FIELDIANA · GEOLOGY

Published by
CHICAGO NATURAL HISTORY MUSEUM

Volume 10 OCTOBER 22, 1959 No. 34

A REVIEW OF THE FAMILY CAPTORHINIDAE

RICHARD J. SELTIN
DEPARTMENT OF GEOLOGY, MICHIGAN STATE UNIVERSITY

INTRODUCTION

This study was undertaken as a result of previous work on the fauna of several early Permian fissure fills in Oklahoma. It was very difficult to determine the species of captorhinomorph reptiles present in these fills by reference to the literature, although it seemed certain that the genus was *Captorhinus*. As a result, a study of this genus was undertaken in an attempt to define the species more closely. At the suggestion of Dr. Everett C. Olson, this study was extended to comprise all of the genera then included in the Captorhinidae. This family contains all of the captorhinomorph reptiles found in early Permian deposits of Clear Fork and later age and a few specimens of one species from the Wichita.

This study is a continuation of a program for the study of the order Cotylosauria which began with Price's study of *Captorhinus* in 1935. That program was continued by White's work on *Seymouria* (1939) and Olson's (1947) study of the family Diadectidae.

The family Captorhinidae has not been studied in its entirety since 1911, when Case's revision of the Cotylosauria appeared. At that time there were two known genera in the family. As a result of discoveries by Stovall (1950) and Olson (1951, 1954a) six genera were included as members of this family at the beginning of this study. It is apparent that these forms need revision.

GEOLOGICAL AND GEOGRAPHICAL LIMITS OF THIS WORK

There is some disagreement as to the delimitation of the various stages of the North American Permian. Romer (1935) and Romer and Price (1940) place the Clyde and Leuders formations in the

Library of Congress Catalog Card Number: 59-15789

Clear Fork group. Olson (1955) places the Clyde in the Wichita group and the Leuders in the Clear Fork. The sediment of the Clyde suggests that it belongs with the Wichita group, while the fauna is a mixture of Clear Fork and Wichita elements. It was most likely a time of transition in fauna and the problem of the assignment of the Clyde may never be settled.

The position of the early-middle Permian boundary line presents another problem. Olson and Beerbower (1953) concluded that the Choza is the most recent formation of the early Permian. This formation is followed by a disconformity and then by the San Angelo formation, which Olson and Beerbower consider to be the oldest of the middle Permian. The reasoning for this is two fold: (1) the disconformity between the Choza and San Angelo, and (2) the difference in make-up of the two formations. This evidence, although not conclusive, is rather convincing. The possibility does exist that this break is merely a group boundary, such as that between the Wichita and Clear Fork groups.

Table 1 (Appendix A) gives the divisions of the North American (Texas) Permian as used here. Permian formations in other states will be discussed later in this study.

Until recently the captorhinomorphs have been found only in North America. There was no apparent reason for their limitation, and their discovery in the Old World has been more or less expected. Dr. Olson has informed me of a recent letter (1956) in which E. Efremov reports the discovery of a captorhinid in the Russian Permian. This form apparently is very similar to the Texas genus *Rothia*. There is certainly little reason not to expect this abundant group to have migrated to the Old World.

One group, the Millerettidae of the South African Permian, has been assigned to the Captorhinomorpha by various workers, including Romer (1945).[1] Broom (1938), who discovered and described these forms, says that there is a superficial resemblance to *Captorhinus*. "When, however, the occiput and the palate are examined it is manifest that the little skull differs considerably from that of *Captorhinus* and all other known cotylosaurs, and will probably have to be placed in a distinct order." Later Broom does assign this family to the Cotylosauria, but not to the Captorhinomorpha. He does not explain this change. Watson (1957) has since studied the group

[1] Romer, in his recently published *Osteology of the Reptiles* (1956, University of Chicago Press), no longer classifies the Millerettidae in the Captorhinomorpha.

and places the family Millerettidae, together with *Mesenosaurus* and *Broomia*, in a new order, the Millerosauria, which he includes in his sauropsid reptiles.

CLASSIFICATION

The taxonomy of the captorhinomorphs has long been in dispute. They were originally placed in the order Cotylosauria, set up by Cope (1880a) on the basis of the genus *Empedocles* (now considered a synonym of *Diadectes;* Olson, 1947), a member of the diadectamorphs. Cope (1896a and b) later included the captorhinomorphs (then the family Pariotichidae) in his discussion of the Cotylosauria. Below is his classification:

Order Cotylosauria
  Family Elginidae
  Family Pareiasauridae
  Family Diadectidae
  Family Pariotichidae

The first disagreement came from Case (1905a, b), when he suggested that the Diadectidae be separated from the Cotylosauria. Williston (1908) said that Case was violating the laws of nomenclature, noting that the name Cotylosauria would have to include the Diadectidae, since the name of the order was based on that family. In his revision of the Cotylosauria in 1911 Case again included the diadectids in that group:

Order Cotylosauria
  Suborder Diadectasauria
  Suborder Pareiasauria
    Family Pariotichidae
    Family Captorhinidae
    Family Seymouridae
    Family Pareiasauridae
  Suborder Procolophonia

Case's classification has been altered slightly on the family level by various authors. Romer's (1945) classification of the group is the one most generally accepted:

Order Cotylosauria
  Suborder Captorhinomorpha
    Family Solenodonsauridae
    Family Limnoscelidae
    Family Captorhinidae
    Family Protorothyridae
    ?Family Millerettidae
  Suborder Diadectamorpha

The position of the family Millerettidae has already been discussed. The pareiasaurids and procolophonids Romer includes under the Diadectamorpha.

Students of primitive reptiles have objected to the inclusion of the captorhinomorphs and the diadectamorphs under one order. The first worker to disagree with the validity of the order Cotylosauria was Sushkin (1927). He studied the development of the mandibular and hyoid arches in primitive tetrapods and reached the conclusion that there were three separate lines of development in the reptiles—a diadectid, a pareiasaurid, and a captorhinomorph.

Broom, in 1938, also questioned the contents of the order Cotylosauria. His ideas express the situation very well: "The order Cotylosauria is at present in an unsatisfactory position. Originally it was proposed for reptiles allied to *Diadectes*. Since then it has been customary to place in it all reptiles with a roofed temporal region. Doubtless they are all Permian and Triassic forms, and all are more or less primitive. But pretty manifestly we have in the Cotylosauria groups that are not at all closely related. When we know more of the structures of some of the forms a reclassification will be necessary."

Olson (1947) has made such a study of the structure of some of these forms, particularly those of the family Diadectidae. In that work Olson mainly studied the otic and basicranial regions. This resulted in the proposal of a new major classification of the reptiles:

CLASS REPTILIA

Subclass Parareptilia
    Order Diadecta
Subclass Eureptilia
  Infraclass Captorhina
    Order Captorhinomorpha

Olson does not go into detail below the ordinal level. His Parareptilia includes those reptiles which have more or less retained the amphibian otic condition, his Eureptilia those which have lost the otic condition seen in the Amphibia. His classification therefore discards the order Cotylosauria. Watson (1954) divides the primitive reptiles in a somewhat similar manner, but he uses Goodrich's terms of Theropsida (Captorhinomorpha) and Sauropsida (Diadectamorpha). This classification differs from Olson's in that Watson has the captorhinomorph line giving rise to only the mammal-like reptiles and the diadectamorph line giving rise to all the rest of the reptiles. In Olson's classification the latter gives rise to the turtles and a few other forms, while the captorhinomorph line gives rise to most of the rest of the reptiles, the "true reptiles" of Olson. Both agree, however, on a diphyletic line of origin of the reptiles from the amphibians.

The classification I shall use here is given below. Included are the known geologic ranges of the genera I have studied.

Class Reptilia

- Subclass Eureptilia
  - Infraclass Captorhina
    - Order Captorhinomorpha
      - Family Protorothyridae
      - Family Limnoscelidae
      - Family Captorhinidae
        - *Captorhinus:* Admiral to late Vale.
        - *Labidosaurus:* early Clyde to late Arroyo.
        - *Captorhinoides:* early Vale only.
        - *Rothia:* San Angelo and Flower Pot.
        - *Labidosaurikos:* early Vale to early Choza.
        - *Captorhinikos:* early Vale to early Choza.

METHODS

The types of the species of *Captorhinus* are in the American Museum of Natural History, as is the type of *Labidosaurus hamatus*. The type specimens of *Labidosaurikos meachami* and of *Labidosaurus oklahomensis*, n. sp. (see p. 479), are in the Museum of the University of Oklahoma. The former is represented in the collections of Chicago Natural History Museum by a good cast. The latter I was privileged to examine and name. The types of the remainder of the species studied are in the collections of Chicago Natural History Museum. No specimens of the genus *Paracaptorhinus* (Watson, 1954) were available for study and so that genus is not included in this work. The type of *Captorhinus aduncus* was not examined in detail, since it was on exhibition at the American Museum of Natural History. No other specimens have been assigned to this species.

In referring to specimens the following abbreviations have been used: AMNH = American Museum of Natural History; CNHM = Chicago Natural History Museum; MCZ = Museum of Comparative Zoology; MUO = Museum of the University of Oklahoma.

Seven measurements were made on the skulls of *Captorhinus* and *Labidosaurus* with the idea of testing the morphological separation of the two genera and of their species. These were made to the nearest 0.1 mm. with vernier calipers and are graphically illustrated (fig. 190). Abbreviations used in the tables of measurements are given below:

Skl = skull length, along mid-dorsal line.
Nal = nasal length, along mid-dorsal line.
Frl = frontal length, along mid-dorsal line.
Pal = parietal length, along mid-dorsal line.
Ol = maximum length of orbit.
O-Sl = maximum distance from anterior edge of orbit to tip of snout.
Mxl = length of maxillary.
Iow = interorbital width.

Abbreviations of the names of the various cranial elements used in the figures throughout the text are as follows:

ang = angular
art = articular
bo = basioccipital
bs = basisphenoid
d = dentary
dso = dermosupraoccipital
ept = epipterygoid
fr = frontal
j = jugal
l = lacrimal
mx = maxillary
n = nasal
qj = quadratojugal
pa = parietal
pal = palatine
pas = parasphenoid
po = postorbital
pof = postfrontal
prf = prefrontal
pmx = premaxillary
pt = pterygoid
st = stapes
sang = surangular
sq = squamosal
ta = tabular

A technical problem encountered in this study was the difficulty of making accurate illustrations. This was solved by photographing the fossils on black and white 35 mm. film. After development the negatives were clipped and mounted in 2×2-inch glass slides. These were then projected onto paper and the outlines drawn. The figures were then compared to the fossil material, and details, such as suture lines, were added. This could not be done with the American Museum material since the pictures were not developed until after I had returned from New York. Therefore sketches were made showing the detail. After the correct outline had been drawn, these sketches were used to add details. There may be some objection to this procedure since there is a certain amount of distortion in the projection, but this method is more accurate than sketching directly from the fossil.

CAPTORHINUS and LABIDOSAURUS

INTRODUCTION

These two genera are treated together in this section for two reasons. The first is their close relationship, which will be demonstrated later in this section. The second is that of the family Captorhinidae only these two genera are sufficiently well represented in numbers of specimens to lend themselves to good quantitative analysis of interspecific and intergeneric characters.

In the most recent diagnosis of these two genera (Case, 1911) there were four species assigned to *Captorhinus* and two to *Labidosaurus*. A new species of *Labidosaurus, L. oklahomensis,* is here described.

The analyses by Case (and earlier by Cope) of the species of each genus will be discussed separately. Following the discussion of the species of each genus an analysis of those species will be made.

Class **REPTILIA**

Subclass **Eureptilia**

Order **Captorhinomorpha**

Family **Captorhinidae**

Genus **Captorhinus** Cope

Captorhinus angusticeps Cope (1896)

Type.—AMNH no. 4438, imperfect skull, Cope Collection.

Horizon and locality.—Arroyo formation, Clear Fork group, early Permian, Coffee Creek, Baylor County, Texas.

Referred specimens.—AMNH nos. 4457 and 4334, two good skulls, West Coffee Creek, Baylor County, Texas.

Revised description (from Case).—"Larger; median upper incisors abruptly larger than the others and bent sharply backward. The fifth maxillary much larger than the others, the succeeding teeth much smaller than the preceding."

Captorhinus aguti (Cope) (1882). Figure 190.

Type.—AMNH no. 4333, well-preserved skull, Cope Collection.

Horizon and locality.—Arroyo formation, Clear Fork group, early Permian, Coffee Creek, Baylor County, Texas.

Referred specimen.—AMNH no. 4344, partial skull, Arroyo formation, Baylor County(?), Texas.

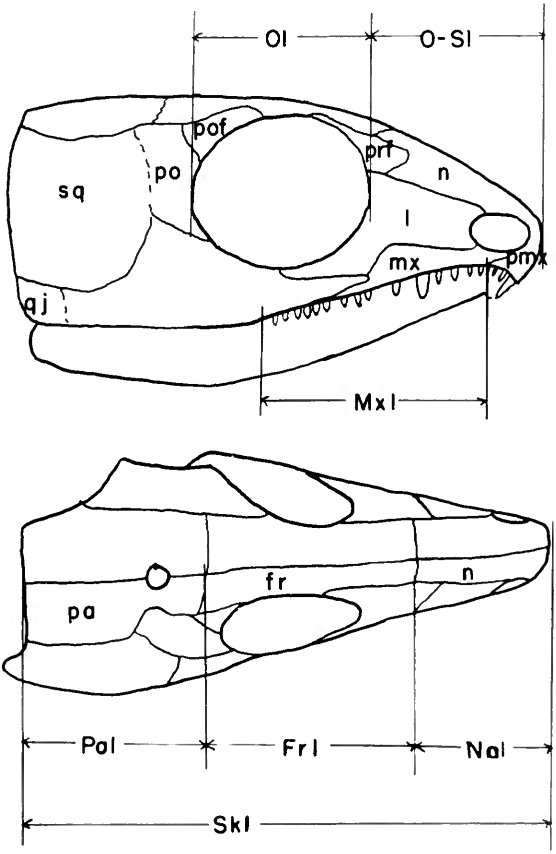

FIG. 190. Lateral and dorsal views of skull of *Captorhinus aguti*, CNHM-UR 382; × 1⅓.

