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CTENOSPONDYLUS NINEVEHENSIS, A NEW SPECIES (REPTILIA, PELYCOSAURIA) FROM THE LOWER PERMIAN DUNKARD GROUP OF OHIO

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ABSTRACT

A new species of sphenacodontine pelycosaur, *Ctenospondylus ninevehensis*, is described on the basis of disarticulated elements of the skull and postcranial skeleton from the Lower Permian Greene Formation, Dunkard Group of east-central Ohio. This is only the second species of this rare genus to be recognized and the first to be reported from the eastern United States. *C. ninevehensis* existed at the same time or very probably somewhat later than *C. casei*, the other member of this genus, yet its greater primitiveness in a number of features makes it an ideal predecessor to *C. casei*. Geographic isolation by the end of the Pennsylvanian of the Dunkard basin, in which *C. ninevehensis* occurred, from the Midcontinental basin complex, in which *C. casei* occurred, is offered as a possible explanation for the anachronistic appearance of the former. *Ctenospondylus* was most likely already established as a distinct lineage before the beginning of the Permian and, therefore, not a descendant of any of the Early Permian sphenacodontines, such as *Sphenacodon*. It is also improbable that *Ctenospondylus* could have arisen from any of the few poorly known sphenacodontines of the Late Pennsylvanian because of the greater primitiveness of the marginal dentition of *C. ninevehensis*. For these reasons it seems best to take the view that *Ctenospondylus* arose from the haptodontine sphenacodontids at least as early as the Late Pennsylvanian.

INTRODUCTION

Reptiles of the Lower Permian subfamily Sphenacodontinae are considered the most advanced of the order Pelycosauria and closest to the morphological grade of organization of the therapsids, the advanced mammal-like reptiles. *Ctenospondylus* is one of the rarest of the better

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known sphenacodontine pelycosaurs and previously was recognized by only one species, *C. casei*, recorded from only two regions in the United States, north-central Texas and southeastern Utah. It is distinguished from other members of this group mainly by its long, laterally flattened, neural spines that form a high dorsal sail. In addition to *Ctenospondylus*, four other genera comprise the sphenacodontines as follows: *Bathygnathus*, known only from the front part of a skull found on Prince Edward Island, Canada, may be a senior synonym of *Dimetrodon* (Langston, 1963); *Neosaurus*, based on a maxilla from the Jura region of France; *Sphenacodon* and *Dimetrodon*, known from complete skeletons from North America and an upper jaw of the former from England (Paton, 1974). The holotype of *C. casei*, discovered by W. F. Cummins in 1881 in the Lower Permian Belle Plains Formation, Wichita Group of north-central Texas, consists of a complete dorsal vertebra, a dorsal vertebra with partial neural spine, a cervical vertebra lacking the spine, a probable cervical spine, the distal part of a spine, and several fragments of ribs. This specimen was not noted until 1910, however, when Case referred briefly to it and suggested that it be assigned to the European Lower Triassic genus *Ctenosaurus* Huene, a reptile known only from its vertebral column in which the spines are greatly elongated as in *Ctenospondylus*. About a quarter century later the uniqueness of this specimen was recognized by Romer (1936), who named *Ctenospondylus casei*. Further remains of *C. casei* went unreported until Vaughn (1964) discovered many skeletal elements referable to this species in the Lower Permian Organ Rock Shale, Cutler Group of southeastern Utah. Vaughn's descriptions (1964, 1970) included not only portions of the postcranial skeleton, but also, most importantly, the skull. The skull is nearly identical to those of *Sphenacodon* and *Dimetrodon* and provides indisputable evidence that *C. casei* is a sphenacodontine, as well as that it is closely related to these genera.

The specimens described here from the Lower Permian Greene Formation, Dunkard Group of east-central Ohio were first noted by Olson (1975), who referred them to the genus *Ctenospondylus* without specific designation. Examination of the Dunkard *Ctenospondylus* reveals that it represents a new species, herein named *C. ninevehensis*, and that it is more primitive than the contemporaneous, or very likely somewhat earlier, *C. casei*. Despite its late appearance, *C. ninevehensis* is viewed as an ideal, structural antecedent to *C. casei*.

