

**Article XXXIV.**—A COMPLETE SKULL OF *MONOCLONIUS*,  
FROM THE BELLY RIVER CRETACEOUS OF ALBERTA.

BY BARNUM BROWN.

PLATES XXXVIII-XL.<sup>3</sup>

A rare specimen secured by the American Museum Expedition of 1912 is a complete skull of *Monoclonius* from the Judith River (Belly River) exposures on the Red Deer River, one mile below the mouth of Berry Creek. It is unusually perfect, lacking only the vomers, and the sutures are for the most part still well defined, a condition that enables us to understand more clearly the structure of the primitive Ceratopsian skull. Compared with other known skull material it shows the range of variation in horns, and in the peculiar outgrowths on the back of the crest in this genus.

In order to clear up some of the synonymy of related forms it will be necessary to review briefly the work of previous writers.

The genus *Monoclonius* was established by Cope (Proc. Acad. Nat. Sci. Phila., Vol. XXVIII, pp. 255-256, 1876), the type of the genus being *M. crassus* which includes parts of the skeleton and the posterior crest of a skull.

In 1889 Cope (Am. Nat., Vol. XXIII, p. 716) briefly described and gave the name *M. recurvicornis* to another skull that had previously (Bull. U. S. Geological and Geographical Survey of the Territories, Vol. III, pp. 588-594) been described in detail but without name. In the same paper (pp. 716-717) a nasal horn and premaxillary were described to which he gave the name *M. sphenocerus*.

A fourth species *M. fissus* (*ibid.*, p. 717) was at this time proposed for a pterygoid which he identified as a squamosal.

The types of these four species were all collected from the Judith River beds of Montana and now form a part of the collection of the American Museum.

In a Monograph of the Ceratopsia Hatcher (Monograph 49 of the U. S. Geological Survey, Vol. XLIX, p. 81, 1907) rightly regards the species *M. fissus* as a *nomen nudum*, for the specimen is neither generically nor specifically determinable. Hatcher (*ibid.*, p. 87) was also probably right in transferring *M. recurvicornis* to the genus *Ceratops* Marsh.

With the knowledge of the complete skull herein described a comparison of the types of *M. crassus* and *M. sphenocerus* leaves little doubt that they

are specifically identical, in which case *M. sphenocerus* becomes a synonym of *M. crassus*. This leaves only one identifiable species of the genus from the Judith River beds of Montana, *M. crassus*, although future discoveries will probably disclose as great a variety of horned dinosaurs there as further north in Canada.

From the Belly River beds exposed on the Red Deer River, Alberta, Lambe (Contributions to Canadian Palæontology, Vol. III (quarto), Part II, 1902) obtained and described three species of the genus *Monoclonius*, *M. dawsoni*, *M. canadensis* and *M. belli*. The second and third of these, *M. canadensis* and *M. belli*, have been removed by Hatcher to the genus *Ceratops*. The first species, *M. dawsoni*, was founded on two imperfect skulls (No. 1173 and No. 971 Coll. Can. Geol. Surv.). No. 1173, of which a sketch was made in the field before the bones were removed, is figured on page 58 (Fig. 14) (*loc. cit.*) and includes some of the bones surrounding the orbits, the right maxilla, a quadrate, the occipital condyle, a part of the posterior crest, fragments of the frontal-nasal bones and a curved horn. The second specimen (No. 971 Coll. Can. Geol. Sur.) on which this species was founded is a complete posterior part of a crest with which there was a separate pointed bone, thought to be a horn.

After examining this material Hatcher (*loc. cit.*, pp. 91-92) says: "I am inclined to regard the present species (*M. dawsoni* No. 1173) as closely allied to if not identical with the *M. crassus* of Cope. . . . The peculiar parietal (No. 971) associated by Lambe with the type of *M. dawsoni* I regard as pertaining to a distinct species and perhaps also to a distinct genus." In his conclusion as to the separation of this material Hatcher was influenced chiefly through consideration of the supposed horn, which he discusses at some length (*loc. cit.*, p. 93). Mainly due to Hatcher's suggestion (*loc. cit.*, foot note p. 93) Lambe (Ottawa Naturalist, Vol. XVIII, No. 4, pp. 81-83, pl. i, 1904) redescribed the specimen No. 971 and proposed for it the new generic and specific name *Centrosaurus apertus*, basing the generic distinction solely on the peculiar hook-like processes of the postfrontals (parietals) and the supposed nasal horn. This supposed nasal horn was later found to be a process of the crest and to extend diagonally forward above the right fontanelle and the specimen was refigured with it in place (Lambe, Ottawa Naturalist, Vol. XXIV, pp. 149-151, pl. iii, 1910).

