

ART. LII.—*Additional Characters of the Ceratopsidæ, with notice of New Cretaceous Dinosaurs*; by O. C. MARSH.
(With Plates V-VII.)

THE gigantic horned Dinosaurs from the Laramie, which have already been described by the writer, in this Journal,* are still under investigation, and many new points in their structure have recently been brought to light. Some of these are here placed on record for the first time, and taken in connection with those previously made known by the writer, indicate that the group is a very distinct one, worthy to be called a sub-order, which may be termed the *Ceratopsia*.

Some of the main characters of this group are shown in the specimens figured in the accompanying plates, and others will be fully represented in the illustrations of the memoir now in preparation.

The new forms described make it still more evident that the Cretaceous Dinosaurs, of which so little has hitherto been known, are quite as remarkable as their allies from the Jurassic.

Skull of Triceratops.

In addition to the armature of the skull of *Triceratops*, already described, another ossification has been found attached to the lower extremity of the jugal bone. This is a separate element, like the epoccipital bones, but in very old animals, it is coössified with the jugal, on which it rests. The external surface is rugose, indicating that it was covered with horn. It formed an anterior extension of the lateral series of ossifications on the squamosal, and served to protect the side of the head. This element may be called the epijugal bone. Its form and position are shown in Plate V, fig. 1, *d*.

The pterygoid bones and their position have already been described by the writer. The palatine bones are much smaller than the pterygoids. They are vertical, curved plates, outside, and in front of the pterygoids, and uniting firmly with the maxillaries. The vomers join the pterygoids in front, where they appear as thin bones, closely applied to each other.

* This Journal, vol. xxxvi, p. 477, December, 1888; vol. xxxvii, p. 334, April, 1889; vol. xxxviii, p. 173, August, 1889, p. 501, December, 1889; and vol. xxxix, p. 81, January, 1890.

The transverse bones give a weak support to the maxillaries, which are strengthened by close union with the pterygoids. They meet the pterygoids behind, and the palatines in front.

The Brain.

The brain of *Triceratops* appears to have been smaller in proportion to the entire skull, than in any known vertebrate. Its position and relative size are shown in Plate V, fig. 1, *f*. A side view of the brain-cast of another specimen is shown in Plate V, fig. 2, one-half natural size.

The position of the brain in the skull does not correspond to the axis of the latter, the front being elevated at an angle of about thirty degrees, or somewhat more than is indicated in Plate V, fig. 2.

The brain-case is well ossified in front, and in old animals, there is a strong septum separating the olfactory lobes.

Rostral Bone.

This bone, which has already been described by the writer, is well shown in Plate V, figs. 3, 4 and 5. Although firmly coössified with the premaxillaries in this specimen, the suture uniting them is quite distinct. In this species, the rostral bone is very large, and unusually sharp in front. The pre-dentary bone that meets it below is also very sharp, with corresponding massive dimensions.

Nasal Horn-core.

This protuberance is a separate ossification, and is free in young animals. It varies much in shape and position, in different species. In *Triceratops prorsus*, it is directed nearly forward, as shown in Plate V, figs. 3 and 4. In adult animals, it unites with the nasals, and slightly with the premaxillaries, and in old animals, the suture is entirely obliterated, as in the present specimen.

Teeth of Triceratops.

The teeth of *Triceratops* and its near allies are very remarkable in having two distinct roots. This is true of both the upper and lower series. These roots are placed transversely in the jaw, and there is a separate cavity, more or less distinct, for each of them. One of these teeth from the upper jaw is shown in Plate VI, figs. 1-4.

The teeth form a single series only in each jaw. The upper and lower teeth are similar, but the grinding face is reversed, being on the inner side of the upper series, and on the outer side of the lower series. The sculptured surface in each series is on the opposite side from that in use.

The teeth in this family are entirely confined to the maxillary and dentary bones. The rostral bone, the premaxillaries, and the pre-dentary, are entirely edentulous.