The ancestry of *Ctenospondylus* remains vague. Of the Lower Permian sphenacodontines, only *Sphenacodon*, *Dimetrodon*, and *Ctenospondylus* are known from complete or substantial portions of their skeletons, which are essentially identical except for their distinctly different neural spines. In all three genera the spines are elongated; in *Dimetrodon* the spines are flattened laterally at their bases only, becoming very

long, slender rods distally, whereas the spines of *Ctenospondylus* are intermediate in length between those of *Dimetrodon* and *Sphenacodon* and, as in the latter, have a basically normal, blade-like structure. It might be suggested that the longer-spined *Ctenospondylus* was derived from the shorter-spined *Sphenacodon* as a result of the well-documented evolutionary trend toward disproportional increase in spine length with increase in overall size seen not only in the latter, but in other pelycosaurs as well. A *Sphenacodon-Ctenospondylus* lineage cannot be correct, however, because *C. ninevehensis* possesses a more primitive dentition than the oldest and most primitive species of *Sphenacodon*. Features of the maxillary dentition of *Neosaurus* suggest that this poorly known genus was also not ancestral to *Ctenospondylus*. Probably *Ctenospondylus*, as well as *Sphenacodon*, represented independent lineages during the Early Permian. The few incompletely known sphenacodontines of the Late Pennsylvanian are also eliminated as possible ancestors of *Ctenospondylus* because of their more advanced dentitions than that of *C. ninevehensis*. It is suggested that *Ctenospondylus* became established as a separate evolutionary line by the Late Pennsylvanian or earlier, most likely stemming from the Late Pennsylvanian-Early Permian haptodontine pelycosaurs, which are generally considered as ideal predecessors of the sphenacodontines and as probably having an antiquity that extends back to the Early or Middle Pennsylvanian.

The greater primitiveness of *C. ninevehensis* over the contemporaneous or probably earlier-occurring *C. casei* is explained as the result of isolation. Paleogeographic reconstructions suggest that the Dunkard basin, once the terminal portion of a northeastern arm of the Midcontinental seaway, became widely separated from the Midcontinental basin complex at the end of the Pennsylvanian by the continued growth of a vast, intervening area of low relief occupying the continental interior.

The following abbreviations are used to refer to repositories of specimens: AMNH, American Museum of Natural History, New York; NTM VP, Navajo Tribal Museum, Window Rock, Arizona; MCZ, Museum of Comparative Zoology, Harvard University.

SYSTEMATIC PALEONTOLOGY

Class Reptilia

Order Pelycosauria

Family Sphenacodontidae

Subfamily Sphenacodontinae

Genus *Ctenospondylus* Romer, 1936

Ctenospondylus ninevehensis, new species

Holotype.—MCZ 3386 consists of the following disarticulated elements of the skull, lower jaw and postcranial skeleton: premaxillae, left

maxilla and small part of right, right prefrontal, probable right jugal, left pterygoid, left dentary, axial neural spine, three dorsal vertebrae and spine, lumbar vertebra, four caudal vertebrae and probable spine, three cervical ribs and parts of cervical and dorsal ribs, part of scapular blade, left humerus and distal end of right, and right pelvis. The holotype, as well as the referred specimen, were collected by Dr. Donald Baird of Princeton in June 1955.

Referred specimen.—MCZ 4458, a right maxilla.

Horizon.—Lower Permian Nineveh Limestone, Greene Formation, Dunkard Group.

Locality.—Clark Hill on County Route 43, 1.1 miles west of junction with State Route 7, sec. 16, Salem Township, Monroe County, Ohio.

Diagnosis.—All the features that distinguish *Ctenospondylus ninevehensis* from *C. casei* express a more primitive grade of organization in the former; these include: 1) a greater number of marginal teeth, consisting of four premaxillary, 21 maxillary, including three precanines, and an estimated 31 dentary teeth; 2) relative length of neural spine of dorsal vertebra about 23% shorter; 3) axial neural spine of the more generalized sphenacodontine shape; 4) smaller overall body size.