Through the courtesy of Mr. Lambe I have been able to examine the types of *M. dawsoni* and *Centrosaurus apertus*. Although the greater part of the nasal is missing in No. 1173 there is a portion of the anterior upper border of the nares present as well as the tip of the premaxillary, demonstrating conclusively that the nasal horn curves backward as Mr. Lambe described it. With the complete skull as a guide I can see no characters that distinguish

*Centrosaurus apertus* from *M. dawsoni* and consider the former a synonym of the latter.

This leads us to consider the new, complete skull of *Monoclonius* from Canada which is specifically different from *M. crassus* and *M. dawsoni* (*Centrosaurus apertus*).

### **Monoclonius Cope.**

*Generic characters:* Skull small to medium sized with three horns; nasal horn large, curved or straight, rising from middle of nasals immediately above the posterior border of the nares; supraorbital horns small or incipient and flattened on the outer surface. Nasals large; nares nearly separated by osseous septum formed by premaxillaries and nasals. Premaxillaries deep with vertical plate forming septum non-fenestrated. Crest composed of short, broad squamosals and extension of elongate coössified postfrontals ('parietals') perforated by large fenestræ; each fenestra wholly within the boundary of the postfrontal. Margin of crest crenulated, each prominence bearing a separate ossification. A pair of long curved hook-like processes on posterior border of postfrontals.

This definition differs considerably from that given by Hatcher and Lull (*loc. cit.*, p. 162), but a reëxamination of all the known material confirms it.

### **Monoclonius flexus** sp. nov.

*Specific characters:* Skull medium sized. Nasal horn long and curved forward. Supraorbital horns short.

The relation of the various elements of the skull is essentially the same as in *Triceratops*, but those parts connected with the horns, the nose, and the posterior crest are greatly modified. The facial portion anterior to the orbit is comparatively longer than in any related genus and the nares are extremely deep.

*Styracosaurus* Lambe (Ottawa Naturalist, Vol. XXVII, No. 9, pp. 109-116, 1913) seems to be the closest related genus and the elements of the skull are similarly developed but in *Styracosaurus* the entire facial portion appears to be shorter, the nasal back of the horn is short, squamosal shorter, postfrontal (parietal) fontanelles reduced, epoccipital bones extremely long and posterior hooks of crest absent.

In profile (Plates XXXVIII and XXXIX) the most prominent feature is the nasal horn, which curves forward and is longer than in any described species of the family. Apparently it was derived from one center of ossification. It is ovate in cross section at the base, with the broad end of the oval posterior, and gradually tapers to a sharp terminal point. It rises from the nasals in midline antero-posteriorly and its center is directly above the

posterior border of the nares. This is a marked departure from *Triceratops* where in all species the nasal horn rises from the extreme anterior end of the nasals and the opening of the nares extends far back. In *M. crassus* (*sphenocerus*) the nasal horn is thin transversely, a character accentuated by crushing, erect and vertical to the nasals. In *M. dawsoni* the nasal horn is nearly as long as in the present species and it has the same degree of curvature but in the opposite direction.

The supraorbital horns are considerably larger than in *M. dawsoni*, and in this specimen they are asymmetrical, that of the left side being higher than the right. They are compressed laterally and very rugose, especially on the inner side. If the points of the supraorbital horns were derived from separate centers of ossification it is quite possible that the one from the right side has been lost and we have here only the rugose elevated portion of the postfrontal forming its base of attachment. Hatcher states (*loc. cit.*, p. 33), that the nasal horn, like the rostral, prementary, epoccipitals and epijugals may be considered dermal or epidermal ossifications, that they "differ greatly from the supraorbital horn cores, which are simple outgrowths of the postfrontals, and therefore are morphologically a part of their supporting elements." Whether or not they were sheathed in horn in this rudimentary stage is doubtful.

Anteriorly the rostral is developed the same as in *Triceratops* but the anterior ascending process is not carried upward as far.

The premaxillaries unite anteriorly to form a broad smooth vertical plate-like septum more nearly separating the nares than in *M. crassus* (*sphenocerus*) and non-fenestrated, whereas in all species of *Triceratops* this portion is fenestrated. In front they are convex and swelled out forming the front of the nose. Each sends upward a process reaching nearly to the base of the nasal horn, which is overlapped by a descending process of the nasals. Posteriorly each unites with the maxillary, lacrymal and nasal.

