THE TYPE OF THE JURASSIC REPTILE MOROSAURUS AGILIS REDESCRIBED, WITH A NOTE ON CAMPTOSAURUS.

By Charles W. Gilmore,

Of the Department of Geology, U. S. National Museum.

INTRODUCTION.

In 1889[a] Prof. O. C. Marsh described briefly *Morosaurus agilis*, a new species of the Morosauridæ.

The type specimen (Cat. No. 5384, U.S.N.M.[b]) which was collected by Mr. M. P. Felch from the Upper Jurassic (Morrison Beds) of "Garden Park," near Canon City, Colorado, is now preserved in the fossil vertebrate collection of the U. S. National Museum.

The several elements comprising the type specimen were recently carefully prepared and important characters, hitherto unobserved because of adhering matrix, were disclosed. On account of the exceedingly brief original designation of this species, as well as new characters recently noted, the writer believes it of importance to describe and figure the specimen more in detail than was attempted by Professor Marsh.

REVIEW OF THE TYPE MATERIAL.

Marsh's original description of the species is as follows:

MOROSAURUS AGILIS, sp. nov.

A second new species, which apparently belongs to the same genus, is represented by the posterior half of the skull, the anterior cervical vertebræ, and other parts of the skeleton. This animal was in direct contrast with the one[c] last described, the skull and skeleton being especially light and delicate in structure for one of the *Sauropoda*. It was also much smaller in size, being the most diminutive known member of the genus, probably not more than fifteen feet in length.

[a] O. C. Marsh, Amer. Jour. of Sci., XXXVII, April, 1889, p. 334.

[b] Marsh's original accession numbers are as follows: 1607 and 12, 1904 catalogue number of the Yale University Museum.

[c] Marsh refers here to *M. grandis*, a larger species described in the same paper.

The figure below represents the back of the skull with the atlas attached, and the post-occipital bones in place. The axis and third cervical were also found in position. These will serve to distinguish the present species from the others of the genus, as they are proportionally much longer and of lighter structure.

The hind feet of the present specimen agree in general structure with those of *Morosaurus grandis*, but differ in having the first digit unusually large and massive in comparison with the others. The third, fourth, and fifth are especially slender.

The writer has been unable to find the "other parts of the skeleton" mentioned by Marsh in his original description. Moreover, a rough field sketch accompanying the type specimen only shows the posterior portion of the skull, atlas, axis, and third cervical, and these elements in all probability constitute the type specimen.

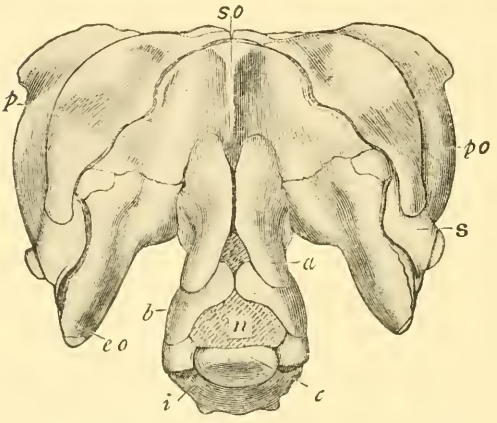


FIG. 1.—SKULL OF MOROSAURUS AGILIS (CAT. NO. 5384), POSTERIOR VIEW, ½ NAT. SIZE. *a*, PROATLAS; *b*, LATERAL PLATE OF ATLAS; *c*, ODONTOID PROCESS, OR CENTRUM, OF SAME; *eo*, EXOCCIPITAL; *i*, INTERCENTRUM OF ATLAS; *n*, NEURAL CANAL; *p*, PARIETAL; *po*, POSTORBITAL; *s*, SQUAMOSAL; *so*, SUPRAOCCIPITAL.

The hind foot which is mentioned as appertaining to the "present specimen" is also missing, unless Marsh refers here to the right pes (Cat. No. 5369, U.S.N.M., 1655 Marsh's accession number, figured in Plate XXXVII, fig. 2, in Dinosaurs of North America), and which he has identified as belonging to *Morosaurus agilis*. See fig. 2*b*. Marsh must have inadvertently referred the pes to this species as the original field labels still with the specimens discussed here, show the type was collected in 1883, while the hind foot was not found until 1888, five years later. Fig. 1, Plate XXXVII, Dinosaurs of North America represents the right manus (Cat. No. 5371, U.S.N.M., Marsh's original number 1655) of *M. agilis*, also in the collection of this Museum. See fig. 2*a*. With the foot are the radius and ulna. Both of the feet were collected by Mr. Felch at the same time and place, "Garden Park," near Canon City, Colorado, from the Upper Jurassic (Morrison Beds), in 1888. Whether they belong to the same specimen or even to the same species, in the state of our present knowledge can not be determined with any degree of certainty.

The "quarry" at Canon City, where Marsh secured the remains of various specimens of the Dinosauria, is commonly known as a "general quarry," as from it have been obtained the remains of a large number of individuals representing several genera and species in a

disarticulated and scattered condition, so intermingled that, unless a skeleton has become isolated or is still articulated, the several elements composing it can not be reassembled with the absolute assurance that they pertain to a single individual. The writer is inclined to the opinion that the identification of the manus and pes of *M. agilis* has not been accurately made, and until we have more positive evidence it would be well to reserve our decision.