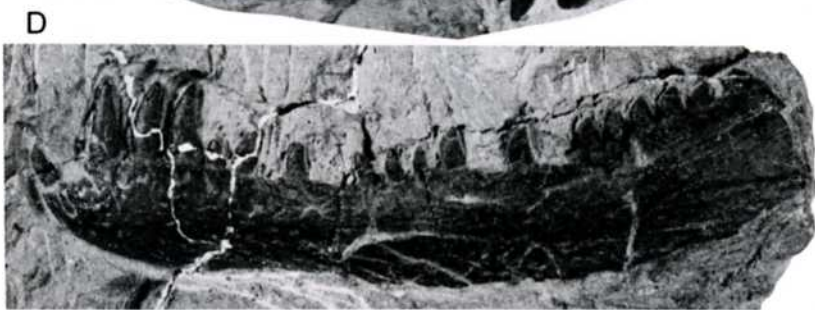
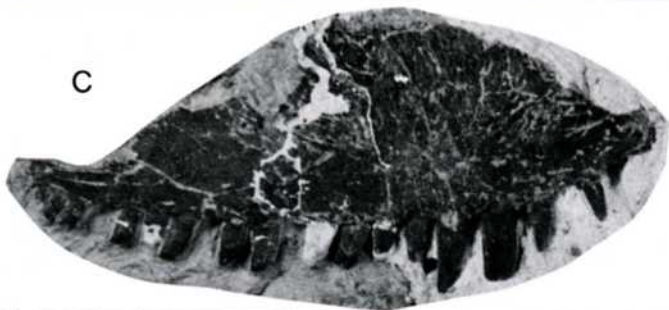
Etymology.—Name refers to the stratigraphic unit in which the specimens were found.

Description

Cranial elements.—Cranial elements of the holotype include right and left premaxillae, left maxilla and small part of right, right prefrontal, probable right jugal, left pterygoid, and left dentary. The reasons for believing that these elements, as well as those described below as belonging to the holotype, came from one individual is their discovery close together, their appropriateness in size to one another, and the absence of duplicate elements of the same size or evidence of the presence of any additional pelycosaur species. A right maxilla, MCZ 4458, is also referred to *C. ninevehensis*. Both the right and left premaxillae (Fig. 1) are nearly complete and possess spaces for four teeth, which is one or two more than is seen in most of the sphenacodontine pelycosaurs. The teeth appear to have been alternately replaced, so that only two functional teeth are present in each premaxilla; further, the tooth replacement sequence of one premaxilla alternates with that of the opposite side. In the right premaxilla only the basal halves of the first and third teeth are preserved and the second and fourth are represented by empty sockets, whereas in the left the second tooth is nearly intact, the fourth has been broken off at the base and the first and third sockets are empty except for the tip of a replacement tooth seen in the third. Judging from what is preserved of the functional teeth and the sizes of the unoccupied sockets, the size relationships of the premaxillary teeth are of the typical sphenacodontine pattern; the teeth decrease in size considerably posteriorly, with the anterior pair being much larger than the posterior pair. The teeth

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Fig. 1.—*Ctenospondylus ninevehensis*, new species A, right and left premaxillae, B, left maxilla, and D, left dentary of holotype MCZ 3386. C, right maxilla of referred specimen MCZ 4458.



