A FOSSIL PORPOISE FROM THE CALVERT FORMATION OF MARYLAND.

By Remington Kellogg,

Of the Bureau of Biological Survey, United States Department of Agriculture.

INTRODUCTION.

Our knowledge of the fossil cetacean fauna of the Calvert formation has hitherto been and still is very imperfect, notwithstanding the description of a number of forms by E. D. Cope. Until lately imperfect vertebrae represented our entire knowledge of most of the cetaceans described from this formation. Notwithstanding the recent explorations of the Calvert Cliffs and the acquisition of a number of skulls, detailed information as to the zonal range of the cetacean fauna is still wanting. The exact localities for the fossil cetaceans described by Cope and collected by James T. Thomas in Charles County, Maryland, have never been published. In consequence the zonal position of most of these specimens will probably remain unknown, unless subsequent discoveries show that some of the fossil cetaceans are limited in their geologic range to one zone. It is very unlikely that any cetacean had such a short geologic range.

The collection of fossil cetaceans in the United States National Museum includes a fairly representative assemblage of the cetaceans known to have frequented the Chesapeake embayment during the interval in which the Calvert formation was deposited. Most of the types of fossil cetaceans necessary to a complete understanding of this material as well as additional specimens from Tertiary marine deposits of North America have been studied. The object of the present paper is to describe a fossil porpoise collected by Norman H. Boss on one of his trips to the Calvert Cliffs on the western shore of Chesapeake Bay, Maryland.

For the privilege of describing this fossil cetacean I am indebted to C. W. Gilmore and J. W. Gidley, of the Division of Vertebrate Palaeontology, United States National Museum. For permission to examine types of fossil and living cetaceans I desire to extend my thanks to Dr. Witmer Stone and James A. G. Rehn, of the Academy

of Natural Sciences, Philadelphia; to Dr. W. D. Matthew, of the American Museum of Natural History, New York; and to Gerrit S. Miller, jr., of the Division of Mammals, United States National Museum. Dr. John C. Merriam, president of the Carnegie Institution of Washington, has kept in touch with this work as it progressed and I am indebted to him for assistance.

THE GENUS ZARHACHIS COPE.

Type.—*Zarhachis flagellator* Cope, E. D., Proc. Acad. Nat. Sci., Philadelphia, vol. 20, pp. 186, 189, 1868; vol. 21, pp. 9–10, 1869.

Type locality.—Miocene marl of Charles County, Maryland. Calvert formation. Upper Miocene.

Type specimen.—An anterior caudal vertebra. Cat. No. 11231, Academy of Natural Sciences of Philadelphia.

Cope proposed *Zarhachis flagellator* for two lumbar and two caudal vertebrae which were assumed to represent three different individuals. Three of the vertebrae mentioned in 1868 were subsequently withdrawn by Cope and referred to other species. In 1868, Cope referred the genus *Zarhachis* to the family Delphinidae, but in a later article[1] he allocated the genus with the Platanistidae. The original description consists of the following:

ZARHACHIS Cope.

This genus is established on vertebrae which bear a general resemblance to those of *Priscodelphinus*, but differ in the essential point of having flat and broad diapophyses of the caudals. It is therefore intermediate between that genus and *Delphinapterus*. The posterior of the caudals in our museum exhibits a narrowing of the diapophyses, as certain of the lumbars do in *Priscodelphinus*.

ZARHACHIS FLAGELLATOR Cope.

This species is represented by only two lumbar and two caudal vertebrae, which belonged to at least three different individuals, none of them adult. Neither is any one entirely perfect, but they indicate a very distinct species, by clear characteristics. All of these vertebrae are of greater length as compared to the diameter than in any other cetacean known by me except the great *Basilosaurus*. The lumbars, when compared with those of *T. lacertosus*, differ in their broadly obtuse median line, which offers distinct trace of the two keels. An anterior caudal either exhibits unusually broad diapophyses, which are directed downwards, or else is a lumbar with two keels, and a median groove below, which is not seen in any other species. The caudals exceed in length those of any other species. One of these, from a large individual, resembles that of *P. atropius* in the narrow basis of the diapophysis which is probably narrow, and not perforate. The length of the vertebrae is nearly double the vertical depth of the articular faces. The diapophysis is nearly median; the basis of each neurapophysis is one-half the length of the centrum, and median.

---

[1] Cope, E. D., The Cetacea. American Naturalist, vol. 24, p. 615. July 31, 1890.

	In.	Lin.
Length lumbar (epiphyses hypothetical)	3	6.5
Depth	2	2.0
Width	2	3.0
Width neural canal	2	8.0
Length caudal (one epiphysis supplied)	3	10.5
Depth caudal	2	4.0
Distance between inferior keels	....	10.5
Width basis diapophysis	....	10.5

A year later, Cope[2] corrected his original description and gave a synopsis of the characters of the species of this genus. It is evident from the following quotation that the genus *Zarhachis* as amended by Cope is not a natural assemblage.

It was stated to differ from *Priscodelphinus* in that, while some caudals had spinous diapophyses, others possessed them flat, but imperforate. A vertebra supposed to indicate the latter characters I am now compelled to refer to another species and probably genus. Other vertebra assigned to *C. flagellator* must be referred elsewhere. A lumbar vertebra represents another species of probably the same genus, while a third has evidently pertained to still a third species. The genus will be characterized by the extraordinary length and slenderness of the lumbar vertebrae, and similar, though slightly abbreviated form of the caudals. The latter have spinous diapophyses, and in one species the former also. While the width of the articular faces of the centra of these vertebrae in the typical *Priscodelphinus* is but a few lines less the length, in the species of this genus the diameter of the same is only from four-sevenths to one-half of the length. The nearest approach is made by *Priscodelphinus stenus*, where this diameter is six-sevenths of the length.

I. Median or anterior caudal with strong longitudinal keel above the diapophysis—which is therefore probably present on the distal lumbars.
Epiphysis thicker, larger ------------------------------------ *Z. flagellator*

II. No longitudinal keel on lumbars, Diapophyses broad, flat; epiphyses thin, large -- *Z. tysonii.*

III. Diapophyses narrow, subspinous; epiphyses thin, small.
-- *Z. velox.*

At this time the writer proposes to restrict the application of the generic name *Zarhachis* to *flagellator;* the allocation of *tysonii* and *velox* will be discussed in connection with other material which is now being studied. So far as the present evidence goes, there are some grounds for believing that caudal vertebrae like those of *Zarhachis flagellator* can properly be associated with the present specimen.

The caudal vertebra in the Academy of Natural Sciences of Philadelphia which appears to be the type, and is so labeled, is much worn at both ends, and the anterior epiphysis is missing. The lateral processes and the neural spine are broken off; the neural arch is com-

[2] Cope, E. D., Proc. Acad. Nat. Sci., Philadelphia, vol. 21, p. 9. 1869.

plete, the canal narrow and slitlike posteriorly and broadly oval anteriorly. This vertebra is peculiar in having the transverse processes set in elliptical depressions, divided posteriorly by a thin ridge extending back from the base of the process. This depression is bounded superiorly by a longitudinal ridge, above which is another depression at the base of the neural arch. The posterior epiphysis is thick and flat. The articular surface has about 12 or 14 radiating lines. The double keels [3] are emarginate at the middle, and the surface of the centrum between them concave. This caudal belonged to a large porpoise as is shown by the following measurements.

	mm.
Length of vertebra (one epiphysis lacking)	101
Greatest depth of centrum	59
Breadth of centrum anteriorly (worn)	55
Depth of centrum anteriorly (worn)	53
Height neural canal anteriorly	12
Height neural canal posteriorly	27
Length of base of neural arch (where margins are vertical)	41
Length of base of transverse process (about)	25
Height of depression surrounding transverse process (measured to emargination of keel below)	42

A satisfactory comparison of the present specimen and the vertebra upon which Cope based *Zarhachis flagellator*, however, is not possible as the corresponding vertebra was not found. The measurements for the lumbar vertebrae of the specimen from the Calvert Cliffs and for the caudal of *Zarhachis flagellator* bear out the assumption that they belong to the same type of cetacean. In addition to a correspondence in size of the vertebrae, there are certain structural peculiarities which favor such an association. The posterior lumbars of the fossil porpoise from the Calvert Cliffs have an elongate centrum as well as a relative narrow and deep neural canal. The neural arch does not occupy the full length of the centrum and on the largest caudal there are double ventral keels and corresponding development of the depressions on either side. There is no trace, however, of a longitudinal keel above the transverse process. The type caudal of *Zarhachis flagellator*, as remarked above, is peculiar in having the transverse processes set in elliptical depressions, but on the whole the structural features of this caudal vertebra and those of the lumbars described in the following text are of the same general type, when one takes into consideration the corresponding differences between the lumbar and caudal vertebrae of the living porpoises, *Platanista gangetica* and *Inia geoffrensis*. In addition both of these specimens were obtained from deposits belonging to the Calvert formation.

[3] Case, E. C., Miocene Atlas, Maryland Geol. Surv., Baltimore, pl. 14, fig. 3, 1904.

From the type caudal of *Zarhachis flagellator* and the specimen described in the following pages, the following characters have been derived which are considered diagnostic of the genus.

Diagnosis.—General architecture of top of skull as in *Lipotes* and resembling *Platanista* in certain details, but with a long attenuate rostrum comprising more than five-sixths of the total length of the skull. The beak is neither bowed upward, nor bent downward, but is approximately straight; the basicranial axis presumably is not strongly bent downward from the axis of beak. The internal portion of the proximal extremity of the premaxilla is thin and platelike as in *Lipotes* and *Platanista*, and does not form a convex raised anterior border to the nasal apertures as in *Inia*. For more than four-fifths of the total length of the rostrum the raised convex portions of the premaxillae are closely appressed and parallel each other to the tip of the rostrum, thus forming the roof for the mesorostral gutter. The presphenoid rises to the level of the premaxilla as in *Lipotes*. The maxillae posterior to the maxillary notches expand laterally, sheath the internal faces of the thick up-built supraorbital processes of the frontals, and partially roof over the temporal fossae. The zygomatic process of the squamosal is in contact with the post-orbitial projection of the supraorbital process of the frontal. The external pterygoids extend forward beyond the level of the maxillary notches and conceal the palatines. The nasal passages are situated anterior to the level of the anterior margins of the squamosals. There is a deep groove between the squamosal and frontal bones into which the foramen ovale opens. The total number of teeth exceeds three hundred. The first tooth on either side of the rostrum is considerably larger than any of the following teeth. The enamel crowns of the teeth are ornamented with fine longitudinal striae. The roots are slightly thickened. The ankylosed symphysial portion of the mandibular ramus equals eight-elevenths of the total length of either mandible.

The periotic bone bears a close resemblance to that of *Platanista*. The most important differences consist of a more elongated internal acoustic meatus, and a wider interval between the foramen singulare and the cerebral aperture of the facial canal. The tympanic bone also is very similar in general features to that of *Platanista*.

The hyoid bones differ from those of *Platanista* and agree in some respects with those of *Inia*. They consist of a central portion (basihyal) with large, expanded, subcrescentic wings (thyrohyals) and a pair of short, anterior, conical projections (ceratohyals). The stylohyals are free, elongate, and slightly curved.

The atlas is free and possesses both upper and lower transverse processes. The greatest length of the atlas is about one-half of the greatest width across the anterior articular facets. A pair of large vertebrarterial canals pierce the neurapophyses and in addition there are foramina for the spinal nerves. Ten dorsal and at least four lumbar vertebrae are present. As a whole the vertebral column bears a closer resemblance to *Platanista* than to any other living porpoise. The neural spines are deep, flattened, and rather squarely truncated on their upper extremities. The transverse processes of anterior caudals are set in elliptical depressions. The posterior caudals are perforated dorso-ventrally by paired arterial canals. The first seven pairs of ribs have capitula articulating with the centra as well as tubercula articulating with the transverse processes. The three posterior ribs articulate with the transverse process. The first three pairs of ribs are compressed and their necks are bent at right angles to the shafts. The eighth, ninth, and tenth ribs lack necks. The sternum resembles that of *Platanista* and differs from that of *Inia* in the absence of vertical conical processes behind the articular facets for the first ribs.

Remains of river porpoises are relatively rare in the Calvert Cliffs, and only one skull and associated skeleton have been obtained. A few imperfect vertebrae which apparently belong to the same type of cetacean have been examined by the writer, but these specimens do not warrant description. Judging by the relative quantity of remains of fossil cetaceans which have been assembled in institutions to which acknowledgments have been given, the family Platanistidae seems to have been outnumbered by long and short beaked dolphins as well as by whalebone whales during the deposition of the Calvert formation in the Chesapeake embayment.

Specimen.—Cat. No. 10485, Division of Vertebrate Palaeontology, United States National Museum. The skeleton of this fossil porpoise is incomplete. It includes a nearly complete skull. The rostrum is entire and the preservation is excellent, but most of the posterior end of the cranium, with the exception of the bones which form the vertex, was missing when the skull was collected. The lachrymals and jugals are missing and the right pterygoids are imperfectly preserved. The periotic and the two tympanic bones found with the skull are all imperfect or broken. Both lower jaws are preserved, though they are badly crushed in the region of the coronoid. The sternum is incomplete. The hyoid bones are perfect and entire. One cervical, ten dorsal, four lumbar and three posterior caudal vertebrae, as well as four chevron bones, were found associated with the skull. Sixteen ribs and eighteen bones of the paddle also belong to this specimen.

Locality.—The occurrence of the specimen is as follows: Near latitude 38° 40′ 30″ North and longitude 76° 32′ West, on the western shore of Chesapeake Bay, approximately one mile south (1,610 meters) of

Chesapeake Beach, Calvert County, Maryland. Shown on Patuxent quadrangle or Patuxent folio, No. 152, United States Geological Survey.

Horizon.—The specimen was discovered and excavated by Norman H. Boss on August 8, 1921. It was dug from the cliffs three feet (0.92 meter) above the water level. The oyster shell zone is not visible at this point, and lies below the beach level. The specimen was dug from Shattuck's zone 5 of the Calvert Miocene formation of Maryland.

It may seem surprising that the skull of this fossil porpoise manifests many of the peculiar features of *Platanista*, *Lipotes*, and *Inia.* The combination of characters is of much interest, though this form can not be considered an ancestor of any of these living genera. Although the skull of this fossil porpoise possesses more features in common with *Lipotes* than with *Inia*, there are obvious differences in the details of structural modification which are present throughout those parts of the skeleton which are available for comparison.

The resemblance of certain portions of the skulls of *Lipotes* and *Platanista* to this fossil is undoubtedly a common inheritance from more primitive ancestors. The modifications of the bones which take part in the formation of the nasal passages and the structural peculiarities of the premaxillae are essentially the same in all three skulls. This fossil skull in common with *Platanista* possesses a large expanded external pterygoid, a deep groove between the squamosal and frontal bones, a zygoma with broad glenoid surface, a supraorbital process in contact with the zygoma, maxillary teeth with narrow recurved crowns, and a peculiar type of tympanic and periotic bones.

Skulls of *Lipotes* and *Inia* may appear more specialized than that of *Zarhachis* because of the elevation of the vertex and the shifting of the nasals to a vertical position. On the other hand, the skull of *Zarhachis* is characterized by an unusually long attenuated rostrum, by the great vertical depth of the extremity of the supraorbital process, and by a zygomatic process which extends forward beyond the level of the anterior wall of the brain case and underlies the postorbital projection of the frontal. *Lipotes* possesses a rather high maxillary crest, but the extremity of the supraorbital process is relatively shallow and the rostrum is proportionately shorter than in *Zarhachis;* the frontal plate of the maxilla is nearly horizontal above the temporal fossa and the rostrum is constricted behind the tooth rows. In *Inia*, however, the outer edge of the frontal plate of the maxilla is bent upward and forms a vertical crest above the temporal fossa, the extremity of the supraorbital process is less strongly curved upward, the premaxilla in front of the nasal aperture is swollen or conspicuously convex internally, and the rostrum is not constricted behind the tooth rows.

As seen from ventral view, the nasal passages of the *Platanista* skull are far posterior to that which is normal for practically all living porpoises, for their posterior margins lie in the same level as the anterior margins of the squamosals. In skulls of *Lipotes* and *Inia*, and in practically all of the Delphinidae, the nasal passages are situated considerably in advance of the anterior ends of the squamosals. The ventral opening for the infraorbital canal in the skull of *Platanista* is considerably behind the supraorbital process and entirely within the temporal fossa. In most dolphins, including *Lipotes* and *Inia*, the opening for this canal is situated in advance of or but slightly posterior to the anterior margin of the supraorbital process of the frontal and never within the temporal fossa. The optic canal is floored by the frontal bone in *Platanista* while in *Lipotes* the ventral wall of the canal is missing.

The external and internal pterygoids project forward in front of the nasal passages in the *Platanista* skull. In skulls of *Lipotes* and *Inia*, the forward projecting external pterygoid is absent and a large expanded alisphenoid fills the space between the squamosal, parietal, frontal, and internal pterygoid. Skulls of *Lipotes* and *Inia* thus lack one of the characteristic bones of the *Platanista* skull. It is not surprising that the external pterygoid should disappear, for it arises from the *processus alaris* of the basisphenoid and in some cetaceans, including *Platanista*, prevents the ascending process (alisphenoid) of that bone from appearing in the temporal fossa. The development and pressure of air sacs in this region according to Winge may account for the final disappearance of the external pterygoid. The relations of the internal pterygoid, vomer, and maxilla to one another are described in another part of this paper (pp. 15–16).

The cavity for the brain in the skull of *Platanista* is relatively smaller than that of *Lipotes*. It does not necessarily follow that the brain of *Platanista* is either a primitive or a secondarily degenerated type. Although more than 40 years have elapsed since the publication of Anderson's notable memoir on *Platanista*, no additional information regarding the brain of this porpoise has been published. The following quotations [4] summarize the conclusions reached by Anderson.