While Marsh pointed out in his original description that *M. agilis* is the most diminutive member of the Morosauridæ, from our present knowledge of the skeletal structure of the Opisthocœlian dinosaurs, the writer believes that his estimate of the length of *Morosaurus agilis*

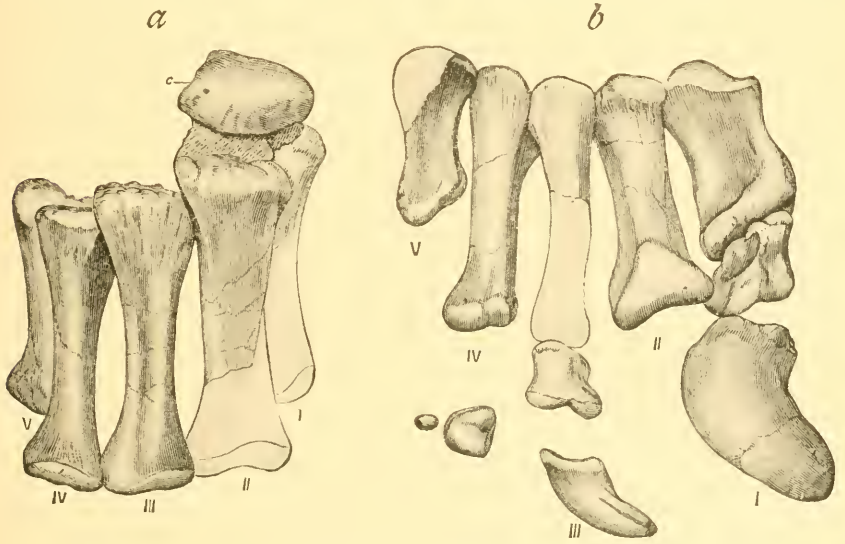


FIG. 2.—MOROSAURUS AGILIS? ¼ NAT. SIZE. *a*, FRONT VIEW OF RIGHT FORE FOOT (CAT. NO. 5371); *c*, CARPAL BONE; I-V, METACARPALS; *b*, FRONT VIEW OF THE RIGHT HIND FOOT; I-V, DIGITS (CAT. NO. 5369), ¼ NAT. SIZE.

at 15 feet would fall far short of the total length, and it would not be surprising were the skeleton found to exceed twice the original estimate.

DESCRIPTION OF THE TYPE SPECIMEN.

With the exception of two genera our knowledge of the skull of the Opisthocoelian dinosaurs is extremely limited. Recently Dr. W. J. Holland[a] has published a very complete description of the skull of *Diplodocus* based on all of the known material, and in a preliminary paper Prof. Henry F. Osborn[b] has mentioned some of the important

[a] W. J. Holland, Osteology of Diplodocus Marsh, Memoirs of the Carnegie Museum, Pittsburg, Pennsylvania, II, No. 6, 1906.

[b] H. F. Osborn, Nature, LXXIII, Jan. 18, 1906, p. 283, fig. 2.

features of a beautifully preserved skull of *Morosaurus grandis* now in the American Museum of Natural History, New York.

Although Marsh determined most of the elements composing the posterior aspect (see fig. 1) of the skull of *Morosaurus agilis*, he did not describe them in detail; therefore the writer, because of the rarity of the Opisthocoelian dinosaurian skulls, as well as to make our knowledge of these crania a little more exact, now attempts such a description.

DESCRIPTION OF SKULL.

The skull of *M. agilis*, although somewhat distorted by crushing, shows quite clearly the relationship of the several elements of the posterior portion. The occipital segment consists of four bones, basioccipital, exoccipitals, and supraoccipital, and the plane of the occiput forms an obtuse angle (see Plate XII) with the fronto-parietal part of the skull. The basioccipital extends well posterior to the median portion of the skull and forms the greater part of the subcircular convex condyle. Dorsally it unites by suture with the exoccipitals (see fig. 3). The latter bones enter into the formation of the occipital condyle and entirely exclude the basioccipital from the boundary of the foramen magnum. This arrangement of the occipital bones approximates the conditions found in the Chelonia. *Atlantosaurus montanus*, as figured[a] by Marsh, shows a similar arrangement of these elements.

The ventral side of the basioccipital in advance of the condyle is somewhat concave longitudinally and convex transversely, thus forming a well-defined neck. Anterior to this constriction a broad hypophysis begins to develop, being directed downward. Ventrally, however, this region has been badly injured, and the greater part of the basioccipital processes are missing. The suture between the basioccipital and basisphenoid is entirely obliterated.

The *exoccipitals* are not as broad nor as strongly developed as in *Diplodocus*, and they also differ in the backward extension of the basal portion for articulation with the basioccipital. The exoccipitals entirely enclose the foramen magnum and also enter into the formation of the occipital condyle. Laterally they articulate with the parietals and squamosals, the articulation with the latter being principally with the paraoccipital process which extends outward, backward, and downward. This process is expanded medially, but tapers to a rounded obtuse end. There are no posterior fossa in the skull of *Morosaurus agilis*. The suture at the union of the exoccipitals is entirely closed.

