CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

(Continuation of Contributions from the Museum of Geology)

UNIVERSITY OF MICHIGAN

VOL. V, No. 1, pp. 1–36 (1 pl., 21 text figs.) JULY 31, 1936

A NOTHOSAUR FROM THE TRIASSIC OF WYOMING

BY

E. C. CASE

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VOLUME V

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A NOTHOSAUR FROM THE TRIASSIC OF WYOMING

By E. C. CASE

IN NOVEMBER of 1935 Dr. S. H. Knight, director of the State Geological Survey of Wyoming, sent to the author a specimen for identification and study. The history of the discovery, the location, and the geological horizon are given by Dr. Knight:

The specimen was discovered by Don Allsen, a student in geology at the University of Wyoming, during the summer of 1935, on a quarry dump, the rock of which was derived from an excavation in the Alcova limestone member of Chugwater formation. The excavation is located in Jackson Canyon nine miles southwest of Casper, Natrona County, Wyoming. The site of the discovery was later visited by Dr. Horace D. Thomas, in company with Mr. Allsen, at which time some additional fragments were discovered.

The Alcova limestone in which the specimen is embedded rests upon typical Chugwater red shales and sandstones six hundred feet thick. Directly beneath the Chugwater in this locality is a succession of red and green sandstones and sandy shales some sixty feet thick, which are believed to be equivalent to the Dinwoody formation. This succession rests on the Ervay limestone, which in adjacent localities contains a distinctive middle Permian invertebrate fauna characteristic of the Word formation of Texas. Overlying the Alcova limestone are approximately one hundred feet of massive cross-laminated, variously colored sandstones and thin shale beds, which are believed to be equivalent to the Jelm formation of the Laramie Basin. The Jelm formation is considered late Triassic in age.

The Alcova limestone is composed of an alternating succession of plates of hard blue and purplish limestone and thin seams of red sandy shale. It is six feet thick to ten feet or more thick. It exhibits the crinkled or wavy structure characteristic of the thin limestones of the "Red Beds." This limestone thins abruptly and disappears south of the Freezeout Hills. The thinning is believed to be due to an erosional unconformity.

No vertebrate fossil remains have previously been reported from the Alcova limestone. Pelecypods of doubtful correlative significance have been collected from it in a number of localities.

The specimen, number 51,000 in the geological collection of the University of Wyoming, for which the name *Corosaurus*[1] *alcovensis* is suggested, proves to be of especial interest, since it is a typical Nothosaur, the first recovered specimen of this group from North America. This is probably due rather to the scarcity of marine Triassic deposits upon the continent than to the rarity of the animals. The only other material demonstrating the presence of marine vertebrate life in the Triassic deposits of North America is that including the various reptiles described by Merriam from the Hosselkuss of California and the Middle Triassic of Nevada. One of these was tentatively referred to "*Nothosaurus*" by J. P. Smith (1894), but later recognized as an Ichthyosaur and described by Merriam as *Shastosaurus* (1902).

The close limitation of the Nothosaurs to the Triassic in Europe indicates very strongly the age of Alcova limestone, hitherto in some doubt.

DESCRIPTION OF THE SPECIMEN

The discovery of the specimen, broken into many pieces and scattered through the dump from an excavation, rendered its collection very difficult, and it speaks strongly for the patience and care of Dr. Knight and his associates that so much was recovered. The bones lie in a very dense, hard limestone or calcareous deposit, a centimeter or a few centimeters thick, concreted around them. Beyond this layer there is an irregularly bedded, sandy calcareous shale of a red or a gray color. The quartz grains are minute and vary in quantity, but are always present in sufficient amount to dull very rapidly the fine needles used in excavation. The shaly layers are more conformable to the denser limestone around the bones than to any bedding plane and are probably an expression of the concretionary process that enclosed the specimen. The limestone is harder than are the bones, and the fractures of the block went through the bones rather than elsewhere. This has injured the specimen in places, but there is always enough of bone or of its impression to give an accurate knowledge of the parts preserved. The limestone is so dense and devoid of structure or

[1] *Corus*, "northwest quarter."

crystalline form that it was extremely difficult to remove with the fine tools required, mostly needles, and under a 10-power binocular microscope. For this reason resort was made to grinding, where possible, with small carborundum wheels attached to a flexible

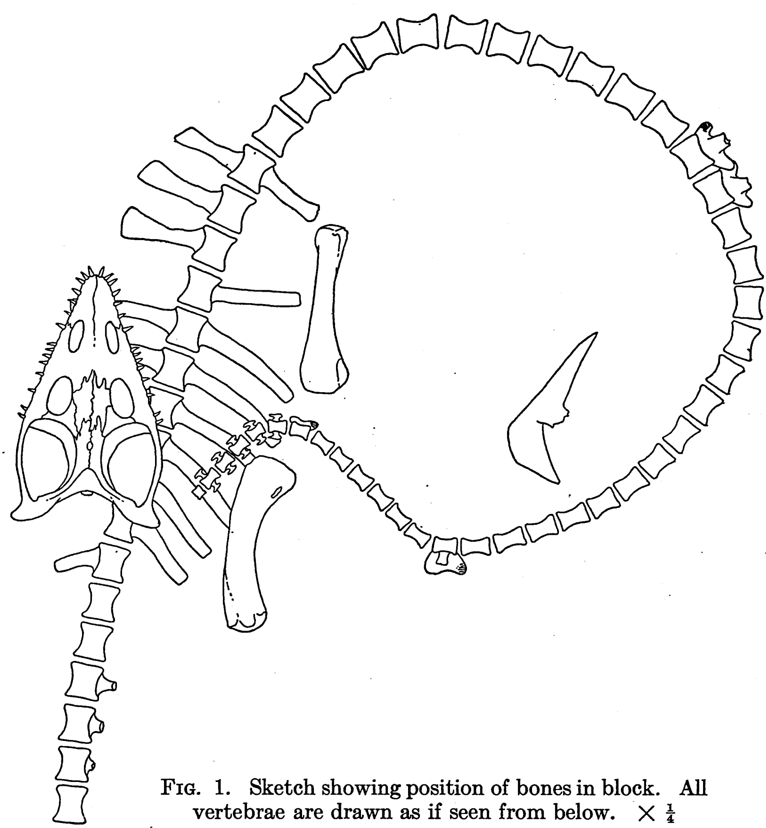


FIG. 1. Sketch showing position of bones in block. All vertebrae are drawn as if seen from below. × ¼

shaft. In most places there is a very thin layer of hematite or hematite-stained material next to the bone, and by careful work the last touch of the wheels caused this to crumble from the bone, leaving the surface beautifully clean.

The recovery of the skeleton of an unknown form by collecting blocks from the dump was, of course, very difficult and, though much was found, it was inevitable that some was not. A small block containing six vertebrae is missing from the middorsal series and a small piece, most unfortunately, from the left side of the posterior portion of the skull. Probably the posterior portion of the caudal series of vertebrae and the posterior limbs and pelvis were present originally, but were not recovered.

The specimen as preserved consists of fifty-eight vertebrae in series, beginning with the atlas, the skull and imperfect lower jaws, two humeri, two ulnae, a radius represented largely by the mould in the matrix, one front foot nearly complete, a clavicle, an interclavicle, a scapula, and an unidentifiable element, possibly a part of the coracoid or of the pelvis, a considerable number of ribs, and a portion of the ventral armor of gastralia.

The specimen lies in the matrix as represented in Figure 1, but the vertebral column is twisted in the course of the loop, so that it makes a half revolution, bringing the palatal surface of the skull in contact with the ventral face of the anterior caudal vertebrae. This twist in the column is not represented in the figure, where all the vertebrae are shown from the ventral aspect. The adjustment was made because many of the vertebrae of the middorsal series were injured in the fracturing of the block and had to be restored from fragments or impressions.

DESCRIPTION OF THE BONES

Skull. — The skull lies obliquely across the ventral face of the anterior caudal series, the cranial region is closely pressed upon the forty-eighth to fiftieth vertebrae, and the palatal surface upon the ribs of the forty-sixth to forty-seventh vertebrae. The association is intimate, and the block is so thin under the facial portion of the skull that it has been impossible to clean the palatal surface.

The anterior half of the skull is somewhat flattened and perhaps a little broadened, and the teeth extend obliquely outward and downward. This distortion cannot be very great, and the position of the teeth is as in many other specimens of Nothosaurs. Moreover, the position and the course of the alveolae indicate an oblique direction for the teeth. The posterior portion of the skull seems unduly high in the reconstruction (Fig. 3), but it is the result of careful measurement and such small adjustments as seem justified; if any correction is made, it should probably be an elevation and rounding of the anterior portion.