Description (after Case and Cope).—Smaller; median upper incisors not larger than the others; incisors increasing in size regularly toward the median line. The third, fourth, and fifth maxillary teeth larger than the others. Skull wide at the temporal regions, flat above, and narrowed and compressed anterior to the orbits. Premaxillary alveolar border forms an angle of 45 degrees to the maxillary alveolar border. Sculpture on posterior part of frontals strong ridges radiating posteriorly and situated close together.

Captorhinus isolomus Cope (1896)

Type.—AMNH no. 4338, well-preserved skull, Cope Collection.

Horizon and locality.—Arroyo formation, Clear Fork group, early Permian, Coffee Creek, Baylor County, Texas.

Referred specimens.—CNHM–UC 1702, Arroyo formation, early Permian, Texas.

Description (after Case).—This species resembles *C. aguti* in most particulars, but the skull is wider and lower in proportion to the length. The difference was at first thought to be due to crushing, especially as the skull of *aguti* is somewhat compressed from side to side, but there is also a notable difference in proportions of the parietal bone. Incisor teeth directed back at an angle of 45 degrees. The skull is equilateral and the posterior superior border is nearly straight. In the sculpture of the posterior surface of the skull the longitudinal striae are more prominent than the transverse ones that connect them, except on the muzzle where they are equally conspicuous.

Captorhinus aduncus Cope (1896)

Type.—AMNH no. 4332, imperfect skull and few fragments of skeleton, Cope Collection.

Horizon and locality.—Arroyo formation, early Permian, Texas.

Referred specimens.—None.

Description (after Case and Cope).—Smaller, size of *aguti;* median upper incisors abruptly larger than the second pair, but not so much so as in *angusticeps.* Fifth maxillary larger than the first four, the sixth and seventh diminishing in size from the fifth, but larger than the succeeding teeth. The surface is sculptured with shallow pits connected by rather thick ridges. The recurvature [of the premaxillary] exceeds that seen in any other species of the genus. The orbits are larger than in any other species, exceeding the interorbital width considerably.

ANALYSIS OF THE SPECIES

Introduction.—Case, and before him Cope, used the following characters to separate the several species assigned by Case to the genus *Captorhinus:*

The position of the large maxillary tooth (or teeth); the abrupt difference in size of the median premaxillary tooth (or teeth); and the angle of the premaxillary alveolar border with that of the maxillary. Case also used the size and shape of the skull, the sculpture, the proportions of the bones and the size of the orbits. In addition, in my preliminary examination of this genus I felt that actual number of rows of maxillary and dentary teeth and actual number of premaxillary teeth would be of importance.

There appear to be a great number of characters used in the separation of the species of *Captorhinus*. Even using these characters, however, one cannot accept without question the division of the genus made by Case in 1911. Case himself said that "... each specimen might be considered as distinct and numerous species formed with characters given; or, with a little more freedom, all might be placed in a single species."

The species of *Captorhinus* have been listed above, together with the characters used to differentiate them. It now seems of value to examine these characters individually to see if their actual value as criteria for specific determination may be determined. As many of these characters as possible will be assessed quantitatively by means of frequency distribution histograms and scatter diagrams of measurements. The remainder will be analyzed in relation to their probable taxonomic value.

Size.—Such terms as "larger" and "smaller" have been used a great deal in taxonomic description of fossil material, but relative terms such as these are misleading and more information is needed than they convey.

The first problem in this examination of the use of size in describing species is to determine exactly what *is* "larger" or "smaller." Apparently the taxonomist means that the animal (skull here) is larger or smaller in general; that is, any one gross measurement (such as skull length) will always be larger (or smaller) in one species than in another. This leads directly to the next point, which is the question of the amount one species is larger or smaller than the other.

Table 2 (Appendix A) gives several measurements made on all the available skulls of *Captorhinus*. From this table a frequency histogram has been constructed (see fig. 191) on the basis of the measurement of skull length. Only one point falls out of the central grouping. This is the measurement of AMNH no. 4760, assigned by Case as a homotype of *Pariotichus brachyops*. This specimen is quite likely an immature *Captorhinus*, since it in no way differs from that genus.

The histogram shows no tendency toward polymodalism, as might be expected if species of this genus could be separated on the basis of differences in size. This histogram indicates that size alone may not be used as a character for the separation of species of *Captorhinus.*

Position of the large maxillary tooth.—This character has been used as one of the basic means of differentiating species in this genus. The eight measurements given in Table 2 are insufficient for testing this character and so an additional sample was measured. This consisted mainly of isolated maxillaries from a group of fissure fills, thought to be Arroyo in age, from Richard's Spur, Oklahoma. These measurements are presented in Table 3 (Appendix A). In the sample of 32 specimens, 20 have the fourth maxillary tooth as the largest, and in 11 the third is the largest. In no case is the fifth maxillary the largest, although in two cases where the third is the largest, the fifth is slightly larger than the fourth. In one case the third and fourth are essentially the same length.

FIG. 191. Frequency histogram showing distribution of skull lengths in *Captorhinus.*

Figure 192, A, B and C, gives the histograms of, respectively, the lengths of the third and of the fourth maxillary teeth and the ratio of the third to the fourth. These histograms are not very definitive. Those of the actual measurements are fairly bell-shaped, without a great deal of skewness. The histogram of the ratios is heavily skewed to the left, and the only allowable conclusion is that in most cases the fourth tooth is dominant over the third. That is already known.

Since the histograms were indefinitive, a scatter diagram was prepared (see fig. 192, D) plotting the actual length of the third tooth versus that of the fourth. At first glance it would appear that two

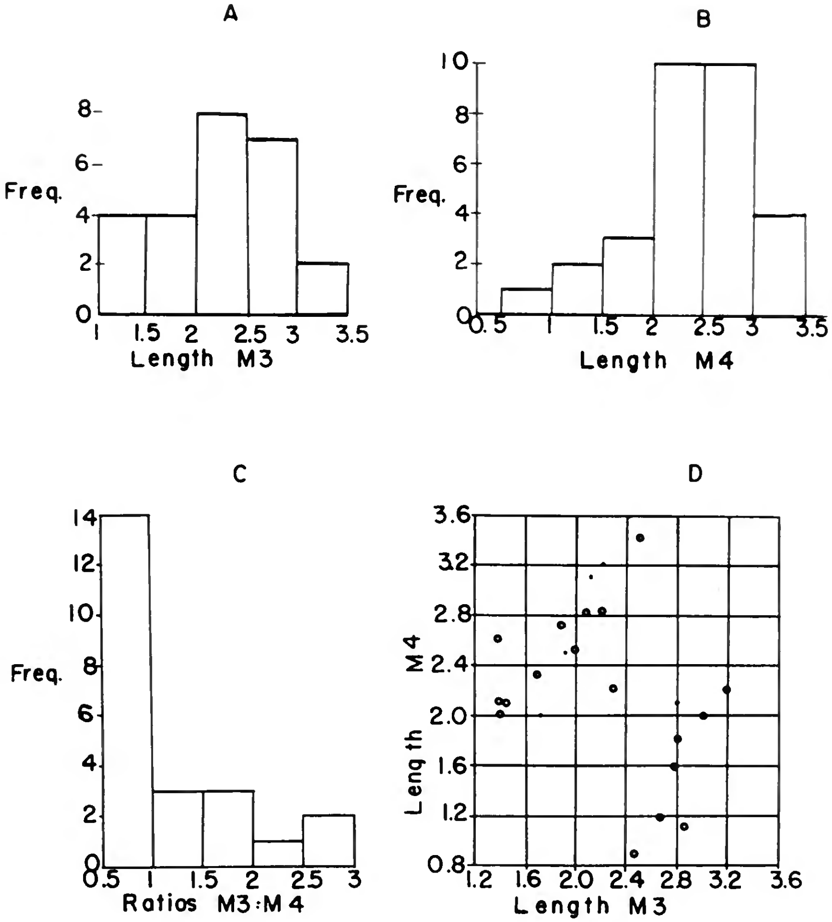

FIG. 192. Maxillary teeth of *Captorhinus:* A–C, frequency histograms of, respectively, lengths of third and fourth maxillary teeth and ratios of the two. D, scattergram plotting length of third versus length of fourth maxillary teeth. N=23. Dots represent specimens from the Texas Arroyo, circles those from the Oklahoma fissure fills.

different groups are represented in the scattergram. Yet this situation may be explained more satisfactorily in another way.

The majority of the specimens represented in this graph were taken from a site that is very local and quite homogeneous (so far as preservation, matrix, etc. are concerned). It is extremely unlikely (although possible) that more than one species is present under such conditions. If the hypothesis that one species is represented in this one locality be accepted then an explanation must be found, other than taxonomic differentiation, for the two lines on the scatter diagram.

Apparently, at some stage during the growth cycle, varying in individuals, the fourth tooth becomes the dominant one. In the younger stages the third tooth is dominant. This can come about in at least two ways: (1) Replacement may take place in either the third or fourth tooth. It would appear from the scatter diagram that, if this is the case, it would have to be the third tooth that was replaced by a smaller one. (2) A new tooth may be added anterior to the third maxillary tooth, thus putting the third tooth in the fourth position so that the same tooth is actually dominant, but in a different position. The scatter diagram supports this idea. In only one individual in the Chicago Natural History Museum collections (CNHM–UR 242) have I observed the fifth tooth to be the largest. This is a large individual and therefore possibly represents a second (or later) stage in this growth process.

This character appears to be part of the growth pattern of the individual animal and therefore it should not be used for the separation of the species of *Captorhinus*.

Abrupt difference in length of the median premaxillary tooth.—This character again is used to separate three of the four species of *Captorhinus: angusticeps, aguti* and *aduncus*. The first and second premaxillary teeth have been measured on a number of specimens from the Richard's Spur fissure fills and from the Texas Arroyo (see Table 4, Appendix A).

A histogram of the ratios of the first to the second premaxillary teeth is given (fig. 193). For the first time a bimodal distribution is indicated. One explanation of this is that the histogram supports

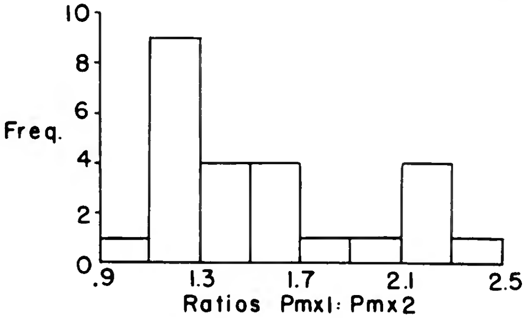

FIG. 193. Frequency histogram showing distribution of ratios of first to second premaxillary teeth in *Captorhinus*.

Case's hypothesis of two types of premaxillary dentition in *Captorhinus*. *C. angusticeps* might be represented by the group with the higher ratios, and *C. aguti* and *C. aduncus*, which have the same premaxillary characteristics, by the group with the lower ratios.

It is possible that this bimodal distribution is only a result of the sample used. The sample here, however, does not appear to differ fundamentally from the sample used in the discussion of the position of the large maxillary tooth, which was not bimodal. In both cases the larger part of the sample (17) is from the fissure fills at Richard's Spur, Oklahoma. The sample is too small to put very much confidence in, but, from the similarity to the previous sample, it seems best to accept the bimodality as indicated.

There may be a sexual difference in this genus. Although sexual dimorphism in dental characters of modern reptiles has not been reported, it has been theorized for some fossil forms. In some pelycosaurs Romer and Price (1940) have noted dental differences which they attributed to sexual dimorphism. Characters of this nature have also been reported in the anomodonts.

In the absence of any supporting character, the difference in the premaxillary dentition should not be used to separate the species of the genus *Captorhinus*.

Skull shape.—The use of the shape of the skull in taxonomy presents a difficult problem. In this case it does not lend itself well to quantitative study. Shape is much too easily affected by post-depositional crushing and twisting. Such appears to be the case in *Captorhinus*, in which all the material from a certain horizon or locality will be of one shape and that from another horizon or locality a different shape; for example, all the skulls from the Mitchell Creek area of the Clyde formation have broadly expanded posterior regions, and so are triangular. Those specimens from the Richard's Spur fissure fills generally have a narrow posterior region and therefore are rectangular.

Examination of the skulls in the collections of Chicago Natural History Museum shows all the stages from the triangular shape through various stages of crushing to a completely rectangular shape. This character appears to be determined by mode of preservation, particularly post-depositional deformities. From my observations it would appear that those specimens with a triangular shape are the least distorted, and therefore that the skull was triangular in the living animal. This character should not be considered a reliable character for separating the species of *Captorhinus*.

Sculpture.—Cope made some use of this character in the separation of the species discussed here. It is, unfortunately, a very difficult, if not impossible, character to treat quantitatively. Observation of specimens has shown little difference. Examination of 24 skulls in the Chicago Natural History Museum collections shows generally that the types of sculpture present could be derived from one type or could be variations of that type. There appears to be no correlation of sculpture with any other character; so sculpture must be considered insufficient as a taxonomic character.

Angle of the premaxillary bone with the maxillary.—Observation of specimens shows the angle between the premaxillary and maxillary alveolar borders to range from zero to 60 or 70 degrees. It appears to be affected greatly by crushing and other post-depositional forces. Probably the normal angle is about 45 degrees, which is seen in most of the apparently least crushed specimens. Since it is affected so by crushing, the angle cannot be considered a good taxonomic criterion for separation of the species of this genus.

