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Philip D. Gingerich, Director

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PALEOCENE-EOCENE LAND MAMMALS FROM THREE NEW LATEST CLARKFORKIAN AND EARLIEST WASATCHIAN WASH SITES AT POLECAT BENCH IN THE NORTHERN BIGHORN BASIN, WYOMING

BY

PHILIP D. GINGERICH[1] AND THIERRY SMITH[2]

Abstract– Mammals are described from three wash sites in a 4-5 meter thick interval of brown paleosols at the south end of Polecat Bench in the northern Bighorn Basin, Wyoming. The sites lie within the lower part of the Paleocene-Eocene carbon isotope excursion (CIE) and are intermediate stratigraphically between beds yielding late Clarkforkian and early Wasatchian mammals known previously. The first site, the SC-435 Shell Bed, is the lowest stratigraphically. The Shell Bed site yielded 56 identifiable specimens, mostly isolated teeth, and the mammalian fauna includes the diagnostically-Clarkforkian species *Apheliscus nitidus*, *Haplomylus simpsoni,* and *Aletodon gunnelli*. The second site, the SC-434 Gar Scale Channel, is two meters or so above the Shell Bed site. The Gar Scale Channel site yielded 103 identifiable specimens, mostly isolated teeth, and the mammalian fauna includes the diagnostically-Wasatchian genera *Macrocranion*, *Meniscotherium*, and cf. *Reithroparamys*. A new leptictid insectivore genus and species, *Amphigyion straitae*, and a new hyopsodontid condylarth species, *Haplomylus zalmouti*, are described from the Gar Scale Channel site. The third site, the SC-434 Brown Mudstone, is a meter or so above the Gar Scale Channel. This yielded 14 identifiable specimens representing species identical to those known from the larger Gar Scale Channel fauna. *Meniscotherium priscum* Granger, 1915, is now known from 10 specimens in addition to the holotype. These come from the northern, western, and southern Bighorn Basin. There are no verifiable records of *Meniscotherium* from the Paleocene anywhere, and all Bighorn Basin specimens come from the earliest Wasatchian *Meniscotherium* zone (Wa-M). *Meniscotherium priscum* and *Haplomylus zalmouti* both appear to be diagnostic of this zone.

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INTRODUCTION

The transition between the Paleocene and Eocene epochs has been much studied in recent years, in the deep sea (Kennett and Stott, 1991; Bains et al., 1999; Zachos et al., 2001; Wing et al., 2003; and others) and on land (Gingerich, 1989; Smith and Smith, 1996; Clyde and Gingerich, 1998; Bowen et al., 2002; Wing et al., 2003, 2005; and others). It represents a time of rapid environmental change with lasting biotic consequences (Bowen et al., 2006), including faunal turnover and intercontinental dispersal that can be correlated globally (Gingerich, 2006; Smith et al., 2006). Details of rapid change in the geological past can only be studied where stratigraphic sections are thick and relatively complete. Small differences in stratigraphic level are important, and must be documented carefully to bring change into focus. This is why detailed studies of faunal change through the Paleocene-Eocene transition are important in general, and why discrete wash sites yielding fossil mammals from successive paleosols at Polecat Bench are important in particular (see below).

Paleocene-Eocene Faunas at Polecat Bench

The Paleocene-Eocene transition is the time in mammalian evolution when the first representatives of several groups of mammals appeared that later came to dominate modern faunas. These include the orders Artiodactyla, Perissodactyla, and Primates (exclusive of Proprimates). The abrupt appearance of these orders in North America has been known for almost a century, and was one of the principal discoveries of a series of American Museum of Natural History expeditions to the Bighorn and adjacent Clarks Fork basins of northwestern Wyoming carried out from 1910 through 1913. During the American Museum expeditions two distinctive mammalian faunas were recognized, a Clarkforkian fauna that later became the basis for the North American late Paleocene land-mammal age of the same name, and a Sandcouleean fauna widely recognized as the first part of the succeeding early Eocene Wasatchian land-mammal age. The first was named for the Clarks Fork Basin itself, and the second was named for Sand Coulee, which is a major drainage within the Clarks Fork Basin.

The 1910-1913 American Museum expeditions demonstrated that the Paleocene and Eocene are significantly different in terms of their mammalian faunas, and this discovery was the principal motivation for acceptance of a Paleocene epoch of geological time different from the Eocene (Sinclair, 1912; Granger, 1914; Matthew, 1914). Following the American Museum expeditions, the dawn horse *Hyracotherium*, representing the first appearance of Perissodactyla, has effectively defined the beginning of the Eocene for North American vertebrate paleontologists (Granger, 1914). There was confusion about this for a time after *Hyracotherium* was reported from the late Paleocene, first in Baja California (Morris, 1966, 1968) and then in Sand Coulee west of Polecat Bench (Jepsen and Woodburne, 1969). However, the Baja California specimens have since been shown to be part of an early Eocene fauna (Novacek et al., 1991), and the Sand Coulee report is almost certainly erroneous (Gingerich, 1989).

Two enigmatic and interesting fossil mammals were found by American Museum collectors in 1912: *Ectocion parvus* and *Meniscotherium priscum*. Both were published as having been found at the head of Big Sand Coulee, on or near the divide separating the Clarks Fork Basin in the north from the Bighorn Basin in the south (Fig. 1). Both were named by Granger (1915). *Ectocion parvus* was never found again until it proved to be common in an approximately 30-meter thick interval of strata at the south end of Polecat Bench (Gingerich, 1982a, 1989). Here it is part of a new and different, seemingly dwarfed (hence the species name *E. parvus*), mammal fauna with *Hyracotherium* that appeared to represent the oldest interval of Eocene strata and Wasatchian time. A local zone and geographically broader biochron were named Wa-0 to distinguish the *E. parvus* interval from succeeding Wasatchian biochrons (Gingerich, 1989).

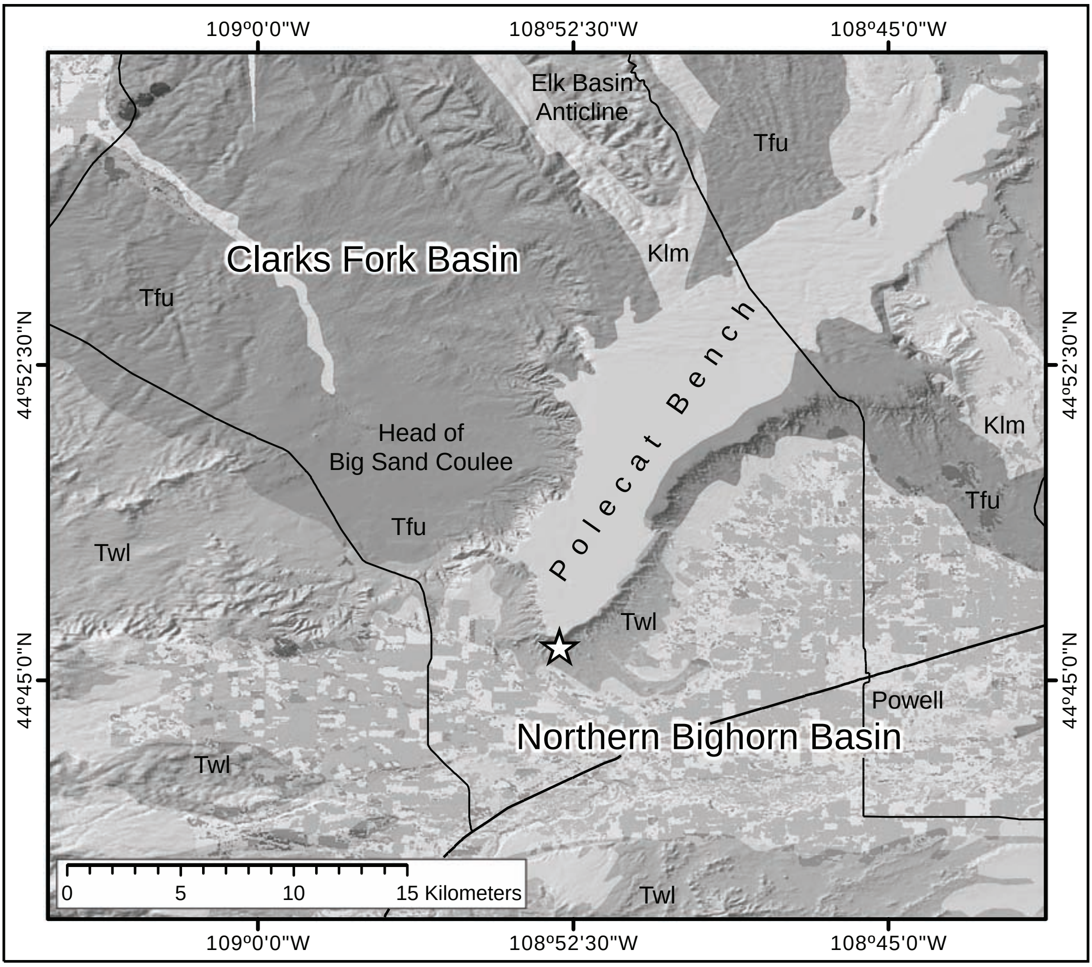


FIG. 1 — Geological map of Polecat Bench on the drainage divide between the Clarks Fork Basin and Bighorn Basin. Polecat Bench is a raised Pleistocene river terrace located north and west of the town of Powell in northwestern Wyoming. Star shows the position of the SC-434 and SC-435 localities discussed here (shown in more detail in Figs. 2-6). Geology is from Love and Christiansen (1985; www.wygisc.uwyo.edu/atlas). Abbreviations: *Klm*, Lance-Meeteetse formations (Cretaceous); *Tfu*, Fort Union Formation (Paleocene); *Twl*, Willwood Formation (late Paleocene and early Eocene).

Paleocene-Eocene Carbon Isotope Excursion and Meniscotherium

The Polecat Bench stratigraphic section and the Wa-0 faunal zone became more significant when a continental Paleocene-Eocene carbon isotope excursion (CIE) was found here and correlated with the deep-sea CIE and Paleocene-Eocene thermal maximum (PETM; Koch et al., 1992). There seemed to be a one-to-one match of the CIE and Wa-0, and the presence of a distinctive Wa-0 fauna could be attributed to a larger, global, Paleocene-Eocene environmental event (Clyde and Gingerich, 1998). Mammalian dwarfing could be explained, as a working hypothesis, as a response to elevated atmospheric carbon dioxide (Gingerich, 2003).

The Paleocene-Eocene CIE was studied at high stratigraphic resolution at Polecat Bench (Bowen et al., 2001; Bains et al., 2003; Magioncalda et al., 2004), and this yielded a surprising result:

the onset of the CIE started in strata yielding a late Clarkforkian (Cf-3) mammalian fauna, some 10 m below the appearance of the Wa-0 mammalian fauna. Development of these high-resolution isotope stratigraphies was accompanied by intensive prospecting in this 10 m interval in an attempt to clarify where exactly the Cf-3 to Wa-0 transition occurred. In 2000 a dentary of *Meniscotherium priscum* was found in distinctively brown, *Celtis*-bearing paleosols in the upper part of the 10 m Cf-3 to Wa-0 transition interval, and this was the first evidence of *Meniscotherium* found at Polecat Bench since the original discovery reported by Granger (1915). The only other *Meniscotherium* from the Bighorn Basin known at the time was a specimen found in 1987 in similar brown, *Celtis*-bearing paleosols overlying a Cf-3 fauna on the west side of the Bighorn Basin north of Meeteetse.

One of the anomalies remaining when the Wa-0 mammalian fauna was described was the occurrence of abundant *Celtis* endocarps in a 4-5 m interval of brown paleosols, seemingly barren of mammals just below the Wa-0 interval (Gingerich, 1989). Discovery of *Meniscotherium* in this otherwise barren interval with *Celtis* indicated additional complexity in the faunal transition from Paleocene Clarkforkian to Eocene Waatchian mammals (Gingerich, 2001). There was not a three-part Cf-3 to Wa-0 to Wa-1 transition within the CIE at Polecat Bench, but rather a four-part Cf-3 to something new to Wa-0 to Wa-1 transition (how much of Wa-1 lies within the CIE depends on how the end of the CIE is defined). The new zone was first called ‘Wa-0?’ (Gingerich, 2001, 2003) to reflect uncertainty about its age, and then Wa-M for *Meniscotherium* (Magioncalda et al., 2004; Yans et al., 2006). Discovery of *Meniscotherium* in association with a perissodactyl, at Halfway Hill in the Honeycombs area of the southern Bighorn Basin (Strait, 2003; Yans et al., 2006), corrobrates the Wasatchian age of this zone.

Wash Sites in the Clarkforkian-Wasatchian Transition

The Wa-M interval is only about 4-5 meters thick where it is best exposed at Polecat Bench, and surface prospecting in the Wa-M zone yields very few fossils. This prompted an intensive search for lithologies and sites where it might be possible to concentrate bones and teeth by screen-washing.

Several seasons of surface prospecting, precision mapping, and test washing identified concentrations of microvertebrate remains, including small mammals. These were found at three sites in two restricted localities, now called SC-434 and SC-435 (see map in Fig. 2). Both localities are shown in the field photograph in Figure 3. All three sites are found within a few meters of each other stratigraphically, above the Purple-0 marker bed and below the Top Brown marker bed (Gingerich, 2001), and for this reason the sites were initially regarded as Wa-M in age. The three sites are listed here in order of their stratigraphic superposition:

(3) The highest wash site stratigraphically is the SC-434 Brown Mudstone locality found by one of us (TS) in 2005. This is a ca. 20 cm thick mudstone unit with occasional vertebrate remains.

(2) The middle wash site stratigraphically is the SC-434 *Lepisosteus* or Gar Scale Channel locality found by Iyad Zalmout in 2003. This is a ca. 0 to 30 cm thick channel fill very close to the stratigraphic level of the UM 108645 *Meniscotherium* specimen found nearby in 2000. The channel fill has thousands of *Lepisosteus* gar scales dispersed throughout (hence the name).

(1) The lowest wash site stratigraphically is the SC-435 Shell Bed locality recognized to be productive by Aaron Weinblatt in 2004. This is a ca. 20 cm thick bed with numerous well preserved gastropods and a concentration of vertebrate remains.

Geographic coordinates of all three sites are listed in Table 1.

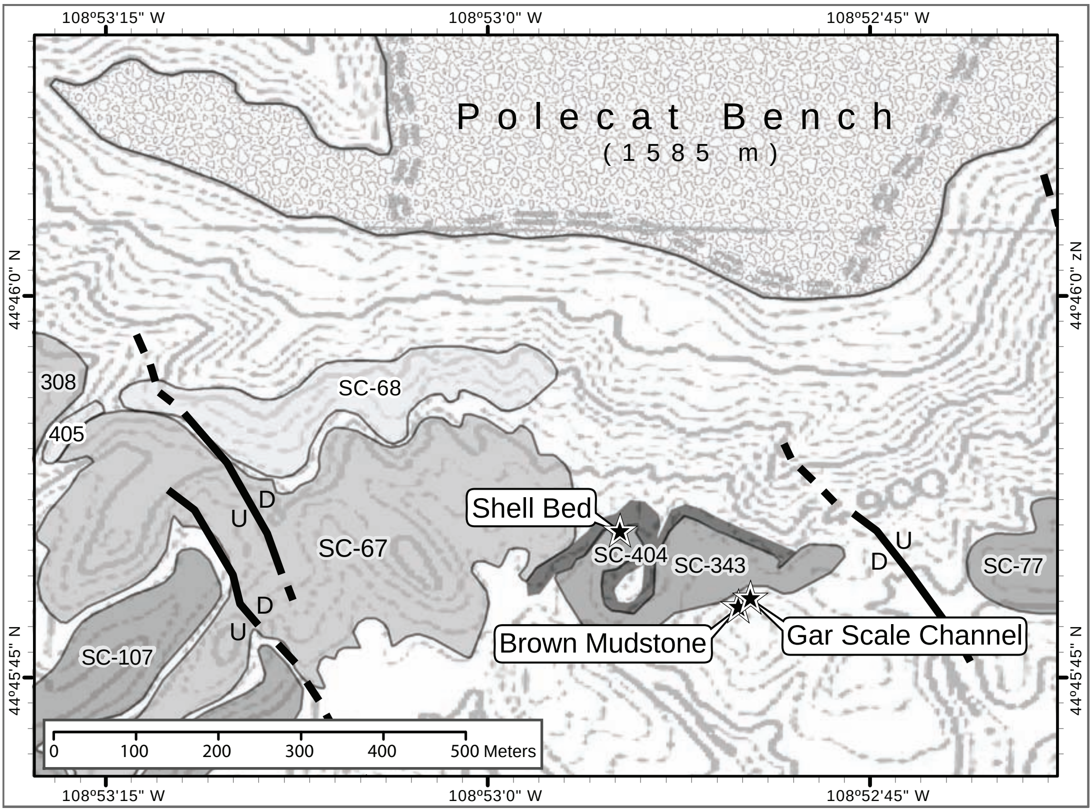


FIG. 2 — Location map showing the latest Clarkforkian and earliest Wasatchian screen-wash sites studied here (see Fig. 1 for location of Polecat Bench). The three sites (stars) are: (1) SC-435 Shell Bed (latest Clarkforkian zone Cf-3); SC-434 Gar Scale Channel (earliest Wasatchian zone Wa-M); and SC-434 Brown Mudstone (earliest Wasatchian zone Wa-M). Clarkforkian Cf-3 localities in the vicinty include SC-77, SC-107, and SC-343. Wasatchian Wa-M localities include SC-404 (dark shading). Wasatchian Wa-0 localities here include SC-67 and SC-308, and Wa-1 localities include SC-68 and SC-405. Solid black circles show the location of *Meniscotherium* specimens found here (in addition to those from the Gar Scale Channel site). Heavy black lines are small-scale normal faults. Topographic contours are at 20-foot intervals (Elk Basin SW base map is a U. S. Geological Survey 7.5 minute topographic quadrangle).

The location of each wash site is shown in Figures 4 and 5, first the SC-435 Shell Bed site (Fig. 4), and then the SC-434 Gar Scale Channel and Brown Mudstone sites (Fig. 5). A photograph showing the stratigraphy of the fossiliferous interval at the Gar Scale Channel site in detail is shown in Figure 6.

Two of the sites, the Shell Bed and the Gar Scale Channel, were tested by quarrying and preliminary screen-washing in 2004, and all three sites were washed intensively in 2005. Results reported here are based on 10 sacks of sediment from the SC-435 Shell Bed site (ca. 275 kg), 19 sacks of sediment from the SC-434 Gar Scale Channel site (ca. 525 kg), and 25 sacks from the SC-434 Brown Mudstone site (ca. 675 kg). All three sites were washed using nested sets of screens, with the finest being a 1 mm screen. In other words, everything that did not pass through a 1 mm screen was collected and examined. Further excavation and screen washing was carried out in 2006, but the resulting concentrate has not been sorted and identified, and hence results from 2006 screen-washing are not included in this report.

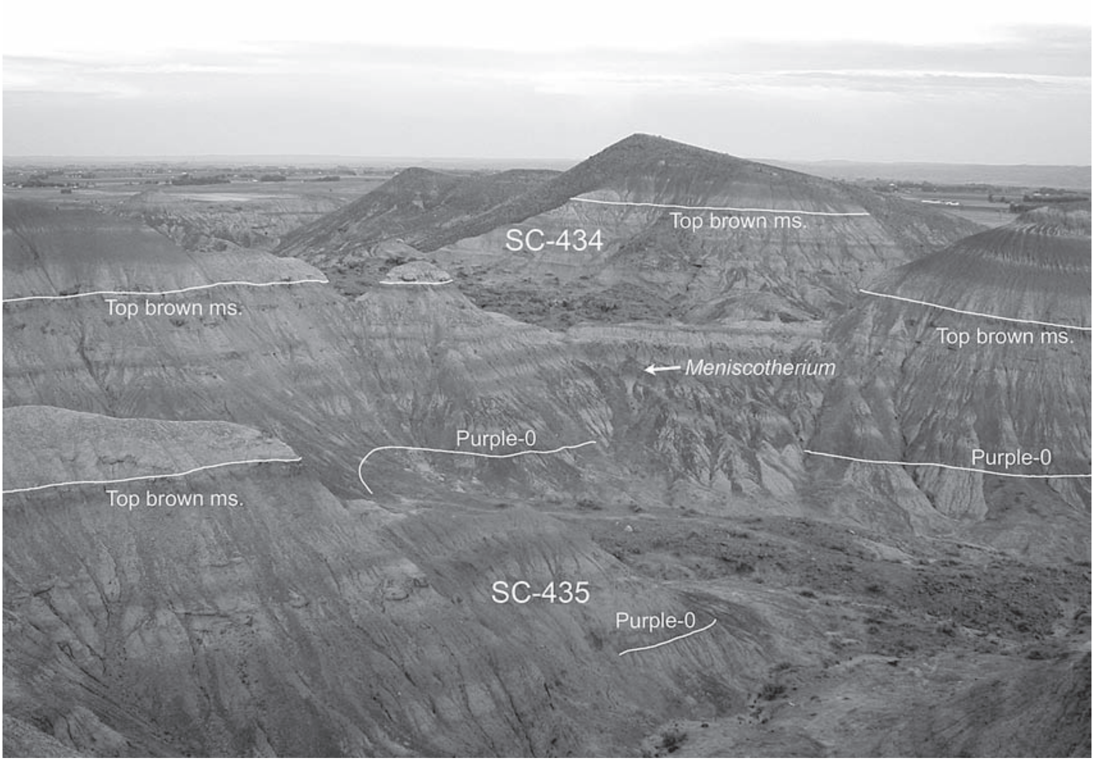


FIG. 3 — Photograph showing the relationship of the SC-434 and SC-435 localities and wash sites to each other and to the local stratigraphy and surrounding topography. More detailed photographs of the localities are given in Figures 4 and 5. View is to the southeast (see location map in Fig. 2). Lines trace the top of the 'Purple-0' marker bed (lower line; discontinuous because it is cut by scours in places) and the top of the 'Top Brown' mudstone (upper line), which together define the interval that includes Clarkforkian mammals in its lower part and Wa-M *Meniscotherium* zone mammals in its middle and upper parts. Arrow labeled *Meniscotherium* points to the site in locality SC-404 where UM 108645 was found. The SC-435 Shell Bed wash site of latest Clarkforkian age (Cf-3) is more than a meter above Purple-0, which means that the Clarkforkian-Wasatchian boundary is also more than a meter above Purple-0.

TABLE 1 — Geographic coordinates for late Clarkforkian (Cf-3) and earliest Wasatchian (Wa-M) localities discussed here.

		Universal Transverse Mercator (Zone 12 N, NAD 1927)			Geodetic (WGS 1984)	
UM locality	Age	Easting (m)	Northing (m)	Elev. (m)	North lat. (°)	West long. (°)
3. SC-434 Brown Mudstone	Wa-M	667733	4958621	1479	44.76322	108.88129
2. SC-434 Gar Scale Bed	Wa-M	667742	4958633	1477	44.76332	108.88117
1. SC-435 Shell Bed	Cf-3	667628	4958712	1482	44.76406	108.88258

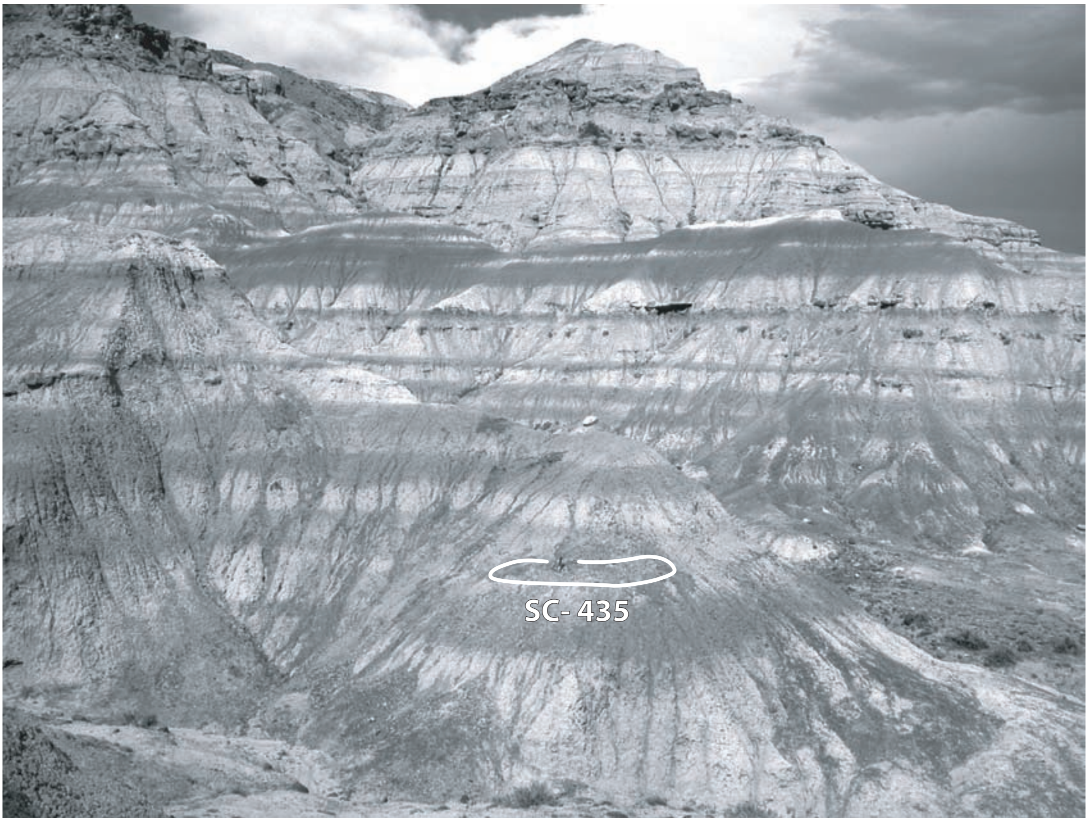


FIG. 4 — Photograph of SC-435 Shell Bed screen-wash site at the south end of Polecat Bench. Site is about one meter above the Purple-0 bed previously used to approximate the Clarkforkian-Wasatchian boundary (Magioncalda et al., 2004). View is to the northeast. For scale, hammer standing in the site is 30 cm long.