The surface of the facial region is somewhat fractured, but the contour of the nares, orbits, and temporal fenestrae is clearly shown in several places, and the size and form given in the restorations can be but little in error. The sutures of the parietal and frontal region are clear and sharp, and the maxillary-premaxillary suture is well defined; many of the others cannot be made out.

The temporal region of the right side is disturbed by its close pressure upon the forty-ninth to fiftieth vertebrae, and the postorbital bone and the parietosquamosal bar are somewhat displaced. The squamosopostorbital bar is incomplete, but its course and position are plain. The squamosopostorbital bar of the left side is not present, since a small block from this region was not recovered. The fracturing of the posterior portion of the skull took place largely through the bones leaving parts of the bone and the impressions on the two adjacent blocks. By comparing these it has been possible to restore much of the cranial region.

The general contour of the skull is shown in Plate I and Figure 2. The rostrum is relatively short, with large narial openings close to the anterior end. The nares were largely upon the superior surface, but may have had an oblique position looking somewhat outward as well as upward. The same statement may be made of the orbits, the present position, looking directly upward, being due in part to the flattening of the skull in the processes of preservation.

Premaxillaries. — These form the anterior half of the preorbital region. They are rounded in front, with a slight elevation of the borders, probably due to the greater resistance to pressure afforded by the roots of the teeth in their sockets. The premaxillary-maxillary suture is sharply defined on the right side, the premaxillary forming the anterior third of the outer border of the narial opening. The median suture is clear, but the premaxillary-nasal suture is less certain. The thinning of the bones and the slight difference in the direction of the fibers suggest that the suture is about opposite the middle of the nares, as shown in Figure 2. There are six teeth in the premaxillary of the right side; the number on the left is less certain. The anterior two are larger

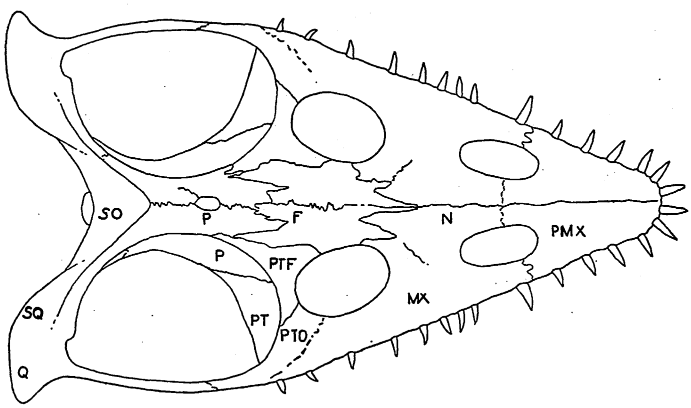


FIG. 2. Restoration of upper surface of skull. $\times \frac{2}{3}$

Explanation of lettering: F, frontal; MX, maxillary; N, nasal; P, parietal; PMX, premaxillary; PT, pterygoid; PTF, postfrontal; PTO, postorbital; Q, quadrate; SO, supraoccipital; SQ, squamosal

than the others and project strongly. There is no suggestion on the edge of the bone of other teeth or alveoli. The teeth show

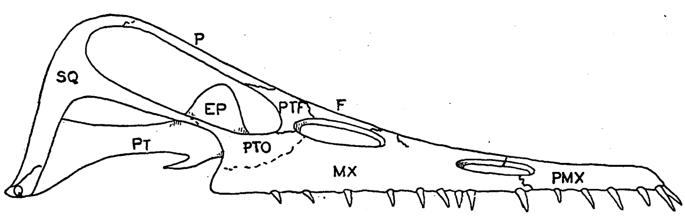


FIG. 3. Restoration of right side of skull. $\times \frac{2}{3}$. EP, epipterygoid; other lettering as in Figure 2

striations on the enamel, but no elevated ridges. They are conical and slightly recurved.

Maxillaries. — These bones are complete and continuous on both sides, but that of the right side is the more perfect. The inner edge forms part of the border of the nares, part of the orbitonarial bar and most, if not all, of the outer border of the orbit. It is probable that the jugal joins the postorbital and forms a part of the posterior-outer border of the orbit, as is common in the European Nothosaurs, but this cannot be definitely made out on either side of the specimen. The lower edge of the maxillary is straight and continues back to the anterior end of the temporal fenestra, where it terminates in a point. There are nine teeth on the right side approximately opposite those of the left side. There is no evidence of empty alveoli but, as indicated below, the larger number of teeth in the lower jaw suggests that there may have been more in the maxillary. The anterior tooth, immediately behind the premaxillary-maxillary suture, is noticeably larger than the others. The teeth are conical, terminating in sharp points and slightly curved. They show a striation of the surface, but no ridges. All the teeth project obliquely outward, but this may be due in part to the flattening of the skull.

Nasals. — These terminate in sharp points posteriorly, extending between the frontals and the prefrontals. Their further contour cannot be made out, except for the suggested anterior end. They are flattened and depressed in the specimen.

Prefrontals. — As shown in Figure 2, the inner end of a small element on each side is distinct from the frontal and the nasal. These form the inner anterior border of the orbits, but their further contour cannot be made out.

Lachrymals. — No outline of these bones can be made out. The possibility of their presence or absence is discussed below, under the comparison of this specimen with other Nothosaurs.

Frontals. — These are relatively large and irregular plates, clearly divided by the median suture. Their shape is shown in Figure 2. They form the middle portion of the inner border of the orbit. The two bones are decidedly asymmetrical, and the median line has a very irregular course.

Parietals. — These bones occupy the usual position and surround the relatively large, oval parietal foramen. They form the inner border of the temporal opening and send a large, almost vertical plate downward forming the inner and part of the anterior wall separating the fenestra from the orbit (see Fig. 7). Just posterior to the parietal foramen there is a clearly defined suture running backward and outward on the left side, as if for a postparietal bone; its continuation backward is lost in the fracture between two blocks. This suture, if present, is obscured on the right side by a slight injury to the bone. Posteriorly each parietal sends a narrow bar outward and backward to join the squamosal.

Postfrontals. — The median portion of the orbitotemporal bar and also part of the inner and most of the posterior border of the orbit are formed by a large postfrontal. The orbital border is heavy and somewhat ridged or rugose. The posterior or temporal border sends a flange vertically downward to meet another vertical flange (see Fig. 7), probably a part of the postorbital or the jugal. This vertical flange, with that of the parietal, forms the vertical wall separating the orbit from the fenestra. The presence of such a wall is made much of by Edinger (1935) in her separation of *Pistosaurus* from the Nothosaurs (see p. 33).

Postorbital. — There is no distinguishable postorbital element, since this portion of the specimen is broken away or covered. A crack divides the left prefrontal into inner and outer halves, but though this occupies the position of the postfrontal-postorbital suture figured by Schroeder (1914), in certain Nothosaurs it cannot be mistaken for a suture. It is probable that the postorbital had a small exposure on the surface of the skull, as in *Simosaurus*, and it is probable that the lower vertical flange described as a portion of the anterior wall of the temporal fenestra belongs to the postorbital (Fig. 7).

Jugals. — The jugals cannot be made out on either side. That of the right side is injured by pressure upon the underlying vertebrae and is covered by the displaced right postorbital. That of the left side is largely or wholly lost in the block that was not recovered, but the fractured surface of its contact with the maxillary is preserved, and the lower vertical flange described above as running under the postfrontal may be a part of the jugal. In several Nothosaurs the jugal is a very slender element lying below the postorbital and taking little or no part in the rim of the orbit (Schroeder, 1914).

Squamosals. — The bones form a continuum of the curve begun by the parietals and complete the posterior borders of the temporal fenestrae. Each bone has the usual tripartite form: a narrow, more or less vertical bar or plate running inward and upward and articulating by squamous overlap with the parietals; a posterior plate running downward to form the posterior angle of the skull; and an anterior, in the form of a bar rising from the median portion of the outer edge of the bone and running directly forward. This bar undoubtedly joined the postorbital in front, but the contact is not preserved on either side. The lower portion of the posterior plate turns outward, as is common in the Nothosaurs, forming the prominent articular angle of the skull. It is probable that a considerable portion of this projection is covered by the quadrate.

