Contributions in Biology and Geology

Number 27
August 31, 1979

Paleontology and Geology of
The Bridger Formation,
Southern Green River Basin,
The Geolabididae (Mammalia, Insectivora)

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Abstract. Two species of Centetodon, *C. pulcher* and *Centetodon* sp. B. (new, Lillegraven and McKenna, MS) comprise the geolabidid record from the Green River Basin, Wyoming. Previously unknown elements of the upper dentition of *C. pulcher* are described along with a reconstruction of the lower antemolar teeth. *C. pulcher*, *Batodon* and *Batodonoides* appear to be the most primitive known geolabidids, and the family seems most closely related to palaenoryctids.

INTRODUCTION

Small insectivores of the Family Geolabididae are poorly represented in most collections of Eocene mammals. Ongoing collecting by the junior author in the Bridger Formation has yielded a modest sample that increases our knowledge of the dental anatomy and evolution of the genus *Centetodon*.

The systematics of *Centetodon* is currently being revised (Lillegraven and McKenna, MS). Reference to this work was published elsewhere (Krishtalka and Setoguchi, 1977), including an informal designation of new species named in Lillegraven and McKenna’s manuscript that will likewise be used here.

Lillegraven and McKenna recognize three Eocene species of *Centetodon*: *C. pulcher* Marsh, 1872 and *Centetodon* sp. B (new) occur in Bridgerian deposits, whereas, *Centetodon* sp. U (new) is known from Uintan horizons of California. Krishtalka and Setoguchi (1977) added *C. magnus* (Clark, 1936) and *Centetodon* sp. C (new) from the Uintan and Duchesnean sediments of the Badwater Creek area to the Eocene record of the genus. Both of these species had previously been reported only from the Oligocene. The earliest known record of *C. pulcher* is from the Wasatchian Huerfano Formation.
Three of these species (C. magnus, Centetodon sp. U, Centetodon sp. C) are known from elements of the upper and lower dentition, whereas C. pulcher and Centetodon sp. B are reported by Lillegarden and McKenna (MS) from the lower dentition alone. Isolated upper molars of Centetodon sp. B have been recovered from the Bridgerian Powder Wash locality, Utah (Krishtalka, 1975). P4 and upper molars of C. pulcher have, until this study, never been identified or described.

The Centetodon material from the Bridger Formation represents two species: C. pulcher and Centetodon sp. B. Analysis of remains of their upper dentitions improves our understanding of their relationships to other species of Centetodon and other geolabidids. Well-preserved partial dentaries of C. pulcher allow some reconstruction of the number and structure of antemolar teeth.

Specimens of both C. pulcher and Centetodon sp. B have been found at localities in the Bridger B (Black's Fork Member of the Bridger Formation) and Bridger C (Twin Buttes Member). A Bridger D locality (MPM locality number 1128) yielded additional C. pulcher material and Gazin (1976) reported this species from the lower and upper Bridger. The occurrence of both species throughout much of the Bridger Formation is coincident with other examples (West, 1973 for apatemyids; Krishtalka and West, 1977 for erinaceids; West, 1979 for Hyopsodus) of the apparent slow rate of evolutionary change in these mammalian taxa during the Bridgerian.

Because of Lillegarden and McKenna's (MS) forthcoming work, only those aspects of the morphology and evolution of Centetodon not broached by them are discussed and figured below.

Abbreviations in this paper are as follows: AMNH, American Museum of Natural History; MPM, Milwaukee Public Museum; L, length; W, width. All measurements in the text and tables are in millimeters. The figures are scanning electron microscope stereomicrographs.

FAMILY GEOLABIDIDAE (McKENNA, 1960)

CENTETODON MARSH, 1872

CENTETODON PULCHER MARSH, 1872

(Figs. 1-3; Table 1)

Referred material: partial dentary with: P4-M3, AMNH 91870; P3, AMNH 91874; P2-M1, AMNH 91873; M1-M2, MPM 3943; M2-L, AMNH 91869, 91875, MPM 3924; M3-L, AMNH 91876, 91878; P4, AMNH 91334, 91877, MPM 3825; M2, AMNH 91871, MPM 3996; isolated M3, AMNH 91881, 91883, MPM 3941; M2, AMNH 91879, MPM 3938; P4, AMNH 91885, 91886, MPM 3927, 3944, 3949; M1, AMNH 91843-91849, 91851, MPM 3920, 3937; M2, AMNH 91850, 91853.
Localities: MPM locality numbers 1129, 2145, 2215, 2401, 2413 (all Bridger B); 1102, 1125, 1098, 2187, 2228, 2827 (all Bridger C); 1128 (Bridger D); with coordinates on file in the Department of Geology, Milwaukee Public Museum.