The nasals are much longer and larger than in *Triceratops* and quite different in form. Posterior to the nasal horn they have early united and all trace of union is obliterated; they form the top and sides of the nose back half-way between the nasal and supraorbital horns, where they unite with the frontals on the top, with the lacrymal and preorbitals on the sides, and with the premaxillaries below. Anterior to the nasal horn they are separated by the ascending processes of the premaxillaries and each sends downward a short plate that unites with the vertical plate of premaxillaries forming the septum. In *Triceratops* no portion of the osseous septum is formed by the nasals.

The maxillary has the same form as in *Triceratops* and as in that genus unites on the side with premaxillary, lacrymal and jugal, below with the premaxillary, palatine, epipterygoid and pterygoid.

The orbit is large and circular with the vertical slightly greater than the anteroposterior diameter. Its borders are rugose and formed by the lacrymal, preorbital, prefrontal, postfrontal, squamosal and jugal.

The jugal, as in *Triceratops*, unites above with the lacrymal, maxillary and squamosal but the quadratic portion is much more extensive than in that genus. The laterotemporal fenestra is entirely surrounded by the squamosal and the jugal. The posterior process of the jugal which forms its lower border overlaps the quadrato-jugal and quadrate whereas in *Triceratops* the quadrato-jugal forms the lower border of the laterotemporal fenestra and more of it is exposed on the side. The epijugals are missing in this specimen.

The posterior crest (text Figs. 1 and 2 and Plate XL) is composed of three bones, the two lateral squamosals suturedly distinct, and the postfrontals (parietals) coössified into a single element. (For interpretation of cranial elements see recent description of *Anchiceratops* (Brown, Bull. Am. Mus. Nat. Hist., Vol. XXXIII, pp. 539-548, 1914. It is broader transversely than long anteroposteriorly and saddle-shaped with a large fontanelle or opening on either side of the longitudinal axis, margins crenulated with distinct epoccipital bones on the prominences, that increase in size toward the posterior margin, the last prominence on each side a long hooked process.

This crest, with the exception of the process across the fontanelle, is similar in form to the specimen (No. 971 Coll. Can. Geol. Surv.) discovered by Lambe in the same locality and described first as *M. dawsoni* and later as the type of a new genus and species *Centrosaurus apertus* (Ottawa Naturalist, Vol. XVIII, No. 4, pp. 81-83, pl. i, 1904, and *ibid.* Vol. XXIV, pp. 149-151, pl. iii, 1910).

The squamosal is a thin irregular quadrilateral plate whose greatest length is oblique to the longitudinal axis of the skull. Anteriorly and above it unites with the postfrontal, postorbital and jugal and sends forward and downward a short process to unite with the posterior process of the jugal and form the lower border of the laterotemporal fenestra. On the free anterior border there is a deep emargination posterior to the quadrate followed by four projections on the right and five on the left squamosal. On the right side there are two separate epoccipitals and the base of a fourth. The upper border unites along its entire length with the postfrontal and forms a part of the border of the supratemporal fenestra.

The posterior two-thirds of the crest is formed by the broadly expanded postfrontals (parietals) coössified to form a single element, perforated on each side by a large fontanelle. This portion has been somewhat distorted through pressure. Between the supratemporal fenestra the postfrontals divide sending forward a bar on each side which expands in front of the posttemporal fossa to form the roof of the skull between the supraorbital horns.