Size of orbits.—Cope used this character to some degree to separate species. It was considered especially important in relation to interorbital width. A frequency histogram based on ratios of interorbital width to orbital length is presented (fig. 194, A). This shows a bell-shaped distribution with only one specimen (AMNH no. 4760, a very small individual) falling out of this distribution.

A scatter diagram of orbital length versus skull length is given (fig. 194, B). The alignment of points is even better than might be expected in a character such as orbital length, which is so greatly affected by crushing. AMNH no. 4760 falls well in line with the rest of the specimens of *Captorhinus.*

The above data show that neither actual orbital size nor the position of the orbit in the skull may be used as a criterion for the separation of species in *Captorhinus.*

Proportions of bones.—Scatter diagrams have been prepared on the basis of the measurements given in Table 2. The total sample here consists of 49 complete and partial skulls. Sample correlation coefficients (r) were determined for 21 of these scatter diagrams by Olson and Miller (1951). Six of these ranged from r-0.90 to r-0.95; nine from r-0.80 to r-0.89; and only two were below 0.70. These last two were interorbital width versus orbital length, at r-0.64, and orbital length versus orbito-snout length, at r-0.63. Orbital length is a measurement that is thought to be affected by crushing, and correlation coefficients based on this measurement might be expected to be low. Nevertheless all indicated a population correlation coefficient (rho, ρ) greater than zero. According to a chart of confidence values in sample correlation coefficients (r) (Dixon and Massey, 1951), with a sample size of 50 and an r of 0.60, 95 per cent of the time ρ can be expected to be 0.40 or higher.

Two of the scatter diagrams are reproduced (fig. 195); figure 195, A, is that of the highest correlation coefficient (r is 0.95), skull length versus frontal length, and figure 195, B, is that of one of the lowest (r is 0.64), orbital length versus interorbital width. An intermediate level correlation coefficient is that for the scatter diagram of skull length versus orbital length (fig. 194, B; r is 0.80).

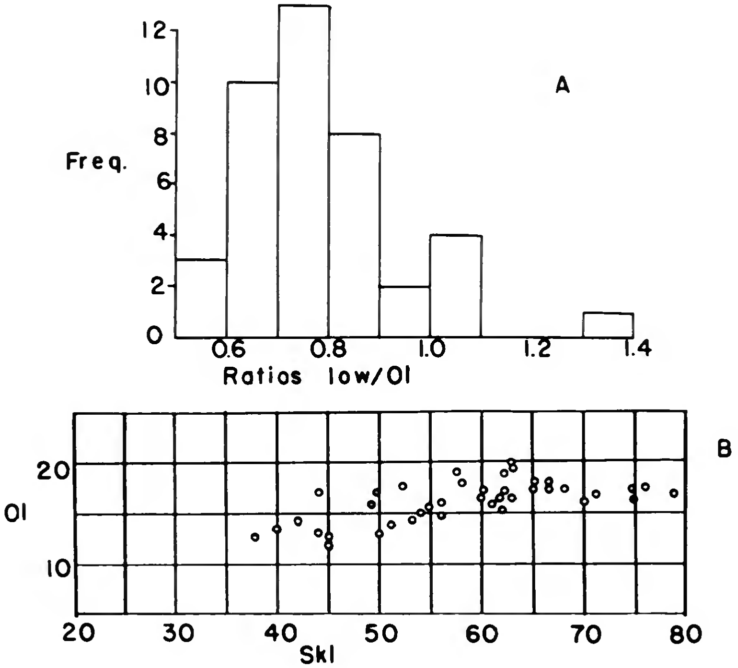

FIG. 194. *Captorhinus:* A, frequency histogram showing distribution of ratios of interorbital width to orbital length. B, scatter diagram plotting skull length versus orbital length. N=40; r=0.80.

The most logical conclusion to be drawn from these data appears to be that the species of *Captorhinus* may not be separated on the basis of proportions of bones, at least so far as the measurements used here are concerned.

Number of rows of teeth.—The number of rows of teeth increases with age and this is therefore a growth character. It is not suitable for the separation of species in this genus. This conclusion is reached after study of all specimens. The number of rows can be seen in only a few specimens, except for the numerous jaws from the fissure fills at Richard's Spur, Oklahoma. In the latter case the smallest specimens have two rows and the largest (though still relatively small) have three. Four rows have been observed in only two of the largest specimens: AMNH no. 4344 and CNHM-UR 118.

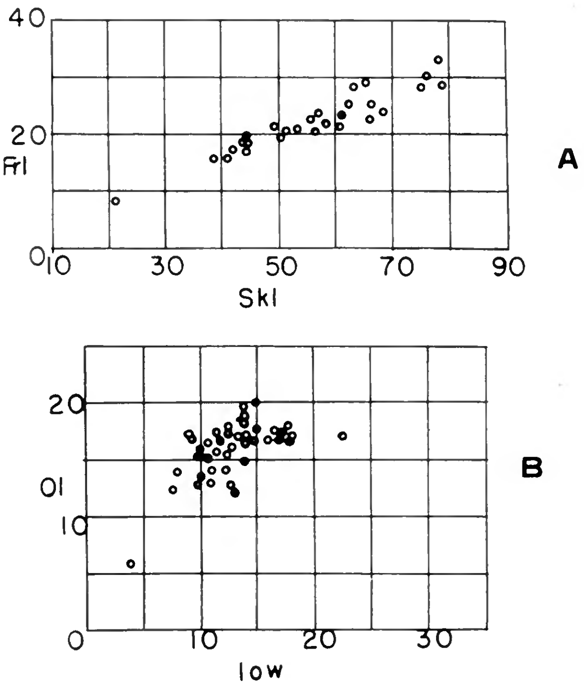

FIG. 195. *Captorhinus:* Scattergrams plotting (A) skull length versus frontal length (N=28; r=0.95), and (B) interorbital width versus orbital length (N=41; r=0.64).

CONCLUSIONS

On the basis of the above evidence it appears highly probable that Case's tentative division of the genus *Captorhinus* into four species is untenable. In this sample there is no evidence of the existence of more than one species of *Captorhinus*—*C. aguti* (Cope), originally described as *Ectocynodon aguti* Cope (1882), but removed from that genus and assigned to *Captorhinus* by Case in 1911.

PRE-CLYDE AND POST-ARROYO CAPTORHINUS

Pre-Clyde forms.—Two specimens of *Captorhinus* are known in which the horizon is definitely Wichita in age. These are MCZ 1160 from the Belle Plains and MCZ 1478 from the Admiral formation. I have not seen either of these specimens, but Dr. Olson, who measured them, informs me that he could detect no morphological difference from *Captorhinus*. In addition, Watson (1954) has figured MCZ 1478 (without assigning it a name) and I can detect no differences on the basis of his figures. Both have four premaxillary teeth, with the two medial ones of equal length in MCZ 1478 and the most medial one somewhat larger in MCZ 1160. In both cases the lateral two premaxillary teeth are much smaller. Both have the fourth and fifth maxillary teeth elongated.

Skull measurements are given with those of the rest of the specimens of *Captorhinus* (Table 2, Appendix A). Ratios were figured on these specimens and plotted on histograms together with the ratios of the rest of the specimens in Table 2. In no case do the measurements (or the ratios) fall outside the distribution for the rest of the specimens. In fact, in most instances the ratios fall in the modal class or else in the size class on either side of the modal class. They also fall in line with the other specimens in all scatter diagrams. No morphological differences have been observed. For these reasons these two specimens are included in the species *Captorhinus aguti*.

Post-Arroyo specimens.—Olson (1954a) lists a specimen (CNHM-UR 118) from the late Vale as *Captorhinus aguti*. The specimen is not complete enough for measurement, but Olson's assignment appears to be valid.

This makes *C. aguti* one of the most long-lived species of Permian reptiles. It ranges from the Admiral formation of the Wichita group through the Vale formation of the Clear Fork group.

Genus **Labidosaurus** Cope 1896

Labidosaurus hamatus (Cope) 1896

Type specimens.—AMNH no. 4341, poorly preserved skull, very little bone left on external surface; Cope Collection.

Horizon and locality.—Arroyo formation, early Permian, West Coffee Creek, Baylor County, Texas.

Referred specimens.—See Appendix B. CNHM–UR 161 is shown in Figure 196.

Description (after Case).—At least twice the size of *Captorhinus*. Skull acuminate anteriorly, very wide posteriorly. Orbits of moderate size, located near middle of skull. Teeth obtusely conical. Maxillary teeth not greatly different in size. Median incisors much larger than others and bent sharply backward. Teeth in more than one row on maxillary and mandible. Skull with reticulate sculpture.

Comments.—The above description was given by Case for the genus *Labidosaurus*. It will later be shown to be applicable only to *L. hamatus*. In 1911 Branson reported the presence of more than one row of teeth in *Labidosaurus*. This report is most likely the reason Case included this character. Branson has since been shown to be in error.

Labidosaurus broilii Case 1911

Type specimen.—Mounted specimen in the Alte Akademie, Munich, Germany. Collected by C. Sternberg.

Horizon and locality.—Unknown; probably Arroyo formation of Baylor County, Texas.

Referred specimens.—None.

Description (after Case).—This species resembles *L. hamatus* in most regards, but differs in the possession of two enlarged incisors in the upper jaw instead of a single pair. Differences in the skeleton are unknown.

Comments.—Differences in the premaxillary teeth of *Captorhinus* have been shown to be unreliable for the separation of species in that genus. In the absence of any other characters, the same may be said of this genus. This species is thus considered indeterminate.

Labidosaurus oklahomensis,[1] new species

Type specimen.—MUO no. 3-1-S7, well-preserved skull (fig. 197) with lower jaws, palate and basicranium. The posterior border is missing.

Horizon and locality.—Wellington formation, McCaren quarry, two miles northeast of Eddy, Oklahoma.

---

[1] The type and referred specimens were graciously lent to me by Dr. D. Kitts of the University of Oklahoma. The species is named in honor of that institution.

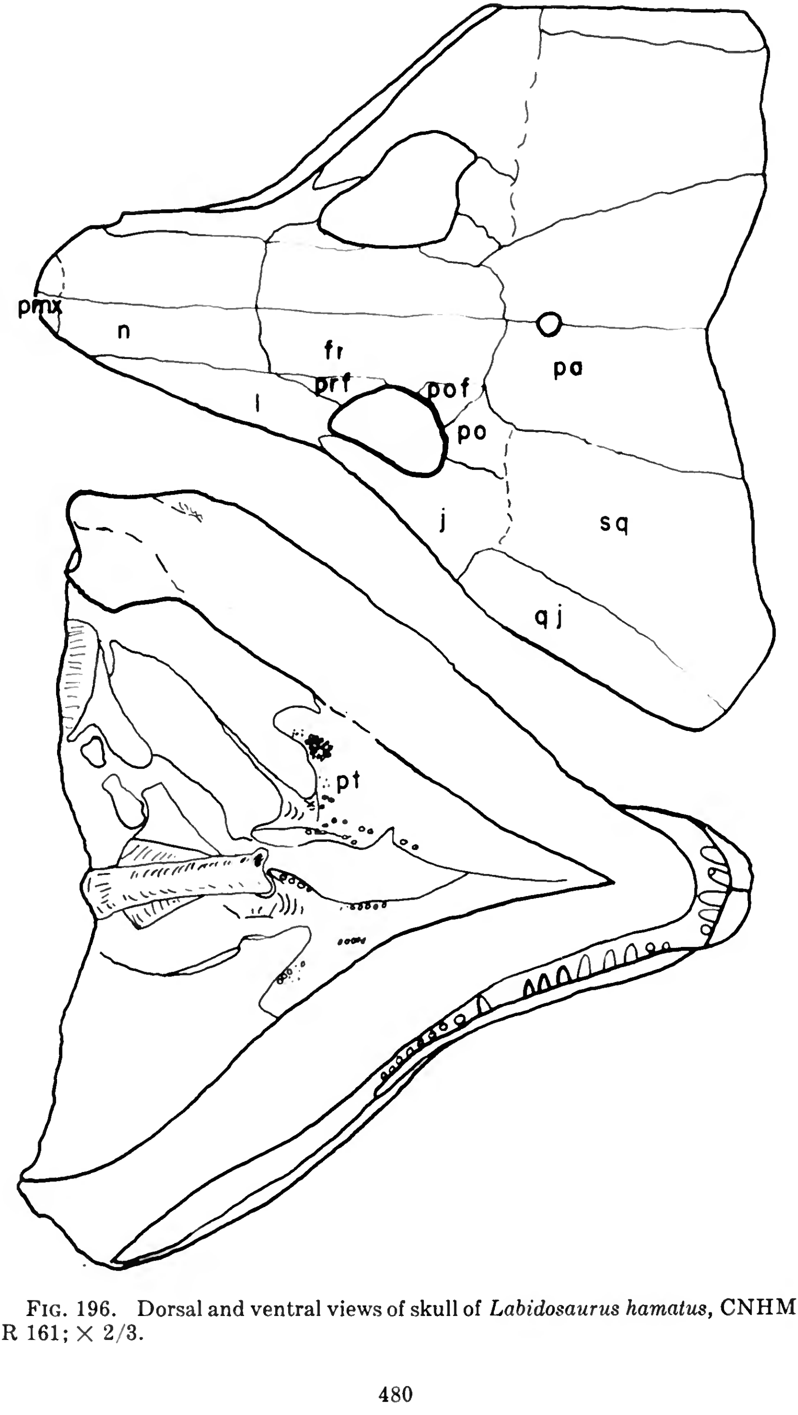

FIG. 196. Dorsal and ventral views of skull of *Labidosaurus hamatus*, CNHM-UR 161; × 2/3.