Together, the three sites studied here span about three meters of stratigraphic section. A broader interpretive study, including a refined stratigraphy and associated new carbon isotope results, will be described elsewhere. Our purpose here is to identify and describe the mammalian remains recovered by screen-washing at all three wash sites. Selected surface finds from SC-434 and 435 collected in 2003 and 2004 are included in wash site faunal lists when they add substantially to the wash sample (these are distinguished by having UM specimen numbers smaller than 113200). We evaluate the significance of the fossils found at each site in the concluding discussion at the end of the paper.

Notes on Systematics

The fauna sections of this study are focused on identification of the species from each wash site. Identification decisions require reference to the type specimen and type locality, to the age and geographic distribution of the species, and to previous literature. This information is presented in a standard format, together with a summary of diagnostic characteristics useful for making the identification (often taken from relevant literature). A ‘summary diagnosis’ is not intended as a substitute for other more complete diagnoses given by original authors, or by authors revising particular taxonomic groups. Finally, we list the specimens documenting each species and describe

FIG. 5 — Photograph of SC-434 Gar Scale Channel and Brown Mudstone screen-wash sites at the south end of Polecat Bench. Both sites are in Wa-M sediment filling a local scour that has removed the Purple-0 bed here. View is to the southeast. Collectors standing in each site provide scale.

their salient characteristics. The discussion at the end of each species section includes a statement about the meaning of the species for the age of the wash site being considered, and these individual statements are summarized in the more general discussion at the end of the paper.

Most specimens described here are isolated teeth, but the species they represent are almost all well known from more complete dentitions collected from upper Clarkforkian or lower Wasatchian strata (or both) in the northern Bighorn and Clarks Fork basins. Hence we are reasonably confident of most identifications, and those for which questions remain are indicated appropriately.

INSTITUTIONAL ABBREVIATIONS

AMNH — American Museum of Natural History, New York, New York
CM — Carnegie Museum of Natural History, Pittsburgh, Pennsylvania
UCMP — University of California Museum of Paleontology, Berkeley, California
UM — University of Michigan Museum of Paleontology, Ann Arbor, Michigan
YPM-PU — Princeton University collection, Peabody Museum of Natural History, Yale University, New Haven, Connecticut

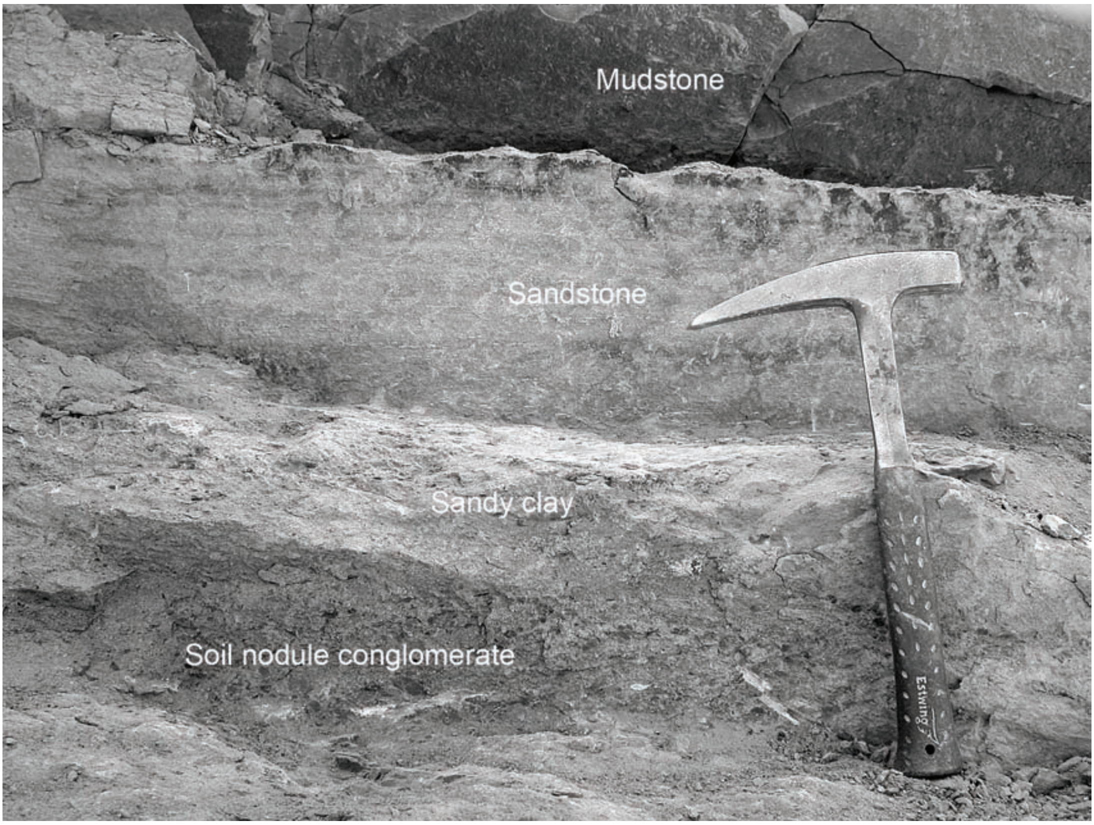


FIG. 6 — Detailed cross-section of the bone-bearing interval at the Gar Scale Channel site within locality SC-434. Base of scour fill is a lithified bed of cm-scale conglomerate that is principally reworked soil nodules with occasional mammalian jaws and teeth (soil nodule conglomerate). This is overlain by a sandy clay with isolated teeth and occasional jaws with teeth. The bone-bearing interval is capped by a sandstone, which is overlain in turn by mudstone. Hammer is 30 cm long.

SYSTEMATICS OF MAMMALS FROM THE SC-435 SHELL BED SITE

Order MULTITUBERCULATA
Family NEOPLAGIAULACIDAE

Ectypodus Matthew and Granger, 1921

Ectypodus powelli Jepsen, 1940

Ectypodus powelli Jepsen, 1940, p. 308. Krause, 1980, p. 1169. Rose, 1981, p. 33.

Holotype.— YPM-PU 13979, left dentary with P_4-M_2.

Type locality.— Princeton Quarry, late Tiffanian land-mammal age (Ti-5), late Paleocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— *Ectypodus powelli* ranges through the late Tiffanian and Clarkforkian land-mammal ages, late Paleocene, of the Bighorn and Clarks Fork basins (Krause, 1980; Rose, 1981).

Summary diagnosis.— Common species of *Ectypodus*, with a trenchant P^4 having one high, arched shearing row of conjoined cuspules and 4-5 small anteroexternal cuspules (Jepsen, 1930); about 10-15% larger than Wasatchian *E. tardus* (Krause, 1980).

Referred specimens.— UM 113368 (R P^4: 2.13 × 0.84 mm; cusp formula 2:6:0), 113373 (R P^4: 2.04 × 0.76; 3:6:0), 113380 (R M^2: 1.22 × 1.19; 4:4:0), 113383 (R M^2: 1.18 × 1.13; 4:3:0), 113393 (broken R M^1; — × 1.13), and 113396 (left or right P^1 or P^2).

Description.— The wash sample from the SC-435 Shell Bed locality includes two crowns of P^4, two crowns of M^2, a partial crown of M^1, and the crown of an anterior premolar. M_1 is broken, precluding measurement of its length and precluding accurate cusp counts.

Discussion.— This species of *Ectypodus* is represented by a small collection of teeth consistent with the size and morphology of Clarkforkian *E. powelli*, and larger than Wasatchian *E. tardus*.

Order MARSUPIALIA
Family PERADECTIDAE

Peradectes Matthew and Granger, 1921

Peradectes protinnominatus McKenna, 1960

Peradectes protinnominatus McKenna, 1960, p. 41. Krishtalka and Stucky, 1983, p. 246. Strait, 2001, p. 131.
Peradectes chesteri (in part), Bown, 1979, p. 54.
Peradectes cf. *P. chesteri,* Rose, 1981, p. 34.

Holotype.— UCMP 44077, associated right M^{1-3}.

Type locality.— Alheit Pocket, Four Mile Creek area, Wasatchian land-mammal age, early Eocene, Sand Wash Basin, Colorado.

Age and distribution.— Early Wasatchian land-mammal age, early Eocene, Four Mile Creek area, Colorado; Clarkforkian to early Wasatchian, late Paleocene to early Eocene, Bighorn Basin, Wyoming.

Summary diagnosis.— Small polyprotodont marsupials. Upper molars are more rectodont than dilambdodont, the paracone is slightly smaller than the metacone, conules are present but very small, and stylar cusps B and D are the most prominent. On lower molars, the hypoconulid and entoconid are more closely twinned, the entoconid is less acute and more separated from the metaconid, the hypoconulid is less lingual and less projecting posteriorly than in, for example, *Peratherium* (Setoguchi, 1975; Rose, 1981).

Referred specimens.— UM 113358 (L M_x; 1.58 × 0.91 mm), 113369 (R M_1; 1.56 × 0.89), 113378 (L M^2 or M^3; 1.41 × 1.71), 113384 (L M^1; 1.47 × 1.39), 113387 (R M^2; 1.53 × 1.80), 113390 (R M_1; 1.61 × 0.76), and 113391 (R M^2; 1.53 × 1.86).

Description.— All of these teeth are consistent in size and form with those from the Clarkforkian previously referred to *Peradectes protinnominatus* (Rose, 1981).

Discussion.— Upper molars of *Peradectes* are rectodont, and easily distinguished from the dilambdodont upper molars of *Peratherium*. Lower molars lack the deep notch between the hypoconulid and entoconid that is characteristic of *Peratherium*.

Peradectes protinnominatus is known from both the late Clarkforkian and the early Wasatchian land-mammal ages, and hence is not characteristic or diagnostic of either.

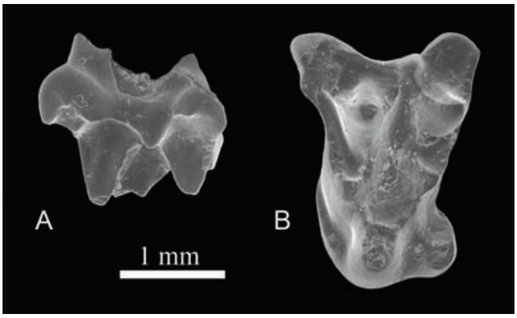


FIG. 7 — *Wyonycteris chalix* Gingerich, 1987, from the SC-435 Shell Bed. Left M^2 (UM 113363) is shown in labial (A) and occlusal view (B).

Order LIPOTYPHLA
Family NYCTITHERIIDAE

Leptacodon Matthew and Granger, 1921

Leptacodon rosei Gingerich, 1987

Cf. *Leptacodon packi,* Rose, 1981, p. 39.
Leptacodon rosei Gingerich, 1987, p. 302.

Holotype.— UM 71650, left dentary with P_2-M_3.

Type locality.— UM locality SC-188, middle Clarkforkian land-mammal age (Cf-2), late Paleocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— Middle through late Clarkforkian land-mammal age, late Paleocene.

Summary diagnosis.— Relatively low-crowned nyctitheriid differing from Tiffanian species in having P_3 much smaller and lower crowned than P_4, and in having a broader talonid basin and a larger and higher paraconid in P_4. Differs from Wasatchian *Leptacodon* in retaining more prominent paraconids on P_4 and M_1. Differs from *Wyonycteris* and *Pontifactor* in lacking prominent stylar cusps on upper molars (Gingerich, 1987).

Referred specimens.— UM 113374 (L M_1 or M_2; 1.53 × 1.21 mm).

Description.— This specimen is a typical lower molar of Clarkforkian *Leptacodon rosei* (Rose, 1981; Gingerich, 1987), and it is substantially larger than the corresponding teeth in *Wyonycteris chalix* (Gingerich, 1987).

Discussion.— The single molar known to date is adequate to distinguish the species from a larger cf. *Leptacodon* sp. and smaller cf. *Plagioctenodon krausae* reported from the Clarkforkian of northwestern Wyoming (Rose, 1981; Gingerich, 1987).

Wyonycteris Gingerich, 1987

Wyonycteris chalix Gingerich, 1987
Fig. 7

Wyonycteris chalix Gingerich, 1987, p. 306.

Holotype.— UM 76910, right dentary with P_4 to M_2.

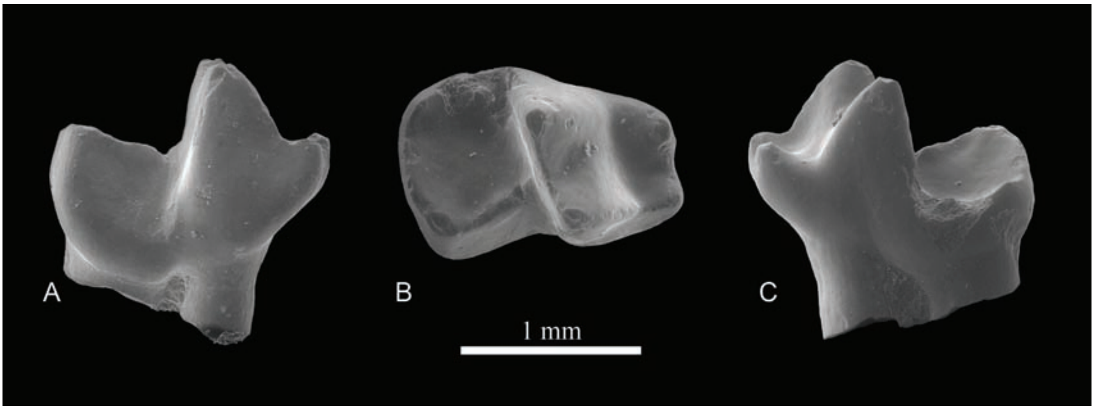


FIG. 8 — *Labidolemur kayi* Simpson, 1929, from the SC-435 Shell Bed. Right M^1 (UM 113349) is shown in labial (A), occlusal (B), and lingual view (C).

Type locality.— UM locality SC-29, late Clarkforkian land-mammal age (Cf-3), late Paleocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— Late Clarkforkian land-mammal age, late Paleocene, of northwestern Wyoming.

Summary diagnosis.— Nyctitheriid with a narrow P_4 with a reduced metaconid, a cristid oblique rising to the metaconid on M_2, and reduced labial cingulid on lower molars. Upper molars have a W-shaped ectoloph, crested mesostyles, well developed conules, and sometimes small pericone cusps on the anterior cingulum.

Referred specimens.— UM 113363 (L M^2; 1.30 × 1.80 mm).

Description.— The single upper molar of *Wyonycteris chalix* from SC-435 is almost identical in size and form to the M^2 from the type locality (Gingerich, 1987, fig. 22H).

Discussion.— *Wyonycteris* was originally described as a primitive chiropteran. This misinterpretation has been corrected by several authors. The age of the type locality, SC-29, and other middle and late Clarkforkian localities has also been revised as late Paleocene rather than early Eocene as originally reported (Gingerich, 1989).

Order APATOTHERIA
Family APATEMYIDAE

Labidolemur Simpson, 1929

Labidolemur kayi Simpson, 1929
Fig. 8

Labidolemur kayi Simpson, 1929, p.120; Gingerich and Rose, 1982, p. 49; Gingerich, 1982b, p. 58.

Holotype.— CM 11703, left dentary with P_4-M_3.

Type locality.— Eagle Coal Mine, Bear Creek, late Clarkforkian land-mammal age (Cf-3), late Paleocene, Clarks Fork Basin, Montana

Age and distribution.— Late Tiffanian to early Wasatchian land-mammal ages, late Paleocene to early Eocene, southern Montana and northwestern Wyoming.

Summary diagnosis.— Medium-sized apatemyid, with high-crowned lower molars.

Referred specimens.— UM 113349 (R M_1; 1.66 × 1.09 mm), and 113370 (L M_3; 1.76 × 1.03).

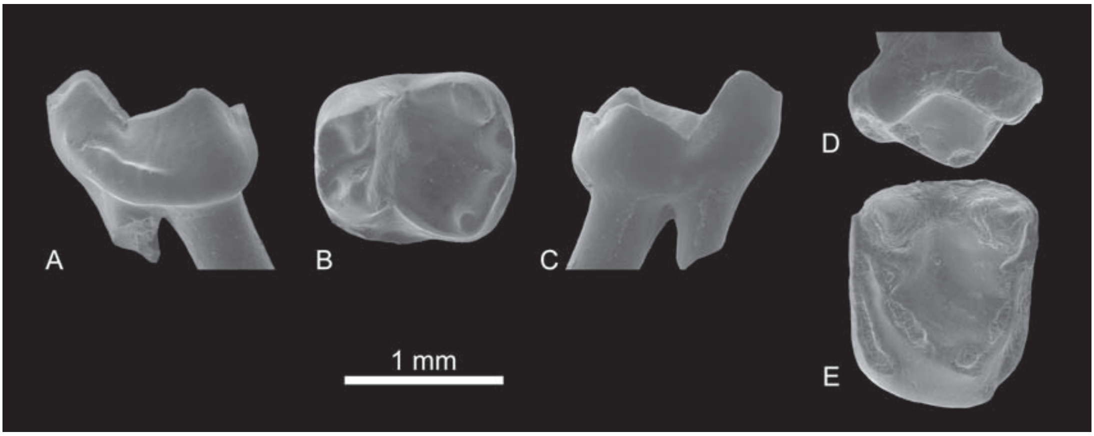


FIG. 9 — *Niptomomys doreenae* McKenna, 1960, from the SC-435 Shell Bed. Left M_2 (UM 113355) is shown in labial (A), occlusal (B), and lingual view (C). Right $M^{1 \text{ or } 2}$ (113353) is shown in labial (D) and occlusal view (E).

Description.— Each of these lower molars has the quadrate, open trigonid typical of lower molars of apatemyids. The trigonid and talond of M_1 are both relatively long and narrow, while the trigonid of M_3 is notably wider than the talonid.

Discussion.— These specimens fit comfortably into the variation observed in late Clarkforkian specimens of *Labidolemur kayi* (Gingerich, 1982b: fig. 5).

Order PROPRIMATES
Family MICROSYOPIDAE
Subfamily UINTASORICINAE

Niptomomys McKenna, 1960

Niptomomys doreenae McKenna, 1960
Fig. 9

Niptomomys doreenae McKenna, 1960, p. 63; Bown and Gingerich, 1972, p. 2; Rose, 1981, p. 53.

Holotype.— UCMP 44081, right dentary with $M_{2\text{-}3}$.

Type locality.— Kent Quarry, Four Mile Creek area, Wasatchian land-mammal age, early Eocene, Sand Wash Basin, Colorado.

Age and distribution.— Middle Clarkforkian to early Wasatchian land-mammal ages, late Paleocene to early Eocene, northern Colorado to northwestern Wyoming.

Summary diagnosis.— Very small microsyopid. Upper molars are broadly basined, with low cusps, a weakly developed hypocone, conules close to the paracone and metacone, and the latter widely separated from each other and from the protocone. P^4 has low, conical buccal and lingual cusps, with weak anterior and posterior cingula. Lower molars are broadly basined, with low cusps, a relatively narrow trigonid lacking a paraconid, and a broad talonid. P_4 is dominated by a single conical cusp with a small metaconid and a broad talonid.

Referred specimens.— UM 113353 (R $M^{1 \text{ or } 2}$; 1.23 × 1.54 mm), 113355 (L M_2; 1.29 × 1.18), 113362 (R M^1; 1.30 × 1.56), 113371 (L I_1; 3.30 × 1.12 × 1.63 high), and 113397 (R $M^{1 \text{ or } 2}$; 1.20 × 1.59).

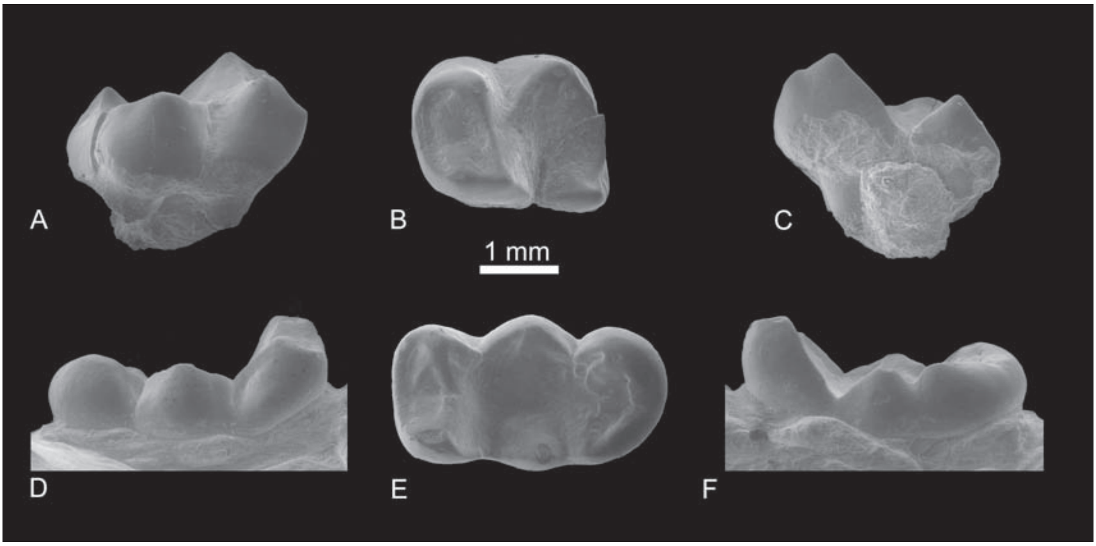


FIG. 10 — *Phenacolemur praecox* Matthew, 1915, from the SC-435 Shell Bed. Right M_1 (UM 113348) is shown in labial (A), occlusal (B), and lingual view (C). Right M_3 (113344) is shown in labial (D), occlusal (E), and lingual view (F).

Description.— Four of these five teeth are molars with low crowns, broad basins, and separated cusps typical of *Niptomomys doreenae*. The exception is the lower incisor with a straight root and a long, narrow, lanceolate crown like that documented by Bown and Gingerich (1972).

Discussion.— These specimens are nearly twice as large as *N. favorum* named by Strait (2001) from Wa-0, and they fit comfortably into the range of variation observed in Clarkforkian through early Wasatchian specimens of *N. doreenae*. The latter ranges through the Clarkforkian-Wasatchian transition and is not diagnostic of either land-mammal age.

Family PAROMOMYIDAE

Phenacolemur Matthew, 1915

Phenacolemur praecox Matthew, 1915

Fig. 10

Phenacolemur praecox Matthew, 1915b, p. 479. Rose, 1981, p. 66.

Holotype.— AMNH 16102, right dentary with the root of I_1 and crowns of P_4-M_2.

