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NEW AND LITTLE KNOWN GENERA AND SPECIES OF
VERTEBRATES FROM THE LOWER PERMIAN
OF OKLAHOMA

EVERETT C. OLSON

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NEW AND LITTLE KNOWN GENERA AND SPECIES OF
VERTEBRATES FROM THE LOWER PERMIAN
OF OKLAHOMA¹

INTRODUCTION

In the course of studies that led to a report on "Early Permian Vertebrates from Oklahoma" (Olson, 1967) large collections of fishes, amphibians and reptiles were made. Parts of these are now housed in the Stovall Museum at The University of Oklahoma, and others are at Field Museum of Natural History in Chicago. In general, allocation of specimens has been made so that collections from particular sites and particular horizons are located in one place.

As noted in the cited publication, specimens representing both new genera and species were found in the course of the work. Review of older materials showed that some additional information upon previously described but very poorly known genera was at hand. The present report is devoted to description and discussions of some of these materials.

Thorough analysis of the wealth of fragmentary materials from the Orlando site undoubtedly will reveal specimens that will eventually require description. Other studies, to be published separately, are also in progress. Among these are an analysis of the lungfish *Gnathorhiza serrata* (Carlson, 1968, and in press); studies of *Crosstotelos*, also by K. J. Carlson; a study of the brain case of *Labidosaurikos meachami*, by William MacLean (in press); a study of a new, puzzling, procolophonian reptile from near Grandfield, by Eleanor Daly (1968); and a study of the vertebrates associated with this specimen, also by Miss Daly.

The present paper treats specimens from three important sites: Orlando; Perry site 6, about 9 miles northwest of Perry; and a site

¹ This study was supported by National Science Foundation grants GB2543 and GB7070X.

in the Hennessey formation, just south of Norman. Each of these was described briefly in Olson (1967).

CRICOTILLUS BRACHYDENS CASE AND
PLEURISTION BRACHYCOELOUS CASE
FROM ORLANDO, OKLAHOMA

THE ORLANDO DEPOSITS

About two miles northeast of Orlando, Logan County, Oklahoma, in the SE $\frac{1}{4}$ sec. 31, T. 20 N. R. 1 W. occurs one of the oldest known sites of early Permian vertebrates in Oklahoma. Case (1902) described a collection from this site and since then various parties have collected additional specimens. For the most part, specimens are fragmentary and occur in sandy ironstone nodules. They have been collected from surface concentrations that have formed as the gray shale in which the nodules are formed has weathered. The concentration in the parent bed is so low that attempts to get material by excavating it have had little success.

This locality was described in some detail earlier (Olson, 1967), and a measured section was presented. It lies in the Wellington formation about 100 feet below the contact of the Wellington and the Garber formations.

A full restudy of the collections from this site is in order, but this is a major project which will not be completed for some time. The two genera that are the subject of this study, however, can be treated at present. Both have been carried in the literature since their first description by Case (1902) with sporadic mentions and suggestions on relationships, but almost without any additional study. Much can now be done to supplement descriptions and to fix the relationships of the two genera more closely. This is the purpose of this report.

***Cricotillus brachydens* Case**

HISTORY

In 1902, Case described very briefly two amphibians, *Trimero-rhachis leptorhynchus*, a new species, and *Cricotillus brachydens*, a new genus and species. Later Case (1911) dropped *T. leptorhynchus* as indeterminate, but suggested that it might belong to *Cricotillus brachydens*. Except for a listing of *T. leptorhynchus* in Case (1915), this specimen, KU 350, has dropped out of the literature.

Cricotillus brachydens was named on the basis of a specimen, KU 349, that consisted of a pair of teeth-bearing bones, accompanied by two other smaller pairs of bones (Pl. 1). The specimen, which is about an inch long, was called part of a skull by Case (1902) and this has not been questioned. As will be shown, however, this determination cannot be correct, and the specimen appears to represent a portion of a pair of lower jaws.

Case made no familial assignment of the genus in his 1902 description, but inasmuch as its description follows that of *Cricotus* directly in sequence and the name *Cricotillus* was given, he appears to have recognized affinities with *Cricotus*. Case (1911) placed the genus in the family Cricotidae and listed it similarly later (Case, 1915, 1946). Romer (1966) gave a tentative reference to the family Cricotidae as well.

Under this determination, *Cricotillus brachydens* is considered to be an embolomeres amphibian generally related to *Cricotus* of the Pennsylvanian and, perhaps more closely, to *Archeria* of the Early Permian. The only dissent from this placement is found in a casual remark by Williston (1910a) to the effect that *Cricotillus* probably belonged to *Crossotelos*, an amphibian generally assigned to the Neotridea, close to *Diplocaulus*, but only very remotely related to the embolomeres.

In the course of the study of collections of the Lower Permian beds of Oklahoma, the holotypes of *Trimerorhachis leptorhynchus* Case and *Cricotillus brachydens* were borrowed from the Paleontological Museum of The University of Kansas to aid in identification of other Orlando materials. Nothing that can be definitely assigned to *Cricotillus* has been found, but it is possible that full preparation of some of the material in various collections will eventually reveal other specimens.

DESCRIPTION

Original description: Case's (1902) original description which has remained unchanged in later publications, was as follows:

"A fragment of rostrum indicates the presence of a new genus and species of amphibian. The fragment is from the middle portion of the maxillaries between which appear in the posterior half the anterior parts of the nasals (sic), and on the lower surface the vomers. The upper surface of the maxillaries is sculptured by low longitudinal ridges, especially on the upper surface. The maxillary is triangular in section, the upper surface is convex and the inner or vomerine side

and the dentigerous surface are flat or slightly concave. The inner and lower surfaces meet in a very sharp ridge. The vomers are very narrow but of considerable vertical extent and lie closely apposed to the vomerine sides of the maxillary; they project as sharp ridges on the lower sides of the skull. The teeth are represented by the roots alone, their chief characteristic is the relative breadth of the roots, approaching in this respect the Diadectidae. They are from two to three times as wide as long. The tooth line is somewhat concave inwardly following the curve of the maxillary bone and the teeth are ankylosed to the flat dentigerous surface.

Measurements:

Total length of the fragment (about half the length of the head, probably).....	.030 m.
Width of anterior end.....	.015 m.
Width of posterior end.....	.021 m."

Discussion and revised descriptions: The specimen was figured to show the dental surface by Case (1911, 1946). The drawing, while reasonably accurate, shows little detail and does not show the features of the opposite side, which are hard to reconcile with the interpretation that this is a portion of the maxillaries. Photographs are included in Plate I of this paper.

Case's description, if the names of the bones are omitted, is fairly accurate. If, however, Case's identifications are used, the situation is morphologically untenable. Nasals are presumed to wedge in between the maxillae and to terminate some distance posterior to the end of the maxillae, leaving no place for contact with nares, unless these be considered to have lain far back and out of contact with the premaxillae. If the maxillae of Case are considered premaxillae it is remotely possible that this specimen might represent a very elongated region anterior to the narial openings into which the nasals penetrated. No parallel, however, is to be found among any of the known amphibians. Even if this improbable situation is granted, the presumed vomer-maxillary arrangement of the palate is an impossible one. The vomers would then be closely appressed splints in a very narrow snout and the internal nares must have lain somewhere far back, after considerable lateral expansion had occurred. But a passage between the external nares and internal nares is impossible under this interpretation unless premaxilla, maxilla, vomerine are modified in a way unlike that in any other known tetrapod.

A much simpler interpretation is that the two teeth-bearing elements are dentaries, that the medial bones are the splenials and that the wedges between the dentaries, the triangular bones, are postsplenials. This also does not produce an entirely usual situation, for the supposed splenials do not appear at the ventral margin of the lower jaw and the contact of the splenials and postsplenials is not broad; but only a slight modification of the conditions found in various labyrinthodonts is necessary to produce this condition. It appears much more reasonable to assume that such a change took place than to require the major reorganization necessary to interpretation of this fragment as part of a skull.

Case's suggestion (1911) that the specimen he first called *Trimero-rhachis leptorhynchus*, KU 350, might pertain to *Cricotillus brachydens* appears to be well founded. If the type of *C. brachydens* is considered to be from the lower jaws, then the two rami appear to make a nice extension of the lower jaws of the skull and jaws of KU 350. The type of *C. brachydens*, however, is from a somewhat larger individual. In Figure 1, a cross-section from the posterior end of the jaw in *C. brachydens*, KU 349, and one from the anterior end of the jaw in KU 350 are shown diagrammatically. The latter lies just at the level of the anterior termination of the postsplenial, whereas the former is a short distance farther back in the jaw. Some overlap of the two specimens does occur. The positions of the two sections are indicated in the reconstruction of the jaw, Figure 1.

Case made special note of the teeth of *C. brachydens*, in particular of the transverse breadth of the base of the crowns. The teeth are rather badly preserved, but their essential condition is well shown in Plate I. Teeth in KU 350 also are not well preserved. One lower is present and this shows a transversely wide base and a simple, somewhat recurved, conic crown. In both specimens the teeth are ankylosed to a broad, slightly concave dorsal surface of the lower jaw. On the basis of the teeth, assignment of the two specimens to the same genus and species is certainly reasonable.

The skull, KU 350, is in a poor state of preservation. It is shown in Plate I, but photographs do not differentiate bone and matrix well. Semi-diagrammatic drawings in Figure 1 make this distinction and a reconstruction is given in Figure 1. The lower jaws have been rotated somewhat mediodorsally and are pressed into the skull in such a way that the palate cannot be prepared. Much of the pre-orbital region is missing.

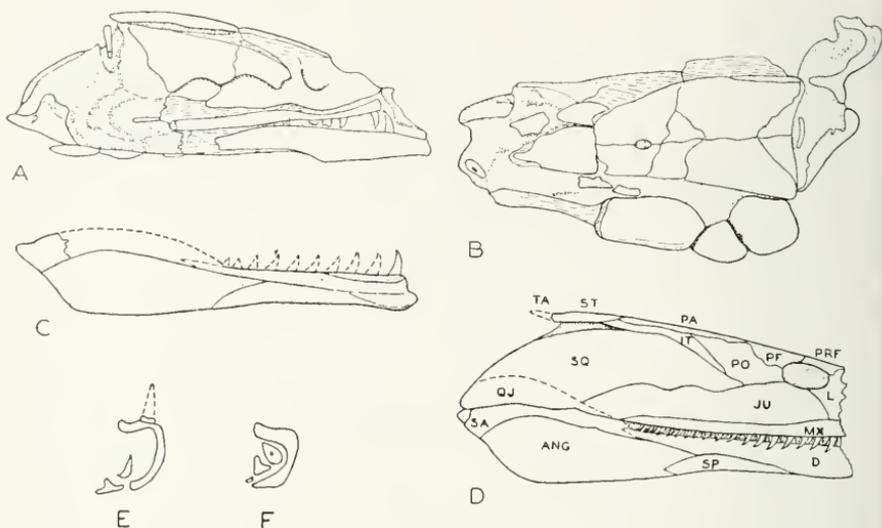


FIG. 1. Skull and jaws of *Cricotillus brachydens* Case. A, lateral view; B, dorsal view; C, reconstruction of jaw; D, reconstruction of skull; E, section of jaw at anterior end of jaw in K. U. 350; F, section of jaw at posterior end of K. U. 349, lying slightly posterior to section in E. All based on K. U. 349 and K. U. 350. A-D $\times 1.0$. Abbreviations for all figures are given on page 424.

The general pattern of the bones of the skull as far as it can be made out conforms more or less to that found in a variety of labyrinthodonts. The narrowness, of course, is a feature found only in a few genera. The parietals are long and the postparietal is fairly prominent. The pineal lies far forward in the parietal in a somewhat unusual position. In Figure 1 a small, splintlike bone, identified as supratemporal, is shown on the right side of the parietal platform, lying behind a poorly preserved element identified as intertemporal. The element called supratemporal appears to be a distinct bone and not merely the result of a crack in the parietal. However, it should be noted that it is not evident on the other side of the skull.

A small part of the posterior part of the platform is missing and there is a suggestion that "horns" were present. It is assumed, as shown in Figure 1, that the tabular was present but has been almost completely lost. If the interpretation is correct the tabular was in contact with the parietal and, if it was present as seems highly likely, the position and proportions of the postparietal make this interpretation mandatory.

The orbit is only partly preserved on one side and the small size shown in the restoration may be an exaggeration. The circumorbital bones are present on three sides, but missing anterior to the orbit, as shown in the reconstruction. The temporal series, however, is badly preserved and not entirely clear. It appears that three temporal elements were present, as in the reconstruction, but this, as noted, is somewhat conjectural.

The suspensorium of the lower jaw slanted sharply postero-ventrally from the area of the otic notch and the jaw articulation was well back of the parietal table. Between the table and the more ventral elements was a deep otic notch. The depth in the reconstruction may be excessive, due to exaggeration by crushing of the specimen.

RELATIONSHIPS

On the basis of what he considered skull but what is here considered lower jaw, Case (1902, 1911, 1946) assigned *Cricotillus* either tentatively or positively to the Family Cricotidae. The evidence was clearly insufficient. The skull, assigned to the genus and species in this paper, and as suggested earlier by Case (1911), adds some useful information. Much is now available that was not to be seen earlier, since additional preparation has been carried out. The skull pattern very clearly is that of a labyrinthodont amphibian. The two commonest amphibians in the Orlando collections are *Diplocaulus* and *Crossotelos*. The skull of *Diplocaulus* is, of course, very well known, but this is not the case for *Crossotelos*. The vertebrae of *Crossotelos* are very similar to those of *Diplocaulus*, although readily distinguishable on the basis of the transverse processes, and this, among other features of the postcranium, strongly indicates that *Crossotelos*, like *Diplocaulus*, is a neotridean, as has been generally accepted. Williston's (1910a) suggestion that *Cricotillus brachydens* is referable to *Crossotelos* is thus untenable.

All other references have been to the Cricotidae, but with very little more basis than that supplied by Case. Actually, the assignment was based upon the presumed elongation of the rostrum of the skull and the fact that embolomorous, *Cricotus*-like centra, occur at Orlando. The skull, KU 350, adds weight to this assignment. If it has been properly interpreted, the full temporal series of intertemporal, supratemporal and tabular was present. The tabular appears to have been in a position in which contact with the parietal was inevitable.

The otic notch appears to have been very deep and this, in conjunction with the temporal elements, strongly suggests anthracosaur affinities. Within this group, relationships are quite clearly with the embolomeres rather than the seymouriamorphs.

In many respects *Cricotillus* resembles *Archeria* and the question as to whether they are congeneric can be raised. Most definitive in differentiation are the teeth, for the lower teeth in KU 349 are distinctive, as Case noted, and not matched by those in specimens of *Archeria* from the Permian of Texas. A slight broadening of the bases is found in some of the more posterior teeth of the upper jaw in some specimens of *Archeria*, but in none is the extreme condition of *Cricotillus* approached. Also, it would seem from the material available, that *Cricotillus* was somewhat more elongated and narrower, particularly in the rostral region, than *Archeria*. The conditions of preservation, however, argue for caution in any such interpretation. Minor features of the pattern of skull bones and the position of the parietal appear to be different in *Cricotillus* and *Archeria*. For these reasons, it is concluded that *Cricotillus* is a distinct genus.

FORMAL SYSTEMATICS

In view of the above considerations it is now possible to formalize the systematics of the genus and species, which has not been done previously, as follows:

CLASS AMPHIBIA

Subclass Labyrinthodontia

Order Anthracosauria

Suborder Embolomeri

Family Cricotidae

Cricotillus Case

Diagnosis.—A small, narrow-skulled cricotid amphibian. Parietal long, narrow, and with pineal opening far forward. Otic notch deep. Teeth: slightly recurved crowns and transversely broad bases, width ranging from 2 to 3 times basal length. Teeth ankylosed to broad, slightly concave surface on dentary and maxillary. Splenial not exposed along ventral margin of jaw, but rising to flank dentary tooth-bearing surface medially.

Cricotillus brachydens Case

Holotype.—KU 349, part of a pair of lower jaws.

Horizon and locality.—Wellington Formation, lower Permian, 100 feet below Wellington-Garber contact. From two miles northeast of Orlando, Logan County, Oklahoma, SE $\frac{1}{4}$ sec. 31, T. 20 N., R. 1 W.

Diagnosis.—Same as for genus.

Referred specimen.—KU 350. Partial skull and lower jaws. Horizon and locality same as for holotype. Obtainable measurements as follows:

	mm.
Overall length of skull as preserved, from the posterior end of suspensorium to region just anterior to orbit	52.0
Length of parietal along midline suture	21.0
Width of parietal, maximum	15.0
Length of interparietal along median suture	4.5
Distance from posterior end of parietal along midline to posterior margin of parietal bone	14.0

Pleuristion brachycoelous Case

HISTORY

This genus and species was described by Case (1902) on the basis of vertebrae from the Orlando site. Two specimens were involved. These are now in the collections of the University of Kansas under the single number KU 351. Case did not designate one or the other as the holotype and used both in his description. One comprises three vertebrae of an adult and the other several vertebrae and some limb elements. Both appear to pertain to the same species, but the specimen with three vertebrae is adult and the other subadult or juvenile. In the section of formal systematics, following the descriptions, the adult specimen is designated as the holotype and the other is considered to be a referred specimen.

Pleuristion has received little attention since it was established, and what attention has been given apparently has not involved any serious re-examination of the Kansas specimens. Case (1907) placed it tentatively in the Pelycosauria, but said also that it might pertain to *Bolosaurus*, a genus which itself poses some taxonomic problems. In this publication he figured one of the three vertebrae of the adult specimen, KU 351 (Pl. 1, figs. 14, 15).

In 1911 Case (p. 14) included *Pleuristion* in an unnamed family under *Incertae sedis* in the amphibian suborder Temnospondyli. No explanation is given, but since the designation follows family Gym-

narthridae, it may be that the common confusion resulting from similarity of form of microsaur and captorhinomorphs, to which *Pleuristion* quite certainly pertains, was involved. Williston (1910c) noted that *Pleuristion* was the smallest Permian reptile and made comparisons with *Araeoscelis*. He figured a humerus that he felt belonged to the genus and made the remark that a number of specimens of the genus, from Texas, were in the collections of the American Museum of Natural History. Since no designation of the source or number of the figured specimen was given and since the original materials lack any vestige of a humerus, the reference cannot be confirmed or denied.

In 1916 Williston (1916) gave the following citation: "*Pleuristion* Case.—Vertebrae and humerus of the *Captorhinus* type, all that are known. Oklahoma."

Von Huene (1925, p. 249, fig. 28) revived the pelycosaur designation of *Pleuristion*. Romer and Price (1940) noted that vertebrae and a skull existed and stated that affinities were clearly with the cotylosaurians. Romer (1956, p. 494; 1966, p. 364) placed the genus in the family Captorhinidae. Although a skull was mentioned by Romer and Price (1940), no information on it has been published. The skull undoubtedly is one so designated in the collections of Field Museum of Natural History formerly at Walker Museum. FMNH UC 676 (formerly UC 676) carried the label of *Pleuristion* and is, as far as I know, the only prepared skull of this type from Orlando.

DESCRIPTION

Case (1902) gave the original description of *Pleuristion brachycoelous* as follows:

"*Pleuristion brachycoelous*, gen. et sp. nov.; Several series of small vertebrae of characteristic form indicate the presence of a new form whose position is somewhat doubtful. They are chiefly characterized by the union of the parapophyses ad (sic) diapophyses in a broad winglike transverse process, and by the peculiarly broad and large neural canal. The centra are proportionately very broad and the bottom line is devoid of sculpture and with no trace of a keel. The vertebrae are deeply amphicoelous. The neural spine is low and the zygapophyses are relatively large and with flat faces. In some the neural arch seems to be co-ossified with the centrum and in others it is separated. The transverse process is broader above and becomes narrower below where it curves forward to touch the anterior edge of the centrum. There is no evidence of the presence of an inter-centrum.