Diagnosis.—Measurements of type and referred specimens as in Table 6, Appendix A. The observed range of skull length is 59–85 mm. All skulls are at least moderately mature.

Discussion.—The type and referred specimens were found in a maroon-colored sandstone of the Wellington formation. This formation is of Clear Fork age and thought to correlate with the Arroyo and Vale formations of the Clear Fork of Texas. The exact correlation of the horizon from which the specimens came is unknown.

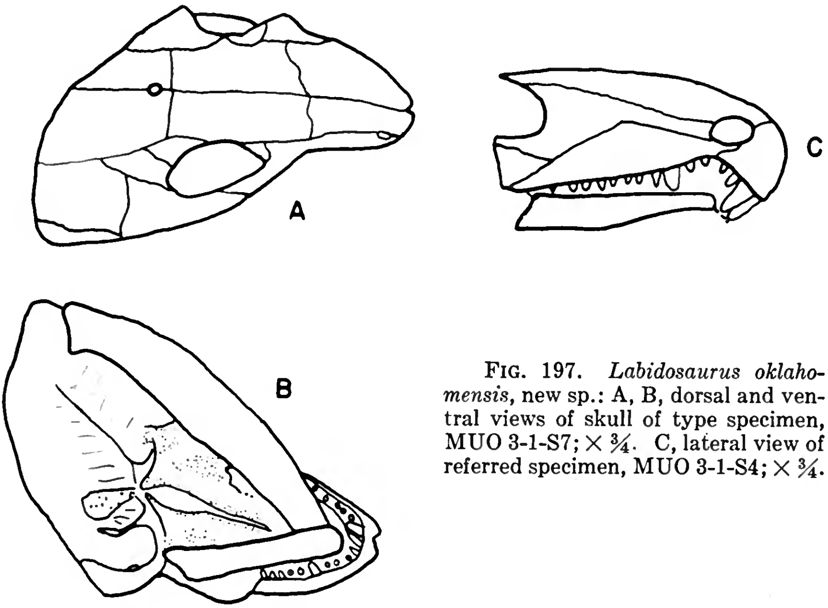

FIG. 197. *Labidosaurus oklahomensis*, new sp.: A, B, dorsal and ventral views of skull of type specimen, MUO 3-1-S7; × ¾. C, lateral view of referred specimen, MUO 3-1-S4; × ¾.

This species superficially resembles *Captorhinus* very closely. The dentition, however, consists of only one row of teeth on both the maxillary and the mandible. The teeth are subconical and flattened laterally, very much as in *Labidosaurus hamatus*, and reference to that genus is fairly certain.

Four or five premaxillary teeth are present. The first premaxillary tooth is large, as in *L. hamatus*. The second is considerably smaller in all cases. The fourth or fifth maxillary tooth is the largest and the third dentary tooth is the largest in the lower jaw.

The maturity of the specimens is indicated by the high degree of ossification of the ends of the limb bones and by the close joining by sutures of the skull bones. The dentition is the basis for assignment to the genus *Labidosaurus* and the size range of 59–85 mm. is the basis for taxonomic differentiation.

L. hamatus is a larger species than *L. oklahomensis* (see fig. 198).

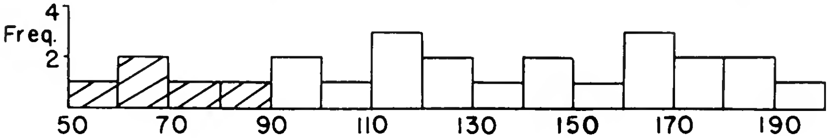

FIG. 198. Frequency histogram showing distribution of skull lengths of *Labidosaurus oklahomensis*, new sp. (hachured), and *L. hamatus* (clear).

DISCUSSION OF THE TWO GENERA

Olson and Miller (1951) have compared regression patterns of *C. aguti* with those of *L. hamatus* and *L. oklahomensis*. They have found that in 28 comparisons between *C. aguti* and *L. hamatus* there are 13 cases in which appear differences in one or the other of the constants in the linear equation $y = bx$. In comparisons of *C. aguti* and *L. oklahomensis* there are six differences out of 28, and in comparisons of *L. hamatus* and *L. oklahomensis* there are only two differences out of 28.

The growth pattern indicated in *L. hamatus* differs more from that indicated in *C. aguti* than does the growth pattern indicated in *L. oklahomensis*. The growth patterns indicated in the two species of *Labidosaurus* are more closely related to each other than either is to that of *C. aguti*.

Size is not a significant difference between *Captorhinus* and *Labidosaurus*, since all specimens of *L. oklahomensis* fall within the range of distribution of size of *C. aguti*.

The only real difference between the two genera is in the dentition, *Captorhinus* having multiple rows of teeth and *Labidosaurus* having but a single row. The two genera have extremely similar growth patterns.

Collection data, discussed by Olson and Miller (1951), show *C. aguti* to have inhabited the flood plains of the delta streams and the divides between them, while *L. hamatus* inhabited the margins of small lakes and ponds. The habitat of *L. oklahomensis* is not known.

Although the possibility exists that *Labidosaurus* and *Captorhinus* are not separate genera, the present data do not support this hypothesis sufficiently to warrant its acceptance. It is believed that both

C. aguti and *L. oklahomensis* are close to the ancestral form of the family, *L. oklahomensis* possibly giving rise only to *L. hamatus* while *C. aguti* gave rise to the various other members of the family.

CAPTORHINIKOS and LABIDOSAURIKOS

INTRODUCTION

These two genera are closely related. They are first found in the early Vale formation in Texas and their last certain occurrence is in the early part of the Choza (and the Hennessey of Oklahoma). Both are clearly derivatives of the *Captorhinus* line. Each genus will be described and analyzed separately.

Genus **Captorhinikos** Olson 1954

Type species.—*Captorhinikos valensis* Olson 1954.

Diagnosis (after Olson).—Lower jaw with four regular rows of bulbous, subconical post-canine teeth. Outer and inner rows not extending full length of post-canine series and not overlapping so that there are but three effective rows at any level. Enlarged "canine" tooth above and below. Maxillary dentition with five rows of bulbous, subconical teeth, forming a crescentic tooth plate; teeth increasing in size from anterior and posterior ends of plate to center and rows most widely spaced at center. Skull heart-shaped in outline.

Neural spines of vertebrae tending to be better developed than those of *Captorhinus*. Neural arches broad and flat. Dimensions of various skeletal elements of adults consistently greater than comparable dimensions of large specimens of *Captorhinus*.

Captorhinikos valensis Olson 1954

Type specimen.—CNHM–UR 101 (fig. 199, A, B). Anterior part of lower jaw and maxillary tooth plate.

Horizon and locality.—Late Vale formation, Clear Fork group, early Permian, Knox County, Texas.

Referred specimens.—See Appendix B.

Diagnosis (from Olson).—"Lower jaw slender for full length of tooth-bearing portion. Vertebral spines short to moderate in length in pre-sacral part of column."

Captorhinikos chozaensis Olson 1954

Type specimen.—CNHM-UR 97 (fig. 199, C), lower jaws with fragments of skull, including maxillary tooth plates.

Horizon and locality.—Middle part of the early Choza formation, Clear Fork group, early Permian green nodule site, Foard County, Texas.

Referred specimens.—See Appendix B.

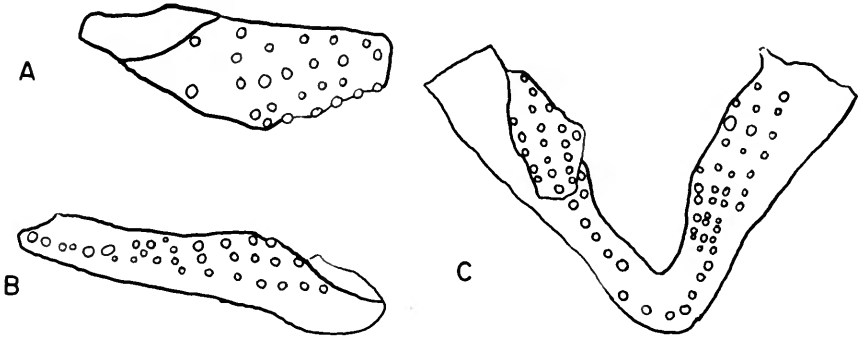

FIG. 199. A, B, upper and lower dentitions of type specimen of *Captorhinikos valensis*, CNHM-UR 101; × $1^{1}/_{10}$. C, lower dentition of type specimen of *C. chozaensis*, CNHM-UR 97; × ¾.

Diagnosis (from Olson).—"Lower jaw expanded dorso-ventrally below region of multiple rows of dentition. Outer rows of teeth in lower jaw set in from lateral margin of lower jaw. . . . Neural spines of thoracic vertebrae high as compared with those of *Captorhinikos valensis.*"

ANALYSIS OF THE GENUS

Unfortunately, there is insufficient material for a quantitative analysis of the genus. There are no skulls known upon which measurements might be made so that it could be determined if the form would fall on the regression line of *Captorhinus.*

The two species are placed in the same genus on the basis of similarity in the numbers of rows of teeth and the general makeup of the dental patterns. Both have an enlarged "canine" tooth above and below.

There are, however, fundamental differences between the two species. In addition to the antero-posterior regularity seen in the multiple tooth rows of *C. valensis*, *C. chozaensis* shows a close approach to a latero-medial regularity; and besides the increased regularity in the tooth rows the outer and inner rows overlap to a greater degree than in *C. valensis.* In *C. valensis* only one tooth of the outer row overlaps the inner row, while in *C. chozaensis* at least four, and certainly more, teeth in the outer row overlap the inner row.

In addition to the dorso-ventral broadening of the jaw in *C. chozaensis* there is also a latero-medial broadening in conjunction with the increased size of the multiple tooth row surface.

Another possible difference between the two species is in skull shape. The skull size of the type of *C. chozaensis* may be estimated from the jaws. Skull length would be about 104 mm. and width at the posterior end 112.3 mm. This is an unusual shape, probably best described by Olson's appellation of "heart-shaped." Although very little material is known of the skull of *C. valensis,* the lower jaws indicate that the skull was probably not heart-shaped. They are slender and of a shape similar to that seen in the lower jaw of *Captorhinus.* The skull of *C. valensis* was probably similar in shape to that of *Captorhinus.* This form might easily be considered ancestral to the heart-shaped form found in *C. chozaensis.*

There is a possibility that the condition seen in *C. chozaensis* is merely the adult form of *C. valensis,* similar to the condition seen in *Captorhinus.* I feel, however, that in this case the difference is too fundamental to be explained in that way. In the absence of more complete series of specimens the two named species are considered valid.

Genus **Labidosaurikos** Stovall, 1950

Type species.—Labidosaurikos meachami Stovall, 1950 (fig. 200).

Type specimen.—MUO 3-1-S2. Skull and jaws.

Horizon and locality.—Hennessey Shale, near Crescent, Logan County, Oklahoma.

Referred specimens.—No specimens were referred to this species previous to this study (see Appendix B).

Description (after Stovall).—Larger than *Labidosaurus;* one round, large premaxillary and anterior dentary tooth: a battery (six rows) of remarkably uniform maxillary and dentary teeth; small nares; tabular and dermosupraoccipitals posterior to parietals and extending on top of skull; ratio of orbit to skull length smaller than in *Labidosaurus.*

Labidosaurikos barkeri Olson 1954

Type specimen.—CNHM–UR 110. Partial skeleton, including lower jaw, vertebrae, parts of limb bones and miscellaneous fragments.

Horizon and locality.—Early Choza formation, Clear Fork group, early Permian, "pipe site," Foard County, Texas.

Referred specimens.—This species is considered synonymous with *L. meachami* and all specimens assigned to this species are herein reassigned to *L. meachami* (see Appendix B).

Diagnosis (from Olson).—"Lower jaw with four even rows of bulbous, semiconical teeth. Maxillary dentition consisting of five regular rows of evenly spaced teeth and forming attenuated, roughly triangular plate with the apex anterior."

ANALYSIS OF THE GENUS

Labidosaurikos (fig. 200) is separated from *Captorhinus* on the basis of the great regularity of the multiple tooth rows in the former. In addition to this is the fact that there are more than four rows of teeth present in the maxillary, a situation never seen in *Captorhinus.*

Labidosaurikos is separated from *Captorhinikos* on the basis of dental characters. In the jaws of the latter the multiple tooth rows are well separated posteriorly but converge anteriorly, grading almost insensibly into the single row at the anterior end of the jaw. In *Labidosaurikos* the multiple tooth rows are again well separated posteriorly but do not converge at the anterior end as much as in *Captorhinikos.* The multiple tooth rows end abruptly, with a gap between them and the single row of teeth at the anterior end of the jaw. In *Captorhinikos* the multiple tooth row plate is an elongated triangle with the point anterior. In *Labidosaurikos* the tooth plate is almost a rectangle.

Quantitative interpretation of the species of *Labidosaurikos* is impractical, again due to lack of material. Two skulls are known, however. They are MUO 3-1-S2, the type of *L. meachami,* and CNHM–UR 183, tentatively assigned to *L. barkeri,* since it has only five rows of teeth in the maxillary. These skulls were measured and the *Captorhinus–Labidosaurus* regression lines were extrapolated upward so these measurements could be plotted.

It was possible to plot both points on six scatter diagrams. In all six cases CNHM–UR 183 fell on, or close to, the *Captorhinus aguti* line. In three cases MUO 3-1-S2 fell on the *C. aguti* line; in one case (*Skl* vs *O-Sl*) it was off the *C. aguti* line and on the *Labidosaurus* line, and in two cases it was off both lines. The sample is, unfortunately, not large enough to determine if this difference is in any way definitive. The two may be at both ends of their own peculiar regression line.

