

ART. XXX.—A Description of the Skulls of *Diadectes lentus* and *Animasaurus carinatus*; by E. C. CASE and S. W. WILLISTON.

THE two skulls here described have recently come to light. The first was collected by Case in the Baldwin Bone Bed on Poleo Creek in Rio Arriba County, New Mexico, and the second was collected by Baldwin near Animas, Colorado nearly thirty years ago, but has lain undescribed among the abundant material of Yale University. The matrix of the second skull, an indurated blue clay, is different from any occurring in the New Mexican localities, but the similarity of the skull to that of *Diadectes* and the geographical proximity indicate that it is a member of the same fauna.

DIADECTES LENTUS Marsh. (Figs. 1 and 2.)

Nothodon lentus Marsh, this Journal, vol. xv, p. 410, 1878.

Nothodon lentus Case, Publication 145, Carnegie Institution, p. 30, 1911.

Nothodon lentus Williston, American Permian Vertebrates, Chicago, p. 16, 1911.

The only portions of the skull of this animal known previously were the few teeth described by Marsh and the imperfect top of a skull described by Williston in the paper cited above. The history of the discovery and description of the original specimen has been given by Williston in the paper cited above (pages 7 and 8) and need not be repeated. The uncertainty as to the generic identity of *Nothodon* and *Diadectes* has been removed by the discovery of this specimen associated with typical diadectid vertebræ with hyposphene and hypantrum in the original Baldwin bone bed.

The skull was found in a matrix of soft, blackish, friable clay on the banks of Poleo Creek about a mile above its junction with the Puerco river in Rio Arriba County, New Mexico. Closely associated with the skull were found the two jaws described in this paper and they would have been regarded as belonging to the same specimen if several other jaws of the same size had not been found with them.

The anterior portion of the skull, as far back as the post-orbital region, was taken out in plaster and the relation of the parts can not be questioned. The posterior portion was broken in the ground and recovered as fragments. As restored, the skull resembles very closely that of *Diadectes* in form and proportions.

The top of the skull is very rugose in the occipital and frontal regions, but on the sides of the temporal and facial regions the bones are marked by a sculpture of fine pits. The

sutures can not be made out nor can any grooves such as figured by Williston (Am. Permian Verts., fig. 1 and pl. xxxviii) be seen. In the specimen figured by Williston the bones were separated and the sutures thus determined resemble very closely those shown in the single specimen of *Diadectes* from Texas, in which the sutures can be made out. Cope mentions the occurrence of grooves on the skull of *Chilonya*, considering them to be the marks of attachment of corneous plates, but these could not be seen by Case. Seeley mentioned the occurrence of mucous grooves on the skull of *Pareiasaurus*, but this has been questioned. So far as we are aware, these are the only mentioned cases of anything resembling the grooves described by Williston. The only notable differences from the skull of *Diadectes phaseolinus*, the best known, are:

1. There are no pits on the surface of the supraoccipital bone.
2. The pits on the surface of the temporal region are very obscure and cannot be certainly distinguished from the deep interspaces of the rugosities.
3. There are small pits on the surface of the prosquamosal bones just anterior to the upper anterior border of the quadrate.
4. The jugal descends to the lower edge of the quadrate.

These differences are certainly not of generic value.

The *nares* are far anterior and in the crushed condition of the specimen appear to look upward; this is, however, an exaggeration of the natural condition, in which the nares were inclined somewhat inward and forward and looked almost directly outward. The nasal canal is inclined inward and downward and opens on the sides of the palatines and prevomers (vomers) at the posterior edge of the premaxillaries, a little posterior to the anterior opening.

The *orbits* are elongate oval in outline and inclined slightly inward at the upper edge.

The *parietal foramen* is, as in all the *Diadectidae*, 'enormous'. These are the only openings in the skull except the otic.

The *premaxillaries* are short and very heavy. Each one carries four strong incisor teeth (not two as described by Marsh) very prominent and protuberant; this is most evident in the median ones; the inclination becomes less in the outer teeth. The inner surface of the crown is beveled by a flat surface forming a strong chisel-like cutting edge. The surface of the crown is smooth but the roots are marked by deep striations. An isolated incisor tooth from another specimen has an imperfect root 22^{mm} long with the crown 17.5^{mm} long. There can remain no question of the true thecodonty of the teeth.