Measurements:

Breadth across transverse processes0095 m.
Height from base of centrum to top of neural spine011 m."

This description as it stands hardly serves to separate these vertebrae from those of various captorhinomorphs and it is somewhat difficult to find an adequate basis for the later assignments to the pelycosaurs.

Associations of the specimens: The two specimens of KU 351 appear to be the basis for this description, although no designation is made in the paper. These are herein designated as 351a, the adult specimen of three vertebrae and 351b, the immature specimen. The latter includes 11 identifiable vertebrae, with possible fragments of others, some rib fragments, an immature femur, and some phalangeal elements. Both specimens are illustrated in Plate II.

In addition to these specimens the skull and partial jaws (fig. 2), FMNH UC 676 and a partial skeleton OUSM 3-0-S19 appear to pertain to this genus and species. Associations are based upon the resemblances of the vertebrae and features of the other parts of the skeleton that differ from those of *Captorhinus*, the only other known captorhinomorph from this site. Association by vertebrae poses something of a problem since variation of form along the column is fairly extensive, as shown in OUSM 3-0-S19. Figure 3 shows vertebrae from KU 351a and OUSM 3-0-S19 from approximately the same part of the column, with that of the latter being somewhat more posterior in the presacral series. The resemblances are evident. The vertebrae also resemble those of *Captorhinus* fairly closely, differing somewhat in the proportionate height and width of transverse processes. Some details of the postcranium of OUSM 3-0-S19 brought out in the descriptions that follow tend to confirm these somewhat tentative differences of the vertebrae.

The skull, UC 676, is rather badly damaged and has been distorted so that the right side has been much shortened. Some postcranial elements have been pressed into the posterior part of the skull. These include vertebrae, two of which are shown in Figure 3F and G. Once again these are distinctly *Captorhinus*-like. In view of the poor preservation, it is doubtful that the available measurements can be shown to exceed the range of comparable measurements of the genus *Captorhinus*.

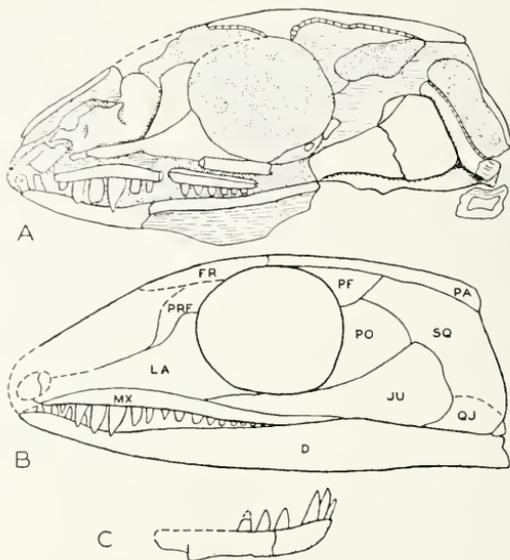


FIG. 2. *Pleuristion brachycoelus* Case. Skull and jaws based on FMNH UC 676. A, skull as preserved, somewhat diagrammatic; B, reconstructed skull; C, lower jaw to show teeth. All \times approx. 1.5.

In spite of the poor preservation of the skull, there can be no question that it is not *Captorhinus* on the basis of the dentition. This being the case, inasmuch as only two captorhinomorph genera, *Captorhinus* and *Pleuristion*, have been found in the extensive collections from Orlando, it is reasonable to assume that the skull, which is that of a captorhinomorph, is in fact *Pleuristion*. This is the interpretation that is made in this paper.

The skull: Much of the information on the skull is presented in Figure 2A, B, and C, and in Plate II. It all comes from UC 676. The restoration is based on both sides of the skull, with the proportions taken from the left side. Overall length is between 35 and 38 mm. along the midline, from snout to the end of the parietal platform, and the distance from the tip of the snout to the posterior end left quadrate is 41 mm.

The bone of the temporal area is badly damaged on the right side, with the squamosal missing. The upper portion of the squamosal is present but the base is missing. In spite of the damage, it seems nearly certain that there was no temporal fenestra, although the presence of a small one cannot be definitely ruled out.

The dentary and maxilla are very slender in proportion to their lengths, considerably more so than in *Captorhinus*. Each carries but a single row of teeth, rather than the multiple rows found in *Captorhinus*. These teeth, however, are very different in form and wear patterns from the rather blunt and somewhat chisel-like teeth of *Labidosaurus*. The fourth and fifth maxillary teeth are long and robust, with the third smaller, and the first very small. Back of the fifth tooth there is a rapid reduction in length. Twelve teeth are present in the maxilla of UC 676 and probably only three or four more were present on the posterior part of the maxilla, which is missing. Only the smallest fragments of premaxillary teeth are present, the premaxillae being completely destroyed. These fragments suggest that the teeth were rather small, in contrast to *Captorhinus*, but the evidence is far from conclusive.

The lower teeth (fig. 2C) consist of a very slender first tooth, two long, robust teeth, a gap, and then several smaller teeth. The first is about one-half the length of the third tooth, and there is a gradual decrease posteriorly from the third. This is not greatly different from the condition in the front part of the jaw of *Captorhinus* and *Labidosaurus*.

Although the palate is badly mashed, it is possible to identify the two pterygoids. The element has a very strong transverse flange. The posterior part of it is set with relatively strong teeth, irregularly arranged. On either side of the interpterygoidal vacuity, the pterygoids carry a strong patch of palatal teeth arranged in a series of four fairly regular rows. These appear to be much more fully developed than in comparable specimens of *Captorhinus* and *Labidosaurus*.

Vertebrae and ribs: The ribs are holocephalous throughout and are slender, without expanded shafts. The vertebrae, as shown in Figure 3, are generally similar to those of *Captorhinus*, with broad arches, unicipital transverse processes and relatively short neural spines. Case defined the genus on the basis of vertebrae, but made no comparisons with those of any other animals. He stressed the broad, open neural canal and the broad plate-like transverse processes. Both features are evident, but they are only slightly modified from the conditions found in specimens of *Captorhinus* of comparable size. Measurements in Table 1 bear on this point.

The vertebrae of KU 351a, which were the principal basis of Case's description, are from the anterior part of the presacral column, an area in which broad, flat transverse processes occur in the

TABLE 1.—Postcranial measurements of specimens of *Pleuristion brachycoelous* Case.

	Femur	L_{max}	P.W.	D.W.				
OUSM 3-0-S19								
	right.....	21.9	...	8.2				
	left.....	22.0	7.2	...				
KU 351b								
	right.....	16.5	5.8	6.2				
Fibula								
	right.....	13.0*	...	4.5				
Vertebrae	C_w	C_l	Ht.	Wazp	Wppz	Wtvp	Wnc	
OUSM 3-0-S19								
	ant. ps.....	3.8	4.0	5.0	...	5.1	7.1	3.0
	mid. dor.....	...	4.8	...	5.8	5.3	6.3	...
	sacral.....	3.1	...	5.0*	...	4.0	...	3.0
UC 676								
	ant. ps. (1)....	3.5	4.0	5.8	...	5.6*	...	3.1
	ant. ps. (2)....	3.5	...	4.9*	8.5	3.0
KU 351a ¹								
	ant. ps. (1)....	4.2	3.6	5.8	...	4.3	10.1	3.6
	ant. ps. (2)....	3.4	3.3	5.6	...	4.4	10.8	...
	ant. ps. (3)....	3.6	3.0	6.0	3.4*
KU 351b								
	sac. reg.....	...	2.1
	mid. dor.....	...	2.3

* Approximate

¹ These vertebrae, although listed as anterior presacrals (ant. ps.) are farther forward in the column than others so listed.

Abbreviations:

- | | |
|----------------------------------------------------------------------|------------------------------------------------------------------------|
| ant. ps., anterior presacral | sac. reg., in vicinity of sacrum, position not certain |
| C_w , maximum transverse width of centrum | Wazp, width anterior zygapophyses, outer margin to outer margin |
| C_l , maximum ventral length of centrum | Wnc., posterior width neural canal |
| D.W., maximum distal width | Wppz, width posterior zygapophyses, outer margin to outer margin |
| Ht., height from base of centrum to base of neural arch | Wtvp, maximum width transverse processes, outer margin to outer margin |
| L_{max} , maximum length | |
| mid. dor., mid-dorsal vertebra | |
| P.W., maximum proximal width, for femur at level internal trochanter | |

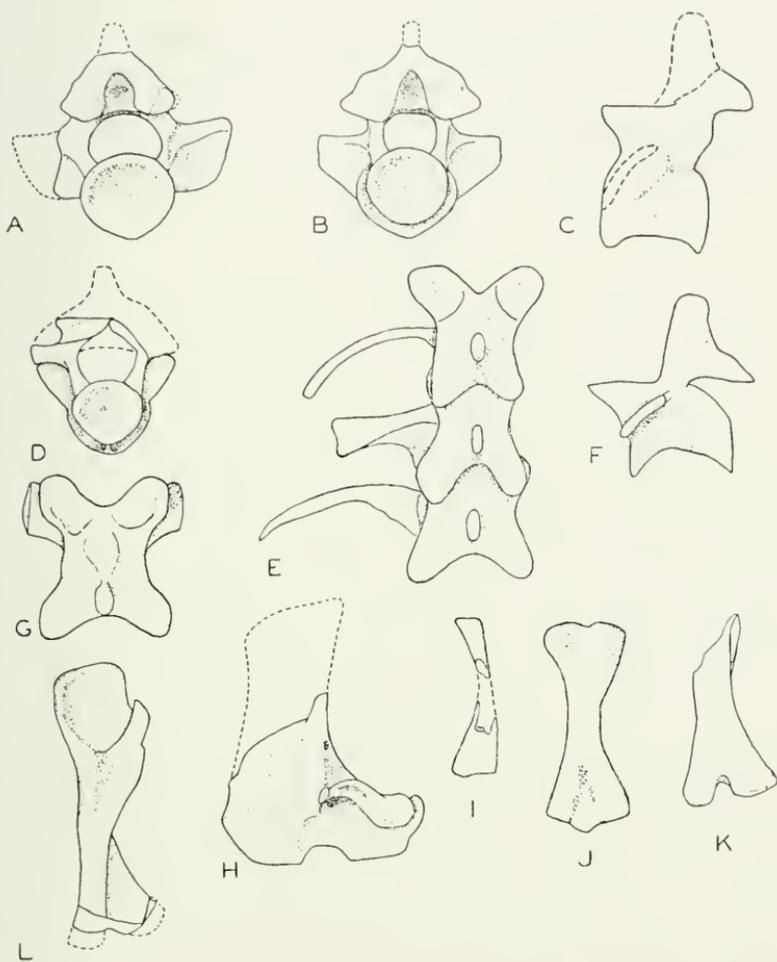


FIG. 3. *Pleuristion brachycoelous* Case. Postcranial elements. A, vertebrae of holotype, K. U. 351A, anterior; B, vertebrae of holotype, K. U. 351A, posterior; C, Vertebrae of holotype, K. U. 351A, lateral; D, mid-dorsal vertebra of OUSM 3-0-S19; E, sacral, 1st presacral and 1st caudal; F, vertebra of FMNH 676, lateral; G, mid-dorsal vertebra of FMNH 676, dorsal; H, scapulocoracoid of OUSM 3-0-S19, lateral; I, fibula of OUSM 3-0-S19; J, femur of KU 351B, dorsal; K, femur of OUSM 3-0-S19, distal end, dorsal; L, femur of OUSM 3-0-S19, ventral. All vertebrae approx. $\times 2.0$; femora and fibula approx. $\times 1.5$; scapulocoracoid $\times 1.25$.

captorhinomorphs. Thus this feature is in some large part an expression of the position in the column. Here, and in the more posterior parts as well, however, the transverse processes are very prominent and do appear to be somewhat more strongly developed than in *Captorhinus*. A major problem, however, comes from the fact that the extent of variation in *Captorhinus* is not known.

Captorhinus has two sacral vertebrae (Case, 1911, fig. 43, p. 98; Fox and Bowman, 1966). OUSM 3-0-S19 has the sacrum well preserved with both presacral and postsacral vertebrae in articulation (fig. 3E). There is but a single sacral vertebra, with the rib of the first postsacral directed sharply backward, and that of the first presacral slender, long and recurved. The iliac head is slightly displaced in the specimen, but there seems no question of the interpretation that only one sacral rib articulated with it.

Intercentra are prominently preserved in the mid-dorsal part of the column and probably were present throughout. The ribs did not articulate with them, in the areas in which the intercentra are present in OUSM 3-0-S19.

Limbs and girdles: Most of the information comes from OUSM 3-0-S19 and KU 351b. The well preserved elements are illustrated in Figure 3. The scapulocoracoid has no features that are recognizably different from those found in this complex in *Captorhinus*. A clavicle is present in UC 676, but this too is not distinctive. The only remains of a humerus consist of partly concealed distal ends, which show no distinctive features. Some carpal or tarsal elements are present in KU 351b and metapodials and phalanges are present in this specimen and in OUSM 3-0-S19. In both, the elements are sufficiently displaced that no details of the composition of the feet can be determined. The shapes and proportions are those characteristic of small captorhinomorphs. Ungual phalanges were narrow and claw-like.

The tip of the iliac blade and part of the pubo-ischiadic plate are present in OUSM 3-0-S19, but neither is well exposed. In this specimen, however, the right and left femora are well preserved and between them show most of the features of this bone. As evident in Figure 3C, the bone has a general *Captorhinus* cast, but is short, stout and set with strongly developed trochanters and ridges. The internal trochanter is very strong, the fourth trochanter moderate, and the adductor ridge prominent. The distal condyles are strong and set well apart. An immature femur is present in KU 351b as illustrated in Figure 3J. It shows no special features. The femur of *Pleuristion*, in the general shape and development of its processes,

is very similar to that of *Captorhinus*, but appears to be slightly different in some of the features noted from the well preserved femora of *C. aguti* from the Oklahoma, Richard's Spur, fissure fills.

Parts of some of the lower limb elements of the fore and hindlimb are present, but for the most part they are not well shown. Much of a fibula is present (fig. 31) and it appears to be indistinguishable from the same bone in *Captorhinus*.

RELATIONSHIPS

Very clearly, *Pleuristion* is a member of the family Captorhinidae, as Romer (1956, 1966) has indicated. In this family it is very close to *Captorhinus* in most of its features. Some of the proportions of the bones of the postcranium probably will differentiate the two, but in the absence of a good estimation of the variation of structure in the genus *Captorhinus* a positive statement to this effect is not possible. The vertebrae of the holotype do appear to be distinctive in the width of the transverse processes (see Table 1), and this is to some degree reflected in the other assigned specimens. The femur appears to be somewhat distinctive as well. The dentition of the skull, UC 676, is the most definitive feature, with the single row of maxillary and dentary teeth. This is, of course, matched in *Labidosaurus*, but the tooth form of *Pleuristion* is more like that of *Captorhinus* than of *Labidosaurus*. The palatal teeth are more fully developed in *Pleuristion* than in either of the other two genera.

Taking the various features into consideration, one must, it appears, agree that this is a genus separate from *Captorhinus*. The dentition suggests that it is adapted to a somewhat different diet. There is no question, however, that the two genera are very closely related.

FORMAL SYSTEMATICS

CLASS REPTILIA

Subclass Anapsida

Order Captorhinomorpha

Family Captorhinidae

Pleuristion Case

Diagnosis.—A small captorhinid reptile close to *Captorhinus*, differing principally in the presence of but a single row of maxillary and dentary teeth. Fourth and fifth maxillary and second and third den-

tary teeth long, robust, and sharp. About 15 teeth in each jaw. Maxilla and dentary both long and slender.

Anterior presacral vertebrae with broad, plate-like unicipital transverse process. Only a single sacral vertebra. Femur with strong condyles, trochanters and ridges, with adductor ridge prominent. Measurements as in Table 1.

Pleuristion brachycoelous Case

Holotype.—KU 351a. Three anterior presacral (cervical) vertebrae. One of two specimens used by Case in his original description (Case, 1902, p. 67) and the one figured by Case (1907, Pl. I, figs. 14 and 15).

Horizon and locality.—Wellington formation, 100 feet below Wellington-Garber contact. From two miles northeast of Orlando, Logan County, Oklahoma, SE $\frac{1}{4}$ sec. 31, T. 20 N. R. 1 W.

Diagnosis.—Same as for genus.

Referred specimens.—KU 351b, 11 intercentra, femur, foot elements, fragments of ribs of an immature individual. One of two specimens used by Case in his original description (Case, 1902). OUSM 3-0-S19, a partial skeleton, lacking skull, in a single nodule. FMNH UC 676, a skull, partial lower jaws, several vertebrae, clavicle and fragments of other postcranial elements. Horizon and locality of all referred specimens same as that of the holotype.

A NEW ARAEOSCELOID REPTILE FROM THE WELLINGTON FORMATION

INTRODUCTION

Among the sites listed in Olson (1967) is Perry site 6 (SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 26, T. 23 N, R. 2W.) in Noble County. The "insect" beds lie near the base. A measured section (see Olson, 1967), is repeated in Table 2. The lower part consists mostly of alternating thin dolomites and shales, but bed 16 is a highly varied yellow, red and gray shale that carries plants and vertebrates, and beds 18 through 21 consist of a series of sandstones and shales, capped by a thin dolomite. Beds, 18, 19 and 21 also carry vertebrate remains and have yielded the reptile which is the subject of this report.

These uppermost beds, as discussed briefly in the cited paper, appear to have originated in a lake, very near to shore. Some of the

TABLE 2.— Measured Section at Perry Site 6.
(from Olson, 1967)

Bed	Description	Thickness (feet)
21	Argillaceous, gray dolomite; bones	0.7
20	Deep gray shale	0.2
19	Red sandstone, medium to coarse; bone, conchostracans	1.6
18	Black to maroon shale	4.0
17	Yellow shale	3.0
16	Lenticular yellow, gray to red fossiliferous shale, with sandstone lenses to 3 feet in thickness. Limonitic with selenite crystals. Vertebrates and tree trunks, fronds, leaves, seeds	10.0
15	Blue-gray shale	1.0
14	Red sandstone	1.0
13	Gray shale	1.6
12	Gray dolomite	0.7
11	Red shale, nodular at top	2.0
10	Dolomite and shale in thin alternating layers	1.0
9	Gray shale	2.0
8	Gray dolomite	0.1
7	Gray shale	1.8
6	Red shale	1.1
5	Impure gray dolomite	0.4
4	Red nodular shale	0.6
3	Gray, dolomitic shale	0.9
2	Gray shale	5.0
1	Gray dolomite	0.9

vertebrate remains come from varied lenses of sandy shale which were formed in shallow swales on the lake bottom. Others are found rather widely scattered in an overlying red sandstone and a few specimens have been found in the capping dolomite.

Several hundred bones have been recovered, mostly from the lenticular sandy shales where they occur in close packed concentrations (Pl. III). Most of these pertain to the new reptile described in this paper, but some are bones and scales of a rather large platysomid fish, and scraps of amphibians and other reptiles. The platysomids occur in greater concentrations in very fine grain, dark lenses of silt in which few reptile bones are found.