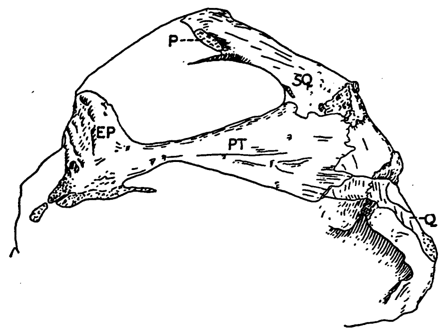


FIG. 4. Inner surface of block from right side of skull, showing pterygoid and associated bones. × 1. EP, epipterygoid; other lettering as in Figure 2

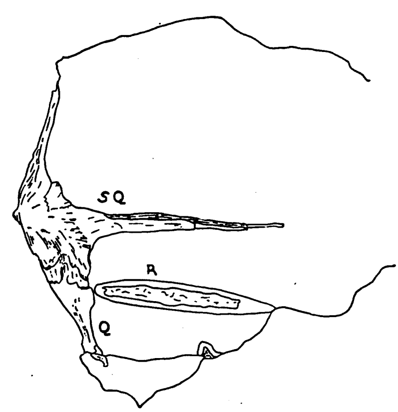


FIG. 5. Right side of temporal region, showing arch. × 1. R, oblique section of a rib; other lettering as in Figure 2

Quadratojugals. — This bone is absent in most of the Nothosaurs illustrated and described by Arthaber, Peyer, and Huene, but seems to be persistently present in *Simosaurus*. In *Corosaurus* there is apparently a small, nearly vertical plate connecting the squamosal and the quadrate or covering their connection. It is obscurely visible on both the right and the left sides either as bone or as impression. More perfect specimens will prove or disprove its presence.

Quadrate. — The articular surface of the quadrate is rather large and is transversely extended. There is an upward extension meeting the squamosal, perhaps overlapped externally by a quadratojugal. There is a strong contact with the expanded posterior end of the pterygoid, as shown in Figure 4.

The posterior portion of the skull is carried upon a separate block and its outer surface is partly covered with matrix but the general relations of the bones can be made out. In Figure 7 the posterior branch of the squamosal is shown descending to the quadrate; the probable course of the sutures is indicated. As shown in the restored skull (Fig. 2), the space between the diverging parietals is floored by the surface of the supraoccipital, with the condyle just visible in a superior view. This region is filled with matrix, which is not removable because of the presence of two

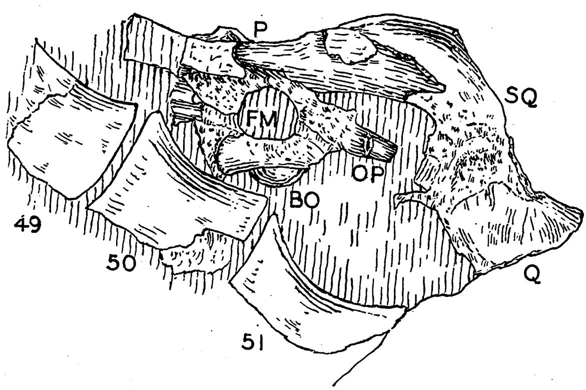


FIG. 6. Occipital region, showing surface of break just anterior to foramen magnum. $\times \frac{2}{3}$. BO, basioccipital; FM, foramen magnum; OP, opisthotic; 49, 50, 51, caudal vertebrae; other lettering as in Figure 2

small elements partly revealed that are in the position of the preatlas bones, and is restored from the parts visible on the anterior side of the block, which is broken through the bones just anterior to the foramen magnum. The break, which is nearly vertical in the skull, passes through the proximal end of the right opisthotic and cuts the bones surrounding the foramen magnum, passing slightly forward toward the left side, where it cuts through the left opisthotic near the middle of its proximal end. Projecting through the matrix is the distal end of the opisthotic, visible on the posterior face. The sutures between the occipital bones are not evident in all places, but it is obvious that all four take part in the foramen magnum (see Fig. 6).

Basioccipital. — This is fairly thick, forming a strong floor for the brain case. The condyle is small and prominent, with a noticeable constriction at the origin. As shown in Figure 6, the sutures between the basioccipital and the exoccipital are clear and distinct.

Exoccipital. — This cannot be distinguished from the opisthotic or from the supraoccipital above.

Opisthotic. — The distal portion extends outward toward the squamosal and the quadrate in the usual way. Its full length is

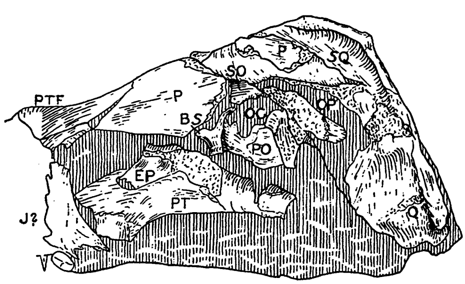


FIG. 7

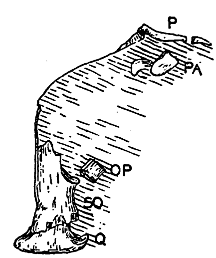


FIG. 8

FIG. 7. Temporal region of left side, showing cranial bones. × $\frac{2}{3}$. BS, basisphenoid; EP, epipterygoid; J ?, jugal; OC, otic cavity; OP, opisthotic; PO, proötic; other lettering as in Figure 2

FIG. 8. Posterior view of left side of skull. × $\frac{2}{3}$. OP, opisthotic; PA, preatlas; other lettering as in Figure 2

shown on the left. In Figure 7 the distal portion is shown disappearing into the matrix, and in Figure 8 the distal extremity is shown appearing from the matrix and in close relation to the squamosal. The proximal portion is indistinguishable in the specimen from the exoccipital and the other otic bones.

Supraoccipital. — This is shown in section as a strong bone passing beneath the parietals and separated from them by a thin layer of matrix. The supraoccipital and the parietals were in contact during life, or very closely adjacent, and separated by a thin layer of cartilage.

The *cranial region* of the skull is revealed by breaks which followed and involved the bones. For this reason each block carries fragments of bone or impressions of its surface and can be checked by the adjacent block. There are three such blocks fitting together and a surface exposed by the loss of a block from the left temporal region.

The larger block carries the greater part of the skull; a second block is separated from the larger one by a nearly vertical fracture a little posterior to the parietal foramen; it carries the bones of the posterior portion of the skull as described above; the third block is broken from the right side of the second through the length of the pterygoid bone; its outer side carries the right squamosal and articular region and connects with the postorbital portion of skull on the larger block; the fourth block was lost, but came from the left temporal region, and the fracture reveals the left pterygoid, the epipterygoid, the side of the brain case, and the left opisthotic.

Pterygoid. — The inner side of the third block reveals the right pterygoid in its relations to the other bones. Figure 4 is drawn from the inner side of this block and is therefore seen as if one were looking from the median line of the skull outward; in other words, it appears as a mirror image of the true position. The posterior end is expanded vertically and applied largely to what appears to be the squamosal and in lesser amount to the quadrate. This is not the usual arrangement in the Nothosaurs. The figures of various forms presented by different authors show the pterygoid connecting with the quadrate in the normal manner, but in some forms coming close to or touching the squamosal. It is very possible that owing to crushing, since this region lies directly upon the rib of the forty-ninth vertebra, the distal end of the pterygoid has been elevated somewhat. The middle portion of the pterygoid narrows and runs inward and forward; anteriorly there is a process reaching nearly to the level of the roof of the skull. The upper end of the process appears in the temporal fenestrae, but if the distortion of this portion of the skull be corrected, the point will lie much closer to the median line and adjacent to the parietal foramen. It seems probable that this process is the epipterygoid, and this probability is increased by the appearance of the bones of the left side described below. Beneath the rising process there is a peculiar hooklike projection extending to the rear. This shows clearly on both blocks. Its position and form suggest that it may be the process for articulation with the basisphenoid. Anterior to the rising process or coincident with it, the pterygoid becomes a flat horizontal plate. This is best shown on the left side (Fig. 7), and the description is continued from that side.

The basicranial and related bones of the left side are revealed by the fracture which separated the fourth block, unfortunately not recovered. Since the recess is very deep and terminated by the prominent maxillary-jugal and squamosoquadrate regions, it has been difficult to figure the parts accurately, but they are shown in Figure 7 with a minimum of distortion. The pterygoid is continuous by bone or impression from the anterior portion of the temporal fenestra almost to its contact with the squamosoquadrate. Anteriorly it presents a vertical face curving outward to the border of the skull. Above, the bone turns at right angles and is visible as a broad horizontal plate as far forward as it can be cleared from the matrix. The outer portion of this plate probably includes the ectopterygoid, but the suture cannot be detected. It is unfortunate that the palatal surface of the skull is closely pressed upon the ribs and that the block is thin in this region, for this renders it impossible to clean and examine the palate, which is a critical region in the osteology of the Nothosaurs. The broad horizontal portion of the pterygoid has every appearance of continuing forward beneath the matrix for some distance, closing the palate and bearing out the other evidence of the skeleton that *Corosaurus* is a true Nothosaur. An attempt to reveal the structure of the palatal surface by X-ray photographs was unsuccessful.