Known distribution: Late Wasatchian, Colorado; Bridgerian, Wyoming.

Description: Lillegraven and McKenna (MS) present a full account of the morphology of P3-M3. Teeth anterior to P3 are unknown in C. pulcher, but MPM 3943, a partial right dentary, preserves M2, the talonid of M1 and twelve alveoli anterior to the alveolus for the M1 trigonid. P4 and P3 in other specimens of C. pulcher are two-rooted, accounting for the posterior four antemolar alveoli. The four alveoli anterior to those for P3 on MPM 3943 are slightly inclined anteriorly, but are otherwise similar to those for P3 and probably contained two-rooted P3 and P4. Of the remaining four alveoli anterior to those for P3, the posterior three are inclined anteriorly at more than a 45 degree angle to the vertical. The size, position and shape of these four alveoli imply that they contained a single-rooted canine and three incisors. Sequentially, from I1 to C, the alveoli are: tiny and nearly vertical (I1); large and circular (I2); smaller than that for I2 and circular (I3); slightly larger than that for I2 but elliptical longitudinally (C). If the alveolar morphology is an indication of the size, shape and inclination of the teeth, I1 was tiny, I2 and C markedly procumbent and I1 much larger than I2; the canine was larger than I2 and laterally compressed.

Isolated P's, M's and M's of C. pulcher were identified on the basis of their resemblance to comparable teeth of other species of Centetodon and similarity in size and abundance to remains of the lower dentition of C. pulcher.

P4, T-shaped in occlusal view, is much longer labially than lingually. The paracone, tall and spire-like, dominates the buccal half of the crown. The parastyle is a small cusp, completely separated from the paracone, and forms the anterolabial spur of the crown. A short ridge runs from the para- style to the anterior part of the base of the paracone. The metastyle, not a discernible cuspule, forms the sharp posterolabial end of the high, dorsally sloping postparaerista. In buccal view the metastyle is much higher on the crown than the parastyle and the two are connected by a weak, sinuous ectocingulum. Two tiny accessory cuspules occur irregularly on the ectocingulum. When discernible, the anterior one is just posterior to the apex of the parastrate and the posterior one occurs a short distance anterior to the metastyle. The protocone is anteroposteriorly compressed, crescentic and about one-third as high as the paracone. A metaconule is absent but a swelling on the preprotoerista may be interpreted as a paraconule. On unworn P's faint paraconulecristae are evident. The postprotoerista is short but the protoerista extends along the anterior margin of the crown to the para- style. Weak pre- and postcingula occur on either side of the protocone but
Figure 1. *Centetodon pulcher*, MPM 3943, showing partial right dentary with (a) alveoli for I₂-P₄; (b) M₁ talonid, M₂₃, and alveoli for P₃-M₁.
Figure 2. *Centetodon pulcher*, AMNH 91870, partial right dentary with P3-M1.

Figure 3. *Centetodon pulcher* (a) MPM 3944, LP; (b) AMNH 91843, RM; (c) AMNH 91850, RM2.

are not continuous lingually. The postcingulum ends lingually in a tiny hypocone and extends labially along the base of the high postparacrista. The precingulum, narrower and shorter than the postcingulum, is limited to the anterior part of the base of the protocone. The lingual root of P is not divided.

M1 and M2 are essentially triangular in occlusal aspect and transverse, with flaring stylar lobes. The paracone and metacone, connate along the first one-third of their height, occur internally, so that the stylar shelf is broad. The paracone is tall, nearly vertical and conical, whereas the metacone, shorter than the paracone, leans posteriorly and is crescentic. On M1 the metastylar salient is larger than and extends buccally beyond the para-stylar one. On M2 the para-stylar area is more expanded labially and the ectoflexus is deeper than on M1. The preparacrista on both upper molars extends to a small stylcone, just posterior to the para-style. The postmata- Cristina, a high trenchant crest, slopes posterolabially and dorsally to the tip of the metastylar wing.
Table 1. Dimensions of teeth of Centetodon pulcher and Centetodon sp. B from the Bridger Formation, Green River Basin, Wyoming.