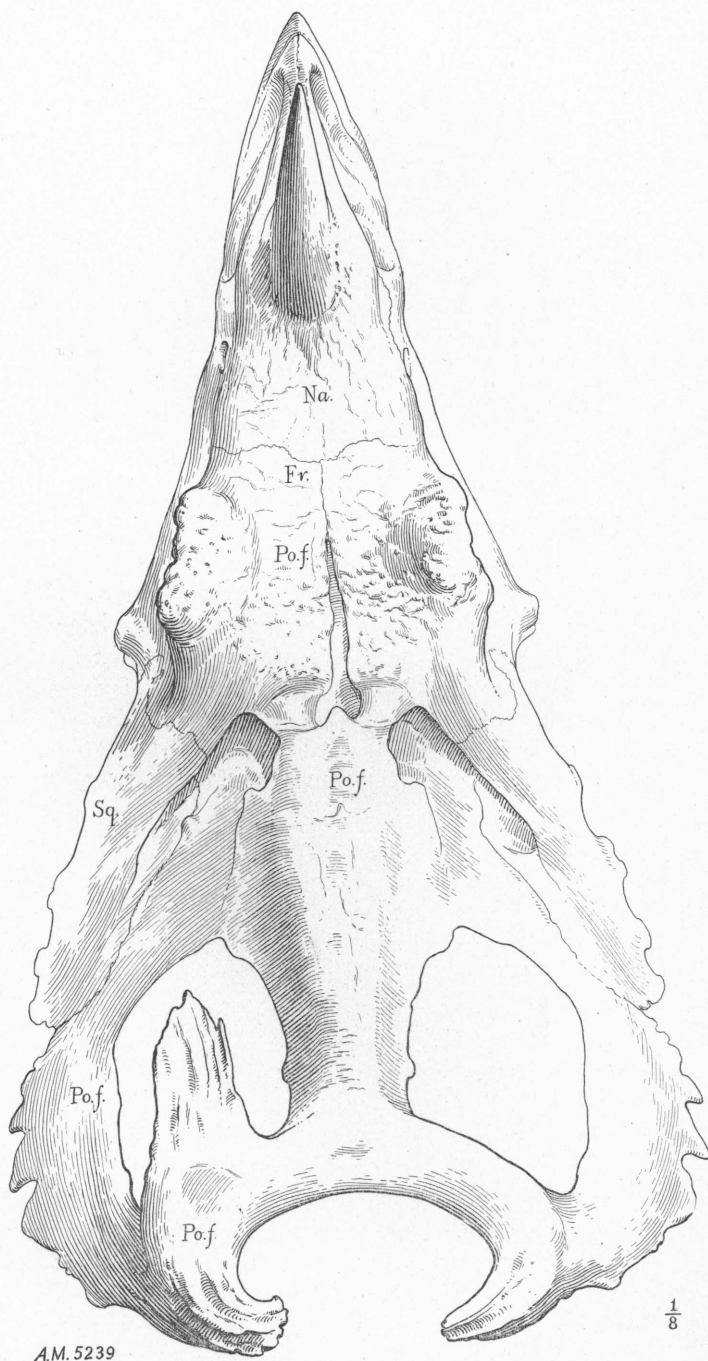


Fig. 1. *Monoclonius flexus*, top view, one eighth natural size. Type, No. 5239.

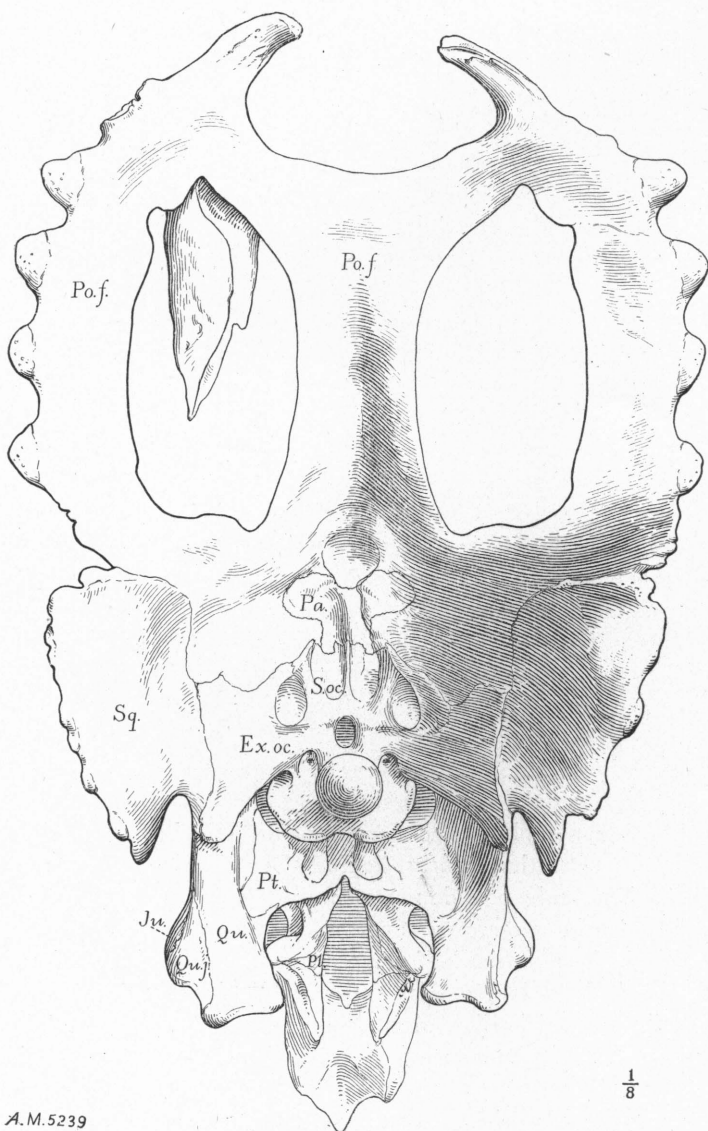
 $\frac{1}{8}$ 

Fig. 2. *Monoclonius flexus*, occipital view parallel with spinal cord, one eighth natural size. Type, No. 5239.