Epipterygoid. — Upon the horizontal portion of the pterygoid lies another element, which is in the position of the epipterygoid; it is most clearly described by comparing its form with that of a shoe, the toe pointing outward and forward and the top rising toward the descending plate of the parietal. The toe part is very thin and was closely applied to the pterygoid, but a small amount of matrix has penetrated between the two bones, raising the epipterygoid slightly and making their individuality obvious. The posterior part, corresponding to the upper part of the shoe, is thickened and sends upward a plate which must have touched or have been very close to the descending flange of the parietal. In the specimen the upper part of this plate is gone, but the impression reaches as high as the lower edge of the parietal plate and is separated from it by a thin layer of matrix. The posterior end is obscured by a crack, but is certainly not continuous with the bones of the brain case. As shown in Figure 7, the side of the brain case is exposed in a rather unsatisfactory manner by the loss of a block from the left temporal region. Between the opisthotic and the epipterygoid the otic capsule is outlined by fragments of bone and impressions. The surface of the vestibule is broken away, revealing a filling of calcite. The continuity of the bone can be traced around the cavity, but it is impossible to distinguish the contour of the several bones. The anterior wall of the vestibule, the proötic portion, descends into a deep crack and cannot be followed farther. The epiotic ascends to close proximity to or contact with the supraoccipital.

Basisphenoid. — Deep within the matrix a small portion of the basisphenoid has been partially cleared. Little more than its presence can be made out, but there appear to be well-defined basipterygoid processes.

Lower jaws. — The incomplete lower jaws are exposed on a fracture surface adjacent to a small block which was not recovered. They lie anterior to the skull and in a reverse position. The rami are in normal position, exposed from below in part, and from the sides. The jaws were injured before fossilization. The posterior half of the right ramus is missing, and the left ramus was bent sharply near its posterior third, and the articular portion is missing (see Fig. 9). There was a strong and fairly broad symphysis, as is revealed by the impression, and this region carried large teeth corresponding to those of the premaxillaries; the large teeth continue back as far as the first maxillary tooth on the skull. Posterior to this point the teeth are smaller. The anterior dentition is exposed on the right side and the posterior on the left; if one allows for the overlap, it is estimated that twenty-one or twenty-two teeth were present in each ramus, a greater number than are exposed in the upper jaw, a condition which suggests that there may be several partly developed teeth and alveoli not exposed in the maxillaries.

FIG. 9. Sketch showing parts of jaws preserved, as seen from below. $\times \frac{2}{3}$. The bone is broken through over most of the jaw. The posterior one fourth of the left ramus is straightened from its bent position

Vertebral column. — There were originally fifty-eight vertebrae in the blocks as preserved, but a small piece was not recovered; this block contained six complete vertebrae of the middorsal series and the halves of two more, i.e. the posterior half of the thirty-eighth, the anterior half of the thirty-first, and all between. This block broke out cleanly, and there can be no doubt of the number of vertebrae lost.

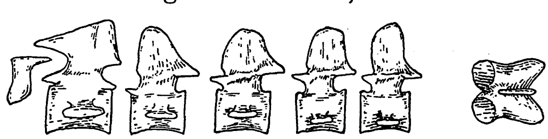
As shown in Figure 1, the vertebrae lie in a continuous series in the form of a loop, with the anterior end close to its proper position with regard to the skull. Since the palatal surface of the skull lies upon the ventral surface of the anterior caudal vertebrae, the column made a half turn in the course of the loop. The figure does not show this, since the breaking of the block was largely through the vertebrae, and they are represented by shattered parts and impressions in the matrix.

The most anterior vertebrae are disturbed somewhat, but can be easily followed.

Preatlas. — In the space between the diverging parietals two small plates appear in the matrix. They are approximately square in outline as exposed and lie directly over the foramen magnum. It is impossible to clear them completely because of their fragility. From their character and position they are regarded as the paired elements of the preatlas.

Atlas. — Deeply buried in the hard matrix the atlas lies in its normal relation to the axis. Seen from the side, the only possible exposure by most careful preparation, each half of the neural arch of the atlas has the shape of a reversed L. The short arm of the L carries the posterior zygapophysis and is in normal position and relation to the axis. There is a very slight rise toward the anterior end, angle of the L, indicating a rudimentary neural spine. The long arm of the L is much heavier and somewhat swollen at the lower end. It is probable that this element is the neural arch of the right side, since the zygapophysis is in position and the lower end does not reach far below the neural canal of the axis. No trace of a centrum or an intercentrum was found near the atlas.

Axis. — The tip of the neural spine and the posterior half of the centrum are missing from the axis; otherwise it is complete.



a b

FIG. 10. a, lateral view of first six cervical vertebrae; b, upper view of neural arch of sixth cervical vertebra. × $\frac{2}{3}$

The form is shown in Figure 10. The spine is elevated, rising almost vertically from the posterior end of the neural canal; this edge is thickened, as is common in the reptiles. The anterior edge slopes sharply forward and downward. The centrum is slightly more elongate than in the immediately succeeding cervicals. The lower surface is contracted with a shallow median groove. There are rather strong transverse processes extending from the upper part of the side of the centrum which support short hatchet-shaped ribs.

Third, fourth, and fifth cervical vertebrae. — These are injured by fracture, but the height, the length, and the presence of hatchet-shaped ribs can be made out.

Sixth and seventh cervical vertebrae. — These are broken through the center vertically and reveal all parts. The shape is shown in Figure 10. The neural arch of the sixth is already very broad, 14 mm. across the anterior zygapophyses and 14 mm. in anteroposterior extent. The centrum is 8.5 mm. long. The neural spine of the seventh is high, 17 mm. above the base of the neural canal, but relatively narrow, 8 mm. anteroposteriorly. The ribs are still hatchet-shaped, but attached much nearer to the base of the centrum.

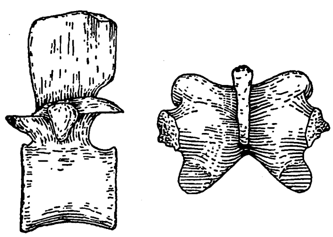
Eighth to eleventh cervical vertebrae. — Between the seventh and the twelfth vertebrae a small block has been lost, but sufficient portions of these vertebrae remain to show that the form has changed but slightly. The tenth carries a well-developed hatchet-shaped rib attached to the middle of the side of the centrum.

Twelfth and thirteenth cervical vertebrae. — These show the spines and much of the body. The spines are relatively lower, 11 mm. above the floor of the neural canal, and wider anteroposteriorly, 10 mm. The centrum is 14 mm. long.

Fourteenth vertebra. — In this the fracture cuts through the centrum anteroposteriorly and just below and parallel to the neural arch, showing the under face of the anterior zygapophysis. The spine is concealed in the matrix, but the next posterior that can be measured, number eighteen, is 12 mm. above the floor of the neural canal and 14.5 mm. anteroposteriorly; the centrum is 14.5 mm. long.

Fourteenth to twenty-fifth vertebrae. — These are broken through the centra anteroposteriorly, and the neural spines are exposed from the left side. They show a gradual elevation and are so broad anteroposteriorly as to be practically in contact. The centra gradually increase in length. Upon the fourteenth the transverse process is already well developed, but short, extending 6 mm. from the mid-line of the centrum and 3 mm. from the side of the vertebra. The change from the hatchet-shaped rib to the normal dorsal rib probably occurred several vertebrae anterior to this. Since the thoracic girdle is not in place, it is impossible to determine the point of separation between the cervical and the thoracic vertebrae. The character of the ribs does not indicate this point. In the restoration of the specimen the thoracic girdle is placed opposite the nineteenth vertebra. This cannot be far wrong.

Twenty-sixth to thirty-first vertebrae. — These are typical mid-dorsals. The twenty-ninth and the thirtieth have been cleaned on the right side. The twenty-ninth is described as typical of this portion of the series (see Figs. 11a and 11b). The neural spine is relatively high, 24 mm. above the floor of the neural canal, and broad anteroposteriorly, 19 mm. The length of the centrum is 20 mm. The spines are nearly horizontal on the upper edge, and the posterior border is expanded by decided thickening. The neural arches are broad, 28 mm. across the zygapophyses. The upper surface of the posterior zygapophysis is slightly swollen. The transverse process rises from the side of the neural arch, its upper surface slightly above the level of the neural arch, but the main portion below. It extends 29 mm. from the mid-line of the centrum and 15 mm. from its side. The centrum is concave anteroposteriorly on the lower surface; the section is a rather narrow oval, the two sides meeting in a sharp line, almost a keel, on the lower edge.