Type locality.— Three miles southeast of the mouth of Pat O'Hara Creek, early Wasatchian land-mammal age, Clarks Fork Basin, Wyoming.

Age and distribution.— Late Clarkforkian and early Wasatchian land-mammal ages, late Paleocene to early Eocene, of northwestern Wyoming.

Summary diagnosis.— *Phenacolemur praecox* is the largest species of the genus. The upper central incisor, I^1, is enlarged, with a tricuspid crown like that of *Plesiadapis*. P^4 and upper molars are almost square, with prominent trigon cusps near the corners of the square and a prominent postprotocingulum filling in the posterolingual corner of the tooth. The lower central incisor, I_1, is procumbent and elongated, with a delicate almost straight crown. Lower molars are quadrate with a reduced protoconid and little or no development of a hypoconulid. Isolated teeth of *Phenacolemur* are sometimes difficult to distinguish from those of *Ignacius*, but they are generally a little more massive and higher crowned, and the crown of P_4 is conspicuously larger than that of *Ignacius* (Bown and Rose, 1976).

Referred specimens.— UM 113344 (R dent. M_3; 3.57 × 2.08 mm), 113348 (R M_1; 2.71 × 2.19), 113357 (L M_3; 3.55 × 1.90), 113359 (tip of crown of I^1), 113367 (R M^3; 2.38 × 2.03), 113389 (R P^4; 2.30 × 2.67), 113392 (L dP_4; 2.82 × 1.63), 113394 (L P_4; 3.10 × 1.88), and 113395 (L P^4; 2.20 × 2.64).

Description.— Nine teeth are known, including the tip of an upper incisor. The cheek teeth are similar in size and form to those of *Phenacolemur praecox* although, as Rose (1981) noted, it appears that there is a gradual transition between late Tiffanian *Phenacolemur pagei* and late Clarkforkian to early Wasatchian *P. praecox*.

Discussion.— It is possible that there are teeth of *Ignacius* cf. *I. graybullianus* included here, but the diagnostic upper and lower premolars, P^4 and P_4, all have the form characteristic of *Phenacolemur*. The specimens are the size of *Phenacolemur praecox* and distinctly larger than *P. pagei*.

Phenacolemur praecox ranges through the late Clarkforkian and early Wasatchian and is not diagnostic of either land-mammal age.

Order CONDYLARTHRA
Family HYOPSODONTIDAE
Subfamily APHELISCINAE

Apheliscus Cope, 1875

Apheliscus nitidus Simpson, 1937

Fig. 11

Apheliscus insidiosus (partim), Matthew, 1918, p. 596.
Apheliscus nitidus Simpson, 1937, p. 4. Rose, 1981, p. 83.

Holotype.— AMNH 15849, left maxillary fragment with P^4-M^1.

Type locality.— Head of Big Sand Coulee, late Clarkforkian land-mammal age, Clarks Fork Basin, Wyoming.

Age and distribution.— Clarkforkian land-mammal age, late Paleocene, of northwestern Wyoming.

Summary diagnosis.— Small condylarth with relatively large upper and lower P^4 and P_4, simple triangular upper molars, and distinctively elongated quadrate lower molars. *Apheliscus nitidus* differs from early Wasatchian species *A. wapitiensis* and *A. chydaeus* in being substantially larger (Gingerich, 1994).

Referred specimens.— UM 113346 (L M^3; 2.71 × 2.60 mm), 113350 (R P_3; 2.09 × 1.10), 113354 (L M^2; 2.69 × 2.99), and 113405 (R M^1; 2.23 × 2.42).

Description.— The three upper molars described here have the distinctive form typical of upper molars of *Apheliscus*, and they are the size of upper molars of *A. nitidus* (Rose, 1981). P_3 is the size expected for this tooth in *Apheliscus*, but more closely resembles P_4 in shape than seen in some specimens with a more simplified P_3 (this is clearly variable).

Discussion.— Presence of *Apheliscus nitidus* in the SC-435 Shell Bed locality is a resemblance to earlier Clarkforkian faunas and a clear difference from later Wasatchian-age faunas.

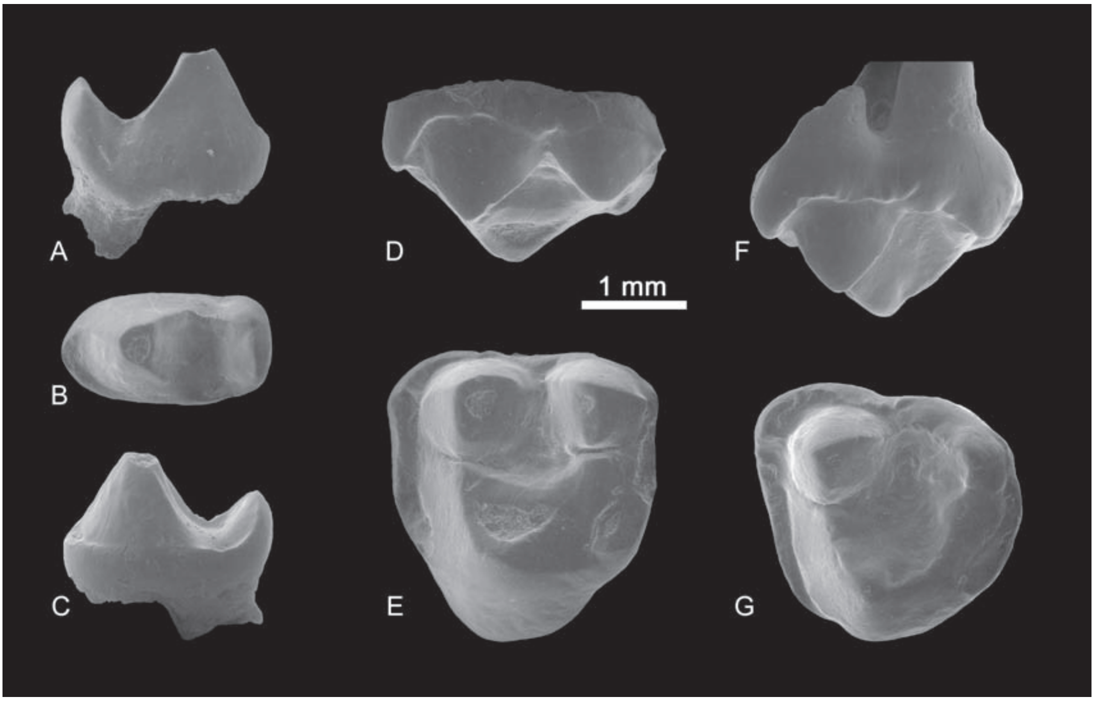


FIG. 11 — *Apheliscus nitidus* Simpson, 1937, from the SC-435 Shell Bed. Right P_3 (UM 113350) is shown in labial (A), occlusal (B), and lingual view (C). Left M^2 (113354) is shown in labial (D) and occlusal view (E). Left M^3 (113346) is shown in labial (F) and occlusal view (G).

Subfamily HYOPSODONTINAE

Haplomylus Matthew, 1915

Haplomylus simpsoni Rose, 1981
Fig. 12

Haplomylus simpsoni Rose, 1981, p. 78.

Holotype.— UM 65249, left dentary with P_4-M_3.

Type locality.— UM locality SC-29, late Clarkforkian land-mammal age (Cf-3), Clarks Fork Basin, Wyoming.

Age and distribution.— *Haplomylus simpsoni* is known from the middle and late Clarkforkian land-mammal age (Cf-2 to Cf-3), late Paleocene, of northwestern Wyoming.

Summary diagnosis.— Small condylarth with premolars P^4 and P_4 enlarged but more molarized than those of *Apheliscus*. Upper molars are relatively high-crowned for a condylarth, with bulbous cusps and a simple triangular crown expanded posterolingually by a postprotocingulum-like crest. Lower molars are similarly high-crowned, with bulbous cusps, a distinct paraconid on the trigonid of M_1, and all three talonid cusps. M^3 and M_3 are notably smaller than the other molars. Larger size is the most distinctive characteristic of *Haplomylus simpsoni* compared to earlier Clarkforkian and later early Wasatchian species (Gingerich, 1994).

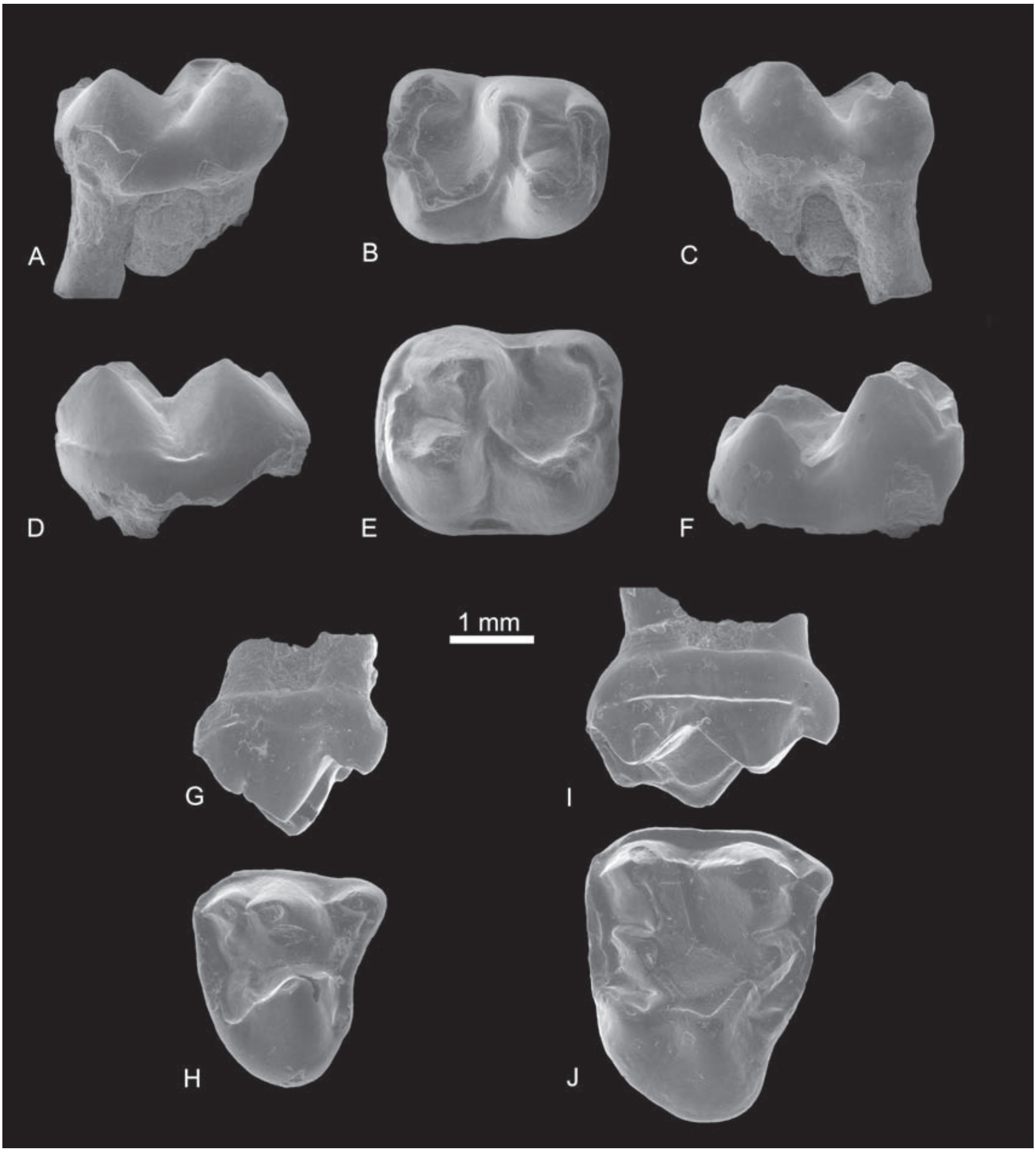


FIG. 12 — *Haplomylus simpsoni* Rose, 1981, from the SC-435 Shell Bed. Right M_1 (UM 113352) is shown in labial (A), occlusal (B), and lingual view (C). Left M_2 (113351) is shown in labial (D), occlusal (E), and lingual view (F). Right P^4 (113365) is shown in labial (G) and occlusal view (H). Right M^2 (113364) is shown in labial (I) and occlusal view (J).

Referred specimens.— UM 113351 (L M_2 ; 2.96 × 2.62 mm), 113352 (R M_1; 2.78 × 2.23), 113364 (R M^2; 2.94 × 3.67), 113365 (R P^4; 2.34 × 2.74), 113366 (R P_4; 3.33 × 1.83), and 113404 (R M_3; 2.83 × 2.15).

Description.— The six cheek teeth recorded here cover much of the upper and lower dentition. Each tooth is typical for its position in the tooth row, and all are consistent with expectation for size in a single species, namely *Haplomylus simpsoni* (Rose, 1981; Gingerich, 1994).

Discussion.— Like *Apheliscus nitidus*, presence of *Haplomylus simpsoni* in the SC-435 Shell Bed locality is a resemblance to earlier Clarkforkian faunas and a clear difference from later Wasatchian-age faunas.

Aletodon Gingerich, 1977

Aletodon gunnelli Gingerich, 1977

Aletodon gunnelli Gingerich, 1977, p. 239. Rose, 1981, 78.

Holotype.— UM 66301, right dentary with P_4-M_1 and M_3.

Type locality.— UM locality SC-90, late Clarkforkian land-mammal age (Cf-3), Clarks Fork Basin, Wyoming.

Age and distribution.— *Aletodon gunnelli* is known from the middle and late Clarkforkian land-mammal age (Cf-2 to Cf-3), late Paleocene, of northwestern Wyoming.

Summary diagnosis.— Relatively large hyopsodontid with a long, simple P_4, which lacks any distinct paraconid, metaconid, or entoconid accessory cusps. Upper molars are larger than *Haplomylus*, but similarly high-crowned, with a triangular shape like upper molars of that genus and a small, distinct, hypocone in place of a postprotocingulum-like crest. Lower molars are high-crowned, quadrate, and generally lack a paraconid. M_3 has a narrow talonid but is not conspicuously reduced in size in comparison to the other two molars.

Referred specimens.— UM 113400 (R M^2; 5.09 × 6.20 mm). UM 113399 (L P^2 or P^3; 3.60 × 2.22) might possibly represent this species.

Description.— The M^2 described here is somewhat worn, but enough of the crown remains to identify it as *Aletodon gunnelli* with confidence, and the size of the tooth lies within the range of previously known specimens (Gingerich, 1977).

Discussion.— *Aletodon gunnelli* is a diagnostically Clarkforkian-age species that has no close relatives known from later faunal zones.

Family PHENACODONTIDAE

Ectocion Cope, 1882

Ectocion osbornianus (Cope, 1882)

Fig. 13

Oligotomus osbornianus Cope, 1882a, p. 182.
Ectocion osbornianum, Cope, 1882b, p. 522. Granger, 1915, p. 352.
Ectocion osbornianus, Rose, 1981, p. 73. Gingerich, 1989, p. 52. Thewissen, 1990, p. 35.

Holotype.— AMNH 4409, upper and lower jaw fragments.

Type locality.— Gray Bull beds, early Wasatchian land-mammal age, Bighorn Basin, northwestern Wyoming.

Age and distribution.— *Ectocion osbornianus* is known from the Clarkforkian (Cf-1 to Cf-3) and early Wasatchian (Wa-M to Wa-4) land-mammal ages of northern Colorado and Wyoming.

Summary diagnosis.— *Ectocion osbornianus* is a bunodont condylarth with highly molarized P^4 and P_4. It has slightly more crested lophs on upper and lower molars than contemporary species of *Copecion* and *Phenacodus*. Upper molars have prominent conules and a distinct hypocone on

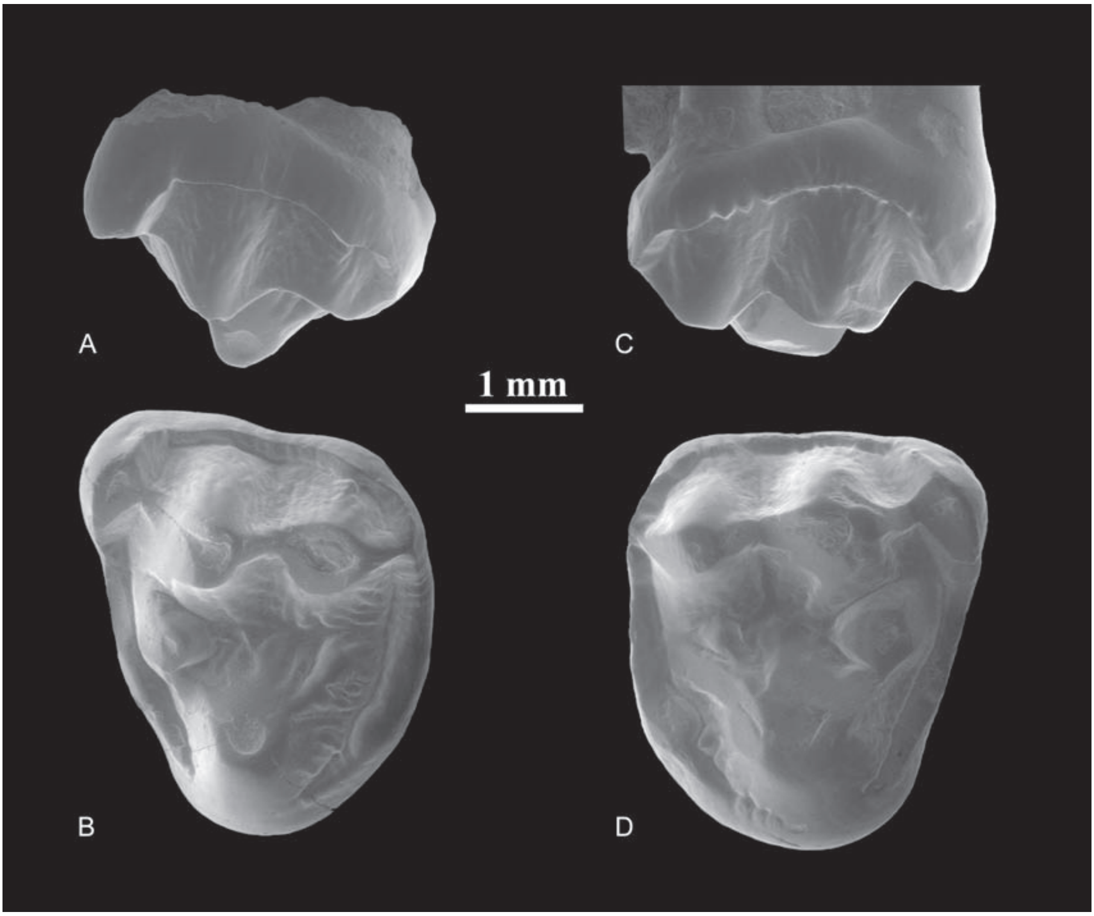


FIG. 13 — *Ectocion osbornianus* (Cope, 1882), from the SC-435 Shell Bed. Left $P4$ (UM 113345) is shown in labial (A) and occlusal view (B). Right P^4 (113347) is shown in labial (C) and occlusal view (D).

M^{1-2}. Lower molars generally lack paraconids. *E. osbornianus* differs from Wa-0 *E. parvus* in being substantially larger (Gingerich, 1989).

Referred specimens.— UM 113345 (L P^4; 6.10 × 7.78 mm), and 113347 (R P^4; 6.40 × 7.65).

Description.— The two teeth identified as *Ectocion osbornianus* are each a highly molarized P^4 falling within the range of sizes expected for late Clarkforkian and early Wasatchian representatives of this species (Thewissen, 1990).

Discussion.— *Ectocion osbornianus* has a long stratigraphic range spanning the Clarkforkian to Wasatchian transition and hence is not diagnostic of one age or the other.

Order RODENTIA
Family ISCHIROMYIDAE
Subfamily MICROPARAMYINAE

Microparamys Wood, 1959

Microparamys cheradius Ivy, 1990

Microparamys cheradius Ivy, 1990, p. 52.

Holotype.— UM 73609, left dentary with P_4 and M_{1-2}.

Type locality.— UM locality SC-188, middle Clarkforkian land-mammal age (Cf-2), late Paleocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— *Microparamys cheradius* is known from the middle and late Clarkforkian land-mammal age (Cf-2 to Cf-3), late Paleocene, of northwestern Wyoming. It may also range into the Wasatchian land-mammal age, based on questionably referred specimens (Ivy, 1990).

Summary diagnosis.— Small ischiromyid with the anterior cingulid separated from the protoconid, relatively high trigonid, more complete metalophid, less separated anterior cingulid, arm from the metaconid entering the trigonid basin, and a less isolated entoconid on lower molars. Hypocone is separated from the protocone on upper molars. Enamel is smooth.

Referred specimens.— UM 113356 (R I_1; 1.37 × 0.48 mm cross-sectional diameters), 113361 (L P_4; 1.07 × 1.05), 113375 (R M_1; 1.51 × 1.53), 113376 (L I_1; 1.36 × 0.49), 113382 (L M^1 or M^2; 1.49 × 1.78), 113385 (R M^1 or M^2; 1.36 × 1.57), 113386 (R M_3; 1.73 × 1.44), 113388 (L P^4; 1.19 × 1.50), and 113402 (R M_1; 1.37 × 1.27).

Description.— UM 113361 is a P_4 with a talonid like that of the holotype but with an anteroposteriorly shorter trigonid and closely appressed roots. UM 113375 is an M_1 closely resembling that in the holotype but with a broader talonid. UM 113402 is an M_1 more worn, but othewise similar to M_1 in the holotype. Comparisons are complicated by natural population variation and by differing stages of wear of many of the teeth described here.

Discussion.— We follow Wood (1962) and Dawson (2001) in recognizing a subfamily Microparamyinae for *Microparamys* and its relatives.

Ivy (1990) interpreted the anterior cheek tooth in the holotype dentary as dP_4, presumably because its roots are well separated, but there is no trace of a replacement tooth erupting beneath it, the teeth are all the same color, and they are all comparably worn. Hence we interpret the anterior cheek tooth in the type as P_4.

Teeth that can compared to the holotype of *Microparamys cheradius* resemble it closely, and all of the teeth described here are comparable in size. It is possible that some teeth represent one or more additional similar-sized species, but we cannot substantiate this with the sample at hand.

The holotype is Clarkforkian in age, but Ivy (1990) reported two questionably-identified teeth of *Microparamys cheradius* from early Wasatchian localities so the species is not diagnostic of Clarkforkian or Wasatchian age.

Order CARNIVORA
Family VIVERRAVIDAE

Viverravus Marsh 1872

Viverravus rosei Polly, 1997

Viverravus rosei Polly, 1997, p. 26.

Holotype.— UM 69960, left dentary with P_4-M_1.

Type locality.— UM locality SC-128, middle Wasatchian land-mammal age (Wa-3), early Eocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— *Viverravus rosei* is known from the late Clarkforkian (Cf-3) through middle Wasatchian (Wa-4) land-mammal age in northwestern Wyoming.

Summary diagnosis.— Smallest species of *Viverravus*. P_4 has a narrow crown with a large apical cusp followed by prominent first and second posterior accessory cusps. Differs from other species of *Viverravus* in having a more closed trigonid on lower molars.

Referred specimens.— UM 113360 (R P_4 talonid; — × 1.24 mm).

Description.— The specimen described here is the posterior part of the crown of P_4, with both posterior accessory cusps. This crown fragment matches the comparable part of UM 85863, a referred specimen of *Viverravus rosei*, very closely in size and form, and identification of UM 113360 as *V. rosei* is almost certainly correct.

Discussion.— *Viverravus rosei* has a long stratigraphic range spanning the late Clarkforkian through early Wasatchian, and hence is not diagnostic of one land-mammal age or the other.

Family MIACIDAE

Uintacyon Leidy, 1871

Uintacyon rudis Matthew, 1915

Uintacyon massetericus rudis Matthew, 1915a, p. 31.
Uintacyon rudis, Rose, 1981, p. 102. Gingerich, 1983, p. 201.

Holotype.— AMNH 16855, right dentary with M_{1-2}.

Type locality.— Head of Big Sand Coulee, early Wasatchian land-mammal age, early Eocene, Clarks Fork Basin, northwestern Wyoming.

Age and distribution.— Late Clarkforkian and early Wasatchian land-mammal ages, late Paleocene to early Eocene, of northwestern Wyoming.

Summary diagnosis.— *Uintacyon rudis* is a medium-sized miacid with robust molars decreasing in size posteriorly. Talonids on M_2 and M_3 are generally more basined in early forms and more trenchant later, but this is somewhat variable.