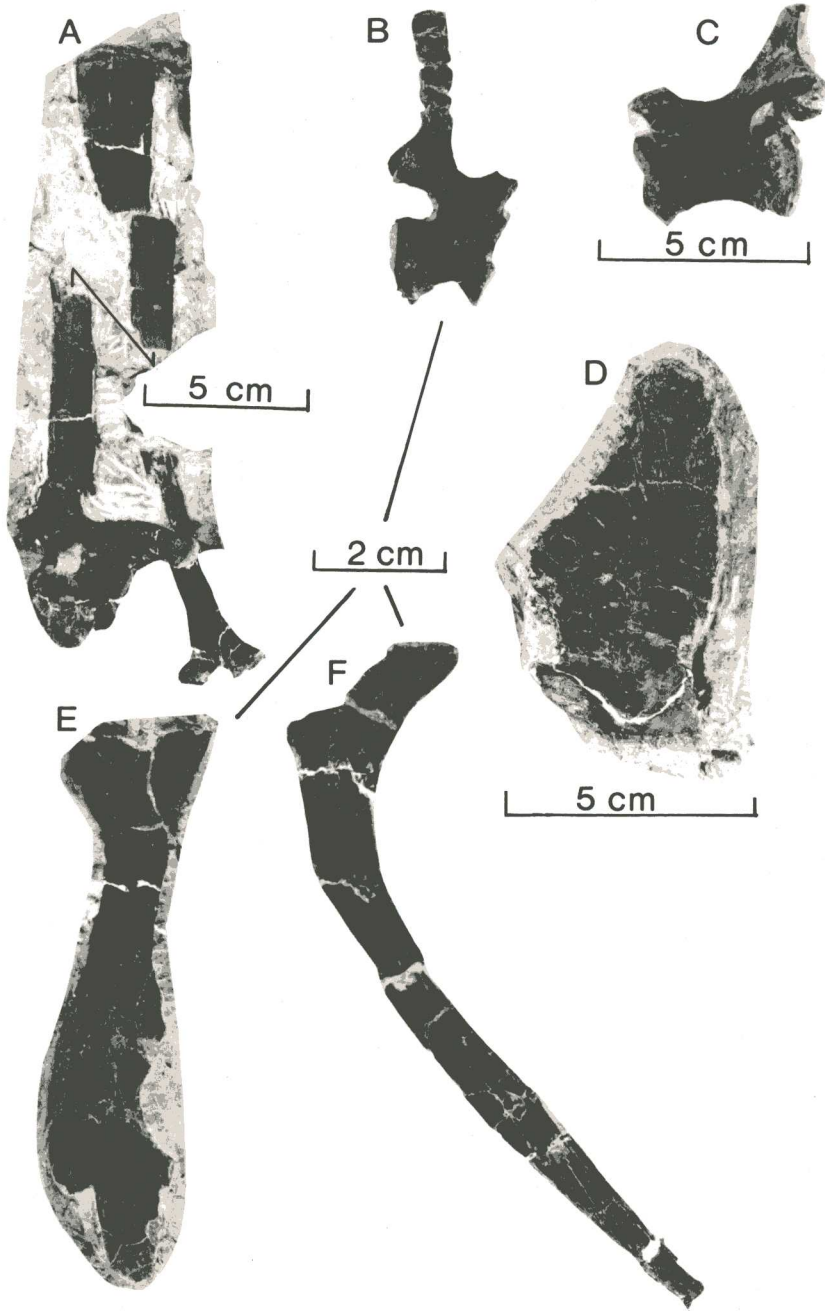
are subcircular in cross-section and exhibit only a slight development of anterior and posterior cutting edges. The holotypic left maxilla (Fig. 1) is complete along its lightly convex, ventral margin and has a maximum length of 133 mm; the upper half of its dorsal lamina is missing. Sixteen teeth are preserved and there are spaces for five more, giving a total of three precanines, two canines, and 16 postcanines. The precanines decrease in size anteriorly from a maximum length of 14 mm; the canine pair are nearly equal in size and measure 25 mm in length; the first postcanine is slightly smaller than the posteriormost precanine and the second postcanine (missing) is presumed to have been smaller as in the referred right maxilla MCZ 4458 (Fig. 1); the remaining postcanines exhibit a steady decrease in size posteriorly from a maximum length of about 13 to less than 4 mm. In sphenacodontid fashion all the teeth are slightly to moderately recurved and laterally compressed with moderately developed, nonserrated, posterior cutting edges; postcanines 8 through 21 are slightly bulbous compared to the other teeth. There is a moderate swelling of the maxilla above the canine pair and anterior to the precanines the ventral margin of the maxilla is only very slightly arched dorsally, forming a very weakly-developed maxillary "step." The referred right maxilla MCZ 4458 (Fig. 1) is essentially complete and except for a couple of very minor differences that are undoubtedly related to its smaller size (length 106 mm) is identical to that of the type. The two canines appear to be relatively slightly smaller, with the anterior one, though not complete, being definitely larger; its maxillary step and lateral canine swelling are also less pronounced than in MCZ 3386.