In this specimen the two expanded portions do not touch in the middle and the border of the fossa is carried forward almost to the frontals. Between the posttemporal fossa and the supratemporal fenestra the bar portion of the postfrontals is smooth and set below the plane of the rugose surfaces in front and behind. Over this bar blood-vessels probably passed into the fossa supplying nourishment to the base of the horns but the fossa is distinct from the supratemporal fenestra and does not communicate with the brain cavity. The postfrontal is a continuous bone from the base of the supraorbital horns to the posterior end of the skull.

The central portion is a convex longitudinal bar which continues back on the same plane with the face but is elevated at the posterior end where it sends off on each side a stout lateral bar which continues outward then forward and inward to join the central portion completely enclosing the large fontanelles. The longitudinal bar increases in thickness toward the posterior end and the lateral bars are about 6 cm. thick. From the lateral bar on the left, a large process extends forward above the fontanelle of that side. On the right side it is absent. In one specimen of *M. dawsoni* (*Centrosaurus apertus*), No. 971 Coll. Can. Geol. Surv., there is a similar process on the right side but none on the left. This process is an irregular mass of bone on the upper surface of which there are seven parallel longitudinal ridges. Morphologically it is similar to the tendon bones and was probably the posterior attachment of the large temporal muscles which passed forward and down through the supratemporal fenestra.

The free lateral border of the postfrontal is crenulated like the squamosal and the projections are surmounted by epoccipital bones which increase in size toward the posterior end. On the right side the first and last are missing and on the left side the last is missing.

In the Monograph on the Ceratopsia by Hatcher and Lull (*loc. cit.*, p. 162), it is stated that in *Monoclonius* "The margin of the crest is crenulated but the prominences do not seem to have arisen from separate ossifications, as in the succeeding genera of this phylum." Now the type of *M. crassus* is the posterior half of a crest or frill of an old individual, and it had evidently been subjected to considerable abrasion during fossilization so that the sutural borders of the epoccipitals are indistinct. Moreover, the two posterior prominences, one on either side of the central concave border, are the remains of the posterior hook-like processes complete on the type of *M. dawsoni* (*Centrosaurus apertus*) and on the present specimen.

These hook-like processes are in structure exactly like the process that overlies the postfrontal fontanelle and clearly different from the horn cores although they may have had the same morphological origin. The horn cores are composed of open cellular tissue while these processes are



made up of dense fibers separated by long canals and clearly analogous to the tendon bones that are present along the vertebral column of most dinosaurs. In fact they resemble a compact bundle of tendon bones fused together and were possibly the attachment of those muscles used chiefly in the vertical movement of the skull.

The occipital region is similar to that of *Triceratops* and the bones composing it have the same relation and proportional size. A part of the sutures only are well defined. Those below the condyle and the exoccipitals are distinct.

From the superior border of the foramen magnum a ridge passes diagonally downward and outward marking the line of contact of the exoccipitals and supraoccipitals as in *Triceratops* and on each side of the foramen magnum there is a large round shallow depression wholly within the supraoccipital. The suture marking the upper border of the supraoccipital is clearly defined on the left side, where it is separated from the postfrontals. The line of separation between it and the parietals is indicated but not well defined. Above the foramen magnum and within the boundary of the supraoccipital and parietal there is an extensive shallow depression divided by a high sharp vertical ridge slightly swollen near the middle. A line drawn transversely through this swollen part marks the lower border of the parietal. The upper border of the parietal is not distinct but is indicated by the low protuberance on either side of the central ridge. Above the parietal the postfrontal continues to the posterior border of the crest first as a wide overhanging roof but near the end becoming thick and narrow.