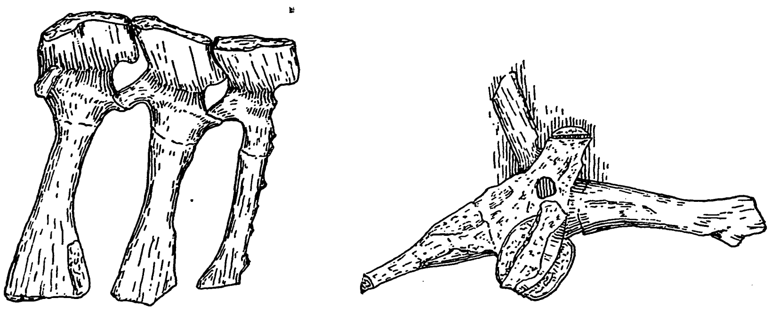
a b

FIG. 11. a, lateral view of twenty-ninth vertebra; b, upper view of neural arch of same vertebra. × $\frac{2}{3}$

Thirty-first and thirty-eighth vertebrae. — These are represented each by a half of the vertebrae, and all between are lost in an unrecovered block.

Thirty-ninth and fortieth vertebrae. — These are largely concealed in the matrix and are somewhat distorted by pressure. The form is much like that of the middorsal series, but the transverse processes are heavier and shorter, extending 21 mm. from the mid-line of the centrum and 15.5 mm. from its side.

Forty-second to forty-fourth vertebrae. — These are sacral vertebrae. They are not anchylosed, but the neural arches are shorter anteroposteriorly and the zygapophyses narrower. The transverse processes are short, extending only 17 mm. from the center of the vertebrae on the forty-second and only 13 mm. on the forty-third and the forty-fourth. The ribs are short and straight, with



a b

FIG. 12. a, oblique view of right side of sacrum; b, anterior view of first sacral vertebra; a portion of centrum of preceding vertebra is attached. $\times \frac{2}{3}$

expanded distal ends, increasingly so backward, the first of the three being 10 mm., the second, 13 mm., and the third, 17 mm. broad at the distal end. They are anchylosed to the transverse processes, but the point of union is still clearly marked. The ribs are successively 25.5, 34, and 37 mm. in length. The centra of these vertebrae are somewhat crushed and distorted. The neural spines are not greatly different from those of the middorsal series (see Figs. 12a and 12b).

Forty-fifth to fifty-eighth vertebrae. — These are the preserved caudals. They change slowly in size, height of the neural spine, and length of the ribs. The forty-fifth to the forty-seventh are exposed from the ventral surface. The centra are shorter and more robust than those of the dorsal series, are more nearly circular in section, and show but slight concavity of the lower surface anteroposteriorly.

The rib of the forty-fifth is narrower than are those of the sacrum and terminates with a constricted distal end. It extends

45 mm. from the vertebra and is inclined slightly forward on the left side. The rib of the forty-sixth extends 38 mm. until it is covered by matrix, but this must be very near its terminus. The rib of the forty-seventh extends 29 mm. until covered, that of the forty-ninth, 52 mm.; it is much more slender than are the ribs of the preceding caudals and is bent downward and inclined backward. The ribs of the fiftieth and the fifty-first are similar to that of the forty-ninth; their distal ends are hidden in the matrix. Posterior to this the ribs cannot be traced; they are either lost or displaced; apparently they shortened rapidly. The neural spines diminish in height rapidly from the fifty-first, caudally.

Fifty-fifth to fifty-eighth vertebrae. — These were recovered in a separate block, which fits directly upon the one bearing the preceding vertebrae; the series is unbroken. Though these vertebrae

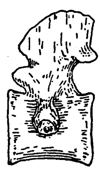


FIG. 13. Lateral view of fourteenth caudal vertebra. $\times \frac{2}{3}$

are not greatly shortened, the neural arch is much narrowed, being not over 15 mm. across the anterior zygapophyses of the fifty-seventh, in which the centrum is 17 mm. long. The neural spines are somewhat crushed, but they have lost the characteristic anteroposterior extent and are mere pointed processes. The transverse processes shorten rapidly from a length of 9 mm. on the fifty-fifth to a mere prominence in the fifty-eighth. There is no suggestion of chevrons or of facets for their attachment (see Fig. 13).

Ribs. — There are many of the long thoracic ribs scattered through the matrix, but none in attachment with the vertebrae. The longest fragment, probably, to judge from its position and size, associated with one of the dorsal vertebrae, is 107 mm., and the distal end of the fragment has diameters of 8 and 11 mm. The proximal end is flattened, having diameters of 9 and 4.5 mm., near the attachment to the transverse process. A shorter fragment lying near the one just described shows a slightly increased curvature as it approaches the vertebra. On the thirtieth vertebra the face of the transverse process is somewhat elongated; other than this there is no indication of a double head on the ribs.

Gastralia. — A separate block contains a portion of the abdominal armor; this is shown in Figure 14 and in Plate I, Figure 2.

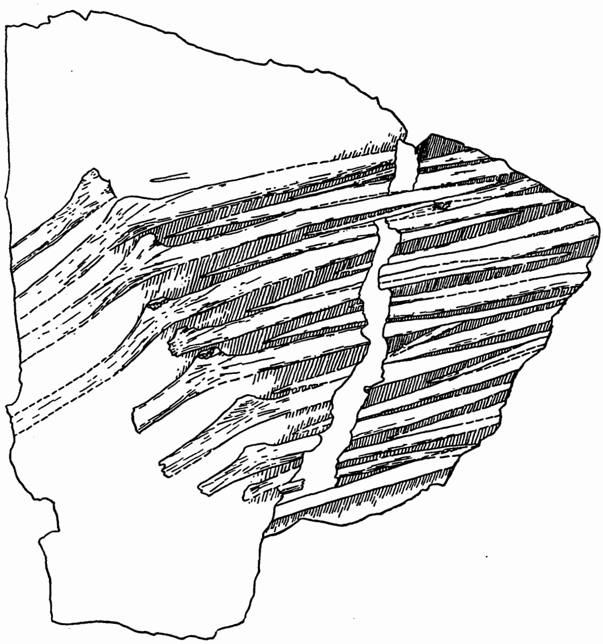


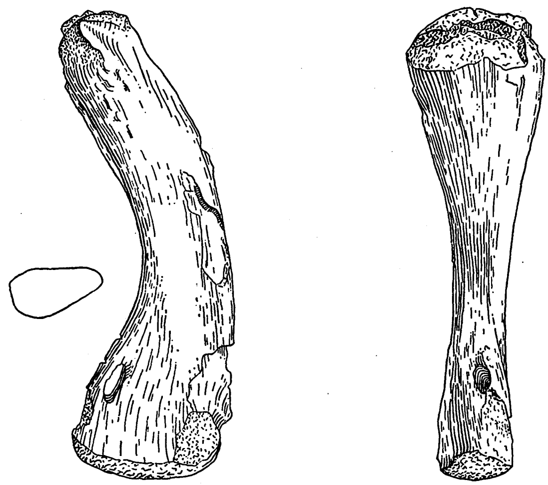
FIG. 14. Portion of gastralia. × $\frac{2}{3}$

The armor consists of a median piece with the two sides meeting at a large angle, and two lateral pieces on each side, all arranged in the usual pattern of the gastralia. The lateral elements of the ventral armor are incomplete, making it impossible to give the width of abdominal surface, but since the parts preserved have a width of 176 mm. and at least one fourth must be added to this, it is evident that the body possessed considerable breadth in relation to the precaudal length.

Appendicular skeleton. — As mentioned above, it is probable that more of the skeleton was present, but owing to the method of excavation and the difficulties of recovery no part of the posterior limbs or recognizable portion of the pelvis was found. An unidentifiable fragment of a large flat bone may be a part of a coracoid or of one of the pelvic bones, and certain impressions of larger elements, also unidentifiable, may be indications of the presence of the pelvic bones.

There have been identified the interclavicle, a clavicle, a scapula, both humeri, both ulnae, a radius, an incomplete carpus, and one front foot. The bones of the forelimb and of the foot have been flattened by pressure; the others seem little distorted.

Humeri. — Both humeri are present and are little injured, except that half of each end of one has been broken away and lost; the other, the right, is complete. As shown in Figures 15a and 15b,



a b

FIG. 15. a, lower view of right humerus, with cross section of shaft; b, anterior view of same bone. × $\frac{2}{3}$

there is a decided curvature of the bone, such as occurs in many of the European Nothosaurs. The proximal and distal ends are expanded almost at right angles to each other; the cross section of the shaft near the middle point is ovate; there is a relatively large entepicondylar foramen and a well-marked ectepicondylar notch. All these characters speak for a less advanced stage of aquatic adaptations than in most of the previously described forms. The proximal end is almost quadrangular in section and is marked by slight depressions in the position of the insertion of the *M. scapulohumeralis anterior*, *M. subscapularis*, and *M. coracoidei*, as indicated by Peyer in Figure 17 of *Ceresiosaurus*, 1932, p. 37, but there is no distinct head. The dorsal, or posterior, face is nearly flat. The ventral, or anterior, face is convex, and the ectepicondylar notch is much more obvious on that face. The two faces meet sharply on the postaxial border in the lower half of the bone. There are no distinct condyles on the lower end; evidently the articulation with the radius and the ulna had become very weak and motion at the elbow was limited.