<table>
<thead>
<tr>
<th>Centetodon pulcher</th>
<th>Centetodon sp. B</th>
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<tbody>
<tr>
<td>Range N Mean</td>
<td>Range N Mean</td>
</tr>
<tr>
<td>P2 L 2.1-2.3 3 2.2</td>
<td>—</td>
</tr>
<tr>
<td>W 2.5-2.8 4 2.6</td>
<td>—</td>
</tr>
<tr>
<td>M2 L 1.8-2.1 10 2.0</td>
<td>—</td>
</tr>
<tr>
<td>W 2.6-3.0 10 2.8 1.9 1</td>
<td>—</td>
</tr>
<tr>
<td>M2 L 1.6-1.8 2 1.7 1.3 1</td>
<td>—</td>
</tr>
<tr>
<td>W 2.6-2.7 2 2.6 1.9 1</td>
<td>—</td>
</tr>
<tr>
<td>M2 L — — — 1.0 1</td>
<td>—</td>
</tr>
<tr>
<td>W — — — 1.7 1</td>
<td>—</td>
</tr>
<tr>
<td>P3 L 1.7-1.8 6 1.8 1.2-1.6 6 1.4</td>
<td></td>
</tr>
<tr>
<td>W 1.0-1.2 6 1.1 0.7-0.9 6 0.8</td>
<td></td>
</tr>
<tr>
<td>M3 L 1.8-2.1 7 2.0 1.4-1.7 6 1.5</td>
<td></td>
</tr>
<tr>
<td>W 1.4-1.5 6 1.4 0.9-1.1 6 1.0</td>
<td></td>
</tr>
<tr>
<td>M3 L 1.8-2.0 10 1.8 1.3-1.4 4 1.3</td>
<td></td>
</tr>
<tr>
<td>W 1.4-1.5 5 1.5 0.9-1.0 4 0.9</td>
<td></td>
</tr>
<tr>
<td>M3 L 1.7-1.8 3 1.7 1.2-1.4 8 1.3</td>
<td></td>
</tr>
<tr>
<td>W 1.0-1.3 3 1.2 0.8-0.9 8 0.8</td>
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The protocone, about one-half the height of the paracone, is subcrescentic, with well developed protocristae. Acute V-shaped conules occur on these cristae with the paraconule slightly larger than the metaconule and closer to the protocone. The preparaconulecrista runs to the stylocone and the postmetaconulecrista to the tip of the metastylar salient. These crests demarcate a broad paracingulum and metacingulum along the base of the paracone and metacone, respectively. Narrow pre- and postcingula occur along the lingual half of the base of the crown and, although they may extend weakly around most of the lingual base of the protocone, they are not usually continuous. The two cingula do meet lingually on the two referred M3s. The cingula end labially at a point basal to the conules where, consequently, the crown is shortest and most emarginate. The postcingulum, wider than the precingulum, bears a tiny hypocone. The single lingual root of M2 and M3 is broad anteroposteriorly, but is not divided into anterior and posterior columns. M3 and teeth anterior to P4 have as yet not been identified.

Remarks: Diagnostic features of the lower dentition of C. pulcher are discussed by Lillegraven and McKenna (MS). Compared to other species of Centetodon, P4 of C. pulcher has a more medial rather than anteriorly dis-
placed protocone. M\textsuperscript{1-2} of *C. pulcher* are distinct and more primitive in four specific features: (1) the lingual root is a single, broad, undivided column; (2) the pre- and postcingula are narrower lingually; (3) the pre- and postvalum walls of the trigon form a more obtuse V; and (4) the stylar shelves are somewhat wider. In contrast, among the four other known Eocene species of *Centetodon* (Krishtalka and Setoguchi, 1977): (1) the lingual root of M\textsuperscript{1} and M\textsuperscript{2} is either divided by a groove into anterior and posterior columns or is partially bifurcate (*Centetodon* sp. B, *Centetodon* sp. U) or two separate roots occur (*C. magnus*, *Centetodon* sp. C); (2) the cingula are much wider lingually and more shelf-like, so that, in occlusal view, the lingual half of the crown is more nearly rectangular than triangular; (3) the anterior and posterior walls of the trigon form a more acute-angled V; and (4) the stylar shelves are narrower. Consequently, M\textsuperscript{1-2} of these species are more transverse than those of *C. pulcher*.

**CENTETODON SP. B LILLEGRAVEN AND McKENNA (MS)**  
(Fig. 4; Table 1)

Referred specimens: partial dentaries with: P\textsubscript{4}, AMNH 91864; P\textsubscript{4}-M\textsubscript{1}, AMNH 91857, 91860; M\textsubscript{1-3}, AMNH 91855, MPM 3919; M\textsubscript{2-3}, AMNH 91862, 91863, 91856, MPM 3917; P\textsubscript{4}, AMNH 91865; M\textsubscript{1}, AMNH 91858; M\textsubscript{3}, AMNH 91854, 91861, 91859; isolated P\textsubscript{4}, AMNH 91866, 91880; M\textsubscript{1}, AMNH 91867, 91882; M\textsubscript{1}, AMNH 91852; partial maxilla with M\textsubscript{2-3}, MPM 3918.

Localities: MPM locality numbers 1129, 2215, 2401, 2409 (all Bridger B); 1098 (Bridger C); with coordinates on file in the Department of Geology, Milwaukee Public Museum.