The *maxillaries* have the alveolar portion greatly swollen

to accommodate the wide sockets for the teeth. The outer portion, forming the sides of the facial region, is thin and marked with a sculpture of fine pits. The swollen portion departs abruptly from the inner side, forming a gently swelling prominence; from a point near the middle of the inner side of this swollen portion rises the palatine process of the maxillary which projects from the bone at a fairly steep angle and leaves a deep groove between it and the bone proper. The process is thin and the lower edge is slightly rugose. It extends in a gentle curve, following the outline of the inner edge of the maxillary, from the third or fourth tooth to beyond the last tooth. The character of this process has been in doubt, Cope and Case believing that it might possibly be the palatine bone, but the condition of this specimen leaves no doubt of its true nature. There are 11 maxillary teeth; the first has the form of the incisors except that the face is not so broad and chisel-like. It is smaller than the incisors and there is no approach to a canine character. The second is smaller than the first and more conical in form. Both of these are nearly vertical. The succeeding teeth, except the last, have the characteristic transverse widening; the first of these, the third of the series, has a sharp median cusp and the inner and outer edges are rounded; the rest, except the eleventh, have a median cusp and lateral cusps on the inner and outer edges, identical with the teeth of *Diadecies phaseolinus* Cope. The teeth increase in width to the sixth or seventh and then decrease to the posterior end. The eleventh is not preserved, but the outline of the base shows it to have been small and conical. When first erupted the enamel of the teeth was marked by rugose lines which radiate from the central cusp, but these are soon removed by wear, and in old individuals the surface is nearly flat. There is a deep pit on the inner side of the base of each of the teeth, marking the position of successional teeth.

The *prevomers* (vomers) are paired and articulate strongly with the premaxillaries in front, the pterygoids behind, and the palatines laterally. They are of considerable vertical extent and closely applied to each other in the median line. Case (Publication 145, Carnegie Institution, p. 71) has described the posterior ends of the prevomers as spreading apart above at the posterior end and receiving the lower edge of the ethmoid. It is now apparent that this open portion is the anterior end of the pterygoids or the posterior of the palatines. The lower surface of the prevomers is flat and there is a series of small, sharp, conical teeth about a millimeter in length. The posterior limit can not be determined as the suture between the prevomer and the pterygoid is not distinguishable.

The *palatines* are gently convex upward; the outer edge is

attached to the maxillaries throughout their length; there is no palatine vacuity. The position of the palatine-ptyergoid suture can not be made out. The anterior portion of the inner edge of the palatine is applied to the outer surface of the prevomers, the attachment being by overlap. There are no teeth on the palatine.

FIG. 1.

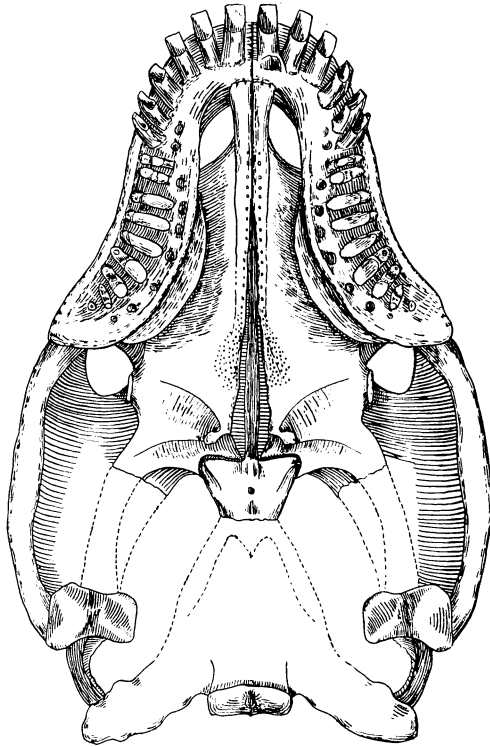


FIG. 1. Palate of *Diadectes lentus* Marsh. $\times \frac{1}{2}$. Mus. University of Chicago.

The *ptyergoids* are slightly convex upwards in the anterior portion; the inner edges of the two bones meet, if at all, at the anterior ends, leaving an elongate vacuity which widens posteriorly. It is uncertain whether the anterior ends of the pterygoids meet or whether the vacuity is closed by the union of the prevomers (vomeres). The edges of the pterygoids forming the sides of the median vacuity are lined with small teeth and the flat surface of the bone adjacent to the posterior part of the vacuity is covered with small shagreen-like teeth. The

middle portion of the pterygoid widens and is slightly concave on the lower face; this portion is marked by a low line convex anteriorly. On the outer side of the middle of the bone is the low ectopterygoid process: its outer edge and a portion of the upper surface is slightly rugose, but there is no approach to the prominence which the same process gains in *Labidosaurus* and *Captorhinus* and there are no teeth on the process. Near the median vacuity there is slightly prominence on the inner edge of the bone which curves inward and backward over the vacuity. The articulation with the basisphenoid is by strong flat faces. The pterygoids are separate from the basisphenoids in the specimen, but were found articulated in position so that the nature of the free articulation is beyond doubt. Posteriorly the pterygoids send the usual vertical plates back to join the quadrate.