The *supraoccipital* is roughly an irregular subtriangular plate of bone occupying the space between the parietals above and the exoccipitals below. On the median posterior surface a very pronounced,

[a] O. C. Marsh, Dinosaurs of North America, Sixteenth Ann. Rept., U. S. Geol. Survey, Pt. 1, 1896, pl. xv, fig. 1.

somewhat roughened ridge is developed, which in *Diplodocus*, Doctor Holland has interpreted as the point of attachment for the nuchal ligament. Marsh has represented the suture between supraoccipital and exoccipital as continuing straight across toward the median line, but after removing the pro-atlas it was found to turn upward. (Compare figs. 1 and 3.) The further direction of this suture can not be determined from this specimen.

The *parietals* appear as two lateral processes extending from either side of the crest of the skull backward and downward, thus forming the anterior and inner lateral margins of the supratemporal fossa. The parietal suture is not indicated in this specimen. As shown by Professor Osborn in *M. grandis*, the parietals hardly enter into the composition of the roof of the cranium. Anteriorly they unite with the frontals, posteriorly with the supraoccipital which they enclose on three sides. At their posterior termination they overlap the squamosals. To a limited extent the parietal articulates with the exoccipitals. The great backward and downward extension of the parietals seem peculiar to this species.

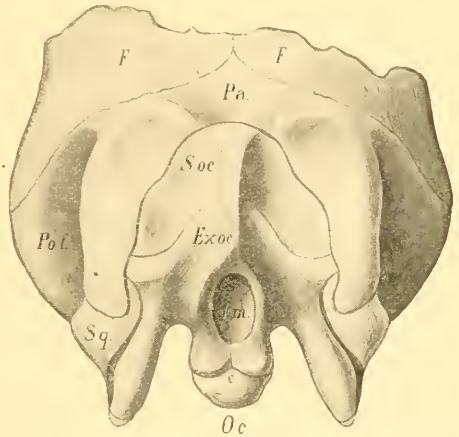


FIG. 3.—OBLIQUE POSTERIOR VIEW OF THE SKULL OF MOROSAURUS AGILIS (CAT. NO. 5384), ½ NAT. SIZE. *Ex. oc*, EXOCCIPITALS; *F*, FRONTALS; *F. m*, FORAMEN MAGNUM; *O. c*, OCCIPITAL CONDYLE; *Pa*, PARIETALS; *Po. f*, POST FRONTALS; *S. oc*, SUPRAOCCIPITAL; *Sq.*, SQUAMOSAL. RIGHT SIDE RESTORED SOMEWHAT FROM THE LEFT.

Only a portion of the *squamosal* of the left side is preserved with this specimen. It forms the posterior boundary of the supratemporal fossa. Along its inner margin it articulates with the paraoccipital process of the exoccipital. Anteriorly it is overlapped by the posterior extremity of the parietal and externally it meets the postfrontal.

The *frontals* appear to be united on the median line by an interlacing suture. Over the orbital cavities the bone is thickened and the exterior margins somewhat roughened and rounded. Anteriorly and medially these bones thin out to a sharp edge. A broad process is sent out from the outer anterior margin which probably articulated with the prefrontal while the median part articulated with the nasals. The orbital surface is concave antero-posteriorly. Its inferior surface united by sutnre with the orbitosphenoid.

The element here designated by the writer as *postfrontal* is the one Marsh identified as the postorbital bone. (See fig. 1 *po.* and Plate

XII*po. f.*). He also omitted the suture between postfrontal and frontal, which is plainly shown on the specimen. (See Plate XIII.) While there is no positive evidence that the postfrontal is now correctly identified, yet after a comparison with other reptilian skulls, both fossil and recent, it appears to the writer the most logical arrangement of this region of the skull. The postfrontal at its anterior extremity articulates with the frontal and parietal, with the former by a long lapping suture. (See Plates XII and XIII.) Its inner margin constitutes the outer posterior boundary of the supratemporal fossa. At the posterior boundary of this fossa an inwardly directed expansion of this bone unites with the squamosal. Its anterior surface enters into the boundary of the orbital cavity.

The *basisphenoid* articulates posteriorly with the basioccipital and exoccipitals and laterally with the alisphenoids and orbitosphenoids. The basipterygoid processes are broken off and gone.

The *alisphenoid* and *orbitosphenoid* bones are present, but their boundaries can not be definitely defined at this time. Where the orbitosphenoid articulates with the ventral surface of the frontals are several notches or openings leading into the cerebral cavity.

OPENINGS IN THE SKULL.

The *foramen magnum* is wholly inclosed by the exoccipitals. The outline of the foramen has been distorted somewhat by crushing, but it appears higher than wide and was probably oval, as represented in the restored drawing. (See fig. 3.)

The *supratemporal* fossa is suboval in form and opens outward and backward. It is bounded anteriorly by the parietal and postfrontal; the inner wall is formed by the parietal and bounded posteriorly by the squamosal, its outer wall by the postfrontal.