Referred specimens.— UM 113398 (L M_3; 2.34 × 2.04 mm), and 113401 (R M_2; 4.17 × 3.01).

Description.— These molars are undoubtedly M_2 and M_3 of *Uintacyon rudis* because they match more complete specimens in size and shape, but they are unusual in having trenchant talonids on both teeth. All three talonid cusps are well developed on M_2, but the metaconid is much reduced on M_3.

Discussion.— *Uintacyon rudis* has a long stratigraphic range spanning the Clarkforkian to Wasatchian transition and hence is not diagnostic of one age or the other.

SYSTEMATICS OF MAMMALS FROM THE SC-434 GAR SCALE CHANNEL SITE

The Gar Scale Channel fauna is a distinctly different fauna from the Shell Bed fauna just described (see discussion), but both share some species. Background systematic information for the shared species is repeated here so that this fauna can be studied independently of that above.

Order MULTITUBERCULATA
Family NEOPLAGIAULACIDAE

Ectypodus Matthew and Granger, 1921

Ectypodus sp.

Fig. 14A

Age and distribution.— *Ectypodus powelli* ranges through the late Tiffanian and Clarkforkian land-mammal ages, late Paleocene, and *Ectypodus tardus* ranges through the early Wasatchian land-mammal age in Wyoming and Colorado (Krause, 1980, 1982).

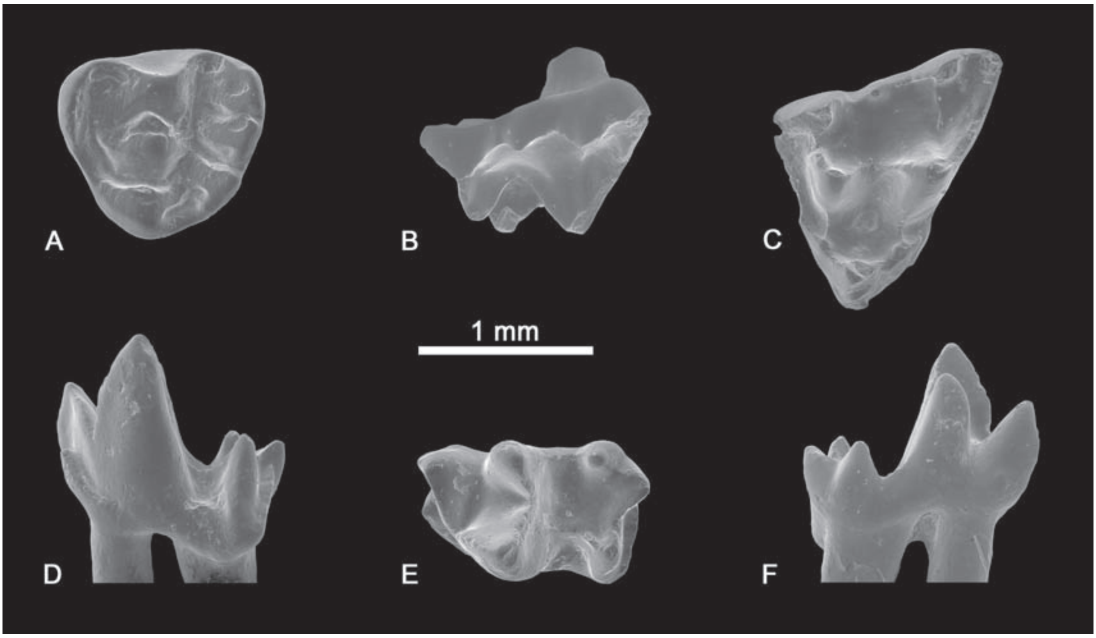


FIG. 14 — *Ectypodus* sp. (A) and *Peradectes* sp. 1 (B-F) from SC-434 Gar Scale Channel. *Ectypodus* sp., right M^2 (UM 113427) is shown in occlusal view (A). *Peradectes* sp. 1 left M^1 (113431) is shown in labial (B) and occlusal view (C); and left M_2 or M_3 (113437) is shown in labial (D), occlusal (E), and lingual view (F).

Referred specimens.— UM 113427 (R M^2; 1.11 × 1.19 mm; cusp formula 3:3:1), and 113473 (L M^2; 1.08 × 1.06; cusp formula 3:3:1).

Description.— The two molars described here, both M^2, are similar, and typical of M^2 in *Ectypodus powelli* and *E. tardus*.

Discussion.— There is little doubt that the *Ectypodus powelli* to *E. tardus* lineage is represented, but the specimens at hand are inadequate for identification at the species level.

Order MARSUPIALIA
Family PERADECTIDAE

Peradectes Matthew and Granger, 1921

Peradectes protinnominatus McKenna, 1960

Peradectes protinnominatus McKenna, 1960, p. 41. Krishtalka and Stucky, 1983, p. 246. Strait, 2001, p. 131.
Peradectes chesteri (in part), Bown, 1979, p. 54.
Peradectes cf. *P. chesteri*, Rose, 1981, p. 34.

Holotype.— UCMP 44077, associated right $M^{1\text{-}3}$.

Type locality.— Alheit Pocket, Four Mile Creek area, Wasatchian land-mammal age, early Eocene, Sand Wash Basin, Colorado.

Age and distribution.— Early Wasatchian land-mammal age, early Eocene, Four Mile Creek area, Colorado; Clarkforkian to early Wasatchian, late Paleocene to early Eocene, Bighorn Basin, Wyoming.

Summary diagnosis.— Small polyprotodont marsupials. Upper molars are more rectodont than dilambdodont, the paracone is slightly smaller than the metacone, conules are present but very small, and stylar cusps B and D are the most prominent. On lower molars, the hypoconulid and entoconid are more closely twinned, the entoconid is less acute and more separated from the metaconid, the hypoconulid is less lingual and less projecting posteriorly than in, for example, *Peratherium* (Setoguchi, 1975; Rose, 1981).

Referred specimens.— UM 113449 (L M^2 or M^3; — × 1.89 mm), 113481 (R M_2 or M_3; 1.65 × 0.96), and 113557 (L M_1 or M_2; — × 0.94).

Description.— These three teeth are typical of *Peradectes protinnominatus* molars in terms of size and molar shape. The paracone and metacone are rectodont, and stylar cusps B and D are prominent on the upper molar. The hypoconulid is positioned posterolaterally relative to the entoconid on the lower molars.

Discussion.— *Peradectes* is a common marsupial present in many North American late Paleocene to late Eocene faunal samples. However, good specimens are rare, species variability has never been well sampled, and the number of species present at any given time is rarely well documented. The common species in the Clarkforkian and early Wasatchian is *P. protinnominatus*, which is present in the SC-434 Gar Scale locality. It appears that there are two additional species of *Peradectes* present in this locality, here called *Peradectes* sp. 1 and *Peradectes*. sp. 2. These are distinguished in being smaller and larger, respectively, than *P. protinnominatus*.

Peradectes protinnominatus is known from both the late Clarkforkian and the early Wasatchian land-mammals ages, and hence is not characteristic or diagnostic of either.

Peradectes sp. 1
Fig. 14B-F

Referred specimens.— UM 113431 (L M^1; 1.36 × 1.43 mm), and 113437 (L M_2 or M_3; 1.35 × 0.86).

Discussion.— Teeth of this species are distinctive in being smaller than those of most *Peradectes protinnominatus*, but they are similarly gracile. A larger sample will be required to confirm the size distinction.

Peradectes sp. 2

Referred specimens.— UM 113443 (R M^3 in maxillary fragment; 1.76 × 2.11 mm), 113478 (L M^2 or M^3; 1.75 × 2.14), 113535 (R M_2 or M_3; 1.77 × 1.11), and 113556 (R M_2 or M_3; 1.73 × 1.06).

Discussion.— Teeth of this species are larger than those of *Peradectes protinnominatus*, and in addition the molars appear to be more robustly rectangular, with less delicate cusps. A larger sample will be required to confirm these distinctions.

Mimoperadectes Bown and Rose, 1979

Mimoperadectes labrus Bown and Rose, 1979
Fig. 15A-D

Mimoperadectes labrus Bown and Rose, 1979, p. 90. Gingerich, 1989, p. 22. Strait, 2001, p. 130.

Holotype.— UM 66144, associated left and right maxillae with left and right dentaries.

Type locality.— UM locality SC-69 at the southwest end of Polecat Bench, early Wasatchian land-mammal age (Wa-0), early Eocene, Bighorn Basin, northwestern Wyoming.

Age and distribution.— *Mimoperadectes*, and sometimes *Mimoperadectes labrus*, has been reported from the late Clarkforkian through early Wasatchian land-mammal ages, late Paleocene to early Eocene, of Colorado and Wyoming.

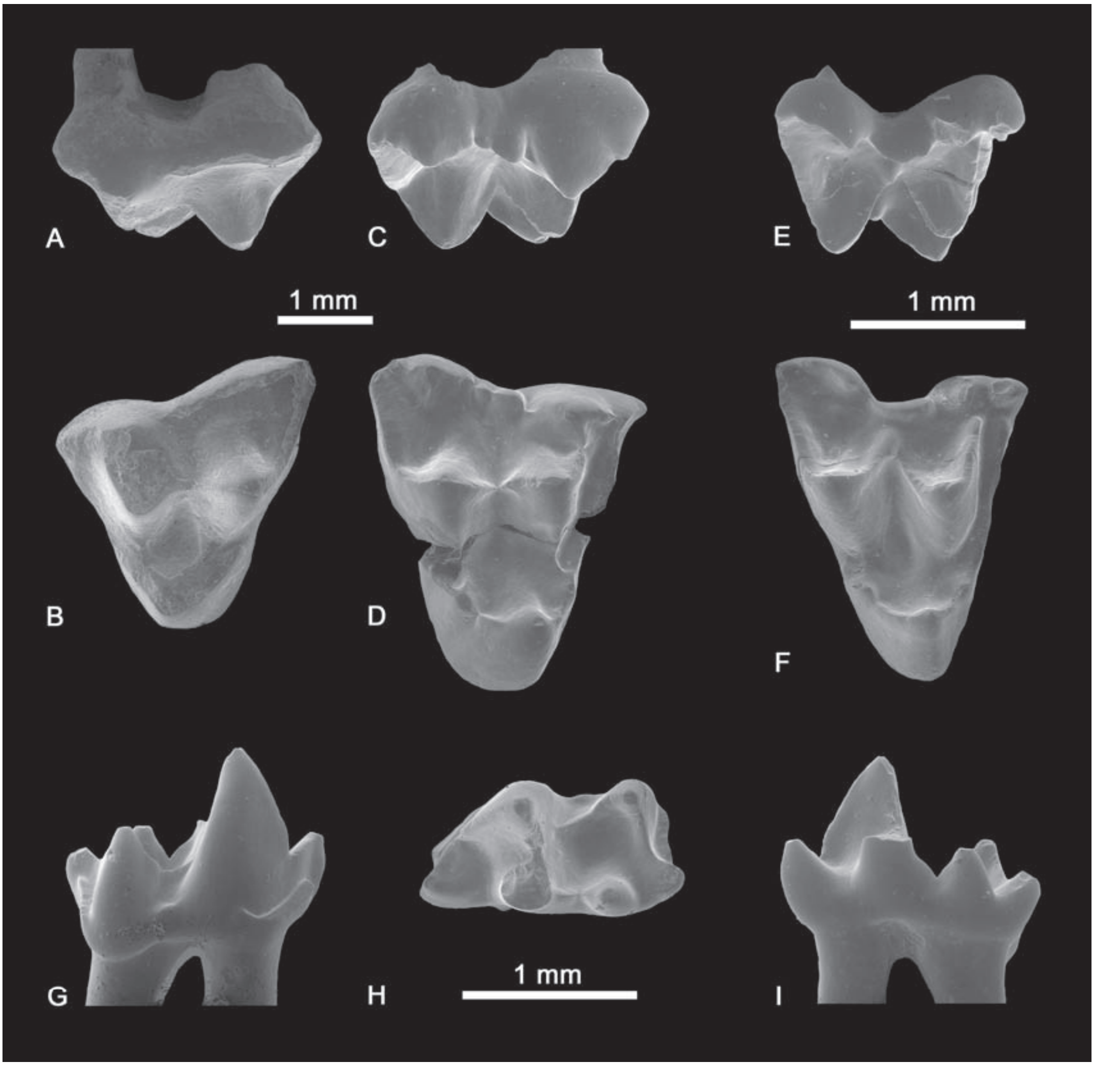


FIG. 15 — *Mimoperadectes labrus* Bown and Rose, 1979 (A-D), and *Peratherium innominatum* Simpson, 1928 (E-I), from SC-434 Gar Scale Channel. *Mimoperadectes labrus* left M^1 (UM 113418), is shown in labial (A) and occlusal view (B); and right M^2 (113426) is shown in labial (C) and occlusal view (D). *Peratherium innominatum* right M^2 or M^3 (113434) is shown in labial (E) and occlusal view (F); and right M_2 or M_3 (113423) is shown in labial (G), occlusal (H), and lingual view (I).

Summary diagnosis.— Relatively large peradectid. Upper molars are more rectodont than dilambdadont, with relatively small conules; stylar cusp B is the largest. Lower molars generally have the paraconid larger than the metaconid, and the entoconid and hypoconulid are *Peradectes*-like.

Referred specimens.— UM 113418 (L M^1; 2.85 × 2.90), and 113426 (R M^2 or M^3; 3.01 × 3.45).

Description.— These two upper molars are very similar in size and form to those described by Bown and Rose (1979).

Discussion.— *Mimoperadectes labrus* has been reported from a late Clarkforkian site (Rose, 1981, p. 36), and the type is from the early Wasatchian. Hence *Mimoperadectes* may not be diagnostic of age. However Paleocene-Eocene marsupial systematics are in need of revision, and *Mimoperadectes* is much better known in the Wasatchian than it is in the Clarkforkian.

Family HERPETOTHERIIDAE

Peratherium Aymard, 1846

Peratherium innominatum Simpson, 1928

Fig. 15E-I

Peratherium innominatum Simpson, 1928, p. 6. Krishtalka and Stucky, 1983, p. 232. Strait, 2001, p. 131.
Peratherium macgrewi (in part) Bown, 1979, p. 55.

Holotype.— AMNH 11493, left dentary with M_{1-4}.

Type locality.— Millersville, early Bridgerian land-mammal age (Br-2), early to middle Eocene, Bridger Basin, southwestern Wyoming.

Age and distribution.— *Peratherium innominatum* is known from the early Wasatchian through Duchesnian land-mammal ages in the Western Interior of North American (Krishtalka and Stucky, 1983), and hence spans much of the Eocene epoch.

Summary diagnosis.— Simpson (1928) distinguished this species as being markedly smaller than other species of the genus. Upper molars of *Peratherium* are distinctly dilambdodont, with a well-developed stylar cusp C on the labial cingulum. Lower molars have an acute entoconid positioned relatively close to the metaconid, and a lingually-placed hypoconulid that is more posteriorly projecting than it is in species of *Peradectes*.

Referred specimens.— UM 113423 (R M_2 or M_3; 1.50 × 0.79), 113434 (R M^2 or M^3; 1.43 × 1.88), and 113549 (R M_2 or M_3; 1.62 × 0.89).

Description.— The upper molar has the distinctively dilambdodont form seen, for example, in UCMP 44095 illustrated by McKenna (1960: fig. 18a). The lower molars have the distinctively acute entoconid, and the lingually-placed, posteriorly-projecting hypoconulid characteristic of the genus.

Discussion.— *Peratherium* has been reported from a late Tiffanian site (Rose, 1981, p. 156), and it is reasonably common in the early Wasatchian. Hence *Peratherium* may not be diagnostic of age. However, as noted above, Paleocene-Eocene marsupial systematics are in need of revision, and *Peratherium* is much better known in the Wasatchian than it is in the Tiffanian or Clarkforkian.

Order LIPOTYPHLA
Suborder ERINACEOMORPHA
Family AMPHILEMURIDAE

Macrocranion Weitzel, 1949

Macrocranion cf. *M. junnei* Smith et al., 2002

Fig. 16A,B

Macrocraniun junnei Smith et al., 2002, p. 374.

Holotype.— UM 93378, right maxilla with P^4-M^3.

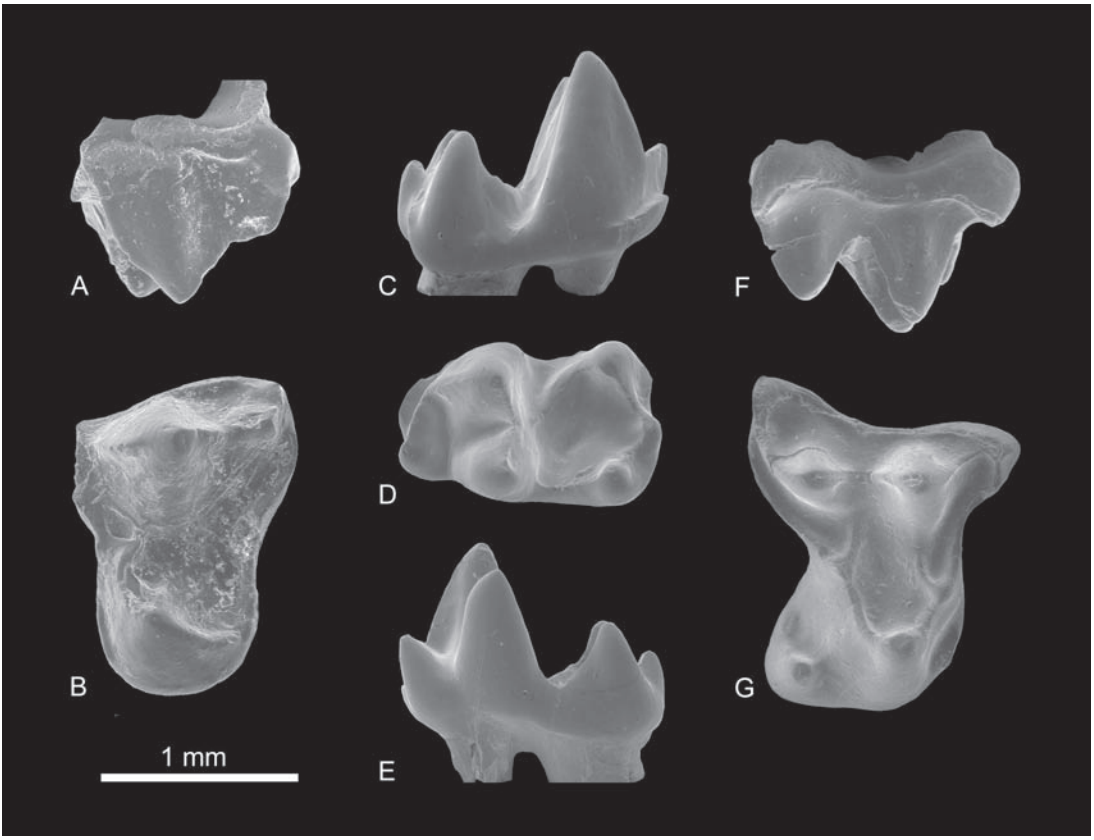


FIG. 16 — *Macrocranion* cf. *M. junnei* Smith et al., 2002 (A-B), and *Leptacodon* sp. (C-G), from SC-434 Gar Scale Channel. *Macrocranion* cf. *M. junnei* left P^4 (UM 113553), is shown in labial (A) and occlusal view (B). *Leptacodon* sp. right M_1 (113440) is shown in labial (C), occlusal (D), and lingual view (E); and right M^1 (113446) is shown in labial (F) and occlusal view (G).

Type locality.— University of Michigan locality SC-67, early Wasatchian land-mammal age (Wa-0), northern Bighorn Basin, Wyoming.

Age and distribution.— *Macrocranion junnei* is known from the early Wasatchian land-mammal age (Wa-0), early Eocene, of northwestern Wyoming. If the specimen described here is *M. junnei*, it would extend the temporal range of the species to Wa-M.

Summary diagnosis.— Small species of *Macrocranion* similar in morphology and size to European *M. vandebroeki*. Differs in having a less anteriorly projecting parastylar lobe and a more reduced metastylar lobe on P^4. Differs also in having the metaconid more posterior on P_4 and the lower molars.

Referred specimens.— UM 113553 (L P^4; 1.22 × 1.61 mm).

Description.— The only specimen of *Macrocranion* found at the SC-434 Gar Scale locality is a P^4 with the more reduced metastylar lobe characteristic of *M. junnei*. This specimen differs from the type in being smaller, but the type specimen is at the large end of the size range known for *M. junnei* (Strait, 2001). A larger sample will be required to determine whether the specimen at hand really represents *M. junnei*.

Discussion.— There is little question that UM 113553 is a P^4 of *Macrocranion* and, whatever the species identification, it is the oldest record of the genus in North America. *Macrocranion* is a characteristically Wasatchian taxon in North America, and it is evidence for including Wa-M in the Wasatchian land-mammal age.

Suborder SORICOMORPHA
Family NYCTITHERIIDAE

Leptacodon Matthew and Granger, 1921

Leptacodon sp.
Fig. 16C-G

Age and distribution.— *Leptacodon* is known from the Tiffanian through Wasatchian land-mammal ages, late Paleocene through early Eocene, in western North America; and from the lowest Ypresian early Eocene of Europe.

Summary diagnosis.— *Leptacodon* is a common late Paleocene and early Eocene nyctithere with relatively low-crowned cheek teeth. P_2 and P_3 are relatively small, simple teeth, while P^4 and P_4 are larger and molarized. Upper molars are tritubercular, with a prominent protocone, paracone, and metacone enclosing a basined central area of the crown. A paraconule and metaconule are present but relatively small. There is a relatively narrow labial cingulum, and the hypocone is posterior to the protocone on a posterolingual cingulum. Lower molars are similarly tritubercular, with the paraconid set well forward of the metaconid. The talonid is about as broad as the trigonid. All three talonid cusps are present and these are spaced well apart.

Referred specimens.— UM 113440 (R M_1; 1.41 × 0.89 mm), 113446 (R M^1; 1.39 × 1.70), 113463 (L M^1; 1.68 × —), 113480 (L dent. with intact crown of P_4; 1.15 × 0.67), and 113521 (R M^2; 1.46 × 1.89) .

Description.— These teeth are typically *Leptacodon* in form, but insufficiently known to justify attempting to distinguish, e.g., Clarkforkian *L. rosei* from early Wasatchian *L. krausae*.

Discussion.— Smith (1996) synonymized *Plagioctenodon* Bown (1979) with *Leptacodon*, and the latter will have to be revised based on new and better specimens before it will be possible to determine how many lineages of *Leptacodon* were present in North America during the Paleocene-Eocene transition. As the genus is now known, new specimens of *Leptacodon* described here do not contribute to understanding whether the Wa-M fauna has greater affinity with the preceding Clarkforkian or succeeding Wasatchian land-mammal age.

Order LEPTICTIDA?
Family LEPTICTIDAE

Amphigyion, new genus

Type species.— *Amphigyion straitae*, new species

Age and distribution.— *Amphigyion* is presently known only from the type locality.