There is no evidence of an *ectopterygoid*. This bone has been in question, but it seems to us there can no longer be doubt of its absence.

The *basisphenoid* is represented by the anterior end, only. There is a small but well developed foramen in the middle line. The parasphenoid rostrum is strong; the lower edge is thick and flat but the upper edge is thin and the whole bone becomes thin anteriorly; it terminates freely a little beyond the point where the median vacuity is closed by the approximation of the pterygoids or prevomers. It is apparently this bone which was figured by Case as the ethmoid in *Diadectes phaseolinus*. It is worthy of note that this bone, so strong in this specimen, is wanting in many of the described skulls of *Diadectes*, perhaps by accident; and it was originally reported that it was absent.

Above the parasphenoid process there are the shattered remains of very thin plates of bone which can not be restored. It is apparent that they were paired and that they reached up to the lower surface of the parietal or frontal bones. They are probably the anterior ends of the sphenoid plates described by Case.

The *quadrate* resembles the same bone in the specimen of *Diadectes* described by Case from Texas (No. 4839 Am. Mus. Nat. Hist.), but the shaft is a little longer and there is a prominent tuberosity on the posterior surface just above the articular surface. It is probable that there was such a tuberosity on the Texas specimen but that it was destroyed by the accidents of fossilization.

It is necessary here to correct certain errors in the restoration of the skull of *Diadectes* published by Broom (Bull. Am. Mus. Nat. Hist., vol. xxviii, Art. XX, pp. 216-217, figs. 11 and 12). In figure 11, the side view, Broom shows an enlarged anterior maxillary tooth resembling a canine, a diastema,

and a decrease in the size of the incisors from within outward. The character of the incisors is evidently hypothetical as they are shaded, but the arrangement is wrong as can be made out from this specimen and from several others in the American Museum. There is no diastema and in no specimen of *Diadectes* is there any indication of an enlarged maxillary. It was upon such an error that Cope founded the genus *Empedias*.

In figure 12, the palate, the arrangement of the bones is wrong. The premaxillaries are never so wide, antero-posteriorly, as figured; the prevomers extend much farther forward than figured; the palatine process of the maxillary is figured as a palatine; the pterygoids are figured as short bones with

FIG. 2.

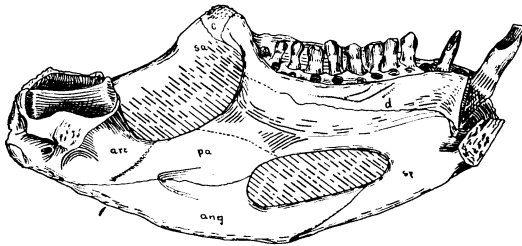


FIG. 2. Lower jaw of *Diadectes lentus* Marsh. $\times \frac{1}{2}$. Mus. University of Chicago.

the prevomers extending back as far as the posterior end of the maxillaries; an ectopterygoid is figured,—as already stated we find no evidence of such a bone in the *Diadectidæ*. We have studied the known skulls of *Diadectes* carefully for several years and have found no evidence to warrant drawing the sutures of the temporal region so definitely as Broom has done, though they may be correct.

The lower jaw.—The resemblance to the lower jaw of the specimens of *Diadectes* from Texas is very close, but the jaws from New Mexico show the sutures and permit the outline of the individual bones to be determined. On the inner side the suture between the splenial and dentary is distinct in front but is not traceable behind: its probable continuation is indicated by the dots in the figure. Below the anterior Meckelian opening the suture between the splenial and the surangular is very distinct. The splenial takes the usual large part in the symphysis. The suture between the angular and the bone above it in the posterior portion of the jaw is distinct, but it is somewhat uncertain what this bone is. The articular is not marked off by distinct sutures, but on the surface of the bridge between the anterior and posterior openings of the lower