Only the superior boundary of the *orbital cavity* is shown in this specimen. This is concave antero-posteriorly and is formed above by the frontal and postfrontal. The inner posterior wall is bounded chiefly by ali- and orbitosphenoids. See Plate XII *O. sp.* and *Al. sp.*

There is no evidence of a *pineal foramen* in *M. agilis*. However, Marsh makes the following observation:[a] "In one specimen of *Morosaurus*, a similar opening has been observed, but in other *Sauropoda* the parietal bones, even if thin, are complete." He probably refers here to the skull of *Morosaurus grandis*, of which he figures a posterior portion in the Dinosaurs of North America. Plate XXX, fig. 2. The presence of a well-defined pineal foramen in the skull of *Morosaurus grandis* appears now to be definitely determined by Professor Osborn after a preliminary study of three *Morosaurus* skulls, of which he has published a figure of the more complete one.[b] He makes the

[a] Am. Jour. Sci., XXVII, February, 1884, p. 162.

[b] H. F. Osborn, Nature, LXXIII, 1906, p. 283, fig. 2.

following comments: "The most important point brought out is that all three skulls exhibit a well-defined tubular opening on top of the skull at the junction of the parietals and paraoccipitals. This foramen is smoothly lined with bone and leads directly down into the cerebral cavity."

Lesser foramina.—The brain cast of *Morosaurus grandis*, figured by Professor Marsh, shows at its anterior extremity the olfactory lobes. Just anterior to the place these lobes would occupy in the brain case of *M. agilis* is a large V-shaped opening, through which the olfactory nerves must have had exit. (See I, Plate XII.) The opening is bounded above by the frontals and below by the orbitosphenoids.

Twenty millimeters posterior to the olfactory foramen are two deep circular openings, the optic foramina. (See II, Plate XII.) These appear to merge into one another, but if separated at all it is by a very thin septum of bone. In *Diplodocus* Doctor Holland says they are separated by a "short filament of bone."

Posterior and external to the optic foramina, shown best on the right side of the skull, is a subcircular foramen, which probably gave exit to the oculomotor nerve. (See III, Plate XII.)

Situated at a higher level and posterior to the last-mentioned opening is an oval foramen (this is also best shown on the right side of the skull), which, according to analogy of the recent reptilia, is the exit for the trigeminal nerve. (See IV, Plate XII.)

As mentioned before, where the orbitosphenoids unite with the frontals along their superior lateral margins is quite a prominent foramen, which may have served as an entrance for blood vessels or the exit of nerves.

Just above the suture between exoccipitals and basioccipital and below the paraoccipital process in the exoccipitals are three foramina which the writer identifies as follows: The larger and superior one probably gave exit to the hypoglossal nerve; this opening passes through the exoccipital and enters the posterior margin of the foramen magnum a little in advance of its posterior boundaries. External to the hypoglossal foramen is the foramen for the pneumogastric nerves, while more ventrally still is the foramen through which the internal carotid artery enters the skull.

Pro-atlas.—The pro-atlas or postoccipital is composed of two subtriangular lateral pieces; when in position, as found with this specimen, they are attached to the occiput just above the foramen magnum, and extend backward and outward (see fig. 1. *a*. and Plates XII and XIII *P. At.*), overlapping the neural arches of the atlas, thus affording a protection to the spinal cord at this point.

These lateral pieces in profile are subtriangular, flattened, and somewhat curved antero-posteriorly. The anterior ends (see fig. 4*b*.) are greatly thickened and somewhat concave transversely, to better fit the

posterior surfaces of the exoccipitals with which they articulate. A notch and groove on the anterior end and side appear to indicate the course of a nerve. The internal surface of this bone is gently concave antero-posteriorly. The shaft gradually converges from the thick anterior to a thin posterior end.

Marsh has found the pro-atlas present in two members of the *Opisthocœlia* (*Sauropoda*), i. e., *Morosaurus* and *Apatosaurus* (*Brontosaurus*).[a] They have not been found in *Diplodocus*, although, after an examination of the posterior part of two skulls in the collection of this museum, a flattened roughened surface on the exoccipitals just above the foramen magnum would appear to indicate that these bones were also present in this genus.

The *pro-atlas* is often regarded as a vestige of a degenerate vertebra in front of the atlas, but Reynolds[b] says in the *Crocodilia* it is a membrane bone, and therefore not properly a vertebral element. In the crocodile these lateral pieces are united on the median line, thus forming a single element.

FIG. 4.—RIGHT HALF OF THE PRO-ATLAS OF MOROSAURUS AGILIS (CAT. NO. 5384), ½ NAT. SIZE. *a*, LATERAL VIEW; *b*, ANTERIOR END OF SAME.

Marsh has designated these elements in *M. agilis* as the "post occipital bones," but as they appear homologous with the dorso-lateral elements in *Rhynchocephalia*, certain *Lacertilia*, *Crocodilia*, *Pterosauria*, and *Chelonia*, to the writer there seems no good reason why the older term, pro-atlas, should not apply here.

Marsh gives the following measurements of the pro-atlas of *Morosaurus grandis:*

	mm.
Greatest length	65
Greatest length of surface opposed to exoccipital	30
No. 5384. Greatest length proatlas of *M. agilis*	45
No. 5384. Greatest length of surface opposed to exoccipital of *M. agilis*	27

Atlas.—The atlas is composed of four separate pieces, the intercentrum, two neural arches or neurocentra, and the odontoid process.