All of the bones are disarticulated, even those of the skull. It has been necessary to reconstruct the reptile described here from these individual elements. Fortunately, one specimen in the dolomite, denoted later as the holotype, was a partially articulated individual which provided basis for assignment of many of the isolated elements. It has been rather badly damaged by ground water action, and some of the bones are preserved only as molds. The skull in the dolomite specimen is not well preserved and this has made it necessary to reconstruct the skull from isolated elements. Since these represent

individuals over a wide size range, difficulties in determining proportions of the various skull regions exist. The fact that skull elements of the large platysomid are also present in the deposits has left open the possibility that some of these have been mistaken for bones of the reptile. These problems are discussed further in comments on the reconstruction of the skull and the descriptions of its salient features.

CLASS REPTILIA

Subclass Euryapsida

Order Araeosceloidea

Family Uncertain

Dictybolos new genus¹

Diagnosis.—Overall length about 25 to 30 inches for fully grown adults. Skull bones thin, lacking surface sculpture and possessing a fine canal structure which reached the surface in small circular pores. Frontal lacking median suture. Nares set well back from anterior end of snout. Dentary long and slender with anterior end slightly reflected ventrally. Marginal dentition consisting of 25 to 30 teeth above and below. Teeth with sharp, recurved terminal ends, with enamel finely fluted distally. Basal portions with deeper fluting and broadened longitudinally.

Vertebrae with broad, flat zygapophyses and slightly expanded arches. Neural spines moderately developed, centra deeply amphicoelous. Ribs with expanded shafts, heads partially double to holocephalous. Limbs and girdles poorly ossified, with no osseous attachments of scapula to coracoid, or ilium to pubis and ischium. Scapula very short and broad, and recurved posteriorly. Ilium with strong, broad, dorsal caudal process. Limb elements relatively slender with very thick cartilaginous caps. Tarsals and carpals apparently unossified; metatarsals and metacarpals long and slender. Phalangeal elements short and broad.

Dictybolos tener new species

Holotype.—FMNH UR 1041. Partial skeleton in dolomite, including some elements as molds. Part of skull and jaws, vertebral column, girdle and limb elements.

Horizon and locality.—Wellington Formation, bed 21 of section, Table 2. Perry site 6 (Olson, 1967), about nine miles northwest of Perry, Logan County, Oklahoma, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 26 T. 23 N, R. 2 W.

¹ The name, meaning fisher, has been given because of the presumed habits of this new reptile as a semi-aquatic, fish-eating creature.

Diagnosis.—As for genus.

Referred specimens.—A large number of specimens have been referred to this genus and species and are important in the descriptions. They have come from beds 18 and 19 of section at Perry site 6 (Olson, 1967). These materials consist almost entirely of isolated bones and no assemblage into individuals has been possible. Thus many of the specimens in the list that follows are composites which include the same elements from many individuals. Specimens that have been figured have been given separate numbers and those that have contributed to a composite reconstruction of an element in the figures have in some instances been grouped under a single number. The specimens are listed in Table 3.

Conditions of occurrence.—Some aspects of the occurrence are important to an understanding of the descriptions, in particular of assignment of the separate elements to a single species. Except for the holotype all the bones are separate, although they occur in profusion and closely packed in some small lenses of matrix. There is no sound evidence that the assemblages of bones pertain to one individual, and in many cases the size range definitely precludes this possibility.

Bones occur under three circumstances. The best preserved occur in the red sandstone, bed 19 of the section. In this bed, however, they are widely scattered. The condition of these bones is excellent; they are essentially unmineralized and uncrushed. Although some moderate concentrations occur in sandstone, there is no evidence that the clustering has any relationship to life associations. Overlying the red sandstone and separated from it by a bed of unfossiliferous black shale is the thin dolomite from which the type specimen has come. Although there is little crushing of the bones in the dolomite, preservation is rather poor, due largely to recent action of ground water.

By far the greatest concentration of bones occurs in small lenses that lie just under the red sandstone, in bed 18 of the section. These lenses were formed in shallow depressions on the surface upon which the red sandstone was deposited. They run from two to five feet in diameter, and are roughly ovoid in shape. The rock is a heterogeneous mixture of sandy shale, shale, sandstone, and masses of mud which are rich in organic remains. It appears to have been formed by deposition within an active zone of waves which sorted the contents of the small depressions. These are quite comparable to the mucky masses of sediment and organic remains found in weedy bot-

TABLE 3.—A list of specimens of *Dietybolos tener* new genus and species.

1041, holotype, part of skull and skeleton	1104, phalanges
1042, ilium	1105, humerus
1043, pterygoid	1106, ilium
1044, dentary, radius, etc.	1107, scapula
1045, mid-dorsal vertebra	1108, caudal vertebra
1046, anterior dorsal vertebrae	1109, nasal
1047, pterygoid	1110, radius
1048, part of scapula	1111, scapula
1049, humerus	1112, ilium
1050, right ischium	1113, prefrontal
1051, dentary	1114, quadratojugals, identity uncertain, may be platysomid
1052, lumbar vertebra	1115, jugal
1053, pubis	1116, anterior caudal rib
1054, cervical vertebra	1117-18, fibula
1055-58, premaxilla	1119, radius
1059, sacral vertebra	1120, ?tibia
1060, anterior caudal vertebra	1121, lacrimal
1061, radius	1122, frontal, part.
1062, ?interclavicle	1123-24, postfrontal
1063, femur and tibia	1125, frontal
1064, quadratojugal, parts of postcranium	1126, caudal rib
1065, ?femur	1127, anterior dorsal rib
1066, scapula coracoid	1128, foot elements
1067, maxilla, vertebra, rib, part limb bone, skull fragments	1129, ulnae, poor
1068, scapula	1130, coracoid
1069, slab, many bones	1131, skull parts and fragments
1070, squamosal	1132, premaxilla
1071, teeth	1133, cervical rib
1072, ilium	1134, premaxilla
1073, part skull, caudal vertebra	1135-37, femur
1074, ilium	1138, dorsal rib
1075, cervical vertebra and rib	1139, partial rib
1076, base of pelvis	1140, skull parts and vertebra
1077, postorbital	1141-42, prefrontal
1078, postorbital	1143, ribs
1079, 2 caudal vertebrae	1144, miscellaneous vertebrae
1080, skull plates, various	1145-52, maxilla
1081-84, fibula	1153, 9 partial maxillae
1085-92, femur	1154-63, dentary
1093, partial femora	1164, incomplete dentaries and teeth
1094-97, radius	1165, partial tibia and fibula
1098-1100, ulna, partial	1166-69, humerus
1101, parts of about 30 vertebrae	1170, ulna
1102, 6 partial limb bones	1171, frontal
1103, about 30 miscellaneous and partial limb bones	1172, dentary
	1173, various skull bones

toms of lakes today, and it is believed that the conditions of deposition are comparable in the two cases.

Some of these lenses have high concentrations of bones, with the new reptile predominant but with remains of other reptiles, some amphibians, and fish, making up as much as 5 per cent of the total. The matrix appears to have been highly compressible and the contained vertebrate remains are always severely crushed. These pockets are much the most prolific source of bones, but the crushing has limited their morphological value. Most of the reconstructions are based upon bones from the red sandstone, but concepts of size range and abundance have come largely from the remains in the lenses.

The bed below the sandstone, of which these lenses make up the topmost part, is predominantly a dark, red to brown, sandy shale. In its upper part it also carries some lenses of very fine, chocolate colored sandy shale, with very fine sand and some mica. In these lenses occur remains of partially complete bodies of a platysomid fish that probably was about 6 inches in total length. Scales of this fish are found associated with the reptile remains and, it appears, some of their skull bones are also in the reptile-bearing deposits. The type of scale, which is found in direct association with the partially intact bodies of these platysomids, is identical with that found with the reptiles and no other scales of fish have been found in these deposits. Associated with one specimen of platysomid is a partial skull. This shows the skull bones of this fish to have been highly pustulose and ornamented. In the reptile-bearing lenses a few such sculptured bones have been found, and these are considered to be platysomid.

These associations and interpretations have considerable bearing upon the reconstructions of the skull of *Dictybolos*. These have been made from single bones and the positions in the skull determined from characteristics of the bones and the ways that they appear to fit together. It is quite possible to confuse fish and reptile skull plates in such a process. The fact that the skull bones of the platysomids are pustulose and sculptured is of great use, since all of those considered to be reptilian lack any sculpturing. The absence of evidence, exclusive of the skull, of any other large fish, suggests that the bones without sculpture are non-fish. Some bones of tetrapods, other than those referred to *Dictybolos*, are present in the deposits, but these have characteristic features of well known genera of amphibians. Thus, all of the non-sculptured bones have been considered as pertaining to *Dictybolos* and used in reconstructions of the skull. As

noted in specific consideration of the skull, there are rather specific textural and histological features that strengthen this assumption.

Description.—*Dictyobolos* differs markedly from any other reptile known from the Lower Permian, so that there is no evident basis for

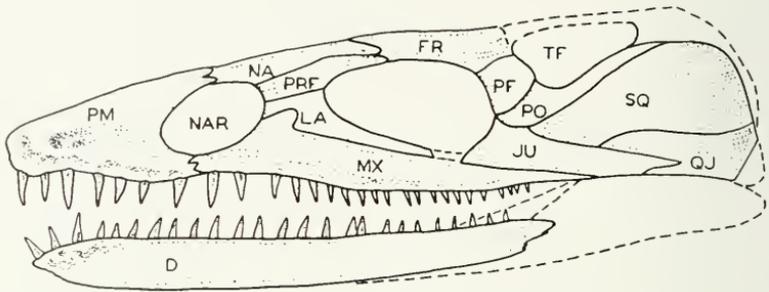


FIG. 4. Restoration of the skull of *Dictyobolos tener* n. g. and sp. in lateral view. The reconstruction is based on single skull elements from many individuals of different sizes. Hence the proportions may be somewhat off. The elements used are listed under the bone names in Table 3.

using comparisons in description. Superficially it appears somewhat like *Mesosaurus* and *Stereosternum*, but no close morphological resemblances actually exist. Some of the features resemble those of *Araeoscelis*, but clearly the two were adaptively very different. The morphology of the new reptile can best be portrayed by illustrations. The figures and drawings in the plates, made by Tibor Perenyi of Field Museum, are rather detailed, and will serve as the basis for short descriptive comments upon the principal structures.

1. The Skull and Jaws: A lateral view of the skull is shown in Figure 4. It is, as already noted, based entirely upon individual bones. Some parts are quite reliable, whereas others are less so. No bone that could be identified as a parietal has been found, although it is quite possible that such bones are present and have not been recognized. Several small paired median elements are in the collections, but they are sculptured and seem not to pertain to the reptile. The depth of the skull is probably essentially correct, for there are good guides in the premaxilla, maxilla and orbit.

The premaxilla and maxilla are known from many specimens and their form and the dentition associated with them are completely reliable. The nares are set well back from the end of the snout, shown well by the notch in the posterior end of the long premaxilla in a number of specimens. On the palate the right and left premaxillae are joined by a suture for their full length. The maxilla is a

long, slender element. Other features of the facial and orbital region are well shown on a number of elements in which the narial and orbital margins are developed. All of the elements had broad marginal overlaps with adjacent bones and none are joined by interlocking sutural contacts. It would appear that there may have been considerable movement between the various elements.

The frontal, as interpreted, is a peculiar bone in that it is single, not paired. This is based in particular upon the bone in the holotype (FMNH UR 1041), but support comes from several other specimens of the same bone. Clearly there does exist a large, median bone with a well-finished, concave margin. It cannot be a parietal, since its structure is inappropriate, and hence by elimination, it has been interpreted as frontal.

The temporal opening is indicated as lying above the junction of the postorbital and squamosal, giving a euryapsid cast to the skull. Of the related elements, the postfrontal poses the most problems. The small, somewhat quadrilateral bone shown in the restoration has been so placed because it has about the right dimensions and a pair of finished edges. There are several of these in the collections. The position, however, is somewhat odd and this designation is one of the more questionable ones. The dorsal margin of the temporal opening has not been determined, in view of the lack of an identified parietal.

The postorbital and squamosal offer no particular problems, but the quadratogjugal is based on rather slender evidence, mostly on one small element. Other somewhat similar bones are present, larger and more robust, but they do not show the usual texture of the bones associated in the reptile skull, and may pertain to the platysomid.

In the collections are two or three presumably cranial elements which have not been placed in the skull, and these may represent some of the palatal elements. One median bone may be a parasphenoid, but its margins are not well preserved, and it may also be a stemmed interelavicle. The only identified palatal bone is the pterygoid (Pl. IV). Two representatives have been found. This is a fairly "normal" primitive reptilian pterygoid, set with a median and lateral cluster of teeth. It was suturally joined to the palatine and appears to have made a very open contact with the basipterygoid process of the basisphenoid.

No elements of the brain case have been found in the deposit. It may be that these were poorly ossified and hence not well pre-

served, or it may merely be that they were not present in the sample that has been studied.

All of the dermal elements are thin, lightly constructed, and characterized by a network of canals that run more or less parallel to each other along the long axes of the bones. They issue to the surface either as small, round pores, or in shallow channels. These seem to be vascular in nature and would appear to have brought a large supply of blood to the surface of the skull, presumably to the skin. What functional significance they may have had is obscure.

2. Dentition: The marginal teeth (fig. 4, Pl. IV) are distinctive in form, attachment to the jaw, and in surface features. In lateral aspect they appear to be long, slender, slightly recurved teeth, but the lower portions are relatively broad transversely. The long axis is not completely normal to the jaw but slants posteriorly from the outer to inner margin, with an angle of about 80 degrees to the longitudinal axis of the jaw.

The teeth are not set in sockets, but rest, firmly attached, on the jaw margins. Clearly tooth replacement took place, for there are unfilled spaces and different sizes of teeth along the tooth row. The dental lamina, however, appears not to have been enclosed in bone, for no evidence of replacement teeth has been found in the jaws. At the front and back margins of some of the teeth are small, sharp dentine spurs which are rather closely appressed to the crown margins. The nature of these is uncertain and they are currently being studied as a part of a thorough histological investigation of the dentition and jaws by William MacLean.

The more distal parts of the crown are covered by a thin enameloid substance which is to varying degrees marked by a complex grooving or fluting. Superficially, this gives the appearance of a labyrinthine structure, but it is confined to the enameloid material and not impressed on the underlying dentine. More basally, especially on the anterior and posterior flanks of the crowns, there is a more regular, deeper fluting, not closely connected to that on the enamel. Both of these features are unique and require more study of their detailed histology for interpretation.

The gross features of the dentition of *Dictybolos* are distinctive and not matched by any other reptiles of their time or, as far as I am aware, by any other reptiles at all. Combined with the very long jaws, they provide a feeding apparatus that is distinctly aberrant among those known from the lower Permian of North America, but which has a rough counterpart in *Mesosaurus*.

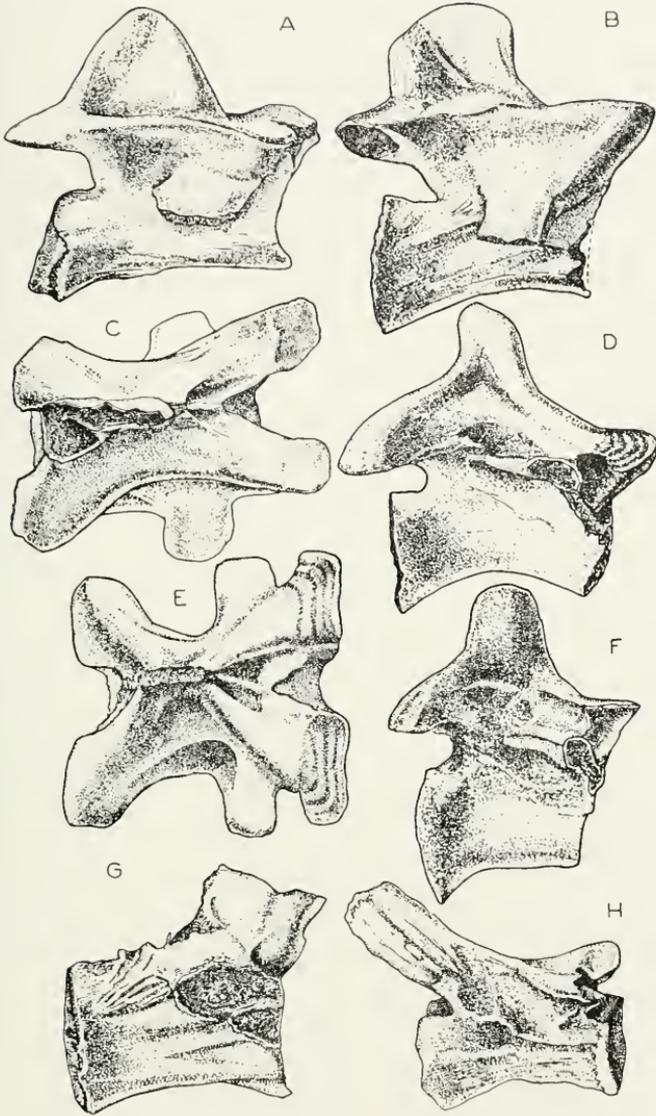


FIG. 5. Vertebrae of *Dictybolos tener* n. g. and sp. A, cervical, UR 1054; B, anterior dorsal, lateral (UR 1046); C, anterior dorsal, dorsal (UR 1046); D, mid-dorsal, lateral (UR 1045); E, mid-dorsal, dorsal (UR 1045); F, partial presacral from lumbar region (UR 1052); G, sacral, UR 1059; H, caudal, about 10th, UR 1060. All approx. $\times 2.0$.

3. Vertebrae and Ribs: The vertebrae are strongly ossified and characterized by widely spaced, broad, nearly horizontal zygapophyses. The neural arches, however, are relatively narrow and neural spines are moderately high. The zygapophyses are somewhat reminiscent of those of captorhinomorphs, but the arches are not of the characteristic swollen type. The closest resemblances are to the vertebrae of *Araeoscelis*. The principal features of the vertebrae are shown in Figure 5 in which a series along the column is shown. The ordering is based on vertebral features, and not upon details available from an articulated column. Some of the vertebrae of the holotype are in articulation but, except for a series of caudals, the details are poor enough that they do not serve as a basis for ordering.

The transverse processes vary somewhat along the column. On the most anterior vertebrae they are quite ventral, essentially arising from the centra. More posteriorly they pass laterally from the arch and the dorsal and ventral portions are essentially fused to form a single process. In the lumbar region this singularity tends to weaken and the facets for the dorsal and ventral heads of the ribs become more distinct. They are both clearly shown in the sacral vertebrae. Caudal vertebrae are high and narrow. The first several have very strongly recurved ribs with two partially distinct heads.

The centra are deeply amphicoelous and strongly ossified. They are slightly keeled. Many of them show a pitting and vascular structure much like that which is seen in the skull bones. Centra and arches are strongly fused and show no sutures.

A characteristic feature of the surfaces of the zygapophyses of many of the vertebrae is a pattern of "growth" rings, much like those seen on specimens of *Diadectes*. Some of the larger specimens carry as many as six concentric bands.