> I may sum up this much of the cerebral anatomy by stating that, so far as the convolutions and sulci are concerned, this species of dolphin has a brain of a considerably simpler type than in the porpoise or common dolphin, tending perhaps to some of the Carnivora, though in such a slight degree as still to impress it with all the attributes of the complex convoluted cerebrum of the

---

[4] Anderson, J., Anatomical and Zoological Researches: Comprising an account of the Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875. London (1878), pp. 465, 466–467, 1879.

Cetacea. * * * All things considered, the brain of *Platanista* is wanting in the broad rotundity of the whale group generally and so marked in *Orcella*. To a very limited degree it has Elephantine characters, viz, height and moderate breath, though one can not regard it in any other light than that of a modified Cetacean form.

The eyes of the Ganges River dolphin are of small size and probably do not function beyond conveying sensory impressions of varying degrees of light and darkness. Functional eyes would be of relatively little use in the muddy waters of the Ganges River.

The relations of the basicranial bones suggest that the rostrum and brain case have been telescoped together to a greater extent than in other river porpoises. To recapitulate the evidence in favor of this observation it might be pointed out that in correlation with the rostrum being depressed below the brain case, the nasal passages have moved backward and are situated on a level with the enterior margins of the squamosals, the internal and external pterygoids extend forward to the level of the maxillary notches and thus entirely conceal the palatines, the opening for the infraorbital canal is within the temporal fossa, the zygoma is in contact with the supraorbital process of the frontal, the antero-posterior diameter of the supraorbital process of the frontal has been shortened and the process as a whole deflected obliquely forward as would be expected to result from a lowering of the rostrum, and the lachrymal has been pushed inward and its posterior projection has been wedged into the maxilla instead of being inserted between the maxilla and the supraorbital process of the frontal as in *Lipotes*. In skulls of *Lipotes* and *Inia*, the postpalatal axis bends downward from the axis of the rostrum while both axes of the *Platanista* skull lie in approximately the same plane.

Although there seems to be great diversity of opinion as expressed in the published writings of many investigators regarding the allocation of the genus *Platanista*, the majority agree that this genus bears some relationship to *Inia* and *Lipotes*. Of course, one can only surmise the incipient modifications which marked the development of those types of porpoise skulls we now know either fossil or living. In cases of the river porpoises, practically nothing is known about their past geological history. Among the living forms, *Platanista* may represent the most highly specialized type. The architecture of the *Platanista* skull in the region around the palatines, as shown above, is singularly modified in comparison with the conditions found in *Phocaena*. Skulls of *Lipotes* and *Inia* represent advanced stages of another type of cranial architecture. The basicranium of the *Zarhachis* skull closely conforms with that of *Platanista*, but the general architecture of the dorsal face of the skull and rostrum agrees with that of *Lipotes*. No comparisons can be made with *Eoplatanista* Dal

Piaz because the extremities of the supraorbital processes are missing and the cranium is very imperfectly preserved.

Whenever forms which are manifestly different from each other as regards certain structures are associated together within limited groups, it follows that such forms should possess some fundamental structures in common. Here again difficulties are obvious for each investigator naturally holds that the structures with which he is most familiar are fundamental. Usually, it is merely a question of the relative importance to be attributed to each set of structural peculiarities and what group or groups of forms will best elucidate the particular features which each investigator considers most important. In the opinion of the writer, fundamental structures are to be found in the periotic and tympanic bones of the Cetacea. In view of the peculiar combinations of characters which are found in the abovementioned genera and the general similarity of the earbones, it appears that *Zarhachis* represents one line, *Platanista* a second line, and *Inia* or *Lipotes* a third line of a common ancestral stock.

SKULL.

Dorsal view.—The general arrangement of the elements comprising the dorsal portion of this fossil skull (pl. 1) is similar to that of *Lipotes vexillifer.*[5] The differential characters of the present species are shown by the extremely long attenuate rostrum and the accompanying elongation of the ankylosed symphysis of the mandibles, the prolongation of the zygomatic process of the squamosal and of the postorbital portion of the supraorbital process of the frontal so that there is actual contact between them, and the absence of an elevated vertex.

The long, flattened, and attenuated rostrum comprises more than five-sixths of the total length of the skull and is neither bowed upward nor bent downward. Anterior to the premaxillary foramina, the premaxillæ are thick and convex; they decrease in width and in height toward the tip of the rostrum. If the homologies of the bones forming the tip of the rostrum are correctly understood, then the premaxilla extends forward beyond the maxilla as a wedge-shaped splint which is closely appressed to the large recurved front tooth. A small V-shaped indentation (15 mm. long and 6.5 mm. broad anteriorly) separates the two premaxillae at the tip of the rostrum; this indentation leads to a small canal which presumably represents the roofed over mesorostral gutter.

The inner margins of the premaxillae become closely appressed to one another at a point 165 mm. in front of the maxillary notches

---

[5] Miller, G. S., jr., A new river dolphin from China. Smiths. Misc. Coll., vol. 68, No. 9, Publ. 2486, pp. 1–11, pls. 2, 4, 6, Washington, 1918.

and continue in contact to the apex of the above-mentioned indentation at the tip of the rostrum. The premaxillae thus completely roof over the mesorostral gutter throughout most of its length. They diverge posteriorly and commence to spread apart, as remarked above, at a point 165 mm. anterior to the maxillary notches. The mesorostral channel is thus exposed for a distance of 160 mm. in front of the anterior end of the presphenoid. The raised convex portions of the premaxillae are widest just anterior to the premaxillary foramina and taper rapidly as they approach the level of the nasal passages, and disappear slightly posterior to the supraorbital processes of the frontals.

There are three pair of foramina on the distal one-third of the rostrum. No trace of similar foramina can be found in the skull of *Lipotes*, though they are present in *Inia*, but are irregularly placed and are found as far back as the maxillary notches. Since these foramina are present in pairs, measurements were taken and their relative positions are shown in the following table:

Position of the Paired Foramina near tip of Rostrum.

	First pair.	Second pair.	Third pair.
	mm.	*mm.*	*mm.*
Distance from tip of rostrum to foramen on right side.	78.0	109.5	243
Distance from tip of rostrum to foramen on left side.	92.5	115.0	258

The suture between the maxilla and premaxilla becomes obliterated in front of the third pair of foramina. A shallow groove extending forward leads from either of these foramina and follows the assumed line of fusion of maxilla and premaxilla; these grooves terminate behind the second pair of foramina. The grooves for the second pair of foramina are very short, but those for the first pair are well defined and rather deep. The latter terminate on either side anterior to the third tooth. The left premaxillary foramen is large (greatest diameter 7 mm.) and is situated approximately 48 mm. in advance of the nearest maxillary foramen. A broad and deep groove extends backward from each premaxillary foramen and crosses the premaxilla in an oblique course from internal to external margins, terminating at or near the level of the posterior face of the supraorbital process of the frontal. There are several small maxillary foramina on the left side of the skull, but only one can be found on the right side.

The vomer apparently increases in width posteriorly, but, as the rostral extension of this bone is concealed for the most part by the overhanging premaxillae, this interpretation is based solely on the short interval of mesorostral gutter exposed in front of the presphenoid. In this region the vomer forms the floor of the gutter and takes part in the formation of the lateral walls. If any reliance can be placed upon the anterior limit of the exposed vomer as seen from the ventral view of the rostrum and upon analogous relations of the same element in the skull of *Lipotes*, then the vomer disappears in the floor of the mesorostral gutter about 240 mm. in front of the maxillary notches. It appears that the vomer contributes the greater part of either wall of the mesorostral gutter in front of the presphenoid, but the corresponding surfaces of vomer and premaxillae are so smoothly mortised into one another that the actual line of contact can not be determined with any degree of accuracy. It is evident, however, that the contact between the vomer and either premaxilla has its posterior limit near the anterior end of the presphenoid. The dorsal margins of the mesorostral gutter are formed by thin plates of the premaxillae which project inward from the raised convex outer portions and whose edges are deflected obliquely upward.

The premaxillae do not closely approximate each other above the presphenoid to form a slit-like anterior border for the nasal apertures as in *Lipotes*. In consequence most of the anterior end of the presphenoid is visible. This porous bone forms a plug across the proximal end of the mesorostral gutter and rises to the level of the premaxillae above. In this last-mentioned feature, however, the skull of this fossil porpoise agrees more closely with *Lipotes* than with *Inia*.

All of the brain case posterior to the nasal passages, with the exception of a small portion which comprises the vertex, was missing when the skull was excavated. Unfortunately the ascending portion of the mesethmoid also has been largely destroyed. The small fragments of this bone which still adhere to the dorsal surface of the presphenoid show that the mesethmoid forms the partition separating the nasal passages superiorly. Both nasal passages of this fossil skull are well preserved and one is thus permitted to describe these structures in considerable detail. After a most thorough comparison with *Platanista*, *Lipotes*, and *Inia*, it was found that the relations of the various elements which enter into the formation of these passages are essentially the same in all. The mesethmoid sheathes or forms a thin veneer of bone around the dorsal face and the upper halves of the lateral faces of the presphenoid, conceals the frontal fontanelle, and extends downward in either nasal passage to meet the ascending process of the vomer. On the base of the skull the vomer extends backward across the basisphenoid.

Hence the vomer sheathes the ventral face of the presphenoid and extends upward on either lateral face to meet the descending processes of the mesethmoid. Thus the mesethmoid and the vomer line the internal walls of the nasal passages. Ventrally, the posterior, the external, and the lower portion of the anterior wall of either nasal passage are formed by the internal pterygoids. Each internal pterygoid is in contact posteriorly with the vomer and anteriorly with the ascending process of the palatine. The anterior wall of either nasal passage superiorly is thus formed by the ascending process of the palatine externally and by the posterior margin of the maxilla internally. The premaxilla contributes the uppermost portion of the anterior wall and limits the dorsal extension of the ascending process of the palatine. As remarked above, the internal pterygoid curves around the nasal passage and establishes the lower boundary of the passage.

It is difficult to determine whether or not the back of this skull originally resembled *Lipotes* although the curvature of the maxillae as far as preserved suggests that the dorsal surface of this skull must have conformed to that type of cranium. If our interpretations are correct the temporal fossae were roofed over to a large extent by the frontal plates of the maxillae. The maxillae increase in width from the tip of the rostrum posteriorly; they attain their greatest width behind the orbit. When the maxillae reach the maxillary notches they push back over the frontals and expand laterally to form the so-called frontal plates. The outer edge of either maxilla is turned abruptly upward and is closely appressed to the internal face of the "up-ended" supraorbital process of the frontal. This maxillary crest makes a right angle with the horizontal frontal plate of the maxilla; it terminates abruptly at the posterior end of the supraorbital process for the broken edges of the horizontal frontal plate of the maxilla adhere to the base of that process on the left side of the skull.

The small fragment comprising the adjoining portions of the frontals and supraoccipital represents all that is known of the back of the skull. This fragment is very important for it shows that the vertex of the skull was not strongly elevated or at least no prominent protuberance, like in *Inia* or *Lipotes*, was present. It is also evident that the maxillae were in contact with the supraoccipital and that their internal margins overlapped the frontals on the vertex of the skull. The breadth of the combined frontals on the vertex is narrower than the greatest distance between the outer walls of the nasal passages. The posterior end of the right nasal is present; it is closely appressed to the frontal and apparently slopes obliquely forward. From this it appears that the elevation of the vertex of the skull in *Inia* and *Lipotes* has been accompanied by the nasals shifting to a vertical position and consequently becoming closely appressed to that protuberance. If one attempts a restoration of the back of the skull by following the curvature suggested by that fragment of the supraoccipital which is preserved, then the area between the lambdoidal crests was higher than wide, but otherwise bore considerable resemblance to *Inia*.

Lateral view.—A narrow rostrum equaling five times the length of the cranium, a large supraorbital process forming a high crest above the orbit, a thickened zygomatic process of the squamosal, and the absence of an elevated vertex, all contribute to the formation of a skull (pl. 2) that is unlike either *Lipotes*, *Inia*, or *Platanista*. As in other long-beaked dolphins, the rostrum is formed mainly by the closely joined maxillae and premaxillae, these elements being supported internally by the anterior extension of the vomer. More than half of the lateral aspect of the rostrum is formed by the maxilla. The premaxilla is shallower than the maxilla, decreasing in height anteriorly and near the tip of the rostrum is barely visible from a side view. The axis of the rostrum is approximately straight. In this skull and in that of *Lipotes* the rostrum is noticeably broader than deep; this feature is more evident in the former than in the latter. On the other hand the rostrum of the skull of *Inia* is relatively deeper throughout its length and appears to be bent downward.

In this specimen the lambdoidal crests were apparently the highest points of the dorsal profile; in front of these the maxillae slope forward to the rostrum. The skull as a whole is very slender, and the height at the vertex is proportionately low in comparison with that of the base of the rostrum. The alveolar gutter is visible throughout its length from a side view and terminates 118 mm. in advance of the maxillary notch. The temporal fossa as restored is relatively small and equals about twice the length of the orbit.

Above the orbit the supraorbital process of the frontal is bent abruptly upward and forms a vertical crest. The maxilla also bends upward and sheathes the internal face of this crest; the external margin of the maxilla bends over and is closely appressed to the anterior and dorsal faces. The greatest vertical depth of the left supraorbital process of the frontal is 81 mm., and the greatest length is 105 mm. The crestlike portion of the supraorbital process is reduced to a mere vestige in *Lipotes*, *Inia*, and *Platanista*.

The external face of the supraorbital process slopes obliquely upward and inward. It is " fan-shaped " in outline, the anterior and dorsal margins being evenly rounded, while the posterior margin is nearly straight, and the ventral margin is emarginate. Posteriorly, the supraorbital process is drawn out into a narrow postorbital projection which slopes downward; it thus comes in contact with the zygomatic process of the squamosal and is closely appressed to that bone. The postorbital projection is exceedingly long in *Inia* and slightly shorter in *Lipotes*, but does not extend backward to the zygoma in either of these genera. On skulls of *Inia* and *Lipotes*, the lachrymal is closely appressed to the anterior face of the supraorbital process. The lachrymal and ankylosed jugal are missing on the left side of this fossil skull. Originally the lachrymal must have been inserted between the overlapping maxilla and the anterior face of the supraorbital process, as will be shown in another part of this description.

The zygomatic process of the squamosal is greatly thickened dorsoventrally in contrast to the long attenuate zygoma of *Inia* and *Lipotes*. As a whole the zygoma is robust, curved, and rather short; the dorsal surface curves gradually forward and upward. The posterior margin of zygoma is nearly straight and forms an obtuse angle with the axis of the rostrum. Correlated with this difference is the form of the glenoid cavity and the postglenoid process. The latter is relatively thin, directed backward and downward. The greatest length of the zygomatic process along the glenoid face is 99 mm. and the greatest depth is 63 mm. On the whole the zygoma bears a much closer resemblance to *Eoplatanista italica* Dal Piaz [6] than to any living river dolphin.

Ventral view.—The ventral surface of the rostrum (pl. 1) is formed almost entirely by the maxillae which meet mesally in a linear suture in front of the vomer, and extending forward parallel each other throughout the distal three-fourths of the rostrum. All of the teeth in either tooth row are lodged entirely in the maxillae. The maxillae broaden from the tip of the rostrum to the maxillary notches. The rostrum is not narrowed between the tooth rows and the maxillary notches as in *Lipotes*. The lateral borders of the maxillae establish the margins of the rostrum and posterior to the tooth rows these margins are thin and bladelike. The rostrum is emarginate at the tip, the sides of the notch being formed by the premaxillae, small splintlike processes of which extend forward beyond the maxillae. On either side the premaxillae are not visible from a ventral view posterior to the first tooth. Posteriorly, as remarked above, the maxillae separate to allow the keel of the vomer to appear between them. This keel of the vomer is continued backward, and increasing in height, attains its maximum depth at nasal passages and then abruptly subsides.

Posteriorly the maxillae are overlain by the external pterygoids. Near the proximal end and in a middle line each maxilla comes in

[6] Dal Piaz, G., Gli odontoceti del Miocene Bellunese. Parte Quarta. Eoplatanista Italica. Memorie dell'Istituto Geologica della R. Universita di Padova, vol. 5, pl. 1, fig. 1, 1916.

contact with the internal pterygoid, a flattened wedge-like bone which is in contact externally with the external peterygoid. The opening for the infraorbital canal appears in the maxillary bone in front of the nasal passages but posterior to the maxillary notch.

On the ventral surface of the skull the vomer surrounds the prephenoid and entirely conceals it from view. It extends backward across the basisphenoid, but, since the basicranial portion of this skull is missing, the posterior limit can not be determined. The vomer is deepest at the nasal passages and in consequence this portion of the skull is characterized by a prominent keel. This keel increases in height posteriorly and attains its greatest depth immediately in front of the nasal passages; it flattens out anteriorly at the level of the last tooth. The concave areas on the maxilla on either side of this keel extend forward to the tooth rows, while in *Lipotes* they terminate 155 mm. posterior to the tooth rows.

The peculiar features and modifications of the bones surrounding the above-described keel may be compared with *Platanista* and *Lipotes*. Unfortunately, some uncertainty exists as to whether or not the type skull of the Chinese river dolphin [7] has been damaged. The irregular edges of the descending plates or fortuitous projections of the maxillae indicate that part of these bones are missing. If they were complete, they would inclose pyramidal cavities similar to those possessed by this fossil skull. The relations between the vomer, the internal pterygoids, and the palatines are essentially the same in all three genera. It should be noted that the maxillae of *Platanista* and *Lipotes* meet mesially in a linear suture at level of last tooth and thus conceal the keel of the vomer in front of the nasal passages. In this fossil porpoise the keel of the vomer appears between the maxillae.

On the left side of this fossil skull (pl. 2) the external pterygoid extends forward 112 mm. in advance of the posterior wall of the nasal passage. This bone also extends backward beyond the nasal passage; it is bounded by the maxilla anteriorly, by the squamosal posteriorly, and by the frontal superiorly. In these respects the approach is directly toward the relations existing between these bones in the skull of *Platanista* (pl. 6). One of the distinguishing features of skulls of *Platanista* and of this fossil porpoise, as compared with skulls of *Lipotes* and *Inia*, is the expansion of the external pterygoid. In consequence the alisphenoid is not exposed on the side of the skull in the temporal fossa.