The holotypic right maxilla is represented by only a small, poorly preserved portion of its anteroventral margin that contains a canine pair and a precanine that match exactly in size and character those of the left maxilla. The greater portions of the right prefrontal and what appears to be a right jugal exposed in medial view are preserved and are not unlike those of other sphenacodontines. All that remains of the left pterygoid is the proximal portion of the palatal ramus and almost all of the thickened, ventral ridge of the quadrate ramus. The transverse flange is well developed with five of the 10 or more teeth it possessed preserved; the largest of these teeth, located at the center of the series, is about 8 mm in length. The palatal ramus is covered by very small denticles; however, about 15 mm anterior to the transverse flange and close to the medial border of the palatal ramus begins a narrow cluster of relatively much larger denticles, reaching a maximum diameter of about 1.7 mm, that extends about 10 mm to the anterior broken margin of the pterygoid. In all these features the pterygoid of the holotype closely approximates that seen in the reconstruction of the skull of *Dimetrodon limbatus* by Romer and Price (1940:501, Pl. 13).

The left dentary (Fig. 1) as preserved measures 125 mm in length and is missing approximately its posterior fourth, which undoubtedly included a small part of the marginal dentition. The tooth-bearing margin of the dentary is slightly concave except at its very anterior end, where it slants somewhat downward. There are 19 preserved teeth of which only the posteriormost two are incomplete and there are gaps for six more. The total number of marginal dentary teeth was, however, almost certainly greater than 25, judging from the dental counts given by Romer and Price (1940:434, Table 2) for specimens of various species of *Sphenacodon* and *Dimetrodon*. The dental counts in-

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Fig. 2.—*Ctenospondylus ninevehensis*, holotype, MCZ 3386. A, posterolateral view of anterior dorsal vertebra (displacement of spine indicated) and posterior view of proximal half of spine of a preceding dorsal; B, right lateral view of mid-caudal vertebra; C, left lateral view of distal caudal; D, left lateral view of axial neural spine; E, anterior view of atlantal or possibly axial rib; F, posterior view of left cervical rib.



dicate that in sphenacodontines the dentary typically possesses about 50% more teeth than the maxilla. On the basis of this formula, the presence of 21 teeth in the maxilla of the Dunkard *Ctenospondylus* suggests that the actual number of dentary teeth may have been about 31. All the teeth are slightly to moderately recurved and laterally compressed with fairly sharp, nonserrated, posterior edges. In sphenacodontine fashion there are a few teeth very near the anterior end of the jaw that are much enlarged over the rest of the series. In this case three enlarged teeth of essentially identical development and measuring 13 mm in length occupy positions 3, 4, and 5. Missing tooth 2, judging from its empty socket, must have been somewhat larger than tooth 1, which measures 8 mm in length; that part of the series containing teeth 6 to 14 shows great variation in size, with teeth ranging in length from 5 to 8 mm; teeth 15 to 25 diminish slightly in size posteriorly from a maximum length of 7 mm and exhibit a slightly stouter outline than the other teeth of this size range.

Vertebrae and ribs.—Elements of the vertebral column identified as belonging to MCZ 3386 include an axial neural spine, three dorsal vertebrae and a dorsal neural spine, a lumbar vertebra, four caudal vertebrae and a probable caudal neural spine, and three cervical ribs and parts of cervical and dorsal ribs. The axial neural spine (Fig. 2) is essentially complete, exposed in left lateral view and includes a small, proximal portion of the anterior and most of the posterior zygapophyses of this side. In outline the spine conforms very closely to those of *Sphenacodon* and is also not greatly unlike those of various species of *Dimetrodon* (Case and Williston, 1913; Romer and Price, 1940; Vaughn, 1964). In comparison with these genera the holotypic spine differs mainly in not becoming greatly thickened toward its posterior margin. The height of the spine is about 74 mm measured above the posterior zygapophysis along a line parallel to its posterior edge. In sphenacodontid fashion the anteroventral margin projects over the anterior zygapophysis, from which it is separated by a narrow, deep notch.