Ribs appear to have been present on all presacral vertebrae and on the sacrals and several anterior caudals (fig. 6). Except for the most anterior and posterior ribs of the presacral column, the heads are essentially holocephalous. The neck of the ribs is narrow, but beyond it the shaft is somewhat swollen, more or less like the ribs of *Mesosaurus*. Just how this feature is distributed along the column is not clear. Mid-dorsal ribs are quite swollen and this is also true of the anterior caudal ribs. Cervical ribs show less of the character and a few ribs, of uncertain position, which appear to belong to this reptile, do not show marked swelling. The bone of the swollen ribs, in cross-section, is thick and appears to be quite dense. Histological

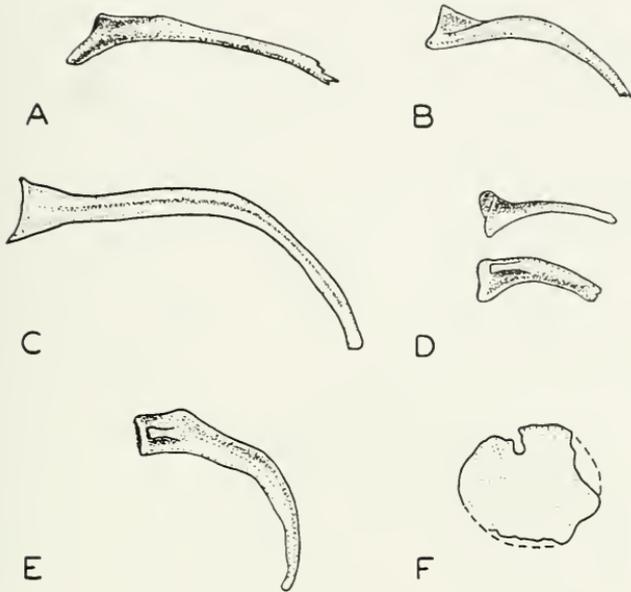


FIG. 6. Representative ribs, A-E and coracoid F, of *Dictyobolos tener* n. g. and sp. A, cervical, UR 1127; B, anterior dorsal, UR 1138; C, mid-dorsal, UR 1139; D, posterior presacral, UR 1121; E, anterior caudal, UR 1116; F, coracoid, UR 1130. All \times approx. 1.0.

studies are being made, along with those of the teeth and jaws, and will be treated specifically in a later paper.

4. Forelimb and Shoulder Girdle: The elements of the pectoral appendage are illustrated in Figures 6 and 7. The scapula and coracoid are not coössified in any preserved specimen, and have not been found together. The scapula is very distinctive, being short, broad and somewhat recurved. The illustrated specimen is the best preserved but there are several in the collections. The coracoid was a thin, plate-like element. In no specimens are the margins well preserved, and the bone appears to have been only partially formed in the cartilage.

The humerus (fig. 8) is a long, slender element with both ends capped by cartilage. Although some 15 identifiable humeri have been found, all are somewhat crushed and none shows the original shape well. The figure is based on a crushed specimen and the breadth is somewhat increased over the life condition. Both the ectepicondylar and entepicondylar foramina are present.

The radius and ulna are much as shown in Figure 8, although there may be some slight distortion due to crushing. The radius

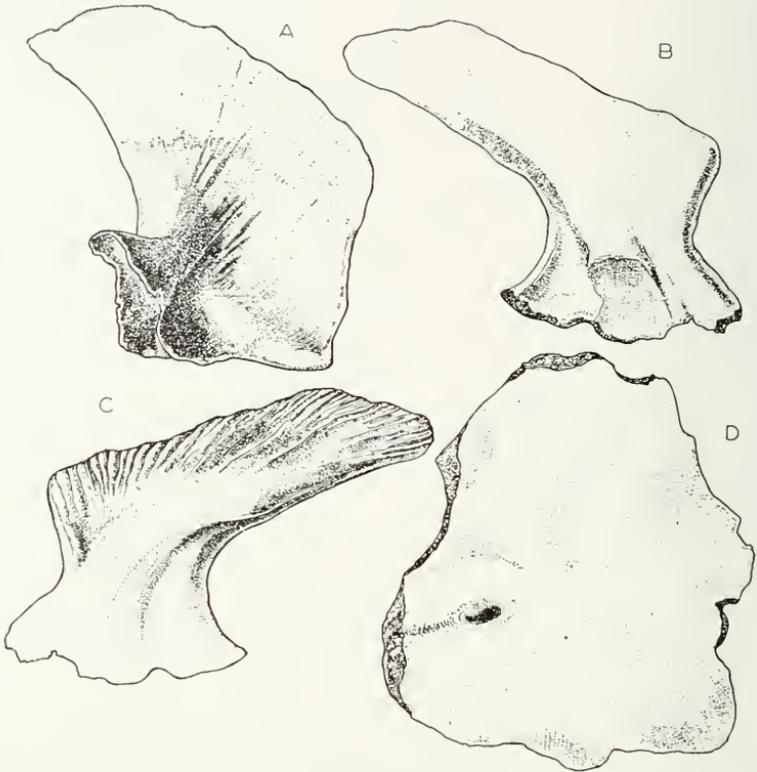


FIG. 7. Postcranial elements of *Dictybolos tener* n. g. and sp. A, scapula, inner view, UR 1111; B, ilium, outer view, based on several specimens, especially UR 1112; C, ilium, inner view, UR 1112; D, damaged pubis, UR 1053. A-C, $\times 2.0$; D, $\times 1.7$.

appears to have been a very strong element and somewhat twisted. In contrast the ulna, of which there are very few recognizable specimens, was very slender and light. Both had strong cartilaginous caps on the proximal and distal ends. No carpals are known and it is presumed that they were unossified. Various long foot elements are present and presumably some of these are metacarpals, but they cannot be differentiated from the metatarsals and no positioning in the foot is possible. Many phalangeal elements are present, but their placement is out of the question. Some of the kinds are shown in the Figure 8.

5. Pelvis and Hind Limb: The ilium, pubis and ischium were not coössified and have only been found as separate elements. The ilium is well shown in Figure 7. It has a fairly strongly developed caudal process. The inner surface of the process and neck show a system of

complex grooves and rugosities that mark the area of what probably was a quite firm ligamentous attachment to the sacral rib(s). The acetabulum was shallow, but well formed and with a strong dorsal buttress. The pubis and ischium were not well ossified and appear to have been rather broad and plate-like. There are no particularly distinctive features preserved.

The femur (fig. 8B) is a long, slender, but robust bone which, like the humerus, was capped by cartilage proximally and distally. The shape of the distal end is well shown in some uncrushed specimens, but the proximal shape is less clear. Trochanters appear to have been weakly developed. The tibia and fibula are lightly built and small relative to the femur. All of their features are subdued. The information on the hind foot is the same as that for the forefoot, for differentiation of elements of the two has not been possible.

Relationships.—*Dictybolos tener* is distinctly different in morphology from all of the well known Early Permian vertebrates of the mid-continent region of North America. These consist mostly of

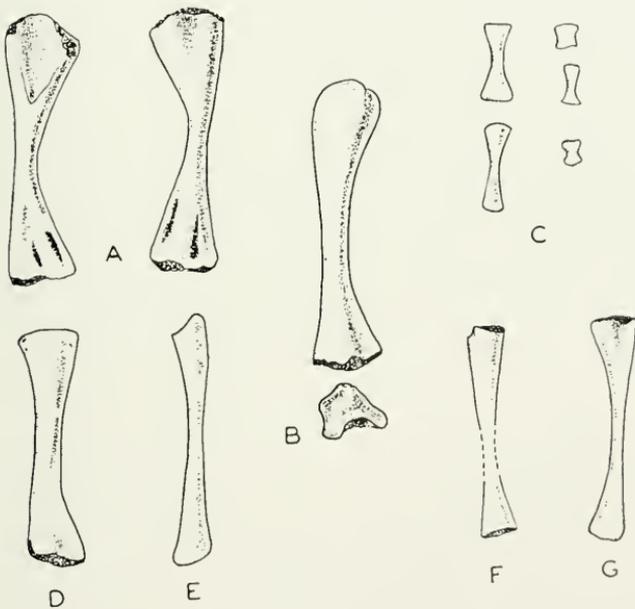


FIG. 8. Limb elements of *Dictybolos tener* n. g. and sp. A, humerus (right), ventral and dorsal respectively, UR 1049 and 1105; B, femur (left), dorsal and distal, UR 1135, 1136, 1137; C, phalangeal elements of various specimens; D, radius (left), UR 1061; E, ulna (left), UR 1129; F, tibia (right), from several specimens, all fragmentary; G, fibula (right), UR 1117 and other specimens. A and B, $\times 0.5$, and others, from various sized individuals, scaled to match.

captorhinomorphs and pelycosaur and the new genus does not conform in any of its major features with members of these two groups. Its unique features, related to its ways of life, tend to overshadow some of the less specialized features which provide clues to its relationships.

The long, slender limbs, with their weak trochanters, placed far distally, suggest possible relationships to *Araeoscelis*, but these could merely reflect special locomotor adaptations. The vertebrae show closer resemblances to those of *Araeoscelis* than to those of any other contemporary reptile. In both, the zygapophyses are broad and rather flat, somewhat captorhinomorph-like, but the neural arches are narrow. In the cervical region the transverse processes lie essentially on the centrum in both. The ribs of *Araeoscelis* are, however, dichoccephalous throughout the column whereas those of *Dictybolos* are holocephalous except in the anterior and posterior parts of the presacral column.

The evidence of the skull must be somewhat suspect in view of the fact that it was reconstructed from individual elements. It has many unique features, but the position of the temporal fenestra as determined in the reconstruction is comparable to that of *Araeoscelis*.

The alternatives are to assign this genus to one of the established groups or to use it as the basis for a new group. The latter would be of very dubious use, and there is at least some basis for relating it to the Araeosceloidea. This group as conceived by Romer (1966) includes some members of the earlier Protorosauria and like the earlier group is open to some question. *Araeoscelis*, *Kadariosaurus*, *Trilophosaurus* and *Toxolophosaurus* do have features that suggest they may form a natural assemblage and it is with these members of the Araeosceloidea that the closest affinities of *Dictybolos* seem to be.

Habits.—Many features of *Dictybolos* indicate that it was a fish-eating reptile which was partially aquatic. The skull appears to have been highly kinetic with junctions between elements formed by overlaps of bone rather than sutures. The consistent loss of the more posterior elements from the dentary suggests a very loose attachment between the elements of the lower jaw. The sharp rows of marginal teeth, with the slight ventral flexure of the anterior part of the dentary tooth row, fit well a general pattern of an active predator. While they are not by any means definitive of fish eating, they could certainly have functioned in this way. The pterygoid was closely articulated to the rest of the skull, but it is not beyond the general

range of form or tooth patterns found among various other Permian reptiles. It does not suggest any particular type of diet. The skull characters, especially the kinetic features, plus the dentition can be interpreted as being adapted to the catching and swallowing of fairly large, complete prey.

The position of the external naris is striking and strongly suggestive of aquatic life, being set far back from the termination of the snout. The postcranium is distinctive in the form of the limbs, but the most impelling argument for possible aquatic life is the very low level of ossification. The ends of all limb bones, apparently the carpus and tarsus, and the junctions of the elements of the girdle are all cartilaginous. This can, of course, be interpreted as the result of immaturity, but the preponderance of creatures of a fairly standard, large size suggests that they were adults, in contrast to the much less well ossified elements from smaller, and presumably younger, individuals.

Vertebrae, while distinctive, do not in themselves give much evidence on the ways of life. Centra show considerable pitting, but they are firmly joined to the arches and terminal ossification is well formed. The ribs, however, have distinctly swollen shafts, as is characteristic of many aquatic creatures. The late Paleozoic *Mesosaurus* is a striking example of a more or less contemporaneous case.

Putting all these features together, it would appear that *Dictyobolos* is most reasonably interpreted as a semi-aquatic, fish-eating reptile. It has not progressed as far in this direction as had *Mesosaurus* and *Stereosternum*. It shows an early tendency toward this sort of habit in the araeoscelidoids, and one not matched otherwise in the Early Permian of North America.

ASSOCIATED ORGANISMS

The assemblages: The beds that contain *Dictyobolos tener* also carry scrappy remains of various other animals. In bed number 16 of the section, a few feet below bed 18, both vertebrates and plants occur. The plants consist of large, partially compressed trunks of trees and layers of excellently preserved leaves, fronds and seeds. A collection has been given to L. R. Wilson of the Oklahoma Geological Survey for study. Detailed identifications have not been made, but the flora is clearly that of the usual lowland Early Permian type.

The assemblage in bed 16 and that in beds 18 and 19 represent quite different types of deposition. Bed 16 consists of a grey to yel-

low and red shale, with occasional sandstone lenses. The shales have the highly leached appearance which is characteristic of swamp deposits from this time and contain selenite crystals. There can be little question that they represent swamp deposits formed close to the margin of fresh water lakes. The higher beds, 18, 19 and 21 were deposited in shallow waters, probably close to the shoreline of a lake, but definitely to the lakeward side. They consist of shales, followed by sandstone, and then with a gap filled by black shale, of the bone-bearing dolomite. Only in bed 16 are plants and vertebrates associated. Beds 18, 19 and 21 lack plants but contain the new reptile *Dictybolos*, which has not been found in bed 16.

Direct associations in beds 18 and 19: The animals listed below have been found in these beds in direct association with *Dictybolos tener*.

Invertebrata

Conchostraca

Estheria sp.

Vertebrata

Chondrichthyes

Xenacanthus sp. (teeth)

"*Ctenacanthus*" (spine)

Osteichthyes

Dipnoi

Gathorhiza serrata Cope (toothplate)

Actinopterygii

Platysomus cf. *P. palmaris* Cope (partial fish, scales)

Sphaerolepis arctata (Cope) (tooth plates)

Amphibia

Trimerorhachis, cf. *T. insignis* Cope (fragments of skull, jaws, limbs and teeth)

Indeterminate remains of small amphibian

Reptilia

Ophiacodon sp. (small part of jaw, teeth)

Dimetrodon sp. (teeth)

Conchostracans are present in some phases of bed 19, mainly in parts made up of rather thinly laminated, gray to brown sandstone.

They tend not to be present in the parts of this layer in which the bones occur, although they are very widely scattered through the red phases of the bed and in a few instances are found in the clusters of bones.

Vertebrate remains, except for those of *Dictybolos* and *Platysomus*, are very fragmentary and widely scattered. Some teeth and bones occur in the red sandstones of bed 19, but most of them are in the sandy shale lenses at the top of bed 18. Except for *Platysomus*, the remains are badly broken and often worn. They appear to have been transported and washed back and forth in the shore currents.

Scales of *Platysomus* occur in both beds 18 and 19 and are found in direct association with bones of *Dictybolos*. Partially complete fish, however, occur in sandy shale lenses of bed 18, with only occasional scraps of reptile bones in association. This fish is a possible food source of *Dictybolos*, although there is no direct evidence that it served in this way. Tooth plates, listed as *Sphaerolepis arcata* in Olson (1967), are a common associate of *Platysomus* and occur rather widely in both beds 18 and 19. It seems quite possible that these actually represent tooth plates of *Platysomus*.

The shark teeth, *Xenacanthus*, are all very small and are widely scattered through beds 18 and 19. One specimen of *Gnathorhiza serrata* has been found, in bed 18. Together with "*Ctenacanthus*" and *Trimerorhachis* the forms listed above make up a typical aquatic assemblage. Added to them are *Dimetrodon* and *Ophiacodon* represented, except for a small fragment of jaw of *Ophiacodon*, only by teeth. These clearly appear to have been transported. *Dictybolos* is much the most common element and fits the environment under the interpretation that it is a partially aquatic reptile.

The "swamp" assemblage: The animals from the deposits of bed 16 are as follows:

Chondrichthyes

Xenacanthus sp.

Osteichthyes

Paleoniscoids (small, genus undetermined)

Amphibia

Trimerorhachis cf. *T. insignis* Cope

Eryops cf. *E. megacephalus* Cope

Diplocaulus cf. *D. magnicornis* Cope

Reptilia

Ophiacodon uniformis (Cope)

Dimetrodon cf. *D. limbatus* (Cope)

The composition of this assemblage is little different from that of beds 18 and 19. It lacks *Platysomus* and includes a small palaeoniscoid and *Diplocaulus magnicornis*. The presence of the small paleoniscoid may well be just a matter of preservation, for the delicate structures are likely to have been destroyed in beds 18 and 19. The presence of *Eryops* and *Diplocaulus magnicornis* may be of some significance, for these two creatures are normally associated with pond and swamp living assemblages. The co-ordinate lack of *Platysomus* and *Dictyobolos* may be of some significance, if there was a food relationship as suggested above.

From what has been observed, it may be concluded that the absence of *Dictyobolos* in the swamp beds and presence in 18, 19 and 21 represents an ecological relationship. This, while quite possibly correct, must be viewed with some caution, for in a sandstone very similar to that of bed 19, the beds at the McCann quarry (Olson, 1967) from which many vertebrates have been obtained, *Platysomus* and conchostracans are abundant, but no sign of *Dictyobolos* has been found. Also, well preserved remains of *Diplocaulus magnicornis*, *Dimetrodon* and *Labidosaurus oklahomaensis* have come from these sands, although not directly associated with *Platysomus* and the conchostracans. It seems evident that the environments of deposition of the McCann Sandstone and bed 19 at Perry site 6 were similar. Thus, although *Dictyobolos* is not known from swamp deposits, the absence loses some of its weight as an indication of the life environment.

AN ASSEMBLAGE OF SMALL VERTEBRATES FROM
THE HENNESSEY FORMATION
EARLY PERMIAN OF OKLAHOMA

GENERAL CONSIDERATIONS

History of the Collecting Site

The site from which the vertebrates described and discussed in this paper have come is located a short distance southeast of the campus of the University of Oklahoma, Norman, Oklahoma (Sec. 13, T. 8 N., R. 2 W.) in Cleveland County. It is on the property of Mr. Amos Moses of Norman, Oklahoma, to whom I wish to express my thanks for the opportunity to make the collection. The site was

brought to my attention about 20 years ago by the late Professor J. Willis Stovall of the University of Oklahoma. A few years later we collected a few specimens, including fragments of *Lysorophus*, a skull of *Captorhinikos*, and some captorhinid vertebrae. The skull, FMNH UR 183, was later (Seltin, 1959) referred to *Labidosaurikos meachami* Stovall, and subsequently (Olson and Barghusen, 1962) following Vaughn (1958), to *Captorhinikos chozaensis* Olson.

The existence of *Lysorophus* at this site has been casually mentioned in the literature, most recently in a faunal list from this site (Olson, 1967).

No additional field work was undertaken until 1965. For some time the site was "lost" as a result of the death of Professor Stovall, changes in the area, and a faulty record of its position in the Museum files. Weathering had almost completely obliterated surface indications of the vertebrate remains. After "rediscovery" in 1965, the hill containing the fossils was excavated, a process not completed at the time of writing. The collection described here has been obtained through these quarrying operations.

Intensive collecting of the Hennessey Formation near Norman by Stovall and his associates yielded a large collection of the pelycosaur *Cotylorhynchus romeri* Stovall (Stovall, 1937; Price and Romer, 1940; Stovall, Price and Romer, 1966; Olson, 1967, 1968). The specimens are all from about the same horizon as the quarry site. In addition, *Captorhinikos chozaensis* has been found in the Hennessey at several places in the Norman area. Except for the site under discussion in this paper, the Hennessey Formation proper has not yielded other vertebrates. One specimen of *Cotylorhynchus romeri*, the holotype, came from about 40 miles to the north (Olson, 1968). *Labidosaurikos meachami* (Stovall, 1950) has been described as being from the Hennessey, but as pointed out elsewhere (Olson, 1967) this genus occurs in transition beds between the Hennessey and underlying Garber formation, along with *Dimetrodon* and *Diplocaulus*.