Ulnae. — The ulna most nearly associated with the right humerus is complete; that associated with the left humerus lacks the distal end; both are much compressed and are probably wider than in the normal condition. There is no suggestion of an olecranon process (see Fig. 16).

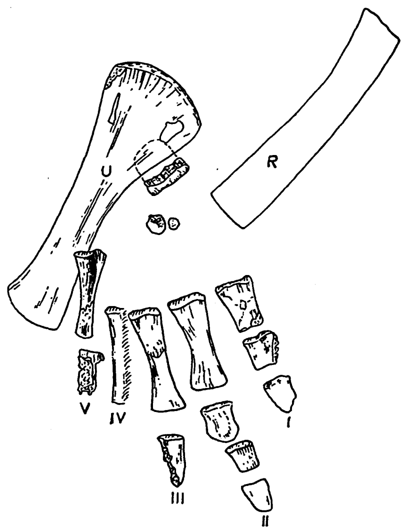


FIG. 16. Right forelimb and foot. $\times \frac{2}{3}$. R, radius; U, ulna; I–V, digits

Radius. — The radius is represented by fragments of the distal ends and the mould in the matrix. In Figure 16 it is drawn from a cast of the cavity, with the preserved fragments added. The bone is not compressed; it has a decided curvature, indicating a fairly large spatium interosseum, and the articular ends are simple.

Carpus. — The foot is somewhat displaced with regard to the radius and the ulna, and only two or three of the carpal bones are preserved. There was one of considerable size (see Fig. 16), which was compressed to a very thin scale. Unfortunately, a part was lost in the preparation of the specimen, but the heavier border was saved. A second, smaller, element and, possibly, a third are preserved. All of these indicate a carpus much like that of known Nothosaurs and one well advanced in aquatic adaptation. The forelimb and foot seem to have preceded the humerus in this process.

Manus. — The manus lies in nearly normal position. The metacarpals and the phalanges are, apparently, somewhat compressed and broadened, but less so than the ulnae. As shown in Figure 16, the bones lie in natural articulation. Of the five metacarpals one, near the distal end of the radius, is much shorter than the others. Both from its position and size it is regarded as the first. The others are of nearly equal length: the second, third, and fourth lie flat, with the dorsal side exposed; the fifth is turned on edge and is slightly displaced proximally; it is slightly shorter than the median metacarpals.

There are two phalanges in series with the first metacarpal. Both are rather broad, and the second has the appearance of an elongate, blunt claw. There are three phalanges in series with the second metacarpal. The first is larger than the second; both show articular ends. The third, the terminal one, has the same blunt clawlike appearance as the last phalange of the first digit. There is but one phalange in series with the third metacarpal; it is at least a fourth longer than the first phalange of the second digit.

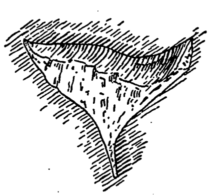


FIG. 17. Interclavicle. $\times \frac{2}{3}$

This phalange dips into the matrix, and succeeding ones have been lost. A small block, which may have contained the phalanges of the fourth and fifth digits, was not recovered. A few fragments appearing at the surface of the fracture surface indicate that these digits may have been curled under the rest of the foot.

Interclavicle. — A fracture passes through a triangular bone which is identified as the interclavicle. As shown in Figure 17, the anterior face is cupped. The sides approach and meet at a sharp angle posteriorly.

Clavicle. — A single clavicle, of the left side, is preserved undistorted. The form is shown in Figure 18. The anterior outer edge is regularly convex and thin. The edge for articulation with the interclavicle is slightly concave and terminates in a notch formed by a sudden widening of the middle portion of the bone. Posterior to the notch the two sides approach regularly and end in a blunt point. Opposite to the expansion forming the notch the outer edge of the bone is thickened, but this subsides gradually toward the posterior end. The whole bone is decidedly convex outwardly.

FIG. 18. Ventral surface of left clavicle. $\times \frac{2}{3}$

Scapula. — This bone from its size and shape is regarded as the scapula of the left side. The cotylar face is very thick and must have formed with the coracoid a fairly deep and efficient articular socket for the humerus. The proximal end, Figure 19, is broad and slightly concave. The spine is narrow at its origin, but expands to the distal end. It is possible that this element may be the coracoid, but it does not correspond in size or in the double process of the distal end as figured by previous writers upon the Nothosaurs. Moreover, there was a much larger bone represented by indetermi-

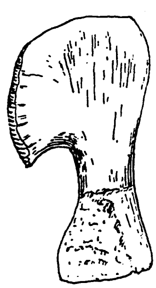


FIG. 19. Upper surface of left scapula. $\times \frac{2}{3}$

nate fragment and impression, which lies close to the interclavicle and the humeri, which is more nearly of appropriate size for the coracoid.

MEASUREMENTS

	Mm.
Length from anterior end of premaxillary to fifty-eighth vertebra, closely approximate	1226
Length of skull	130
Length from center of parietal foramen to anterior end	91
Length from humerus	94
Width of distal end of humerus	33.5
Width of proximal end of humerus	26.5
Greatest length of scapula in straight line	80.5
Length of centrum of twenty-ninth vertebra	17
Width of anterior end of centrum of same vertebra	17
Width of neural arch across anterior zygapophyses of same vertebra	26
Height to top neural of same vertebra	45
Length of incomplete radius, minimum	49
Length of ulna	56
Length of first metacarpal	9.2
Length of second metacarpal	18.5
Length of third metacarpal	21
Length of fourth metacarpal	18
Length of fifth metacarpal	18.5
Length of median element of gastralia	126
Length of first lateral element of gastralia, minimum	82

RESTORATION

From the foregoing description and measurements it is apparent that *Corosaurus* was not unlike the European Nothosaurs in bodily form. Its length, about a meter and a quarter, to the probable midcaudal region, with the addition of 300 mm. for the missing portion, would make it approximately the size of Peyer's *Ceresiosaurus*. Since the size of the last caudal vertebra preserved, the fourteenth, is but little less than that of the anterior caudals, the addition of a number equal to that preserved seems warranted. The animal was evidently a powerful swimmer, with a long, flexible, driving tail. The absence of elevated neural spines and of any indication of chevron bones so far back as the midcaudal region indicates the absence of any vertical expansion of the tail (Fig. 20).

The first transverse process for the support of a simple elongate rib is visible on the fourteenth vertebra. The change from the hatchet-shaped rib to the elongate rib is not an indication of the change from the cervical to the dorsal series. This change occurred at about the twelfth vertebra, but the thoracic girdle must have been opposite the eighteenth or the nineteenth.

The curvature of the humerus, the position of the greatest diameter of the articular ends nearly at right angles to each other, the presence of the entepicondylar foramen and the ectepicondylar notch, and the ovate section of the shaft, with the well-modeled digits of the manus terminated by blunt clawlike ungual phalanges, all speak for a stage of adaptation to aquatic life but little advanced. The feeble articulation of the elbow and the reduction of the carpal bones are evidences of advance in this adaptation.

The great breadth of the neural arches is characteristic of all the Nothosaurs; perhaps it permitted greater flexibility of the body as the articular surfaces of the zygapophyses were increased.

The great breadth of the abdominal armor shows that the body was relatively wide. The ribs probably had greater lateral than vertical extent.

Corosaurus had a somewhat elongate neck, a wide body, and long tail and limbs efficient for swimming, but still capable of use upon land. The animal was probably actively predaceous in the water and re-

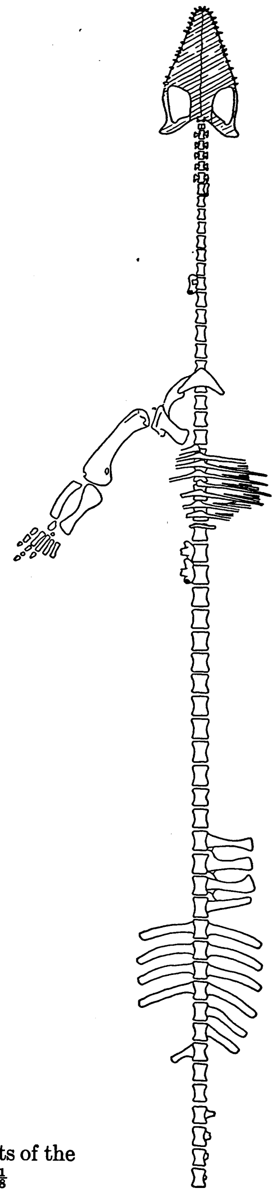


FIG. 20. Reconstruction of such parts of the skeleton as are preserved. $\times \frac{1}{8}$

sorted to the shore to bask in the sunshine or deposit its eggs. The sketch (Fig. 21) adapted from Peyer (1933) gives an idea of its appearance and habits in life.

