5.32	5.70	6.77	5.84	6.51	6.01	5.15	4.87	5.67	5.80	—	—	—
2 : 4	IV : III	—	—	—	—	—	—	1.98	2.01	—	2.00	—	1.89	2.00	2.11	1.97	2.13	1.93	2.02	—	2.03	2.05	1.91	1.96	2.15	1.94	1.98	2.00	2.09	2.13	2.09	2.13	2.03	2.00	1.93	1.92	2.00	2.10	2.18	—	—	—
2 : 10	IV : V	—	—	—	—	—	—	1.94	1.97	—	2.01	—	—	1.94	2.05	2.07	1.99	1.96	1.88	—	—	1.97	1.97	—	1.99	1.90	—	1.91	2.17	2.13	—	2.07	2.06	2.11	1.94	1.98	1.87	2.47	2.53	—	—	—
17 : 18	IX : X	—	—	1.01	—	—	—	1.07	1.00	—	0.97	—	—	1.07	1.05	—	1.03	1.02	1.03	—	—	1.11	1.16	—	1,05	—	—	1.18	1.07	1.10	—	1.13	1.07	1.00	1.08	1.08	1.13	1.11	1.03	1.15	—	—
10 : 9	V : I	3.24	3.28	3.15	3.20	—	3.41	3.07	2.74	—	2.89	—	—	2.97	2.97	3.06	3.24	2.85	3.72	—	—	2.96	2.35	—	2,96	2.65	—	2.72	3.00	2.50	—	3.27	2.84	3.09	3.10	2.60	2.60	2.30	2.29	2.37	2.56	2.60
20 : 9	XIV : I	—	2.86	—	—	—	—	3.03	2.63	—	2.90	—	—	2.88	2.88	—	3.19	2.81	3.35	—	—	2.83	2.31	—	2,75	—	—	2.45	3.15	2.60	—	3.31	2.85	3.15	3.07	2.79	2.30	2.70	2.81	2.61	—	—
1 : 20		—	—	—	—	—	—	2.46	2.57	—	2.53	—	—	2.47	2.55	—	2.43	2.58	2.60	—	—	2.52	2.52	—	2.59	—	—	2.62	2.46	2.54	—	2.49	2.53	2.55	2.49	2.21	2.62	—	2.56	—	—	—
2 : 20	IV : XIV	—	—	—	—	—	—	1.97	2.05	—	2.00	—	—	2.01	2.12	—	2.03	1.99	2.09	—	—	2.06	2.00	—	2.14	—	—	2.12	2.06	2.05	—	2.04	2.05	2.07	1.96	1.85	2.12	2.10	2.06	—	—	—
10 : 20	V : XIV	—	1.15	—	—	—	—	1.01	1.04	—	1.00	—	—	1.03	1.03	—	1.02	1.01	1.11	—	—	1.04	1.02	—	1.08	—	—	1.11	0.95	0.96	—	0.99	1.00	0.98	1.01	0.93	1.13	0.85	0.81	0.91	—	—
10 : 13	V : XVII	1.98	1.55	1.69	1.52	1.55	1.99	2.80	2.32	—	2.77	—	—	2.26	1.87	2.70	2.47	2.20	3.03	—	—	2.37	2.53	—	2.41	2.49	—	2.48	3.14	2.96	—	2.49	2.60	2.30	2.36	2.24	1.98	1.66	1.96	1.43	1.78	—
19 : 7		—	—	—	—	—	—	1.31	1.32	—	1.32	1.30	1.34	1.27	1.29	1.41	1.41	1.41	1.40	—	—	1.45	1.38	1.33	1.46	1.25	1.44	1.40	1.31	1.37	—	1.43	1.41	1.34	1.36	1.18	1.41	—	1.31	—	—	—

TABLE F.

	Nos. of table of measurements Stremme (1911) p. 127	Our own fossil specimens	B. bubalus. var. sondaicus (Kerabau)	B. bubalus (Arni)	B. bubalus var. palaeindicus	"Buffelus palaeokerabau"	Buffelus platyceros
		min. max.	min. max.	min. max.	min. max.	min. max.	
1: 8	XXII: XIX	—	4.42—5.84	4.93—4.99	—	4.96	—
1: 5	XXII: XX	—	2.36—2.83	2.64—2.72	—	2.43	—
4: 13	III: XVII	1.33—1.53	1.82—3.87	1.86—2.28	1.66	2.02	1.86
2: 9	IV: I	—	4.63—7.02	4.87—5.80	—	4.67	—
2: 4	IV: III	—	1.89—2.15	2.00—2.18	—	2.18	—
2: 10	IV: V	—	1.88—2.17	1.87—2.53	—	2.32	—
17: 18	IX: X	1.01	0.97—1.18	1.03—1.13	1.15	1.08	—
10: 9	V: I	3.15—3.41	2.35—3.72	2.29—2.60	2.37—2.60	2.01—2.48	—
20: 9	XIV: I	2.86	2.31—3.35	2.30—2.81	2.61	2.40	—
1: 20	XXII: XIV	—	2.21—2.62	2.56—2.62	—	2.32	—
2: 20	IV: XIV	—	1.85—2.14	2.06—2.12	—	1.95	—
10: 20	V: XIV	1.15	0.93—1.11	0.81—1.13	0.91	0.84	—
10: 13	V: XVII	1.52—1.99	1.87—3.14	1.66—1.98	1.43—1.78	1.71—1.90	—
19: 7	XXIV: XII	—	1.18—1.46	1.31—1.41	—	1.26	—

TABLE G.

	Nos. table of measurements Kütimeyer (1868) p. 86.		Our own fossil specimens		
			α	β	γ
			from E. Java "one-horned" specimen	from E. Java "two-horned" specimen	from E. Java detached horn-core
			old ♂	adult ♂	old ♂
1		Condylo-basal length (from post. border of occipital condyle to front border of premaxillary of the same side	438	433	—
2		Length from vertex cranii to tip of nasals	353	—	—
3	9	Width of constriction of forehead between base of horn-core and orbit	182	176	—
4	8	Greatest width of forehead at superior border of orbit	205	ca 215	—
5		Interval between supra-orbital foramina	95–139	98–126	—
6	14	Interval between tubera malaria	137	140	—
7		Length of horn on outer curve	—	—	—
8		Length of horn-core on outer curve	560	550	610
9		Circumference of horn-core at base	245	248	288
10		Greatest diameter of horn-core at base	89	87	102
11		Transverse diameter of horn-core at base	60	64	76
12		Maximum span of horns	—	—	—
13		Maximum span of horn-cores	ca 924	944	—
14		Tip-to-tip interval of horns	—	—	—
15		Tip-to-tip interval of horn-cores	ca 870	915	—
16		Interval between tip of nasals and tip of horn	—	—	—
17		Interval between tip of nasals and tip of horn-core	550	—	—
18	10	Interval between bases of horns (horn-cores)	ca 260	ca 269	—
19		Interval between vertex cranii and lower border of foramen magnum	152	156	—
20		Interval between ditto and upper border of ditto	—	—	—
21		Interval between occipital crest and vertex cranii	87	ca 82	—
22		Interval between upper border of for. magnum and occipital crest	—	—	—
23		Interval between posterior border of meatus auditivus externus osseus of either side	ca 190	187	—
24	11	Greatest breadth of occiput through petrosals	—	—	—
25	12	Width of occiput between extremities of temporal fossae	116	80	—
26		Greatest interval between temporal fossae in the pre-occipital region	111	109	—
27		Greatest length of temporal fossa	153	159	—
28		Interval between front border of orbit and ditto of premaxillary of same side	243	235	—
29		Height of orbit (measured perpendicular to upper surface of cranium)	61	60	—
30		Interval between upper border of orbit and alveolar margin of molars	130	145	—
31		Interval between outer surfaces of zygomatic arches	207	—	—
32		Width of palate immediately in front of for. palatinum majus	80	76	—
33		Interval between posterior border of palatinum and front border of premaxilla	270	264	—
34	5	Interval between front border of premaxilla and line connecting P^2 of either side	126	124	—
35	6	Length of premolar and molar series	126	124	—
36		Length of fissura palatina	54	47	—
37		Width of ditto	16	14	—
38		Median depth of cranium at post. border of palatinum and perpendicular to palate	149	142	—
39		Interval between extremities of paroccipital processes	—	—	—
40		Interval between external angles of occipital condyles	100	90	—
41		Elevation of tip of nasals above palate	77	—	—