---

[7] Miller, G. S., jr., A new river dolphin from China. Smithsonian Misc. Coll., vol. 68. No. 9, Publ. 2486, pl. 6, Washington, 1918.

In *Platanista*, the palatines are entirely concealed by the overlying external and internal pterygoids; the latter extend forward to the level of the preorbital projection of the supraorbital process. The vaginal plate of the internal pterygoid is suturally united with the vomer posteriorly. The thin plate of the internal pterygoid curves around the nasal passage and meets the maxilla mesally; it then turns abruptly and extends forward beneath the external pterygoid. That portion of the internal pterygoid which lies anterior to the nasal passages is closely appressed to the palatine and the maxilla above; the external margin is fused with the corresponding margin of the external pterygoid. As a result a cavity is formed between the internal and external pterygoids, the opening being along the keel. When the internal and external pterygoids are removed, the palatine is exposed (pl. 5). The peculiar position of the palatine has been pointed out and discussed by Eschricht and Anderson. It has been reduced to a small elongated bone whose antero-posterior diameter is about equal to the diameter of the corresponding nasal passage. The palatine is closely appressed to the maxilla and these two bones combined form the anterior wall of either nasal passage. While similar relations between the palatine, maxilla and internal pterygoid are maintained in skulls of *Lipotes* and *Inia*, the palatine, however, is not entirely concealed by the internal pterygoid.

The similarities and differences obtaining between *Platanista* on one hand, and *Lipotes* and *Inia* on the other have been fully discussed above. Detailed comparisons have shown that the relations of the various bones in the basicranium of this fossil skull are in agreement with *Platanista*. One detail could not be satisfactorily determined from this fossil skull and that is the exact relations between the internal pterygoid and the external pterygoid near their anterior extremities.

The thickened edge of each internal pterygoid appears in the interval between the lower edge of the external pterygoid and the keel of the vomer. Slit-like apertures appear on either side between the keel of the vomer and the exposed edges of the internal pterygoids. It is possible that these apertures may be the result of distortion brought about by crushing. The pyramidal cavity which is thus formed on ether side of the keel is bounded on the inside by the internal pterygoid, on the outside by the external pterygoid, and at the rear by that portion of the former which curves around the nasal passage.

After making careful comparisons between this fossil skull and those of *Lipotes* and *Inia*, it was found that differences were observable in the size and relations of the various bones which comprise the outer wall of the cranium. In these details, however, the approach is directly toward the conditions existing in the skull of *Platanista.* In the latter, however, the position of the lachrymal with reference to the inferior opening of the infraorbital canal is somewhat different. The squamosal is relatively large, but the internal portion which forms part of the outer wall of the cranial cavity is largely missing. The lateral projection of the squamosal forms the forward projecting zygomatic process and the downward projecting postglenoid process. The left zygomatic process is complete; its greatest width is 61.5 mm. and its greatest length is approximately 100 mm. As seen from the ventral view, the zygoma is robust and short in comparison with *Inia.* On the other hand, the zygoma bears a close resemblance to that of *Platanista* and this similarity is accentuated by the contact between it and the supraorbital process of the frontal.

The glenoid surface extends forward upon the zygomatic process; it is rather wide, concave antero-posteriorly, and is limited externally and anteriorly by a distinct outer margin. The external auditory meatus, which commences at the postero-internal margin of the squamosal, apparently, does not wind around the postglenoid process of that bone for no groove can be found. The postglenoid process is directed backward and downward and does not curve forward as in *Lipotes.* The posterior portion of the glenoid articular surface of the Chinese river dolphin skull is deeply concave; in consequence the articulation with the lower jaw is restricted to a narrow area. Such is not the case with this fossil skull, for this portion of the glenoid articular surface is almost flat. On the left squamosal at the inner side of the glenoid area there is a shallow groove which commences behind the postglenoid process, but which does not extend forward to the anterior margin of the glenoid process of the squamosal as in *Lipotes.*

The origin of or possible use for a peculiar shelf formed between the upper margin of the squamosal and the frontal is difficult to explain. A similar groove is present in the skull of a young *Platanista* (Cat. No. 172409, U. S. Nat. Mus.), but this structure does not occur in *Inia* or *Lipotes.* In this fossil skull the shelf and groove (pl. 4) formed by it extends forward to the anterior margin of the supraorbital process of the frontal; it is thus bounded inferiorly by the squamosal and the external pterygoid. The groove is much shorter in the *Platanista* skull and terminates anteriorly at the level of apex of glenoid portion of squamosal; the foramen ovale opens into this groove. In the left temporal fossa of this fossil skull the external pterygoid comes in contact with the squamosal and the maxilla; these two bones combined limit its ventral expansion. Posteriorly, the external pterygoid sends a process forward and upward to meet the frontal.

Certain foramina are present in the skull of *Platanista* which are apparently absent in this fossil skull. No information regarding these foramina can be secured from the right side of the cranium for it has been completely destroyed, and the imperfect preservation of the left side may possibly explain the failure to identify these foramina there. Between the external pterygoid and the frontal there is a small opening which may represent the sphenorbital fissure.

The lachrymal is missing completely on the left side of the skull, but fragments of this bone are present on the right side. A small fragment of the lachrymal is wedged in between the maxilla and the right supraorbital process of the frontal; a horizontal, flattened, proximal piece must have filled in the space between the anterior margin of the frontal and the ventral plate of the maxilla. On the left maxilla and internal to the maxillary notch three oblique grooves are plainly visible. These grooves represent the sutures for the jugal which in turn was ankylosed to the lachrymal, as will be shown below. These three features show that the lachrymal when complete must have maintained approximately the same relations with the surrounding bones as exist in the skull of *Lipotes*.

In the skull of *Lipotes*, the lachrymal is an elongate bone which commences internally behind the opening for the infraorbital canal, and occupies the interval between the frontal and the ventral plate of the maxilla. It extends outward and its distal extremity is closely appressed to the anterior face of the supraorbital process of the frontal. The lachrymal thus forms the outer margin for the so-called maxillary notch. The jugal is fused with the lachrymal and is suturally united to the maxilla at the maxillary notch. It is thus evident that the skull of the living genus *Lipotes* and that of this fossil porpoise possess lachrymals which are essentially the same both in shape and in relation to the surrounding bones. It should be noted, however, that in this fossil skull the outer margin of the maxillary notch is formed entirely by the maxilla. The distal end of the lachrymal is very thin and is merely a wedge between the anterior face of the supraorbital process of the frontal and the maxilla.

Measurements of the skull.

	mm.
Total length (estimated)	1,195.
Length of rostrum (maxillary notches to tip of beak)	1,000.
Breadth of skull across zygomatic processes of squamosals	268.
Height of skull (basisphenoid to vertex, estimated)	122.
Height of rostrum at level of maxillary notches	80.
Total length of maxilla (estimated)	1,125.
Greatest breadth of right premaxilla in front of nares	42.
Greatest breadth of left premaxilla at maxillary notch	37.5
Breadth of rostrum at maxillary notches	155.
Breadth of rostrum at proximal end of alveolar rows	98.
Breadth of rostrum at extremity	25.
Distance between inner margins of maxillae on vertex	28.3
Greatest breadth of left supraorbital process of the frontal	105.
Greatest dorso-ventral depth of left supraorbital process of frontal	81.
Greatest breadth of braincase between temporal fossae (estimated)	106.
Length of exposed frontals on vertex	42.
Breadth of exposed frontals on vertex	23.
Length of right zygoma	100.

PERIOTIC.

In general appearance the periotic of this fossil porpoise agrees more closely with *Platanista gangetica* (Cat. No. 23456, U. S. Nat. Mus.) than with *Inia geoffrensis* (Cat. No. 49582, U. S. Nat. Mus.) It is not distinguished from that of *Platanista* by any sharply marked features other than the possession of a larger fenestra ovalis, a more elongated internal acoustic meatus, and a wider interval between the foramen singulare and the cerebral orifice of the facial canal.

The posterior process is missing as the periotic is broken just posterior to the fenestra ovalis. In case of some of the living dolphins the posterior process is frequently damaged when an attempt is made to remove the periotic bone from the skull and the destruction of the back of the cranium may account for the loss of the posterior process of the periotic of this fossil porpoise. The internal and central portion of the periotic represents the *pars cochlearis.* As a whole, this structure is obliquely compressed dorso-ventrally and is less convex than that of either *Platanista* or *Inia;* the posterior portion is slightly elevated. The fenestra rotundum is large, and internally a thin partition of bone separates it from the *scala vestibuli.* A crescentic fissure following the course of the *scala vestibuli* is present on the internal margin of this partition and this also corresponds in its position to that of *Platanista.* In this periotic the fenestra rotundum is more or less ovoidal in outline, but in a second specimen the orifice is distinctly circular. The posterior face of the *pars cochlearis* is rather abruptly truncated above the fenestra rotundum.

The fenestra ovalis is relatively much larger than in *Platanista*, oval in outline, and extends downward upon the lateral face of the periotic. No stapes is present and it is evident that this element did not completely fill the fenestra ovalis with its foot plate. In this feature also this periotic agrees with *Platanista*, for in the latter the foot plate of the stapes is held in position by an annular ligament. The foot plate of the stapes completely fills the fenestra ovalis in the periotic of *Inia* and is firmly lodged. The groove for facial nerve leads directly to the epitympanic orifice of the facial canal as in *Inia* and thus differs from the type of groove present in *Platanista*. Only that portion of the fossa for the stapedial muscle which extends downward on the external face of the *pars cochlearis* is preserved on this periotic, the remainder having occupied the process which is missing. A characteristic feature of the tympanic face of this periotic is the large swollen tuberosity on the anterior process. The fossa for lodging the head of the malleus is large, rectangular in outline, and situated in the same relative position as in *Platanista* and *Inia*, but extends inward beyond the epi-tympanic orifice of the facial canal. A rather deep but narrow groove for the external auditory tube appears to have been present between the above-mentioned tuberosity and the posterior process. The anterior end of the *fossa incudis* is present.

The anterior process is rather long and is directed obliquely inward; it is thickened dorso-ventrally and compressed laterally, but its ventral and dorsal surfaces are curved and form a bluntly pointed apex at the antero-ventral angle. On the external face of the anterior process is a deep V-shaped groove or crease. An elongate concave articular facet occupies a considerable portion of the ventral face of the anterior process; this facet supports the outer lip of the tympanic bone. It is possible for the uncinate process or accessory ossicle of the tympanic bulla to curve around the posterior face of the anterior process of the periotic (pl. 7, fig. 6), paralleling conditions present in that of *Platanista* (pl. 7, fig. 5) and thus differing from that of *Inia*. In the last mentioned genus the accessory ossicle is lodged in a depression in front of the fossa for the head of the malleus.

The resemblance between the periotic of this fossil porpoise and that of *Platanista* is even more striking when these bones are viewed from the cerebral side. The *tractus spiralis foraminosus*, the cerebral orifice of the facial canal, and the foramen singulare all lie within a common fossa, which is compressed anteriorly and pyriform in general outline. The *tractus spiralis foraminosus* is well defined and at the end of the spiral is the foramen centrale. Anterior and internal to the *tractus spiralis foraminosus* is the cerebral orifice of the facial canal. The position of the foramen singulare corresponds more closely with *Inia* than with *Platanista*. In the latter, the foramen singulare is present as a minute opening on the posterior wall of the facial canal. In the periotic of this fossil porpoise, the foramen singulare is situated relatively nearer to the spiral tract although a low partition separates these structures. The cerebral orifice of the *aquaeductus vestibuli* is of moderate size and elongate; the orifice is situated external and slightly posterior to the internal acoustic meatus as in *Platanista*. A narrow isthmus of bone lies between the cerebral orifice of the *aquaeductus cochleae* and the fenestra rotundum; the canal is relatively large. In both *Inia* and *Platanista* the *aquaeductus cochleae* and its cerebral orifice are very minute. The cerebral orifice of the aquaeduct of the cochlea in this fossil periotic is situated 2.6 mm. from the internal acoustic meatus and at least 4.5 mm. from the same orifice of the *aquaeductus vestibuli*. The *pars vestibularis* is relatively small, with the exposed faces rounded, and largely concealed ventrally by the processes which arise from it.

Measurements of the periotic bone.

	mm.
Greatest length of periotic (tip of anterior process to broken posterior margin)	33.5
Greatest depth of labyrinthic region of the periotic	11.5
Greatest breadth of labyrinthic region of the periotic	19.5

TYMPANIC.

Neither one of these two tympanics is entire. The thin brittle outer lip which arches over the involucrum and the slender processes which project from it are frequently damaged when the tympanic is broken away from the periotic, even in case of the living purpoises. Since the processes which join the tympanic to the periotic are very slender, one may expect to find many broken and otherwise imperfect tympanic bones.

The left tympanic is badly broken, and some of the missing pieces were not found in the matrix. The fragments which were found have been fitted together (pl. 7, fig. 2), but no restoration has been attempted. Comparisons were made with the tympanic bones of some 20 genera of living dolphins and only 1 genus, *Platanista* (pl. 7, fig. 1), exhibited any marked agreement. The tympanic bones of this fossil porpoise and *Platanista* are very similar in general features, even to the matter of size. Among the other living dolphins available for comparison, *Inia* showed the closest approach to this type of tympanic. It is unfortunate that the type skull of *Lipotes vexillifer* lacks both tympanic and periotic bones.

Although imperfect, the left tympanic bone of this fossil porpoise is sufficiently entire to show the size and direction of the anterior outlet or the tympanic aperture of the eustachian canal. The anterior end of the tympanic is drawn out into a narrow laterally compressed process which is directed forward and downward. This process is missing on the right tympanic (pl. 7, fig. 4), but the thin outer lip is practically entire. In *Platanista* (pl. 7, fig. 3) the inferior margin of the outer lip of the bulla turns abruptly and curves inward, forming a shelf. This modification, apparently, was not present on the tympanic of this fossil porpoise.

The tympanic cavity, which is bounded by the overarching outer lip and by the involucrum, is essentially similar to that of *Platanista*. The anterior process of the tympanic, which unites with the periotic, is broken off at the level of the outer lip. When viewed from the external side, the posterior margin of the tympanic is seen to be more rounded than in *Platanista*, the *processus sigmoideus* is longer, and the tympanic as a whole is relatively deeper. The *processus sigmoideus* of the right tympanic (pl. 8, fig. 2) is entire, the terminal half being twisted at right angles to the basal. The groove on the external face of the tympanic anterior to the *processus sigmoideus* is relatively broader than in *Platanista* (pl. 8, fig. 1). The so-called posterior conical apophysis is shorter than in *Platanista*, but otherwise the relations between this apophysis and the *processus sigmoideus* are essentially the same in both genera. The apophysis projects above the level of the superior face of the involucrum.

The posterior process (pl. 7, fig. 2) is broken off at the level of the involucrum. The broken edges show that it projected from the posterior end of the tympanic and that the outer lip and the involucrum contributed to its formation as in *Platanista*. The thick convex involuted portion of the tympanic is slightly and unequally depressed below the level of the overarching outer lip and subsides rather abruptly just posterior to level of the anterior process of the outer lip, while the anterior portion becomes decidedly concave internally. The surface of the thickened or posterior portion of the involucrum is constricted or depressed medially on its internal and dorsal faces.

The ventral surface of the tympanic exhibits a deep groove which is most pronounced near the posterior margin. In *Platanista* (pl. 8, fig. 3), however, this groove is not open, but is filled in with spongy bone. When viewed from the ventral side the outer margin of the bulla (pl. 8, fig. 4) is seen to be biconvex and much broader anteriorly than in *Platanista*. The anterior and posterior margins of the bulla do not slope as strongly from the external to internal faces as they do in the living genus.

In regard to the slight differences which are observable in the tympanic and periotic bones of this fossil porpoise and *Platanista*, one is encouraged to conclude that there must be a closer relationship existing between these dolphins than with the Delphinidae.

Measurements of the tympanic.

	mm.
Greatest length of left tympanic bulla	52.5
Greatest width of right tympanic bulla	27.6
Greatest depth of right tympanic bulla on internal side	20
Greatest depth of right tympanic bulla on external side (ventral face to tip of *processus sigmoideus*	36.5

MANDIBLES.

One distinguishing feature of the combined lower jaws (pl. 3) of this fossil porpoise, as compared with jaws of *Platanista*, *Inia*, and *Lipotes*, is the great length of the symphysis. The free portion of either mandible is less than one-third of its total length. The combined lower jaws taper toward the tip, the width at the proximal end of the symphysis being equal to more than four times the width at extremity. The depth of either mandible at proximal end of the symphysis is nearly three times that at the extremity. There is a conspicuous median longitudinal groove between the tooth rows on the posterior one-half of the symphysis. The distance from the symphysis to last tooth is much less than distance between same tooth of opposite rows.

Back of the symphysis the ramus consists mainly of a thin shell of bone. The external wall of the ramus is continued backward to form the coronoid process, the condyle, and the angle. The internal wall of the right ramus terminates 183 mm. behind the symphysis; at this point the inferior dental canal enters the mandible. Between the symphysis and the terminus of the internal wall the ramus is hollow; the depth of the cavity at the proximal end as estimated is equal to approximately four times that at the symphysis.

The superior margin of the mandible gradually rises from the symphysis to the coronoid, and is accompanied by a downward curvature of the inferior margin. In consequence the coronoid as originally preserved was deep and somewhat convex on the external face. As a result of crushing, the posterior one-third of both mandibles show a longitudinal fracture at the level of the condyle. The lower portions of each of these mandibles as shown on plate 3 are thus pushed inward and lie in a horizontal position. For this reason some allowance must be made in estimating the depth of the mandible at the coronoid. It appears that the depth through the coronoid (135 mm. estimate) is equal to less than one-half of the free portion of the left mandible. The coronoid is broadly rounded, while the angle is abruptly truncated. The condyle is large, flattened, and slopes obliquely backward; the external margin projects laterally beyond the plane of the coronoid.