THE QUARRY: DISTRIBUTION OF SEDIMENTS AND FOSSILS

The bone-bearing sediments that have produced the vertebrates discussed below are between 5 and 6 feet in thickness. The quarry was opened upon the nose of a hill and cut back into the hill to form a north-facing exposure about 30 feet long (Pl. V). About 20 feet to the southeast of the quarry, across a small gully, continuation of the bone-bearing bed was found, but elsewhere, to either side, no fossils

are present, although sediments at the level of the producing layers are exposed. The maximum extent of the fossiliferous shales across the outcrops is about 50 feet.

To date the excavation has covered an area of about 350 square feet and approximately 1,500 cubic feet of sediment have been examined for fossils. Although the specimens are somewhat clumped in occurrence, it can be estimated fairly that they average about three per cubic foot. Thus the total number of specimens in the materials studied ranges in the neighborhood of 4,500. Of these, of course, only a small part, several hundred, has been collected. Much of the material is very fragmentary and with a few exceptions only articulated specimens, skulls, jaws and well preserved single bones were kept. Over one-half of all specimens found pertain to *Lysorophus*, usually consisting of vertebrae and ribs. In general, remains of this amphibian were collected only when preservation was exceptionally good, much of an individual was present, or skulls were found, either alone or associated with skeletons.

Vertebrates are scattered somewhat irregularly through the deposits, with rich and poor zones seeming to have little regular lateral or vertical distribution. The sediments show modest variation through the producing zone, but this as well has no definable pattern. Bones tend to be more abundant and better preserved in some varieties of sediments than others, but the differences are slight and difficult to document.

The position of the quarry in bed number 5 of the general section, first given in Olson (1967), is shown in Table 4. It lies in the upper part of a thick bed of red shale. Not far above the upper level of the bone producing layer are coarser sandy shales. These, of course, bear no relationship to the deposition of the sediments of the quarry. The sediment of the quarry basically is a red-shale. Structureless red clay-shale makes up at least 80 per cent of the total. Irregularly disposed patches of lighter colored, somewhat sandier shale occur and in places small patches of pebbles, 1 to 5 mm. in diameter, are present. The most distinctive sediment is a greenish-brown, brecciated, slightly sandy shale. It shows no regular disposition either vertically or horizontally.

Vertebrates occur in all the shale variants in the 5 to 6 foot fossiliferous zone. Concentration is least in the breccia. The only clear regularity in the deposits is found in the vertical distribution of the kinds of fossils. At the base is a zone, about 1 foot thick that carries almost exclusively specimens of large individuals of *Lysorophus*. This

TABLE 4.—Measured Section of Hennessey Formation.
(from Olson, 1967)

Bed	Description	Thickness (feet)
14	Coarse clastic, base of green fissile shale. Remainder coarse brown sandstone.....	3.0
13	Uniform red shale.....	2.0
12	Hard green sandstone, increasing in thickness northward.....	0.5
11	Red shale with local lenses of sandy shale.....	29.0
10	Sandy siltstone and shale, ranges in thickness from 6 inches to 6 feet (see beds 8 and 9=beds 8, 9 and 10).....	6.0
9	Red shale, passing laterally into sandy siltstone (=bed 10).....	3.0
8	Hard green sandstone, pinching out laterally, but elsewhere passing under red shale (bed 9) to merge with bed 10.....	1.5
7	Uniform red shale.....	7.0
6	Red and green thin-bedded, fissile sandy shale.....	5.5
5	Red shale, sandy in places, bone in 5-foot interval, beginning 5 feet above the base.....	18.0
4	Red and green, fissile sandy shale.....	0.5
3	Red shale, base not exposed.....	5.0
2	Covered interval, some red shale in patches near top.....	58.0
1	Sandstone, top of brown sandstone near top of Garber-Hennessey transition zone.....	2.0+

animal always occurs in compressed masses of vertebrae and ribs, 3 to 5 inches across and 8 to 10 inches deep. As far as can be determined each specimen consists of one individual. It appears that this represents preservation of an estivating phase. After death the animals collapsed. This, along with subsequent compaction of the shale, has produced an intricate mass of intertwined vertebrae and ribs, with limb elements and skulls sometimes discernible. The top of this layer is marked by a bedding plane.

Overlying the basal zone are 3 to 4 feet of sediment through which are scattered remains of all of the types of vertebrates found in the quarry. *Lysorophus* is abundant, over 50 per cent of the total, sometimes in estivation position, and sometimes uncoiled. The remainder is accounted for by individual bones, partial skeletons, skulls, jaws and occasional teeth of lungfish, scales of palaeoniscoids, small amphibians and reptiles. Many specimens have been badly damaged by compaction of the shale. Some small concentrations of bone contain jumbled, sharply broken or cut elements of two or three species. These may well be the product of regurgitation. Coprolites, with mascerated bone, are fairly abundant.

Above this zone, ranging from a few inches to about 1½ feet in thickness, is a zone rich in scrappy, macerated bones of larger animals. From this have come a few large teeth of carnivorous reptiles,

badly broken skulls, and partial skeletons of *Captorhinikos chozaensis*, and teeth and partial skulls of *Gnathorhiza serrata*. Much of the material is so badly broken that it is undeterminable.

At the time of writing, the quarry has not been exhausted. The general fossil content is well known and probably very little new will be found. Some of the genera represented in the present collections, however, are known from but one or a few specimens. Additional materials of these will be important if they can be found in subsequent work. What is described below, however, gives an adequate representation of the overall content of this site.

CLASS OSTEICHTHYES

Subclass Sarcopterygia

Order Dipnoi

Family Lepidosirenidae

Gnathorhiza serrata (Cope)

Holotype.—Lower tooth, AMNH 7258, from the Permian of Texas. Cope, 1883.

Referred specimens.—All from Hennessey Formation about 70 feet above the base, Lower Permian, SW $\frac{1}{4}$, NW $\frac{1}{4}$ sec. 13, T. 8 N., R. 2 W., Cleveland County, Oklahoma. FMNH UF 981, small upper tooth; UF 1024, upper tooth attached to "pterygoid" plate and various scattered skull bones; UF 1023, lower tooth, jaw, cross crests of upper tooth in place relative to lower, part of second lower tooth and fragments of skull bones.

Discussion.—Although once a "rare" genus of lungfish, *Gnathorhiza* has been found in abundance in recent years. Treatment of the genus by Berman (1968) and Carlson (1968) has summarized its history and earlier it was considered by Olson (1951) and by Romer and Smith (1934). Much is now known of the skull morphology and a wide range of teeth has given a good idea of the extent of variation. It now seems clear that the common Lower Permian species is *G. serrata*, with *G. dikeloda* less abundant and absent from the Arroyo Formation and its equivalents, being present only in the Vale and Choza.

G. serrata is abundant in the Wellington Formation of the northern Permian exposures in Oklahoma, being known from the Orlando site and from Perry sites 1, 2, 4, 5 and 6 (Olson, 1967). It occurs as well in the Garber Formation at Pond Creek. Specimens have been

found in the Vale Formation of Texas, in Knox County (Olson, 1951) and in Taylor County (Meade, 1968). Arroyo finds have long been known and Berman (1968) has reported *Gnathoriza serrata* from the Leuders Formation. It appears that *Gnathorhiza* is the lungfish responsible for the many lungfish estivation burrows that are known from the Upper Pennsylvanian and Lower Permian, and finds of specimens from many areas are now being reported, probably mostly representing *G. serrata*.

The specimens referred to *G. serrata* in this paper are the first known from the Hennessey Formation of Oklahoma and extend the vertical range of this species into the upper part of the Lower Permian. *D. dikeloda* has been found in the Choza, a Hennessey equivalent, in Texas, but *G. serrata* has not been reported. No trace of *G. dikeloda* has been found in the Oklahoma Lower Permian beds.

Reference of the new specimens to *G. serrata* is based upon strong morphological resemblances and specifically upon the ratio of the anterior and posterior moiety of the lower tooth of UF 1023, Table 5. It was noted earlier (Olson, 1951) that the known ratio in *G. serrata* ranged from 1.3 to 1.5, whereas in *G. dikeloda* it ranged from 2.2 to 2.4. Additional materials have generally confirmed this marked difference as strongly exceeding variation of the ratio. UF 1023 has a ratio of 1.4. Measurements upon which this is based as well as those of the other referred specimens are given in Table 5.

The three referred specimens and fragments of others that have been observed during collecting have all come from the upper part of the producing beds. The two specimens with skull plates associated with teeth were from the uppermost bed in association with fragmentary specimens of *Captorhinikos chozaensis*. This bed carries scraps of large bones and appears to have been deposited under circumstances different from those that pertained during deposition of

TABLE 5.—Measurements of the specimens referred to *Gnathorhiza serrata* in mm. Taken as in Olson (1951).

Specimen number	Total length	Length of Posterior Moiety	Length of Anterior Moiety
FMNH UF 981 (upper)	7.2
FMNH UF 1024 (upper)	11.2
FMNH UF 1023 (lower)	10.0	4.9	7.3

the earlier beds which contain most of the fossils. The lungfish clearly were not preserved from the estivation phase and they are not known from the lowest producing level where *Lysorophus* occurs in abundance in estivation burrows. No lungfish burrows have been encountered as yet in the Hennessey Formation, although presumably *Gnathorhiza* maintained the same habits as earlier.

SUBCLASS LABYRINTHODONTIA

Order Temnospondyli

Suborder Rhachitomi

Family Dissorophidae

Genus *Tersomius*

Tersomius mosesi¹ new species

Holotype.—FMNH UR 1214. Skull and jaws and postcranial scrap. Skull badly crushed but nearly complete.

Horizon and locality.—Hennessey Formation, about 70 feet above the base, Early Permian, SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W., Cleveland County, Oklahoma

Referred specimens.—All from same horizon and locality as the holotype. FMNH UR 1216, part of lower jaw and skull fragments; UR 1218, front part of skull and lower jaws; UR 1219, skull and lower jaws, ventral side exposed; UR 1220, jaws and part of skull plus 3 or 4 vertebrae and other elements; UR 1221, lower jaw and skull fragments; UR 1222, lower jaw; UR 1223, maxilla with well preserved dentition; UR 1224, snout and lower jaw; UR 1225, jaw and skull fragments; UR 1226, lower jaw; UR 1227, partial lower jaw; UR 1228, partial lower jaw; UR 1229, partial lower jaw; UR 1251a, partial skull; UR 1285, lower jaw and limb elements (assoc.?) (see pl. VIB); UR 1286, lower jaw.

Diagnosis.—A small species of *Tersomius* with skull length, measured from the tip of the snout to the level of the end of the quadra-tojugal, about 25 mm. (see fig. 9). Dermal bones lightly sculptured. Dentary and maxilla-premaxilla with about 30 to 35 teeth, teeth long, slender and slightly recurved. Suspensorium but a short distance back of occipital condyles. Palatal tusks developed posterior to and near the anterior borders of the choanae, with an additional tusk on the vomer somewhat lateral to the midline. Vertebrae with very large hypocentra and strong pleurocentra (Pl. VIA).

¹The species is named for Mr. Amos Moses of Norman, Oklahoma, upon whose property the fossils described from the Hennessey Formation were collected.

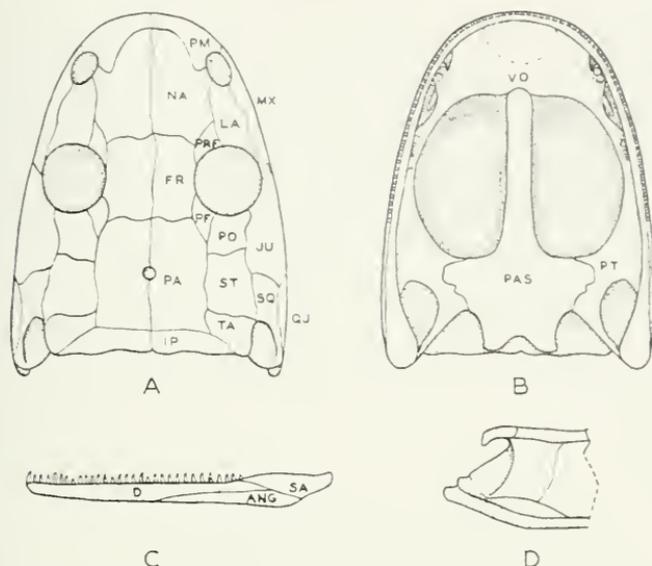


FIG. 9. *Tersomius mosesi* n. sp. A, skull in dorsal view; B, skull in palatal view; C, lower jaw in lateral view; D, back end of skull showing condition of otic notch. All composite, based on various specimens, including the holotype. All \times approx. 2.0.

Description and relationships.—Although there are many specimens of *T. mosesi* in the collections almost all are poorly preserved so that the description, illustrations (see fig. 9) and diagnosis must be based on information from a number of individuals.

In his study of early dissorophid amphibians Carroll (1964) gave a thorough description of the skull and jaws of *Tersomius* and concluded that there was but a single species, *T. texensis*, among the known materials. The specimens on which the new species is based conform in most respects to his generic diagnosis, which is the same as the species diagnosis. The presence of a light sculpturing on *T. mosesi* does not agree with the diagnosis which cites a lack of sculpturing, but some of the specimens of *T. texensis* do, in fact, show faint patterns on the dermal bones.

The diagnosis also cited the number of marginal teeth as 45 to 50, a number significantly larger than that in *T. mosesi*. This must, however, be considered as a species character, which assumes significance now that the genus is no longer monospecific.

That the specimens of *T. mosesi* are correctly assigned generically may, of course, be open to some question, since the skulls and jaws have relatively few unequivocal characters for separation of primitive

dissorophids. Clearly the specimens belong among the primitive dissorophids. The otic notch is open, the skull is flat, with very delicate ornamentation, and lacking the specializations found in the various more advanced genera. Lack of armour may be a primitive feature, as Carroll has indicated. In *Teromius texensis* the interpretation of absence was based merely upon the fact that no armour plate was found in association with the specimens. Almost no vertebrae are known, however, so that the absence of armour plate, while suggestive, is far from conclusive that none existed. *T. mosesi* also has no associated armour plate and, as far as can be told, there was no capping armour on the few preserved vertebrae. Once again, however, it is not certain that no plates were present.

The probable presence of the second vomerine tusk, lateral to the midline, is another feature that suggests relationship with *Tersomius*. The problem is complicated by the fact that the indications of this tusk are not completely trustworthy on the one specimen, UR 1224, on which it seems to exist, and also, of course, by the possibility that this may occur in other genera of dissorophids. On the whole, however, it seems advisable to assign the new materials to *Tersomius* rather than to adopt the alternative of erecting a new genus for which no clear justification can be found.

Occurrence.—Altogether over 100 individuals of *T. mosesi* have been seen in the deposits and about 75 have been identified in the collections now in hand. Many of these are unprepared and have not been formally referred, pending detailed study. All occur in the middle layer of the quarry sediments, and none has been definitely identified either in the lowermost bed, which contains largely *Lyso-sophus*, or in the uppermost, characterized by highly fragmented larger specimens.

The skulls and jaws of this little animal are extremely fragile, more so than the skulls of *Captorhinikos*, *Lyso-sophus* or *Goniorhynchus*, its more common associates in the site. All tend to be badly crushed and broken and some quite clearly appear to be regurgitated remains, often associated with fragments of other animals in a common mass of bone fragments. Occasionally skulls and jaws are associated with postcranial materials that can be assigned to the species, but single jaws are not uncommon. All parts of skulls that have been found have jaws in association, but in many instances only a part of the skull is preserved, as if it had been cut away from the rest by the bite of some small carnivore.

The very sharp, recurved teeth indicate a carnivorous habit for this species, but its food must have been very small animals, perhaps largely small, active invertebrates. What little information there is on the limbs and vertebrae suggests that *T. mosesi* would have been fully capable of locomotion on land. The deposits, however, as noted in other descriptions, probably were formed under aquatic circumstances, but very near to land. Thus this little amphibian may have lived on adjacent land, and been washed in or carried in by predators or may, of course, have been a swimmer. That many of the remains suggest predator action and the fact that very little articulated material is found suggests that the remains were brought into the area of deposition rather than that the animals actually lived in the depositing water.

SUBCLASS LEPOSPONDYLI

Order Microsauria

Family Gymnarthridae

Goniorhynchus new genus

Diagnosis.—A moderately small gymnarthrid amphibian with a single row of lateral teeth in the skull and lower jaw. Six premaxillary and 18 to 20 maxillary teeth above. One row of slender teeth on margin of pterygoid and second row, with 3 or 4 teeth, on palatine just posterior to internal naris. All teeth long, slender and sharp. In marginal rows, longest teeth anterior with regular decrease in length posteriorly along the tooth row.

External nares large and terminal. Overhanging rostrum. Parietal with small pineal foramen, postparietals large, postorbital broad with extensive contact with posterior margin of orbit. Supraoccipital a broad, relatively short element. Dorsal surface of skull not pitted. Measurements in Table 6.

TABLE 6.—Measurements in mm. of skulls of *Goniorhynchus storalli* n. g. and sp.

	Sk _l	IO _w	O _l	Mx _w
FMNH UR 1039	12.8	6.1	3.7	11.2
UR 1040	14.0	6.1	3.6	12.0

Abbreviations:

IO_w, interorbital width

Mx_w, maximum width of skull

O_l, orbital length

Sk_l, skull length along midline

Goniorhynchus stovalli¹ new species

Holotype.—FMNH UR 1039. Skull and lower jaws.

Horizon and locality.—Hennessey Formation, about 70 feet above the base, SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W., Cleveland County Oklahoma.

Referred specimens.—Horizon and locality as for holotype. FMNH UR 1040, skull and jaws; UR 1242, part skull; UR 1243, lower jaws; UR 1244, skull, jaw and vertebrae; UR 1245, part skull and vertebrae; UR 1246, front part of lower jaw, scrap; UR 1247, part of lower jaw; UR 1248, part skull and vertebrae; UR 1284, crushed skull, vertebrae; UR 1341, front of skull and lower jaws.

Diagnosis.—As for genus.

Description.—*Goniorhynchus stovalli* is represented in the collections by the specimens listed above, and by others not as yet prepared. It appears that considerable additional postcranial material pertains to this genus and species but much additional preparation will be necessary to establish associations. This original report, hence, is based primarily upon features of the skull, jaw and dentition. Vertebrae preserved with the skulls are typically gymnarthrid in general structure, with spool-shaped centra and low arches. Both of the best preserved skulls are somewhat depressed by crushing. UR 1039 the holotype has been broadened somewhat in the process whereas UR 1040 has been somewhat elongated. The shape of the skull in the figures has been based upon the holotype and is thus probably somewhat broader in proportion to length than was true during life.

The dorsal and palatal patterns are shown in Figure 10 A and B, and the dorsal in Plate VID. The pattern of the dorsal surface of the skull can be seen to be typically gymnarthrid, fairly close to that of *Cardiocephalus*, *Pariotichus* and *Euryodus*. Minor differences in the shapes, proportions and relationships of the elements occur. The most evident differences are found in the dentitions. The teeth of *Goniorhynchus* are long and slender, with no formation of a bulbous waist on the crowns. The six premaxillary teeth are the longest and the maxillary teeth decrease regularly in length posteriorly. The same relationships hold for the teeth of the dentary. Only one row occurs above and there are no coronoid teeth on the lower jaw.

¹The generic name refers to the angled snout of the animal and the specific name is in recognition of the late J. Willis Stovall.