jaw there is a low, slightly rugose ridge which appears to mark the portion of a suture which has closed. If this is true, the portion of the bridge behind the rugose line may be the anterior portion of the articular, and the anterior portion of the bridge may represent the prearticular; the ridge may, however, be only a surface for the attachment of muscles. The coronoid is a very small bone visible on the inner side of the jaw. The surangular behind and the dentary in front send processes upward which aid in the formation of the coronoid process. The sutures on the outer side of the jaw can not be made out except where a break in one of the jaws shows that the suture between the dentary and the surangular runs downward a little anterior to the coronoid process. The articular face of the articular has two deep parallel grooves which limited the motion of the jaw to the vertical plane. There are fifteen teeth in the jaw. The posterior one is small and conical; the next eight have the expanded form characteristic of the genus. The first four have the chisel-like form of true incisors, the fifth is nearly conical, the sixth has the crown slightly expanded and carries a single median tubercle. The other have wide crowns with three tubercles. The wear was on the outer side of the teeth in the lower jaw and the inner side in the upper.

Animasaurus carinatus, gen. et sp. nov. (Fig. 3.)

The specimen consists of a fairly perfect skull (No. 1107 Mus. Yale Univ.). It is slightly injured in the anterior part so that the premaxillaries, the anterior ends of the maxillaries and the nares are lost. The anterior portion of the facial region is crushed down upon the palate. The teeth are all destroyed, but the outlines of the roots show them to have been transversely expanded as in *Diadectes*. The condition of the specimen is such that the sutures can not be made out and the hard matrix can not be entirely removed from the palate, but enough has been taken away, aided by a fortunate break, to make the structure evident.

The superior surface of the skull.—Due to the position of the quadrate, the posterior portion of the skull is proportionately much broader than in *Diadectes* though the occipital portion is narrower. The surface is roughened by sculpture and the development of tubercular prominences which recall those of the genus *Chilonyx*. This appearance is heightened by the position of the quadrate, which slants inwards instead of lying nearly parallel to the lateral surface, narrowing the occipital region. The parietal foramen is very large, approximately 20^{mm} broad by 25^{mm} long. This opening is farther forward than in *Diadectes*, a line drawn through the posterior edges of the orbits cutting through it at near the center; in *Diadectes*

such a line passes anterior to the opening. The outlines of the various bones can not be made out but it is evident that the frontal was very short and took no part in the superior border of the orbit.

The lateral aspect of the skull.—Allowing for the crushed condition of the anterior end, the lateral profile resembles that of *Diadectes*. The orbits appear to be narrowed vertically, but this is evidently due to crushing. On the right side there is

FIG. 3.

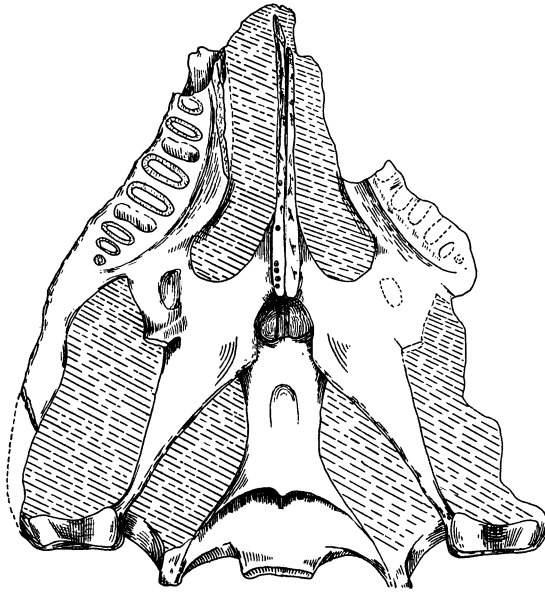


FIG. 3. Palate of *Animasaurus carinatus* Case and Williston. $\times \frac{1}{2}$. No. 817, Mus. Yale University.

a large opening in the temporal region but this is of accidental origin instead of a true temporal foramen, as is evidenced by the sharp break of the edges and the lack of a corresponding opening on the opposite side.

The palatal aspect of the skull.—This shows the great difference between this genus and *Diadectes*. The alveolar edges of the maxillaries are broadened as in *Diadectes* for the accommodation of the widened teeth, but the palatine process of the maxillary is perhaps different: it appears to rise from the inner edge of the alveolar surface instead of from the middle of the inner side of the swollen portion of the bone and there is no deep groove between it and the maxillary proper. The pterygoids and prevomers are united in the median line throughout their

length, forming a deep median keel; there is no median vacuity between the pterygoids but posterior to them there is a deep vacuity, the circular opening of which looks backwards and downwards at an angle of nearly 45° to the horizontal axis of the skull.