Bibos sondaicus					Bibos sondaicus var. lowi			Bibos sondaicus
A	B	C	D	E	a	b	c	
Amsterdam	from Java Amsterdam	Utrecht	from Java Leyden	from Java Leyden	from Borneo Amsterdam	from Borneo Amsterdam	from E. Borneo Leyden	from Java Leyden
old ♂	old ♂	old ♂	typespecimen of old ♂	typespecimen of adult ♂	adult ♂	adult ♂	old ♂	typespecimen of adult ♀
474	500	467	524	491	443	—	477	454
363	450	386	402	410	322	296	342	350
186	205	196	212	182	171	164	200	162
219	232	224	237	210	193	179	233	188
91—155	109—157	98	110—168	98—161	80—133	90—116	89—145	89—110
162	166	170	168	135	133	127	171	158
612	571	L 563. R 615	735	636	466	345	540	331
—	—	—	—	478	321	245	—	—
235	260	268	298	254	232	206	255	170
85	96	96	108	88	82	71	106	52
ca 57	ca 61	ca 63	84	69	61	61	63	46
744	895	684	828	812	459	339	631	309
—	—	—	—	795	443	330	—	—
426	724	371	342	633	210	177	376	74
—	—	—	—	ca 710	384	267	—	—
588	L 655. R 683	598	555	790	579	532	645	587
—	—	—	—	756	537	487	—	598
304	333	314	339	305	256	230	268	230
198	205	210	227	179	162	—	197	158
170	170	180	200	154	135	—	179	137
100	87	95	114	71	77	85	ca 101	66
77	87	85	ca 89	ca 85	66	—	ca 87	78
209	222	206	240	217	174	163	209	176
244	251	248	283	245	205	186	244	205
118	109	94	94	104	62	86	100	76
—	123	110	124	129	107	100	117	112
156	172	164	180	173	150	140	161	151
259	300	L 272. R 260	280	262	243	226	271	254
61	63	57	66	62	57	58	57	59
146	ca 167	145	162	148	138	125	153	141
220	221	210	221	210	184	175	218	191
86	—	88	94	81	79	78	88	94
284	—	286	313	293	266	247	298	279
140	144	135	162	144	132	120	142	142
132	—	140	137	140	133	136	132	132
60	74	55	60	—	64	65	63	60
18	22	16	16	—	17	17	16	16
152	—	158	166	158	136	127	156	151
94	—	ca 118	114	—	82	—	ca 80	—
102	117	109	114	107	97	—	103	93
76	85	75	86	ca 70	74	—	74	70

TABLE **H.**

		Our own fossil specimen	
		α	*β*
		old ♂	adult ♂
1	Condylo-basal length (from post. border of occipital condyle to front border of premaxillary of the same side	500	500
2	Length from vertex cranii to tip of nasals	403	—
3	Width of constriction of forehead between base of horn-core and orbit	208	203
4	Greatest width of forehead at superior border of orbit	234	ca 248
5	Interval between supra-orbital foramina	108—159	113—146
6	Interval between tubera malaria	156	162
7	Length of horn on outer curve	—	—
8	Length of horn-core on outer curve	640	635
9	Circumference of horn-core at base	280	286
10	Greatest diameter of horn-core at base	102	100
11	Transverse diameter of horn-core at base	69	74
12	Maximum span of horns	—	—
13	Maximum span of horn-cores	ca 1055	1090
14	Tip-to-tip interval of horns	—	—
15	Tip-to-tip interval of horn-cores	994	1057
16	Interval between tip of nasals and tip of horn	—	—
17	Interval between tip of nasals and tip of horn-core	628	—
18	Greatest interval between bases of horns (horn-cores)	ca 297	ca 311
19	Interval between vertex cranii and lower border of foramen magnum	174	180
20	Interval between ditto and upper border of ditto	—	—
21	Interval between occipital crest and vertex cranii	99	ca 95
22	Interval between upper border of foramen magnum and occipital crest	—	—
23	Interval between posterior border of meatus auditivus externus osseus of either side	ca 217	216
24	Greatest breadth of occiput through petrosals	—	—
25	Width of occiput between extremities of temporal fossae	132	92
26	Greatest interval between temporal fossae in the pre-occipital region	127	126
27	Greatest length of temporal fossa	175	184
28	Interval between front border of orbit and ditto of premaxillary of same side	278	271
29	Height of orbit (measured perpendicular to upper surface of cranium)	70	69
30	Interval between upper border of orbit and alveolar margin of molars	148	167
31	Interval between outer surfaces of zygomatic arches	236	—
32	Width of palate immediately in front of for. palatinum majus	91	88
33	Interval between posterior border of palatinum and front border of premaxillary	308	305
34	Interval between front border of premaxillary and line connecting P^2 of either side	144	143
35	Length of premolar and molar series	144	143
36	Length of fissura palatina	62	54
37	Width of ditto	18	16
38	Median depth of cranium at post. border of palatinum and perpendicular to palate	170	164
39	Interval between extremities of paroccipital processes	—	—
40	Interval between external angles of occipital condyles	114	104
41	Elevation of tip of nasals above palate	88	—

TABLE **H.**

Bibos sondaicus					Bibos sondaicus var. lowi		Bibos sondaicus
A	B	C	D	E	a	c	
old ♂	old ♂	old ♂	old ♂	adult ♂	adult ♂	old ♂	adult ♀
500	500	500	500	500	500	500	500
383	**450**	413	384	418	363	358	385
196	205	**210**	202	**185**	193	210	178
231	232	**240**	226	**214**	218	244	207
96—164	109—157	105	105—160	100—**164**	90—150	93—152	98—121
171	166	**182**	160	**137**	150	179	174
646	**571**	L 603. R **658**	701	648	526	566	364
—	—	—	—	487	362	—	—
248	260	**287**	284	259	262	267	187
90	96	**103**	**103**	**90**	93	111	57
ca **60**	ca 61	ca 67	**80**	70	69	66	51
785	**895**	**733**	790	827	518	661	340
—	—	—	—	810	500	—	—
449	**724**	397	**326**	645	237	394	81
—	—	—	—	ca 723	433	—	—
620	L 655. R 683	640	**530**	**804**	654	676	646
—	—	—	—	770	606	—	658
321	**353**	336	323	**311**	289	281	253
209	205	**225**	217	**182**	183	206	174
179	170	**193**	191	**157**	152	188	151
105	87	102	**109**	**72**	87	ca 106	73
81	87	**91**	ca 85	ca 87	74	91	86
220	222	221	**229**	221	196	219	194
257	251	266	**270**	**249**	231	256	226
124	109	101	**90**	106	70	105	84
—	123	**118**	**118**	**131**	121	123	123
165	172	**176**	172	**176**	169	169	166
273	**300**	L 291. R 278	**267**	**267**	274	284	280
64	63	**61**	63	63	64	60	65
154	ca **167**	155	155	**151**	156	160	155
232	221	225	**211**	214	208	228	210
91	—	**94**	90	**82**	89	92	103
300	—	**306**	299	**298**	300	312	307
148	**144**	145	**155**	147	149	149	156
139	—	**150**	**131**	143	150	138	145
63	**74**	59	**57**	—	72	66	66
19	**22**	17	**15**	—	19	17	18
160	—	**169**	**158**	161	154	163	166
99	—	ca **126**	109	—	93	ca 84	—
108	**117**	**117**	109	109	109	108	102
80	**85**	80	82	ca **71**	84	78	77