Cervical Vertebrae.

The atlas and axis of *Triceratops* are coössified with each other, and at least one other vertebra is firmly united with them. These form a solid mass, well adapted to support the enormous head.

The cup for the occipital condyle is nearly round, and very deep, as shown in Plate VI, fig. 6, *a*. In fig. 5, the same specimen is shown, seen from the side, with the fourth vertebra in position, but free. In this specimen, the rib of the second vertebra is coössified with it. On the fourth vertebra, the rib had a free articulation.

Scapular Arch and Limbs.

The scapula is massive, especially below. The shaft is narrow, sigmoid above, with a thin edge in front, and very thick posterior margin.

The humerus is large and robust, and similar in form to that of *Stegosaurus*. It is nearly as long as the femur in one individual, proving that the animal walked on all four feet. The radius and ulna are comparatively short and stout, and the latter has a very large olecranon process. The digits were terminated by broad hoof-like phalanges, one of which is shown on Plate VI, figures 7-9.

The femur is short, with the great trochanter well developed. The shaft is comparatively slender, and the distal end much expanded. The tibia is of moderate length, and resembles that of *Stegosaurus*. In one individual, at least, the astragalus is firmly coössified with the distal end of the tibia, as in *Stegosaurus*. The limb bones and other parts of the skeleton are nearly or quite solid.

The Pelvis.

The pelvis in this group is very characteristic, and the three bones, ilium, ischium, and pubis, all take a prominent part in forming the acetabulum. The relative size and position of these are shown in Plate VII, fig. 1, which represents the pelvic elements as nearly in the same plane as their form will allow, while retaining essentially their relative position in life.

The ilium is much elongated, and differs widely from that in any of the known groups of the *Dinosauria*. The portion in

front of the acetabulum forms a broad, horizontal plate, which is continued backward over the acetabulum, and narrowed in the elongated, posterior extension. Seen from above, the ilium, as a whole, appears as a nearly horizontal, sigmoid plate. From the outside, as shown in the figure, the edge of this broad plate is seen.

The protuberance for the support of the pubis is comparatively small, and elongated. The face for the ischium is much larger, and but little produced. The acetabular face of the ilium is quite narrow.

The pubis is massive, much compressed transversely, with its distal end widely expanded, as shown in the figure. There is no post-pubis. The pubis itself projects forward, outward, and downward. Its union with the ilium is not a strong one, and is similar to that seen in the pubis of *Stegosaurus*, as represented in the diagram on Plate VII, fig. 2.

The ischium is smaller than the pubis, but more elongate. Its shaft is much curved downward and inward, and in this respect, it resembles somewhat the corresponding part of the pubis of the ostrich. There is no indication that the two ischia met closely at their distal ends, and they were probably united only by cartilage.

A comparison of this pelvis with that of *Stegosaurus* shows some points of resemblance, but a wide difference in each of the elements. The pubis corresponds very closely, in its essential features, to the pre-pubis of *Stegosaurus*, but the post-pubis is entirely wanting in the specimen figured.

The characters which separate the *Ceratopsia* from the other known orders of the *Dinosauria* may be briefly stated, as follows:

- (1) The skull surmounted by massive horn-cores.
- (2) A rostral bone forming a sharp, cutting beak.
- (3) The teeth with two distinct roots.
- (4) The anterior cervical vertebrae coössified with each other.
- (5) The pubis projecting in front, and no post-pubis.

There are various other characters, more or less distinctive, but not of ordinal importance.

For the discovery of the specimens here described, belonging to this order, science is mainly indebted to the writer's able assistant, J. B. Hatcher, whose genius has done so much to bring to light the rare fossil vertebrates of the West.

NEW CRETACEOUS DINOSAURS.

Triceratops sulcatus, sp. nov.