Like the atlas of *Diplodocus*, this element in *Morosaurus agilis* is short antero-posteriorly and without transverse processes. The pieces composing the atlas were found articulated, and although they have suffered somewhat from lateral compression (see fig. 5), there was not enough displacement to render it difficult to properly interpret them.

The *intercentrum* is, roughly, a moderately thick suberescentic bone, both ends being truncated almost horizontally, thus forming two surfaces for articulation with the neural arches. The upper anterior surface is deeply excavated and well adapted for articulation with the

[a] E. S. Riggs, Field Columbian Museum Publication, p. 82, Geol. Ser., II, No. 4, Aug. 1, 1903. Riggs has shown that *Brontosaurus* is a synonym of *Apatosaurus*.

[b] S. H. Reynolds, The Vertebrate Skeleton, 1897, p. 240.

occipital condyle. Posteriorly it articulates with the odontoid and intercentrum of the axis. The median superior surface is concave transversely and somewhat convex antero-posteriorly. On either side of this median concave portion are broad articular surfaces upon which the pedicels of the neural arch rest. The somewhat roughened surfaces of these facets look upward and slightly outward instead of upward and outward, as Doctor Holland[a] has shown to be the case on the intercentrum of *Diplodocus*. The ventral surface is slightly concave antero-posteriorly and quite evenly rounded transversely. On either side of the median line of the posterior margin of the lower surface are small facets (see fig. 5 and also Plate XII*c*.), which represent the points of attachment for the cervical ribs. Just above these processes on the lateral surfaces the bone is somewhat excavated, forming two shallow pits.

The *neural arch*, or neurocentrum, is an irregularly curved bone, strongly concave inwardly and convex outwardly. It articulates with the intercentrum by means of a heavy articular base from which rises a broad, winglike plate. This articular end has three faces, one which unites with the intercentrum, a second large one which looks forward and inward and forms a part of the cup for the reception of the occipital condyle, and a third, the smallest of the three, which looks backward and inward and opposes the lateral anterior face of the odontoid. These faces all meet one another at obtuse angles. Above the articular end just described the shaft of the neural arch is constricted, but superior to this neck it widens out into a broad, thin, curved plate which, with the plate of the opposite arch, forms the covering of the neural canal. Where these plates oppose one another superiorly the ends are broadly rounded antero-posteriorly, though probably they never united, but were held together by ligamentary attachments. This plate, where it broadens anteriorly, terminates evenly in a thin, sharp, vertical edge, which is overlapped by the posterior extension of the pro-atlas. The posterior extent of the neurocentrum can not be determined accurately from this specimen, although the presence of anterior zygapophyses on the axis (see Plates XII and XIII*a*. *zyg*.) would indicate that the process continued far enough posteriorly to articulate with this surface.[b] Marsh's figure of the posterior view of the skull is apparently defective in this respect. (See fig. 1.) The *odontoid* or *pleurocentrum* has suffered considerably from crushing, but enough is preserved to determine its most important characters. The posterior articular face (see fig. 1*c*.) is

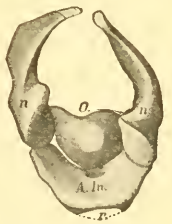


FIG. 5.—ANTERIOR VIEW OF ATLAS OF MOROSAURUS AGILIS (CAT. NO. 5384). ½ NAT. SIZE. *A. In*, INTERCENTRUM OF ATLAS; *n*, NEURAL ARCH; *o*, ODONTOID; *r*, RIB FACETS.

[a] W. J. Holland, Memoirs of Carnegie Mus., Pittsburg, II, No. 6, p. 247

[b] The posterior extension of this element in *M. grandis* is well shown in fig. 6.

slightly cupped and but little roughened, and in this specimen at least, shows no indication of coalescence with the axis. The anterior surface is rounded, not evenly, but somewhat constricted about the middle. The upper surface, which forms the floor of the neural canal, is slightly concave transversely.

Measurements of atlas.

	mm.
No. 5384. Greatest length of intercentrum	15
No. 5384. Greatest width of intercentrum	34
No. 5384. Greatest height of atlas	55

Axis.—The centrum of the axis is opisthocœlus and especially light and delicate in its construction. With certain modifications the centrum is concave longitudinally both on its lateral and ventral surfaces and convex transversely. The greatest length of the centrum is a trifle more than two-thirds the height of the vertebra from the ventral surface to the top of the neural spine. In these dimensions it differs from the axis of *M. grandis*, whose length of centrum is hardly more than one-half the height of the vertebra. (See fig. 6.)