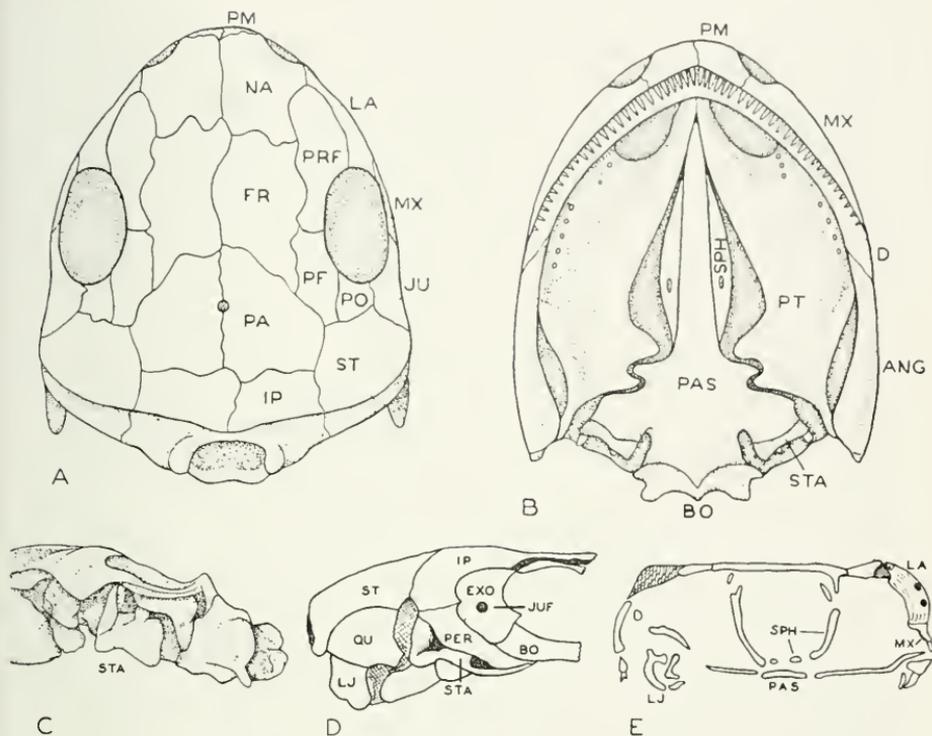


FIG. 10. Skull and lower jaws of *Goniiorhynchus storalli* n. g. and sp. A, dorsal; B, palatal; C, oblique view of left side of posterior of skull to show stapes; D, occipital surface in posterior view; E, cross-section through skull at level of anterior margin of the orbits, based on UR 1341. A, B, and E, $\times 4.0$; C and D, $\times 6.0$.

The shapes and arrangements of the teeth thus differ notably from those of any of the three genera noted in the last paragraph. They are more like those described in *Ostodolepis* (see Romer, 1950). On the basis of the skull elements and skull shape, there seems little question that affinities are closer to the *Cardiocephalus-Pariotichus-Euryodus* assemblage than to *Ostodolepis*, and the resemblance of the dentition to the last mentioned is probably a matter of convergence.

The occipit of *Goniiorhynchus* is illustrated in Figure 10D. It is gymnarthrid in general structure. The exoccipital carries a very large, centrally located foramen, undoubtedly for the hypoglossal nerve. An exoccipital of *Cardiocephalus* cf. *sternbergi* described by Gregory, Peabody and Price (1956) shows a similar large foramen, plus a smaller one, somewhat ventro-anteriorly, both presumed to be for the exit of the hypoglossal nerve. The supraoccipital is pres-

ent and rather small. The occipital condyle is a slightly saddle-shaped structure, characteristic of this group of gymnarthrids.

The stapes is well preserved in UR 1040, as illustrated in Figure 10C and Plate VIC. It consists of a short, rounded shaft, with a stout process rising above it to the opisthotic in the general position of a dorsal process. No enlarged foot-plate is present. As preserved, the stapes does not rest medially against the periotic complex and a fenestra ovalis has not been identified. It may be that crushing has separated the foot from the periotic or it may be that a foot-plate was present and not ossified. Laterally, the rounded shaft passes into a more slender ventral extension, which is directed toward the quadrate. The latter has a medially directed process to which, it would appear, the stapes attached. Once again, however, there is no contact in the specimen and either lack of ossification or crushing may be the reason. In this instance, it appears that separation due to crushing is the more probable explanation. Rising above this lateral part of the stapes is a large, accessory element. Its base is closely appressed to the stapes but does not appear to be fused to it.

The stapes appears to be very different from that described in *Cardiocephalus* by Gregory, Peabody and Price (1956), but rather like that of *Pantylus* (Olson, 1966, on data supplied by Robert Carroll). The functions of the stapes and its relationships to those of other small amphibians are uncertain. What is required is a full study of the detail from all specimens available before any generalizations can be safely made. Robert Carroll (1963, 1966, 1967) has been gathering data for such a study and has made important contributions to understanding of the microsaur. This work is building upon earlier studies by Gregory, Peabody and Price (1956) and by Romer (1950). In addition, studies by Brough and Brough (1967) have added important details to understanding of what they call the "type microsaur" *Microbrachis*. Collation, as planned by Carroll, should do much to clarify the morphology and relationships of these creatures.

Most of the features of the basicranium and palate can be seen in Figure 10B, D and E. No evidence of openings for internal carotid arteries, as described in *Cardiocephalus*, have been found. Posteriorly, lateral to the basicranium, appears a very deep incisure. This probably represents the place that structures from the jugular foramen, nerves IX, X and XI, and possibly a jugular vein emerged. A large sphenethmoid is present. This carries a foramen rather well forward from the basiptyergoid articulation. It does not appear to

be the foramen noted by Gregory, Peabody and Price for the inter-orbital vein, for it lies too far forward. Interpretation requires a more thorough knowledge of its position relative to internal features of the brain case. The shape of the anterior part of the sphenethmoid is shown in Figure 10E, based on the broken surface exposed at the posterior end of UR 1341.

Discussion.—The new specimens, referred to *Goniorhynchus stovalli* add considerably to known details of the structure of gymnarthrids. Only by a full study of these specimens in comparison with other available materials will the full benefit of their excellent state of preservation be realized. The purpose of this paper is to name the new genus and species, to indicate its probable affinities, and to describe its essential features. The study being undertaken by Carroll is well underway and the materials have been made available for his work in which they will be considered in broad context.

The Hennessey specimens occur later in the Permian than any other clearly defined members of the Gymnarthridae. Prior to their discovery the most recent were from the Arroyo Formation of Texas, appreciably earlier than the Hennessey, which appears to be equivalent to the Choza. *Cymatorhiza kittsi* Olson and Barghusen described earlier (Olson and Barghusen, 1962) was tentatively assigned to the gymnarthrids on the basis of the peculiarly *Euryodus*-like structure of the base of the teeth. This specimen is from a tongue of the Chickasha Formation in the middle Flowerpot Formation of the El Reno group and is considerably younger than *Goniorhynchus*. The assignment, however, must remain tentative since no additional materials for further study have been found. No traces of gymnarthrids have been found with the very well preserved specimens from the Omega quarry (Olson, 1965) of about the same age as the beds from which *Cymatorhiza* came.

Family Lysorophidae

Lysorophus tricarinatus Cope

Holotype.—FMNH UC 6526. Partial vertebral centrum. Middle McLeansboro Formation, early Conemaugh, Horseshoe Bend of Vermillion River, Vermillion County, Illinois (Cope, 1877, p. 187).

Referred specimens.—All from Hennessey Formation, Early Permian, SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W. Cleveland County, Oklahoma. FMNH UR 1034, skull and jaws; UR 1036, part skull; UR 1037, part skull and part skeleton; UR 1230, skull and jaws;

UR 1231, part skull; UR 1232, vertebrae, ribs; UR 1233, part skull; UR 1240, skull and jaws; UR 1288, skull and jaws; UR 1289, part skull, vertebrae; UR 1290, skull and part skeleton; UR 1291, part skull and vertebrae; UR 1292, skull and jaws, scrap; UR 1293, skull and jaws, vertebrae; UR 1294, part skull and part skeleton; UR 1295, part skeleton.

Systematics.—As described earlier (Olson, 1956), the systematics of *Lysorophus* pose some difficult problems partly because of the fragmentary nature of the holotype and referred specimens from the type locality and partly because much of the known material consists of vertebrae that are very constant in morphology. Comparisons with the holotype, of course, can involve only vertebrae and the limitations of the holotype and the few referred specimens from the same site do not allow any estimate of the extent of individual variation. As far as vertebrae are concerned, no detectable differences occur between members of any of the samples, which range from the Cone-maugh of Pennsylvanian age to near the top of the Lower Permian.

Collections of *Lysorophus* from the Arroyo Formation contain a substantial number of skulls and jaws as well as vertebrae. In the absence of comparative materials other than vertebrae in the holotype, however, there has been little choice but to assign these materials to the type species, *Lysorophus tricarinatus* Cope. Much the same applied when *Lysorophus* from the Vale and Choza, consisting very largely of vertebrae and ribs, was described. It was unknown whether or not adequate skulls and jaws would show differences were they available.

Now about a dozen skulls and jaws, along with hundreds of specimens of vertebrae and ribs, have been obtained from the Hennessey Formation. The vertebrae and ribs, as is to be expected, show no differences from those from other localities. Detailed analyses of both the gross and small characters of the skulls and jaws from the Arroyo samples and the new one from the Hennessey also fail to reveal any differences whatsoever in the morphology. Gross proportions, proportions of the individual elements, the nature of the sutures, positions of sense organs, jaw structure, hyoidean structure and dentitions all are indistinguishable. As far as morphology is concerned, all of the Clear Fork materials must be assigned to the same species and there is no basis for separation of this species from *L. tricarinatus* of the Pennsylvanian.

Occurrence.—Specimens of *Lysorophus* make up at least 50 per cent of the individuals from the Hennessey quarry site. They occur

at all levels in the producing section and in association with all of the other elements. The distribution, however, is not uniform.

The lowest bed from which vertebrates have come is a slightly sandy clay-shale about 1 foot thick and marked off from the overlying beds by a well-defined bedding plane. This lowest level contains, almost exclusively, specimens of large individuals of *Lysorophus*, each preserved as a closely packed, intricately coiled mass of bone. Each such accumulation appears to represent a single individual. In some, skull elements and limb bones are found, but frequently maceration is such that they are hard to extricate from the mass. It is assumed that these specimens were preserved in crude burrows during an estivating phase of their existence. All are of similar size, based on measurements of the length of mid-column vertebral centra. They vary from about 7 to 10 mm. in this dimension.

The matrix in the immediate vicinity of these specimens is firmly cemented and varies from very light red through green, in contrast to the deep red of the bed as a whole. On a cleaned surface of the bed the specimens can be seen to be irregularly spaced, but not clumped, and averaging about five to the square yard. There seems to be little question but that these represent somewhat irregularly, much compressed, cocoon-like burrows of this animal.

Throughout the remainder of the producing beds *Lysorophus* shows no such regularity in the spacing, size of individuals, or form of preservation. Coiled specimens of various sizes are present. Uncoiled, articulated skulls and vertebral columns are fairly common, and there are large numbers of individual vertebrae and ribs, short segments of column, and occasional skulls and jaws. Sizes in the free specimens range from those with vertebral centra less than 1 mm. in length to some larger than those from the basal bed. In the uppermost beds, in which there are scrappy materials of larger animals, *Lysorophus* is rare and very fragmentary. Like the other materials at this level, specimens appear to have been washed in.

The middle beds, with their mixture of kinds of preservation, seem to include specimens preserved from the free-swimming stages, but the estivation "nodules" also are present. It would appear that there had been considerable reworking at this level and perhaps that the materials had been to some extent transported. The extremely delicate animals that are well preserved, including the small specimens of *Lysorophus*, however, argue strongly against anything but the most gentle actions on either count.

Suborder Nectridea
Family Keraterpetontidae

Peronedon¹ new genus

Diagnosis.—A small keraterpetonid nectridean, with known skull lengths along dorsal midline ranging from 7.6 to 14.0 mm. The skull is longer than wide, orbits elongated, "horns" short and jaw articulation far forward of occipital condyles. But a single element posterior to the orbit—either postfrontal or postorbital. Interpterygoidal vacuities large. Marginal teeth long, slender and sharp, confined to premaxilla, anterior part of maxilla and anterior part of the dentary. Palatal teeth restricted to three or four medial to internal narial opening. Metacarpal and phlangeal elements relatively long, narrow and well ossified. Vertebral centrum lacking scroll-like sculpturing such as found on *Diploceraspis*, *Diplocaulus* and *Crossotelos* among the nectrideans.

Peronedon primus new species

Holotype.—FMNH UR 1234. Skull, jaws, ten vertebrae including atlas, ribs, part of shoulder girdle and part of right and left forelimbs.

Horizon and locality.—Hennessey Formation, about 70 feet above base, Clear Fork group, Early Permian. Southeast of Norman, Oklahoma, SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W., Cleveland County, Oklahoma.

Diagnosis.—As for genus.

Referred specimens.—FMNH UR 1235, parts of two small individuals on single block of matrix; includes partial skulls and lower jaws, badly damaged, two series of vertebrae and associated ribs; UR 1236, large individual, about twice the size of the others, consisting of a crushed skull and two vertebrae; UR 1237, part skull and lower jaw, small; UR 1238, skull.

Description and discussion.—In addition to the holotype and the referred specimens other fragments pertaining to this genus and species, recognized mainly from the sculpture pattern on the bone, are present in the collections. All are within the size range of the referred specimens and most closely approach the size of the smaller specimens. The very small size has made preparation and study of the specimens difficult, but excellent preservation, especially of the holo-

¹ The name is given as an indication of the long, slender nature of the marginal teeth, meaning pin-tooth.

type UR 1234, has made it possible to determine many significant structural features. The morphology is shown in Figure 11, in which a reconstruction of a small, immature specimen of *Diplocaulus*, is shown for comparison. Before consideration of the details of form, it will be helpful to assess the meaning of the small size.

Size.—All of the specimens known are extremely small as compared to adults of *Diplocaulus*, the only known contemporary neotridian. The very high degree of ossification of the endocranium, the vertebrae and the carpal, metacarpal and phalanges seem to argue that the individuals are mature. The skull lengths of UR 1234 and UR 1236 differ in length, 7.6 mm. and 14.0 mm., respectively. The magnitude suggests that growth rather than interspecies variation of adults is involved. It is in the smaller specimen that ossification of the limb bones occurs, but only in the larger are the endocranial bones visible. Although it appears probable that these specimens do represent a very small species, it cannot be determined definitely that they are not actually juveniles of the species.

Very small skulls of *Diplocaulus magnicornis* which can be related to large adults through a series of intermediate stages show ossifications of the dermal surface of the skulls and of the vertebrae comparable to those of *Peronedon*. That this also involves endocranial bones and limb bones is not known, although it may be the case. Also, another lepospondylous amphibian, the microsaurian *Lysorophus*, has a high level of ossification even in very small individuals. It is possible that this is a common feature within this order. Thus, with this additional evidence, reservation upon the adult condition of the specimens on the basis of the degree of ossification must be maintained.

No large individuals are known, but the only specimens of the genus come from one site in which, with the exception of fragmentary materials from the uppermost part of the producing beds, small individuals make up about 98 per cent of the total collection.

The following discussion, for the most part, treats the individuals as if they give a fair representation of the adult conditions, but this may be in error. If this is the case, then descriptions of both the morphology and habits apply only to the juveniles and the comparisons made with adults of other genera and species are open to some question.

Skull and Jaws.—Pertinent features are shown in Figure 11A and B, and measurements are given in Table 7. The outline of the skull has been based upon the holotype UR 1234, and the recon-

TABLE 7.—Measurements in mm. of specimens of *Peronedon primus* n. g. and sp.

	Sk _l	Sk _{lm}	IO _w	Lj _l	H _w	V _l	V _h
FMNH UR 125 (type)	7.6	10.4	0.9	4.6	7.8		
UR 1236	14.0					4.2	1.8
UR 1237	8.8						

Abbreviations:

H_w, maximum width at tips of hornsIO_w, interorbital widthLj_l, maximum length of lower jawSk_l, skull length along midlineSk_{lm}, maximum skull length, to tip of horns from snoutV_h, maximum height of vertebraV_l, central length of vertebra along base

struction of the palate has been made upon this outline, but with the information from UR 1236 and 1237. Figure 11E shows the skull of a small, juvenile specimen of *Diplocaulus magnicornis*. The pattern of the dermal bones and the shape are somewhat different from those of *Peronedon*, but the general features are similar. The most striking differences lie in the absence of a bone in the position of the post-orbital (excluded from the orbit) in *Peronedon*. The large parietal is well preserved and this absence appears to be real, not a matter of preservation. The pattern shown in the immature *Diplocaulus magnicornis* is that found in all members of the genus. Also, no evidence of the lacrimal has been found in *Peronedon*. This may express the actual condition, but the bone may be so small, with the skull less than 8 mm. long, that detection is not possible. Other minor differences in dermal patterns probably are of no great significance.

The most strikingly distinctive feature of *Peronedon* among the keraterpetontids, and especially in comparison to *Diplocaulus* and *Diploceraspis* (Beerbower, 1963) is the shape of the marginal teeth. These, as shown in Figure 11C, are very long, slender and sharp. This is in marked contrast to the short, blunt teeth of the contemporary *Diplocaulus* or the earlier *Diploceraspis*. This type of tooth formation is not found in the juveniles of *Diplocaulus* in which the teeth, as far as known, resemble those of adults very closely.

The palatal reconstruction of Figure 11B may have some inaccuracies, for preservation of UR 1236 and 1237 is only fair. The large interpterygoidal vacuities, the posterior position of the large adductor fossa, the position and number of palatal teeth, and the internal nares are quite certain. The position and size of the opis-

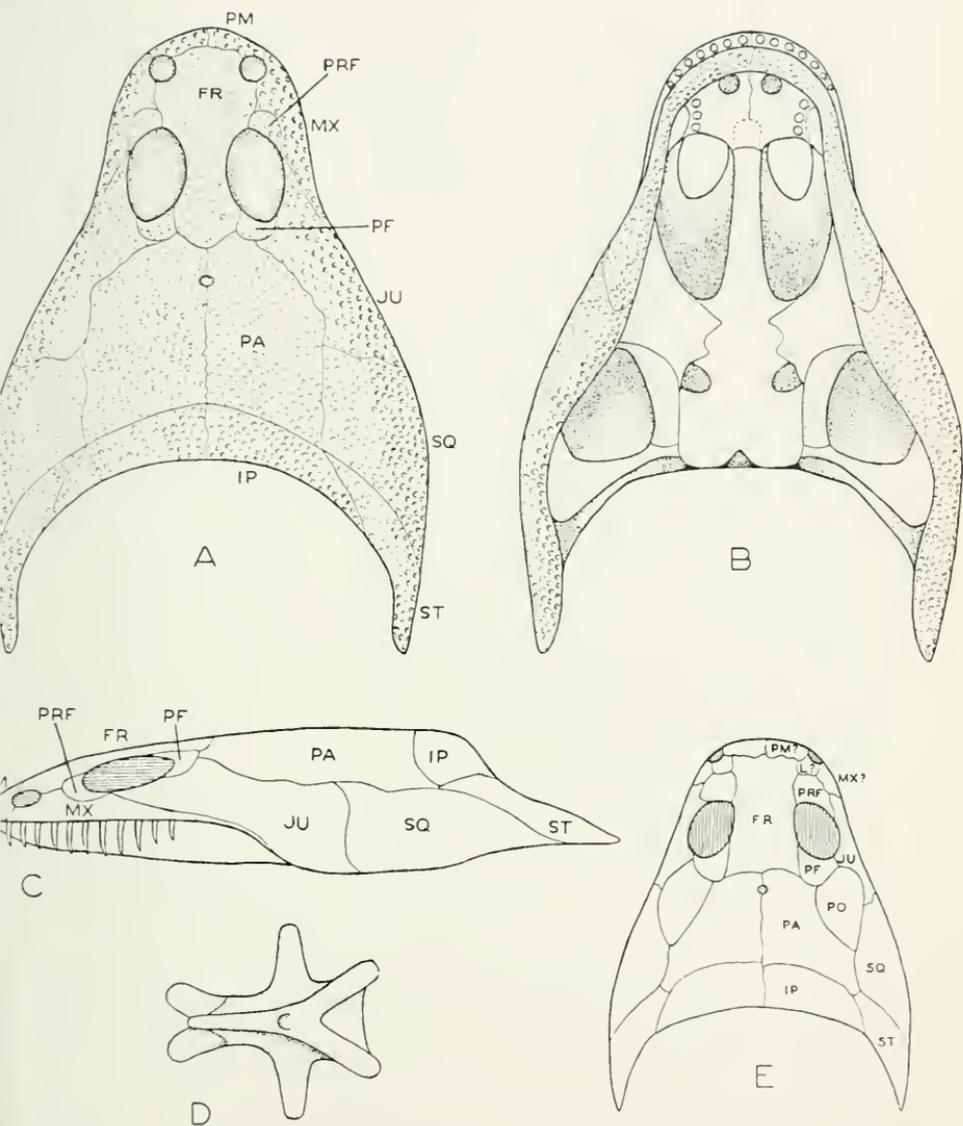


FIG. 11. *Peronedon primus* n. g. and sp. A, dorsal view of skull. Based on various specimens with outline from holotype UR 1234, relative to which the scale is $\times 7.5$; B, palatal view of skull. Based on various specimens with outline from holotype UR 1234, relative to which the scale is $\times 7.5$; C, lateral view of skull, based on UR 1234, $\times 7.5$; D, dorsal view of vertebra from UR 1236, $\times 5$; E, outline of skull and dermal elements of *Diplocaulus magnicornis* Cope based on juvenile animal with skull length about 17 mm. along mid-line.

thotic is more questionable, since this is present only on the left side of UR 1236 and not well preserved there.