Diagnosis.— *Amphigyion* is a small 'protozalambdodont' leptictid. It has the molarized P^4/P_4 and the distinctively long P_4 trigonid and talonid typical of leptictids, but differs in having much higher-crowned cheek teeth resembling those of palaeoryctids. Upper molars differ conspicuously from those of other leptictids in lacking anterior and posterior cingula. Upper molars resemble those of palaeoryctids but differ in having a stronger preprotocrista and postprotocrista enclosing a somewhat basined trigon. Lower molars are high-crowned and proportioned like those of *Palaeoryctes*, but they are distinctly more quadrate, with a more reduced paraconid, an anteroposteriorly shorter trigonid, and a relatively longer talonid. Lower molars have a more prominent hypoconid than is seen in other leptictids. Separation of the hypoconid and hypoconulid is about equal to

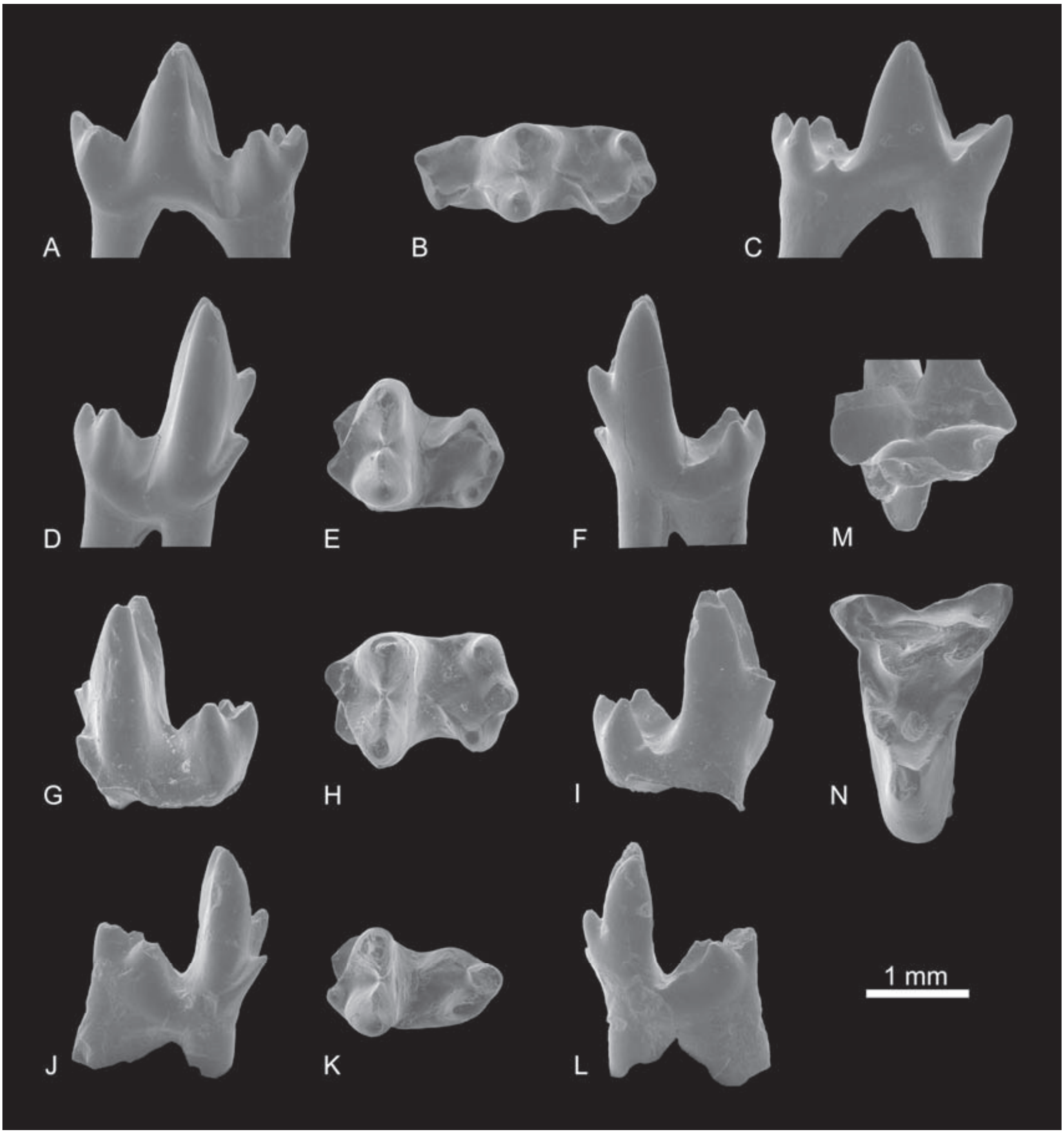


FIG. 17 — *Amphigyion straitae*, new genus and species, from SC-434 Gar Scale Channel. Left P_4 (UM 113345; holotype) is shown in labial (A), occlusal (B), and lingual view (C). Right M_2 (113422) is shown in labial (D), occlusal (E), and lingual view (F). Left M_2 (113514) is shown in labial (G), occlusal (H), and lingual view (I). Right M_3 (113424) is shown in labial (J), occlusal (K), and lingual view (L). Left M^1 or M^2 (113417) is shown in labial (M) and occlusal view (N).

separation of the hypoconulid and entoconid, and the three talonid cusps enclose a broader talonid basin than is seen in palaeoryctids.

Etymology.— *Amphigyion*, Greek (neut.), double-limbed, with a limb at each end. Named in reference to the jointed limb-like extensions of labial crests anteriorly and posteriorly from the dominant protoconid and metaconid cusps on P_4.

Amphigyion straitae, new species

Fig. 17

Holotype.— UM 113445 (left P_4; 2.42 × 0.99 mm).

Type locality.— SC-434 Gar Scale channel wash site. This locality is in the NE¼ SW¼ NE¼ Section 10, Township 55 North, Range 100 West, Park County, Wyoming (44.763350° N latitude, 108.880560° W longitude).

Age and distribution.— *Amphigyion straitae* is presently known only from the type locality.

Summary diagnosis.— As for the genus. *Amphigyion straitae* is most easily distinguished from other known leptictids by its smaller size and by its protozalambdodont molar morphology.

Etymology.— Named for Professor Suzanne Strait of Marshall University in recognition of her persistence in finding and developing the first good wash sites yielding micromammals from small floodplain channels in the Paleocene-Eocene boundary interval of the southern Bighorn Basin. Her success inspired us to find and wash similar channel-fill deposits in the northern Bighorn Basin.

Hypodigm.— UM 113417 (L M^1 or M^2; 1.84 × 2.62 mm), 113422 (R M_2; 1.72 × 1.38), 113424 (R M_3; 1.79 × 1.08), 113445 (L P_4; 2.42 × 0.99; holotype), 113460 (L max. P^{3-4}; 1.70 × 1.35; 1.70* × 2.20*), 113462 (L M^1 or M^2; — × —), 113468 (L M_1 trigonid; — × 1.23), 113514 (L M_2; 1.81 × 1.34), 113520 (L P_4 trigonid; — × 1.09), 113529 (L P_4 trigonid; — × 1.03), 113530 (R M_3; 1.75 × 1.20), 113539 (R M_3; 1.80 × 1.15), 113541 (L M_3; 1.80 × 1.19), 113555 (L M_1; 1.67 × 1.31), 113559 (L M_2; 1.71 × 1.36), and 113560 (L M_3; 1.73 × 1.22).

Description.— *Amphigyion straitae* is known from a maxillary fragment with P^{3-4} and from 15 additional isolated upper and lower cheek teeth. The maxillary fragment preserves the intact crown of P^3. It is narrow and sectorial with a prominent paracone connected by a short centrocrista to a smaller metacone. There is a small but distinct protocone on the lingual margin, and the tooth appears to have been three-rooted. The crown of P^4 is broken but the outline of the crown is intact, showing that it was highly molarized. The protocone is preserved on P^4 and this has a basined labial surface between distinct pre- and postprotocristae like the basined labial surface of the protocone of upper molars.

Upper molars of *Amphigyion straitae* are high-crowned, anteroposteriorly short, and labiolingually broad like those of palaeoryctids. They have a prominent protocone, a similarly prominent paracone with a smaller connate metacone close behind it, and no hypocone, making the tooth protozalambdodont in the terminology of Novacek (1976). The protocone has a basined labial surface surface between distinct pre- and postprotocristae, as was described above for P^4. The paracrista curves anterolabially to a prominent parastyle on an anterolabial projection of the crown, but the stylar shelf itself is very narrow. The centrocrista is short, if it can even be called a centrocrista, because the paracone and metacone are so closely appressed. The metacrista is oriented more transversely and it curves more labially onto a posterolabial projection of the crown. A paraconule is well developed, but there is no metaconule. There is a labial cingulum, but no anterior, lingual, or posterior cingulum. The principal distinction of upper molars of *Amphigyion* from those of palaeoryctids is the anteroposteriorly longer and more basined trigon for occlusion with lower molar talonids. The trigon part of the tooth is much shorter anteroposteriorly than that in other leptictids, but 50-100% longer than is seen in palaeoryctids.

Lower molars are represented by numerous specimens, of which UM 113422 is representative. This tooth is very high crowned, with a relatively short and very high trigonid composed of paired protoconid and metaconid cusps that are well separated from each other but connected by a straight sectorial protocristid. The paraconid is a much smaller and lower cusp attached to the anterior surface of the metaconid. The paraconid is connected to the protoconid by a distinctly crescent-shaped paracristid, which is distinctive in appearance because the paraconid is so close to the metaconid. The talonid, comprising approximately one-half of the length of the tooth, is relatively low on the crown posterior to the trigonid. The hypoconid is more prominent than is seen in palaeoryctids. All three talonid cusps are similar in size and similarly prominent. Separation of the hypoconid and hypoconulid is about equal to separation of the hypoconulid and entoconid. The three talonid cusps enclose a talonid basin that is narrower than the trigonid, but nevertheless

TABLE 2 — Statistical summary of measurements of teeth in the type sample of *Amphigyion straitae* from the SC-434 Gar Scale wash site. Individual measurements are listed in the text. Abbreviations: L, length; W, width; *N*, sample size; $\bar{x}$, mean; *s*, standard deviation; *V*, coefficient of variation. Measurements marked with an asterisk are estimates.

Tooth position		*N*	Range	$\bar{x}$	*s*	*V*
Upper dentition						
P^3	L	1	1.70	--	--	--
	W	1	1.35	--	--	--
P^4	L	1	1.70*	--	--	--
	W	1	2.20*	--	--	--
M^1	L	--	--	--	--	--
	W	--	--	--	--	--
M^2	L	1	1.84	--	--	--
	W	1	2.62	--	--	--
Lower dentition						
P_4	L	1	2.42	--	--	--
	W	3	0.99-1.09	1.04	0.05	4.86
M_1	L	1	1.67	--	--	--
	W	2	1.23-1.31	1.27	0.06	4.45
M_2	L	3	1.71-1.81	1.75	0.06	3.15
	W	3	1.34-1.38	1.36	0.02	1.47
M_3	L	5	1.73-1.80	1.77	0.03	1.81
	W	5	1.08-1.22	1.17	0.06	4.74

broad. The cristid obliqua is a little more prominent than the entocristid, and it is more distinctly angled where it joins the trigonid on the midline of the tooth. The only cingulid is a short but prominent cingulid on the anterolabial corner of the crown.

Crowns interpreted as M_1 differ from those of M_2 in being a little smaller. Crowns of M_3 are similar in size but have a narrower talonid with more posteriorly positioned talonid cusps.

Tooth measurements are summarized in Table 2.

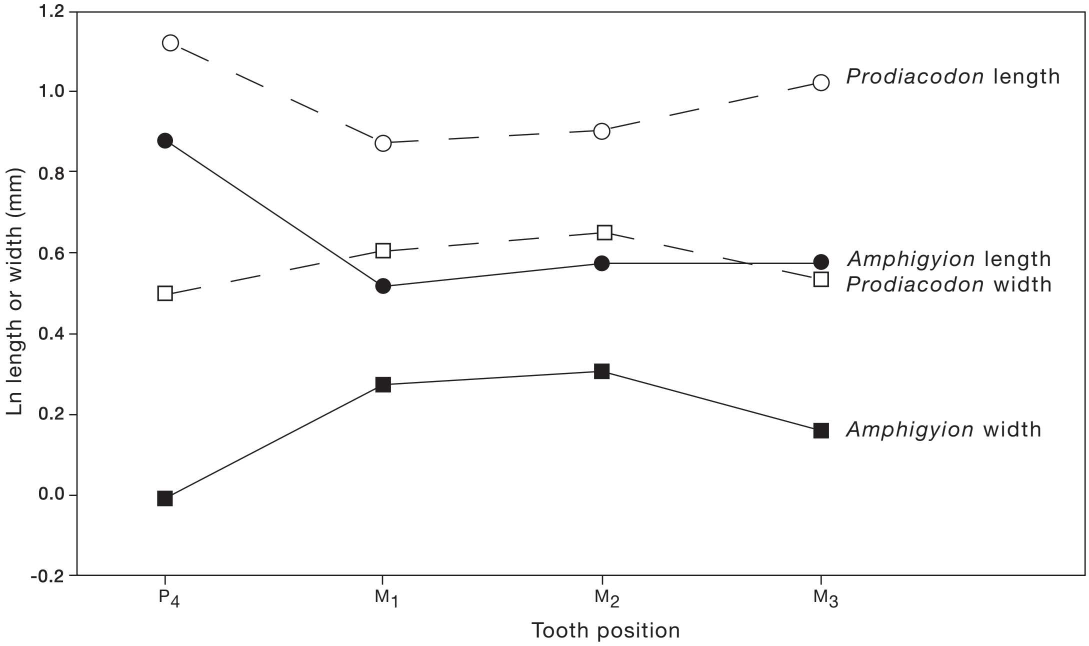


FIG. 18 — Tooth length and width profiles for P_4-M_3 in the leptictids *Amphigyion straitae*, new genus and species, and *Prodiacodon tauricinerei* (Jepsen, 1930). *Amphigyion straitae* is shown with solid lines and symbols, and *Prodiacodon tauricinerei* is shown with dashed lines and open symbols. The range of a species is expected to be about 0.2 units (±2 standard deviations) on the natural-logarithm scale of the ordinate. Note that tooth crown length in *A. straitae* (solid circles) is consistently in the range of 0.25 to 0.36 log units less than that for the same tooth in *P. tauricinerei* (open circles), meaning that teeth of *A. straitae* are generally 22-30% shorter. Similarly, tooth crown width in *A. straitae* (solid squares) is consistently in the range of 0.33 to 0.38 log units less than that for the same tooth in *P. tauricinerei* (open squares), meaning that teeth of *A. straitae* are generally about 28-31% narrower. Measurements for *Amphigyion straitae* are given in Table 2. Measurements for *Prodiacodon tauricinerei* are taken from Novacek (1977).

Discussion.— Tooth length and width profiles for P_4-M_3 of *Amphigyion straitae* are plotted in Figure 18 for comparison with those of *Prodiacodon tauricinerei*. These profiles show that tooth crown length in *A. straitae* (solid circles) is in the range of 0.25 to 0.36 log units less than that for the same tooth in *P. tauricinerei* (open circles), meaning that teeth of *A. straitae* are consistently 22-30% shorter. The one exception is in M_3 length, where *A. straitae* is about 36% shorter. Similarly, tooth crown width in *A. straitae* (solid squares) is in the range of 0.33 to 0.38 log units less than that for the same tooth in *P. tauricinerei* (open squares), meaning that teeth of *A. straitae* are consistently 28-31% narrower. The one exception is in P_4 width, where *A. straitae* is about 40% narrower.

Amphigyion straitae is known only from the SC-434 Gar Scale locality, and hence provides no information about its Clarkforkian or Wasatchian age.

Order PROPRIMATES
Family MICROSYOPIDAE
Subfamily UINTASORICINAE

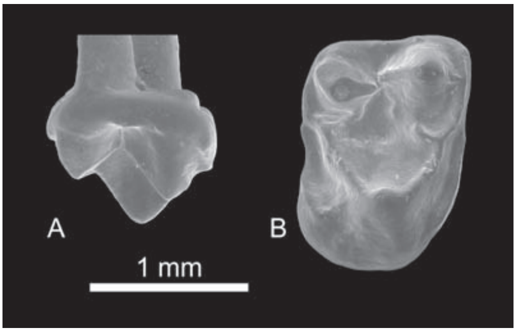


FIG. 19 — *Niptomomys doreenae* McKenna, 1960, from SC-434 Gar Scale Channel. Right M^2 (UM 113447) is shown in labial (A) and occlusal view (B).

Niptomomys McKenna, 1960

Niptomomys doreenae McKenna, 1960

Fig. 19

Niptomomys doreenae McKenna, 1960, p. 63; Bown and Gingerich, 1972, p. 2; Rose, 1981, p. 53.

Holotype.— UCMP 44081, right dentary with M_{2-3}.

Type locality.— Kent Quarry, Four Mile Creek area, Wasatchian land-mammal age, early Eocene, Sand Wash Basin, Colorado.

Age and distribution.— Middle Clarkforkian to early Wasatchian land-mammal ages, late Paleocene to early Eocene, northern Colorado to northwestern Wyoming.

Summary diagnosis.— Very small microsyopid. Upper molars are broadly basined, with low cusps, a weakly developed hypocone, conules close to the paracone and metacone, and the latter widely separated from each other and from the protocone. P^4 has a low, conical, buccal and lingual cusp, with weak anterior and posterior cingula. Lower molars are broadly basined, with low cusps, a relatively narrow trigonid lacking a paraconid, and a broad talonid. P_4 is dominated by a single conical cusp with a small metaconid and a broad talonid.

Referred specimen.— UM 113447 (R M^2; 1.07 × 1.55 mm).

Description.— This tooth has the low crown, broadly basined trigon, and separated cusps typical of *Niptomomys*. It matches *N. doreenae* closely in size (measurements in Rose, 1981) and is substantially larger than *N. favorum* (Strait, 2001).

Discussion.— *Niptomomys doreenae* ranges through the Clarkforkian-Wasatchian transition and is not diagnostic of either land-mammal age.

Family PAROMOMYIDAE

Phenacolemur Matthew, 1915

Phenacolemur praecox Matthew, 1915

Phenacolemur praecox Matthew, 1915b, p. 479. Rose, 1981, p. 66.

Holotype.— AMNH 16102, right dentary with the root of I_1 and crowns of P_4-M_2.

Type locality.— Three miles southeast of the mouth of Pat O'Hara Creek, early Wasatchian land-mammal age, Clarks Fork Basin, Wyoming.

Age and distribution.— Late Clarkforkian and early Wasatchian land-mammal ages, late Paleocene to early Eocene, of northwestern Wyoming.

Summary diagnosis.— *Phenacolemur praecox* is the largest species of the genus. The upper central incisor, I^1, is enlarged, with a tricuspid crown like that of *Plesiadapis*. P^4 and upper molars are almost square, with prominent trigon cusps near the corners of the square and a prominent postprotocingulum filling in the posterolingual corner of the tooth. The lower central incisor, I_1, is procumbent and elongated, with a delicate almost straight crown. Lower molars are quadrate with a reduced protoconid and little or no development of a hypoconulid. Isolated teeth of *Phenacolemur* are sometimes difficult to distinguish from those of *Ignacius*, but they are generally a little more massive and higher crowned, and the crown of P_4 is conspicuously larger than that of *Ignacius* (Bown and Rose, 1976). Crowns of deciduous dP^4 and dP_4 are not pointed like their permanent successors, but are molarized like crowns of M^1 and M_1, differing principally in being relatively longer and narrower.

Referred specimen.— UM 113545 (R dP_4; 2.26 × 1.62 mm).

Description.— The only tooth of *Phenacolemur praecox* known from the SC-434 Gar Scale locality is a deciduous premolar, dP_4. This has been identified by comparison with dP_4 in a dentary with M_1 of the smaller *Phenacolemur simonsi* from early Wasatchian locality SC-2 (UM 71284); and by comparison with an isolated dP_4 of the same size previously identified as *Phenacolemur praecox* from early Wasatchian locality SC-38 (UM 75956).

Discussion.— *Phenacolemur praecox* ranges through the late Clarkforkian and early Wasatchian and is not diagnostic of either land-mammal age.

Order CONDYLARTHRA
Family HYOPSODONTIDAE
Subfamily HYOPSODONTINAE

Haplomylus Matthew, 1915

Haplomylus zalmouti, new species

Fig. 20

Holotype.— UM 113416 (L dentary with P_4 -M_1; 1.60 × 1.46; 2.12 × 1.63 mm).

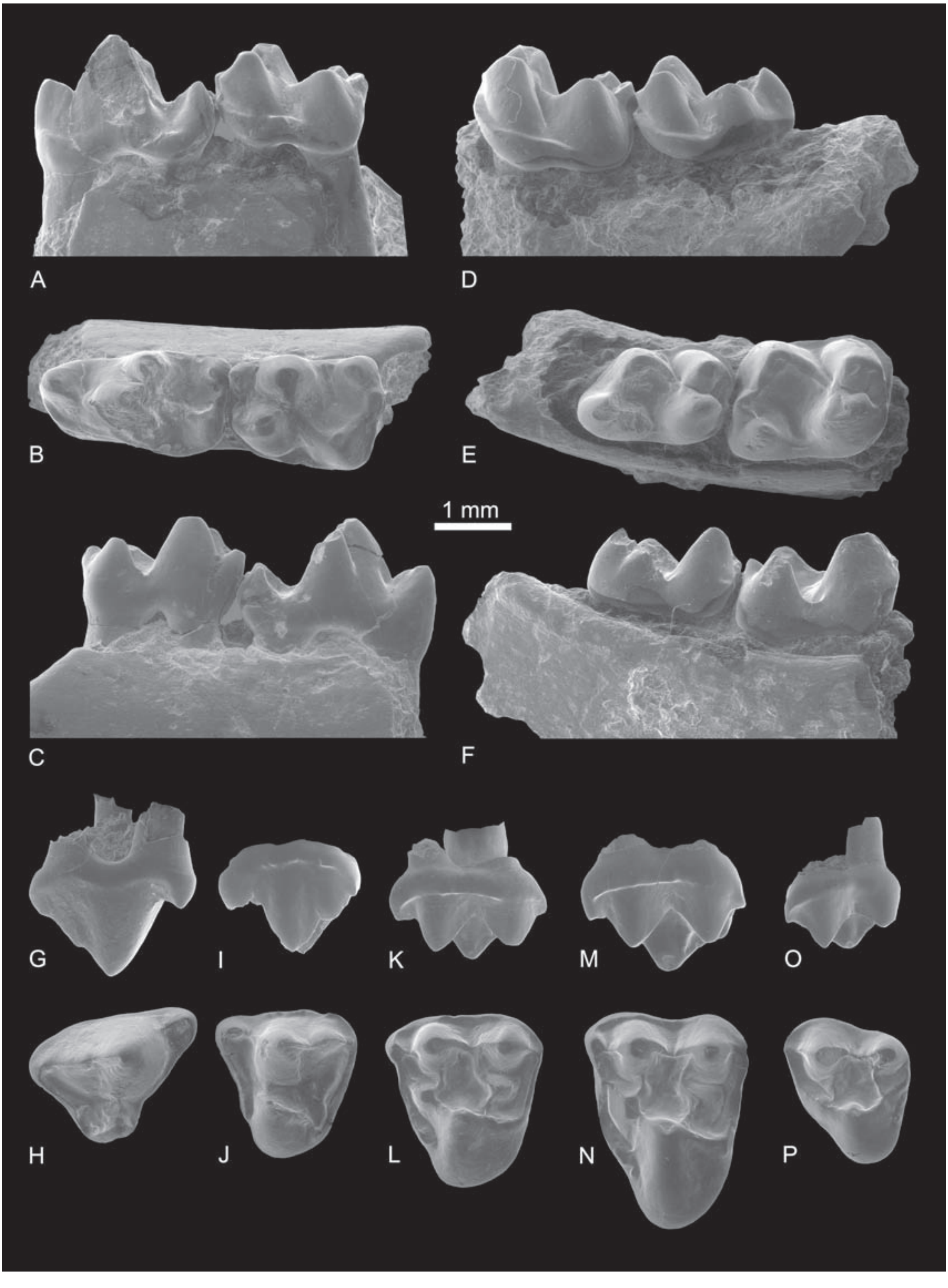
Type locality.— SC-434 Gar Scale channel wash site. This locality is in the NE¼ SW¼ NE¼ Section 10, Township 55 North, Range 100 West, Park County, Wyoming (44.763350° N latitude, 108.880560° W longitude).

Age and distribution.— *Haplomylus zalmouti* is presently known only from the type locality.

Diagnosis.— *Haplomylus zalmouti* differs from all previously known species of the genus in being significantly smaller. The entire range of M_1 sizes, for example, is smaller than that of any previously known species of *Haplomylus* (Fig. 21).

Etymology.— Named for University of Michigan Ph.D. candidate Iyad Zalmout who found the concentration of small bones and teeth on the surface at the SC-434 Gar Scale locality that led us to excavate and wash sediment from the site.