One of the largest skulls of *Triceratops* secured during the past season was not in good preservation, although nearly the whole was recovered, and with it various vertebræ and other portions of the skeleton. The animal was fully adult, as shown by the ossification of the epoccipital and epijugal bones with the portions of the skull on which they rest. The epijugal bones are especially prominent and rugose, and the sutures uniting them with the jugals are nearly obliterated.

The most distinctive character of the skull is seen in the horn-cores of the frontal region, which are very large and elongate. On the posterior surface of the upper half of each horn-core, there is a deep groove, which has suggested the specific name. The horn-cores are narrow in front, and in the upper portion become distinctly ridged.

The antero-posterior diameter of the horn-cores at the base is about nine inches, and above, where the groove begins, about four and a half inches.

The caudal vertebræ in this species are unusually short, and the median caudals have a deep longitudinal groove on the bottom of the centra.

This type specimen was found in the Ceratops beds, in Wyoming, by Mr. J. B. Hatcher.

Trachodon longiceps, sp. nov.

In the same horizon with the *Ceratopsidae*, remains of other gigantic Dinosaurs are found, but as yet only detached portions of the skull and skeleton have been secured. One of the largest of these specimens is a right dentary bone, nearly perfect, which surpasses in size the corresponding part of any of the *Ceratopsidae* hitherto found. This dentary bone is fairly well preserved, and now measures over thirty-eight inches in length. When complete, it must have been fully three and one-half feet long. The front part, extending back eighteen inches, is edentulous. The alveolar portion is of equal length, and the border shows depressions for fifty-one teeth in a continuous series. These teeth had only a single root, and in general form, resemble those of *Hadrosaurus*. On the outer side of this dentary bone, there is a strong, rounded ridge, extending from the base of the coronoid process to the front, as now preserved. The dentary bone, as a whole, is slender, quite unlike any hitherto described, and represents a well-marked species.

The type specimen of the present species was found by Mr. J. B. Hatcher, in the Laramie of Wyoming.

Hadrosaurus breviceps.

Additional remains of the present species, or one nearly allied to it, have been secured since the description of the type specimen.* The latter has now been completely removed from the matrix, and on comparison with more perfect material proves to be a portion of the right dentary bone. The remarkable character of the teeth is well shown in the cuts below, figures 1 and 2.

There were at least five distinct series of teeth in place at once, but only two or three rows were in use at the same time.

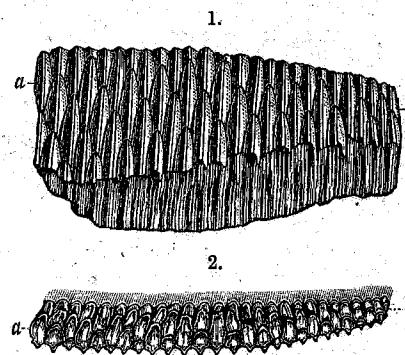


FIGURE 1.—Portion of right dentary of *Hadrosaurus breviceps*, Marsh; side view; one-fourth natural size.

FIGURE 2.—The same; seen from above. a, anterior; b, posterior.

Claosaurus agilis, gen. nov.

The small dinosaur described by the writer, in 1872, as *Hadrosaurus agilis*,† proves on investigation to represent a distinct genus, which may be called *Claosaurus*. The remains of this reptile were found by the writer, in the Pteranodon beds of the Cretaceous, near the Smoky Hill River in western Kansas. After the species was described, the writer again visited the locality, and secured other portions of the skeleton, so that now the more important parts are available for comparison.

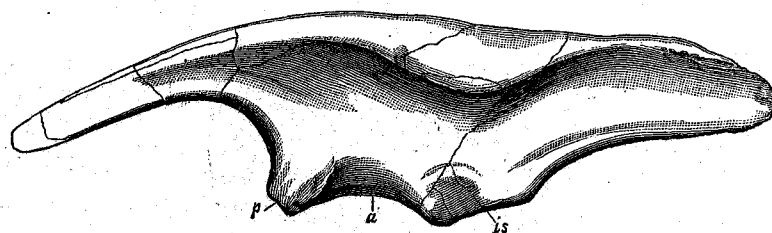
The teeth are of the *Hadrosaurus* type, but, apparently, only a single row was in use at one time. The cervical vertebræ are very short, and strongly opisthocælian. The fore limbs were very small. There are seven vertebræ in the sacrum, firmly coössified. The caudals are longer than wide, and the tail was quite elongate.