The three vertebrae and neural spine from the dorsal region of the column include a complete vertebra and the proximal half of a spine found closely associated with it (most likely belonging to the preceding vertebra) that are probably from the anterior part of the series (Fig. 2) and two vertebrae, consisting mainly of the centrum and the base of the neural spine, believed to be from the middle and posterior parts of the series. All are of sphenacodontid style. The lateral surface of the neural spine just above the transverse process is deeply excavated. The zygapophyses are steeply tilted downward and inward and do not extend laterally beyond the margin of the centrum. The lateral surface of the centrum is deeply concave, flaring outward at the ends of the centrum to form an expanded, subcircular rim surrounding the notochordal funnel. The ventral longitudinal keel of the centrum is sharply pinched and in lateral view is slightly concave, reaching the ventral margins of the centrum rims, which are expanded downward as relatively flat lips for articulation with the intercentra. The dorsals, as well as the lumbar and caudal vertebrae described below, exhibit well developed anterior centrosphenes and posterior centra on the dorsal margins of the centrum rims. In all of the vertebrae there is also a ventral beveling of the ends of the centra to accommodate the intercentra; this feature, which is much more pronounced at the anterior end of the centrum, becomes less prominent toward the posterior end of the column. Standard measurements for the vertebrae of the holotype are given in Table 1.

The preservation of the complete anterior dorsal vertebra (Fig. 2) is fortunate inasmuch as it is the character of the neural spine that provides the basis for identifying the holotype as belonging to the genus *Ctenospondylus*. Although two parts of the neural spine have been displaced small distances along fracture planes, the height of the spine above the posterior zygapophyses can still be accurately measured as 152.4 mm. The spine is laterally compressed, with an anteroposterior length of about 14 mm from just above the buttresses of the posterior zygapophyses to about a third the height of the spine, then constricts to about 12 mm for a very short distance before slowly expanding

Table 1.—Measurements (in mm) of various vertebrae of *C. ninevehensis*, holotype, MCZ 3386; dorsal vertebrae of *Ctenospondylus* aff. *C. casei*, NTM VP 1014 from southeastern Utah (Vaughn, 1964); and *C. casei*, holotype, AMNH 4047 from north-central Texas (Romer and Price, 1940). 1, greatest length of centrum; 2, width of centrum at posterior end (anterior end for NTM VP 1014); 3, height of centrum at posterior end; 4, orthometric linear unit value (radius of centrum to the $\frac{2}{3}$ power; see Romer and Price, 1940); 5, spine length; 6, spine length in orthometric linear units.

Specimen and vertebrae	1	2	3	4	5	6
MCZ 3386						
anterior dorsal	24.5	21.3	24.3	4.8	152.4	31.7
mid-dorsal	27.2	20.0	20.0	4.6		
posterior dorsal	27.0	13.7	22.2			
lumbar	19.5	15.5	14.7			
proximal caudal	18.0	15.9	16.0			
proximal caudal	17.6	15.5	14.2			
mid-caudal	18.0	14.8	13.8			
distal caudal	17.0	10.0	9.5			
NTM VP 1014		22.0		4.9	211.0	42.5
AMNH 4047	34.0	31.0	33.0	6.2	245.0	40.0

to 23 mm at its distal end. In transverse width the spine is about 10 mm just above the buttresses of the posterior zygapophyses and 8 mm at its summit. The basal third of the spine bears fore and aft grooves and ridges, which appear to be more pronounced on the anterior face; at about the level where the spine is narrowest anteroposteriorly these grooves are replaced by rounded margins. The transverse process is well developed and extends 40 mm laterally out from the midline, is directed slightly downward and backward, is roughly triangular in cross section with the apex directed downward, is broadly concave ventrally in end view, and exhibits a rather deep excavation on the posteroventral surface of its base. The articular facet is egg-shaped in outline with the narrower end pointing ventrally and faces ventrolaterally and slightly posteriorly. The line of juncture between the arch and centrum is detectable only as a roughened ridge. By way of comparison with the vertebra described as an anterior dorsal, the vertebra believed to be a mid-dorsal is judged so by differences in its transverse process. The process is shorter, measuring 32.7 mm out from the midline, and extends directly laterally. Its articular facet is triangular in outline with the apex pointing downward and faces ventrolaterally; the apex of the facet is formed by the end of a thin ridge that extends along the ventral length of the process. The presumed posterior dorsal vertebra has undergone lateral crushing, which is most obviously reflected in its relatively very narrow centrum width. The transverse process is short, about 5 mm, and in cross section is narrowly oval with anteroposterior elongation. Its articular facet is also oval and faces laterally and very slightly ventrally. A slightly raised, subcircular facet for the capitulum of the rib is seen high up on the anterior rim of the centrum.