When viewed from the ventral side (pl. 3) the symphysial region is seen to be much broader than that of *Lipotes*. A pair of longitudinal grooves incloses a raised ridge which diminishes in height and in width anteriorly. Eight or more foramina open into each of these grooves. The grooves extend forward to the tip of the symphysis, but on the distal 75 mm. they are reduced to very narrow channels. Posteriorly, they extend backward a short distance beyond the symphysis.

Measurements of the mandibles.

	mm.
Length of right mandible (condyle to tip)	1,097.0
Length of left mandible (condyle to tip)	1,120.0
Greatest breadth of combined mandibles at extremity	18.0
Greatest depth of combined mandibles at extremity	9.3
Greatest breadth of combined mandibles at proximal end of symphysis	90.0
Greatest depth of combined mandibles at proximal end of symphysis	27.0
Greatest depth of right mandible at level of proximal alveolus	21.5
Greatest depth of left mandible at level of proximal alveolus	21.7
Greatest length of ankylosed symphysial portion of ramus	803.0
Length of right alveolar row	820.0
Length of left alveolar row	845.0
Depth of mandible at coronoid (estimated)	135.0
Depth of condyle of left mandible	45.0

TEETH.

The anteriormost pair of teeth on the rostrum is considerably larger than any of the following teeth, but the form of the crown and the character of the enamel are essentially the same in all of the teeth preserved. Nineteen teeth are in place on the right side of the rostrum. Of the mandibular teeth 13 are in place on the right side and 12 on the left side. The alveoli are distinct and anteriorly are arranged in pairs. The alveoli number 87 on the right side and 86 on the left side of the rostrum; 70 alveoli are present on the right and 72 on the left mandible.

The total number of teeth present originally was about 315, of which 45 or about one-ninth are preserved. This fossil skull possessed more than twice as many teeth as an average *Platanista* skull; the anterior teeth are relatively shorter than the same teeth of *Platanista* and all project strongly beyond the sides of the rostrum and lower jaws. The teeth of *Lipotes* project to some extent beyond the sides of the rostrum and mandibles, more so than in *Inia*, but not so strongly as in this fossil skull. The anterior teeth of this fossil skull are noticeably larger and longer than the posterior teeth. The second tooth on the left side possesses the longest enamel crown (10 mm.), while the first tooth on the right side has the broadest crown (5 mm.). The smallest tooth has an enamel crown 7 mm. long and a maximum diameter of 3 mm.

Skulls of *Lipotes* and *Inia* possess teeth whose enamel crowns are strongly rugose. The surfaces of the enamel crowns of these fossil teeth are ornamented with fine longitudinal striae; those of a young *Platanista* skull are smooth. In case of old individuals of *Platanista* the enamel crowns of the teeth almost always show the effects of wear and on many of the teeth the enamel is entirely missing. The crowns of the teeth of this fossil porpoise and those of *Platanista* are compressed antero-posteriorly. There is no well defined neck between the expanded portion of the root and the enamel crown. The swollen part of the root of many of the teeth has a greater diameter than that of the crown. There is no indication of a cingulum. The distal extremities of the roots are slender, elongated, and curved backward. The mandibular teeth are similar to the maxillary teeth in form, but the crowns of the posterior teeth are relatively smaller.

HYOID BONES.

The hyoid bones bear some resemblance to those of the Delphinidae, especially *Phocaena*. Although the basihyal and the two thyrohyals are ankylosed (pl. 9, fig. 1), the sutures between the component parts are apparent. The central portion (basihyal) is strongly compressed dorso-ventrally and possesses two short, anterior, conical projections (ceratohyals) which were joined in front by cartilage with the elongate stylohyals. The expanded lateral wings (thyrohyals) of the hyoid bone curve backward and upward, but their distal ends are bent downward. These thyrohyals are subcrescentic in outline, relatively thin, concave superiorly, and convex inferiorly. Internally there is a slight elevation or ridge which marks the line of fusion of thyrohyal with the basihyal. The antero-external margin of either thyrohyal is recurved and to it were attached the stylohyoid ligaments.

The ankylosed basihyal and the two thyrohyals of this fossil porpoise are similar in some respects to those of *Inia geoffrensis*. They differ widely from the figure given by Anderson[8] for those of *Platanista*, which shows the thyrohyals dilated at their basihyal ends instead of mesially, the presence of free elongate rodlike ceratohyals, and the absence of posterior projections on the basihyal. Small posterior projections are present on the basihyal of this fossil hyoid.

---

[8] Anderson, J., Anatomical and Zoological Researches: Comprising an account of the Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875. London (1878), p. 528 pl. 40, fig. 20. 1879.

The stylohyals (pl. 9, figs. 2–3) are decidedly more like those of *Inia* than those of *Platanista*. Each is an irregular elongate bone, slightly curved upward and suddenly curving forward at the distal end. The anterior edge for its greater part is rounded and the posterior margin compressed so that a cross section of the stylohyal would be somewhat ovoidal. These bones are nearly a third again as long and twice wider than are the flattened stylohyals of *Inia geoffrensis*.

Measurements of the hyoid bones.

	mm.
Greatest length of central portion (basihyal)	36.0
Antero-posterior width across ceratohyals (outside measurement)	36.5
Greatest thickness of thyrohyal at distal end	9.0
Greatest breadth of thyrohyal	49.0
Greatest length of thyrohyal (postero-internal margin to tip)	107.5
Greatest length of left stylohyal	153.5
Greatest breadth of left stylohyal	21.5

CERVICAL VERTEBRA.

All of the cervical vertebrae except the atlas are missing. The atlas is complete and agrees in some respects with the cervical described by Cope and by Case[9] as *Priscodelphinus grandaevus*, but is much larger. While agreeing with the atlas of *Inia geoffrensis* in the presence of both upper and lower transverse processes, it differs in many details of form, some of which may be attributed possibly to individual variation. The atlases of *Lipotes* and *Platanista* have lost the upper transverse process (diapophysis) and the lower one (parapophysis) is considerably shorter. In the living river dolphins a free atlas is accompanied by separated cervicals.

This fossil atlas is relatively deep antero-posteriorly, the length (66 mm.) being about one-half of the greatest breadth (113.5 mm.) across the anterior articular facets. The facets for the occipital condyles (pl. 12, fig. 4) are concave, broader above than below, and inclined obliquely outward. They are separated inferiorly by a rather wide interval (18 mm.). The neural arch is not strongly elevated and is broad antero-posteriorly. On either side the neurapophysis (pl. 8, fig. 5) is pierced by a large elliptical vertebra-arterial canal. The neural arch may have borne a low, blunt spine for a longitudinal rugose area which appears to represent its base is present.

The upper and lower transverse processes project backward. The upper transverse process is broad and flattened dorso-ventrally; the posterior margin is rounded while the anterior is thin and blade-like.

[9] Case, E. C., Miocene Text, Maryland Geol. Surv., Baltimore, p. 15, pl. 12, figs. 1*a*, 1*b*, 1*c*, 1904.

On the dorsal surface of the upper transverse process and adjacent to the large canal is a depressed area. A small circular foramen connects this area with the vertebrarterial canal, and may represent the foramen for the exit of the spinal nerve. The lower transverse process is rounded and attenuated.

The posterior articular facets (pl. 12, fig. 3) for the axis are elongate with nearly straight vertical external margins and are indistinctly set off from the posterior face of the centrum. The hyapophysial process is short, thick, and irregularly pitted or roughened.

Measurements of cervical vertebra (in millimeters).

Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	89.5
Anterior breadth of spinal canal	53.5
Median depth of spinal canal (anteriorly)	47.0
Distance between tip of one lower transverse process (parapophysis) and tip of opposite one	121.0
Greatest distance across vertebrae between outside margins of anterior articular facets	113.5
Greatest height of articular surface for condyle	53.2
Greatest breadth of articular surface for condyle	30.0
Distance across vertebra between tips of upper transverse processes (diapophyses). (Outside measurement)	131.0
Greatest length of superior face (neurapophysis) of vertebra	37.5
Greatest diameter of vertebrarterial canal	14.2
Distance from anterior face (inferiorly) to tip of spinous process (posteriorly)	39.0
Greatest length of lateral face of vertebra	67.5
Distance from tip of upper transverse process (diapophysis) to tip of lower transverse process (parapophysis). (Outside measurement)	64.0

DORSAL VERTEBRAE.

Comparisons have been made between this vertebral column (pl. 10) and those of *Inia geoffrensis* (Cat. No. 49,582, U.S.N.M.) and *Platanista gangetica* (Cat. No. 172,409, U.S.N.M.) Ten dorsal vertebrae are preserved and represent a continuous series. With the exception of the fourth dorsal (pl. 13, fig. 2) which lacks the anterior epiphysis, all of them are practically complete. The dorsals differ noticeably from those of *Inia* and to a less extent from those of *Platanista.* Unfortunately the only skeleton of *Platanista* available for comparison belongs to a young individual. The vertebral column of *Inia* includes thirteen dorsals and three lumbars while that of *Platanista* includes ten dorsals and eight lumbars. As remarked above ten dorsals are known for this fossil porpoise and in addition it possessed at least four lumbars.

These dorsals differ noticeably from all the dorsal vertebrae described by Cope and Leidy, not only in size, but also in structure. They also differ from many recent delphinoids in that the neural spines are nearly vertical instead of being strongly inclined backward or forward (*Inia*). In the first three dorsals the antero-posterior diameter of the spine at the tip is somewhat less than at the base, this being especially noticeable in the first dorsal. The neural spines of the remaining dorsals, however, are of approximately the same depth throughout. In this respect they resemble the dorsals of *Platanista* more closely than those of *Inia* or any other recent species available for comparison.

The anterior dorsal vertebra of this fossil porpoise presents the majority of those features which characterize the first dorsals of *Inia geoffrensis* and *Platanista gangetica.* This vertebra agrees with that of *Inia* in the general appearance of the transverse process and the position of the articular facet for the tuberculum of the first rib, but differs in the great depth of the centrum and the relative width and height of the neural spine.

The anterior dorsal is peculiar as regards the dimensions of the centrum which is almost as long as broad. The epiphyses are relatively thin. There is a distinct oval facet for the accommodation of the head of the second rib on the postero-superior lateral margin of the centrum. The neural arch is low, broad, and thin, with a lateral transverse process on each side which bears an articular facet for the accommodation of the tuberculum of the first rib. The articular facet on the transverse process for tubercle of rib is horizontal, that is it is situated on the inferior face of this process. If any reliance can be placed on the position of this articular facet, then this is actually the first vertebra of the dorsal series.

Compared with the same vertebra in a young *Platanista* skeleton, the principal differences are as follows: The centrum is longer, but not so compressed dorso-ventrally; the neural canal is much larger; and the posterior margin of the neural spine is more arcuate.

In this fossil series of dorsals, the centra increase perceptibly in length from the first to the last. The prezygapophysial facets of the first six dorsals are nearly horizontal in position while those of the last four (pl. 13, fig. 1) are oblique. In the first six dorsals the articular surface for the accommodation of the postzygapophysis is circular; in the others this surface is nearly oval. These facets for the postzygapophyses (pl. 13, fig. 2) are situated on the superior face of the upturned margin of the laminae in front of and below the point where the metapophyses arise. As we go backward along the series they gradually shift from a horizontal to a lateral position.

The prezygapophysial facets are wider apart and are more divergent than the postzygapophysial facets (pl. 14, fig. 2). The metapophyses project beyond the epiphyses of the centrum throughout the series while in the case of the postzygapophyses, with the exception of the first four dorsals, such is not the case. The metapophyses also rapidly increase in size from the seventh to the tenth dorsals and beginning with the seventh dorsal project obliquely upward.

The second and third dorsals are very similar in appearance to the first. The most apparent differences are the increase in distal width of the neural spines and the shifting of the articular facet for tubercle of rib to a more lateral position on the transverse process.

The fourth (pl. 13, fig. 3), fifth, and sixth dorsals possess deep neural spines and their anterior and posterior margins are slightly curved. The transverse processes are well developed and project forward in the first six dorsals. Anteriorly they arise high up on the neural arch and when followed back gradually shift their position on the vertebrae until on the tenth dorsal they project from the middle of the centrum. On the tenth dorsal, the transverse process and its articular facet for the tuberculum of rib are directed backward. The external face of the transverse process is deeply excavated, furnishing a broad concave articulating surface for the accommodation of the tuberculum of the corresponding rib. On either side of the centrum of the first six dorsals, just anterior to the posterior epiphysis, is a circular digital depression for the accommodation of the capitulum of the following rib. On the eighth dorsal (pl. 13, fig. 4) the articular facet for the capitulum lies just below that for the tuberculum. A corresponding facet is not present on the last two dorsals for the ribs articulate solely with the transverse processes.

The facets for the tubercles of the ribs increase in width from the first to seventh dorsals, and gradually shift in position until on the seventh dorsal the facet is behind the level of the anterior epiphysis of centrum. On the anterior dorsals the facet for the tubercle projects in front of the anterior epiphysis. The lateral transverse process which bears the articular facet for tubercle of rib and which internally is continuous with metapophysis increases in size from the first to seventh dorsal. The transverse process drops down to the level of the centrum on the eighth dorsal. The neural canal is roughly semicircular in outline inferiorly, but above, owing to the depression of the neurapophyses, it is pointed, as shown in plate 13, figure 2. The anterior articulating surfaces of the centra are convex, while the posterior faces are slightly concave.

Measurements of dorsal vertebrae (in millimeters).

	1	2	3	4	5	6	7	8	9	10
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	168.0	173.0	183.5	187.5	187.0	190.0	186.0	180.5	184.0	193.0
Greatest depth of spinal canal anteriorly	30.0	24.0	x	25.0	x	x	x	30.0	26.5	x
Greatest breadth of spinal canal posteriorly	x	x	38.0	33.0	x	x	x	27.0	29.0	x
Height anterior face of centrum	43.0	44.5	42.0	[1] 47.5	44.5	44.5	48.0	52.0	54.0	58.0
Breadth anterior face of centrum	62.0	58.0	58.0	[1] 56.0	59.0	x	x	64.0	62.5	x
Height posterior face of centrum	42.6	44.0	45.5	47.5	47.5	53.0	55.0	54.5	59.0	x
Breadth posterior face of centrum (including facet)	72.2	71.0	73.4	70.0	71.0	x	x	66.0	x	x
Greatest length of centrum	56.0	57.5	60.5	[1] 63.0	70.5	77.0	80.0	86.0	90.0	9
Distance across vertebra between tips of the transverse processes	152.4	136.0	116.6	114.0	x	x	x	97.0	x	x
Distance across vertebra between tips of the prezygapophyses	x	x	x	x	x	x	x	[2] 46.0	x	x
Distance across vertebra between tips of the postzygapophyses	[2] 84.0	[2] 67.0	47.5	44.0	x	x	x	[2] 26.5	x	x
Distance between tip of left postzygapophysis and tip of left prezygapophysis	85.0	83.5	82.5	85.0	93.0	95.0	99.0	103.0	107.0	x
Minimum length of neurapophysis	26.0	29.0	36.0	38.0	45.0	43.7	53.0	53.0	52.0	52.5
Antero-posterior breadth of neural spine in a horizontal line immediately above the zygapophyses	65.5	61.5	x	58.0	60.0	62.5	75.0	74.0	73.0	74.0
Antero-posterior diameter left diapophysis at extremity	31.0	37.5	38.0	34.5	32.0	36.5	37.0	34.0	27.0	35.0
Vertical height of neural spine (distance between superior margin of spinal canal and tip of spine	87.5	96.0	115.5	117.0	111.0	107.0	103.0	97.0	87.0	106.0

[1] No epiphysis.

[2] Estimated.

LUMBAR VERTEBRAE.

Four lumbar vertebrae (pl. 10, Nos. 12–15) are preserved, but two are incomplete; the second lacks the posterior end of the centrum and its epiphysis, and of the third only the neural spine remains. The centra of two of these lumbar vertebrae, one of which is practically complete with the exception of some defects due to crushing, were utilized in restoring the second vertebra of the series. They are all considerably longer than broad, and, although the fourth lumbar is the longest, no conspicuous increase in the length of the centra between the first and fourth is apparent. The centra are roughly cylindrical in outline. Inferiorly the centra of the first and second lumbars show a tendency to develop a median keel. This is evidenced by depressed areas on each side of the centrum below the transverse processes. The fourth centrum has a well developed keel which is more pronounced at the middle than at either end. A pair of grooves meeting mesially at the keel and directed obliquely outward and backward pass below the posterior margin of the transverse process and characterize the fourth lumbar.

The neural spines of the vertebrae of this fossil porpoise, if they were arranged in regular serial order and position would describe a gentle curve arising from the first dorsal and declining from the fourth lumbar. These neural spines, viewed laterally, are strongly flattened, rather squarely truncated on their upper extremities, and vertical in position. The neural arch is preserved on three of the four lumbars. The arch is very broad antero-posteriorly, with concave anterior and posterior margins. The posterior margin of the neural spine is slightly concave. The spine is broader antero-posteriorly than the neural arch, and slightly expanded at the tip. The metapophyses are situated a little nearer to the free edge of the spine than to the centrum and are directed obliquely upward and forward.

There is no distinct process for the prezygapophysis. The prezygapophysial facets (pl. 15, fig. 6), which are formed on the superior face of the upturned margin of the laminae in front of and below the point where the metapophyses arise, are concave, and look upward, inward, and forward. The postzygapophyses are laterally convex, and look downward, outward, and backward, but do not overhang the posterior face of the centrum. The transverse processes (pl. 10, Nos. 12–13) are broad, flattened, and project horizontally outward. They are also moderately long, very thin, and expanded (pl. 10, No. 15) at the distal end. This type of lumbar characterizes the genus *Platanista*.

Measurements of lumbar vertebrae (in millimeters).