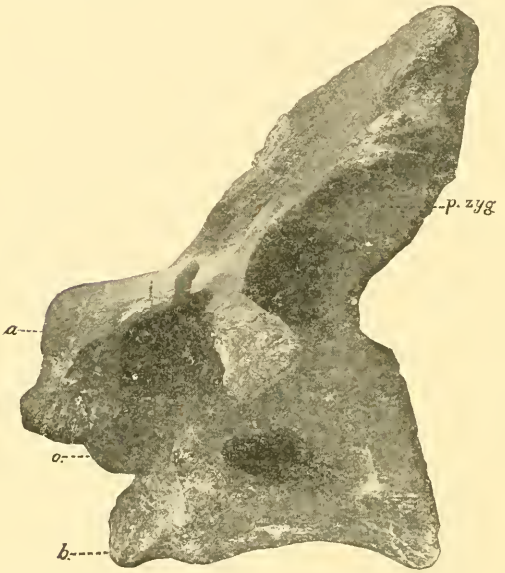


FIG. 6.—SIDE VIEW OF AXIS AND PART OF ATLAS OF MOROSAURUS GRANDIS (NO. 1905 YALE UNIVERSITY MUSEUM), ABOUT $\frac{1}{5}$ NAT. SIZE. *a*, LEFT HALF OF NEURAL ARCH OF ATLAS; *b*, POSSIBLE INTERCENTRUM OF AXIS; *o*, ODONTOID PROCESS; *P. zyg*, POSTERIOR ZYGAPOPHYSIS.

On the left side is a deep pleurocentral cavity, the depth of which is probably somewhat exaggerated by crushing. This cavity is separated from the very shallow one of the opposite side by a thin septum of bone. Posteriorly this cavity is only separated from the cup for the ball of the succeeding vertebra by a thin convex plate of bone. Anteriorly it ends a little in advance of the center of the centrum. The anterior end of the centrum is gently rounded on either side. A vertical plate is developed behind, which is a cuplike excavation and lies in front of the pleurocentral cavity. On either side of the anterior ventral surface are what might be called infralateral cavities. These extend well forward into the ball of the centrum and are separated from one another by a thin median plate of bone. These cavi-

ties, the writer should judge from Hatcher's figures and description, are not present in the axis of *Diplodocus*, and they also appear to be absent in the axis of *M. grandis*. (See fig. 6.)

The anterior ventral surface of the centrum is abruptly truncated transversely, forming a broad, flat facet for the intercentrum of the axis. This element, so far as the writer has been able to ascertain, has never before been found in a member of the Opisothocœlia. In older individuals it may coalesce with the centrum and thus lose its identity. However, many of the sutures one would expect to find distinct in this individual have become entirely obliterated. The specimen of *M. grandis* described and figured by Marsh, which, according to the figures given, is a very much larger individual, shows sutures between the centra and spinous processes of the vertebræ. Yet in this very much smaller specimen there is no indication whatever of their union. So it would appear, as inferred by Marsh in his original description, that this is an adult representing the most diminutive member of the genus.

FIG. 7.—VENTRAL VIEW OF AXIS OF MOROSAURUS AGILIS (CAT. NO. 5384), ½ NAT. SIZE. *Ax. In.*, INTERCENTRUM OF AXIS; *P. zyg.* POSTERIOR ZYGAPOPHYSES; *Tr.* TRANSVERSE PROCESSES.

The second intercentrum (see fig. 7, *Ax. In.*) is a small rectangular block of bone of greater width than length and of medium thickness, being thicker in front than behind. The posterior border is straight and fits closely to the truncated ventral surface of the centrum. It thus occupies a primitive position, as found in *Platecarpus*, and forms a liplike projection. An examination of Marsh's figure of the axis of *M. grandis* would indicate that it also bore an intercentrum, but in that case probably became completely co-ossified with the centrum. (See fig. 6*b*.) The anterior border is gently convex transversely. This element occupies the excavated surface of the centrum and does not extend below the lower surface. It is 22 mm. wide and 14 mm. long.

From the posterior and superior borders of the neural arch two diverging postzygapophysial lamina rise. These extend upward and backward until the postzygapophyses are reached; above them they continue upward and forward, meeting anteriorly and superiorly, forming the prespinal lamina. They thus inclose a deep postspinal cavity which opens posteriorly and superiorly. Prominent rugosities are developed just above the postzygapophyses. These also appear to be present on the axis of *Morosaurus grandis*.

A transverse process is developed on the anterior sides of the neural arch. It is moderately broad and thin and is directed downward, backward, and outward, terminating in a rounded end. The horizontal lamina extends from the transverse process to the postzygapo-

physes at an ascending angle. The inferior blade of the diapophysial lamina connects the transverse process with the side of the neural arch, thus forming the anterior wall of the postdiapophysial cavity. The pre- and supradiapophysial cavities are not present either in *M. agilis* or *M. grandis*. On the left side, just in front of the pleurocentral cavity, is a small foramen (*f*, Plate XII) which is wanting on the opposite side. The axis of *M. agilis* may be distinguished from that of *M. grandis* by the more anteriorly directed spine of the former, by the posterior extension of the postzygapophyses, and by the greater length of the centrum in proportion to its height. The writer believes that the cavities can not be considered sufficiently reliable characters for even specific separation, as they are not at all constant in shape, size, or position. Even on the same vertebra, as shown in this specimen, cavities found on one side may be absent on the other.

Measurements.

	mm.
No. 5384. Greatest length of centrum of axis	70
No. 5384. Greatest height of axis (taken at the middle)	97

Third cervical.—This vertebra was articulated with the axis, so its position may be considered absolutely determined. Like the other elements of the type specimen, it has suffered somewhat from lateral crushing. The transverse processes, postzygapophysial lamina, and postzygapophyses are wanting. This is the first vertebra of the vertebral column to have the anterior zygapophyses prolonged beyond the end of the ball of the centrum. Although the transverse processes are missing, a well-developed articular facet (see *r*, Plate XII) on the lower anterior margin of the centrum shows the place of attachment for the capitulum of the cervical rib.