DISCUSSION OF THE SPECIMEN

The Nothosaurs are exclusively Triassic in age and heretofore have been known only from western Europe, Italy, Germany, Switzerland, and Austria. An imprint of a webbed foot from Cheshire in England has been interpreted as the track of a Notho-

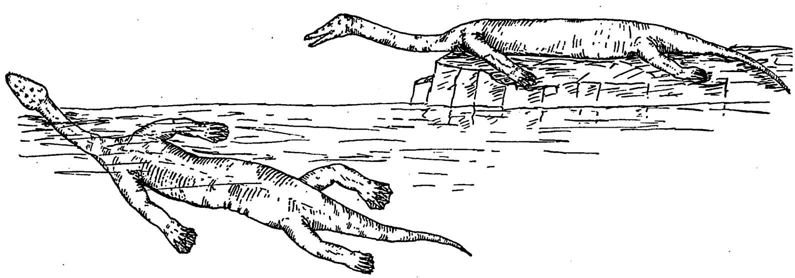


FIG. 21. Restoration of *Corosaurus*. About $\frac{1}{16}$

saur and named *Pontopus* by Nopsca. Despite the very considerable number of specimens known and the number of genera and species described, the classification and the relationships of the suborder are very uncertain. A review of the most recent literature shows a great variation of opinion, ranging from the inclusion of all known forms in a single suborder and a single family (Smith-Woodward, 1932) to a separation into at least two suborders (Edinger, 1935) and two or three families. The basis of classification is equally uncertain, some workers placing emphasis on the number of sacral vertebrae, others on characters of the limbs, others upon characters of the skull, and so forth. The degree of uncertainty is emphasized by the fact that by some authors an effort has been made to separate the older, Lower Triassic, forms from the younger, Middle and Upper Triassic, while others have emphasized the degree of aquatic adaptation and evaluated the group as dwellers upon the strand or denizens of the open sea.

The various more recent suggestions as to classification and relationships have been made by Schroeder (1914), Huene (1921), Arthaber (1924), Broili (1927), Nopsca (1928), Peyer (1932, 1933), and Edinger (1935). The publications by Peyer and Edinger contain detailed reviews of the literature and discussions of the systematic position of the suborder and its members. There is, however, so little accord that it seems profitless to enter upon a discussion of the matter with only the single incomplete specimen described in this article as additional evidence. This is especially true because Peyer is continuing his study of the large amount of beautiful material preserved at Zurich. As a basis for comparison of *Corosaurus* with the European Nothosaurs the arrangement suggested by Peyer in his latest paper (1933) is here quoted.

SUBORDER NOTHOSAUROIDEA

FAMILY PACHYPLEUROSAURIDAE

Temporal opening small. Humerus more or less straight, with rounded section at mid-length. Sacrum with 3–4 vertebrae. Sacral ribs not expanded to contact in proximal portion. Intermedium of carpus small, in most forms lying anterior to the ulna.

Pachypleurosaurus
Phygosaurus (head unknown)
Neusticosaurus
Anarosaurus
Dactylosaurus
Psilotrachelosaurus

FAMILY NOTHOSAURIDAE

Temporal opening large. Humerus more or less bent, with flat-oval section at mid-length. Sacrum with, mostly, 5 vertebrae. Sacral ribs expanded to contact. Intermedium of carpus large, lying opposite space between radius and ulna.[2]

Nothosaurus
Germanosaurus, Cymatosaurus, Pistosaurus (body unknown)
Simosaurus (body unknown)
Proneusticosaurus (head unknown)
Lariosaurus
Ceresiosaurus
Rhäticonia

[2] On another page, 109, Peyer notes the existence of some hyperphalangy in *Lariosaurus* and *Nothosaurus*.

Peyer notes that *Rhäticonia, Partanosaurus,* and *Microleptosaurus* are so imperfectly known as to warrant little more than the suggestion that they probably belong in the Nothosauridae. It is to be added that Edinger (1935) insists, with cogent reasons, that *Pistosaurus* is not a Nothosaur but is in the direct ancestral line of the Plesiosaurs. Peyer adopts the characters used in this arrangement after reviewing those used by previous workers and rejecting all as valueless or doubtful.

He rejects attempts to classify upon:

1. The presence or the absence of suborbital openings in the palate.
2. The number of vertebrae in the column and in different regions of the column.
3. The shape of the skull, long or short; rostrum constricted or not.
4. The form of the vertebrae.
5. The relative proportions of the limbs and the body.
6. The nature of the ribs (a doubtful character).
7. The number of elements in each row of the ventral armor, gastralia.

He accepts as usable:

1. The relative size of the temporal openings.
2. The number of vertebrae in the sacrum.
3. The character of the limbs and feet.

Consideration of the skeleton of *Corosaurus* shows that it occupies a position intermediate between these two groups:

1. The temporal fenestrae are much larger than the orbits and must be considered "large."
2. There are three vertebrae in the sacrum, and the sacral ribs are not expanded to contact with each other.
3. The humerus might be placed in either group since the section at mid-length is ovate, neither round nor flattened-oval, but it has lost much of the expansion of the proximal and distal ends.
4. The carpus is, unfortunately, disturbed, but there was evidently a considerable space between the radius and the ulna.

Because of these intermediate characters it seems wise to place this form simply in the suborder Nothosauroidea and to refrain from any attempt at closer allocation until more is known of the American Nothosaurs and until there is a closer agreement as to the classification of the European forms.

A detailed comparison with the known European genera emphasizes the following points: The skull is without an elongate rostrum, and the rostrum is not marked off from the skull by a sharp constriction of the maxillary region. In this and in the relative proportions of the temporal fenestrae, orbits, and nares it resembles most closely the genus *Simosaurus*, but differs in the much smaller size, the more slender teeth, and the shorter maxillary, which does not extend posterior to the anterior border of the temporal opening. The paired parietals form a wide bar between the temporal fenestrae, agreeing in this regard with the majority of the Nothosaurs and differing from *Nothosaurus* and especially from *Pistosaurus*, in which the bar is reduced to a narrow edge. The parietal foramen is oval, situated at about the mid-length point of the parietal.

Much has been made by Schroeder and Edinger of the relation of the premaxillary to the nasals. Unfortunately, the relation cannot be made out in the specimen, since neither the contour of the nasals nor the posterior edge of the median portion of the premaxillary can be determined, but, since the premaxillary can be traced back to a point between the nares and since a considerable space still separates it from the anterior edge of the frontal, easily traced in an obvious suture, it is altogether probable that there were large nasals present, meeting in the median line and separating the premaxillaries from the frontals. Inability to understand this region is due to crushing and to a slight disturbance of the fragments, which render it impossible to distinguish between matrix-filled cracks and sutures. The same condition makes it impossible to give the exact outline and dimension of the orbits and nares, but, since the edges of these openings are clearly visible in spots, the restoration is offered with confidence that the contours and dimensions are very close to being correct. Unhappily, the condition of the facial region makes it impossible to determine the presence or the absence of a lachrymal bone, since this is one of the regions showing great variation in the European forms.

The orbitotemporal bar is much narrower than the orbitonasal bar. Unfortunately, this bar, so peculiar in the Nothosaurs, is incomplete on the left side, owing to loss of a small block of the matrix containing a portion of the bar, and is covered on the right side by a bit of matrix containing the displaced postorbital. It is impossible to determine the form and extent of either the postorbital or the jugal, but from all visible parts it is probable that the postorbital had a long posterior process meeting the squamosal to form the temporal bar. On the left side the element forming the anterior border of the orbit is divided into two parts by a straight line of parting. This has the appearance of a crack, but is in the position of the postfrontal-postorbital suture in several of the Nothosaurs. If it be a suture, the presence and the form of the two bones are quite normal. If it be a crack, the prefrontal is large and the postorbital is pushed far out to the anterior corner of the temporal fenestra. The size and the position of the bones forming the orbitotemporal bar are decidedly variable, as is shown in the various restorations of European forms. On the right side of the specimen here described there is a displaced bone lying over the anterior part of the temporal fenestra (see Pl. I, Fig. 1), which joins a second bone, shown largely by the impression, which runs posteriorly. The inner part of this is evidently the postfrontal, and the outer part with the posterior extension is probably the postorbital, with its process extending backward to meet the squamosal. Nothing can be made out concerning the jugal; it was possibly reduced to a narrow splint, as in *Nothosaurus* (see Schroeder, 1914, figs. 29–30).