Hypodigm.— UM 113414 (L M^3; 1.56 × 2.07 mm), 113416 (L dent. P_4-M_1, type; 2.60 × 1.46; 2.12 × 1.63), 113421 (L M^2; 2.22 × 2.99), 113425 (R M_1; 2.00 × 1.38), 113435 (L dent. $M_{2\text{-}3}$; 2.07 × 1.76; 2.13 × 1.47), 113436 (R P^3; 2.39 × 1.72), 113439 (L P^4; 1.94 × 2.01), 113442 (L M^1; 2.12 × 2.40), 113451 (R dent. $M_{1\text{-}2}$; 1.93 × 1.66; — × —), 113453 (R dP^4; 2.04 × 2.00), 113456 (R P^4; (2.15 × 2.27), 113458 (R dent. M_2; 2.12 1.86), 113459 (L dP^4; 2.15 × 2.01), 113464 (R M^2; 2.04 × 2.83), 113466 (L M_3; 1.87 × 1.41), 113467 (L M_3; 1.92 × 1.44), 113471 (R M_1; 2.09 × 1.56), 113474 (L dP^3; 2.18 × 1.26), 113476 (R M^3; 1.59 × 2.10), 113483 (L dP_4; 2.26 × 1.83), 113513 (R M^3; 1.45 × 1.98), 113516 (L P^3; 2.50 × 1.86), 113517 (R P^2; 2.17 × 1.47), 113518 (R P^4; 2.06 × 2.11), 113519 (L M_1; 2.02 × 1.64), 113527 (L M_2; 2.00 × 1.79), 113532 (R M_2; 2.14 × 1.78), 113534 (L P_4; — × 1.40), 113538 (R M^3; 1.65 × 2.28), 113542 (L M_1; 2.04 × 1.69), 113543 (R M^3;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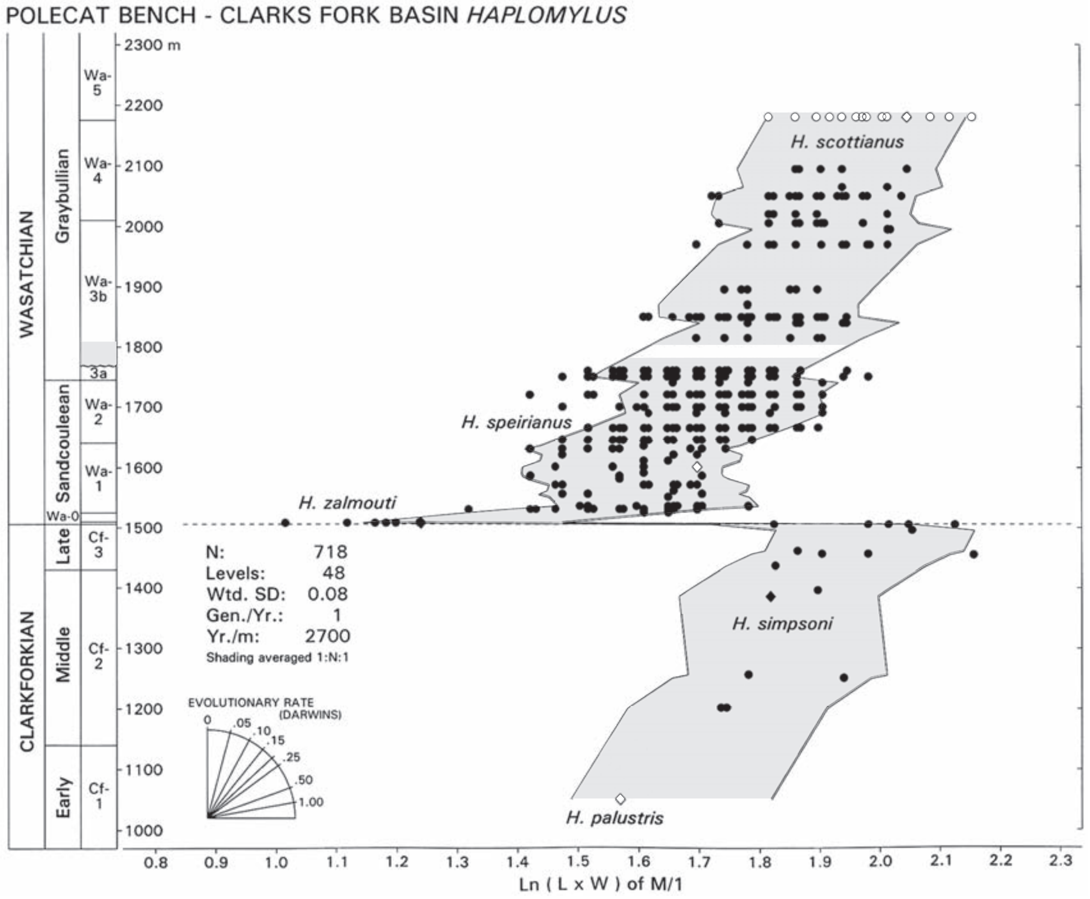

FIG. 21— Stratophenetic plot of Clarkforkian and early Wasatchian *Haplomylus* from the Clarks Fork Basin of northwestern Wyoming. Abscissa is M_1 tooth size (and by inference body size), and ordinate is meter level in measured stratigraphic section. Positions of type specimens are shown by diamonds. Specimens from Bear Creek in the northern Clarks Fork Basin (type of *H. palustris*), the southern Bighorn Basin (type of *H. speirianus*), and the McCullough Peaks area of the northern Bighorn Basin (type sample of *H. scottianus*) are shown with open symbols. Figure is reprinted from Gingerich (1994) with the addition of new specimens described here. Note that there is no overlap in M_1 size between new species *Haplomylus zalmouti* and previously known species of the genus.

FIG. 20 — *Haplomylus zalmouti*, new species, from SC-434 Gar Scale Channel. Left dentary with P_4-M_1 (UM 113416; holotype) is shown in labial (A), occlusal (B), and lingual view (C). Left dentary with $M_{2\text{-}3}$ (UM 113435) is shown in labial (D), occlusal (E), and lingual view (F). Right P^3 (113436) is shown in labial (G) and occlusal view (H). Left P^4 (113439) is shown in labial (I) and occlusal view (J). Left M^1 (113442) is shown in labial (K) and occlusal view (L). Left M^2 (113421) is shown in labial (M) and occlusal view (N). Left M^3 (113414) is shown in labial (O) and occlusal view (P).

TABLE 3 — Statistical summary of measurements of teeth in the type sample of *Haplomylus zalmouti* from the SC-434 Gar Scale wash site. Individual measurements are listed in the text. Abbreviations: L, length; W, width; *N*, sample size; $\bar{x}$, mean; *s*, standard deviation; *V*, coefficient of variation. Measurements marked with an asterisk are estimates.

Tooth position		*N*	Range	$\bar{x}$	*s*	*V*
Upper dentition						
dP^3	L	1	2.18	--	--	--
	W	1	1.26	--	--	--
dP^4	L	3	2.04-2.24	2.14	0.10	4.67
	W	3	2.00-2.15	2.05	0.08	4.08
P^2	L	1	2.17	--	--	--
	W	1	1.47	--	--	--
P^3	L	2	2.39-2.50	2.45	0.08	3.18
	W	2	1.72-1.86	1.79	0.10	5.53
P^4	L	3	1.94-2.15	2.05	0.11	5.14
	W	3	2.01-2.27	2.13	0.13	6.16
M^1	L	1	2.12	--	--	--
	W	1	2.40	--	--	--
M^2	L	2	2.04-2.22	2.13	0.13	5.98
	W	2	2.83-2.99	2.91	0.11	3.89
M^3	L	8	1.45-1.92	1.59	0.15	9.30
	W	8	1.98-2.67	2.19	0.21	9.68
Lower dentition						
dP$_4$	L	1	2.26	--	--	--
	W	1	1.83	--	--	--
P$_2$	L	1	1.95	--	--	--
	W	1	0.88	--	--	--
P$_3$	L	1	2.29	--	--	--
	W	1	1.15	--	--	--
P$_4$	L	1	2.60	--	--	--
	W	2	1.40-1.46	1.43	0.04	2.97
M$_1$	L	7	1.93-2.12	2.03	0.06	3.03
	W	7	1.38-1.69	1.58	0.11	6.90
M$_2$	L	4	2.00-2.14	2.08	0.06	3.00
	W	4	1.76-1.86	1.80	0.04	2.42
M$_3$	L	3	1.87-2.13	1.97	0.14	6.99
	W	3	1.41-1.47	1.44	0.03	2.08

1.92 × 2.67), 113546 (R P_2; 1.95 × 0.88), 113547 (R M^3; 1.49 × 2.14), 113548 (L P_3; 2.29 × 1.15), 113550 (R dP^4; 2.24 × 2.15), 113554 (L M^3; 1.55 × 2.21), 113558 (R M_1; 2.04 × 1.50), 113562 (R M^3; 1.50 × 2.10).

Description.— The type sample includes four one- or two-tooth dentaries, and crowns of virtually all cheek teeth, including representative upper and lower deciduous teeth. All of these teeth are similar to earlier and later *Haplomylus*, for which the cheek teeth are well known, and it would be easy to accommodate them in one of the known species if it were not for their smaller size.

Upper cheek teeth include an isolated P^3 with an anteroposteriorly elongated and relatively narrow crown with a large labial cusp (paracone). There is a distinct basal cusp anterior to this and a small but distinct protocone lingual to it. In contrast, P^4 has a relatively short and broad crown with a well developed protocone, a large paracone, and a distinct metacone. Upper molars have the three main cusps, protocone, paracone, and metacone dominating the crown. A paraconule and metaconule are present. There are anterior and labial cingula, and a well developed postprotocingulum curving posteriorly from the protocone to form a posterior basal cingulum. M^3 is generally much reduced in size compared to M^1 and M^2, but it is rarely fairly large.

The holotype, UM 113416, is a left dentary with P_4-M_1 (Fig. 20A-C). The crown of P_4 is elongated and highly molarized. The trigonid of P_4 occupies the anterior two-thirds of the crown, and the paraconid is placed well forward of the protoconid and metaconid. The latter cusps are massive and high. The talonid is about as wide as the trigonid and it is distinctly basined, with the hypoconid and entoconid defining the limits of the basin. The crown of M_1 has a similarly massive protoconid and metaconid, with a distinct but much reduced paraconid connected to the protoconid by a squared paracristid. The trigonid of M_1 is shorter than the talonid, and the latter is broader than the trigonid. The hypoconid and entoconid are well separated and again define the corners of the talonid basin. There is a weak hypoconulid at the posterior margin of M_1.

UM 113435 is a left dentary with $M_{2\text{-}3}$. These molars lack paraconids and instead have a looping paracristid that rises up the anterior margin of the metaconid. M_3 is reduced in size and narrower than M_2. Both have larger hypoconulids than the hypoconulid of M_1, and this is extended posteriorly to make a slightly elongated talonid on M_3.

Tooth measurements are summarized in Table 3.

Discussion.— The stratigraphic distribution of *Haplomylus* summarized in Figure 21 was unusual before discovery of *H. zalmouti* in having two successive lineages start out relatively small and become substantially larger, first through Clarkforkian time, and then again through early Wasatchian time. Now *H. zalmouti*, in the middle of the stratigraphic range of the genus, is the smallest species of all. If it is a direct descendant of its earlier Clarkforkian congener, then the transition from *H. simpsoni* to *H. zalmouti* was relatively rapid.

Haplomylus zalmouti provides some evidence favoring a Wasatchian age of the SC-434 Gar Scale locality because the species is closer in size to *H. speirianus* than it is to H. *simpsoni*.

Family PHENACODONTIDAE

Phenacodontid sp.

Fig. 22A-B

Referred specimen.— UM 114573 (L dent. with M_3; 11.11 × 7.17 mm; mandibular depth beneath M_3 is 23.8 mm).

Description.— The only phenacodontid from the SC-434 Gar Scale Channel found to date is a piece of a relatively large left dentary with the intact crown of M_3. The dentary and molar are approximately the size of those of *Phenacodus vortmani* or *P. intermedius*. The dentary is distinctive in being narrow but relatively deep (narrowness is affected by compaction, but this seemingly had little effect on mandibular depth). The M_3 differs from those of *Phenacodus* in having a relatively longer and narrower crown, with the paraconid being more prominent and positioned more an-

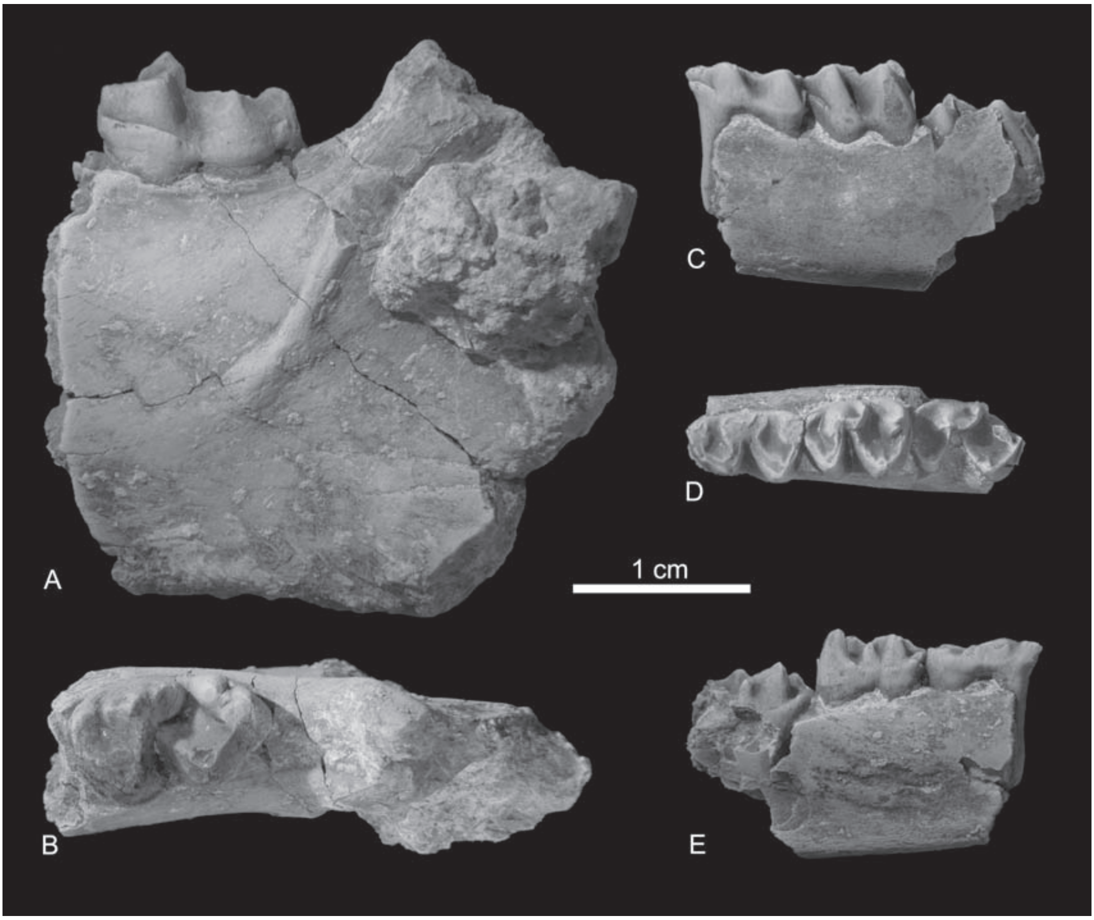

FIG. 22 — Phenacodontid sp. (A-B) and *Meniscotherium priscum* Granger, 1915 (C-E), from SC-434 Gar Scale Channel. Phenacodontid sp. left dentary with M_3 (UM 114573), is shown in labial (A) and occlusal view (B). *Meniscotherium priscum* left dentary with dP_4 and $M_{1\text{-}2}$ (114575) is shown in labial (C), occlusal (D), and lingual view (E).

teriorly than is typical for *Phenacodus*. The metaconid is high. There is no separate metastylid, but the metaconid has distinct crests extending anteriorly and posteriorly on the lingual side of the crown. The trigonid has a prominent labial cingulum. The talonid is relatively narrow and long, with a large hypoconid and hypoconulid, and a smaller entoconid connected to the hypoconulid by a low crest.

Discussion.— It is not possible to identify the genus and species represented here without a more complete specimen. Nevertheless some comparisons are possible. The general shape of the crown of M_3 is more similar to that of *Ectocion* than it is to *Phenacodus*. The species represented was much larger than the common Clarkforkian and early Wasatchian species *Ectocion osbornianus*, and it is close in size to *Prosthecion major* Patterson and West (1973; *Ectocion major* according to Thewissen, 1990).

Family MENISCOTHERIIDAE

Meniscotherium Cope, 1874

Meniscotherium priscum Granger, 1915

Fig. 22C-E

Meniscotherium(?) *priscum* Granger, 1915, p. 360.
Meniscotherium priscum, Gazin, 1965, p. 21. Rose, 1981, p. 76. Gingerich, 1989, p. 55. Gingerich, 2001, p. 58.
Ectocion parvus (in part), Van Valen, 1978, p. 58.
Meniscotherium tapiacitum (in part), Williamson and Lucas, 1992, p. 43.
Meniscotherium, Strait, 2003, p. 101.

Holotype.— AMNH 16145, left dentary with dP_4-M_1 (5.80 × 3.75 mm; 5.20 × 4.40; Rose, 1981).

Type locality.— Gingerich (1982a, 1989) argued that the type specimen of *Meniscotherium priscum* came from Wa-0 strata at the end of Polecat Bench, probably from locality SC-67. It now seems more likely that the type came from the brown mudstones immediately underlying SC-67, where all northern Bighorn Basin specimens of *Meniscotherium* collected subsequently were found (see discussion below).

Age and distribution.— *Meniscotherium priscum* is known from earliest Wasatchian zone Wa-M, earliest Eocene, in the northern and southern Bighorn Basin. The principal literature citations are listed in the synonymy above.

Summary diagnosis.— Teeth of *Meniscotherium* are easily distinguished from those of contemporary early Eocene condylarths, especially similar-sized phenacodontids, by the presence of lophoselenodont shearing crests on upper and lower molars. The conules on upper molars are distinctively crescent shaped as well.

Referred specimens.— UM 111640 (fragments of two left upper molars, probably L M^2 and M^3; no measurements). The tooth fragments cataloged as UM 111640 were found together in a lump of mudstone weathering on the surface when the Gar Scale Channel wash site was discovered in 2003. Excavation in 2006 yielded three more specimens: UM 114574 (R dent. with M_2; 6.33 × 4.78 mm), 114575 (L dent. with dP_4 and $M_{1\text{-}2}$; 6.38 × 4.10; 6.02 × 4.57; 6.46* × 4.61*), and 114576 (R dent. with $M_{1\text{-}3}$; 5.34 × 4.62 ; 5.82 × 4.93 ; 5.80 × 4.02).

Description.— The UM 111640 tooth fragment interpreted as M^2 has the protocone and crescent-shaped paraconule well preserved, while the tooth fragment interpreted as M^3 has the protocone and straight metaconule well preserved. There is little doubt from the size, shape, and position of these cusps that the taxon represented is *Meniscotherium*.

The best preserved of the three new dentaries listed here is UM 114575 with dP_4 and unworn $M_{1\text{-}2}$. M_2 is in the process of erupting. Lower molars of *Meniscotherium priscum* have a very distinctive crown configuration with the paraconid small and the protoconid and metaconid prominent on the trigonid, while a large hypoconid and entoconid are the only two cusps on the talonid. Lower molars of *Meniscotherium* (Fig. 22C) are more selenodont than they are lophodont. There is a prominent anterior or trigonid crescent on the crown starting from the position of the paraconid (there is no distinct cusp here) and curving through the protoconid to join a prominent metaconid. There is a second and larger posterior or talonid crescent on the crown starting just posterior to the metaconid and curving through the hypoconid to join the entoconid. Both the trigonid and talonid are open lingually, and the talonid is effectively open posteriorly as well because there is no hypoconulid on the posterior crescent. There is a distinctively prominent metastylar crest arising posterior and perpendicular to the trigonid crescent, curving lingually to join a large metastylid. The cristid obliqua arises from the latter near the angle formed by the protolophid and this metastylar crest.

New Wa-M specimens tend to be a little larger than the holotype, but the holotype is included in the range of variation in size observed here (Table 6).

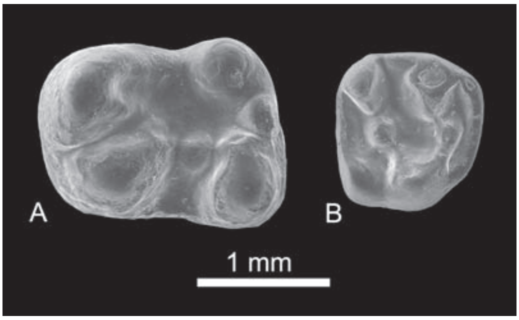

FIG. 23 — *Paramys annectens* Rose, 1981 (A) and *Microparamys hunterae* Ivy, 1990 (B) from SC-434 Gar Scale Channel. *Paramys annectens* left P^4 (UM 113444) in occlusal view (A). *Microparamys hunterae* right M^1 (113430) in occlusal view (B).

Discussion.— *M. priscum* from the early Wasatchian of northern Wyoming has been synonymized with similar-sized *M. tapiacitus* from the late Wasatchian of New Mexico by Williamson and Lucas (1992), and this may prove to be correct. However, the two species are very different in age. Granger (1915) distinguished *M. priscum* from *M. tapiacitus* by its well developed metastylid, which remains a distinctive characteristic, and we continue to recognize *M. priscum* as a valid species.

The type locality of *Meniscotherium priscum* is not precisely known because the type specimen lacks an entry in the Sinclair and Granger field notebook for 1911, the year it was collected. Granger (1915) published both the type of *Meniscotherium priscum* and the type of *Ectocion parvus* as coming from "Clark Fork beds, Head of Big Sand Coulee, in the Clarks Fork Basin." However, the preservation of both specimens is more like that of specimens from the Wa-0 interval than it is like specimens from the head of Big Sand Coulee. It is possible that the type specimen of *M. priscum* came from SC-67 and is Wa-0 in age (Gingerich, 1982a, 1989), but, if so, *M. priscum* is a very rare component of the SC-67 fauna because no new specimens have been found in spite of years of intensive collecting. It now seems more likely that the type of *M. priscum* came from the brown mudstones immediately underlying SC-67 as this is the interval where all northern Bighorn Basin specimens of *Meniscotherium* collected subsequently, including those described here, were found.

Ten specimens of *Meniscotherium priscum* are now known from four localities in the Bighorn Basin in addition to the holotype (Table 6). All come from the brown mudstone interval or equivalent, below the Wa-0 faunal zone, in the northern, western, and southern Bighorn Basin. All are found shortly after the onset of the Paleocene-Eocene carbon isotope excursion (CIE).

Meniscotherium is characteristic of the *Meniscotherium* or Wa-M faunal zone in the northern, western, and southern Bighorn Basin. *Meniscotherium* has never been found in the Wa-0 zone, with the possible exception of the holotype of *M. priscum*. Nothing like *Meniscotherium* has been found in known Tiffanian or Clarkforkian faunas anywhere in the Western Interior of North America, so it is reasonably considered a Wasatchian immigrant, possibly from localities farther south than any sampled in the late Paleocene, or possibly from a different continent (Gingerich, 1982a). *Meniscotherium* is common in later Wasatchian faunas of southern Wyoming, Colorado, and New Mexico (Williamson and Lucas, 1992), but it never occurs in the Bighorn Basin of northern Wyoming after Wa-M (and possibly Wa-0) time.

Order RODENTIA
Family ISCHYROMYIDAE
Subfamily PARAMYINAE

Paramys Leidy, 1871

Paramys annectens Rose, 1981

Fig. 23A

Paramys annectens Rose, 1981, p. 119.

Acritoparamys atwateri (in part), Korth, 1984, p. 31. Ivy, 1990, p. 47. Gingerich, 1989, p. 40. Strait, 2001, p. 139.

Holotype.— YPM-PU 19526, left and right dentaries with I^1 and P_4-M_3.

Type locality.— University of Michigan locality SC-209, middle Clarkforkian land-mammal age (late Paleocene), of the Clarks Fork Basin, Wyoming (see Rose, 1981, for details).

Age and distribution.— This species was synonymized with *Acritoparamys atwateri* soon after it was named (see below, a decision not followed here), so it is difficult to know what the age and distribution might be. Specimens reported here extend the range from the middle Clarkforkian to the earliest Wasatchian land-mammal ages (late Paleocene to earliest Eocene) in the Clarks Fork Basin of northwestern Wyoming.

Summary diagnosis.— *Paramys annectens* was distinguished as a Clarkforkian species of *Paramys* intermediate in size, interpreted as connecting earlier *P. atavus* and later *P. excavatus*. Species of *Paramys* have cheek teeth without prominent crests. Upper molars are basically tritubercular, with a small hypocone, a complete protoloph on unworn teeth, and an incomplete metaloph, Lower cheek teeth have a molariform P_4; molars with a small trigonid and large talonid; mesoconid small to absent; no accessory crests; and enamel generally smooth (Wood, 1962).