	1	2	3	4
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	196	211	x	242.0
Height of anterior face of centrum	57	61	x	69.0
Breadth of anterior face of centrum	x	x	x	78.0
Height of posterior face of centrum	62	x	x	72.0
Breadth of posterior face of centrum	x	x	x	82.0
Greatest length of centrum	103	111	x	123.5
Distance across vertebra between tips of the transverse processes (as preserved)	277	x	x	261.0
Distance between the tip of left post-zygapophysis and tip of left pre-zygapophysis (as preserved)	x	x	x	144.0
Minimum length of neurapophysis	x	55	x	63.0
Antero-posterior breadth of neural spine in a horizontal line immediately above the zygapophyses	76	80	x	99.0
Antero-posterior diameter of left transverse process at extremity	x	58	x	90.0
Vertical height of neural spine (distance between superior margin of spinal canal and tip of spine)	108+	119	x	148.0

CAUDAL VERTEBRAE.

Only three caudal vertebrae have been preserved and they belong near the distal end of the series. In form they somewhat resemble the caudals of *Inia geoffrensis* though the vertebral canals are relatively larger than in *Inia*. The largest of these caudals (pl. 18, fig. 5) is almost circular in outline, while the remaining two (pl. 18, figs. 6–7) are smaller and somewhat flattened dorso-ventrally. The sides of both of the last-mentioned caudals are grooved.

All of these caudals are pierced dorso-ventrally by two large vertebral canals. On the ventral face of the largest caudal (pl. 17, fig. 1) there are two openings for each vertebral canal of which the external ones are nearly closed. The double keels on the ventral face of the largest caudal are approximately parallel and inclose a narrow concave area. The vertebral canals converge ventrally and in the small terminal caudals (pl. 17, figs. 2–3) open only into the longitudinal depressed area. The ventral openings of these canals are partially concealed by overhanging bony shelves. The dorsal openings of the vertebral canals (pl. 17, figs. 4–6) are large and wide apart.

The presence of a pair of neurapophyses on the largest caudal shows that all of the caudal vertebrae with the exception of the terminal ones possess a neural arch. The neurapophyses of the largest caudal (pl. 17, fig. 4) converge mesally and partially close the neural canal posteriorly. The anterior articulating surfaces of the caudals (pl. 18, figs. 5–7) are concave, while the posterior are convex.

Measurements of caudal vertebrae (in millimeters.)

	Pl. 18, Fig. 5.	Pl. 18, Fig. 6.	Pl. 18, Fig. 7.
Height of centrum anteriorly	63.0	58.0	47.0
Breadth of centrum anteriorly	58.5	54.0	61.0
Height of centrum posteriorly	53.5	45.5	47.5
Breadth of centrum posteriorly	54.0	50.0	58.0
Greatest thickness of centrum	52.0	43.5	39.0

Chevron bones.

Four chevron bones were found in the matrix surrounding the skeleton. One of them (pl. 18, fig. 1) is small, elongated, and relatively low. Another (pl. 18, fig. 2) which belongs farther back is somewhat deeper and broader. The chevrons have elongated flattened surfaces for articulation with the corresponding facets on the caudals. The free margin forms a narrow posterior projection and a blunt anterior projection.

RIBS.

The whole, or portions, of 16 ribs are preserved. Only one of the ribs was found associated with the corresponding vertebra; the others lay in a tangled pile alongside of the anterior lumbars. Eight of them (pl. 10) were left undisturbed when the slab in which they were imbedded was prepared for exhibition; the others were freed from the matrix.

This fossil porpoise possesses 10 ribs on each side, of which the first is the shortest. The ribs rapidly increase in length from the first to the sixth (pl. 16, fig. 5), which is the longest, and then decrease in length to the tenth (pl. 16, fig. 7). The convex external curvature of the shafts of the three anterior ribs is less pronounced than in the others; this curvature rapidly increases posteriorly, reaching its maximum development in the fifth, sixth, and seventh ribs. The curvature of these last-mentioned ribs is very nearly the same. All of the ribs show at their distal end provision for the attachment of cartilages. The capitula of the first to the seventh ribs are borne upon long necks and the length of the necks increase as we go backward along the series to the seventh. On the eighth, ninth, and tenth ribs the capitulum and tuberculum are fused with each other.

The first seven pairs of ribs have capitula articulating with the centra, as well as tubercula articulating with the transverse processes; in the three posterior ribs, however, the articulation is limited to the transverse process. Four pairs of ribs are connected by cartilage with the sternum in *Platanista* and similar relations may have been maintained in this fossil porpoise.

The first three ribs are greatly compressed and their proximal portions are bent at right angles to the shafts. The first rib (pl. 16, fig. 1) is short, flattened, and thickest at its distal extremity; the capitulum is borne upon a relatively long flattened neck which is strongly constricted behind the capitulum. The tuberculum and capitulum are relatively small. The second rib (pl. 16, fig. 2) is longer than the first, with narrower shaft and neck. The capitulum is larger than the tuberculum. The third rib is characterized by a longer shaft and the neck, while flattened, is even thicker than the second.

The angle formed by the neck with the shaft of the succeeding ribs becomes less and less acute until in the posterior ones it almost disappears and the ribs are regularly curved. The ninth and tenth ribs (pl. 15, fig. 4–5) retain only vestiges of the angle in the form of a slight swelling below the fused tuberculum and capitulum.

The fourth, fifth, sixth, and seventh ribs are all very much alike. The differences consist of a constant narrowing of the shaft at the angle as we go backward from the fourth (pl. 16, fig. 3) to the seventh ribs, and in addition there is a tendency toward the lengthening of the interval between the capitulum and the tuberculum. The seventh rib (pl. 15, fig. 2) is larger and heavier than any of the others.

In this fossil porpoise the long necks and the distinct capitula do not disappear until the eighth rib (pl. 15, fig. 3) and up to this point are well developed. Upon the eighth rib the tuberculum and capitulum disappear as separate facets. The posterior face of this single facet on the eighth and ninth ribs is indented by a well-marked concavity. The position of this concavity suggests that the neck has been shortened and in consequence the capitulum and the tuberculum have coalesced. If this determination is correct, then the capitulum has not been lost as some writers have held. The eighth and ninth ribs are very much alike except that the former is more convex. The shaft of the tenth rib does not curve as much as the anterior ribs.

Measurements of ribs (in millimeters).

	First rib, right.	Second rib, right.	Third rib.	Fourth rib, right.	Fifth rib, right.	Sixth rib, right.	Seventh rib, left.	Eighth rib, left.	Ninth rib, left.	Tenth rib, right.
Total length in a straight line.	196. 5	294. 0	x	*418	430. 0	482. 0	466. 0	419. 5	407. 5	344. 0
Greatest breadth at angle....	41. 0	37. 5	x	32	32. 0	30. 0	29. 0	22. 0	22. 0	22. 0
Greatest breadth at inferior extremity..................	34. 0	26. 0	x	x	25. 0	13. 5	14. 0	x	14. 0	16. 0
Distance between external margin of tubercle and head......................	60. 5	67. 0	x	61	62. 5	65. 0	65. 0	†26. 0	†23. 5	†22. 5
Greatest thickness of rib near the middle..................	14. 0	13. 5	x	17	18. 5	17. 5	19. 5	18. 5	18. 0	15. 5
Greatest thickness at the inferior extremity...........	21. 0	17. 5	x	7	5. 0	4. 5	4. 5	3. 0	3. 5	5. 5

* As preserved, incomplete. † Breadth of articular face.

STERNUM.

Although the presternum (pl. 11, fig. 1) of this fossil porpoise is crushed and incomplete, it is evident that it must have resembled *Platanista* when perfect. In size it approaches the presternum of *Inia*, but there are no traces of conical processes behind the articular surfaces for the first ribs. The anterior extremity is imperfectly preserved and both angles are missing. The presternum is larger than that of *Platanista* and smaller than that of *Inia;* the posterior extremity is abruptly truncated. The breadth of the presternum posteriorly (52 mm.) equals about one-half of the mesial length (113 mm.). The external margins are rounded and the bone, as a whole, is relatively thick (greatest thickness 24.5 mm.). The articular surfaces for the second ribs are situated on the external face and at the posterior end of the presternum, and not on the posterior face as in *Platanista.*

A pair of curved plate-like bones (pl. 11, fig. 2) which are united on their antero-internal margins may represent the mesosternum. Such a type of mesosternum would be somewhat unusual. The mesosternum of *Platanista* is composed of two flattened bones which are in contact for their entire length.

PADDLE BONES.

Although the phalanges (pl. 9, fig. 4) have been arranged in accordance with the position of similar phalanges in the paddle of *Inia geoffrensis*, no assurance can be given that this arrangement is correct. These bones were found intermingled with other parts of the skeleton and may represent parts of both paddles.

EXPLANATION OF PLATES.

Zarhachis flagellator Cope. Cat. No. 10485, Division of Vertebrate Palaeontology, United States National Museum. Calvert formation, western shore of Chesapeake Bay, about one-half mile south of Chesapeake Beach, Calvert County, Maryland. Collected by Norman Boss, August 8, 1921.

PLATE 1.

Skull of *Zarhachis flagellator* Cope. About ⅕ natural size. Upper figure. Dorsal view; Lower figure. Ventral view. The posterior end of the skull has been restored. Abbreviations: *Ex. pt.*, external pterygoid; *Fo. inf.*, infraorbital foramen; *Fr.* frontal; *In pt.*, internal pterygoid; *Max.*, maxilla; *Max. cr.*, maxillary crest; *N. A.*, external nasal aperture; *Na.*, nasal; *Pmx.*, premaxilla; *Po. gl. p.*, postglenoid process of squamosal; *Po. p.*, postorbital projection of frontal; *Pr. p.*, preorbital projection of frontal; *Prs.*, presphenoid; *So.*, supraoccipital; *S. or. pr.*, supraorbital process of frontal; *V.*, vomer; *Zyg.*, zygomatic process of squamosal.

PLATE 2.

Skull of *Zarhachis flagellator* Cope. Lateral views. Upper figure, Distal end of rostrum; Middle figure, Section of skull. Lower figure, Entire skull, about ⅕ natural size. Abbreviations: *Ex pt.*, external pterygoid; *Fo. inf.*, infraorbital foramen; *Max.*, maxilla; *Pmx.*, premaxilla; *Po. gl. p.*, postglenoid process of squamosal; *Po. p.*, postorbital projection of frontal; *S. or. pr.*, supraorbital process of frontal; *V.*, vomer; *Zyg.*, zygomatic process of squamosal.

PLATE 3.

Mandibles of *Zarhachis flagellator* Cope. Upper figure, Ventral view of mandibles; Lower figure, Dorsal view of mandibles. About ⅕ natural size. Abbreviations: *Ang.*, angle; *C.* condyle; *Cor.* coronoid process.

PLATE 4.

Skull of *Zarhachis flagellator* Cope. About ⅖ natural size. Lateral view, showing external pterygoid and surrounding bones. Abbreviations: *Ch.*, channel or shelf formed between external pterygoid and frontal; *Ex. pt.*, external pterygoid; *Fo. inf.*, infraorbital foramen; *In. pt.*, internal pterygoid; *Max.*, maxilla; *Max. dep.*, maxillary depression; *Po. gl. p.*, postglenoid process of squamosal; *S. or. pr.*, supraorbital process of frontal; *V.*, vomer; *Zyg.*, zygomatic process of squamosal.

PLATE 5.

Skull of *Platanista gangetica* Lebeck. About ⅔ natural size. Lateral view. The external and internal pterygoids have been removed to show position of the palatine. The right squamosal and its zygomatic process has also been removed. Abbreviations: *Bo.*, basioccipital; *Bs.*, basisphenoid; *C.*, condyle; *Ex. o.*, exoccipital; *Fo. inf.*, infraorbital foramen; *Fr.*, frontal; *In. pt.*, internal pterygoid; *Max.*, maxilla; *Max. cr.*, maxillary crest; *Pl.*, Palatine; *S. or. pr.*, supraorbital process of frontal; *V.*, vomer.

PLATE 6.

Skull of *Platanista gangetica* Lebeck. About ⅔ natural size. Lateral view. showing external pterygoids and surrounding bones. The right maxillary crest has been removed. Abbreviations: *Bo.*, basioccipital; *Bs.*, basisphenoid; *C.*, condyle, *Ex. o.* exoccipital; *Ex. pt.*, external pterygoid; *Fo. inf.*, infraorbital foramen; *Fo. ov.*, foramen ovale; *Fr.*, frontal; *In. pt.*, internal pterygoid; *Lac.*, socket for insertion of lachrymal; *Max.*, maxilla; *Max. cr.*, maxillary crest; *Po. gl. p.*, postglenoid process of squamosal; *S. or. pr.*, supraorbital process of frontal; *Sq.*, squamosal; *V.*, vomer; *Zyg.*. zygomatic process of squamosal.

PLATE 7.

Fig. 1, Left tympanic of *Platanista gangetica* Lebeck, Superior view; 2, Left tympanic of *Zarhachis flagellator* Cope, Superior view; 3, Right tympanic of *Platanista gangetica* Lebeck, Internal view; 4, Right tympanic of *Zarhachis flagellator* Cope, Internal view; 5, Left periotic of *Platanista gangetica* Lebeck, Inferior view; 6, Left periotic of *Zarhachis flagellator* Cope, Inferior view, posterior process missing; 7, Left periotic of *Plantanista gangetica* Lebeck, Internal view; 8, Left periotic of *Zarhachis flagellator* Cope, Internal view, posterior process missing. All figures about ⅔ natural size.

PLATE 8.

Fig. 1. Right tympanic of *Platanista gangetica* Lebeck, External view; 2, Right tympanic of *Zarhachis flagellator* Cope, External view; 3, Left tympanic of *Platanista gangetica* Lebeck, Inferior view; 4, Left tympanic of *Zarhachis flagellator* Cope, Inferior view; 5, Atlas of *Zarhachis flagellator* Cope, Dorsal view. Figs. 1–4, about $\frac{7}{10}$ natural size; Fig. 5, about ½ natural size.

PLATE 9.

Fig. 1, Basihyal, ceratohyals, and thyrohyals of *Zarhachis flagellator* Cope Dorsal view; 2, Right stylohyal of *Zarhachis flagellator* Cope, Dorsal view; 3, Left stylohyal of *Zarhachis flagellator* Cope, Dorsal view. All figures about ⅓ natural size. 4, Paddle bones of *Zarhachis flagellator* Cope. The bones have been arranged in a graded series, but do not represent necessarily their true positions. About $\frac{4}{11}$ natural size.

PLATE 10.

Vertebral column and ribs of *Zarhachis flagellator* Cope. Viewed as found in the matrix. 1, Atlas; 2, First dorsal; 3, Second dorsal; 4, Third dorsal; 5, Fourth dorsal; 6, Fifth dorsal; 7, Sixth dorsal; 8, Seventh dorsal; 9, Eighth dorsal; 10, Ninth dorsal; 11, Tenth dorsal; 12, First lumbar; 13, Second lumbar; 14, Third lumbar, centrum missing; 15, Fourth lumbar; 16, Posterior caudal; 17, Posterior caudal; 18, Posterior caudal; 19, First rib, right side; 20, Fourth rib, right side; 21, Third rib, left side; 22, Fourth rib, left side; 23, Fifth rib, left side; 24, Eighth rib, left side; 25, Ninth rib, left side; 26, seventh rib, right side. All elements about ⅛ natural size.

PLATE 11.

Fig. 1, Presternum of *Zarhachis flagellator* Cope, Superior view; 2, Mesosternum of *Zarhachis flagellator* Cope, Superior view. Both figures about ½ natural size.

PLATE 12.

Fig. 3, Posterior view of atlas of *Zarhachis flagellator* Cope; 4, Anterior view. Both figures about ⅔ natural size.

PLATE 13.

Dorsal vertebrae of *Zarhachis flagellator* Cope. About ⅖ natural size. Fig. 1, Eighth dorsal vertebra, Anterior view; 2, Fourth dorsal vertebra, Anterior view, showing missing epiphysis. 3, Fourth dorsal vertebra, Lateral view; 4, Eighth dorsal vertebra, Lateral view.

PLATE 14.

Dorsal vertebra of *Zarhachis flagellator* Cope. About ½ natural size. Fig. 1, Fourth dorsal vertebra, Posterior view; 2, Eighth dorsal vertebra, Posterior view.

PLATE 15.

Ribs of *Zarhachis flagellator* Cope, Left side. About ⅙ natural size. Fig. 1, Sixth rib; 2, Seventh rib; 3, Eighth rib; 4, Ninth rib; 5, Tenth rib; 6, Fourth lumbar vertebra (about ⅓ natural size).

PLATE 16.