The structure of the palate is similar to that of *Triceratops* with little apparent difference in form or relation of its elements. The rostral is V-shaped, the angle prolonged below to form the sharp beak with lateral bars overlapping the premaxillaries, which in this individual are separated along the median line by a space one inch wide. The maxillaries are united anteriorly to form the roof of the mouth, and at the posterior end of this union are notched for articulation with the anterior end of the vomers, missing in this specimen but which were evidently small and rod-like. The vomers formed a long narrow bridge dividing the space between the maxillaries into two large vacuities as in *Triceratops*. The palatines and pterygoids are like those of *Triceratops*. The teeth are not distinguishable from those of *Triceratops*. In the upper jaw there were about thirty-five vertical series of teeth but the number cannot be accurately determined in this specimen. They follow the normal Ceratopsian method of development and implantation.

To recapitulate briefly the three species of *Monoclonius* now recognized are determined as follows:

*M. crassus*. Skull medium sized. Nasal horn straight and vertical. Supra-orbital horns small. Judith River Cretaceous.

*M. dawsoni*. Skull medium sized. Nasal horn curved backward. Supraorbital horns rudimentary. Belly River Cretaceous.

*M. flexus*. Skull medium sized. Nasal horn curved forward. Supraorbital horns small. Belly River Cretaceous.

#### Measurements.

	mm.
Total length of skull, approximately, along facial angle.....	1570
Length between condyle and anterior end of rostral.....	840
"    of nasals.....	420
Width between orbits.....	290
Greatest width of crest between borders of squamosals, over top.....	1130
Height of skull between posterior end of nasals and border of alveolus.....	360
Extreme height of nasal horn from top of nasals, anteriorly.....	330
Circumference of nasal horn at base.....	370
Height of supraorbital horn above top of orbit, left side.....	100

#### Abbreviations used in illustrations of *Monoclonius* skull.

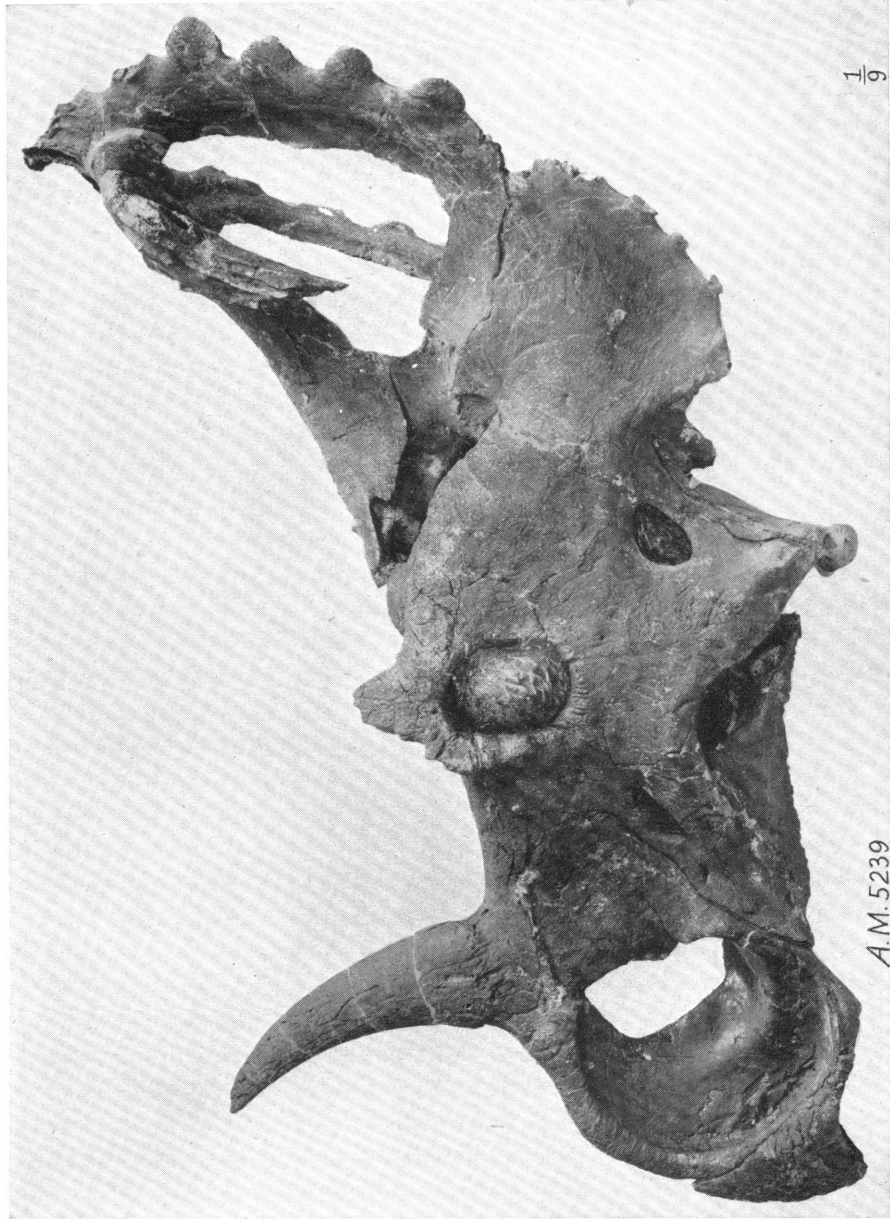
<i>Ex.oc.</i> = Exoccipital.	<i>Po.f.</i> = Postfrontal.
<i>Fr.</i> = Frontal.	<i>Pt.</i> = Pterygoid.
<i>Ju.</i> = Jugal.	<i>Qu.</i> = Quadrate.
<i>Na.</i> = Nasal.	<i>Qu.j.</i> = Quadrato-jugal.
<i>Pl.</i> = Palatine.	<i>S.oc.</i> = Supraoccipital.
<i>Pa.</i> = Parietal.	<i>Sq.</i> = Squamosal.