Size cannot be used as a definitive character. The only skull that can be assigned to *L. barkeri* (CNHM–UR 183) appears to be quite immature. The sutures are not tightly closed and the teeth are worn very little. Certain tooth plates that are assigned to *L. barkeri* contain teeth as large as or larger than those of MUO 3-1-S2.

The main difference between the two species has been thought to be the number of rows of teeth. *L. barkeri* has five rows above and four below, while *L. meachami* has six rows above and five (or six) below. The lower jaw in *L. meachami* has only one tooth in the sixth

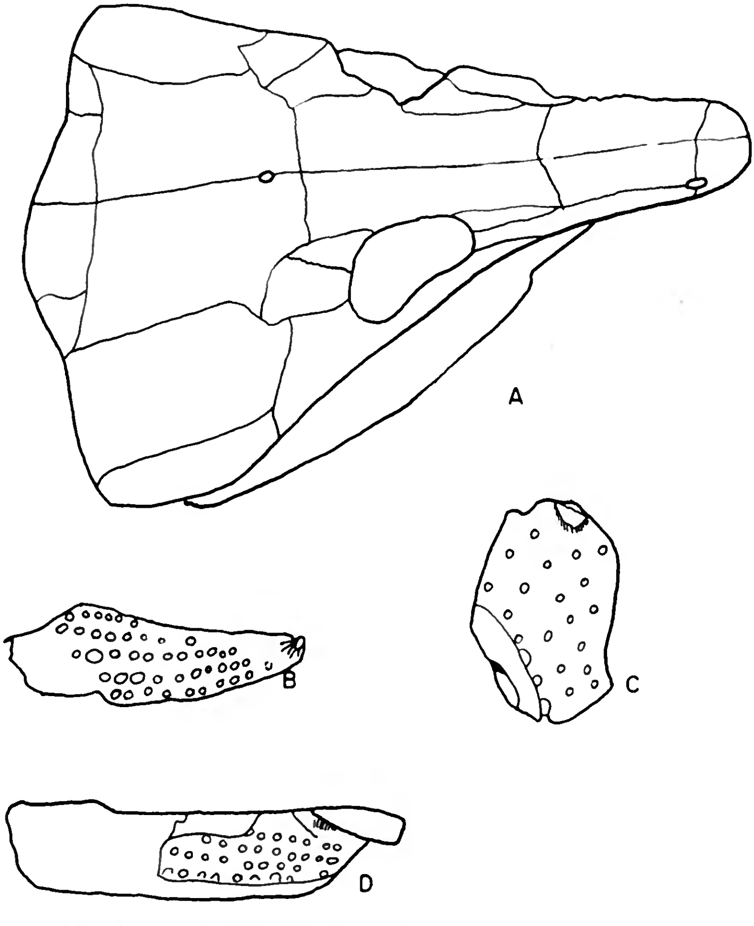

FIG. 200. A–C, *Labidosaurikos meachami:* A, dorsal view of skull, cast of type specimen, MUO 3-1-S2; × 2/9. B, upper dentition, CNHM–UR 109; × ⅓. C, lower dentition, CNHM–UR 110; × ⅔. D, *Labidosaurikos*-like palate from the Flower Pot formation, CNHM–UR 261; × ⅔.

row. This character has been shown to be a growth character in *Captorhinus* and there is no reason to believe that the same is not true in this closely allied genus. Two specimens support this idea. One is the type specimen of *L. barkeri*, CNHM–UR 110, a lower jaw. In this specimen there is one tooth at the anterior end of the tooth plate, forming a fifth row. In CNHM–UR 115, a maxillary tooth plate assigned to *L. barkeri*, there is an indication of a sixth row on the external side. This consists of two small, unworn teeth, much smaller than those in the other five rows, which probably had not erupted at the time of death of the individual. Additional rows in other large tooth plates assigned to *L. barkeri* cannot be seen because of breakage along the edges.

It would appear that there are no good criteria for placing more than one species in the genus *Labidosaurikos*. That species is *L. meachami*, named and described by Stovall in 1950. The specimens assigned to *L. barkeri* appear to be less mature growth stages of the one species.

One additional note must be added to the discussion of this genus. This concerns two specimens from the middle Permian of Texas. The first is a tooth plate (CNHM–UR 261; fig. 200, D) from the Flower Pot formation. I cannot determine with confidence whether it is upper, lower or even palatal. This tooth plate contains five very regular, widely separated tooth rows. The teeth are short, squat, semi-conical and pointed. Since so far no genus has passed the Clear Fork–Pease River group boundary, I am tempted to describe this as a new genus, or at least species, closely related to *L. meachami*. One tooth plate, however, is insufficient for diagnosis.

The second specimen (CNHM, unnumbered) was found in 1956 in a quarry in the San Angelo formation. This is a jaw that is extremely similar to *L. meachami* in make-up, except that it appears to have only three or four rows of teeth. This form will be studied and reported on by Olson.

DISCUSSION OF THE TWO GENERA

Both of these two genera have regular alignment of their multiple tooth rows. They differ, however, in the basic makeup of the tooth rows and in the shape of the skull.

There appear to be two possible choices as to the evolution of these genera. That they originated from *Captorhinus* seems fairly certain, but whether separately or whether one gave rise to the other is not certain. Olson (1954a) favors the idea that *Captorhi-*

nikos gave rise to *Labidosaurikos*. It is impossible to tell on the basis of the present evidence, although I feel that the skull shape of *C. chozaensis* is too specialized to have given rise to that seen in *Labidosaurikos*. Quite possibly *C. valensis* was the ancestor.

CAPTORHINOIDES and ROTHIA

INTRODUCTION

The two genera here discussed are not closely related. *Captorhinoides* is known only from the middle Vale, while *Rothia* occurs, as the only definite captorhinomorph, in the San Angelo and Flower Pot formations. Both apparently originated, either directly, or through unknown intermediate forms, from *Captorhinus aguti*.

Genus **Captorhinoides** Olson, 1951

Type species.—*Captorhinoides valensis* Olson, 1951.

Type specimen.—CNHM-UR 13, incomplete skull and jaws (fig. 201).

Horizon and locality.—Middle Vale formation, Clear Fork group, early Permian, near Vera, Knox County, Texas.

Diagnosis (after Olson).—General configuration of skull similar to that of *Captorhinus*. . . . Stapes with broad foot, very large stapedial foramen and slender, tapering shaft. . . . Basisphenoid-parasphenoid short, with prominent transverse ridge near anterior end.

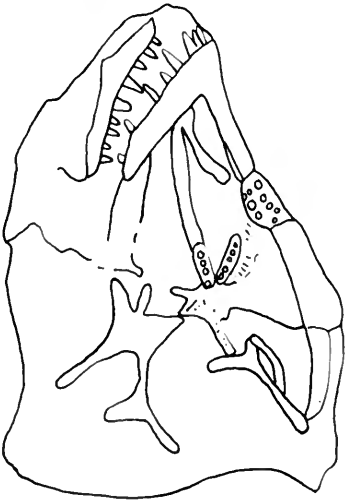

FIG. 201. Ventral view of skull of type specimen of *Captorhinoides valensis*, CNHM-UR 13; × 2½. After Olson, 1951, fig. 43B.

Pterygoid with quadrate process separated into short anterior process and broad posterior plate, the two lacking osseous connection. Epipterygoid with stout, rod-like ascending process. . . . Upper and lower jaws with three irregular rows of teeth. Marginal teeth elongated and somewhat recurved anteriorly, gradually diminishing in height posteriorly. Teeth of inner rows low, somewhat bulbous cones.

ANALYSIS OF THE GENUS

Quantitative analysis of the genus is impossible. It is represented by only one skull and that skull is in such condition as to preclude measurement. The outer bone has been lost, so that essentially only a mold of the external shape remains.

Morphologically, however, there is no question but that this specimen represents a distinct genus. It is separated from *Captorhinikos* and *Labidosaurikos* by the irregularity of the multiple rows of teeth, plus the fact that there are only three rows present. It differs from *Captorhinus* in all characters mentioned in the diagnosis of the genus. The stapes is much more slender than in *Captorhinus,* and the basisphenoid-parasphenoid is shorter.

Olson feels that the form differs so radically from *Captorhinus* that it may require a separation at a higher than generic level. I feel that the evidence is insufficient at the present time to separate this genus at a higher level, but agree that the difference is at least generic.

Genus **Rothia** Olson and Beerbower, 1953

Type species.—*Rothia multidonta* Olson and Beerbower, 1953.

Type specimen.—CNHM-UR 87 (fig. 202, B), partial skull and lower jaws.

Horizon and locality.—San Angelo formation, Pease River group, middle Permian, Hardeman County, Texas.

Referred specimens.—See Appendix B.

Diagnosis (after Olson and Beerbower).—Major skull features, so far as preserved, comparable to such large captorhinids as *Labidosaurus* and *Labidosaurikos.* Palate with "pavement" of irregularly spaced, sharp, conical teeth occupying part of the pterygoid, palatine and dentary bones. Interpterygoidal vacuity nearly or completely closed. Marginal maxillary teeth conical and moderately long. Premaxillary teeth larger and overhanging.

Lower jaw massive and broadly expanded in articular region. Maximum depth at position of insertion of masseteric and temporal

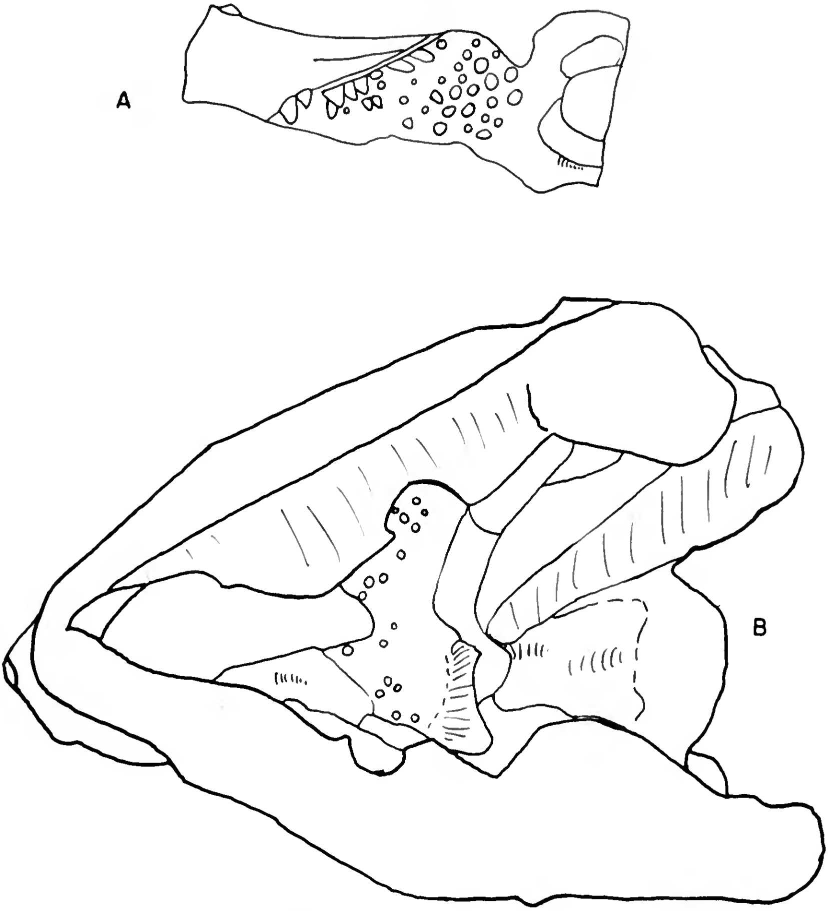

FIG. 202. *Rothia multidonta:* A, lower jaw, CNHM–UR 262; × ½. B, ventral view of skull, type specimen, CNHM–UR 87; × ²/₅.

muscles. Dentary expanded medially into tooth-bearing shelf, with pavement of irregularly spaced, sharp, conical teeth. Marginal teeth forming irregular row. At least one anterior tooth elongated and peg-like. Symphysis of lower jaws narrow.

Vertebrae of captorhinomorph type. Neural arches low, broad, and flat in anterior part of the column; higher and narrower in the lumbar region. Centra deeply amphicoelous, first two or three in column strongly keeled. Single transverse process formed by fusion of dorsal and ventral processes. Ribs holocephalous.

ANALYSIS OF THE GENUS

This genus, as was true of all the more advanced forms, is represented by insufficient material for quantitative analysis. The dorsal surface of the skull of the type specimen (CNHM–UR 87, fig. 202, B) is missing and therefore the measurements used in the earlier part of this study cannot be made.

Rothia is the largest captorhinid with irregular multiple rows of teeth. It differs from *Labidosaurus* in the presence of more than one row of teeth on the maxillary and mandible, and from the *Captorhinikos–Labidosaurikos* group in the irregularity of the multiple tooth rows. *Rothia* is much larger than the largest *Captorhinus* or the single specimen of *Captorhinoides*. It also appears that *Rothia* differs from the latter in retaining the more typical basicranial region of the captorhinids, rather than the specializations seen in that region in *Captorhinoides*. *Rothia* is generally more advanced than the Clear Fork captorhinids with the greater development of the palatal teeth.

Only one species is here allotted to the genus. Although a relatively large number of specimens are known they are too incomplete to allow of division into more than one species. In this regard two series of specimens, both from the Flower Pot formation, are of interest. The first of these is a series particularly represented by CNHM–UR 262, a partial skull from the Flower Pot (fig. 202, A). This material appears to be specifically different from the San Angelo *Rothia*. This may well be an effect of the different mode of preservation in the Flower Pot specimen, however. Generally different skull parts are preserved in the two so that the Flower Pot forms must, at least for the present, be assigned to *R. multidonta*.

A second interesting series has been found in a group of nodules collected from the Flower Pot formation by Olson in 1955. This material has not yet been sufficiently prepared to be able to determine if it differs specifically from *R. multidonta*.