Postcranium.—The vertebrae are typically nectridean, as shown in Figure 11D. The centrum is elongate and spool shaped, but lacks the scroll-like sculpturing found in *Diplocaulus* and *Diploceraspis* (Beerbower, 1963), and also in *Crossotelos* among the urocordylids. The parapophysis and diapophysis are both present, arising from a common base on the centrum, as in *Diplocaulus* and *Diploceraspis*. The most striking feature of the postcranium is the forelimb, as seen in UR 1234. The shoulder girdle was broad and flat, as in *Diplocaulus*, but no details are visible in the specimen. No humeri have been certainly identified but the right and left radius and ulna are present. They are so small, about 2 mm. in length, that details are not well shown. In articulation with one pair are well ossified carpal elements accompanied by partially articulated metacarpals and proximal phalanges. The metacarpals are about one-half the length of the radius and ulna and the proximal phalanges are but slightly shorter. Thus the feet appear to have been very large in comparison to the forelimb and to the body as a whole. This is, of course, in very sharp contrast to the condition in *Diplocaulus*. Without a doubt these creatures could have walked about on land without difficulty.

Relationships and habits.—The characteristics of the skulls, jaws and postcranium given in the preceding paragraphs leave no doubt that *Peronedon* is a fairly normal nectridean and that it is closely associated taxonomically with *Diplocaulus* and *Diploceraspis* within the Family Keraterpetontidae. The forward position of the jaw articulation, the large interpterygoidal vacuities, and the large, posteriorly placed adductor fossa are important in this regard. In addition, the sculpture pattern of the dermal surface of the skull and jaws is typical of that found in *Diplocaulus* and *Diploceraspis*, a pattern that is immediately recognizable even on very small fragments of bone. The dentition, the pattern of the dermal bones, the lack of vertebral sculpture on the centra, and the large forefeet set the genus distinctly apart from these relatives.

Interpretation of the adaptations are based upon the proposition that these specimens are adults or subadults, but it is possible, as noted, that they are juveniles. Dentitions suggest that the teeth are used for selective feeding, rather than for more or less indiscriminate gathering of food from the bottom of ponds or for mud-grubbing.

Very small invertebrates probably were a primary source of food. Whether *Peronedon* fed on land or in the water is uncertain, although feeding on land would be a distinct possibility in view of the arrangement of the teeth and jaws. Feeding habits almost certainly were different from those in *Diplocaulus*. In *D. magnicornis*, for which small juveniles are known, the dentition is known to be very similar throughout the full growth series, so that the differences are not merely juveniles versus adults, if the specimens of *Peronedon* are, in fact, juvenile.

The ability to walk on land has been indicated in connection with the large limbs and feet. That these animals did actually live on land part or full time cannot be known. In the same deposits occur both terrestrial and aquatic creatures. The orbits are directed dorsally, much as in bottom living animals, but the position is little different from that found among semi-terrestrial salamanders of the present time. The adaptations in general appear to be very much like those of the gymnarthrid *Goniorhynchus* from these same deposits.

CLASS REPTILIA

Subclass Anapsida

Order Captorhinimorpha

Family Captorhinidae

Captorhinikos Olson

***Captorhinikos parvus* new species**

Holotype.—FMNH UR 1250. Skull and part of right lower jaw.

Horizon and locality.—Hennessey Formation, about 70 feet above the base. SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W., Cleveland County, Oklahoma.

Diagnosis.—A small species of *Captorhinikos* with skull length ranging from about 23 to 26 mm. Skull broad, with maximum width about two-thirds that of the skull length. Upper dentition with four premaxillary teeth, 13 to 15 marginal maxillary teeth, and two inner rows on maxillary, the outer with five and inner with three teeth respectively. Premaxillary teeth long, but not recurved. Second and third maxillary teeth robust and long.

Lower jaw with second and third teeth elongated. Fifth tooth inset slightly and continuing as part of inner of two rows of teeth in posterior part of tooth row. Labial row of four or five teeth begin-

ning back of level of fifth tooth. Coronoid process of lower jaw strong, and post-coronoid ramus long and slender.

Referred specimens.—Horizon and locality as for holotype. FM-NH UR 1251, part skull, jaws and skeleton; UR 1252, front end of lower jaw; UR 1253, 7 vertebrae; UR 1254, crushed skull, jaws and postcranium; UR 1255, skull and jaws; UR 1256, skull and jaws; UR 1257, skull and jaws; UR 1258, skull and jaws; UR 1259, part skull and jaws; UR 1262, part skull; UR 1263 part skull, showing maxillary teeth; UR 1264, part skull and jaws; UR 1265, part skull and jaw; UR 1266, front end of skull; UR 1267, jaws, skull fragments; UR 1268, part of skull and jaws; UR 1269, part skull and jaws; UR 1270, front of skull and jaws; UR 1271, part lower jaws; UR 1272, lower jaw; UR 1273, lower jaw; UR 1274, part lower jaw; UR 1275, lower jaw; UR 1276, part lower jaw; UR 1277, part lower jaws; UR 1278, lower jaw; UR 1279, parts of skull and jaw; UR 1280, lower jaw; UR 1281, lower jaw; UR 1282, maxillae and dentaries; UR 1283, part of lower jaw.

Descriptions.—The skull and lower jaws of *Captorhinikos parvus* n. sp. are as shown in Figure 12 and Plate VII. The skull is covered over its full outer surface with a fine, reticulate marking not shown in the figures. The general shape of the skull and jaws and the disposition of the component elements are very much as in *Captorhinus*. No supratemporal, however, has been identified and its presence is uncertain.

The skull is quite broad in comparison to its width. The posterior margin of the temporal region appears to exhibit a structure that is unusual among captorhinids. This is shown well in the holotype, as figured, but is not as clear in other specimens. It may have been somewhat exaggerated by crushing in the holotype. The dorsal platform of the skull ends in an abrupt, transverse line, as in most captorhinomorphs, but this line, carried latero-ventrally passes somewhat forward exposing the occipital flange of the squamosal laterally. The squamosal surface carries back ventrally in a somewhat distinct process covering the quadrate nearly to the end of its articular surface. This is the only feature in which the skull surface shows even moderate differences from other captorhinids.

The palate, illustrated in Figure 12C, is reconstructed from the holotype and UR 1250 and UR 1255. It is a normal captorhinid palate, but is distinct in lacking teeth on the pterygoid, palatines or vomers and in being broad and rather flat. An ectopterygoid appears

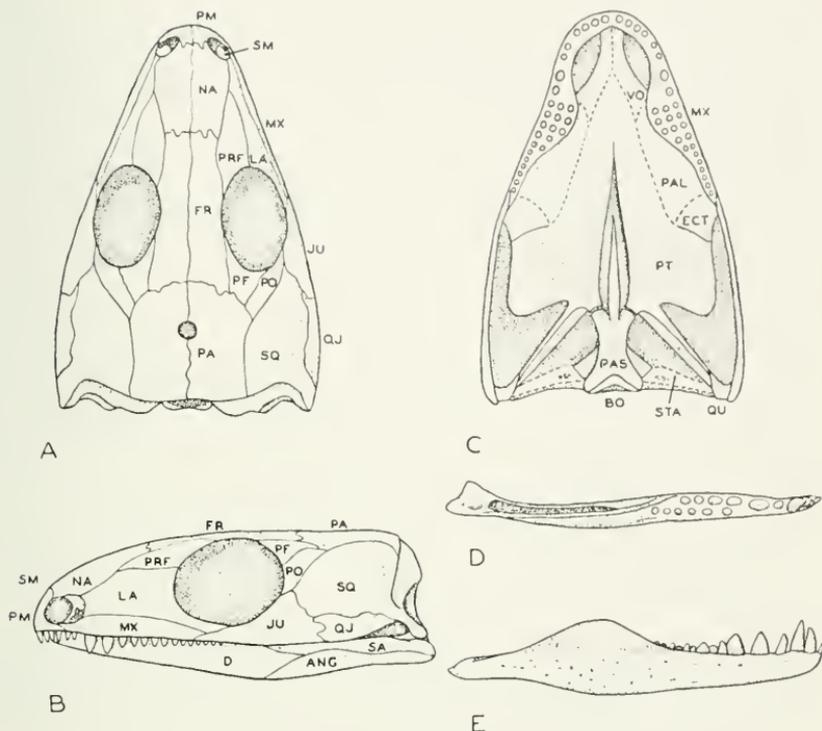


FIG. 12. *Captorhinikos parvus* n. sp. A, skull, dorsal aspect; B, skull and jaw, lateral aspect; C, skull, palatal aspect; D, lower jaw, dorsal to show dentition; E, lower jaw, lateral to show shape, see B for elements. Based on various specimens. All approx. $\times 2.0$.

to be present, but its definition is not completely clear. The interpterygoidal vacuity is moderately open and the cultriform process of the parasphenoid is long and slender.

The lower jaw is as shown in Figure 12D and E. It is rather long and narrow and has a strong coronoid prominence. The post-coronoid ramus is long and slender and a small retroarticular process is developed. There are no striking differences from jaws of other small captorhinomorphs such as *Captorhinus* and small species of *Labidosaurus*.

The dentition is the most distinctive feature of *Captorhinikos parvus*. Principal features are illustrated in Figures 12C, D, E and 13C and F. In the upper jaw four incisor teeth and 14 or 15 marginal maxillary teeth are visible laterally. The incisor teeth are rather long but are not recurved as in *Captorhinus* or *Labidosaurus*. All are

of about the same size. The fourth and fifth maxillary teeth are large and the remainder gradually diminish in size posteriorly.

The maxilla extends lingually from this row of teeth and carries two additional, longitudinal rows. The outer of these, immediately adjacent to the most lateral tooth row, includes five teeth, and the inner three. These numbers appear to be standard, for they are constant in all specimens in which this area is preserved.

The second and third teeth in the lower jaw are long and robust. Traced posteriorly they lead to a large fifth tooth which is somewhat inset and to a series of three to five additional teeth along the inner margin of the dentary. This forms the primary row of teeth of the lower jaw. Latero-posteriorly to the fifth tooth of this row, lies a series of five or six teeth, that form an outer row. Viewed laterally these seem to be continuous with the more anterior teeth, but when the rows are viewed from above this proves not to be the case.

This dentition is unique among the known captorhinids, but is of the general pattern found in *Captorhinikos chozaensis*, and unlike that of *Captorhinus*, on the one hand, and *Labidosaurikos*, on the other (fig. 13).

Many partial skeletons, small suites of associated elements and individual bones of *Captorhinikos parvus* are in the collections. Those listed in the referred specimens have been prepared, but much unlisted and unprepared material also is in the collection. The most important aspect of this material is that it consistently shows a high degree of ossification of the long limb elements, indicating maturity of the individuals. Particularly important in this regard is UR 1254 in which well ossified posteranial elements are associated with a skull.

The posteranial materials fall closely within the habitus of small captorhinids, and are extremely difficult to differentiate from those of small specimens of *Captorhinus*. It may be that this would be possible by use of fairly large samples in which the extent of variation was evident. As matters stand at present, however, no clear-cut distinctions between the vertebrae and limb elements of *Captorhinikos parvus* and *Captorhinus* have been found.

Discussion.—The genus *Captorhinikos* was first named from the Vale and Choza Formations of Texas, with two species, *C. valensis* Olson and *C. chozaensis* Olson (Olson, 1954). Both of these were based on rather fragmentary materials. Vaughn (1958) identified as *C. chozaensis* materials from the Hennessey Formation of Oklahoma. Later, this was accepted by me (Olson and Barghusen, 1962), and other specimens, one from the quarry site that has yielded *C. parvus*,

and two others from just north of Norman, Oklahoma, were used to augment the descriptions. In the course of development of the quarry over the last three years additional material of *C. chozaensis* has been

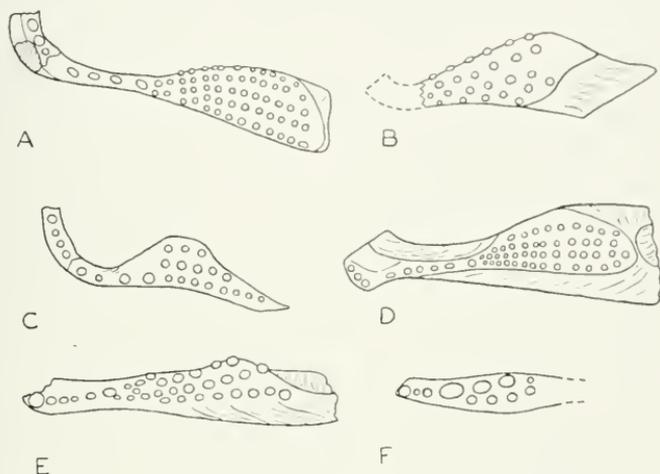


FIG. 13. Diagrams of positions of teeth. A, *Captorhinikos chozaensis* Olson, maxillary and premaxillary; B, *C. valensis* Olson, maxillary and premaxillary; C, *C. parvus* n. sp., maxillary and premaxillary; D, *C. chozaensis* Olson, dentary; E, *C. valensis* Olson, dentary; F, *C. parvus* n. sp., dentary. Not to scale.

found. Most of it is very scrappy and comes from the uppermost level as described on pages 420-421.

When the small individuals were first found, it was assumed that they were immature individuals of this *C. chozaensis*. It has become clear that this is not the case. The long limb elements are strongly ossified, indicating their adult nature, and long bones of specimens of immature *C. chozaensis* from the quarry are poorly ossified, even though they are at least twice the length and width of the elements of *C. parvus*. In addition, as the skulls and jaws were prepared, it was found that the dental patterns differed markedly in the two species (see Fig. 13). The dentition of *C. parvus* bears somewhat closer resemblance to that of *C. valensis* than to *C. chozaensis*. It is known, however, that with increase of age in *Captorhinikos* and in *Labidosaurikos* as well, the number of rows of teeth may increase. Thus on the basis of dentition alone, in particular the lower dentition, it could be argued that *C. parvus* represents a young stage of *C. valensis*, although hardly of *C. chozaensis*. Somewhat greater reorganization during growth would be necessary to derive the upper dentition of

C. valensis from that of *C. parvus* but this is not entirely impossible. It is thus largely the indications of maturity of *C. parvus* that show it to be a distinct species and not an immature growth stage of *C. valensis*. It is probable that other differences would be found were more complete specimens of *C. valensis* at hand, but to date none has been found.

C. parvus is abundant in the quarry. Hundreds of individuals have been recognized in the course of operations, and about 150 have been collected. Most of those not taken consisted of extremely badly preserved specimens, due mostly to very excessive crushing, individual bones, skull plates, fragments of jaws, and miscellaneous jumbles of postcranial elements. The abundance of this delicate animal, the well preserved skulls with the jaws in place, and the partially articulated skeletons suggest that it lived at or near the site of deposition. Undoubtedly processes of concentration acted to bring so many together, but the source area must have been nearby and limited. Only *Lysorophus*, which is shown by its burrows to have lived in this place, exceeds *Captorhinikos parvus* in abundance.

Captorhinikos chozaensis Olson

Holotype.—FMNH UR 97, part skull and lower jaw. Choza Formation, Clear Fork Group, Early Permian, Loc. FA, Foard County, Texas (Olson, 1954).

Referred specimens.—All from Hennessey Formation, early Permian, Cleveland County, Oklahoma (see Olson and Barghusen, 1962). FMNH UR 183, skull and jaws. SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 13, T. 8 N., R. 2 W.; UR 857, partial skull and skeleton, NE $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 29, T. 9 N., R. 2 W.; UR 858, partial skeleton, locality as above; UR 859, partial skull and skeleton, locality as above; OUSM 4-1-53, part skull and jaws, locality as for UR 183; USNM 21275, skull and partial skeleton, S $\frac{1}{2}$, sec. 24, T. 8 N., R. 2 W. (Vaughn, 1958).

Discussion.—Earlier discussions (Vaughn, 1958; Olson and Barghusen, 1962) have considered the existence and distribution of *C. chozaensis* in the Hennessey Formation. One of the specimens involved in these discussions, UR 183, is from the Hennessey site under consideration here. The specimen was collected a number of years before the site was opened by quarrying, so that its precise level in relationship to more recently obtained materials is not certain, although clearly it was from somewhere within the 5 to 6 feet of beds that have produced the rest of the collection.

Remains of *C. chozaensis* are scattered through all but the very lowest producing bed of the quarry section. Remains are mostly very fragmentary, consisting of scraps of skulls and jaws and occasional vertebrae. These have not been given formal status in the collections and have not been numbered. In the uppermost producing bed partial skeletons, associated with skulls and jaws, occur, but they are very badly fragmented by post depositional movement of the enclosing sediment. The most frequent association is with the lung-fish *Gnathorhiza*, but scraps of other genera and much unidentifiable bone occur at this level. It appears that all that is present has been washed in, deposited in a very soft sediment and badly damaged by compaction and lateral stretching of the matrix.

C. chozaensis is readily differentiated from the smaller species, *C. parvus*, described in this report, by the very poor ossification of smaller specimens, the smallest of which exceeds the adults of *C. parvus* by about a ratio of 2:1. The limb elements have very poorly ossified ends in all but the largest specimens of *C. chozaensis*, whereas the small limb bones of *C. parvus*, which runs up to about 10 mm. in length, are fully ossified. Only if very excellent materials are present for comparison can the two species be differentiated on the basis of morphology, without regard to size. This is most readily done by comparisons of the dentition (see fig. 13). Whether or not there are proportional differences in the skulls, jaws and postcranial structures is difficult to determine because of the distortions to which both species are subject.