TABLE **I.**

	Our own fossil specimens		Bibos sondaicus				
	α	*β*	A	B	C	D	E
3 : 23 . .	0.96	0.94	0.89	0.92	**0.95**	0.88	**0.84**
3 : 25 . .	1.57	2.20	**1.58**	1.88	2.09	**2.26**	1.75
19 : 25 . .	1.31	1.95	**1.68**	1.88	2.23	**2.41**	1.72
4 : 3 . .	1.13	1.22	**1.18**	1.13	1.14	**1.12**	1.15
4 : 6 . .	1.50	1.54	1.35	1.40	**1.32**	1.42	**1.56**
19 : 21 . .	1.75	1.90	1.98	**1.36**	2.21	1.99	**2.52**
25 : 40 . .	1.16	0.89	**1.16**	**0.62**	0.86	0.82	0.97
2 : 28 . .	1.45	—	**1.40**	1.50	1.42–1.48	1.44	**1.56**
19 : 23 . .	0.80	0.83	0.95	0.92	**1.02**	0.95	**0.82**
19 : 25 . .	1.31	1.95	**1.68**	1.88	2.23	**2.41**	1.72

TABLE **K.**

	Corresponding Nos. of Stremme (1911), p. 94.	Corresponding Nos. of Toula (1902) table.		Rhinoceros sivalensis (Baker & Durand) 1836, p. 502.	"Rhinoceros sivasondaicus" Stremme (1911) p. 90&94	Our own fossil specimens	
				A	α	a	b
1	—	1	Greatest length of cranium (from tip of nasals to posterior surface of occipital condyles)	—	598	645	ca 610
2	—	—	Greatest width of ditto (interval between outer surfaces of zygomatic arches)	—	—	360	391
3	4	3	Breadth between proc. postorbitales of frontals	254	194	199	198
4	13	2	Transverse width of nasals below vertex of nasal arch	174	95	111	119
5	—	6	Least distance between the cristae fronto-parietales	—	35	54	—
6	—	—	Perpendicular from a line tangential to the summit of occipital crest and vertex of nasal arch to the depression of frontals	99	—	67	—
7	2	14	Greatest breadth of occiput.	341	270	304	—
8	7	10	Interval between outer angles of occipital condyles	195	134	136	—
9	8	15	Horizontal diameter of for. magnum	—	48	46	—
10	1	—	Height of occiput (from lower edge of for. magnum to summit of occipital crest)	259	194	197	—
11	—	22	Interval between naso-maxillary notch and tip of nasals	—	152	145	ca 140
12	—	21	Interval between ditto and anterior border of orbit	—	108	119	ca 115
13	12	20	Distance from posterior surface of occipital condyle to anterior border of orbit of the corresponding side	449	383	398	ca 420
14[1])	5	—	Distance from anterior border of orbit to posterior border of meatus auditorius externus	—	—	323	—
15	14	—	Height of vertex of nasal arch above palate	238	152	154	ca 149
16	6	—	Total length of the seven molars	324	248	272	—
17	—	—	Length of premolar series (measured at the buccal side).	—	—	135	—
18	10	—	Distance between internal extremities of fossae glenoidales	—	86	94	ca 75
19	—	—	Distance between tips of proc. glenoidales (from middle of top to ditto of other side)	—	—	143	—
20	—	24	Distance from post. surface of occipital condyle to ditto of M^3 of corresponding side	—	245	255	267
21	11	42	Interval between lower edge of for. magnum and median posterior extremity of palate	368	283	—	—

[1]) As it is not improbable that Cuvier and Stremme measured from anterior border of orbit to anterior

TABLE K.

RHINOCEROS SONDAICUS

1	2	3	4	5	6	7	8	9	10	11	12	13	Toula (1902) table 14	Cuvier (1822) p. 37 15	16
646	611	641	595	640	639	622	601	616	627	642	634	616	590	—	—
354	328	347	339	365	346	337	326	339	325	354	361	354	—	—	—
218	167	183	182	183	192	194	173	171	182	204	218	190	184	172	197
99	87	88	85	81	93	95	91	94	95	107	107	100	87	87	95
ca 42	55	67	50	56	69	63	47	46	37	60	62	52	70	—	—
59	53	47	60	48	60	59	61	61	57	65	60	58	—	—	—
306	281	275	296	289	299	289	291	289	276	302	310	320	271	294	303
153	142	130	142	139	144	134	123	145	132	149	145	144	130	145	132
50	42	46	45	50	50	48	43	45	45	44	49	45	46	43	42
226	204	212	205	226	212	231	205	210	213	229	222	219	—	196	218
160	152	159	150	159	157	149	144	153	161	163	151	151	160	—	—
117	100	110	97	106	108	103	109	102	102	102	112	102	117	—	—
398	374	393	373	400	401	406	369	376	385	400	404	383	390	390	385
306	309	330	291	326	323	322	302	304	316	304	328	320	—	—	—
ca 154	144	135	152	136	147	143	164	162	ca 137	160	148	163	—	—	—
250	254	247	—	245	243	257	239	241	266	247	256	250	—	248	—
125	133	122	—	125	119	130	126	125	132	128	126	128	—	—	—
99	105	96	87	84	92	100	91	88	101	91	90	92	—	95	90
141	151	135	130	152	150	161	131	148	147	149	162	142	—	—	—
258	241	256	261	274	282	259	239	240	240	264	261	235	230	—	—
295	294	313	290	289	ca 308	303	279	282	290	310	297	ca 290	ca 329	ca 329	305

border or middle of meatus auditorius externus, I thought it better not to use the values given by them.

TABLE **L.**

		Rhinoceros sivalensis.	"Rhinoceros siva-sondaicus."	Our own fossil specimens.	
		A	α	a	b
1	Greatest length of cranium (from tip of nasals to posterior surface of occipital condyles)	—	625	648	ca 581
2	Greatest width of ditto (interval between outer surfaces of zygomatic arches)	—	—	362	372
3	Breadth between proc. postorbitales of frontals	226	203	200	189
4	Transverse width of nasals below vertex of nasal arch	155	99	112	133
5	Least distance between the cristae fronto-parietales	—	37	54	—
6	Perpendicular from a line tangential to the summit of occipital crest and vertex of nasal arch to the depression of frontals	88	—	67	—
7	Greatest breadth of occiput	304	282	306	—
8	Interval between outer angles of occipital condyles	174	140	137	—
9	Horizontal diameter of for. magnum	—	50	46	—
10	Height of occiput (from lower edge of for. magnum to summit of occipital crest	231	203	198	—
11	Interval between naso-maxillary notch and tip of nasals	—	159	146	ca 133
12	Interval between ditto and anterior border of orbit	—	113	120	ca 110
13	Distance from posterior surface of occipital condyle to anterior border of orbit of the corresponding side	400	400	400	400
14[1])	Distance from anterior border of orbit to posterior border of meatus auditorius externus	—	—	325	—
15	Height of vertex of nasal arch above palate	212	159	155	ca 142
16	Total length of the seven molars	289	259	273	—
17	Length of premolar series (measured at the buccal side)	—	—	136	—
18	Distance between internal extremities of fossae glenoidales	—	90	94	ca 71
19	Distance between tips of proc. glenoidales (from middle of top to ditto of other side)	—	—	144	—
20	Distance from post. surface of occipital condyle to ditto of M^3 of corresponding side	—	256	256	254
21	Interval between lower edge of for. magnum and median posterior extremity of palate	328	296	—	—

[1]) See the note on table K.