Origin of the genus is obscure. The dental pattern is most closely related to that of *Captorhinus*. If *Rothia* did evolve from *Captorhinus*, however, it is so far removed morphologically as to require one or more unknown intermediate genera.

EVIDENCE OF THE POST-CRANIUM

By using the evidence of the crania a number of hypotheses can be established and these may potentially be tested by quantitative studies of post-cranial materials. These hypotheses are: (1) that the genus *Captorhinus* consists of only one species; (2) that the genus

Labidosaurus consists of two species of different size ranges; and (3) that the genus *Labidosaurikos* consists of only one species.

For purposes of testing these hypotheses a number of measurements were made on post-cranial material (see Tables 7 and 8, Appendix A). These measurements are also graphed as scatter diagrams (figs. 203 and 204). Figure 203 shows the measurements of length of the centrum versus height of the centrum of two different vertebrae. Figure 204 shows the proximal width plotted against the length of the femur and the distal width plotted against the length of the humerus.

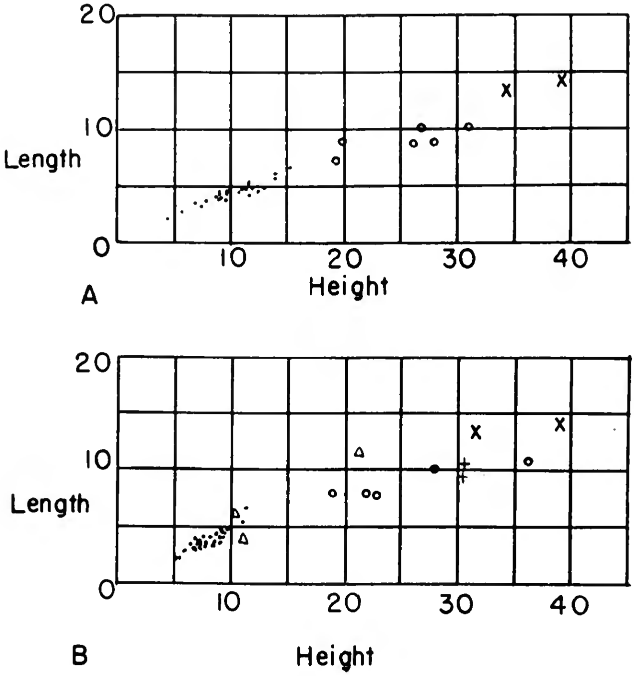

FIG. 203. Scatter diagrams showing maximum height versus length of centrum in specimens of captorhinids: A, vertebra no. 7; B, vertebra no. 10.

The first hypothesis—that *Captorhinus* consists of only one species—appears to be supported by the scatter diagrams. The following data make the graphs somewhat suspect, however. The material is all from one institution (Chicago Natural History Museum) and is not as complete as it might be. Secondly, most of the *Captorhinus* material is from the fissure fills in Oklahoma and therefore from a very restricted locality. It would appear that the only possible conclusion from these data is that the data are not in opposition to the hypothesis.

The second hypothesis—that *Labidosaurus* consists of two species—is not testable on the basis of these data. Measurable post-cranial material was not found in the specimens of *Labidosaurus oklahomensis* examined. There is a corollary to this hypothesis that might be tested, however—that Case's designation of a second species of *Labidosaurus* (*L. broilii*) is not correct. The scatter diagrams present no opposition to this corollary.

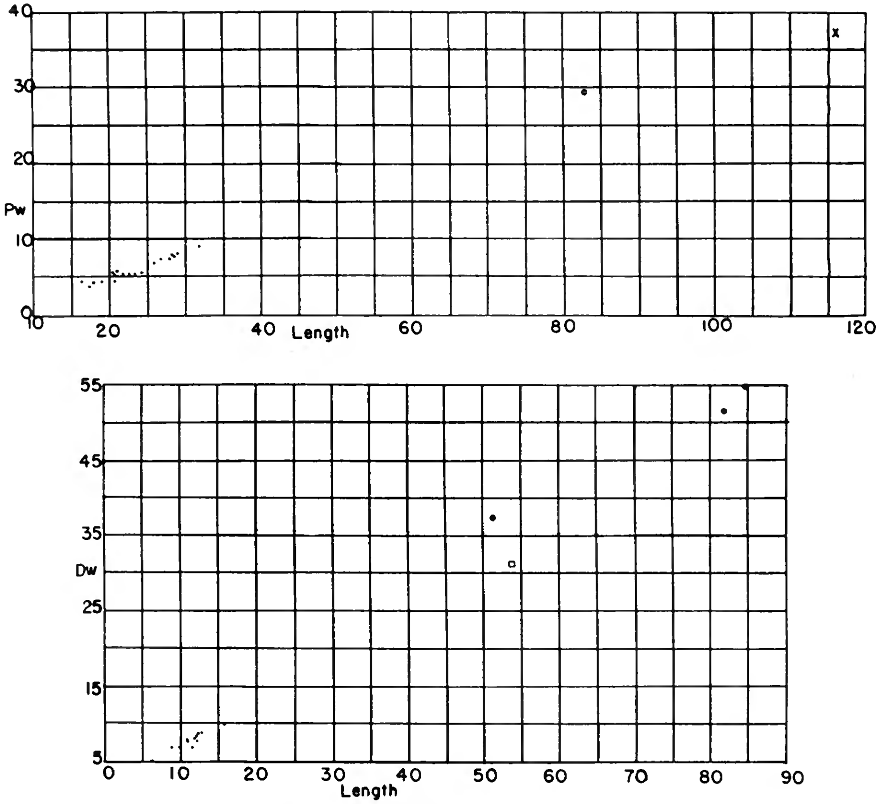

FIG. 204. Scatter diagrams plotting (upper) proximal width versus length of femur and (lower) distal width versus length of humerus, in captorhinids.

The third hypothesis—that the genus *Labidosaurikos* consists of only one species—is also not testable on the basis of these data. Only one specimen of the type species (*L. meachami*) is known and it contains no post-cranial material. This hypothesis must be accepted or rejected on the basis of cranial material alone.

A fourth and more general hypothesis might be advanced and examined at this time—that the family Captorhinidae consists of six genera with similar growth patterns. The evidence that there are six genera is not present in the scatter diagrams. One genus, *Captorhinoides,* is not even represented. The growth patterns, so far as scatter diagrams represent them, are extremely similar and show separation, except possibly on the basis of size, into distinct genera. The division must be based on morphology.

The evidence of these data on post-cranial material is weak, but at least it is not opposed to the hypotheses formed on the basis of data from the crania of the captorhinids. These data do not indicate any new hypotheses.

THE DEVELOPMENT OF THE CAPTORHINIDAE

Watson (1954) has shown a succession from *Protorothyris* through the romeriids to *Captorhinus,* which appears to be a logical idea for the origin of the family Captorhinidae in the Wichita. Various Pennsylvanian forms (e.g., *Cephalerpeton*) have been tentatively assigned to the Captorhinidae, but that assignment is still dubious. Watson's hypothesis appears to me to be the most acceptable at this time.

Specimens of the genus *Paracaptorhinus* Watson, 1954, have not been studied. I agree with Watson (on the basis of his illustrations and discussion) that this form is generically different from *Captorhinus.* Whether or not it is a captorhinid cannot be ascertained, although it would appear to be so different as to require classification in a different family.

The romeriids resemble the captorhinids closely and probably gave rise to them. Whether or not the former should be placed in a separate taxonomic group is a question this paper is not concerned with. For the present they are accepted as the group which gave rise to the captorhinids.

Captorhinus aguti, lasting from the Admiral through the Vale, is one of the most long-lived of all species of Permian vertebrates. Living in the divides of the great delta, *Captorhinus* was apparently in a slowly changing environment until the late Arroyo, at which time the climate apparently became severe enough to cause the gradual extinction of the genus.

Captorhinus was apparently not only a very stable genus but was also widespread. Evidence for this is the presence of the genus in the Arroyo equivalent fissure fills of central Oklahoma.

The Clear Fork is a time of gradual increase in severity of climate and consequent change in environment. In the Arroyo, however, the climate was still moist, with rainfall relatively gentle and spread over the entire year. During this time extensive ponding developed and with the ponds a new captorhinid developed to inhabit the pond margins. This was *Labidosaurus*. Whether or not the smaller species (*L. oklahomensis*) inhabited the pond margins is not known, but the larger, *L. hamatus*, is found almost exclusively in pond margin deposits. *L. oklahomensis* is a small form, very similar to *Captorhinus*, and is thought to have arisen from that genus. *L. hamatus* probably developed from *L. oklahomensis*. At the close of the Arroyo, with a general increase in aridity and a change to seasonal torrential rainfall, the genus became extinct.

In the upland environment only two forms are known from the Vale: *Captorhinus aguti*, which lasts at least through the Vale, and *Captorhinoides valensis*, which is known only from the middle Vale. *Captorhinoides* appears to have originated from *Captorhinus*, probably rather early, since it is radically different.

At about the same time (late Arroyo, very early Vale) *Captorhinus* also gave rise to two pond margin forms: *Captorhinikos valensis* and *Labidosaurikos meachami*. Neither appears to be an ecological replacement for *Labidosaurus*. *Captorhinikos* is too small, and the tooth structure of each is radically different from that of *Labidosaurus*. Olson[1] has suggested that *Labidosaurikos* might be the ecological replacement of the pelycosaur *Edaphosaurus pogonius* and this appears likely.

The relationships of the San Angelo and Flower Pot members of the family are not yet clearly understood and are being worked out by Olson. *Rothia* is the only definitely known genus present at that time. It would now appear that *Rothia* originated from *Captorhinus* through a series of unknown genera. A form extremely similar to *Rothia* has been reported from the middle Permian of Russia, indicating a relatively late distribution of the Captorhinidae to the Old World.

---

[1] E. C. Olson, The evolution of a Permian vertebrate chronofauna. Evolution, 1952, **6**, pp. 181–196.

ACKNOWLEDGMENTS

First and foremost among the persons I wish to thank for their aid and criticism in the preparation of this paper is Dr. E. C. Olson, who has been both an adviser and a friend through all my graduate training. I would also like to thank the following for their advice and criticism: Drs. R. Zangerl of Chicago Natural History Museum and R. L. Miller and J. M. Weller of the University of Chicago.

I also wish to express my appreciation to Chicago Natural History Museum and the American Museum of Natural History, particularly Dr. E. H. Colbert of the latter, for their cooperation in allowing me to examine their collections. The study was completed under two successive fellowship grants awarded by Chicago Natural History Museum.

Some of my fellow students at the University of Chicago read and criticized the paper in its early stages and I wish to thank them. They are Drs. R. L. Konizeski and J. S. Kahn and Messrs. J. Donohoe and H. Barghusen.

Appendix A

Table 1.—DIVISIONS OF THE NORTH AMERICAN (TEXAS) PERMIAN

AGE	FORMATION	STAGE
MIDDLE PERMIAN	Flower Pot	PEASE RIVER GROUP
	San Angelo	
EARLY PERMIAN	Choza	CLEAR FORK GROUP
	Vale	
	Arroyo	
	Leuders	
	Clyde	WICHITA GROUP
	Belle Plains	
	Admiral	

TABLE 2.—CRANIAL MEASUREMENTS ON SPECIMENS OF *CAPTORHINUS*

Specimen	Skl	Nal	Frl	Pal	Iow	Ol	O-Sl	Mxl
AMNH 4760	21.0	4.6	8.5	5.6	4.0	6.0	9.0	10.2
CNHM (Un-No.)	38.0	10.0	16.5	11.5	7.5	12.5	14.0	...
CNHM (Un-No.)	40.0	10.5	16.0	13.0	10.0	13.5	11.5	...
AMNH 4335	42.0	7.5	17.5	15.0	8.0	14.3	16.4	...
AMNH 4877	44.0	...	...	13.5	11.0	13.0	16.0	...
CNHM-UR 262	44.0	7.0	18.0	15.0	9.0	17.0	17.0	...
CNHM-UR 276	45.0	10.0	19.0	14.5	10.0	13.0	17.5	21.0
CNHM-UR 371	45.0	14.0	18.5	12.5	13.0	12.0	...	22.0
CNHM-UC 687	49.0	12.2	21.7	13.5	10.0	16.0	20.5	24.0
AMNH 4459	49.8	10.0	...	...	9.0	17.0	...	25.7
MCZ 1478	50.0	14.5	20.0	15.0	13.0	13.0	19.5	...
CNHM-UR 382	51.0	15.0	21.0	15.0	11.0	14.0	18.0	23.0
CNHM-UR 372	52.0	14.9	20.2	15.2	11.5	17.5	20.5	25.0
CNHM-UR 385	53.0	14.5	21.0	18.0	11.0	14.5	18.0	...
AMNH 4332	54.0	...	...	...	10.0	15.0	...	...
AMNH 4458	55.9	...	...	...	12.4	15.4	...	31.0
MCZ 1160	56.0	16.0	21.0	17.0	14.0	15.0	20.0	...
CNHM-UC 700	56.0	14.0	23.0	...	...	16.0	21.0	26.0
CNHM-P 12757	57.4	17.7	23.5	17.0	13.9	19.0	...	31.3
CNHM-UR 384	58.0	15.0	22.0	18.0	11.0	...	23.0	...
CNHM-UC 1043	58.0	...	...	...	13.0	18.0	17.5	...
AMNH 4455	60.0	...	...	...	...	16.5	22.0	...
AMNH 4410(A)	60.0	...	22.0	16.5	11.5	17.0	24.0	24.0
AMNH 4334	61.0	16.0	23.5	17.5	11.0	16.0	26.0	26.0
AMNH 4457	62.0	14.5	24.5	19.0	12.0	16.5	24.0	27.0
AMNH 4443	62.0	...	...	...	16.0	17.0	23.5	...
AMNH 4438	62.0	...	...	...	...	15.4	...	...
CNHM-UC 1702	62.0	...	...	...	14.0	19.0	20.5	...
CNHM-UC 1703	62.0	...	...	...	14.0	17.0	24.0	...
CNHM-UC 185	63.0	...	...	...	15.0	20.0	17.0	...
AMNH 4444	63.0	...	...	...	15.0	...	22.0	...
CNHM-UC 642	63.0	17.4	28.7	16.0	13.9	19.5	23.0	26.0
CNHM-UR 377	65.0	19.0	24.0	20.0	13.0	18.0	25.0	28.0
AMNH 4410(B)	65.0	...	...	21.5	15.0	17.5	20.5	24.0
AMNH 6790	66.0	20.5	22.5	19.0	12.5	17.5	27.0	30.0
AMNH 4338	65.8	17.4	25.6	...	12.7	18.0	...	33.1
AMNH 4407	68.0	...	24.0	20.5	16.5	17.5	28.0	...
AMNH 4340	70.0	...	...	22.5	14.0	16.5	...	...
AMNH 6791	71.0	...	...	...	14.0	17.0	30.5	...
AMNH 4333	75.0	...	28.5	22.0	18.2	17.0	25.0	32.0
AMNH 4344	76.0	22.0	30.3	...	17.8	17.8	...	36.5
CNHM-UC 242	78.0	20.0	33.5	22.0	...	...	32.0	36.0
AMNH 4408	79.0	22.5	28.5	25.0	22.5	17.0	34.0	...
CNHM-UR 387	...	13.0	...	...	9.0	...	17.5	...
CNHM-UR 386	...	...	...	17.0	12.0	16.0	...	...
CNHM-UR 383	...	...	...	...	11.0	16.5	...	...
CNHM-UR 388	...	9.5	...	...	10.0	15.0	17.0	...
CNHM-Un-No.	...	...	...	10.0	6.5	...	...	...
CNHM-UR 274	...	...	...	...	11.0	16.0	...	...