The anterior wall of the temporal fenestra is well developed and is clearly shown in the specimen; it is formed by the descending process of the parietal, the thickened edge of the postfrontal (or postfrontal-postorbital), and an element that comes in from the outer side, below the postfrontal, and approaches contact with the parietal (see Fig. 7); this is either the postorbital or the inner end of the jugal, probably the former. The development of this wall between the orbit and the temporal fenestra is emphasized by Edinger (1935) in her discussion of *Pistosaurus* as a character of the Plesiosaurs.

The posterior portion of the skull is undisturbed on the left side, but is concealed in part by matrix that may not be removed. The parietals meet the squamosals in a prominent arch. The condition of this arch seems normal, and the apparent undue elevation of the posterior portion of the skull, Figure 3, is rather the result of depression of the facial region. The squamosal descends in a sweeping arch and turns outward at the lower end in the manner so characteristic of the Nothosaurs. The articular portion is formed largely by the quadrate, but the upper limits of that bone and the presence or the absence of a quadratojugal cannot be certainly determined. The presence of a quadratojugal is reported and it is figured in *Simosaurus* by Huene (1921), but in other genera it is either absent or doubtfully present. Evidently this bone was in an advanced state of reduction or had disappeared in the Nothosaurs.

The presence of unremovable matrix over the occipital region prevents an exact delineation of the posterior face of the skull, but a break through the region just anterior to the foramen magnum makes it apparent that the face was of the "open" type rather than the "close." The opisthotic sent a well-defined process outward toward the squamosal and the quadrate. In Figure 7 this process is shown entering the matrix, and in Figure 8 its distal end is shown appearing through the matrix near the squamosal. There was evidently a fair-sized posttemporal fenestra.

The loss of the block from the region of the left temporal fenestra reveals in large part the lateral walls of the brain case (see Fig. 7). The outer wall of the otic cavity is broken away, but the filling of calcite reveals the size and form of the vestibule, which was developed in the three otic bones, though their exact boundaries cannot be made out from the impressions and the fragments of bone clinging to the broken surface.

The lower surface of the skull is closely applied to the vertebrae and ribs of the anterior caudal region and cannot be cleaned for examination, but it is evident from such excavation as is possible in the left temporal region that the pterygoids (or pterygoids plus ectopterygoids) are broad plates extending beneath the orbital region and continuing beneath the cranial region and the posterior end of the skull. This is the condition shown in all the forms with shorter head and expanded temporal region. Any restoration from the parts exposed would result in a palatal surface such as is common to the Nothosaurs. The presence and the form of the openings in the palatal surface and the possible slight divergence of the pterygoids beneath the occipital region cannot be determined in the specimen.

FORM AND ADAPTATIONS

The specimen from Wyoming was a medium-sized Nothosaur with limbs adapted for swimming rather than for progress upon land. The form of the limb bones and the nature of the articular surfaces indicate that there was little possible movement at the elbow. The large space between the radius and the ulna, the disk-like form of the preserved carpal bones, and the broad and diverging digits with blunt terminal phalanges all speak for a limb well advanced toward a rigid paddle with, probably, a webbed foot. The length of the tail is, of course, problematical, but the rapid reduction of the transverse process and the neural spines of the caudal vertebrae suggests a fairly rapid termination; the addition of a number of vertebrae equal to those preserved, making thirty in all, is perhaps a fair estimate. The breadth and strength of the ventral armor suggest a flat ventral surface, and the length of the ribs indicates a rather gently rounded and not elevated body.

That the length of the neck is not determinable by the character of the ribs has been shown in many specimens. The only usable criterion is the position of the pectoral girdle. A comparison with the most similar European forms shows that it cannot be far amiss to place the interclavicle opposite the eighteenth to nineteenth vertebrae.

GEOLOGICAL OCCURRENCE

According to the report of Dr. S. H. Knight, director of the Geological Survey of Wyoming, the Alcova limestone "is a locally occurring limestone lens which rests directly on the Chugwater red shales over a considerable area through the central part of Wyoming," [3] and, further, the specimen "occurs in a lower horizon than anything that we have found before in the central or the southern part of the state. The Alcova limestone is just under the Jelm formation, and it may be the equivalent in part of Williston's Popo Agie."

The specimen assumes considerable stratigraphic significance since the Nothosaurs were distinctly marine or marine-littoral forms. It is apparent that there was a short-lived extension of the Triassic sea from the Pacific into Wyoming; this is in confirmation of suggestions by Branson and Mehl (1929) and by Schuchert and Dunbar (1933). The age of the limestone is less certain. The Triassic marine vertebrates of the Upper Triassic (Hosselkuss) of California and the Middle Triassic of Nevada are all open-sea forms far advanced in aquatic adaptations and lend no aid to the interpretation of the age of the littoral form from Wyoming.

The Nothosaurs are limited to the Triassic, but whether *Corosaurus* occurs in a lower, a middle, or an upper stage cannot be determined. The close association of the limestone with the Popo Agie beds suggests its Upper Triassic age. There is nothing in the specimen here described which permits a closer determination. Repeated studies of the degree of aquatic adaptation of the Nothosaurs in reference to their age have not resulted in any definite criteria.

[3] Personal communication.

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PLATE I

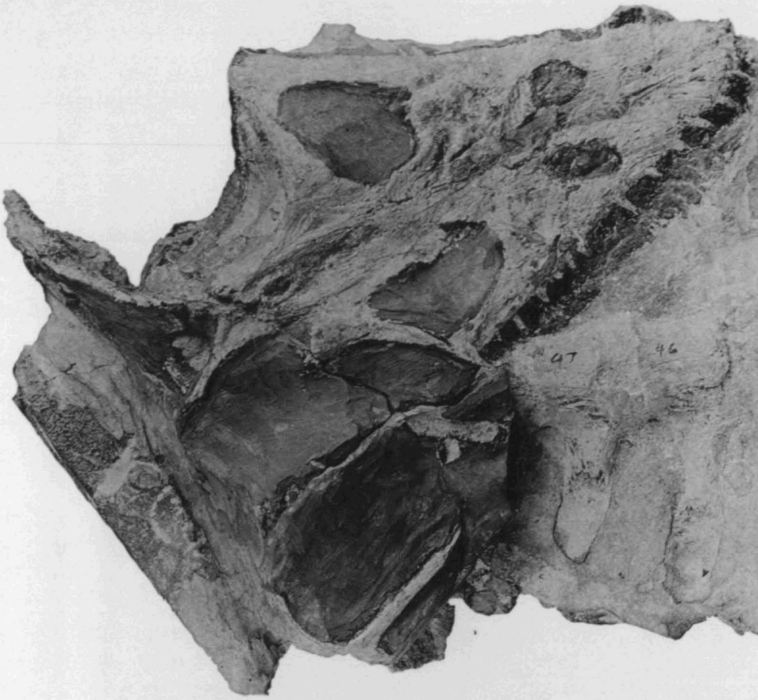

Fig. 1. Upper surface of skull of *Corosaurus alcovensis*

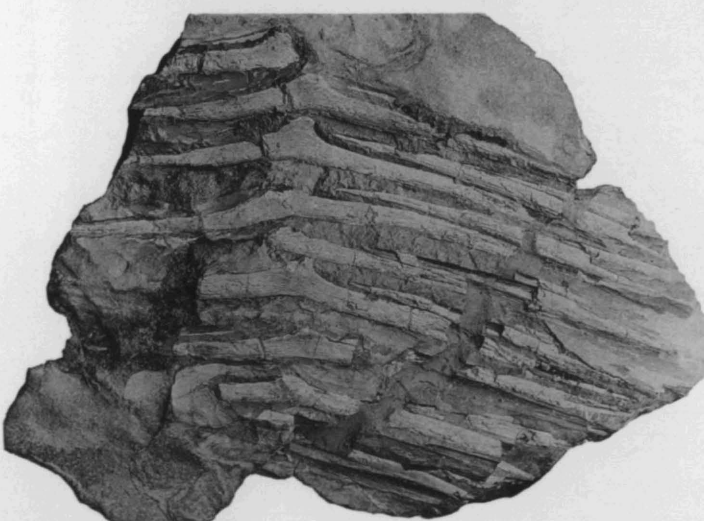

Fig. 2. Gastralia of the same specimen