Referred specimens.— UM 113444 (L P_4; 1.75 × 1.44 mm), and 113461/65 (R dent. M_{1-2}; 2.17 × 2.15; 2.34 × 2.22; these teeth were found and catalogued separately but have a matching interproximal facet and were originally part of the same individual animal).

Description.— P_4 has the metaconid as the largest cusp, with the protoconid, hypoconid, and entoconid approximately equal in size. The protoconid is simple without accessory crests, and the mesoconid is very small.

M_1 is trapezoidal in occlusal outline, with a very short and narrow trigonid and a much longer and broader talonid. The metaconid is large, the protoconid is much smaller, and there is no paraconid. A mesoconid is present but small. There is no entoconid crest extending into the talonid basin. M_2 is similar, but with a broader trigonid giving the tooth a more rectangular occlusal outline.

Discussion.— Korth (1984) synonymized Clarkforkian *Paramys annectens* Rose with middle to late Wasatchian *Acritoparamys atwateri* (Loomis), claiming that they are “equal in size and identical in morphology.” However, the type specimen of *Paramys annectens* is typically *Paramys*-like. If the *P. annectens* and *A. atwateri* type specimens are identical and conspecific, it is not at all clear how *Acritoparamys* would differ from *Paramys*. Further, if measurements of the type specimen of *Reithroparamys atwateri* reported by Wood (1962) are correct, then the species are substantially different in size.

Paramys annectens ranges through the late Clarkforkian and early Wasatchian and is not diagnostic of either land-mammal age.

Subfamily MICROPARAMYINAE

Microparamys Wood, 1959

Microparamys hunterae Ivy, 1990

Fig. 23B

Microparamys hunterae Ivy, 1990, p. 56.

Holotype.— UM 66968, left dentary with M_{1-3}.

Type locality.— UM locality SC-123, early Wasatchian land-mammal age (Wa-1), early Eocene, of the Clarks Fork Basin, Wyoming.

Age and distribution.— *Microparamys hunterae* is principally from the type locality.

Summary diagnosis.— *Microparamys hunterae* is distinguished from contemporary *M. cheradius* by its 20% smaller size, by its less complete and more oblique metalophid, and by its less well separated anterior cingulum (Ivy, 1990).

Referred specimens.— UM 112756 (R M^2; 1.26 × 1.46 mm), 113430 (R M^1; 1.10 × 1.24), and 113454 (R M^2; 1.24 × 1.47).

Description.— These are the first upper molars of *Microparamys hunterae* to be described. The best-preserved tooth is UM 112756, which has well developed conules, including an unusually large, metaconule, and a well developed hypocone connected to the protocone by a weak crest.

Discussion.— These teeth match lower molars in the type specimen of *Microparamys hunterae* in size and occlusion. They are smaller than upper molars of *Microparamys cheradius*, and further differ in having a more prominent metaconule.

The presence of *Microparamys hunterae* in a Wa-M fauna is evidence favoring its Wasatchian age as this species has not been found in Clarkforkian faunas.

Subfamily REITHROPARAMYINAE

Cf. *Reithroparamys*, new species

Fig. 24

Referred specimens.— UM 111776 (L dent. M_{1-2}; 2.16 × 1.99; 2.18 × 2.08 mm), 113419 (L M^1 or M^2; 2.17 × 2.74), 113420 (R P^4; 1.68 × 2.50), 113428 (R dP_4; 1.59 × 1.31), 113429 (L M_3; 2.81 × 2.18), 113438 (L M_1; 2.14 × 2.21), 113441 (R M_3; 2.46 × 1.91), 113452 (L M_1; 2.06 × 1.91), 113477 (L M_1; 2.13 × 1.99), 113540 (R P_4; 1.76 × 1.53), 113544 (L P_4; 1.70 × 1.40). Two deciduous upper premolars are tentatively referred to this species based on their size and primitive tritubercular morphology: UM 113415 (L dP^4; 1.60 × 2.12 mm), and 113552 (R dP^4; 1.52 × 2.10).

Description.— The upper dentition is represented by two isolated teeth. Both are relatively high crowned compared to teeth of contemporary rodents. P^4 is relatively short anteroposteriorly, but it is quadrate and molarized. The protocone is the largest cusp, and the paracone is notably larger than the metacone. The paraconule and metaconule are both well developed, as is the hypocone on the postprotocingulum crest connecting the protocone to the posterior cingulum. Anterior and posterior basal cingula are well developed. There is no cusp in the mesostyle position. M^2 is like P^4 in being quadrate. The protocone is the largest cusp, but the paracone and metacone are equal in size. The hypocone is nearly as large. The paraconule and metaconule are well developed conical cusps. There are prominent anterior and posterior basal cingula. A small but distinct cusp is present in the mesostyle position.

The lower dentition is represented by a dentary with M_{1-2} and by seven additional isolated cheek teeth. P_4 is variable in size but consistently has a narrow trigonid and a broader talonid. The trigonid has two cusps, with the metaconid being the largest. The protoconid, hypoconid, and entoconid are approximately equal in size, and a hypoconulid is present but smaller. The protoconid is sometimes connected to the metaconid by a small crest linking them directly, and there is always a distinctive crescent-shaped crest extending anterolingually and posterolingually from the protoconid. There is generally a small crest in the position of the mesoconid running from the back of the protoconid and flaring to join the hypoconid. The talonid cusps are connected by a low crest at the posterior margin of the tooth.

Lower molars are generally high crowned and quadrate like their upper counterparts, although here the length is greater than the width. The metaconid is the largest cusp on M_1 and M_2, and the protoconid, hypoconid, and entoconid are large, marking the remaining three corners of the quadrate molar. The trigonid is relatively longer anteroposteriorly than that in *Paramys*, and the

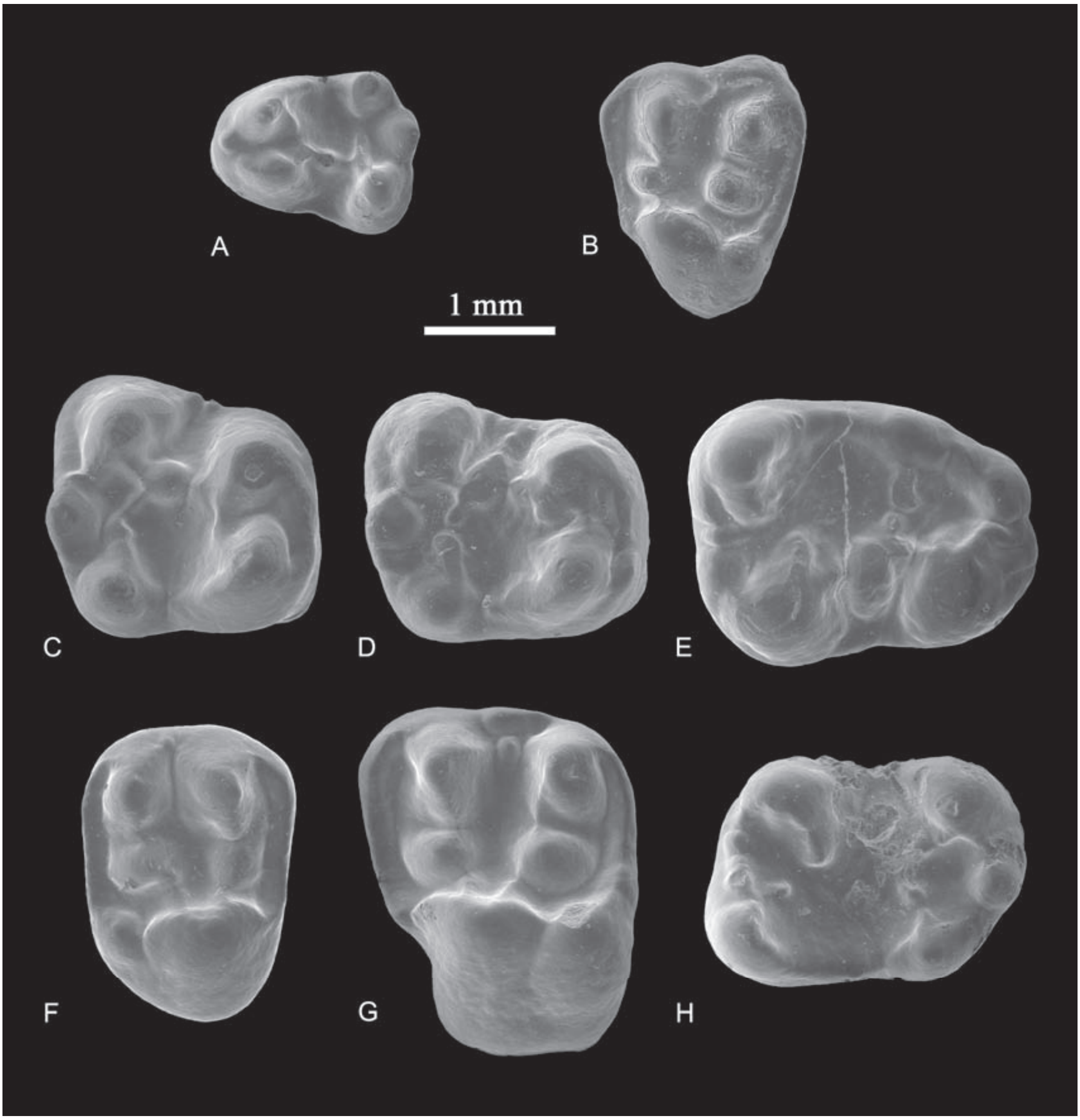

FIG. 24 — Deciduous and permanent cheek teeth of Cf. *Reithroparamys*, new species, from SC-434 Gar Scale Channel. All are shown in occlusal view. A, right dP^4 (UM 113428); B, left dP_4 (113415, questionably referred); C, left M^1 (113438); D, left M^1 (113477); E, left M^3 (113429); F, right P_4 (113420); G, left M_1 (113419); and H, right M^3 (113441).

talonid is correspondingly smaller proportionally. The mesoconid and hypoconulid are well developed on M_1 and M_2. There is a small crest connecting the metaconid to the hypoconid on M_1 in UM 111776, but not on M_2, and there is a small crest connecting the mesoconid to the entoconid on M_2. Stating this another way, there is a small entoconid crest running into the middle of the talonid on M_1, but this crest crosses the talonid and connects to the mesoconid on M_2. Two isolated cheek teeth, M_1 and/or M_2, are even less worn than the teeth in UM 111776, and both show the small transverse mesoconid-entoconid crest to be well developed, making the teeth incipiently trilophodont. The crown of M_3 resembles those of M_1 and M_2 but differs in having a shorter, lower trigonid, and in having the hypoconid dominate the other talonid cusps. The hypoconulid and entoconid are smaller on a curving crest bordering the posterolingual part of the talonid. M_3 is lower crowned than M_1 or M_2.

All of the teeth have smooth enamel except in the talonid basins of the lower molars where the development of a transverse entoconid or entoconid to mesoconid crest interrupts the smooth enamel. There are lower molars that lack this crest but these are seemingly rare (e.g., UM 113452).

Discussion.— This species is being studied and described by Drs. S. Strait and P. Holroyd, and our observations are based on a subset of the known specimens.

Cf. *Reithroparamys*, new species, is a small reithroparamyinae with the entoconid separated from the posterolophid, as is typical for the subfamily (Korth, 1984). Upper cheek teeth are relatively high crowned and quadrate. Lower molars are distinctive in having the metaconid as the largest cusp; a well-formed and slightly basined trigonid with paired anterior and posterior enamel crests connecting the protoconid and metaconid; a prominent mesoconid; a round hypoconulid connected to both the hypoconid and entoconid by low crests; and, almost always, a small crest of enamel running from the entoconid into the talonid, which often connects with the mesoconid. Lower incisors are distinctive in being oval rather than ovoid, and in being relatively shallow and broad in cross-section (preserved in a referred Wa-0 dentary).

Cf. *Reithroparamys*, new species, is most easily distinguished from contemporary rodents by its small size, well formed trigonids on lower molars, and by the complexity of its molar morphology. The entoconid and mesoconid are prominent, and an entoconid-mesoconid crest connecting these is common.

Cf. *Reithroparamys*, new species, differs from *Acritoparamys* in having a more prominent mesoconid and a round hypoconulid; differs from later *Reithroparamys* in having broader incisors, in retaining a more primitive trigonid on lower molars, and in having more complexly crested lower molars. Cf. *Reithroparamys*, new species, resembles *Lophiparamys* to some extent in general appearance, but lacks the complex crenulations so well developed on lower molars of the latter.

Some specimens referred to *Acritoparamys* by Gingerich (1989), following Korth (1984) and Ivy (1990), probably belong here, and the same may be true for some specimens referred to *Acritoparamys* by Strait (2001).

We are not aware of any rodents like Cf. *Reithroparamys*, new species, present in the Clarkforkian land-mammal fauna. First appearance of this species in Wa-M, and its known continuation into Wa-0 and probably later Wasatchian strata, favors inclusion of Wa-M in the Wasatchian land-mammal age. There are rodents like Cf. *Reithroparamys*, new species, in the contemporary Dormaal fauna in Europe, and further comparison with European specimens may indicate a biogeographic link.

Order CARNIVORA
Family VIVERRAVIDAE

Viverravus Marsh, 1872

Viverravus bowni Gingerich, 1987

Fig. 25A,B

Viverravus cf. acutus, Bown, 1979, p. 94.
Vierravus undescribed new species, Rose, 1981, p. 101.
Viverravus bowni Gingerich, 1987, p. 312; 1989, p. 37.
Viverravus acutus (in part), Polly, 1997, p. 20.

Holotype.— UM 76928, left dentary with impression of P_3 and crowns of M_{1-2}.

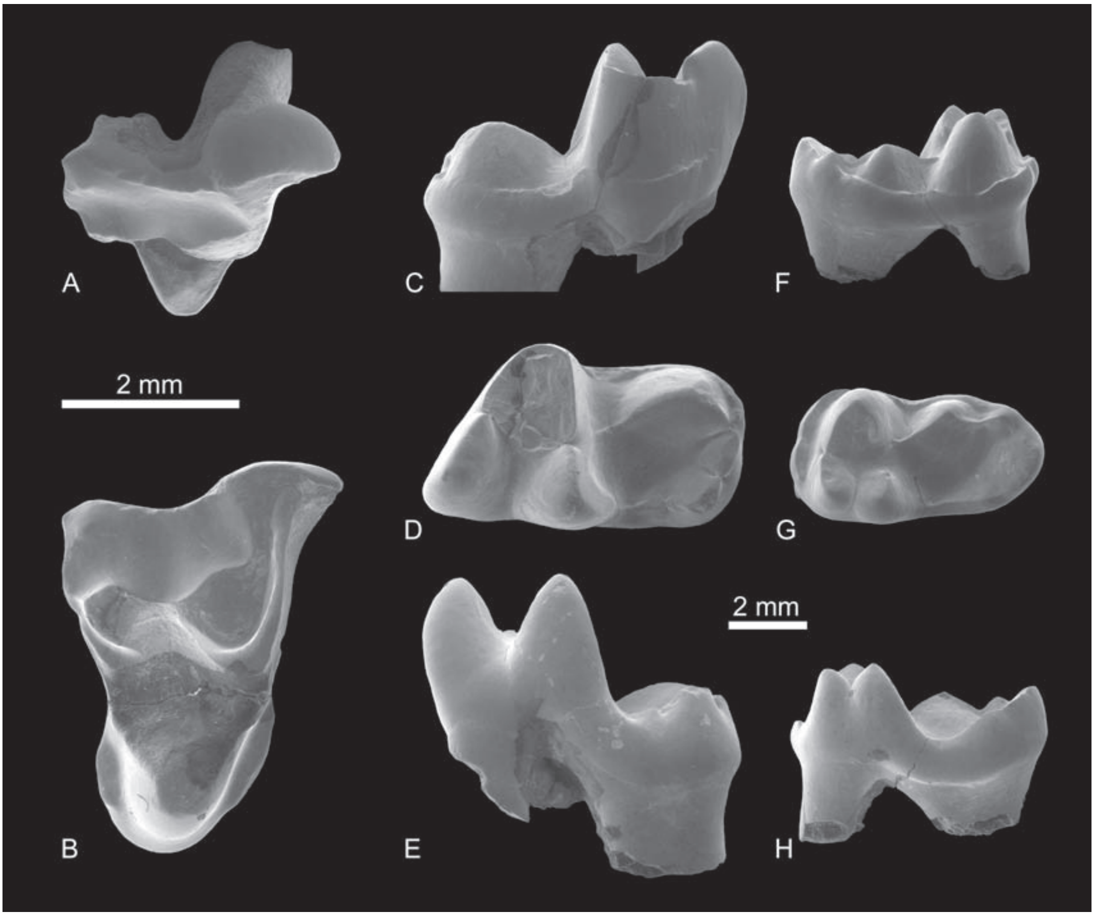

FIG. 25 — *Viverravus bowni* Gingerich, 1987 (A-B) and *Didymictis leptomylus* Cope, 1880 (C-H), from SC-434 Gar Scale Channel. *Viverravus bowni* right M^1 (UM 113413) in labial (A) and occlusal view (B). *Didymictis leptomylus* right M_1 (113432) in labial (C), occlusal (D), and lingual view (E); right M_2 (113433) in labial (F), occlusal (G), and lingual view (H). *Didymictis* M_1 and M_2 were found on the same screen during the washing process, and almost certainly represent a single individual animal.

Type locality.— UM locality SC-29, late Clarkforkian land-mammal age (Cf-3), late Paleocene, of the Clarks Fork Basin, Wyoming.

Age and distribution.— *Viverravus bowni* is known from the middle and late Clarkforkian and early Wasatchian land-mammal ages of the Bighorn and Clarks Fork basins in northwestern Wyoming.

Summary diagnosis.— *Viverravus bowni* differs from the contemporary and closely related species *Viverravus acutus* in being some 16-17% smaller in linear dimensions (Gingerich, 1987). Polly (1997) interpreted the distribution of sizes differently and synonymized *V. bowni* with *V. acutus*.

Referred specimens.— UM 113413 (R M^1; 3.10 × 4.75 mm), and, possibly, 113450 (R M_1 trigonid; — × 1.93).

Description.— The upper molar described here is virtually identical to M^1 in a well preserved palate (UM 69870) and maxilla (UM 80546) of *Viverravus bowni* from the early Wasatchian of the Clarks Fork Basin. M^1 of *Viverravus* is buccolingually broader than that of *Miacis*, and the trigon basin is more angled.

The M_1 trigonid described here is clearly that of *Viverravus*, but it is intermediate in size between *V. rosei* and *V. bowni*, and possibly represents a second species of *Viverravus* in the faunal sample.

Discussion.— *Viverravus bowni* is a species ranging through the late Clarkforkian and early Wasatchian, and it thus provides no evidence linking the SC-434 Wa-M fauna to one land-mammal age or the other. The same is true for *V. rosei* if the trigonid described here should prove to represent that species.

Didymictis Cope, 1875

Didymictis leptomylus Cope, 1880

Fig. 25C-H

Didymictis leptomylus Cope, 1880, p. 908. Gingerich, 1989, p. 39.
Didymictis protenus leptomylus, Matthew, 1915a, p. 20.
Didymictis proteus (in part), Polly, 1997, p. 34.

Holotype.— AMNH 4238, left dentary with $M_{1\text{-}2}$.

Type locality.— Southern Bighorn Basin, Wyoming. The type specimen was collected during the summer of 1880 when Jacob Wortman made a brief foray into the Bighorn Basin while working for E. D. Cope in the Wind River Basin.

Age and distribution.— *Didymictis leptomylus* is now known from earliest Wasatchian zones Wa-M and Wa-0 (Gingerich, 1989), and it continues through zones Wa-1 to Wa-3 in the Clarks Fork and Bighorn basins (Polly, 1997).

Summary diagnosis.— Specimens of *Didymictis leptomylus* are generally smaller than those of Clarkforkian *D. proteus* and early Wasatchian *D. protenus,* but these species are sometimes difficult to distinguish.

Referred specimens.— UM 113432 (R M_1; 7.89 × 4.91 mm), and 113433 (R M^2; 6.48 × 3.50). These two specimens were found on the same washing screen and probably represent the same individual animal.

Description.— The M_1 carnassial is the mirror image of M_1 in the type specimen of *Didymictis leptomylus*, and the M_2 described here is similarly the mirror image of M_2 in the type specimen. It is possible that these two teeth belonged to the same individual animal in life, but there is no way to confirm this as the M_2 appears to be unworn and possibly not fully erupted at the time of death. Neither tooth has any interproximal wear that would enable them to be matched.

Discussion.— Polly (1997) regarded *Didymictis leptomylus* as an early Wasatchian species. Here the range is extended down to the base of the Wasatchian, but *D. leptomylus* remains a Wasatchian element of the SC-434 Wa-M fauna.

SYSTEMATICS OF MAMMALS FROM THE SC-434 BROWN MUDSTONE SITE

All of the mammals from the Brown Mudstone site are also known from the underlying and slightly older Gar Scale Channel site. Background information about each species can be found in the text above, and here we provide for each species only a list of specimens and a brief description and discussion.

Order MARSUPIALIA

Family PERADECTIDAE

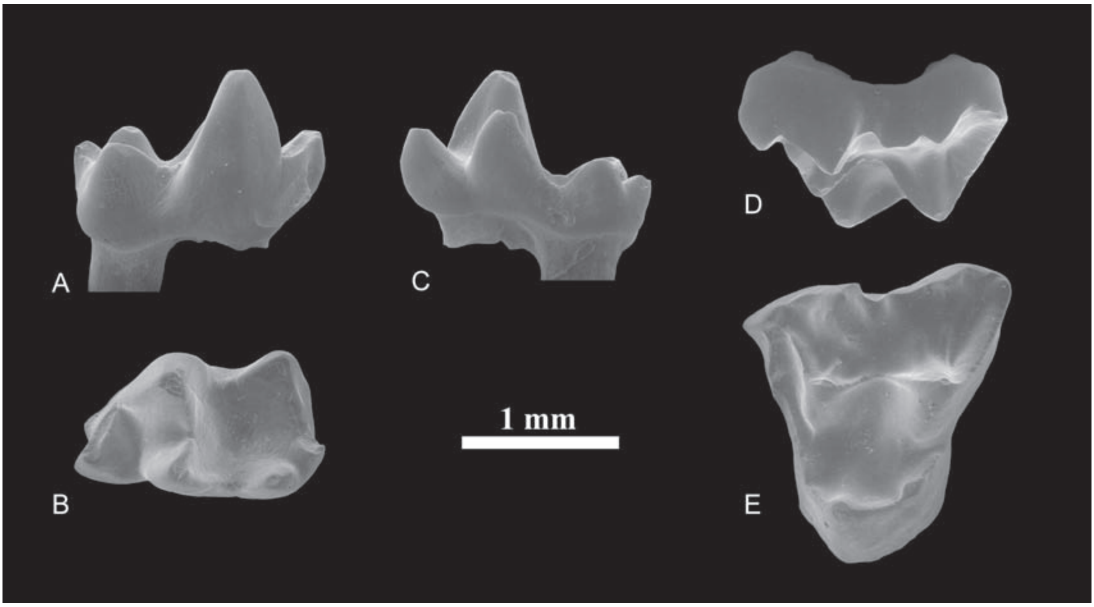

FIG. 26 — *Peradectes protinnominatus* McKenna, 1960, from SC-434 Brown Mudstone. Right M_3 (113307) in labial (A), occlusal (B), and lingual view (C). Left M^2 or M^3 (113305) in labial (D) and occlusal view (E).

Peradectes Matthew and Granger, 1921

Peradectes protinnominatus McKenna, 1960

Fig. 26

Referred specimens.— UM 113305 (L M^2 or M^3; 1.75 × 1.90 mm), 113307 (R M_3; 1.60 × 0.98).

Description.— Here again these teeth are typical of *Peradectes protinnominatus* molars in terms of size and molar shape. The paracone and metacone are rectodont, and stylar cusps B and D are prominent on the upper molar. The hypoconulid is positioned posterolaterally relative to the entoconid on the lower molar.

Discussion.— The discussion above concerning *Peradectes protinnominatus* from the SC-434 Gar Scale Channel site is pertinent here.

Family HERPETOTHERIIDAE

Peratherium Aymard, 1846

Peratherium innominatum Simpson, 1928

Referred specimens.— UM 113311 (R M^2; 1.65 × 1.80), 113312 (R M_1; 1.54 × 0.73), and 113325 (L M^3; 1.60 × —).