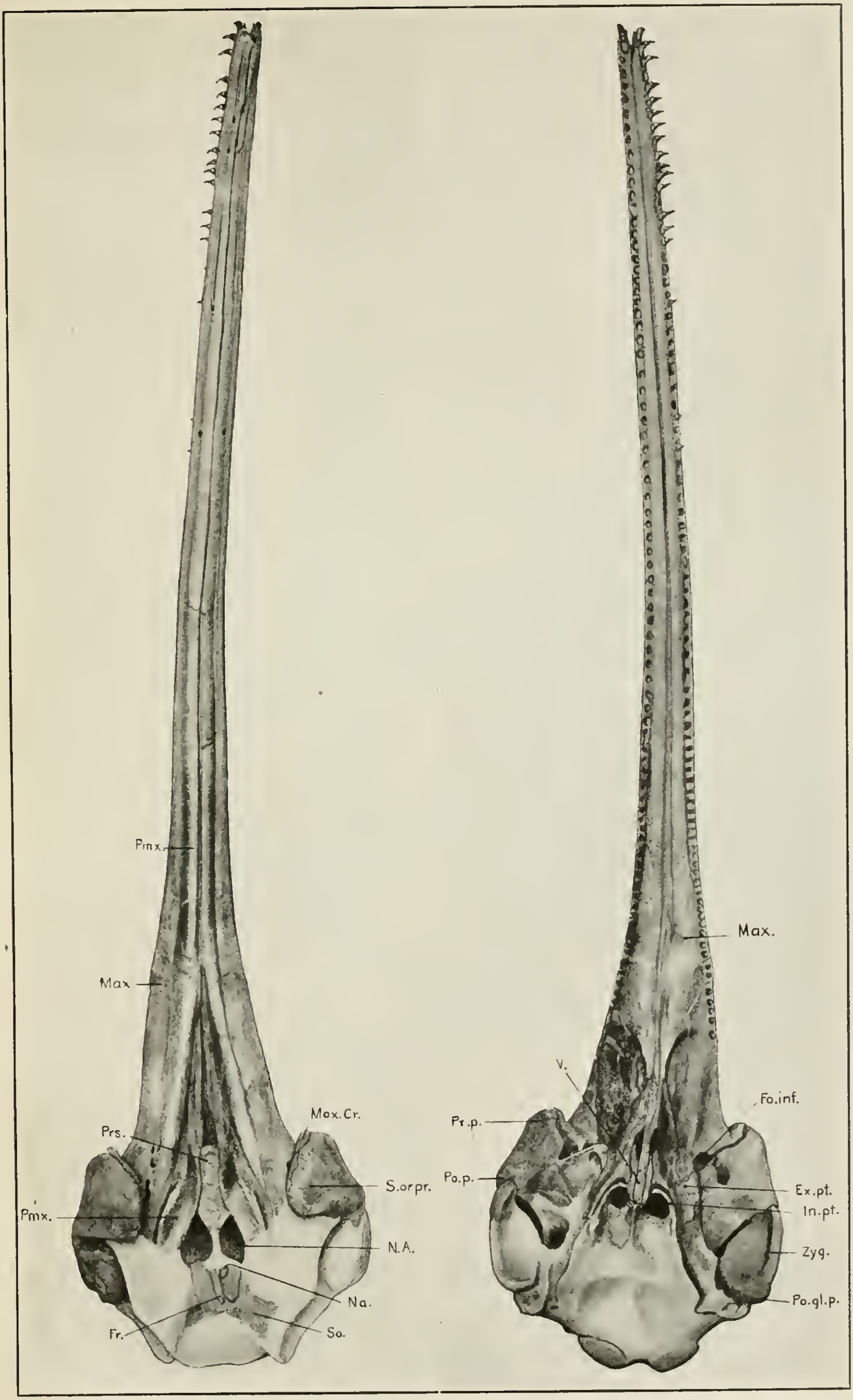
Ribs of *Zarhachis flagellator* Cope, Right side. About ⅙ natural size. Fig. 1, First rib; 2, Second rib; 3, Fourth rib; 4, Fifth rib; 5, Sixth rib; 6, Ninth rib; 7, Tenth rib.

PLATE 17.

Posterior caudal vertebrae of *Zarhachis flagellator* Cope. About ⅗ natural size. Figs. 1–3, Inferior views of caudals; 4–6, Superior views of caudals.

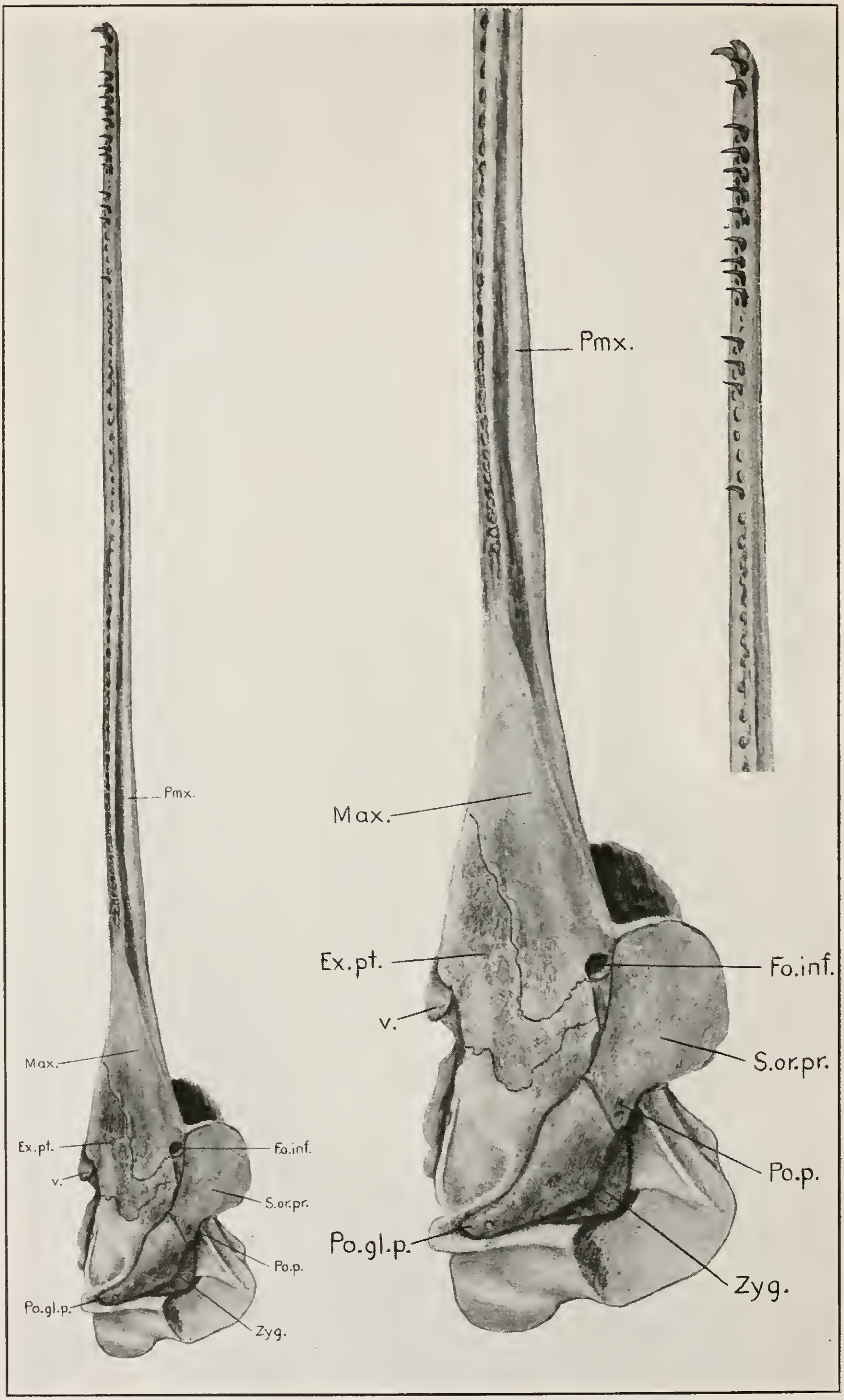
PLATE 18.

Figs. 1–4, Chevrons of *Zarhachis flagellator* Cope, Lateral view; 5–7, Caudal vertebrae of *Zarhachis flagellator* Cope, Anterior views. All figures about ⅗ natural size.



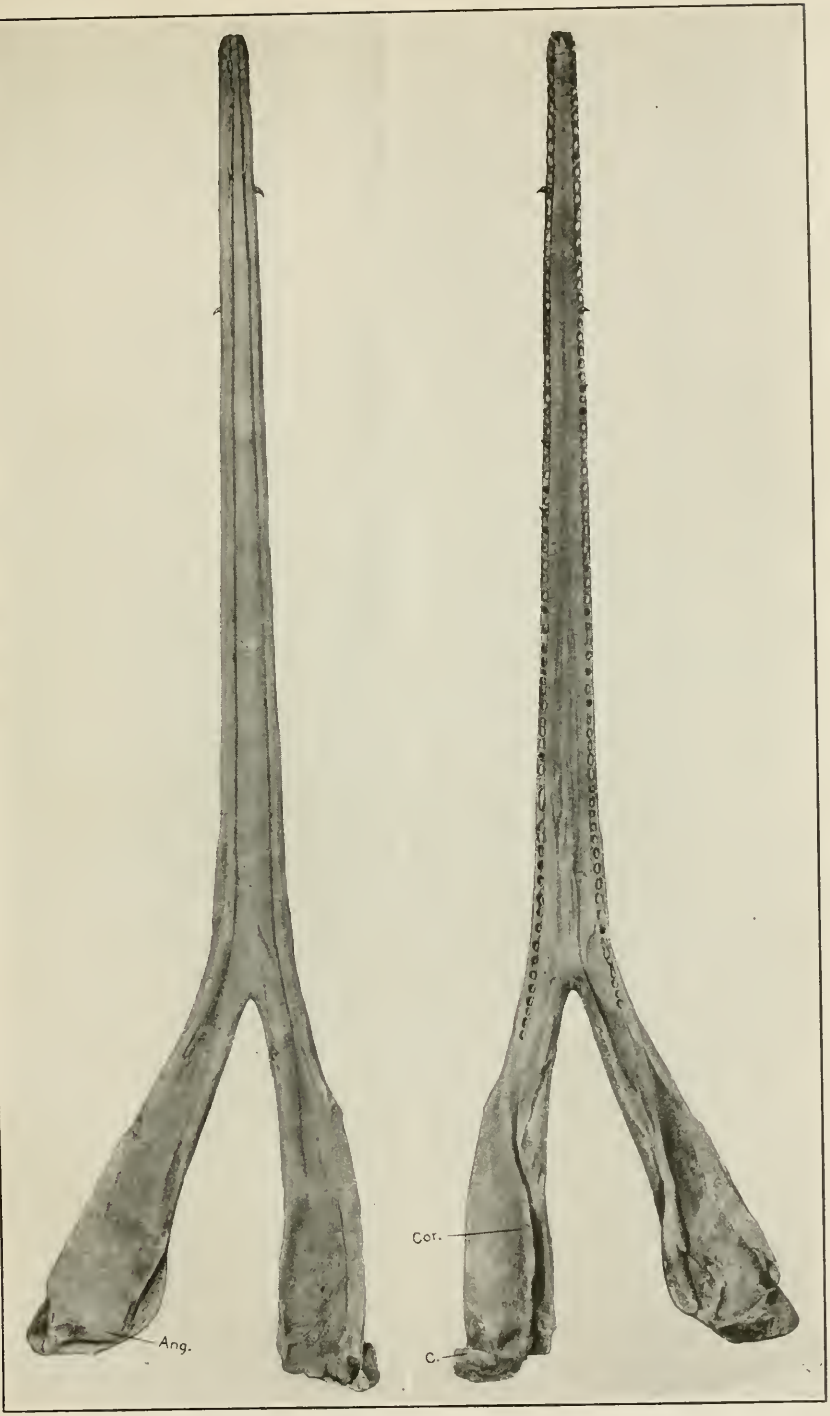
DORSAL AND VENTRAL VIEWS OF SKULL OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 36.



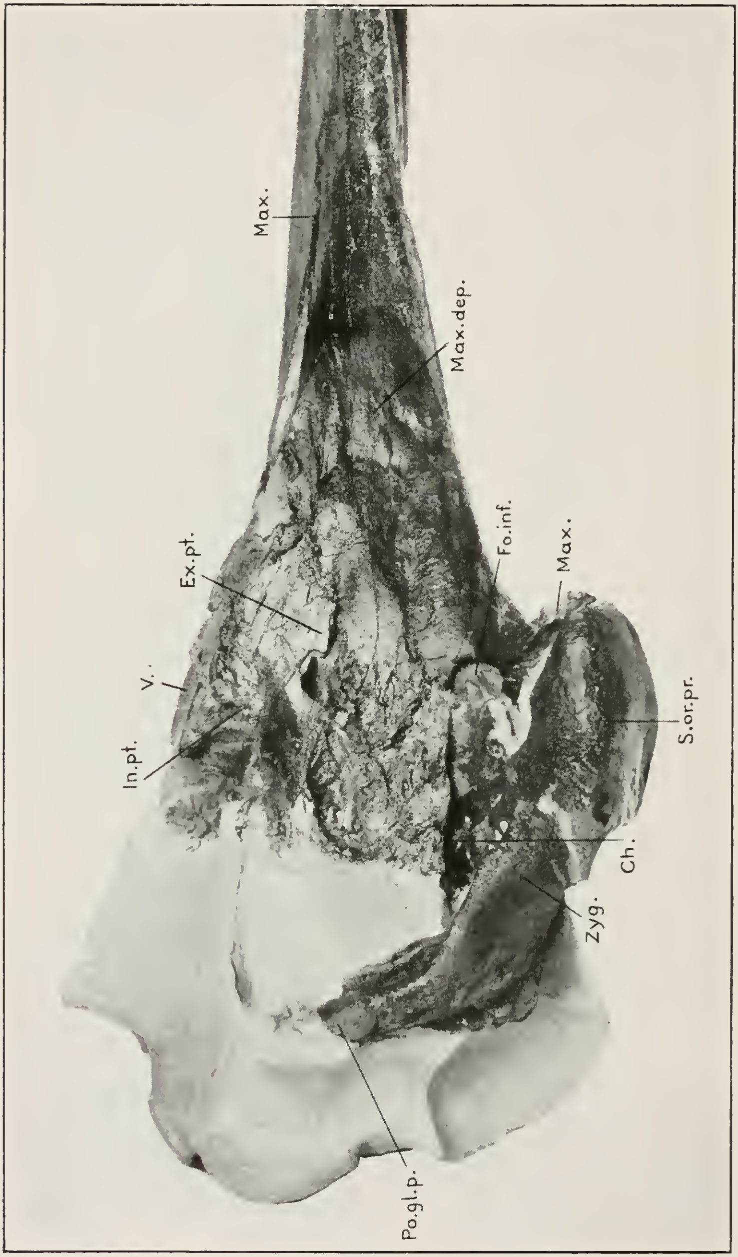
LATERAL VIEW OF SKULL OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 37.



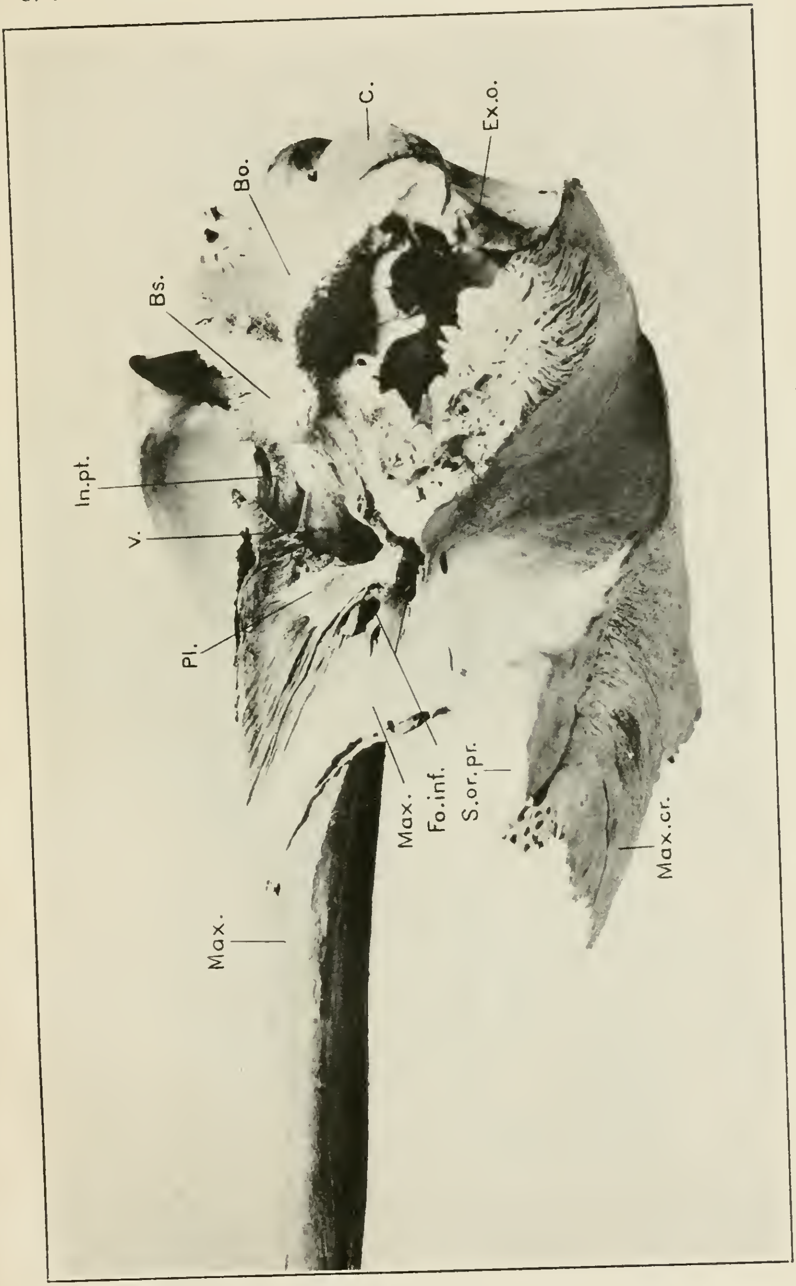
DORSAL AND VENTRAL VIEWS OF MANDIBLES OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 37.