TABLE 3.—MEASUREMENTS OF MAXILLARY TEETH OF *CAPTORHINUS*

Specimen	Horizon and locality	Position in maxillary series						
		1	2	3	4	5	6	7
CNHM–UC 242	Arroyo, Texas	...	...	2.2	3.2	...	...	1.5
CNHM–UC 700		0.9	1.4	...	2.5	...	...	...
CNHM–UC 687		...	1.8	2.1	3.1	2.7	...	1.7
CNHM–UC 1702		...	0.9	1.7	2.0	...	...	1.1
CNHM–UR (Un-No.)		...	...	1.9	2.5	...	...	...
CNHM–UR (Un-No.)		...	1.5	...	2.9	2.6	...	2.0
CNHM–P 12757		...	...	2.8	2.1	...	...	...
CNHM–UC 642		...	...	...	3.3	1.4	1.4	1.2
CNHM–UR 401	Arroyo (?), Oklahoma	...	...	...	2.3	2.2	1.9	1.8
		...	0.9	1.9	2.7	1.9	...	...
		1.1	1.1	1.4	2.0	0.9	0.8	0.6
		...	...	...	2.5	...	1.4	1.5
		...	1.3	1.4	2.6	1.5	1.2	1.3
		1.1	1.7	2.8	1.6	...	...	...
		1.1	1.4	2.5	0.9	...	...	...
		1.1	1.3	2.5	3.4	2.4	2.4	1.8
		1.4	1.6	2.2	...	...	...	...
		1.8	2.6	3.0	2.0	1.4	1.8	1.3
		1.0	1.3	2.3	2.2	1.6	1.3	...
		...	...	2.2	2.8	1.1	0.9	...
		0.9	0.7	...	2.5	1.5	...	...
		1.3	1.4	1.4	2.1	1.3	...	...
		...	1.3	1.4	2.1	...	1.4	1.3
		1.3	1.5	2.8	1.8	1.3	0.9	1.1
		2.1	2.9	3.2	2.2	1.5	2.1	1.3
		0.6	1.0	2.0	2.5	1.7	1.6	0.9
		1.5	2.0	2.9	1.1	1.5	...	...
		0.2	...	2.2	2.8	1.1	0.9	0.9
		0.7	0.7	...	1.9	1.9	...	1.1
		1.0	1.4	2.7	1.2	1.6	...	...
		1.0	1.4	2.4	...	...	...	...
		0.8	1.3	1.7	2.3	1.6	1.5	1.0

TABLE 4.—LENGTHS OF FIRST AND SECOND PREMAXILLARY TEETH OF *CAPTORHINUS*

Specimen	Horizon and locality	Pmx 1	Pmx 2
CNHM-UR 687	Arroyo, Texas	2.3	1.8
CNHM-UR 401		2.5	2.1
CNHM-UR 176		2.8	1.7
CNHM-UC 700		3.1	1.4
CNHM-UC 700		3.5	1.8
CNHM-UC 242		4.0	2.8
CNHM-UC 687		4.0	3.0
CNHM-UC 1043		4.5	4.0
CNHM-UR 425	Arroyo(?), Oklahoma	0.9	0.9
		2.9	1.9
		2.9	2.3
		3.0	1.9
		3.0	2.5
		3.0	1.4
		3.1	2.4
		3.2	2.5
		3.2	2.5
		3.5	2.7
		3.5	1.6
		3.6	1.7
		3.8	1.6
		4.2	2.9
		4.2	3.5
		5.2	3.0
		5.9	3.6

TABLE 5.—CRANIAL MEASUREMENTS ON SPECIMENS OF *Labidosaurus hamatus*

Specimen	Skl	Nal	Frl	Pal	Iow	Ol	O-SL	Mxl
AMNH 4406	92.9	24.0	39.4	24.2	18.8	27.0	...	52.3
Univ. Mich. (Un-No.)	98.0	26.0	41.0	30.0	20.0	24.0	39.0	...
CNHM–UC 183	107.0	25.0	50.0	26.0	24.0	26.0	48.0	56.0
AMNH 4421	113.4	...	38.2	34.9	24.0	31.5	...	60.0
CNHM–UR 273	114.0	30.0	56.0	34.0	25.0	32.0	66.0	58.0
AMNH 4427	116.2	36.2	40.4	28.8	21.8	25.3	...	52.4
CNHM–UC 634	129.0	32.0	58.0	36.0	27.0	36.0	62.0	62.0
CNHM–UC 174	129.0	34.0	55.0	37.0	24.0	31.0	53.0	62.0
Univ. Mich. (Un-No.)	131.0	39.0	50.0	34.0	23.0	...	60.0	...
AMNH 4341	143.3	...	...	...	32.0	38.2	...	74.1
CNHM (Un-No.)	149.8	44.3	56.9	39.5	27.0	37.9	...	73.9
CNHM (Un-No.)	152.0	...	...	...	28.0	33.0	70.0	...
CNHM (Un-No.)	162.0	47.0	62.0	44.0	29.0	39.0	70.0	...
CNHM–UC 176	164.0	48.0	60.0	48.0	29.0	40.0	71.0	...
AMNH 4414	168.5	47.7	66.2	54.9	30.4	37.8	...	74.2
CNHM–UC 696	173.1	45.2	71.3	36.8	28.7	41.2	...	96.3
CNHM–UC 643	179.0	50.0	74.0	48.0	27.0	...	70.0	82.0
CNHM–UC 180	180.0	47.0	72.0	54.0	32.0	37.0	75.0	87.0
CNHM (Un-No.)	185.0	...	72.0	...	28.0	43.0	76.0	...
CNHM–UR 161	199.7	61.4	73.5	44.3	32.3	45.9	...	105.0

TABLE 6.—CRANIAL MEASUREMENTS ON SPECIMENS OF *Labidosaurus oklahomensis*, sp. nov.

Specimen	Skl	Nal	Frl	Pal	Iow	Ol	O-Sl	Mxl
MUO 3–1–S5	59.0	15.2	23.0	14.5	14.0	17.0	25.0	29.4
MUO 3–1–S7	63.0	16.0	26.0	18.0	15.0	18.0	25.0	29.0
MUO 3–0–S4	60.0	16.2	24.0	17.0	12.0	17.0	23.0	28.8
MUO 3–1–S3	78.0	22.0	28.0	21.0	14.0	20.0	31.0	32.2
MUO 3–1–S6	85.0	...	35.0	25.0	17.0	21.0	...	...
MUO 3–1–S4	...	23.0	...	...	20.0	...	34.0	...
MUO 3–1–S8	...	19.0	...	...	12.0	...	25.0	...

TABLE 7.—MEASUREMENTS ON CAPTORHINID VERTEBRAE[1]

Cl	Cht	Cl	Cht	Cl	Cht
A. VERTEBRA NUMBER SEVEN					
Captorhinus aguti					
6.5	15.0	4.0	9.4	3.4	7.4
5.7	13.8	3.8	9.5	3.9	8.9
4.9	11.5	4.6	10.7	3.7	7.6
4.9	11.1	4.3	9.7	2.2	4.3
3.9	9.8	4.0	8.6	2.9	5.5
5.0	11.4	3.7	8.8	3.5	6.7
4.7	11.5	4.4	10.9	4.0	8.5
4.0	9.0	4.0	8.8		
Labidosaurus hamatus					
9.0	20.0	9.0	26.0	9.0	28.0
7.0	19.0	10.0	27.0	10.0	31.0
Captorhinikos valensis					
6.4	9.9				
Rothia multidonta					
13.7	34.0	14.4	39.0		
B. VERTEBRA NUMBER TEN					
Captorhinus aguti					
5.4	12.5	4.0	8.8	3.9	7.2
4.9	9.7	4.4	9.5	3.7	6.8
5.2	11.0	3.9	8.3	3.5	6.3
4.8	9.2	3.7	8.9	3.1	6.2
4.1	7.6	4.1	7.9	3.5	7.2
4.5	8.8	3.5	7.8	3.8	8.1
4.3	8.2	3.5	7.5	3.7	8.5
4.2	8.4	3.5	7.0	3.5	6.9
3.5	7.5	3.8	7.8	3.3	7.0
3.8	7.3	4.2	8.3	2.4	5.0
4.5	8.8	3.8	7.6	3.5	7.0
3.4	7.8	3.4	7.1	3.1	6.6
3.8	7.8	3.4	8.0	3.1	6.9
3.9	8.9	4.2	7.8	2.9	5.5
3.6	7.1	3.4	7.5	3.7	7.1
Labidosaurus hamatus					
8.0	22.0	8.0	19.0	8.0	22.0
10.0	28.0	11.0	36.0		
Captorhinikos valensis					
6.2	10.3	11.5	22.2	4.0	11.0
Labidosaurikos meachami					
10.4	30.5	9.6	30.3		
Rothia multidonta					
14.2	36.3	13.5	32.0		

[1] Cl = length of centrum; Cht = height of centrum

TABLE 8.—MEASUREMENTS ON LIMB BONES OF CAPTORHINIDS[1]

L	Pw	Dw	L	Pw	Dw
A. FEMUR					
Captorhinus aguti					
28.5	7.2	8.6	27.0	7.6	10.0
28.0	7.2	9.8	22.5	5.6	7.4
24.5	5.9	8.2	21.0	5.5	7.2
18.0	4.6	5.6	21.0	5.4	7.3
19.0	4.6	6.1	21.0	5.7	7.2
21.0	5.5	7.2	20.5	5.1	7.5
22.5	5.7	8.0	22.0	5.1	7.3
21.0	5.3	7.2	17.5	4.0	5.4
23.5	5.4	7.6	29.0	8.1	10.7
26.2	6.8	8.8	20.5	5.0	7.2
22.5	5.6	7.6	26.5	6.5	8.4
20.5	5.2	7.2	32.0	9.1	...
28.3	8.4	10.5	16.6	4.5	5.3
Labidosaurus hamatus					
81.0	26.0	37.0			
Rothia multidonta					
116.0	37.5	57.7			
B. HUMERUS					
Captorhinus aguti					
27.6	9.3	14.2	26.3	8.4	12.5
30.4	10.6	...	30.7	10.3	16.4
26.7	8.3	12.4	23.9	7.8	11.0
21.9	6.8	9.9	20.9	7.2	9.5
20.7	6.9	9.9	15.0	5.0	6.3
25.4	7.9	12.1			
Labidosaurus hamatus					
51.0	...	38.0	82.0	30.0	52.0
85.0	32.0	55.0			
Captorhinikos chozaensis					
53.5	22.0	31.2			

[1] L = length; Pw = proximal width; Dw = distal width.

APPENDIX B: REFERRED SPECIMENS

Captorhinus aguti

Wichita Forms: MCZ 1478, skull, Admiral formation, Rattlesnake Canyon, Archer County, Texas. MCZ 1160, skull, Belle Plains formation, Archer County, Texas. CNHM-US 735, miscellaneous fragments, Abo formation, Poleo Creek, Rio Arriba County, New Mexico.

Clyde Formation, Mitchell Creek, Baylor County, Texas: CNHM-UC 687, good skull. CNHM-UC 642, good skull (type of *Pariotichus laticeps* Williston). CNHM-UC 1698, crushed skull (equal C 262). CNHM-UC 185, flattened skull. CNHM-UC 196, miscellaneous fragments. CNHM-P 12757, good skull.