Description.— The upper molar is worn but it appears to have the distinctively dilambdodont form typical of *Peratherium*. The lower molar has the distinctively acute entoconid, and the lingually-placed, posteriorly-projecting hypoconulid characteristic of the genus.

Discussion.— The discussion above concerning *Peratherium innominatum* from the SC-434 Gar Scale Channel site is pertinent here.

Order LIPOTYPHLA
Suborder ERINACEOMORPHA
Family AMPHILEMURIDAE

Macrocranion Weitzel, 1949

Macrocranion cf. *M. junnei* Smith et al., 2002

Referred specimen.— UM 113316 (L P^4; 1.34 × 1.66 mm).

Description.— This tooth is worn, but it is the size and conformation to belong to *Macrocranion* and hence is identified as *Macrocranion* cf. *M. junnei*.

Discussion.— *Macrocranion* from the Gar Scale Channel site is the oldest record of the genus in North America, and this appears to be a second early record of the genus. The discussion above concerning *Leptacodon* sp. from the SC-434 Gar Scale Channel site is pertinent here.

Suborder SORICOMORPHA
Family NYCTITHERIIDAE

Leptacodon Matthew and Granger, 1921

Leptacodon sp.

Referred specimen.— UM 113302 (L M^1; 1.48 × 01.77 mm).

Description.— This tooth is typically *Leptacodon* in form, but insufficient to identify to species.

Discussion.— The discussion above concerning *Leptacodon* sp. from the SC-434 Gar Scale Channel site is pertinent here.

Order CONDYLARTHRA
Family HYOPSODONTIDAE
Subfamily HYOPSODONTINAE

Haplomylus Matthew, 1915

Haplomylus zalmouti, new species
Fig. 27

Referred specimens.— UM 113303 (R M^2; 2.10 × 2.90 mm), 113304 (R P^4; 2.05 × 2.12), 113306 (R M_2; 2.08 × 1.82), 113308 (R M^3; 1.37 × 1.82), 113314 (R P^2 or P^3; 2.22 × 1.54), 113318 (L M_1; 2.07 × 1.68).

Description.—M_1 described here is at the large end of the size range for *Haplomylus zalmouti* but it is still smaller than specimens of any species described previously.

Discussion.— The discussion above concerning *Haplomylus zalmouti* from the SC-434 Gar Scale Channel site is pertinent here.

Order CARNIVORA

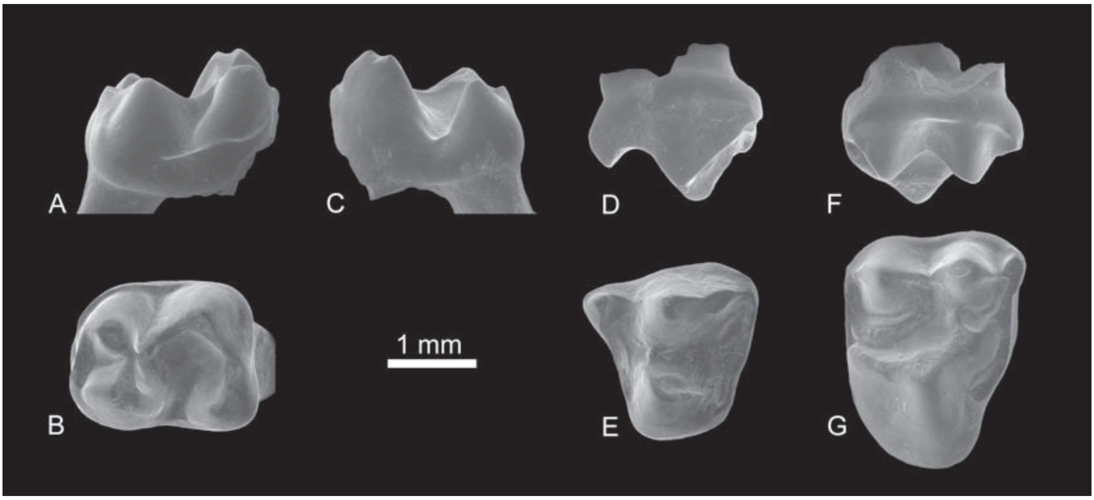

FIG. 27 — *Haplomylus zalmouti*, new species, from SC-434 Brown Mudstone. Right M_2 (113306) in labial (A), occlusal (B), and lingual view (C). Right P^4 (113304) in labial (D) and occlusal view (E). Right M_2 (113303) in labial (F) and occlusal view (G).

Family VIVERRAVIDAE

Viverravus Marsh, 1872

Viverravus sp.

Referred specimens.— UM 113315 (L M_1 trigonid; — × 1.98 mm).

Description.— The M_1 trigonid described here is clearly that of *Viverravus*. It is the size of the trigonid described above, which may or may not be *V. bowni* (see above).

Discussion.— The discussion above concerning *Viverravus bowni* from the SC-434 Gar Scale Channel site is pertinent here.

DISCUSSION

The two principal sites chosen for screen washing, the SC-435 Shell Bed site and the SC-434 Gar Scale Channel site, were selected because each seemed to be yielding a small concentration of teeth found on the surface. The third site, the SC-434 Brown Mudstone site, was chosen because it came from a higher level and yielded teeth in a test sample. All three sites are approximately two meters apart stratigraphically, in the 4-5 meter thick sequence of brown mudstones lying between marker beds Purple-0 and Top Brown (Fig. 3). All three sites were thought to be in the *Meniscotherium* or Wa-M zone (which proved not to be the case). We sampled the three sites thinking that different lithologies might have a different yield in terms of numbers of specimens, and also that different lithologies might preserve slightly different faunal facies.

Results presented here show that the Shell Bed site yielded 56 specimens, including whole teeth, for 275 kg of sediment washed; the Gar Scale Channel yielded 103 specimens for 525 kg of sediment washed; and the Brown Mudstone yielded 14 specimens for 675 kg of sediment washed. At the first two sites the yield is approximately equal, about one tooth per 5 kg of processed sediment, while at the Brown Mudstone site the yield is an order of magnitude less, about one tooth

TABLE 4 — Faunal list of mammals from the SC-435 Shell Bed wash site. Total number of species identified to date is 14, of which one is a marsupial, based on study of 56 whole teeth or jaw fragments (number of specimens for each taxon is shown in parentheses at right). All species are consistent with a latest Clarkforkian age for this fauna (Fig. 28).

MULTITUBERCULATA			
	Neoplagiaulacidae		
		Ectypodus powelli Jepsen, 1940	(6)
MARSUPIALIA			
	Peradectidae		
		Peradectes protinnominatus McKenna, 1960	(7)
LIPOTYPHLA			
	Nyctitheriidae		
		Leptacodon rosei Gingerich, 1987	(1)
		Wyonycteris chalix Gingerich, 1987	(1)
APATOTHERIA			
	Apatemyidae		
		Labidolemur kayi Simpson, 1929	(2)
PROPRIMATES			
	Microsyopidae		
		Niptomomys doreenae McKenna, 1960	(5)
	Paromomyidae		
		Phenacolemur praecox Matthew, 1915	(9)
CONDYLARTHRA			
	Hyopsodontidae		
		Apheliscus nitidus Simpson, 1937	(4)
		Haplomylus simpsoni Rose, 1981	(6)
		Aletodon gunnelli Gingerich, 1977	(1)
	Phenacodontidae		
		Ectocion osbornianus (Cope, 1882)	(2)
RODENTIA			
	Ischiromyidae		
		Microparamys cheradius Ivy, 1990	(9)
CARNIVORA			
	Viverravidae		
		Viverravus rosei Polly, 1997	(1)
	Miacidae		
		Uintacyon rudis Matthew, 1915	(2)

per 50 kg. The latter site is easier to wash, because the sediment breaks down more rapidly in water, but the yield per kg is much less.

Latest Clarkforkian and Earliest Wasatchian Faunas

When we started screen washing, we expected that each site would yield more or less the same fauna, and there was no reason to suspect that the fauna from the Shell Bed site would be as different as it proved to be. The Gar Scale Channel and the Brown Mudstone sites together share all of the genera known at the latter, and both of these sites appear to sample the same fauna. However, the Brown Mudstone sample is so small in terms of number of specimens that it adds little information to any general comparison, and it will not be considered further here.

The Shell Bed fauna includes 14 species of mammals classified in 14 genera (Table 4). It includes three common, standard index fossils restricted to the Clarkforkian land-mammal age, all

TABLE 5 — Faunal list of mammals from the SC-434 Gar Scale Channel wash site. Total number of species identified to date is 18, of which five are marsupials, based on study of 103 whole teeth or jaw fragments (number of specimens for each taxon is shown in parentheses at right). SC-434 Brown Mudstone wash site has the same fauna, in so far as it is known, and hence it is not listed separately. All species are consistent with an earliest Wasatchian age for this fauna (Fig. 28).

MULTITUBERCULATA			
	Neoplagiaulacidae		
		Ectypodus sp.	(2)
MARSUPIALIA			
	Peradectidae		
		Peradectes protinnominatus McKenna, 1960	(3)
		Peradectes sp. 1	(2)
		Peradectes sp. 2	(4)
		Mimoperadectes labrus Bown and Rose, 1979	(2)
	Herpetotheriidae		
		Peratherium innominatum Simpson, 1928	(3)
LIPOTYPHLA			
	Amphilemuridae		
		Macrocranion cf. *M. junnei* Smith et al., 2002	(1)
	Nyctitheriidae		
		Leptacodon sp.	(5)
LEPTICTIDA?			
	Leptictidae		
		Amphigyion straitae, new species	(16)
PROPRIMATES			
	Microsyopidae		
		Niptomomys doreenae McKenna, 1960	(1)
	Paromomyidae		
		Phenacolemur praecox Matthew, 1915	(1)
CONDYLARTHRA			
	Hyopsodontidae		
		Haplomylus zalmouti, new species	(38)
	Phenacodontidae		
		Phenacodontid sp.	(1)
	Meniscotheriidae		
		Meniscotherium priscum Granger, 1915	(4)
RODENTIA			
	Ischyromyidae		
		Paramys annectens Rose, 1981	(2)
		Microparamys hunterae Ivy, 1990	(3)
		Cf. *Reithroparamys*, new species	(13)
CARNIVORA			
	Viverravidae		
		Viverravus bowni Gingerich, 1987	(1)
		Didymictis leptomylus Cope, 1880	(1)

condylarths: the genus *Aletodon*, represented by *Aletodon gunnelli*, and the common species *Apheliscus nitidus*, and *Haplomylus simpsoni* (see Rose, 1981). The rodent *Microparamys cheradius* is less well known (Ivy, 1990), but it may prove to be an index species of the Clarkforkian as well. Remaining Shell Bed species range through both the late Clarkforkian and early Wasatchian.

The Gar Scale Channel fauna includes 19 species of mammals classified in 16 identifiable genera (Table 5; the phenacodontid is not identifiable to genus). Eight of the 16 genera identified in the Gar Scale Channel fauna are shared with the Shell Bed fauna, but eight of the genera are different as well, and two of the eight genera that are shared are represented by different species. Differences in total numbers of genera and species between the two sites can easily be explained by differences in amount of sediment washed and in the total number of specimens recovered, but the observed compositional differences cannot be explained away by sampling.

The Gar Scale Channel fauna includes three genera that are found only in the Wasatchian: *Macrocranion* (Smith et al., 2002), *Meniscotherium* (Williamson and Lucas, 1992), and cf. *Reithroparamys* (Strait and Holroyd, in preparation). *Haplomylus zalmouti* described here is more similar to early Wasatchian *H. speirianus* than it is to late Clarkforkian *H. simpsoni* (Fig. 21). *Microparamys hunterae* of Ivy (1990) is less well known than the other taxa mentioned here, but it may prove to be an index species of the Wasatchian. The marsupials *Mimoperadectes* and *Peratherium* are generally considered to make their first appearance in the North American fossil record in the early Wasatchian, but there appear to be credible records from the late Clarkforkian for *Mimoperadectes*, and possibly the late Tiffanian for *Peratherium* (Rose, 1981). North American Paleocene-Eocene marsupials are problematic too because they have not received a comprehensive review for many years and there are many new specimens being referred to a number of poorly characterized taxa. The remaining Gar Scale Channel species are either confined to this narrow stratigraphic interval (*Amphigyion straitae*) or range through both the late Clarkforkian and early Wasatchian.

These observations are summarized in Figure 28, where labeling of age-diagnostic taxa shows the Shell Bed and Gar Scale Channel faunas to be very different. We interpret the compositon of the Shell Bed site to indicate a latest Clarkforkian mammalian fauna because the age-diagnostic taxa are all Clarkforkian. Further, we interpret the composition of the overlying SC-434 Gar Scale Channel site with *Meniscotherium* to indicate an earliest Wasatchian fauna because the age-diagnostic taxa are all Wasatchian.

Stratigraphic Distribution of Bighorn Basin *Meniscotherium*

The age of *Meniscotherium* is commonly cited as being Clarkforkian and Wasatchian, or late Paleocene and early Eocene. The idea that *Meniscotherium* appeared in the Clarkforkian land-mammal age and in the late Paleocene epoch is based on Bighorn Basin specimens, principally the type specimen of *Meniscotherium priscum* (Granger, 1915; see also Gazin, 1965; Rose, 1981; and Williamson and Lucas, 1992). As noted above, when the type was published in 1915 it was described as having come from Clarkfork beds at the head of Big Sand Coulee, but its preservation is different from that of fossils found in Clarkforkian strata at or near Polecat Bench. The circumstances of its discovery suggested that the type specimen came from Wa-0 strata at Polecat Bench (Gingerich, 1982a, 1989). However, we now know that *Meniscotherium* is relatively common in the Wa-M brown paleosols just below Wa-0, and it appears more likely that the holotype came from this interval as well.

Our conclusion that the first appearance of *Meniscotherium* is at the beginning of the Wasatchian land-mammal age rather than earlier in the Clarkforkian is reinforced by recovery of ten additional specimens of *Meniscotherium* in the Bighorn Basin over the past twenty years (Table 6). These come from eight sites at four localities in the northern, western, and southern Bighorn Basin. All are from the brown paleosol interval or equivalent above Clarkforkian Cf-3 mammals and below Wasatchian Wa-0 mammals, or, where the mammal sequence is not complete, from within the lower part of the Paleocene-Eocene carbon isotope excursion or CIE (which is, by definition, earliest Eocene because the Paleocene-Eocene boundary is now defined by the onset of the CIE; Aubry et al., 2002; Dupuis et al., 2003). There is as yet no verifiable record of *Meniscotherium* from Clarkforkian or Paleocene-age strata in the Bighorn Basin or anywhere else.

It appears that several different paleosols in the Wa-M brown mudstone sequence may yield *Meniscotherium*, but we have not yet attempted to correlate the individual sites in detail to determine exactly how many actually have yielded *Meniscotherium*. Some specimens have been found

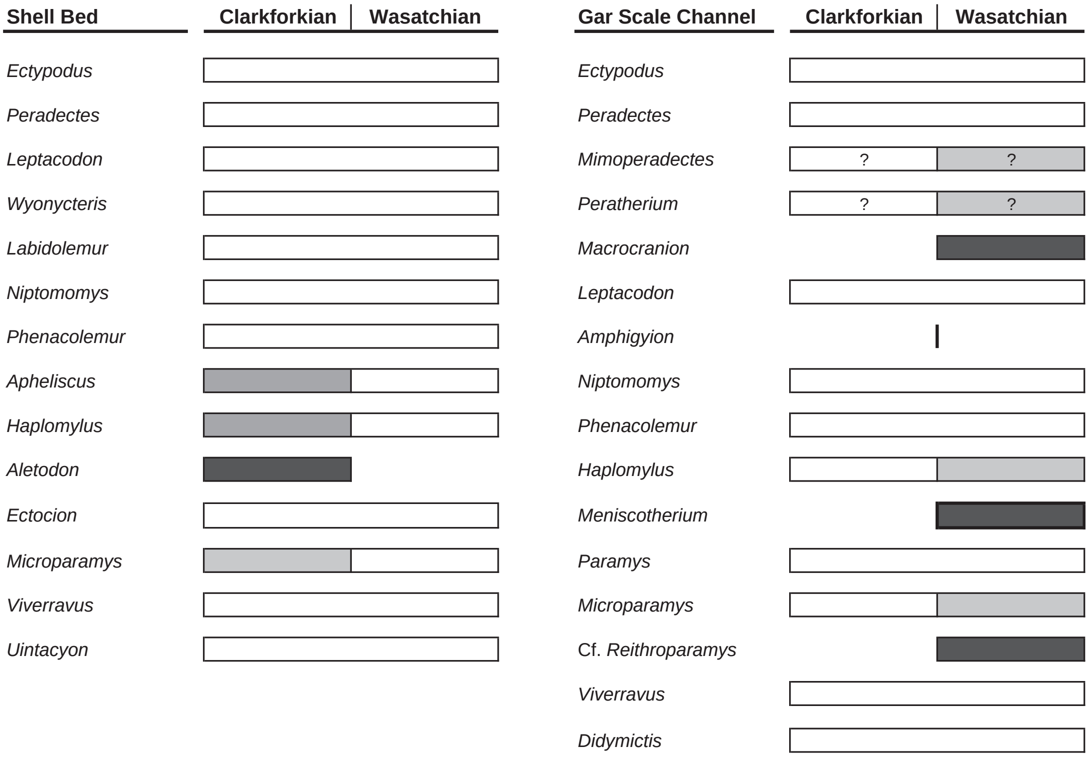

FIG. 28 — Age interpretation of the SC-435 Shell Bed fauna (left; derived from Table 4) and SC-434 Gar Scale Channel fauna (right; derived from Table 5). Note that all taxa found in the Shell Bed are consistent with a late Clarkforkian age. *Aletodon* (black) is a common genus ranging through the Clarkforkian. *Apheliscus nitidus* and *Haplomylus simpsoni* (gray) are well known Clarkforkian species with successor species in the Wasatchian. *Microparamys cheradius* (light gray) is a less well known Clarkforkian species (light gray) with successor species in the Wasatchian. All taxa found in the Gar Scale Channel are consistent with an early Wasatchian age. *Macrocranion, Meniscotherium,* and cf. *Reithroparamys* (black) are common genera found in the Wasatchian but not Clarkforkian. *Mimoperadectes labrus* and *Peratherium innominatum* (gray) are Wasatchian species with questionable generic records from the Clarkforkian. *Haplomylus* (light gray) is more similar to Wasatchian *H. speirianus* than it is to Clarkforkian *H. simpsoni*, and *Microparamys hunterae* (light gray) is a less well known Wasatchian species with precursor species in the Clarkforkian. Open bars represent range-through genera with similar or identical Clarkforkian and Wasatchian species. *Amphigyion* is uninformative because it is known only from the Gar Scale Channel.

in place in a brown paleosol, while others, like the specimens described here, have been found in channel fill constrained stratigraphically to be the age of the brown paleosol sequence.

Earliest Wasatchian *Meniscotherium* or Wa-M Zone and Fauna

The *Meniscotherium* fauna from SC-404 and from the Gar Scale Channel site is stratigraphically intermediate between underlying Clarkforkian localities like SC-343 and the SC-435 Shell Bed site described here, and overlying Wasatchian localities yielding a Wa-0 mammalian fauna like SC-67 (Fig. 2). Hence the stratigraphic section contining the SC-404 and SC-434 sites, between

TABLE 6 — Geographic coordinates for earliest Wasatchian (Wa-M) *Meniscotherium priscum* specimens from the Bighorn Basin, Wyoming.

					M_1			Geodetic coordinates (WGS 1984)		
	Specimen	Discovery year	Reference	Description	L (mm)	W (mm)	Locality	North lat. (°)	West long. (°)	Collector
1.	AMNH 16145	1912	Granger (1915)	L dent. dP^4-M_1	5.50	4.50	—	—	—	W. Sinclair (?)
2.	UM 91419	1987	Gingerich (2001)	R P^4; LM_2	—	—	MP-71	44.23433	108.84456	L. Roe
3.	UM 108645	2000	Gingerich (2001)	L dent.$M_{1\text{-}3}$	6.04	4.61	SC-404	44.76381	108.88227	M. Arif and G. Junne
4.	—	2001	Strait (2003)	Assoc. teeth	—	—	Halfway Hill N	43.94436	107.57554	S. Strait
5.	UM 111500	2003	This paper	Dent. M_x	—	—	SC-404	44.76390	108.88094	I. Zalmout
6.	UM 111640	2003	This paper	Frag. max. $M^{2\text{-}3}$	—	—	SC-434	44.76332	108.88119	I. Zalmout
7.	UM 111774	2003	This paper	L & R dent. (edent.)	—	—	SC-404	44.76370	108.88083	P. Gingerich
8.	UM 112237	2004	This paper	L dent. $M_{2\text{-}3}$ (?)	—	—	SC-404	44.76418	108.88186	G. Junne
9.	UM 114574	2006	This paper	R dent. M_2	—	—	SC-434	44.76332	108.88117	T. Smith and P. Missian
10.	UM 114575	2006	This paper	L dent. dP_4-M_2	6.02	4.57	SC-434	44.76332	108.88117	T. Smith and P. Missian
11.	UM 114576	2006	This paper	R dent. $M_{1\text{-}3}$	5.34	4.62	SC-434	44.76332	108.88117	T. Smith and P. Missian

Purple-0 and the Top Brown paleosol at the south end of Polecat Bench shown in Figure 3, can be considered the type section of Wasatchian zone Wa-M. The fauna from the Gar Scale Channel site has distinctive species like *Amphigyion straitae, Haplomylus zalmouti,* and *Meniscotherium priscum* found at no other stratigraphic level, and it lacks representatives of two of the modern orders Artiodactyla and Primates mentioned in the introduction that are present in the overlying Wa-0 fauna.

Additional taxa distinctive of this zone are known from other localities. A perissodactyl has been reported from the *Meniscotherium* zone in the Honeycombs area of the southern Bighorn Basin (Strait, 2003; Yans et al., 2006), but perissodactyls were probably not yet as common as they are in Wa-0 and later faunas. There is a medium-sized *Hyopsodus,* larger than *H. loomisi* from Wa-0, known from the Wa-M interval in Sand Coulee. One specimen, UM 71049, was described by Rose (1981: fig. 36b) as coming from Clarkforkian locality SC-153, but UM 71049 was almost certainly found in the brown paleosols overlying the Clarkforkian strata at this locality (the other *Hyopsodus* specimen reported from the Clarkforkian almost certainly represents a cataloging error). A second specimen of large Wa-M *Hyopsodus* is also known from an unnumbered locality in brown paleosols in Sand Coulee (specimen UM 110901). Normal-sized *Ectocion osbornianus,* as distinct from the smaller Wa-0 species *Ectocion parvus*, is also known from several Wa-M localities in Sand Coulee and elsewhere.

The Wa-M stratigraphic interval is several meters thick and it includes several individual brown paleosols with a number of correlative channel-fill sequences. We do not know if the Gar Scale Channel fauna described here and the taxa just listed (Honeycombs perissodactyl, large *Hyopsodus, Ectocion osbornianus*) will ever all be found at the same site, but all appear to have lived in the Bighorn Basin within the same few thousands of years of geological time. The Wa-M fauna cannot be considered well known, but there is substantial evidence that it differs from both the preceding Cf-3 fauna, and from the succeeding Wa-0 fauna.

Clarkforkian-Wasatchian Boundary

The end of the Clarkforkian land-mammal age is defined by the beginning of the Wasatchian, of course, but *Aletodon gunnelli, Apheliscus nitidus,* and *Haplomylus simpsoni* found here are important taxa enabling recognition of the Clarkforkian fauna. The beginning of the Wasatchian land-mammal age is generally defined by the first appearance of Perissodactyla, but it can also be recognized by the first appearance of *Macrocranion, Meniscotherium,* and the rodent *Reithroparamys* or cf. *Reithroparamys*.

The Shell Bed and Gar Scale Channel wash sites together bracket the Clarkforkian-Wasatchian boundary. They lie within a meter or two of each other stratigraphically, and are located within 200 meters of each other geographically, in strata with numerous well defined marker beds (Figs. 2-3). This means that the Clarkforkian-Wasatchian land-mammal age boundary at Polecat Bench can now be recognized and related to the onset of the Paleocene-Eocene carbon isotope excursion (CIE) with better temporal resolution than was possible before. This has required new isotopic studies, and the CIE context of the faunas and sites described here will be published in the near future.

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