Except in the uppermost level of the quarry, *C. chozaensis* is much less abundant than *C. parvus*. The absence of anything but fragments in the middle beds, those in which *C. parvus* is abundant, suggests that remains of *C. chozaensis* may have been carried in from some distance, whereas the smaller species presumably lived close to the site of deposition.

OTHER REMAINS

In addition to the materials described in the preceding pages, many undescribed specimens are in the collections from the Hennessey Quarry. Most of these are unprepared and are either tentatively assignable to the genera and species already known or will be assignable once they have been exposed. Some specimens, however, do not pertain to the described species, but are at present not considered to be sufficient for designation of new taxons or for assignment to established genera or species. In addition to identifiable remains,

a large number of coprolites containing badly decomposed bone, completely unidentifiable, and small agglomerations of macerated but undecomposed bones and teeth are present. The latter, which on occasion do include identifiable specimens, appear to be concentrations that have resulted from regurgitations of undigested hard fragments. The bones often show evidence of breakage, which appears to be due to biting and crushing, and the concentrations may contain two or three species and frequently include small fish scales.

These additional remains add considerably to the knowledge of the assemblage at this site and for that reason are summarized below, even though treatment must be very tentative.

Palaeoniscoid fishes: Small scales that appear to pertain to palaeoniscoid fishes are scattered throughout the deposits and occur in small concentrations in the regurgitated bony pellets. The scales are essentially rhombohedral, ganoid structures with the surfaces marked by several parallel ridges oriented along the long axis of the scale. They all seem to pertain to a single type of fish, but it has not been possible to identify them beyond probable palaeoniscoid affinities. The only other fish remains in the deposits are those of *Gnathorhiza*, for no crossopterygians or xenacanth sharks, which might be part of the fauna, have been found.

Labyrinthodont amphibian: A single "large" central element of a vertebra has been found. It is a crescentic piece, probably a hypocentrum, which measures about 15 to 17 mm. in greatest width. The shape is very different from the hypocentra of *Tersomius*, appearing more like that common to such labyrinthodonts as *Trimerorhachis*. This specimen probably represents a labyrinthodont, but the possibility that it is a reptilian intercentrum cannot be completely excluded. No such intercentra have been found associated with *Captorhinikos*. In the sacral region of *Cotylorhynchus*, however, rather large intercentra occur between the centra proper, fused into the complex in adults. It is possible that in juveniles these elements might be free and that the intercentrum found in the Hennessey locality might have come from this genus. This is improbable, but not impossible.

Pelycosaurs: Unless the intercentrum noted in the last paragraph is pelycosaurian, the only remains that have been found of reptiles of this group appear to be related to the sphenacodonts. One of the odd aspects of the Hennessey Formation and its fauna (see Olson, 1967) is the absence of any carnivorous reptiles, in particular the absence of *Dimetrodon*, which might be expected since it is present in the equivalent Choza Formation of Texas and is also abundant in the

transitional beds from the Garber to the Hennessey, which lie from about 70 to 120 feet lower in the section.

A lower jaw, FMNH UR 1241, illustrated in Plate VIII, appears to be from a small, predaceous pelycosaur. The dentary is strongly developed, with a prominent, anterior, chin-like symphysis and a deep, flat dentary ramus that rises up to form a subdued coronoid prominence. The teeth are somewhat curved, slender, sharp-pointed cones, with the anterior teeth somewhat longer than the posterior. The posterior part of the jaw is damaged so that the presence or absence of an angular flange has not been determined. This specimen appears to be a very advanced sphenacodont reptile, and as such may be of considerable significance. It occurs in deposits of the Early Permian that almost immediately predate those of the Upper Permian from which very primitive proto-therapsids are first known. This specimen is sufficiently preserved to be definitive of a new genus and species, but since work will continue in the quarry, it is hoped that more complete specimens will be found and that they can be used for a more adequate description and diagnosis.

Another small specimen, FMNH 1243, is a maxilla with teeth that are similar to those of the lower jaw of UR 1241. It is about the same size and may possibly pertain to the same species. It does, however, have a fine sculpture pattern, rather like that found in some specimens of *Tersomius*. No sculpturing is present on the outer surface of the dentary of the lower jaw. Assignment thus is uncertain. Also in the collections is a very poorly preserved small skull and lower jaws in which the skull has a temporal fenestra low in the partly preserved temporal area. The teeth seem to be rather different from those of UR 1243, being blunted and more widely spaced and the temporal fenestra lies rather more ventrally than might be expected if the specimen were of a genus as advanced as UR 1243 appears to be. This specimen, UR 1342, probably is a small pelycosaur, but its affinities are very uncertain.

In addition to the small, presumably pelycosaurian specimens, a few large teeth of carnivores have been found, UR 1343. These are without much question the teeth of a large sphenacodont, perhaps *Dimetrodon* (Pl. VII). One was found in the middle zone of the quarry and the others in the upper zone associated with scrappy fragments of bone. They give the first evidence of a large, predaceous carnivore in the Hennessey Formation.

ABBREVIATIONS USED IN FIGURES

ANG, angular	PF, postfrontal
BO, basioccipital	PM, PMX, premaxilla
D, dentary	PO, postorbital
ECT, ectopterygoid	PRF, prefrontal
EXO, exoccipital	PT, pterygoid
FR, frontal	QJ, quadratojugal
IP, interparietal	QU, quadrate
IT, intertemporal	SA, SANG, surangular
JU, jugal	SM, SMX, septomaxilla
JUF, jugular foramen	SP, splenial
L, LA, lacrimal	SPH, SPHETH, sphenethmoid
MX, maxilla	SQ, squamosal
NA, nasal	ST, supratemporal
NAR, naris	STA, stapes
PA, parietal	TA, tabular
PAL, palatine	TF, TEMP FEN, temporal fenestra
PAS, parasphenoid	VO, vomer
PER, periotic	

ABBREVIATIONS USED IN DESIGNATION OF SPECIMENS

FMNH, Field Museum of Natural History
KU, University of Kansas
OUSM, University of Oklahoma, Stovall Museum

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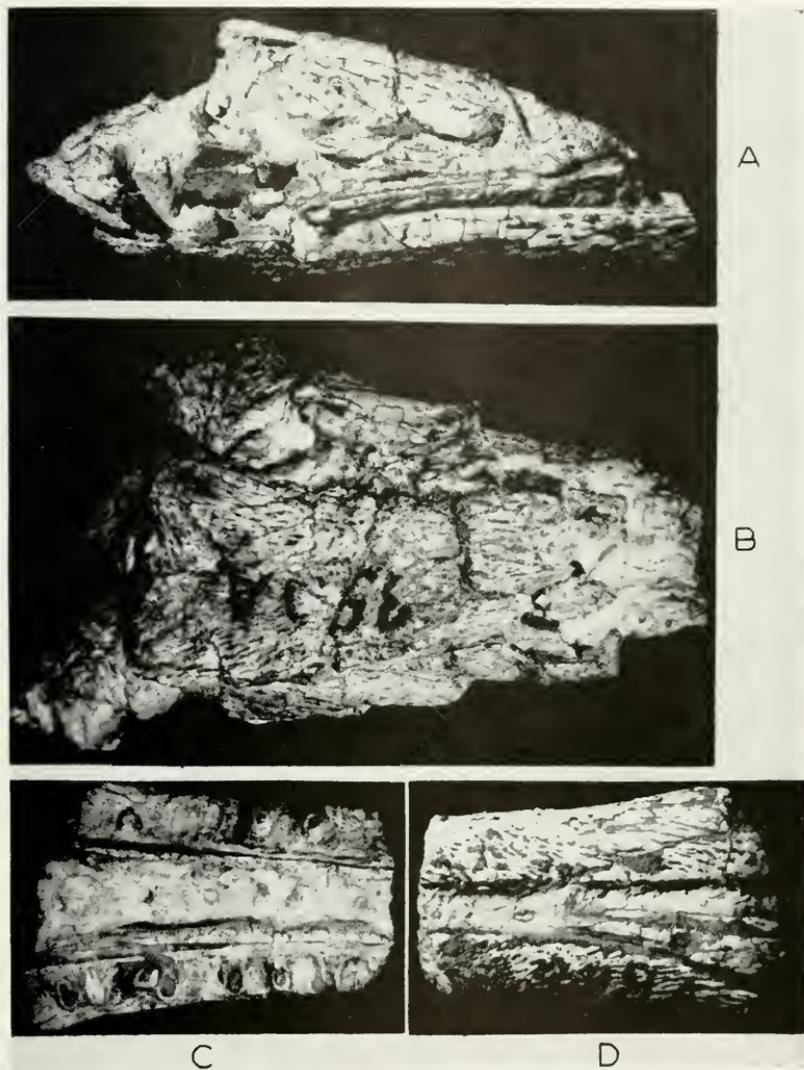


Plate I. *Cricotillus brachydens* Case.

A. Skull, lateral, K. U. 350.

B. Skull, dorsal, K. U. 350.

C. Lower jaw fragment, dorsal, holotype, K. U. 349.

D. Lower jaw fragment, ventral, holotype, K. U. 349.

All $\times 1.5$.

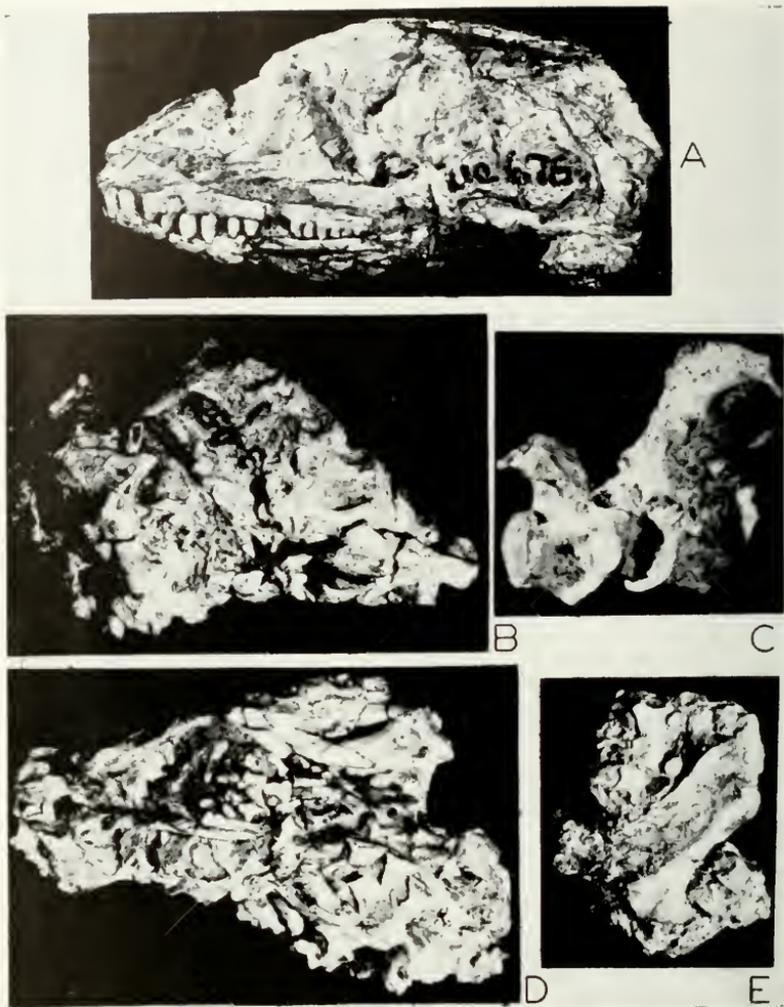


Plate II. *Pleuristion brachycolous* Case.

- A. Skull, lateral, UC 676, $\times 1.6$.
- B. Skeleton in nodule, OUSM 3-0-S19, $\times 1.2$.
- C. Skeleton in nodule, OUSM 3-0-S19, $\times 1.2$.
- D. Vertebrae of holotype, K. U. 351a, $\times 2.4$.
- E. Vertebrae and femur of referred specimen, K. U. 351b, $\times 1.25$.



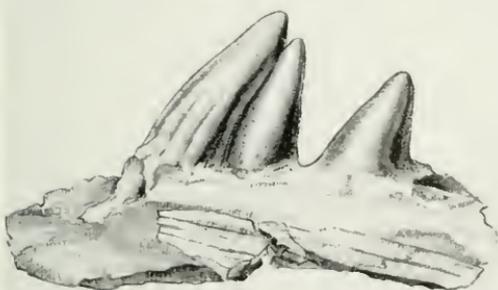
Plate III. Bone concentrate in matrix from Wellington, Perry site 6, from which isolated elements of *Dictyobolus tener* n. g. and sp. have come. This is typical of the concentrations that occur in the sandy shale lenses.

Plate IV. Drawings of *Dictybolos tener* n. g. and sp. to show details of some structures.

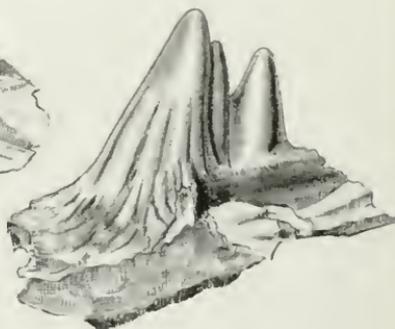
- A. Pterygoid in ventral view, UR 1043.
 - B. Small part of dentary showing basal fluting of teeth, lateral.
 - C. Small part of dentary showing basal fluting of teeth, posterior.
 - D. Large tooth showing strong development of fluting and the broad base in postero-lateral aspect, UR 1132.
 - E. Maxillary teeth showing distal fluting, UR 1157.
- All much enlarged.



A



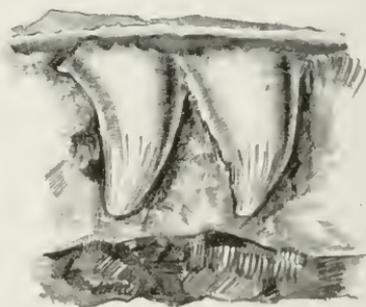
B



C



D



E



Plate V. The quarry site in the Hennessey in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 8 N., R. 2 W. Various stages in the excavation are shown.

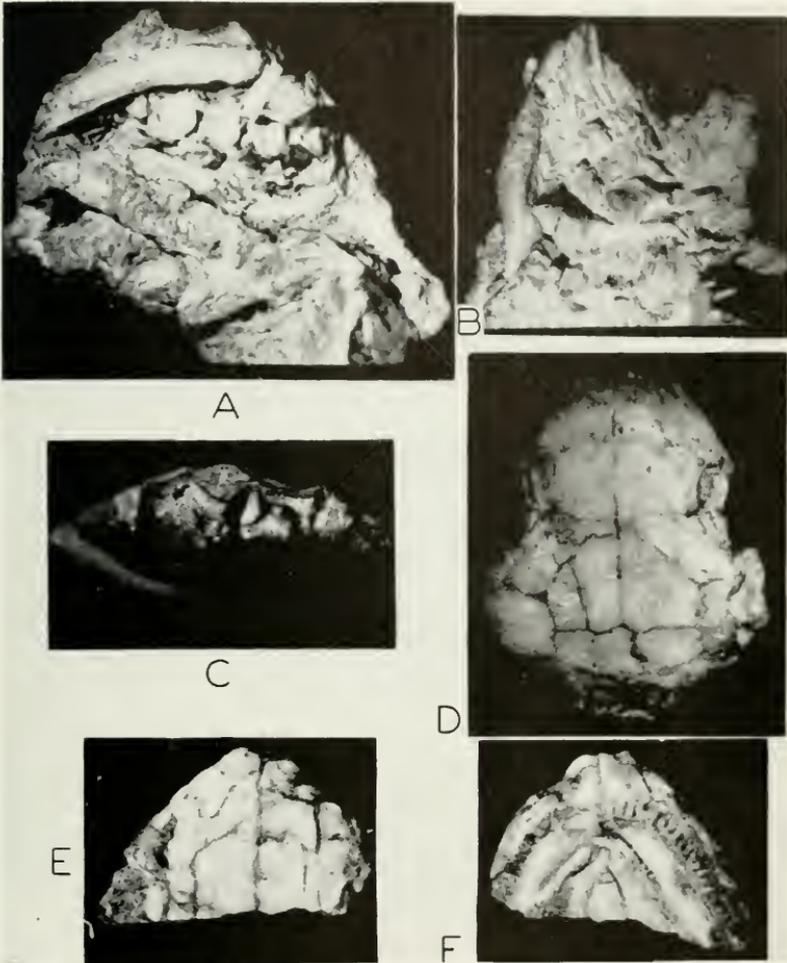


Plate VI. A. *Tersomius mosesi* n. sp., part of lower jaw and vertebrae in ventral view, UR 1220, $\times 2$.
 B. *Tersomius mosesi* n. sp., UR 1285, part of jaw and limb elements, $\times 2$.
 C. *Goniorhynchus storalli* n. g. and sp., left side of back of skull from ventro-postero-lateral, showing stapes and its relationships to surrounding elements, UR 1040, $\times 5.0$.
 D. Skull of holotype of *G. storalli* in dorsal view, UR 1039, $\times 3.0$.
 E. Snout of *G. storalli* in dorsal aspect, UR 1341, $\times 3.0$.
 F. Snout of *G. storalli* in ventral aspect, UR 1341, $\times 3.0$.

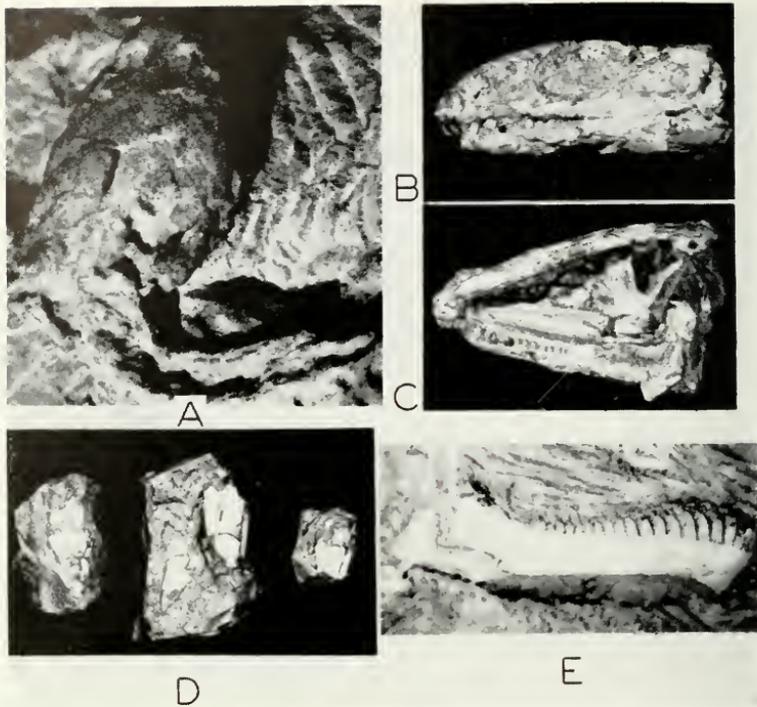


Plate VII. A. Skull and part skeleton of *Peroncdon primus* n. g. and sp. UR 1234, $\times 4$.
 B. Skull of *Captorhinikos parvus* n. sp., lateral view of holotype UR 1250, $\times 1.6$.
 C. Skull of *Captorhinikos parvus* n. sp., palatal view of holotype UR 1250, $\times 2.0$.
 D. Teeth of carnivorous pelycosaurs, UR 1343, $\times 0.8$.
 E. Lower jaw of very small sphenacodont pelycosaur, UR 1241, $\times 4$.



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