The single, presumed lumbar vertebra consists essentially of the centrum and the base of the neural spine. The base of the spine is about 8 mm in anteroposterior length and is only very slightly excavated laterally. The transverse process, or diapophysis, is positioned on the upper half of the centrum, is oval in cross section with its long axis directed anterodorsally, and projects outward from the centrum just barely at its anterior edge to about 5 mm at its posterior edge. Its oval articular surface extends from a point near the upper margin of the anterior rim of the centrum posteroventrally to a little

beyond the mid-length of the centrum and faces laterally and slightly anteriorly. The parapophysis is considerably smaller than the diapophysis, appears as a slightly raised, vertically elongated oval area located beside the anterior rim of the centrum and is separated from the diapophysis by a very narrow channel for the passage of the segmental artery; its articular surface faces ventrolaterally. The lower half of the lateral surface of the centrum is lightly excavated and the ventral, longitudinal keel is weakly developed.

The four caudal vertebrae of the holotype include two from the proximal and one each from the middle and distal regions of the tail. The proximal caudals consist for the most part of the centrum and the base of the spine. The spines are laterally compressed and only slightly excavated at their bases. In anteroposterior length the spine of the larger vertebra is 9 mm, whereas that of the smaller one is about 7.3 mm. Enough of the spines are preserved to indicate that they were inclined slightly anteriorly. In both proximal caudals the transverse processes are for the most part preserved and probably include very small portions of the fused ribs. The process has a broad base, extending across the upper half of the centrum from the anterior rim to within a short distance of the posterior rim, and projects ventrolaterally. A well-developed ridge extends upward from the lateral edge of the anterior rim of the centrum to buttress the process along the anterior margin of its ventral surface. The mid-caudal vertebra (Fig. 2) lacks essentially only the posterior zygapophyses and portions of the anterior zygapophyses. The neural spine is about 24 mm high, measured above the posterior zygapophyses, is moderately excavated at its base, and curves very slightly posteriorly. In anteroposterior length the spine is 5.2 mm just above the buttresses of the posterior zygapophyses, then gradually expands to 5.7 mm at its termination. The transverse process is reduced to a low protuberance high up on the centrum and somewhat anterior to its mid-length; posterior to the process is a rather deep, dimple-like depression. The incompletely preserved ventral keel of the centrum is represented by a low ridge. The distal caudal vertebra (Fig. 2) is complete except for the tip of the spine and very small portions of the anterior zygapophyses. The spine is inclined slightly posteriorly and tapers to what was probably a blunt point. Excavation of the neural arch at its base is reduced to a slight depression and the median ventral keel or ridge has been replaced by a narrow, flat surface. An isolated, laterally flattened neural spine that is complete to just below the posterior zygapophyses but incomplete distally has been catalogued with the holotype as probably belonging to a proximal caudal. As preserved it extends 23.4 mm above the posterior zygapophyses, has an anteroposterior length of 7.8 mm just above the buttresses of the zygapophyses, but expands distally to about 10.2 mm.