* This Journal, vol. xxxvii, p. 335, April, 1889.

† Ibid., vol. iii, p. 301, April, 1872.

The astragalus was closely applied to the end of the tibia, but not coössified with it. The fibula is strong and complete, with both ends nearly equal in size. There were three functional digits in the pes, with their metatarsals moderately elongate. The terminal phalanges are broad, and ungulate in form.

The ilium is intermediate in form between that of *Hadrosaurus* and *Stegosaurus*, and its general characters are shown in the cut below. The portion in front of the acetabulum is very slender, and elongate. The face for the pubis is much smaller than that for the ischium.



Ilium of *Claosaurus agilis*, Marsh; side view; one-sixth natural size. *a*, acetabulum; *is*, surface for ischium; *p*, surface for pubis.

The present genus is very distinct from *Nodosaurus*, which was described by the writer from a higher horizon of the Cretaceous. The present animal had apparently no dermal armor, and was of much more slender proportions. When alive, it was probably not more than fifteen feet in length.

The American Cretaceous Dinosaurs now known represent several well-marked families, which may be arranged as follows:

Order Theropoda. Carnivorous.

(1) The *Dryptosauridae*, including the large carnivorous forms, of which only imperfect specimens have been found, but sufficient to indicate that they are distinct from the *Megalosauridae* of the European Jurassic. Limb bones hollow. Fore limbs very small. Feet digitigrade, with prehensile claws.

Order Ornithopoda. Herbivorous.

(2) The *Trachodontidae*, herbivorous forms of large size, with teeth of the *Hadrosaurus* type, in many rows. Cervical vertebrae opisthocœlian. Limb bones hollow. Fore limbs small. Feet digitigrade.

(3) The *Claosauridae*. Only a single row of teeth in use. Cervical vertebrae opisthocœlian. Limb bones solid. Fore limbs small, and feet ungulate.

(4) The *Ornithomimidae*. Limb bones hollow. Fore limbs very small; hind limbs of avian type. Feet digitigrade, and unguiculate.

Order Ceratopsia. Herbivorous.

(5) The *Ceratopsidae*, highly specialized forms fully defined above.

(6) The *Nodosauridae*. Heavy dermal armor. Bones solid. Fore limbs large. Feet ungulate.

No *Sauropoda* are known from the American Cretaceous.

New Haven, Conn., April 22d, 1890.

EXPLANATION OF PLATES.

PLATE V.

FIGURE 1.—Skull and brain-cast of *Triceratops flabellatus*, Marsh; seen from above; one-twentieth natural size.

c, supra-temporal fossa; *d*, epijugal bone; *e*, epoccipital bone; *f*, brain-cast; *h*, horn-core; *h'*, nasal horn-core; *n*, nasal bone; *p*, parietal; *r*, rostral bone; *s*, squamosal.

FIGURE 2.—Brain-cast of *Triceratops serratus*, Marsh; side view; one-half natural size.

c, cerebral hemispheres; *cb*, cerebellum; *m*, medulla; *ol*, olfactory lobe; *on*, optic nerve; *p*, pituitary body.

FIGURE 3.—Anterior part of skull of *Triceratops prorsus*, Marsh; side view; one-eighth natural size.

FIGURE 4.—Front view of same.

FIGURE 5.—The same; seen from below.

h', nasal horn-core; *n*, nasal bone; *na*, nasal aperture; *pm*, premaxillary; *r*, rostral bone.

PLATE VI.

FIGURE 1.—Maxillary tooth of *Triceratops serratus*, Marsh; outer view; natural size.

FIGURE 2.—The same tooth; side view.