The posterior aspect of the skull.—The occipital portion is narrower than *Diadectes* owing to the position of the quadrates and the paroccipitals and exoccipitals are shorter. The articular face of the quadrate is much narrower than in *Diadectes* and the whole bone occupies a very different position with relation to the basicranium. In *Diadectes lentus* the quadrate lies much farther forward, the articular surface being opposite the posterior end of the basisphenoid; in *Diadectes phaseolinus* the articular face of the quadrate lies opposite the middle of the same bone, while in *Animasaurus carinatus* it lies posterior to the posterior end of the bone. This accounts largely for the wider appearance of the posterior end of the skull in the latter.

The individual bones can not all be made out, but such as can are described below.

The *maxillaries* are similar to those of *Diadectes* except as noted in the description of the palatine process. The posterior end of the bone is continuous with and on the same level as the jugal; in *Diadectes* it stands out as prominent point. There are nine bases of teeth and alveoli in the portion of the bone preserved. The posterior one was small and conical, as indicated by the base. The others are gradually enlarged until the 6 or 7 from the posterior end is reached, then they begin to diminish in size. There should be two more teeth in the maxillary if the number was the same as in *Diadectes*.

The *pterygoids* have the general form of those in *Diadectes*; the posterior vertical plate, reaching to the quadrate, is identical in form; the ectopterygoid process is similar but is more prominent. Laterally the pterygoid joins the maxillary with no indication of an ectopterygoid bone, but the sutures can not be made out. Anterior to the ectopterygoid process the bone widens and dips beneath the matrix, but it is apparent from a break on the left side that it joins the palatine and maxillary as in *Diadectes*. Just anterior to the ectopterygoid process there is a large shallow pit on the flat surface of the bone but there is no perforation. In fact there is not, in any American Permian reptile known to us, any indication of a lateral palatal opening or of a separate ectopterygoid. On the inner side of the bone the posterior portion rises abruptly to form the side of the circular vacuity anterior to the basisphenoid. Immediately in front of this opening the keel formed by the conjoined edges of the pterygoids of the two sides is very high.

The edges of the two bones forming the keel were lined with small conical teeth, now indicated by the bases. At the posterior end there are four such teeth in 15^{mm} ; similar teeth can be detected throughout the length of the keel. No small teeth can be detected on the sides of the pterygoids adjoining the keel, but this may be due to the condition of the bone or the accidents of preparation; the surface of the bone is partly destroyed.

The *prevomers* are hidden by the matrix except the lower edge; it seems probable, however, from the appearance of the upper surface of the palate, revealed by the crushing of the facial region, that the palatines had the same relation to the prevomers as in *Diadectes*.

The *basisphenoid* is similar to that of *Diadectes* but is very much longer and there is no foramen in the median line. In the deep pit anterior to the basisphenoid can be seen the posterior end of a strong parasphenoid rostrum. The posterior end of the basisphenoid is not entirely cleared but it is quite similar in general form to that of *Diadectes*.

The *quadrate* is inclined inward so that its outer surface looks rather backward than outward. There is no indication of the pit opposite the anterior edge of the quadrate. The inner edge describes the same sharp curve as in *Diadectes* and there is the same deep notch at the upper end of the otic opening. The articular face is very much narrower than in *Diadectes*, the anterior posterior diameter being only 9.5^{mm} and the transverse at least 24^{mm} . In *Diadectes lentus* the same diameters are 17^{mm} and 24^{mm} . Moreover the outer half of the articular surface is nearly the same width as the inner; in *Diadectes* the outer is much wider than the inner.

The genus evidently belongs in the family *Diadectidae*, but may be distinguished by the following characters:

1. The union of the pterygoids in the midline to form, with the prevomers, a prominent keel.
2. The absence of any interpterygoid space.
3. The elongation of the basisphenoid and the absence of a foramen in the median line.
4. The inward inclination of the quadrates narrowing the occipital region.

The animal must have been similar in form and habits to *Diadectes*. It has been customary to regard the members of this family as herbivorous, but the strong, chisel-like incisor teeth, the absence of any power of trituration in the unworn maxillary teeth and the possibility of the use of the palatine processes of the maxillaries as accessory agents of mastication lead to the suspicion that the animals were not exclusively if at all herbivorous, and that they may have included the less well-protected invertebrates in their diet.