#### EXPLANATION OF PLATES.

Plate XXXVIII. *Monoclonius flexus*, left side, one ninth natural size. Type, No. 5239.

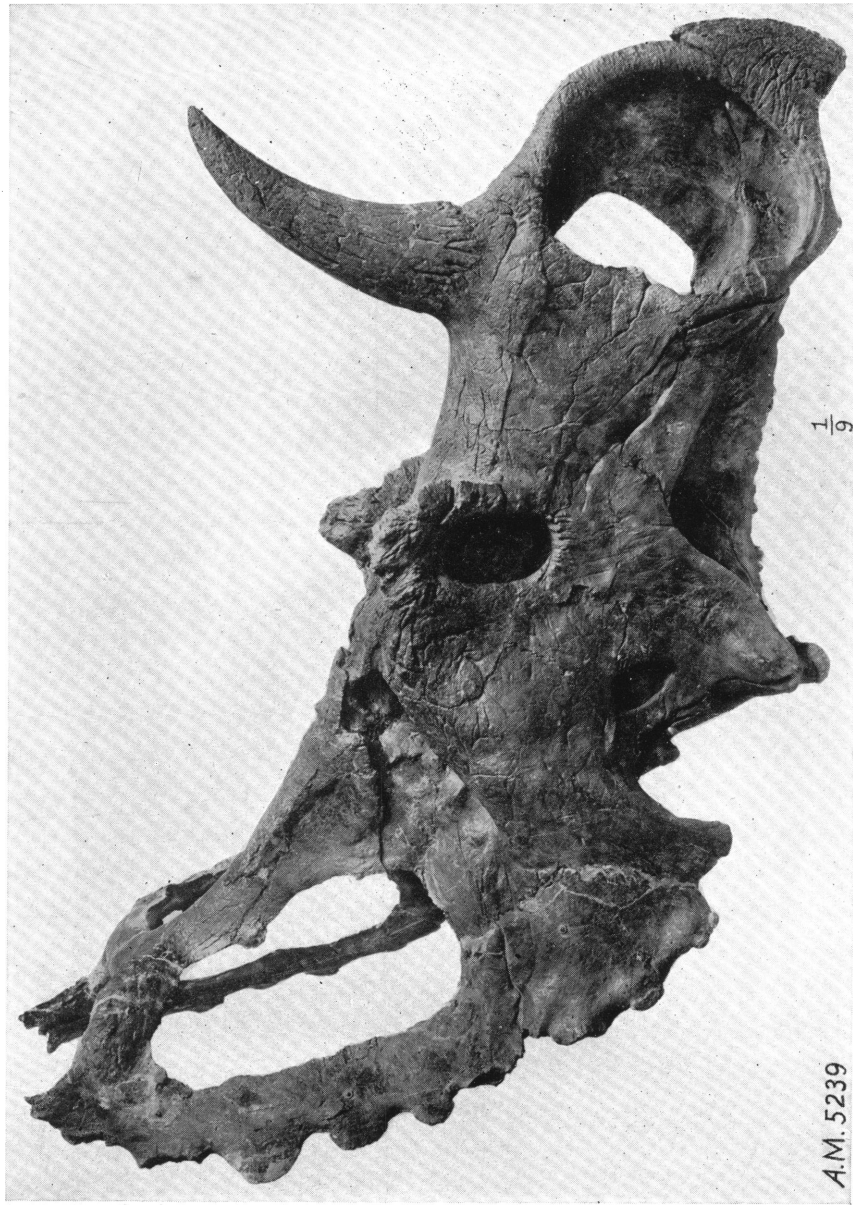
Plate XXXIX. *Monoclonius flexus*, right side, one ninth natural size. No. 5239.