FIGURE 3.—The same tooth; inner view.

FIGURE 4.—The same tooth; seen from below.

FIGURE 5.—Anterior cervical vertebrae of *Triceratops prorsus*, Marsh; side view; one-eighth natural size.

FIGURE 6.—The same; front view.

a, anterior face of atlas; *d*, diapophysis; *p*, posterior face of fourth vertebra; *r*, rib; *s*, neural spine of axis; *s'*, neural spine of third vertebra; *s''*, neural spine of fourth vertebra; *z'*, posterior zygopophysis.

FIGURE 7.—Ungual phalanx of *Triceratops horridus*, Marsh; front view; one-fourth natural size.

FIGURE 8.—The same bone; side view.

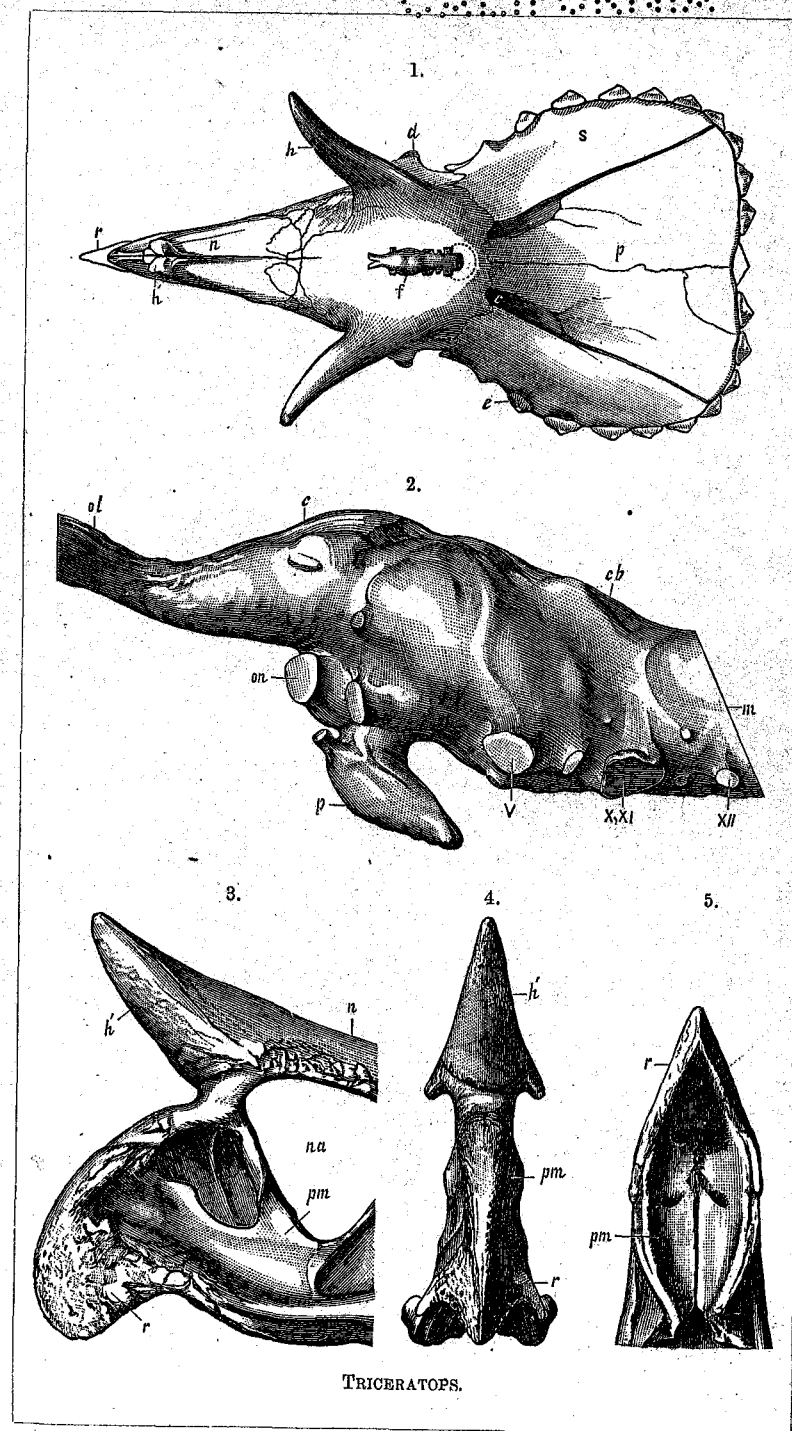
FIGURE 9.—The same; posterior view.