Arroyo Formation, Baylor County, Texas: AMNH 4340, skull. AMNH 4760, skull, West Coffee Creek. AMNH 4335, skull. AMNH 4438, Coffee Creek. AMNH 6791, skull. AMNH 4444, fair skull, West Coffee Creek. AMNH 4877, fair skull, Big Wichita River. AMNH 4443, poor skull. AMNH 4410, fair skull, East Coffee Creek. AMNH 4457, excellent skull, West Coffee Creek. AMNH 4334, excellent skull. AMNH 4410A, skull, Coffee Creek. AMNH 6790, excellent skull, West Coffee Creek. AMNH 4407, good skull, West Coffee Creek. AMNH 4408, excellent skull, West Coffee Creek. AMNH 4455, good skull, locality unknown. CNHM-UR 372, good skull, East Coffee Creek. CNHM-UR 276, skull, East Coffee Creek. CNHM-UR 377, excellent skull, Hog Creek. CNHM-UR 242, excellent skull, Indian Creek. CNHM-UC 1702, badly crushed skull, East Coffee Creek. CNHM-UC 1703, cast of skull, West Coffee Creek. CNHM-UR 274, incomplete skull, West Coffee Creek. CNHM-UR 371, skull, Middle Coffee Creek. CNHM-UC 700, good half skull, Coffee Creek. CNHM-UC 1043, fair skull, Coffee Creek. CNHM-UC 1315, femur, Craddock Ranch, Bushy Creek. CNHM-UR 1206, fragmentary skull, near Seymour. CNHM-UC 951, fragmentary skull, Indian Creek. CNHM-UR 351, partial skull, East Coffee Creek. CNHM-UR 292, partial skull. CNHM-UR 275, poor skull, Middle Coffee Creek.

Arroyo(?) Formation, Fissure Fills, Richard's Spur, Oklahoma: CNHM-UR 387, anterior part of skull. CNHM-UR 383, posterior part of skull. CNHM-UR 386, posterior part of skull. CNHM-UR 388, anterior part of skull. CNHM-UR 384, badly crushed skull. CNHM-UR 385, good skull. CNHM-UR 382, good skull. CNHM-UC 1699, miscellaneous vertebrae. CNHM-UR 392, foot. CNHM-UR 391, anterior part of vertebral column, part of girdle. CNHM-UR 390, humerus, femur. CNHM-UR 389, part of pectoral girdle, one limb. CNHM-UR 393, frontal bones. CNHM-UR 394, quadrate bones. CNHM-UR 395, parietal bones. CNHM-UR 396, nasal bones. CNHM-UR 400, scapulae. CNHM-UR 399, femora. CNHM-UR 398, stapes. CNHM-UR 397, caudal vertebrae. CNHM-UR 401, maxillaries with teeth. CNHM-UR 402, dentaries with teeth. CNHM-UR 425, premaxillaries with teeth.

Vale Formation, Knox County, Texas: CNHM-UR 118, lower jaws, part of skull, thirteen presacral vertebrae, head of humerus, etc.

Labidosaurus hamatus

Clyde Formation, Mitchell Creek, Texas: CNHM-UC 183, skull.

Arroyo Formation, Baylor County, Texas: AMNH 4406, skull, West Coffee Creek. AMNH 4421, skull, West Coffee Creek. CNHM-UR 273, skull, Middle

Coffee Creek. AMNH 4427, skull, Coffee Creek. CNHM-UC 174, skull and skeleton, Indian Creek. CNHM-UC 176, skull, Indian Creek. AMNH 4414, skull, West Coffee Creek. CNHM-UC 696, skull, Hog Creek. CNHM-UC 643, skull, Coffee Creek. CNHM-UC 180, skull, West Coffee Creek. CNHM-UR 161, skull, Middle Coffee Creek. CNHM-UC 177, skeleton, Indian Creek. CNHM-UC 634, skull and partial skeleton, near Seymour. CNHM-UC 726, partial skeleton, Coffee Creek. CNHM-UC 178, lower jaws, partial vertebral column, Indian Creek. CNHM-UC 724, very poor skull, Coffee Creek. CNHM-P 12758, mixed specimen (partial skeleton, basicranium, small skull), Coffee Creek. CNHM, no number, good skull, no data. CNHM-UC 728, miscellaneous fragments, Upper Coffee Creek. CNHM-UC 181, partial skeleton, Indian Creek. CNHM-UC 727, lower jaw, Pony Creek. CNHM-UC 1102, skull plate (assignment dubious), Abo Formation, New Mexico. CNHM-UC 730, partial skeleton, Coffee Creek. CNHM-UC 1199, lower jaw. CNHM-UC 732, miscellaneous fragments, Coffee Creek. CNHM-UC 1059, miscellaneous fragments, Coffee Creek. CNHM-UC 725, lower jaw, Coffee Creek. CNHM-UC, lower jaw, near Seymour. CNHM-UC 729, miscellaneous fragments, Coffee Creek. CNHM-UC 731, miscellaneous fragments, Indian Creek.

Captorhinikos valensis

Vale Formation, Knox County, Texas: CNHM-UR 107, pre-sacral vertebrae, middle Vale. CNHM-UR 108, vertebrae, upper Vale. CNHM-UR 105, lower jaw, upper Vale. CNHM-UR 106, vertebrae and possibly skull fragments, upper Vale. CNHM-UR 103, upper tooth plate, upper Vale. CNHM-UR 104, part of palate, upper Vale. CNHM-UR 102, partial lower jaw, upper Vale. CNHM-UR 219, miscellaneous fragments, including identifiable part of lower jaw, early Vale. CNHM-UR 224, miscellaneous vertebrae. CNHM-UR 216, partial jaw with teeth.

Captorhinikos chozaensis

Choza Formation, Foard County, Texas: CNHM-UR 99, part of skeleton. CNHM-UR 100, part of skull and skeleton. CNHM-UR 239, partial jaw. CNHM-UR 98, miscellaneous vertebrae.

Labidosaurikos meachami

Early Vale Formation, Baylor County, Texas: CNHM-UR 114, tooth bearing maxillary, Crooked Creek. CNHM-UR 116, part of side wall of skull, Crooked Creek. CNHM-UR 115, partial maxillary tooth plate, Fish Creek. MCZ 1352, maxillary tooth plate.

Middle Vale Formation, Knox County, Texas: CNHM-UR 113, maxillary with dentition. CNHM-UR 109, partial maxillary with dentition.

Choza Formation, Foard County, Texas: CNHM-UR 120, two partial maxillary tooth plates, "pipe site." CNHM-UR 111, two partial lower jaws, "pipe site." CNHM-UR 112, lower jaw, "pipe site."

Hennessey Formation, Oklahoma: CNHM-UR 183, incomplete skull.

Rothia multidonta

San Angelo Formation, Texas: CNHM–UR 129, part of left side of skull, four vertebrae, Pease River, Hardeman County. CNHM–UR 130, two vertebrae, Pease River, Hardeman County. CNHM–UR 131, four vertebrae, Little Croton Creek, Knox County. CNHM–UR 252, miscellaneous fragments, Swanson Quarry, Knox County. CNHM–UR 379, fragmentary tooth plate, Knox County.

Flower Pot Formation, Knox County, Texas: CNHM–UR 262, fragmentary partial skull. CNHM–UR 263, partial skeleton, including vertebrae, femur, part of pelvis.

REFERENCES

Branson, E. B.

1911. Notes on the osteology of the skull of *Pariotichus*. Jour. Geol., **19**, pp. 135–139.

Broili, F.

1904. Permische Stegocephalen und Reptilien aus Texas. Paleontographica, **51**, pp. 1–120.

1908. Ein montiertes Skellet von *Labidosaurus hamatus* Cope, einem Cotylosaurier aus der Perm von Texas. Zeitschr. deutsch. Geol., **60**, pp. 63–67.

Broom, R.

1910. A comparison of the Permian reptiles of North America with those of South Africa. Bull. Amer. Mus. Nat. Hist., **28**, pp. 197–234.

1913. On the cotylosaurian genus *Pantylus* Cope. Bull. Amer. Mus. Nat. Hist., **32**, pp. 527–532.

1938. On a new type of primitive fossil reptile from the Upper Permian of South Africa. Proc. Zool. Soc. London, (B), **108**, pp. 535–542.

Case, E. C.

1899. A redescription of *Pariotichus incisivus* Cope. Zool. Bull. Boston, **2**, pp. 698–729.

1905a. The osteology of the Diadectidae and their relationship to the Chelydosauria. Jour. Geol., **13**, pp. 126–159.

1905b. Characters of the Chelydosauria. Science, **21**, p. 298.

1911. A revision of the Cotylosauria of North America. Carnegie Inst. Washington, **145**, pp. 1–122.

1915. The Permo-Carboniferous red beds of North America and their vertebrate fauna. Carnegie Inst. Washington, **207**, pp. 1–176.

Cope, E. D.

1878. Description of extinct Batrachia and Reptilia from the Permian formation of Texas. Proc. Amer. Phil. Soc., **17**, pp. 505–530.

1880a. The skull of *Empedocles*. Amer. Nat., **14**, p. 304.

1880b. Second contribution to the history of the vertebrates of the Permian formation of Texas. Proc. Amer. Phil. Soc., **19**, pp. 38–58.

1881. On some new Batrachia and Reptilia from the Permian beds of Texas. Bull. U. S. Geol. Surv. of the Terrs., **6**, p. 79.

1886. Systematic catalogue of the species of vertebrates found in the beds of the Permian epoch in North America with notes and descriptions. Trans. Amer. Phil. Soc., **16**, pp. 285–297.

1896a. The reptilian order Cotylosauria. Proc. Amer. Phil. Soc., **34**, pp. 436–456.

1896b. Second contribution to the history of the Cotylosauria. Proc. Amer. Phil. Soc., **35**, pp. 123–149.

CUMMINS, W. F.

1908. The localities and horizons of Permian vertebrate fossils in Texas. Jour. Geol., **16**, pp. 737–745.

DIXON, W. T., and MASSEY, F. J.

1951. Introduction to statistical analysis. 370 pp. New York, McGraw Hill.

HUENE, F. VON

1913. The skull elements of the Permian Tetrapoda in the American Museum of Natural History, New York. Bull. Amer. Mus. Nat. Hist., **32**, pp. 315–386.

KUHN, O.

1937. Cotylosauria et Theromorpha Fossilium Catalogus I: Animalia, pars. 79, pp. 1–209.

MAYR, E., LINSLEY, E. C., and USINGER, R. L.

1953. Methods and principles of systematic zoology. 328 pp. New York, McGraw Hill.

MEHL, M. G.

1912. *Pantylus cordatus* Cope. Jour. Geol., **20**, pp. 21–27.

OLSON, E. C.

1947. The family Diadectidae and its bearing on the classification of reptiles. Fieldiana, Geol., **11**, pp. 1–53.

1948. A preliminary report on vertebrates from the Permian Vale formation of Texas. Jour. Geol., **56**, pp. 186–198.

1951. Fauna of upper Vale and Choza: 1–5. Fieldiana, Geol., **10**, pp. 89–128.

1952. Vertebrates from the San Angelo formation, early Permian of Texas. Jour. Geol., **60**, pp. 286–288.

1954a. Fauna of the Vale and Choza: 9. Captorhinomorpha. Fieldiana, Geol., **10**, pp. 211–217.

1954b. Vertebrates from the Flower Pot formation, Permian of Texas. Jour. Geol., **62**, pp. 512–513.

1955. Fauna of the Vale and Choza: 10. *Trimerorhachis*, including a revision of pre-Vale species. Fieldiana, Geol., **10**, pp. 225–274.

OLSON, E. C., and BEERBOWER, J. R.

1953. The San Angelo formation, Permian of Texas and its vertebrates. Jour. Geol., **61**, pp. 389–423.

OLSON, E. C., and MILLER, R. L.

1951. A mathematical model applied to a study of the evolution of species. Evolution, **5**, pp. 325–338.

PRICE, L. I.

1935. Notes on the braincase of *Captorhinus*. Proc. Boston Soc. Nat. Hist., **40**, pp. 377–386.

1937. Two new cotylosaurs from the Permian of Texas. Proc. New England Zool. Club, **16**, pp. 97–102.

ROMER, A. S.

1935. Early history of Texas red beds vertebrates. Bull. Geol. Soc. Amer., **46**, pp. 1597–1658.

1945. Vertebrate paleontology. 2nd ed., 687 pp. University of Chicago Press.

ROMER, A. S., and PRICE, L. I.

1940. Revision of the Pelycosauria. Geol. Soc. Amer., Spec. Paper, **28**, 538 pp.

STOVALL, J. W.

1950. A new cotylosaur from north central Oklahoma. Amer. Jour. Sci., **248**, pp. 46–54.

SUSHKIN, P. P.

1927. On the modifications of the mandibular and hyoid arches and their relations to the brain case in the early Tetrapoda. Paleont. Zeitschr., **8**, pp. 263–321.

WATSON, D. M. S.

1916. On the structure of the brain case in certain primitive lower Permian tetrapods. Bull. Amer. Mus. Nat. Hist., **35**, pp. 611–636.

1954. On *Bolosaurus* and the origin and classification of reptiles. Bull. Mus. Comp. Zool., **111**, pp. 299–449.

1957. On *Millerosaurus* and the early history of the sauropsid reptiles. Phil. Trans. Roy. Soc. London, **24**, pp. 325–400.

WESTOLL, T. S.

1942. Ancestry of the captorhinomorph reptiles. Nature, **149**, pp. 121–124.

WHITE, T. E.

1939. Osteology of *Seymouria baylorensis* Broili. Bull. Mus. Comp. Zool., **85**, pp. 325–409.

WILLISTON, S. W.

1908. The Cotylosauria. Jour. Geol., **16**, pp. 139–149.

1909. New or little known Permian vertebrates: *Pariotichus*. Biol. Bull., **17**, pp. 241–255.

1910. The skull of *Labidosaurus*. Amer. Jour. Sci., **10**, pp. 69–81.

1916. Synopsis of the American Permo-Carboniferous Tetrapoda. Contr. Walker Mus., **1**, pp. 193–236.

1917. *Labidosaurus* Cope, a lower Permian cotylosaur reptile from Texas. Contr. Walker Mus., **2**, pp. 45–57.

1925. The osteology of the reptiles. 300 pp. Harvard University Press.