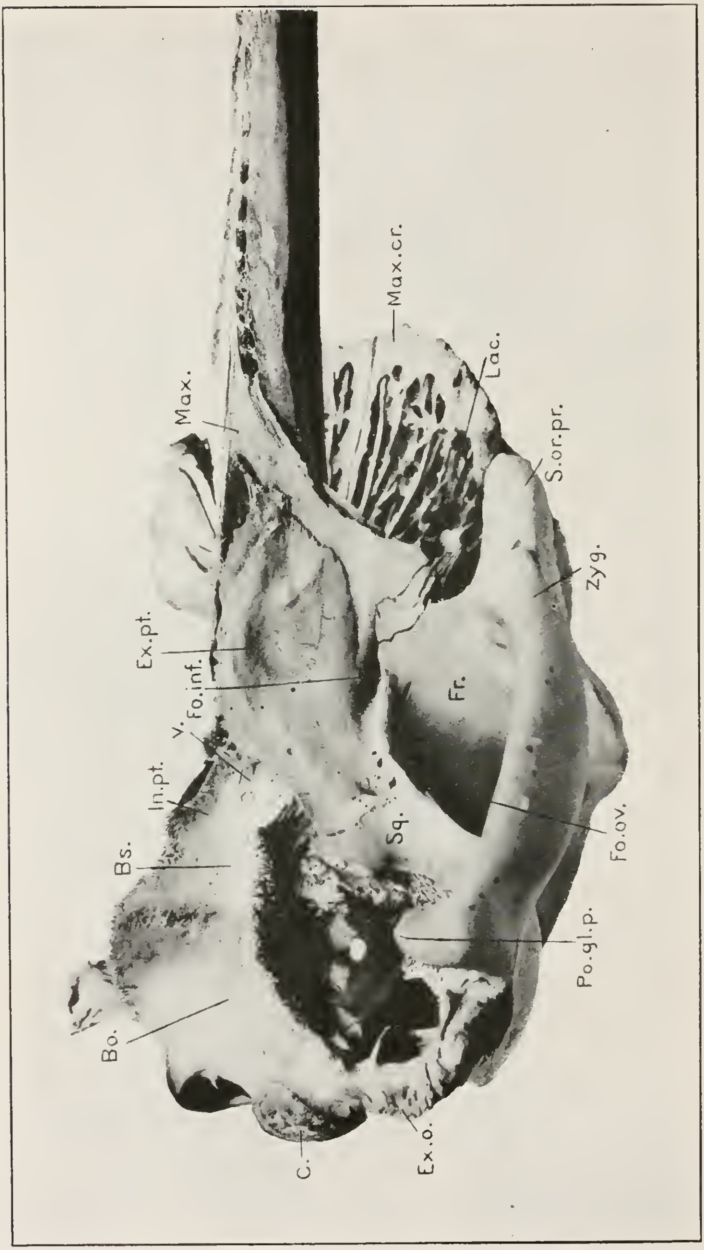
LATERAL VIEW OF SKULL OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 37.



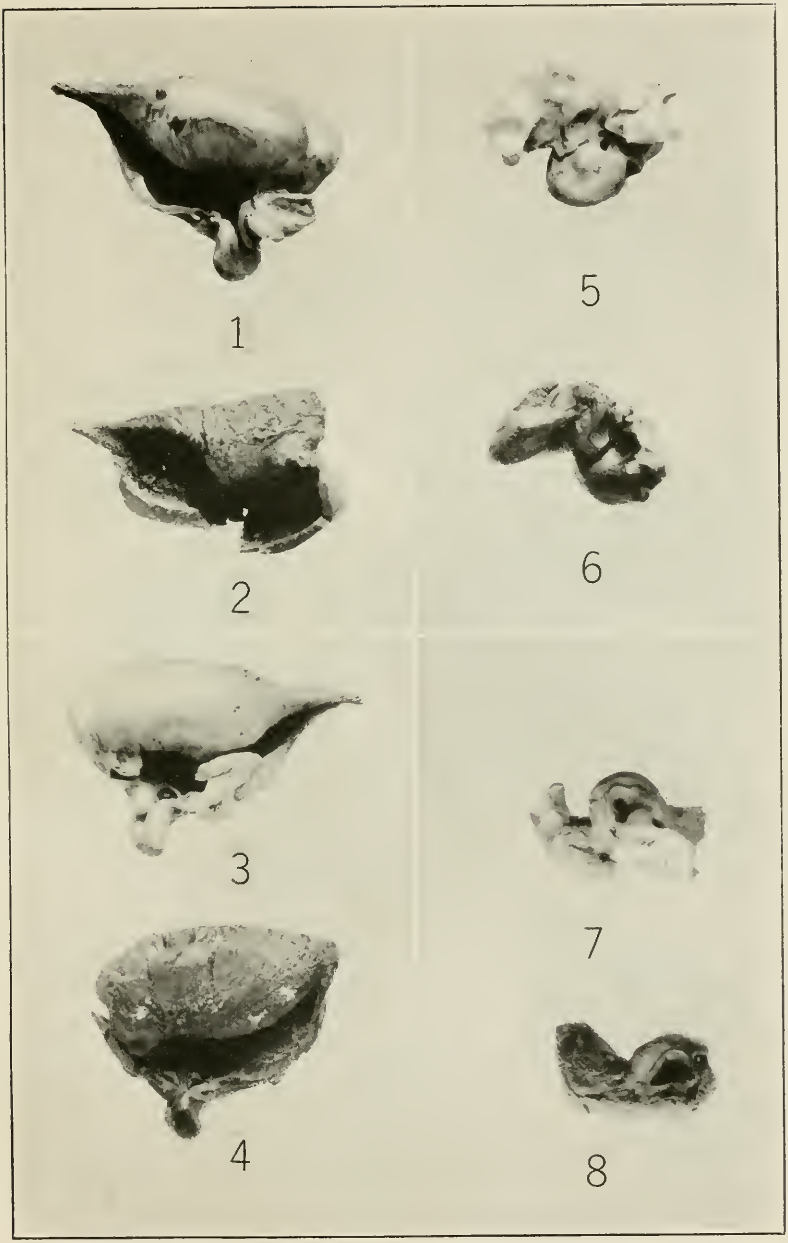
LATERAL VIEW OF SKULL OF PLATANISTA GANGETICA.

FOR EXPLANATION OF PLATE SEE PAGE 37.



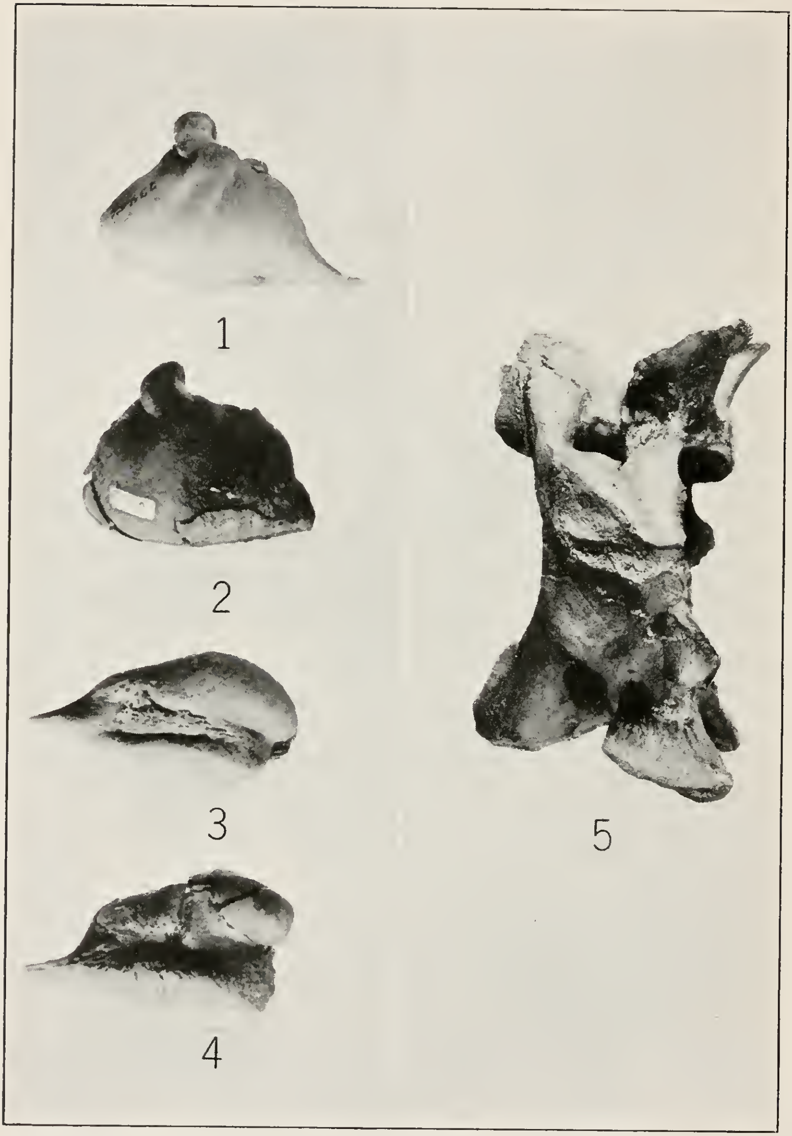
LATERAL VIEW OF SKULL OF PLATANISTA GANGETICA.

FOR EXPLANATION OF PLATE SEE PAGE 37.



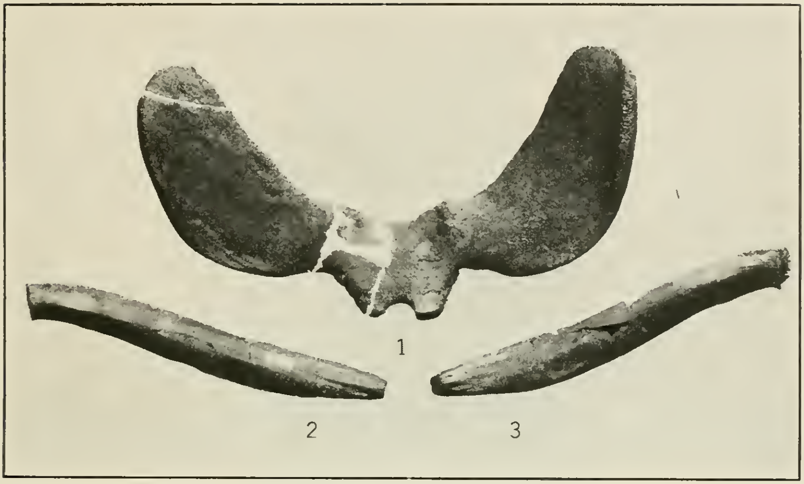
Views of Tympanic and Periotic Bones.

For explanation of plate see page 37.



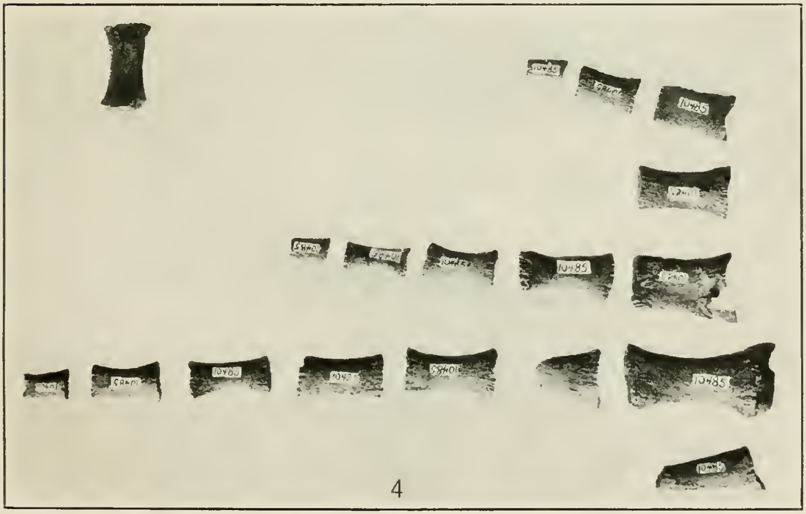
Views of Tympanic Bones (1-4) and Dorsal View of Atlas (5).

For explanation of plate see page 38.



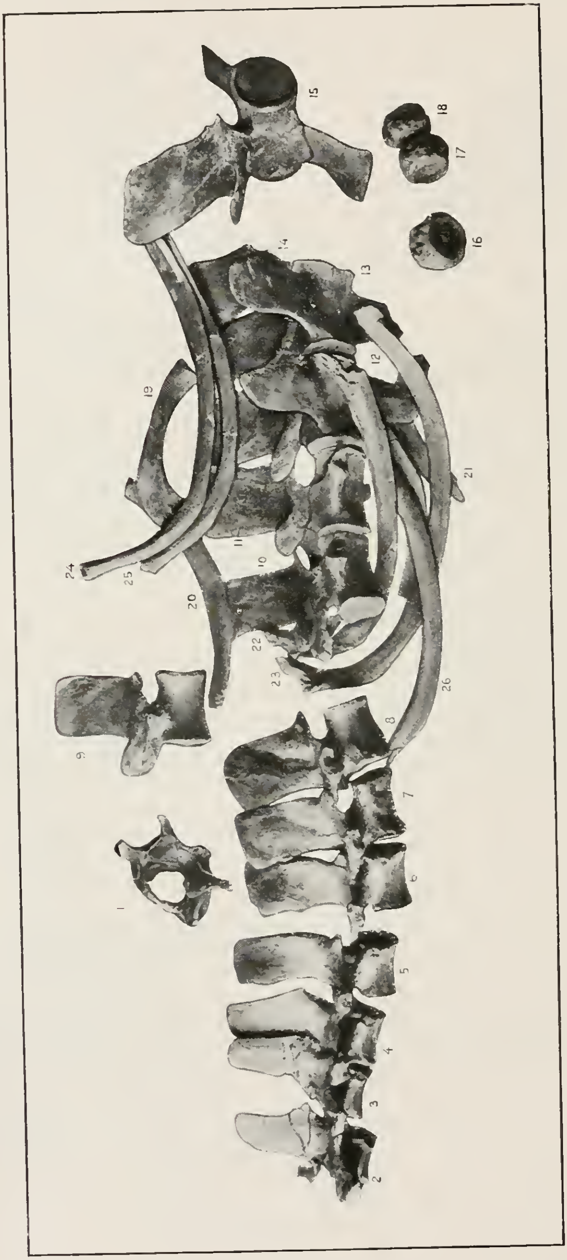
HYOID BONES OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.



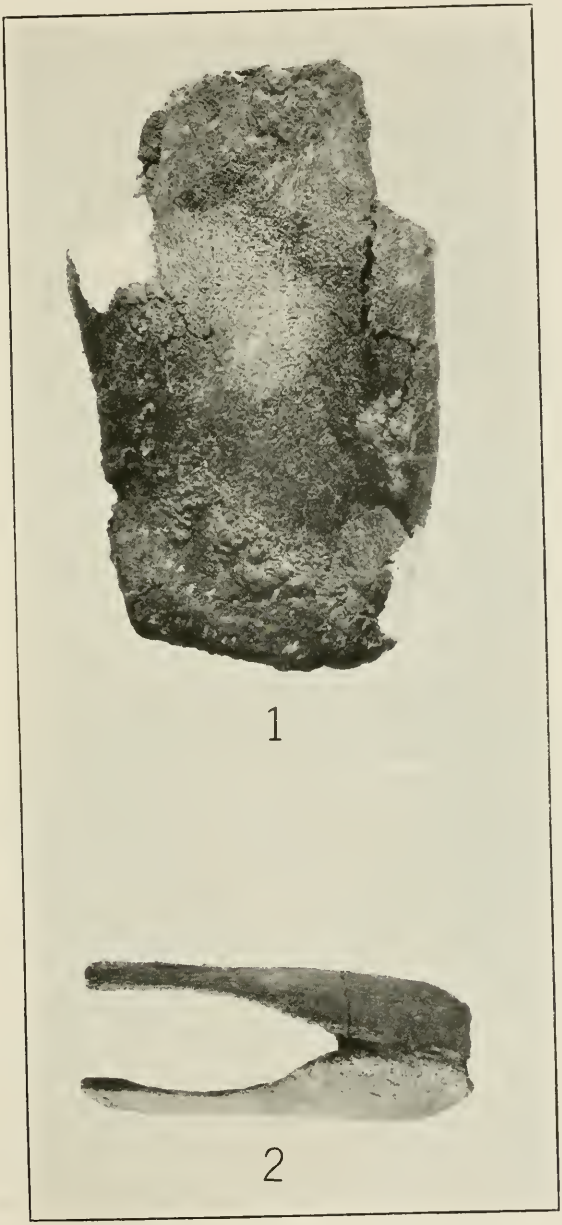
BONES IN THE MANUS OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.



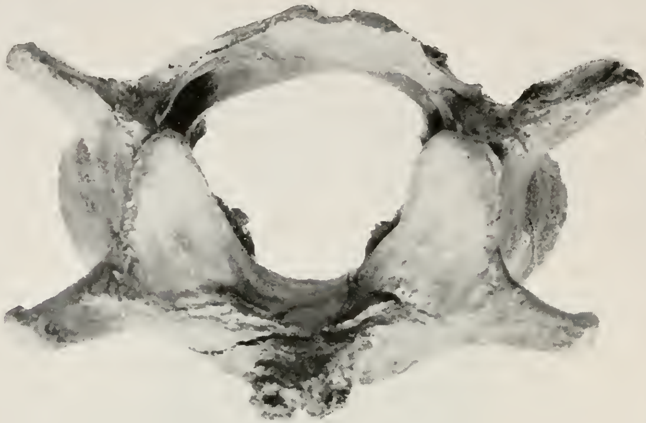
VERTEBRAL COLUMN AND RIBS OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.



STERNUM OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.