RHINOCEROS SONDAICUS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
649	653	652	638	640	637	613	651	**655**	651	642	628	643	**605**	—	—
356	351	353	364	365	345	**332**	353	361	338	354	357	**370**	—	—	—
219	179	186	195	183	192	191	188	182	189	204	216	198	189	**176**	205
99	93	90	91	**81**	93	94	99	100	99	**107**	106	104	89	89	99
ca 42	59	68	54	56	69	62	51	49	**38**	60	61	54	**72**	—	—
59	57	**48**	64	**48**	60	58	**66**	65	59	65	59	61	—	—	—
308	301	280	317	289	298	285	315	307	287	302	307	**334**	**278**	302	315
154	152	**132**	152	139	144	**132**	133	**154**	137	149	144	150	133	149	137
50	45	47	48	50	**50**	47	47	48	47	**44**	49	47	47	**44**	**44**
227	218	216	220	226	211	228	222	223	221	**229**	220	**229**	—	**201**	226
161	163	162	161	159	157	**147**	156	163	**167**	163	150	158	164	—	—
118	107	112	104	106	108	**101**	118	109	106	102	111	107	**120**	—	—
400	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**
308	330	**336**	312	326	322	317	327	323	328	**304**	325	334	—	—	—
ca155	154	137	163	**136**	147	141	**178**	172	ca142	160	147	170	—	—	—
251	272	251	—	245	**242**	253	259	256	**276**	247	253	261	—	254	—
126	**142**	124	—	125	**119**	128	137	133	137	128	125	134	—	—	—
99	**112**	98	93	**84**	92	99	99	94	105	91	89	96	—	97	94
142	**161**	**137**	139	152	150	159	142	157	153	149	160	148	—	—	—
259	258	261	280	274	**281**	255	259	255	249	264	258	245	**236**	—	—
296	314	319	311	**289**	ca307	299	302	300	301	310	294	ca303	**337**	**337**	317

TABLE M.

	Corresponding nos. of Stremme (1911), p. 94	Rhinoceros sivalensis	"Rhinoceros siva-sondaicus"	Our own fossil specimens		Rhinoceros sondaicus															
		A	α	a	b	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7 : 10	2 : 1	1.32	1.39	1.54	—	1.35	1.38	1.30	1.44	1.28	1.41	**1.25**	1.42	1.38	1.30	1.32	1.40	1.46	—	**1.50**	1.39
7 : 18	2 : 10	—	3.14	3.23	—	3.09	**2.68**	2.86	3.40	3.44	3.25	2.89	3.20	3.28	2.73	3.32	3.44	**3.48**	—	3.09	3.37
16 : 18	6 : 10	—	2.88	2.89	—	2.53	**2.42**	2.57	—	**2.92**	2.64	2.57	2.63	2.74	2.63	2.71	2.84	2.72	—	2.61	—
16 : 3	6 : 4	1.28	1.28	1.37	—	**1.15**	**1.52**	1.35	—	1.34	1.27	1.32	1.38	1.41	1.46	1.21	1.17	1.32	—	1.44	—
15 : 4	14 : 13	1.37	1.60	1.39	1.25	1.56	1.66	1.53	1.79	1.68	1.58	1.51	**1.80**	1.72	1.44	1.50	**1.38**	1.63	—	—	—
13 : 21	12 : 11	1.22	1.35	—	—	1.35	1.27	1.26	1.29	**1.38**	1.30	1.34	1.32	1.33	1.33	1.29	1.36	1.32	**1.19**	**1.19**	1.26

TABLE N.

	No. of cranium.	P^1			P^2			P^3			P^4			M^1			M^2			M^3			
		l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	l	b	$\frac{l}{b}$	
Rhinoceros sondaicus	1	—	—	—	30	41	0.73	36	53	0.68	41	57	0.72	43	57	0.75	ca 47	57	**0.82**	55	51	1.08	left
		—	—	—	29	41	0.71	37	53	0.70	38	56	**0.68**	43	56	0.77	ca 46	56	**0.82**	ca 52	51	1.02	right
	2	21	23	**0.91**	31	43	0.72	37	54	0.69	41	56	0.73	41	57	0.72	44	57	0.77	ca 48	57	0.84	l.
		ca 21	23	**0.91**	31	44	0.70	37	54	0.69	42	58	0.72	42	57	0.74	45	58	0.78	49	50	0.98	r.
	3	ca 21	19	1.11	ca 28	41	0.68	ca 36	49	0.73	—	—	—	ca 45	58	0.78	45	58	0.78	46	53	0.87	l.
		ca 20	20	1.00	ca 27	41	**0.66**	ca 35	50	0.70	ca 40	54	0.74	41	58	0.71	ca 45	59	0.76	ca 44	50	0.88	r.
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	ca 38	56	**0.68**	ca 43	44	0.98	l.
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r.
	13	21	21	1.00	31	42	0.74	36	52	0.69	40	53	**0.75**	43	54	**0.80**	45	55	0.82	44	47	0.94	l.
		22	21	1.05	29	42	0.69	35	50	0.70	38	53	0.72	43	54	**0.80**	43	55	0.78	43	46	0.93	r.
	8	21	20	1.05	29	39	0.74	35	49	0.71	36	50	0.72	ca 38	50	0.76	39	51	0.76	—	42	—	l.
		—	—	—	30	38	**0.79**	33	49	0.67	37	50	0.74	ca 40	51	0.78	42	51	0.82	44	44	1.00	r.
	7	21	19	1.11	28	40	0.70	34	53	0.64	38	56	**0.68**	41	56	0.73	ca 46	59	0.78	46	51	0.90	l.
		ca 20	18	1.11	27	40	0.68	36	52	0.69	39	56	0.70	41	56	0.73	45	58	0.78	48	51	0.94	r.
	9	22	20	1.10	27	39	0.69	34	50	0.68	36	52	0.69	ca 41	54	0.76	43	54	0.80	ca 42	46	0.91	l.
		22	20	1.10	28	39	0.72	34	50	0.68	37	52	0.71	40	54	0.74	41	54	0.76	ca 44	45	0.98	r.
	5	ca 25	21	**1.19**	ca 28	40	0.70	ca 36	50	0.72	ca 40	56	0.71	ca 42	58	0.72	ca 42	58	0.72	ca 46	56	**0.82**	l.
		ca 24	21	1.14	ca 29	39	0.74	ca 35	50	0.70	ca 38	56	0.68	ca 40	58	**0.69**	ca 42	58	0.72	ca 45	54	0.83	r.
	6	20	19	1.05	28	41	0.68	33	56	**0.59**	40	58	0.69	41	57	0.72	46	59	0.78	65	52	**1.25**	l.
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45	52	0.87	r.
	11	—	—	—	30	42	0.71	35	52	0.67	40	56	0.71	43	57	0.75	44	57	0.77	ca 43	49	0.88	l.
		—	—	—	30	41	0.73	37	52	0.71	40	56	0.71	43	58	0.74	44	58	0.76	ca 46	49	0.94	r.
	12	—	—	—	29	42	0.69	36	55	0.65	43	60	0.72	45	59	0.76	46	60	0.77	ca 48	52	0.92	l.
		—	—	—	30	42	0.71	37	55	0.67	43	60	0.72	45	60	0.75	46	60	0.77	ca 49	53	0.92	r.
	14	18	17	1.06	27	34	**0.79**	37	47	**0.79**	36	51	0.71	40	54	0.74	44	56	0.79	51	48	1.06	
"Rhinoceros sivasondaicus"	α	20	24	0.83	28	40	0.70	36	52	0.69	38	51	0.75	39	56	0.70	45	56	0.80	52	49	1.06	
		21	28	0.75	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Our own fossil specimen	a	—	—	—	30	42	0.71	—	—	—	40	ca 56	0.71	41	58	0.71	45	61	0.74	51	52	0.98	l.
		22	22	1.00	30	ca 41	0.73	37	52	0.71	40	58	0.69	40	—	—	44	62	0.71	50	53	0.94	r.

TABLE O.