The spinous process, as figured, has been crushed forward somewhat from its normal position. This spine anteriorly is a thin plate of bone formed by the union of the prezygapophysial lamina, but shows no indication of being bifid at its apex, as Hatcher has represented the spine on the third cervical of *Diplodocus*, or as the fourth cervical of *M. grandis* is known to be. The large pleurocentral cavities posteriorly are separated by a thin septum of bone, but anteriorly this partition fails and they become confluent. As in the axis, this cavity occupies the posterior half of the centrum. On the anterior part of the centrum just above the facet for the cervical rib is another lateral cavity, nearly round in outline and extending well into the ball of the centrum. There is also a prediapophysial cavity which is separated from the postdiapophysial cavity by the lower blade of the diapophysial lamina. This cavity is not present on the right side of the centrum.

Principal measurements.

	mm.
No. 5384. Greatest length of centrum of third cervical	95
No. 5384. Greatest height of third cervical	100

OCCURRENCE AND RELATIONSHIPS.

Of the five species Marsh has proposed under this genus, two (*M. grandis*[a] and *M. agilis*) were first known from the Jurassic of Colorado. The other forms (*M. impar*, *robustus*, and *lentus*), as well as *M. grandis*, have been found in the Jurassic of Wyoming. If Hatcher's suggestion proves correct—that the beds at Canon City, Colorado (from which Marsh obtained some of his type specimens), are the equivalent of the marine or Baptanodon beds of northern localities, and therefore represent a lower horizon of the Jurassic—it would be to this region that we would naturally turn for the ancestors of those species found in the higher beds of the Wyoming localities.

The small size, in addition to the presence of a second intercentrum on the axis and no evidence of bifurcation of the single spine of the third cervical of *M. agilis*, might suggest a somewhat primitive condition as compared with the later forms. This supposition, however, bears but little weight and is not substantiated by other paleontological evidence, as several genera and species of the Opisthocœlia, apparently identical, have been found in both regions, and it is quite probable that later we shall find that *M. agilis* enjoys a like geological and geographical distribution. Already Professor Osborn[b] has referred to a forefoot from the "Bone Cabin" quarry as possibly being *M. agilis*, but this is doubly doubtful since we are uncertain of the identification of the so-called forefoot of *M. agilis* by Marsh. Of the five species named by Marsh but few distinguishing characters have been given, and at this time little can be said regarding the relationship of the several forms.

The primitive characters found in *Morosaurus agilis* suggest to the writer the possibility that the type specimen, when more complete material is known, may be found to pertain to one of the members of the more primitive family Brachiosauridæ,[c] possibly the smaller genus *Haplocanthosaurus*.[d] Unfortunately, none of the representatives of this family have the anterior cervical region preserved; so judgment on the question raised here must be deferred until homologous parts are discovered. While the writer is aware of the close relationship of the Brachiosauridæ and Morosauridæ, the simple spine of the third cervical of *Morosaurus agilis* is particularly suggestive as to the possibility of its being a member of the former family.

---

[a] Williston has pointed out that *M. impar* and *grandis* are synonyms (Kans. Univ. Quart., VII, p. 173).

[b] H. F. Osborn, Bull. Am. Mus. Nat. History, III, 1899, p. 170.

[c] E. S. Riggs, Field Columbian Museum Publication, p. 94, Geol. Ser., II, No. 6, Sept. 1, 1904.

[d] J. B. Hatcher, Memoirs of Carnegie Museum, Pittsburg, II, No. 1, 1903.

A NOTE ON THE GENUS CAMPTOSAURUS.

In comparing the axis of *Morosaurus agilis* with the homologous parts of other Dinosaurian specimens in the U. S. National Museum, the writer found, on the axes of two individuals of the genus *Camptosaurus*, intercentra attached by suture to the centra of the axes. So far as the writer is aware, this element has not been observed before in a representative of the Orthopoda. In the smaller (No. 5474, U.S.N.M.) and probably younger specimen the intercentrum has been somewhat crushed out of position, but in the larger specimen (No. 5473, U.S.N.M.) it is retained in place, as shown in fig. 8 (*Ax. In.*).

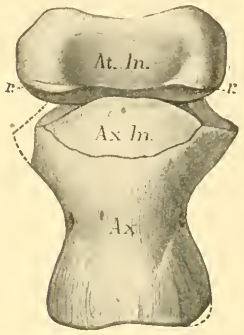


FIG. 8.—VENTRAL VIEW OF ATLAS AND AXIS OF CAMPTOSAURUS (CAT. NO. 5473), ½ NAT. SIZE. *At. In.*, ATLAS INTERCENTRUM; *Ax.*, AXIS; *Ax. In.*, AXIS INTERCENTRUM; *r.*, FACETS FOR RIBS.