One of the three complete or nearly complete cervical ribs (Fig. 2) of MCZ 3386 is suspected of belonging to the atlas or possibly the axis. In this rib the capitulum and tuberculum appear to be about equally developed, are set close together, and meet at an angle between them of about 35°. There is a small gap in the triangular sheet of bone connecting the two heads that is probably due to imperfect preservation and the rib can, therefore, be described as holocephalous. Unusual is the very thin, paddle-like expansion of the distal portion of the rib shaft. Romer and Price (1940) point out that in ophiacodonts there is some development of a flat, paddle-like blade of the cervical rib shaft for attachment of the levator and anterior serratus muscles supporting the scapula; they also see some evidence of a similar condition in edaphosaurs. Further, their figures (Romer and Price, 1940:299, Fig. 58) of the primitive sphenacodontid *Haptodus* show a distal dialation of the anterior cervical ribs. However, they state that among the more advanced sphenacodontids there is no distal expansion of the cervical ribs. They note that the first seven cervicals of *Dimetrodon* end in pointed tips, but do not comment on *Sphenacodon*, for which this information is apparently lacking. It is interesting that Vaughn (1964) has described a fragmentary cervical rib in *Ctenospondylus* that is somewhat expanded distally. As preserved the presumed axial or atlantal cervical rib of *C.*

ninevehensis is 81 mm long, 19.8 mm wide at its proximal end, 8.8 mm wide at its narrowest point just distal to the union of the rib heads, and about 19 mm across the widest point of its distally expanded shaft. Because the distal portion of the rib is incompletely preserved, the actual maximum width and length of the rib are at least slightly greater than the measurements given above. Although the proximal ends of the other two cervical ribs (Fig. 2) are somewhat incomplete, they also appear to be at least nearly holocephalous. Their shafts are essentially complete and are typically sphenacodontid in being slender and oval in cross-section, and in having pointed ends. The smaller and presumably more anterior of the two ribs is 105 mm long, 27.8 mm wide at its proximal end, and about 8 mm wide at about mid-length of the shaft; the same measurements for the larger rib are 131, 26, and 8 mm respectively. Among the materials assigned to MCZ 3386 are portions of rib shafts and a poorly preserved proximal end of a dichoccephalous rib that was undoubtedly from the dorsal region of the column.

Appendicular elements.—All that remains of the appendicular skeleton of the holotype is a small part of a scapular blade, a nearly complete left humerus, the distal end of a right humerus, and the greater part of a right pelvis. These elements exhibit no marked differences from those of the advanced sphenacodontids *Dimetrodon* and *Sphenacodon* and they need not be described in detail here (see Romer and Price, 1940, for descriptions and illustrations). The left humerus (Fig. 3) lacks mainly the supinator process and the posterodistal margin of the entepicondyle. It has undergone some dorsoventral crushing, but still retains a slight twisting of the proximal and distal planes. The rugosities and muscle scars are well developed, suggesting a fully adult individual. As preserved, the humerus is 142.7 mm long, 69 mm wide across the proximal end, 62.1 mm across the distal end, and has a minimum dorsoventral thickness through the narrowest portion of the shaft of 11.3 mm. Important areas missing in the right pelvis (Fig. 3) include the posterior extension of the dorsal blade of the ilium, a very small amount of bone along the posterior end of the ischium, and that part of the pubis contributing to the puboischiadic plate. As preserved the ilium is 82.5 mm high, 42.4 mm across the neck, and 58.5 mm across the base, the pubis is 101 mm long, and the ischium is 80 mm in length and height. In overall proportions the only noteworthy difference I can detect between the pelvis of MCZ 3386 and those of most sphenacodontids is the relatively shorter length of its ischium compared to that of the pubis. This is true, even if one takes into account that a very small amount of bone is missing along the posterior margin of the ischium. In advanced sphenacodontids the length of the ischium normally exceeds that of the pubis by about 10%; the reverse appears to be the case in MCZ 3386.

COMPARISONS

Generic assignment of MCZ 3386 to *Ctenospondylus* is based solely on the shape and length of the neural spine of its dorsal vertebrae. In the absence of this structure it would be almost impossible to determine whether MCZ 3386 pertains to *Ctenospondylus*, *Sphenacodon*, or *Dimetrodon*, because their skeletons are otherwise essentially identical. Though Vaughn (1964, 1970) has recently found some additional differences in detail of the dermal skull roof, braincase, and the atlas-axis complex of these three genera, the neural spines remain as the major feature for distinguishing them. In *Dimetrodon* the spines are of the normal, laterally flattened shape for only a short distance above the neural arch, then abruptly change to slender, transversely expanded rods having fore and aft grooves that give them a figure-8 shape in