	No. of cranium.	P^1		P^2		P^3		P^4		M^1		M^2		M^3		
		l	b	l	b	l	b	l	b	l	b	l	b	l	b	
Rhinoceros sondaicus.	1	—	—	0.73	0.72	0.88	0.93	1.00	1.00	1.05	1.00	ca 1.15	**1.00**	1.34	0.89	left
		—	—	0.76	0.73	0.97	0.95	1.00	1.00	1.13	1.00	ca 1.21	**1.00**	ca 1.37	0.91	right
	2	0.51	**0.41**	0.76	0.77	0.90	0.96	1.00	1.00	**1.00**	1.02	1.07	1.02	ca 1.17	**1.02**	l.
		ca **0.50**	0.40	0.74	0.76	0.88	0.93	1.00	1.00	**1.00**	**0.98**	1.07	**1.00**	1.17	0.86	r.
	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	l.
		ca **0.50**	0.37	ca 0.68	0.76	ca 0.88	0.93	1.00	1.00	1.03	**1.07**	ca 1.13	1.09	ca 1.10	0.93	r.
	13	0.53	0.40	0.78	**0.79**	0.90	**0.98**	1.00	1.00	1.08	1.02	1.13	1.04	1.10	0.89	l.
		0.58	0.40	0.76	**0.79**	0.92	0.94	1.00	1.00	1.13	1.02	1.13	1.04	1.13	0.87	r.
	8	0.58	0.40	**0.81**	0.78	0.97	**0.98**	1.00	1.00	ca 1.06	1.00	1.08	1.02	—	**0.84**	l.
		—	—	**0.81**	0.76	0.89	**0.98**	1.00	1.00	ca 1.08	1.02	1.14	1.02	1.19	0.88	r.
	7	0.55	0.34	0.74	0.71	0.89	0.95	1.00	1.00	1.08	1.00	ca 1.21	1.05	1.21	0.91	l.
		ca 0.51	**0.32**	0.69	0.71	0.92	0.93	1.00	1.00	1.05	1.00	1.15	1.04	1.23	0.91	r.
	9	0.61	0.38	0.75	0.75	0.94	0.96	1.00	1.00	ca **1.14**	1.04	1.19	1.04	ca 1.17	0.88	l.
		0.59	0.38	0.76	0.75	0.92	0.96	1.00	1.00	1.08	1.04	1.11	1.04	ca 1.19	0.87	r.
	5	ca **0.63**	0.38	ca 0.70	0.71	ca 0.90	**0.89**	1.00	1.00	ca 1.05	1.04	ca **1.05**	1.04	ca 1.15	1.00	l.
		ca **0.63**	0.38	ca 0.76	0.70	ca 0.92	**0.89**	1.00	1.00	ca 1.05	1.04	ca 1.11	1.04	ca 1.18	0.96	r.
	6	**0.50**	0.33	0.70	0.71	**0.83**	0.97	1.00	1.00	1.03	**0.98**	1.15	1.02	**1.63**	0.90	l.
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	r.
	11	—	—	0.75	0.75	0.88	0.93	1.00	1.00	1.08	1.02	1.10	1.02	ca **1.08**	0.88	l.
		—	—	0.75	0.73	0.93	0.93	1.00	1.00	1.08	1.04	1.10	1.04	ca 1.15	0.88	r.
	12	—	—	**0.67**	0.70	0.84	0.92	1.00	1.00	1.05	**0.98**	1.07	**1.00**	ca 1.12	0.87	l.
		—	—	0.70	0.70	0.86	0.92	1.00	1.00	1.05	1.00	1.07	**1.00**	ca 1.14	0.88	r.
	14	**0.50**	0.33	0.75	**0.67**	**1.03**	0.92	1.00	1.00	1.11	1.06	**1.22**	**1.10**	**1.42**	0.94	
"Rhinoceros sivasondaicus".	*α*	0.53	0.47	0.74	0.79	0.95	1.02	1.00	1.00	1.03	1.10	1.18	1.10	1.37	0.96	
Our own fossil specimen.	a	—	—	0.75	0.75	—	—	1.00	1.00	1.03	1.04	1.13	1.09	1.28	0.93	l.
		0.55	0.38	0.75	ca 0.71	0.93	0.90	1.00	1.00	1.00	—	1.10	1.07	1.25	0.91	r.

TABLE **P.**

		1	2	3	4	5	6	7	8	9
		H. constrictus. Angola. Miller, 1920, n°. 7, p. 2, pls. 1—4, below.	H. amphibius. Zambezi. Miller, 1910, n°. 7, p. 2 pls. 1—4, above.	H. amphibius. Zanzibar.	H. amphibius. Africa.	H. amphibius. Mozambique.	H. amphibius. Africa.	H. amphibius. Africa.	H. amphibius. Congo.	
		U.S. Nat. Mus. n°. 34787	U. S. Nat. Mus. n°. 123387	Leyden	Leyden	Leyden	Leyden	Leyden	Leyden	Amsterdam
		M_1	M_1	M_3	M_3	M_2	M_3	M_3	M_3	M_3
1	Condylo-basal length.	690	730	652	627	637	—	645	646	764
2	Zygomatic breadth	ca 435	435	404	405	400	386	396	ca 418	468
3	Rostral constriction	110	144	118	120	115	101	107	110	163
4	Rostral expansion	332	370	340	308	319	290	299	ca 342	381
5	Occipital breadth	278	332	277	277	272	254	287	ca 278	315
6	Occipital depth (to basion)	196	214	197	192	188	—	178	ca 198	222
7	Median depth between orbits.	181	208	167	171	165	147	162	165	175
8	Nasal [greatest length]	390	400	ca 372	345	372	347	377	353	374
9	Height of orbit	75	90	81	76	72	64	70	69	82
10	Width of orbit	70	65	66	65	63	70	70	ca 68	76
11	Elevation of orbit above level of forehead .	24	40	50	35	30	40	35	ca 34	43
12	Mandible (condyle to front of alveolus of canine)	587	620	547	524	552	514	542	531	607
13	Coronoid height	355	410	372	335	358	311	340	319	363
14	Canine width [between outer alveolar margin of canines]	385	403	361	345	361	307	346	ca 354	427
15	Length of symphysis [without median spine]	168	224	179	177	162	160	160	171	197
16	Maxillary toothrow (alveoli)	265	258	254	246	254	239	234	231	265
17	Mandibular toothrow (alveoli)	293	286	277	264	277	258	260	261	294
18	Width of palate at anterior lobe of M^1 . . .	68	76	59	68	70	61	57	60	93
	first upper molar [length [1]) × breadth at base of crown]	45×41	46×46	41×41	39×45	40×39	39×40	37×41	33×37	43×48
	second upper molar [length × breadth]. .	53×45	51×51	48×51	49×55	47×48	44×51	47×52	37×42	48×54
	third upper molar [„ „]. .	−×−	−×−	53×49	51×55	52×—	50×50	48×50	44×45	54×56
	fiirst lower molar [„ „]. .	46×31	51×34	41×35	36×33	37×31	−×−	36×35	38×32	40×42
	second lower molar [„ „]. .	59×35	57×39	56×42	47×40	46×33	44×42	48×42	48×38	50×48
	third lower molar [„ „]. .	−×−	−×−	74×44	72×40	70×—	72×41	64×41	64×35	77×45

[1]) Measured at outer side of tooth.

[2]) It is almost certain, that cranium and lower jaw of specimen 12 do not belong to one another.