Known distribution: Bridgerian of Wyoming and Utah.

Description and remarks: Lower teeth anterior to P\textsubscript{4} of this species are unknown. Lillegraeven and McKenna (MS) thoroughly describe and diagnose *Centetodon* sp. B on the basis of P\textsubscript{4} and molar morphology.

Isolated upper molars of this species have been recovered from the Bridgerian Powder Wash locality in the Green River Formation, Utah (Krishtalka, 1975; Krishtalka and Setoguchi, 1977) and are reported here from the Bridger Formation Green River Basin, Wyoming. M\textsuperscript{1} and M\textsuperscript{2} are similar to those of *C. pulcher* described above with the following distinctions: the crowns are more transverse, with broader, more shelf-like lingual cingula that do not continue around the lingual base of the protocone; the protocone and trigon are more compressed anteroposteriorly and the lingual root is either bifurcate or divided by a lingual groove into two columns. These distinctions imply that *Centetodon* sp. B is derived with respect to *C. pulcher* and more closely related to other known species of the genus—a conclusion also reached by Lillegraeven and McKenna (MS) on the basis of the lower dentition. M\textsuperscript{1} resembles M\textsuperscript{1-2} except that the metastylar
area is not developed, the lingual cingula are reduced and the lingual root is not divided.

**DISCUSSION AND CONCLUSIONS**

The newly recovered upper molars of *C. pulcher* and the additional material of *Centetodon* sp. B appear to confirm an earlier conclusion (Krishalka, 1975; Krishtalka and Setoguchi, 1977) concerning the evolution of *Centetodon* during the Eocene. One apparent morphoclone is the division of the lingual root of the upper molars into two vertical columns (*Centetodon* sp. B, *Centetodon* sp. U) and then into two separate roots (*Centetodon* sp. C, *C. magnus*). All post-Eocene species of *Centetodon* have a separate protoconal and hypoconal root on the upper molars. This morphoclone seems to be correlated with the expansion of the postcingulum into a hypoconal shelf in the evolution of these species. *C. pulcher* is primitive in these features. The lingual root on the upper molars is single and undivided, and the postcingulum is narrow.

Other genera of the Geolabididae are *Batodon*, from the late Cretaceous of Alberta, Wyoming and Montana (Lillegraven, 1969; Clemens, 1973), and *Batodonoides*, from the Uintan of California (Novacek, 1976). *Batodonoides* differs dentally from *Batodon* and *Centetodon* as described by Novacek (1976). *Batodon* is distinguished from *Centetodon* as follows: presence of an incipient metacone on P4; larger conules and absence of a hypocone on M2; and a longer talonid relative to the trigonid on M2 of *Batodonoides* and M2 of *Batodon* most closely resemble those of *C. pulcher* among the known species of *Centetodon* in having a single, undivided lingual root, but this is a primitive feature that is not indicative of a special relationship among these taxa.

Before *Batodon* was recently recognized as a geolabidid (McKenna, per-

![Figure 4. Centetodon sp. B. MPM 3918, partial right maxilla with M2-3.](image)
sonal communication; Novacek, 1976), the genus was identified as a palaeoryctid with close affinities to *Cimolestes incisus* (Lillegraven, 1969; Clemens, 1973). The sparse material referred to *Batodon* differs from *Cimolestes* but shares with *Centetodon* and *Batodonoides* the following derived geolabidid features: a metaconid and narrow, lingually displaced talonid basin on P4; much stronger cingula on M2. Other features shared by *Batodon, Batodonoides* and *Centetodon* are also present in *Cimolestes*: the upper molars are transverse, with connate paracone and metacone, broad, flaring stylar areas, high, blade-like postmetaenristae, strong conulecristae and antero-posteriorly compressed trigons and protocones. On the lower molars the trigonids are wider than the talonids and about three times as high, with tall, shearing protoconids and metaconids. Many of these similarities may, as Novacek (1976) also suggested, indicate a close phylogenetic relationship between the geolabidids *Batodon, Batodonoides* and *Centetodon* and at least some palaeoryctids, such as *Cimolestes*.

ACKNOWLEDGEMENTS

We are grateful to Drs. Jason A. Lillegraven (University of Wyoming) and Malcolm C. McKenna (American Museum of Natural History) for the use of unpublished information from their monograph on *Centetodon* evolution, and to Dr. Mary R. Dawson (Carnegie Museum of Natural History) for her critical comments and review of the manuscript. Jack Capenos (Crucible Research Division, Colt Industries) took the scanning electron micrographs and Ms. Elizabeth Hill typed the manuscript.

LITERATURE CITED


Lillegraven, J. A. and M. C. McKenna [MS]. Phylogenetic history and evolutionary mosaicism of Centetodon.


