Overview

A lack of morphological information makes it difficult to interpret the relationships of advanced cynodonts and early mammals. To address this problem, we studied new skulls of *Sinoconodon* and *Morganucodon oehleri* from the Liassic of Yunnan, China, and *Dinnetherium* from the Kayenta Formation of Arizona.

*Sinoconodon* possesses a mosaic of primitive and derived cranial features. Many of *Sinoconodon*’s cranial characters are plesiomorphies compared with the successively more distant outgroup cynodonts, *Pachygenelus*, *Probainognathus*, *Tritylodon*, and *Thrinaxodon*. *Sinoconodon* retains a large septomaxilla with a transverse shelf and intermediate pterygoid crests on the palate; the prootic vein passes through the cavum epiptericum; the incisors were replaced alternately more than once, and the canines at least four times. The postcanine row is restricted to five multicusped longitudinally ovate teeth that possess only vestigial cingula and do not occlude with one another. The erupting postcanines were successively added to the posterior end of the postcanine row. There is no evidence of replacement of the first four postcanines, but the ultimate postcanine may have been replaced. At least two anterior postcanines were lost in the older specimens.

*Sinoconodon* shares several derived characters with other mammals. The most notable are the expansion of the brain vault in the parietal region, complete ossification of the medial wall of the orbit, a dentary condyle, and a concave glenoid fossa in the squamosal. These characters suggest that *Sinoconodon* and other mammals form a monophyletic group. *Sinoconodon* lacks a number of diagnostic apomorphies shared by *Morganucodon*, *Dinnetherium*, and other mammals. In addition, *Sinoconodon* developed some autapomorphic characters: an extraordinarily large canine; a massive dentary condyle; a large occipital condyle; and, relative to skull length, postdental bones more reduced in size than in the other known Liassic mammals. These characters suggest that *Sinoconodon* is the sistergroup to a taxon that includes all other mammals.

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Introduction

Several competing hypotheses on the interrelationships of the earliest mammals and their relationship to advanced therapsids have been advanced during last decade (Kemp, 1982, 1983; Crompton and Jenkins, 1979; Crompton and Sun, 1985; Hopson and Barghusen, 1986; Kermack et al., 1973, 1981; Sues, 1985; Rowe, 1988). Both lack of knowledge of the structure of many critical taxa and the uneven emphasis the authors have accorded to various characters have contributed to these conflicting interpretations. Hopson and Barghusen (1986) claim that the trithelodontids (ictidosauromorph synapsids) are the sistergroup of mammals, whereas the tritylodontids are the sistergroup to the gomphodont (herbivorous) cynodonts. This latter relationship is partly based on a similar pattern of occlusion (bilateral, with a posteriorly directed movement of the lower jaw during the final stages of jaw closure) (Crompton and Ellenburger, 1957; Crompton, 1972). Kemp (1982, 1983), on the other hand, lists several apomorphies shared by mammals and tritylodontids, concluding that they are sistergroups. He (Kemp, 1983: p. 380) dismisses the dental evidence “since convergence of dental structures seems to occur.” Sues (1985: p. 216), in a critique of Kemp’s character analysis, concludes that “extensive parallel evolution in features of both skull and postcranial skeleton is evident among advanced synapsids, regardless of the preferred hypothesis of tritylodontid relationships.” On the basis of his character analysis, Sues agrees with Hopson and Barghusen, that tritylodontids are the sistergroup of gomphodont cynodonts, specifically the Exaeretodon-Massetognathus assemblage. Rowe (1988), on the basis of numerous cranial and postcranial characters, argues that the tritylodontids, trithelodontids, and haramiyids are the sistergroup of all the remaining taxa that are generally included within the Mammalia. Several authors (Jenkins and Crompton, 1979; Kermack et al., 1973) suggest a close relationship between the morganucodontids and triconodontids because of dental and petrosal similarities. Rowe (1988), however, concludes that these are not reliable characters for determining phylogenetic relationships of the triconodontids. This controversy underscores the necessity to evaluate more character complexes, carefully interpret the morphology in order to differentiate synapomorphic and homoplastic characters, and perhaps more important, to discover a greater assemblage of late Triassic and early Jurassic synapsids.

Previous studies of Sinoconodon (Patterson and Olson, 1961; Crompton and Sun, 1985) are based on isolated skull and postcranial fragments, as well as a complete skull in which the palatae and the medial wall of the orbit are damaged. The descriptions of Morganucodon are based on an extremely large collection of isolated fragments and a complete skull. This material enabled Kermack et al. (1973, 1981) to give an excellent account of this genus. For the existing account of Dinitherium, only lower and upper jaws and dentitions were discussed (Jenkins et al., 1983; Jenkins, 1984). In this chapter we address the relationship of some Liassic mammals (Sinoconodon, Morganucodon, Megazostrodon, and Dinitherium) and the relationships of trithelodontids and tritylodontids to these early mammals.

Thanks to the generosity of Professor Sun Ailin and Mr. Cui Guihai at the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) at Beijing, we are currently studying a number of nearly complete skulls and partial skulls of the mammals Sinoconodon and Morganucodon oehleri and a tritylodontid, Yunnanodon. All of this material comes from the dark red beds of the Lower Lufeng Formation (Liassic) in the Lufeng Basin of Yunnan Province, China (Sun and Cui, 1986). Other cranial materials available for this study include the extensive but largely undescribed skull materials of Dinitherium and Pachygenelus. These studies have revealed a mass of new information.

In assessing the character-state polarity, we primarily rely on outgroup comparison (Wiley, 1979; Eldredge and Cracraft, 1980; Maddison et al., 1984). Trithelodontids, probainognathids, tritylodontids, and galeosaurs are taken as successively more distant outgroups to Sinoconodon and other early mammals.

Dentition

The dentitions of the new material of Sinoconodon can be arranged in series of increasing length (Figs. 4.1 and 4.2). These confirm that Sinoconodon did not occlude the postcanine teeth and that no consistent pattern in the positions of upper and lower postcanines can be observed (Crompton and Sun, 1985). Some of the better preserved postcanines possess a faint buccal cingulum on the uppers and a more distinct one on the post-erolingual surface of the lowers.

The smallest upper jaw (IVPP 8683) has five upper incisors, all with damaged crowns (Fig. 4.1). Pits for replacing teeth lie internal to I² and I⁴. The tip of a replacing upper canine is visible in the posterior wall socket for the reception of the lower canine. Three functional postcanines and a fourth in the process of erupting are present. The precise form and size of the erupting tooth have not been determined. With increasing size, the postcanine diastema enlarges. At least two anterior postcanines were lost without replacement. The empty alveoli is filled with spongy bone. In IVPP 4727 the ultimate postcanine is considerably smaller and simpler than other postcanines, whereas in an older specimen (IVPP 8692), it is about the same size as the more anterior postcanines. This suggests replacement of the small ultimate tooth in IVPP 4727. The size and degree of eruption of the functional