10	11	12 [2])	13	14	15	16	17	18	19	20	21	22	23	24	25
		H. amphibius.				H. amphibius.		H. amphibius. Mozambique.		H. amphibius. Zannibar.	H. amphibius. Congo.	H. amphibius. Congo.	H. amphibius. Zambezi.	H. amphibius. Cape.	H. amphibius. Nile.
Amsterdam	Amsterdam	Utrecht	Amsterdam	Amsterdam	Amsterdam	Utrecht	Leyden	Leyden	Amsterdam	Leyden	Leyden	Leyden	Leyden	Leyden	Leyden
M_3	M_3	M_3	M_3?	M_2	M_2	M_2	M_2	M_2	M_1	M_1	M_1	M_1	M_1	M_1	M_1
ca 685	765	ca 655	695	635	668	665	712	626	541	603	497	514	ca 585	—	ca 660
410	480	410	431	410	410	385	405	390	329	373	356	337	362	367	402
117	177	127	109	100	117	98	115	119	88	106	102	100	94	114	122
344	386	337	322	304	308	296	325	285	244	287	230	218	272	257	290
278	339	297	292	296	281	284	296	278	225	271	256	222	254	—	291
—	221	197	ca 195	197	188	171	185	192	167	194	172	163	169	—	196
162	208	185	179	156	166	165	180	152	145	155	131	130	147	146	157
380	430	350	410	360	365	357	401	304	284	342	234	260	332	312	345
79	78	79	79	78	82	73	80	70	66	75	69	66	72	65	73
66	67	61	66	60	66	59	72	60	60	65	57	60	57	64	62
38	22	30	44	41	50	40	36	34	18	37	25	15	27	36	32
556	601	571	581	541	513	525	585	509	450	476	406	405	476	480	524
363	402	348	350	340	352	320	359	326	249	314	264	272	360	315	325
395	407	366	374	341	351	346	388	307	265	315	259	258	340	282	322
169	197	177	167	164	171	181	169	152	134	151	120	115	144	149	157
261	272	—	282	—	—	—	—	—	—	—	—	—	—	—	—
285	310	—	286	—	—	—	—	—	—	—	—	—	—	—	—
63	95	—	69	63	63	66	68	65	55	67	60	71	46	64	70
42×45	46×43	—	41×44	37×42	35×40	36×40	45×46	40×46	38×41	42×42	41×42	40×37	40×45	41×44	49×–
52×57	50×50	42×49	47×44	42×47	45×44	48×49	54×58	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–
61×55	54×50	51×50	50×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–
39×38	45×36	36×35	42×32	37×30	36×33	37×32	41×40	41×39	37×34	41×36	37×34	39×30	38×35	40×37	40×–
51×46	50×41	46×41	46×38	49×33	44×36	42×41	50×45	56×39	–×–	–×–	–×–	–×–	–×–	59×41	–×–
70×44	72×42	66×40	68×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–	–×–

TABLE Q.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 : 7	3.81	3,51	3.90 **con**	3.67	3.86 **con**	—	3.98 **con**	3.92 **con**	4.63 **con**	4.23 **con**	3.68	3.54	3.88 **con**	4.07 **con**	4.02 **con**	4.03 **con**	3.96 **con**	4.12 **con**
1 : 3	6.27	5.07	5.53	5.23	5.54	—	6.03	5.87	4.69 **am**	5.85	4.32 **am**	5.16	6.38 **con**	6.35 **con**	5.71	6.79 **con**	6.19	5.26
4 : 2	0.76	0.85	0.84	0.76 **con**	0.80	0.75 **con**	0.76 **con**	0.82	0.81	0.84	0.80	0.82	0.75 **con**	0.74 **con**	0.75 **con**	0.77	0.80	0.73 **con**
1 : 11	28.75	18.25	13.04 **am**	17.91 **am**	21.23	—	18.43	19.00	17.77 **am**	18.03 **am**	34.77 **con**	21.83	15.80 **am**	15.49 **am**	13.36 **am**	16.63 **am**	19.78	18.41
1 : 6	3.52	3.41	3.31 **am**	3.27 **am**	3.39 **am**	—	3.62 **con**	3.26 **am**	3.44	—	3.46	3.32 **am**	3.56 **con**	3.22 **am**	3.55 **con**	3.89 **con**	3.85 **con**	3.26 **am**
9 : 10	1.07	1.38	1.23	1.17	1.14	0.91 **con**	1.00 **con**	1.01 **con**	1.08	1.20	1.16	1.30	1.20	1.30	1.24	1.24	1.11	1.17
13 : 12	0.60	0.66	0.68 **am**	0.64	0.65	0.61	0.63	0.60 **con**	0.60 **con**	0.65	0.67 **am**	0.61	0.60 **con**	0.63	0.69 **am**	0.61	0.61	.064
15 : 12	0.29	0.36	0.33	0.34	0.29 **con**	0.31	0.30	0.30	0.32	0.30	0.33	0.31	0.29 **con**	0.30	0.33	0.34	0.29 **con**	0.30
5 : 6	1.42	1.55	1.41	1.44	1.44	—	1.61	1.40	1.42	—	1.53	1.51	1.50	1.50	1.49	1.66	1.60	1.45
15 : 14	0.44	0.56	0.50	0.51	0.45	0.52	0.46	0.48	0.46	0.43	0.48	0.48	0.45	0.48	0.49	0.52	0.44	0.50

TABLE **R.**

	1	2	3	4	5	6	7
1 : 2	1.59 **am**	1.68	1.61	1.55 **am**	1.59 am	—	1.63
Difference in mm. between height and breadth of orbit	+ 5 **am**	+ 25 **am**	+ 15 **am**	+ 11 **am**	+ 9 am	— 6 **aus**	0 **am**
1 : 16.	2.60	2.83 **aus**	2.57 **am**	2.55 **am**	2.51 am	—	2.76
Situation of top $\overline{C}$ with regard to alveolar margin of $\underline{C}$	—	—	above **aus**	above **aus**	above aus	above **aus**	above **aus**
Situation of posterior border of for. infraorbitalis with regard to upper premolars	middle P^3 **am**	front P^4 **aus**	front P^4 **aus**	middle P^4	front P^4 aus	front P^4 **aus**	middle P^3 **am**

[1]) See note 2 belonging to table P.

[2]) Only M^2 and M^3 are present.

8	9	10	11	12	13	14	15	16	17	18
1.60	1.57 **am**	1.67	1.59 **am**	1.60	1.61	1.55 **am**	1.63	1.73 **aus**	1.76 **aus**	1.61
+ 1 **am**	+ 6 **am**	+ 13 am	+ 11 **am**	+ 18 **am**	+ 13 **am**	+ 18 **am**	+ 16 **am**	+ 14 **am**	+ 8 **am**	+ 10 **am**
2.80 **aus**	2.88 **aus**	2,62	2.92 **aus**	2.47 **am**	—	—	—	—	—	—
above **aus**	above **aus**	above **aus**	above **aus**	— [1])	above **aus**	above **aus**	above **aus**	above **aus**	above **aus**	above **aus**
front P^4 **aus**	front P^3	front P^4 **aus**	middle P^3 **am**	— [2])	front P^4 **aus**	front P^4 **aus**	front P^3 **am**	front P^4 **aus**	middle P^3 **am**	front P^4 **aus**

TABLE **S.**

		H. sivalensis			H. iravaticus	H. nama	
		F.A.S. pl. LXI, fig. 5	small variety ?var angustidens	typecal form	F.A.S. pl. LVII, fig. 10	F.A.S. pl. LVIII, fig. 2	F.A.S. pl. LVIII, fig. 3
		Lydekker 1884, p. 40	Lydekker 1884, p. 41 pl. VI, fig. 1	Lydekker 1884, p. 41	Lydekker 1884, p. 42	Lydekker 1884, p. 44	Lydekker 1884, p. 44
2	Length of symphysis	180	—	—	130	104	132
2	Interval between canines 1 : 2 . .	203	—	—	113	183	236
	1 : 2.	0.89	—	—	1.13	0.57	0.56
3	Depth at P_1.	117	—	—	74	110	118
4	Longer diameter of C	61	—	—	38	42	47
5	Depth of ramus at M_2.	—	107	112	—	—	—
6	Lenght of flve last cheek teeth .	—	196	216	—	—	—
7	Length of M_1.	—	31	38	—	—	—
8	Width of ditto.	—	24	33	—	—	—
9	Length of M_2.	—	43	48	—	—	—
10	Width of ditto.	—	31	39	—	—	—
11	Length of M_3.	—	56	72	—	—	—
12	Width of ditto.	—	33	41	—	—	—
13	Longer diameter of I_1	34	—	—	—	31	32
14	Longer diameter of I_2	25	—	—	—	25	23
15	Longer diameter of I_3	33	—	—	—	31	36