Plate XL. *Monoclonius flexus*, *A* three quarters front view, *B*, occipital view, one ninth natural size. Type, No. 5239.



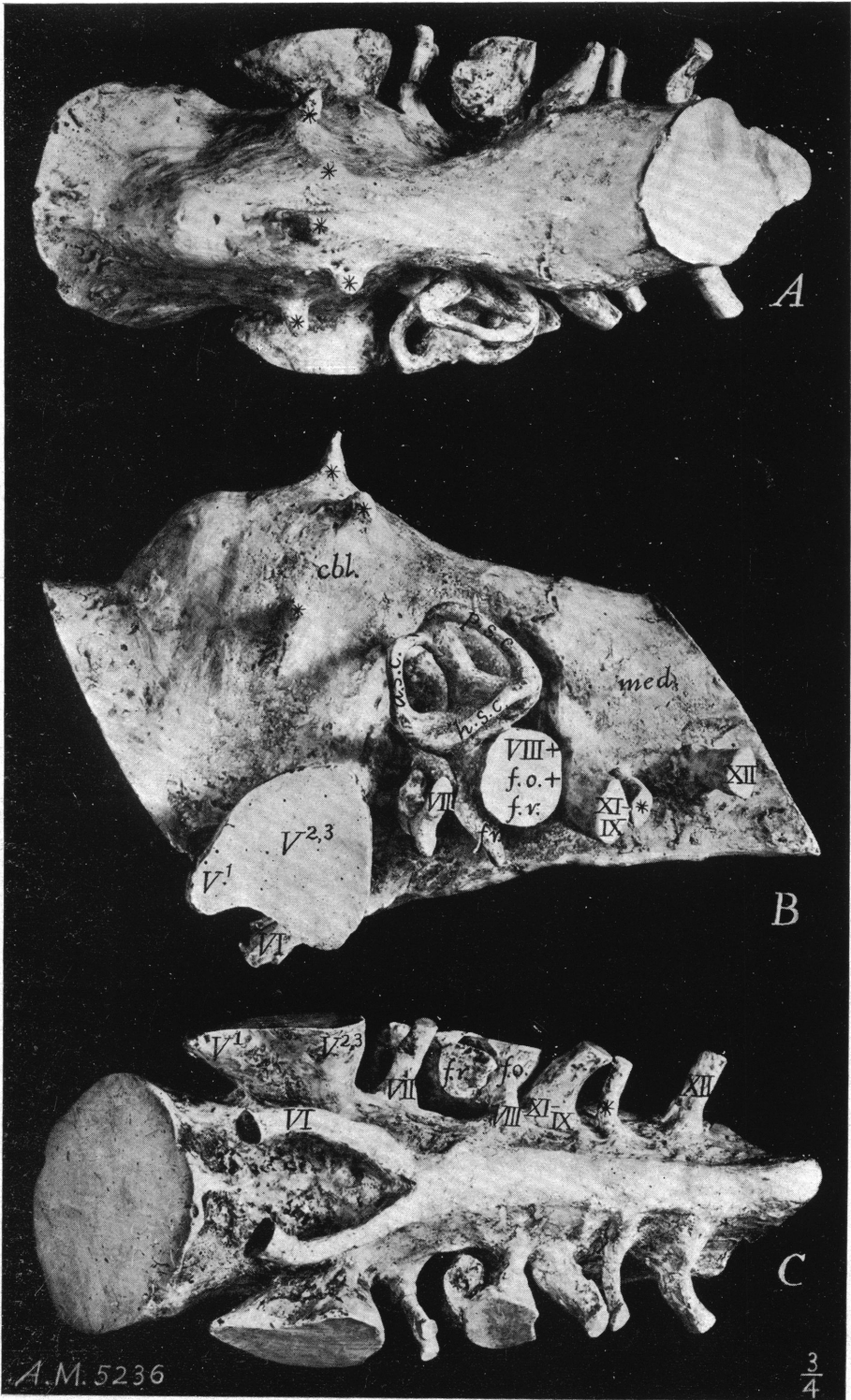
MONOCLONIUS FLEXUS. Type.





MONOCLONIUS FLEXUS. Type.





TRACHODONT.