Inferiorly the intercentrum of *Camptosaurus* is roughly subelliptical in form, the longer axis being transverse. It is closely united by suture to the lower half of the anterior end of the centrum, forming a prominent liplike projection which, when articulated, underlaps somewhat the intercentrum of the atlas. In a fully adult specimen this element would probably become co-ossified, as in *Morosaurus grandis*, and thus lose its identity. Viewed from the side, it is triangular in form, the deepest portion being next to the centrum. The inferior surface is gently convex transversely and slightly concave antero-posteriorly. Seen from the front, the center has the greatest vertical depth, the upper margins gradually sloping down to the lateral borders. The anterior face is smooth and somewhat concave supero-inferiorly. There are two small pits on the median anterior part of the inferior surface. The presence of an axis intercentrum in both the Opisthocœlia (Sauropoda) and Orthopoda (Predentata) tends to confirm somewhat the contention of Marsh and Hatcher that the Dinosauria is a natural group, and in the examples cited here it should be considered a persistent primitive character which was present in a remote but common ancestor.

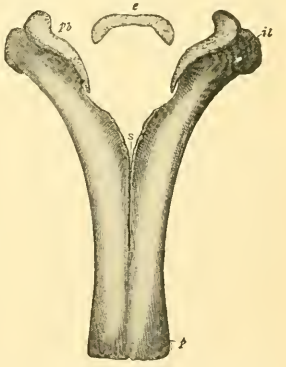


FIG. 9.—ISCHIA OF MOROSAURUS; INFERIOR VIEW, ⅛ NAT. SIZE. *e.*, DISTAL ENDS; *il.*, FACE FOR ILIUM; *p.*, DISTAL EXTREMITY; *pb.*, FACE FOR PUBIS; *s.*, SYMPHYSIS.

NOTE.

The writer takes this opportunity to call attention to fig. 3, Plate XXVIII, "Dinosaurs of North America" (reproduced here as fig. 9), which, according to Professor Marsh, illustrates the ischia of *Diplodocus longus*. After an examination of the original specimen, No. 4275,[a] now in the U. S. National Museum, it appears beyond question, as shown by the characteristic union of their distal ends, that these ischia pertain to the pelvis of one of the larger species of the Morosauridæ. The greatest length of the better preserved ischium is 800 mm.

EXPLANATION OF PLATES.

PLATE XII.

a.	Neural arch of atlas.	*O. sp.*	Orbitosphenoid.
Al. sp.	Alisphenoid.	*Pa.*	Parietal.
At.	Atlas.	*P. At.*	Pro atlas.
Ax.	Axis.	*Po. f.*	Postfrontal.
a. zyg.	Anterior zygapophysis of axis.	*r.*	Articular facet for attachment of cervical rib.
b.	Intercentrum of atlas.		
B. occ.	Basioccipital.	*S. F.*	Supratemporal fossa.
c.	Odontoid.	*S. oc.*	Supraoccipital.
d.	Intercentrum of axis.	*Sq.*	Squamosal.
Ex. oc.	Exoccipital.	*I.*	Olfactory foramina.
F.	Frontal.	*II.*	Optic foramen.
f.	Foramen.	*III.*	Oculomotor foramen.
O. C.	Occipital condyle.	*IV.*	Trigemenial foramen.

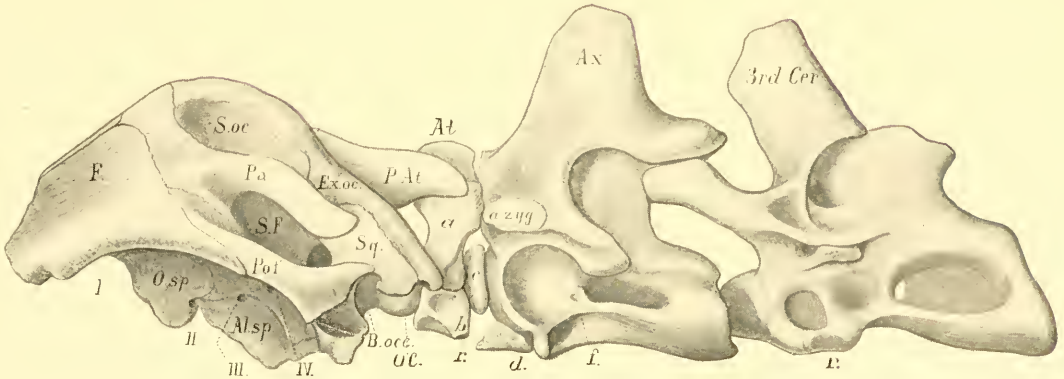
Side view of the posterior portion of the skull, the atlas, axis, and third cervical of *Morosaurus agilis*.

Type specimen (No. 5384) one-half natural size.

PLATE XIII.

Side view of the type of *Morosaurus agilis* (No. 5384), one-half natural size. From a photograph.

[a] Marsh's original accession number is 1655. The specimen is from the Morrison Beds of the Jurassic, near Canon City, Colorado.



SIDE VIEW OF NECK AND SKULL OF MOROSAURUS AGILIS.

FOR EXPLANATION OF PLATE SEE PAGE 165.

SIDE VIEW OF NECK AND SKULL OF MOROSAURUS AGILIS.

FOR EXPLANATION OF PLATE SEE PAGE 165.