dicus		H. palaeindicus				Our own fossil specimens		
F.A.S. pl. LVIII, fig. 1 Lydekker 1884, p. 44	Lydekker 1884, p .44	Lydekker 1884, p. 46	Lydekker 1884, p. 46	Lydekker 1884, p. 46 pl. VI. fig. 2	type- F.A.S. pl. LVII. fig. 5 Lydekker 1884, p. 46	I Lower jaw	II Right horizontal ramus	III Fragmentary lower jaw
149	—	127	137	—	—	ca 145	ca 132	—
251	—	208	236	—	—	ca 215	ca 220	—
0.59	—	0.61	0.58	—	—	0.67	0.60	—
132	—	124	132	—	—	—	74	—
54	—	57	60	—	—	46	ca 41	—
—	—	—	—	—	—	108	103	ca 100
—	—	—	—	—	—	194	ca 198	—
—	—	—	—	—	—	35	34	—
—	—	—	—	—	—	29	28	—
—	—	—	—	—	—	32	39	33
—	—	—	—	—	—	35	32	30
—	—	—	—	—	—	55	—	48
—	—	—	—	—	—	36	34	30
33	30	46	46	50	38	—	ca 27	—
23	23	16	18	15	—	—	ca 25	—
38	34	47	46	51	47	—	19	—

TABLE T.

		MEASUREMENTS OF M³ OF													
		Fore talon		1		2		3		4		5		6	
		molar		molar		molar		molar		molar		molar		molar	
		r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
Greatest length at base of crown	A	—	—	87c	90c	96c	97c	94	—	—	95	—	—	—	—
	B	—	ca 68	—	77	—	82	—	85	—	86	—	86	—	85
	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	D	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	E	—	—	—	—	—	—	—	—	86	—	86	—	87c	—
	F	—	—	—	—	—	—	—	—	—	—	—	84	—	85
	G	—	—	—	—	—	—	—	—	—	—	86	—	85	—
	H	—	—	—	—	—	—	—	83	—	87c	—	ca 65c	—	89c
Breadth at base of crown [1]	A	—	—	—	—	24	—	24-26	—	26	—	26	—	—	—
	B	—	7–14	—	—	—	19	—	20	—	19-20	—	21	—	20
	C	—	—	—	—	—	—	—	—	—	—	19	—	19	—
	D	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	E	—	—	—	—	—	—	—	—	19	—	19	—	19	—
	F	—	—	—	—	—	—	—	—	—	—	—	ca 20	—	ca 19
	G	—	—	—	—	—	—	—	—	ca 13 [2]	—	ca 20	—	ca 19	—
	H	—	—	—	22 [3]	—	20	—	ca 20	—	—	—	—	—	—
		—	—	—	—	—	—	—	19	—	22	—	—	—	—
Height of worn or very slightly worn ridge-crest	A	—	—	56	55	59	59	—	—	—	—	—	—	—	—
	B	—	—	—	—	—	—	—	54	—	54	—	—	—	56
	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	G	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	H	—	—	—	—	—	—	—	—	—	—	—	—	—	—

A = l. and r. M³. N°. a of Janensch's table n°. 5.
B = „ M³. „ b „ „ „ „ 5.
C = „ and r. M³. „ c „ „ „ „ 5.
D = „ „ „ „ „ d „ „ „ „ 5.
E = „ „ „ „ „ e „ „ „ „ 5.
F = „ M³, our own specimen. Total length, measured along median line of crown 16,5 cm.
G = r. „ „ „ „ „ „ „ „ „ „ „ „ „ „ 17,3 „ „
H = l. „ „ of our own fragment of the cranium. Total length, measured along median line of crown 25 cm.

TABLE T.

STEGODON AIRÂWANA.

7		8		9		10		11		12		Hind talon	
molar		molar		molar		molar		molar		molar		molar	
r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
93	—	—	—	86	—	—	—	—	—	—	—	—	—
—	85	—	83	—	77	—	69	—	60	—	44	—	32
—	87	85	85	82	81	79	75	70	71	62	62	ca 45	49
—	85 c	85	85 c	81 c	84 c	77 c	80 c	69 c	73 c	—	—	—	—
84 c	—	81 c	82 c	76 c	79 c	68 c	76 c	64 c	71 c	61 c	64 c	—	—
—	83	—	76	—	72	—	68	—	65	—	56	—	—
83	—	77	—	71	—	68	—	63	—	55	—	—	—
—	82	—	80	—	74	—	66 c	—	59 c	—	n	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	20–22	—	22–23	—	20–22	—	17–19	—	16–18	—	14	—	—
19	19	19	19	19	19	19	19	19	19	ca 18	19	ca 13	13
—	21	22	22	—	—	—	—	—	—	—	—	—	—
19	—	21	21	22	21	20	20–22	ca 20	ca 21	—	—	—	—
—	ca 21	—	ca 20	—	ca 19	—	ca 18	—	ca 16	—	ca 16	—	—
ca 21	—	ca 20	—	ca 20	—	ca 18	—	ca 15	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	n	—	—
—	22	—	22	—	21	—	17	—	ca 14	—	n	—	— at buccal side — at palatinal side
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	55	—	50	—	47	—	45	—	44	—	39	—	31
—	—	—	—	—	—	—	—	—	46	—	37	—	ca 20
—	—	—	—	46	—	46	—	44	—	36	—	ca 21	—
—	53	—	55	—	—	—	—	—	—	—	n	—	—

c = cement included.

n = not developed.

[1]) I cannot see why JANENSCH gives sometimes two values, as he emphasized: "Gemessen auszen an der Basis" (p. 176).

[2]) See text p. 135.

[3]) Breadth of fore talon included.

TABLE U.

Concerning m^3 and M_1^1		Fore talon		1		2		3		4		5		6		7		Hind talon	
Concerning M_2		(x)		(x + 1)		(x + 2)		(x + 3)		(x + 4)		(x + 5)		(x + 6)		(x + 7)			
		r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
Greatest length at base of crown	A	—	—	—	—	79	—	82	80	83	82	87c	87c	88c	89c	—	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	74	75	ca 68	71	—	—
	C	—	—	ca 56	—	60	—	62	—	65	—	65	—	64	—	62	—	—	—
	D	—	—	51	54	54	54	55	56	58	58	57	57	58	—	59	—	43	—
	E	—	—	—	—	—	—	—	—	—	62	—	65c	66	66	58c	57c	—	—
	F	—	—	44	43	46c	45c	48c	48c	50c	50c	51c	51c	52	53	48	50	—	—
	G	—	—	43	—	45	—	47	—	48	—	48	—	47	—	43	—	—	—
Breadth at base of crown	A	—	—	—	—	16–23	—	16–23	—	20–23	—	24	22–23	ca 24	ca 24	ca 16–19	ca 18	—	ca 9
	B	—	—	—	—	—	—	—	—	—	—	—	—	20	20	ca 15–19	ca 19	ca 13	15
	C	—	—	—	—	18–20	—	18–20	—	18–23	—	18–23	—	15–18	—	13	—	—	—
	D	8	9	13	13	15	16	15	16	16	16	—	—	—	—	—	—	—	—
	E	—	—	—	—	—	—	—	—	16	15–17	16–18	16–18	17	18	12–15	13	—	—
	F	3–8	3–8	11–14	11–14	14	14	ca 14	ca 14	14	14	15	14	14	14	—	—	—	—
	G	ca 7	—	11–16	—	12	—	12	—	12	—	12	—	11	—	9	—	4	—
Height of worn or very slightly worn ridge-crest	C	—	—	—	—	—	—	—	—	—	—	—	—	41	—	42	—	38	—
	D	—	—	—	28	—	31	—	—	—	—	—	—	—	—	—	—	—	—
	F	—	—	—	—	—	—	—	—	—	—	—	28	29	28	28	28	—	—
	G	17	—	22	—	24	—	25	—	27	—	27	—	28	—	27	—	21	—

A = l. and r. M_2. n°. a of Janensch's table n°. 6.
B = l. and r. M_2. n°. b „ „ „ 6.
C = r. M_1, our own specimen.
D = l. and r. M^1. n°. a of Janensch's table n°. 3.
E = l. and r. M^1. n°. b of Janensch's table n°. 3.
F = l. and r. m^3. n°. a „ „ „ 2.
G = r. m^3. n°. b „ „ „ 2.
c = cement included.