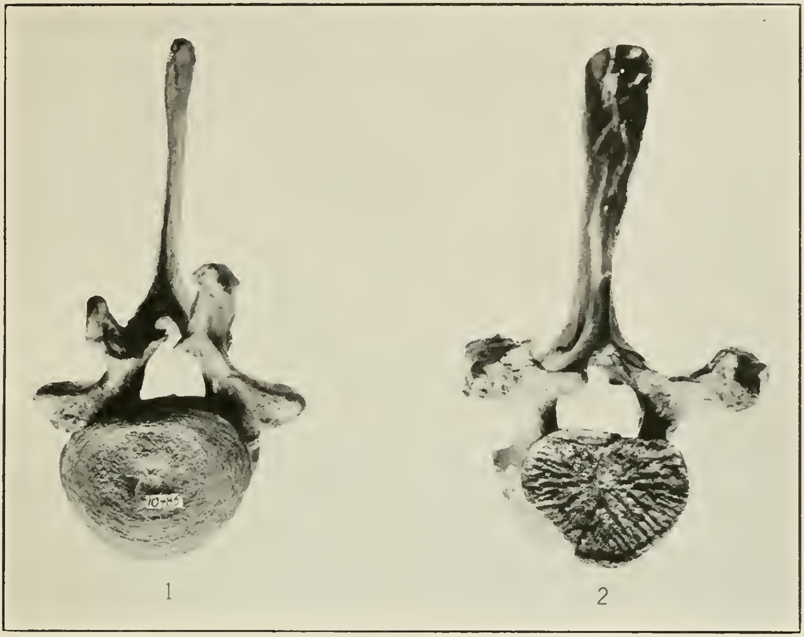


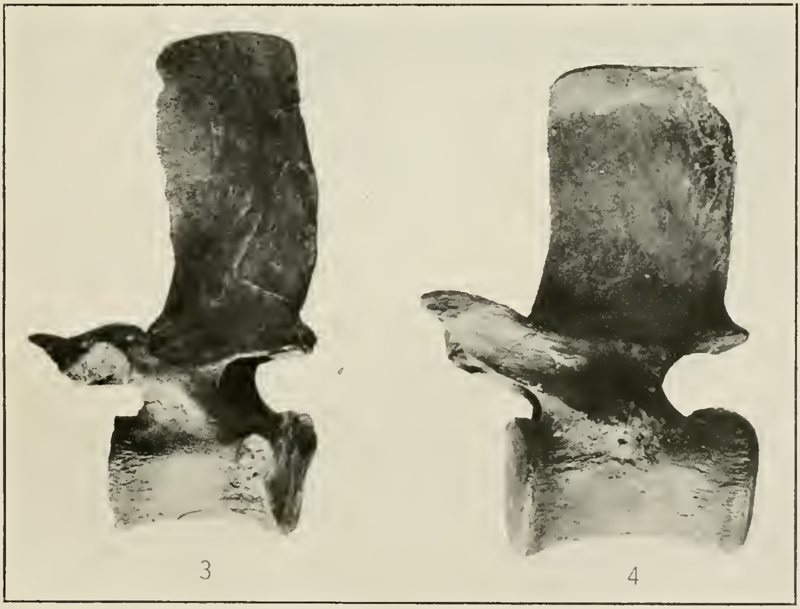
3

4

VIEWS OF ATLAS OF ZARHACHIS FLAGELLATOR.

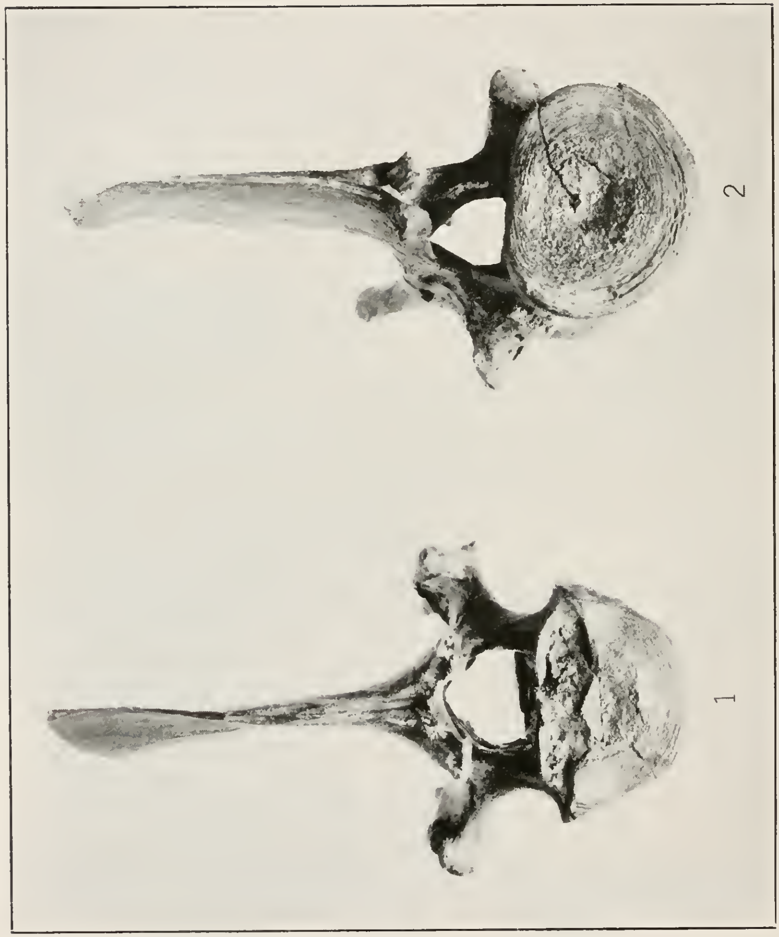
FOR EXPLANATION OF PLATE SEE PAGE 38





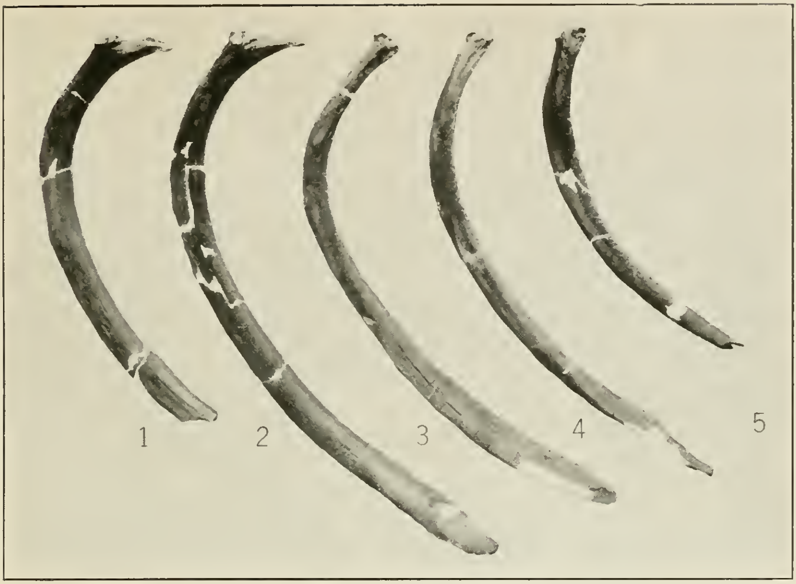
VIEWS OF DORSAL VERTEBRAE OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.

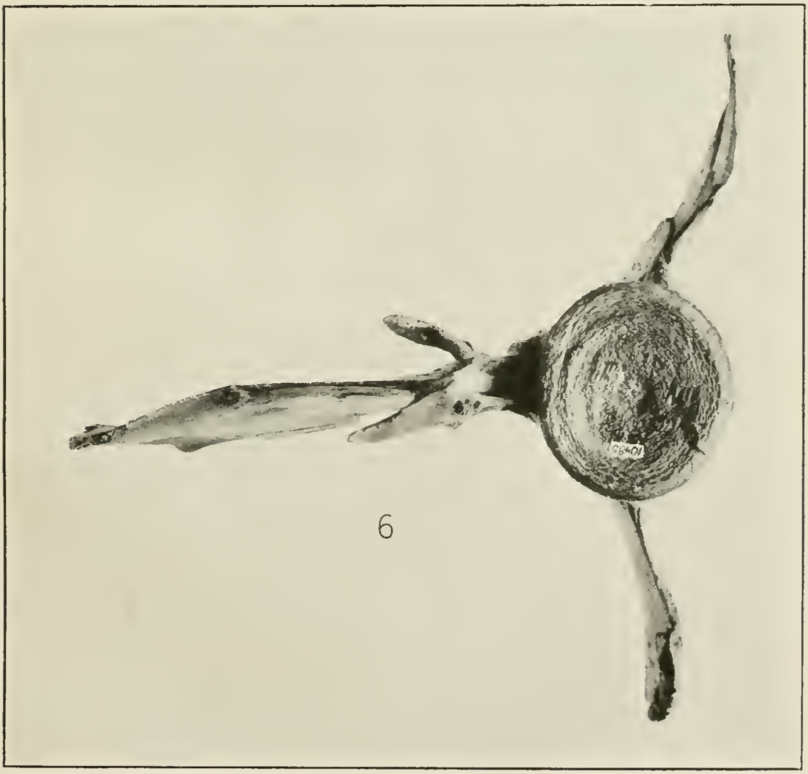


Posterior Views of Dorsal Vertebrae of Zarhachis flagellator.

For explanation of plate see page 38.

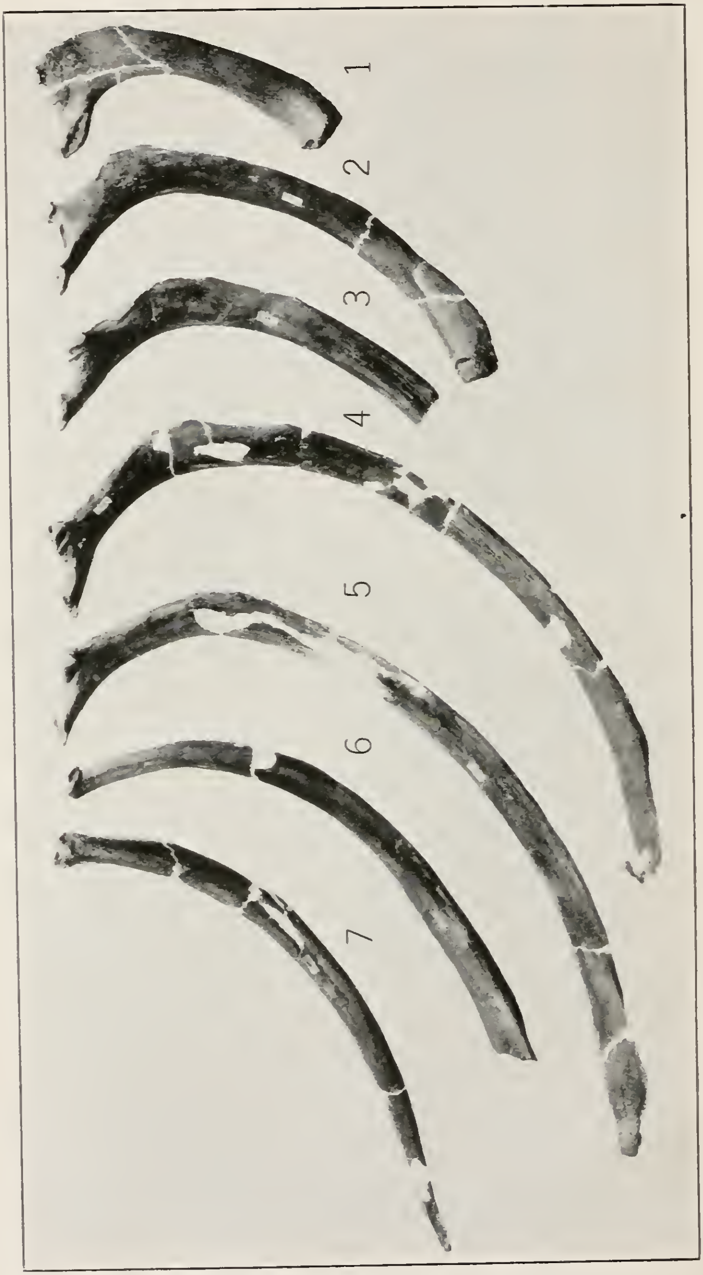


VIEWS OF RIBS OF ZARHACHIS FLAGELLATOR.



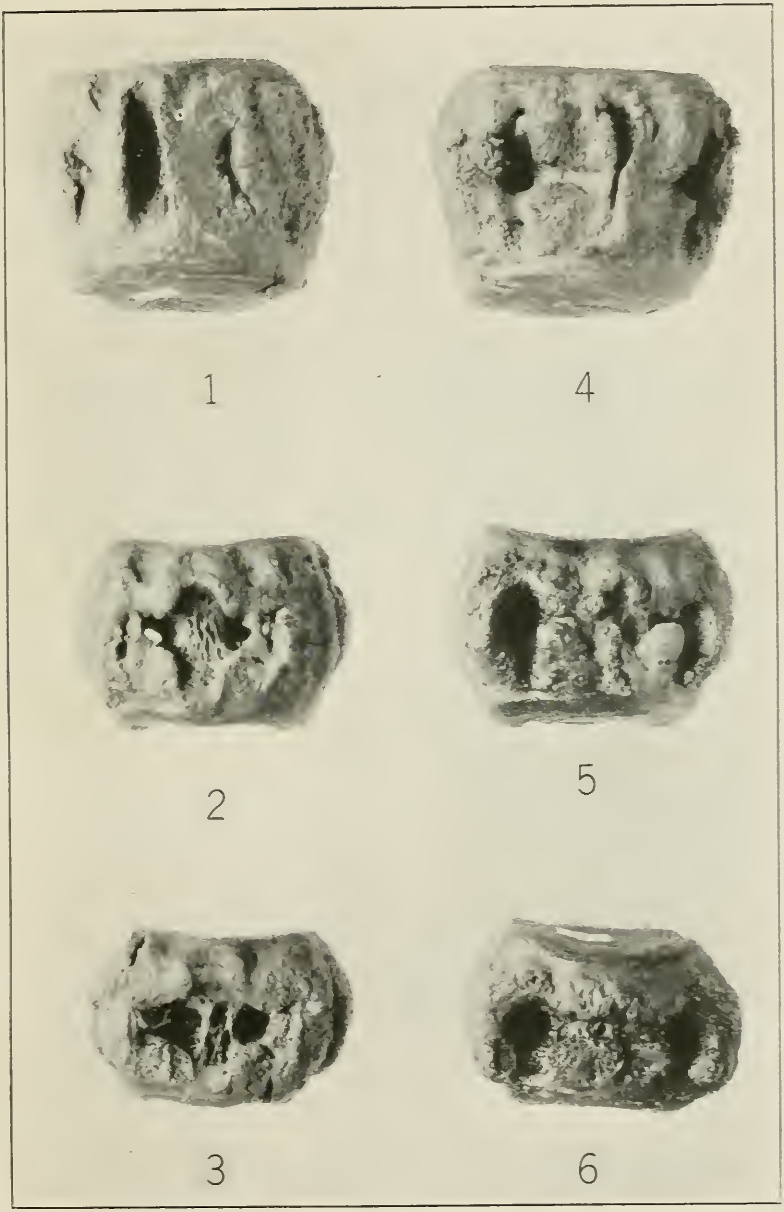
ANTERIOR VIEW OF FOURTH LUMBAR VERTEBRA OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 38.



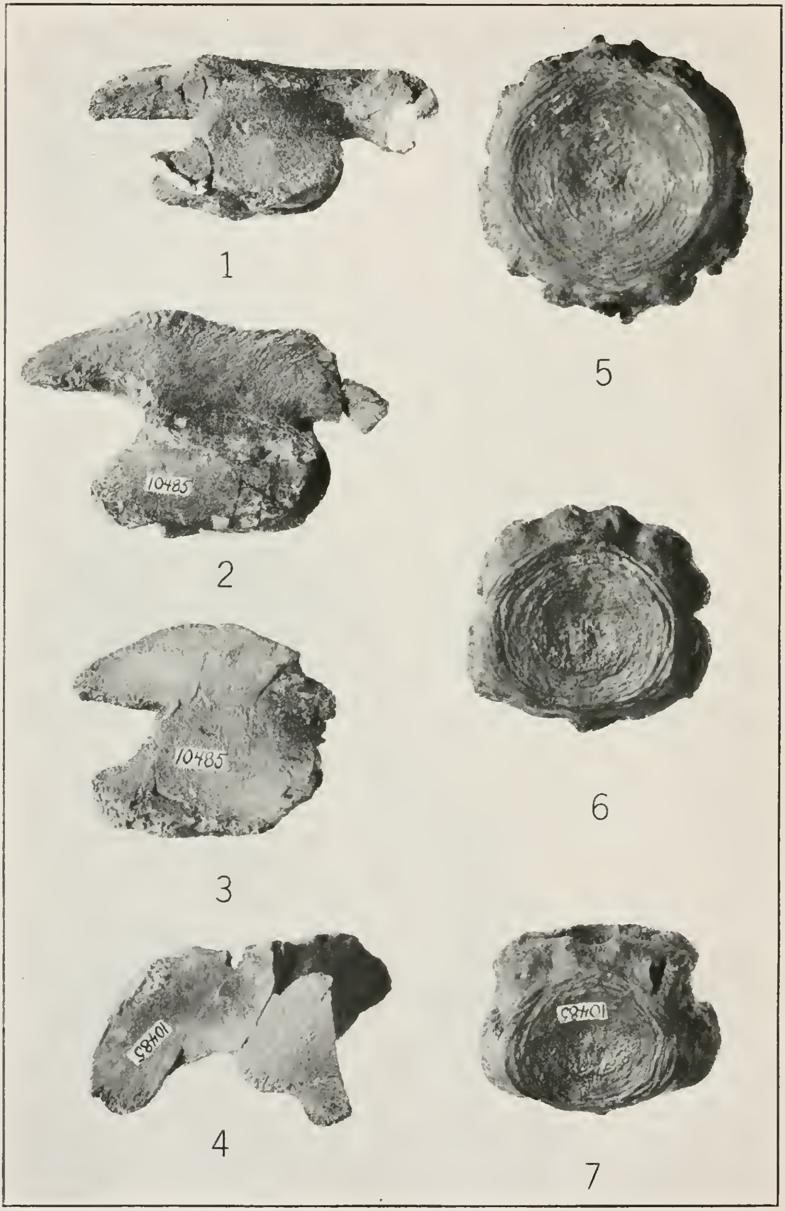
VIEWS OF RIBS OF ZARHACHIS FLAGELLATOR.

FOR EXPLANATION OF PLATE SEE PAGE 39.



Views of Posterior Caudal Vertebrae of Zarhachis flagellator.

For explanation of plate see page 39



CHEVRON BONES AND POSTERIOR CAUDAL VERTEBRAE.

FOR EXPLANATION OF PLATE SEE PAGE 39.