PLATE VII.

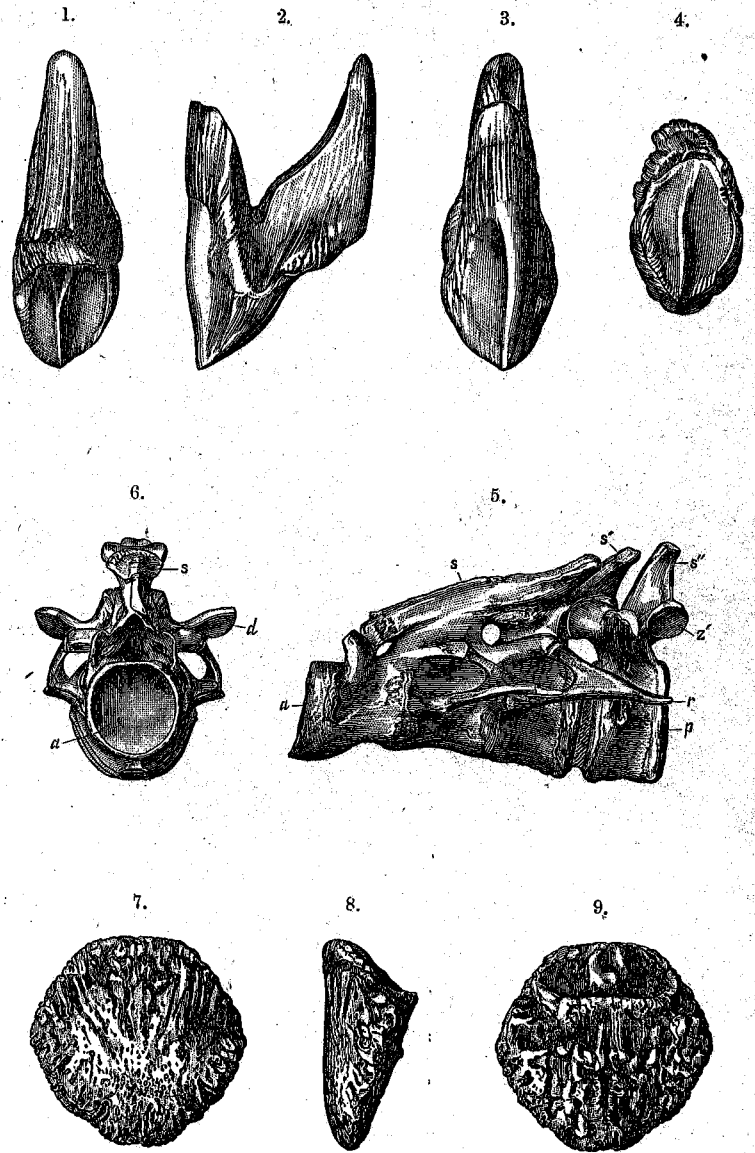
FIGURE 1.—Pelvis of *Triceratops flabellatus*, Marsh; side view; one-twelfth natural size.

FIGURE 2.—Pelvis of *Stegosaurus stenops*, Marsh; side view; one-tenth natural size.

a, acetabulum; *il*, ilium; *is*, ischium; *p*, pubis; *p'*, post-pubis.



TRICERATOPS.



TRICERATOPS.