TABLE V.

MEASUREMENTS OF M_3 OF

		Fore talon		1		2		3		4		5	
		molar		molar		molar		molar		molar		molar	
		r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
Greatest length at the base of the crown	A	—	ca 38	76c	76c	83c	82c	89c	86c	91	—	90	—
	B	ca 39	—	64	65	76	77	77	80	82	82	82	80
	C	—	—	—	—	—	—	—	—	83	—	81	—
	D	—	—	—	—	—	—	—	—	—	—	—	—
	E	—	—	ca 71	71	79	76	87	87	89	89	87	86
Breadth at the base of the crown.	A	ca 9	ca 12	19	16	18–22	18–22	19–23	17–26	19–24	17–26	19–23	18–23
	B	ca 10	ca 10	17	16	18	18	19	ca 18	—	—	—	—
	D	—	—	—	—	—	—	—	—	—	—	—	—
	E	12	9	20–21 [1]	16–19 [1]	21–25	24–24	23–27	24–30	18–30	22–30	18–30	20–27
Height of unworn or very slightly worn ridge-crest.	A	—	—	—	—	—	—	—	—	—	—	60	—
	C	—	—	—	—	—	—	—	—	—	—	—	—
	E	—	—	—	—	—	—	—	—	—	—	+50 [2]	+50 [2]

A = l. and r. M_3 n°. a of Janensch's table n°. 7.
B = l. and r. M_3 n°. b „ „ „ „ 7.
C = r. M_3 n°. c „ „ „ „ 7.
D = l. M_3 n°. d „ „ „ „ 7.
E = l. and r. M_3 of lower jaw of our own collection. Total length of r. M_3 (measured along the median line of the surface of the crown) 27 cm.

TABLE V.

STEGODON AIRÂWANA

6		7		8		9		10		11		12		13		Hind talon	
molar		molar		molar		molar		molar		molar		molar		molar		molar	
r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.	r.	l.
91	—	91	91	91	92	89	90	87	86	76	81	67	75	ca 53	ca 58	—	—
—	—	—	—	—	—	—	81	—	—	—	—	—	—	—	—	—	—
78	—	77	—	77	—	76	—	74	—	72	—	67c	—	ca 53	—	—	—
—	—	—	—	—	—	55	—	—	—	—	76	—	70	—	ca 60	—	ca 40
86	86	—	—	—	—	—	—	—	—	—	—	n	n	n	n	—	—
19–24	19–22	21-27	20-25	22-27	22-26	23-26	22-25	23-26	22-24	19-23	21	19	21	16	16-19	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	22	—	22	—	19	—	16	—	—
20–27	20–28	—	—	—	—	—	—	—	—	—	—	n	n	n	n	—	—
61	—	61	61	58	59	56	59	56	61	53	60	52	51	47	48	31	45
—	—	58	—	58	—	56	—	54	—	54	—	—	—	ca 42	—	20	—
+45[2])	+45[2])	—	—	—	—	—	—	—	—	—	—	n	n	n	n	—	—

n = not developed.
c = cement included.
[1]) Fore talon included.
[2]) + means more than. The base of these ridge-crests is still concealed by the bone.

TABLE W.

	DIMENSIONS OF FEMORA in cm.												
	Total height	Corpus femoris		Caput femoris		Distal extremity						Interval between outer surface of caput femoris and ditto of trochanter major.	∠ α
		Smallest breadth	Smallest girth	Diameter	Girth	Breadth between epicondyli	Girth at same level	Breadth of facies articularis patellaris	Breadth between condyli femoris	External length	Internal length		
Stegodon airâwana.	110	14	38	15	51	25	76	10	21	21	25	—	15°
Elephas maximus. Berlin . . .	100	10,5	30	—	—	—	—	—	—	—	—	—	up to 40°
Mastodon giganteus. Cambridge	90	—	32,5	—	—	—	—	—	—	—	—	—	ca 0°
N°. 1 (Our own specimens)	—	17	43	17	55	—	—	—	—	—	—	42	—
„ 2	82	10	29	12,5	39,5	ca 22	—	—	17,5	—	—	28	15°
„ 3	—	ca 9,5	ca 27	11	35,5	18	51	7,5	15	14,5	16,5	25,5	—
„ 4	75	10,5	28	11,5	36	18	49	8	15	14	16,5	23	22°
„ 5	87	12	32,5	13	42	20	56	10,5	16,5	17,5	20	28	27°
„ 6	—	10	28	—	—	—	—	—	—	—	—	—	—
„ 7	—	13	33,5	—	—	—	—	—	—	—	—	—	—

In tables W—Z "breadth" means the intero-external dimension, and "length" the antero-posterior dimension.

TABLE X.

	DIMENSIONS OF HUMERI in cm.											
		Corpus humeri		Proximal extremity		Distal extremity			Distal plane of articulation		
	Total height.	Smallest breadth.	Smallest girth.	Interval between outer surface of caput humeri and ditto of tuberculum majus.	Greatest antero-posterior diameter of caput humeri.	Breadth at level of epicondylus lateralis.	Greatest interval between ep. lat. and capitulum.	Greatest interval between ep. med. and trochlea.	Breadth.	Greatest length of trochlea.	Greatest length of capitulum.
Stegodon airâwana . . .	—	8	28	—	—	17	22	12	15,5	13	8,5
N°. 1 (Our own specimens)	88	12,5	43	24,5	22	24,5	33	18	20,5	19	14,5
„ 2 (Our own specimens)	ca68	8,5	36	—	—	—	—	12	18	14	10
„ 3 (Our own specimens)	—	11	45	—	ca 20	—	—	—	—	—	—

TABLE IJ.

	DIMENSIONS OF RADII in cm.						
	Total height	Corpus radii		Proximal plane of articulation		Distal extremity	
		Smallest breadth	Smallest girth	Breadth	Girth	Greatest breadth	Greatest girth
Stegodon airâwana . . .	—	5	14	12	27	13	36
N°. 1 (Our own specimens)	54,5	5,5	17	11	28,5	ca 12	ca 38,5
N°. 2 (Our own specimens)	53,5	5	13,5	10	26	12,5	35,5

TABLE Z.

	DIMENSIONS OF ULNAE in cm.										
		Corpus ulnae		Distal extremity		Proximal plane of articulation				Olecranon	
	Total height.	Smallest breadth.	Smallest girth.	Greatest breadth.	Greatest girth.	Greatest breadth.	Greatest width of internal, horizontal lobe.	Greatest width of external, horizontal lobe.	Interval be ween tip of proc. anconaeus and notch between ext. and int. horizontal lobes.	Greatest breadth.	Greatest interval between tip of proc. anconaeus and post surface of olecranon.
Stegodon airâwana . . .	64	7	22	10,5	33	16	—	—	—	—	—
Elephas antiquus München . . .	111	15	48,5	—	—	—	—	—	—	—	—
Mastodon giganteus. Berlin	64	8	26	—	—	—	—	—	—	—	—
N°. 1 (Our own specimens)	62,5	9	27	13,5	43	18	8	5	ca 9	17,5	ca 15,5
„ 2 (Our own specimens)	60	8	26	ca 13	ca 39	16,5	6,5	4,5	—	17	ca 15,5
„ 3 (Our own specimens)	—	7,5	25	—	—	18	7,5	5	ca 9	—	—