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RODENTS (MAMMALIA) FROM THE MILL POINT LOCAL FAUNA, (OLIGOCENE) OF MONTANA

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ABSTRACT

The Mill Point local fauna from Montana has not been previously described in detail, and has been suggested as early Arikareean North American Land Mammal Age (latest Oligocene). Five species of rodents are identified: the aplodontid *Niglarodon brachyodon* Korth, 2009; the sciurid *Nototamias* sp.; the castorid *Palaeocastor wahlerti* Korth, 2001; and the cricetids *Leidymys* sp., cf. *L. blacki* (Macdonald, 1963) and *Geringia gloveri* (Macdonald, 1970). Three of these species, *Nig. brachyodon*, *P. wahlerti*, and *L.* cf. *blacki* are elsewhere known from the Whitneyan, and *Nototamias* sp. and *G. gloveri* are elsewhere limited to the Arikareean, suggesting an age of the fauna either latest Whitneyan or at the Whitneyan-Arikareean boundary. Analysis of the remainder of the fauna is necessary to determine a more precise age. The fauna appears to be an attritional accumulation based on the survivorship curve produced by the sample of *Nig. brachyodon*.

INTRODUCTION

The Mill Point local fauna is from the Grasshopper Basin of southwestern Montana (Nichols et al., 2001: figs. 1, 2). It is from an unnamed formation that consists of predominantly lacustrine sediments of ashy shales and marls and is an equivalent of the Renova Formation (Duchesnean to Arikareean Land Mammal Ages [=NALMA]; Fields et al., 1985: 17; Janis et al., 2008: 730). The first fossil mammals reported from this fauna were by Douglass (1907). Later, Kay et al. (1958) provided a faunal list of the fossil mammals but mistakenly included species from two horizons. These were later divided into the earlier Mill Point local fauna and later Grasshopper Creek local fauna by Tabrum et al. (2001), and were cited as early Arikareean (?Ar2) and late Arikareean (Ar4) in age, respectively (see Janis et al., 2008: appendix I).

Tabrum et al. (2001) also provided a preliminary faunal list of the fossil mammals from the Mill Point. None of the taxa listed by Tabrum et al. (2001: 104–105) was attributed to species, mainly to family or as a questionable genus. The only taxa tentatively identified to species were the menisocmyine aplodontids *Niglarodon* sp., cf. *N. koerneri* Black, 1961, and *N.* sp., aff. *N. blacki* Rensberger, 1981, and the leptomerycid artiodactyl *Pronodens* sp., cf. *P. silberlingi* Koerner, 1940. Of these three species, the two rodents are elsewhere limited to the early Arikareean (Ar1 to Ar2) of Montana, Wyoming, and South Dakota (Rensberger, 1981; Flynn and Jacobs, 2008), and the leptomerycid was known from early to late Arikareean localities (Ar1 to Ar3) from Montana and South Dakota (Koerner, 1940; Webb, 1998; Tedford et al., 2004). A detailed study of the rodent fauna from Mill Point has led to the re–identification of the aplodontids along with the recognition of other typically Whitneyan species, suggesting the fauna is possibly late Whitneyan in age or at the boundary between the Whitneyan and Arikareean NALMA.

Dental Terminology.—Terminology for aplodontid cheek teeth follows that of Rensberger (1981, 1983); for castorids follows Stirton (1935); and for all others follows Wood and Wilson (1936). Upper teeth are designated by capital letters, lower teeth by lower–case letters (e.g., M1 and m1). All measurements are to the nearest 0.01 mm, measured with an optical micrometer.

Abbreviations for Dimensions of Meniscomyine Cheek Teeth (after Rensberger, 1981).—CH1, height of anterior enamel chevron on m1; DLIP/, difference in depth of bases of anterolingual and anterolabial inflections on P4; ECPT/, length of ectoloph segment of P4; HAI1, height of base of anterolabial inflection on m1; HALP, height of anterolabial inflection on P4; HPIP, height of posterolabial fossettid on p4; RLWP, average length/width ratio of p4; WLP3/, width to length ratio of P3.

Abbreviations for Institutions—CM, Carnegie Museum of Natural History; LACM, Los Angeles County Museum.

SYSTEMATIC PALEONTOLOGY

Order Rodentia Bowdich, 1821
Family Aplodontidae Brandt, 1855
Niglarodon Black, 1961
Niglarodon brachyodon Korth, 2009
(Figures 1–3; Table 1)

Amended Diagnosis.–P4/p4 shorter but molars equal in size to those of *N. koerneri* and smaller than all other species; p4 narrower than other species (average length/width ratio [RLWP] = 1.28); cheek teeth lower–crowned than other species of *Niglarodon* with less pronounced enamel inflections at the bases of the teeth (height of posterolabial fossettid on p4 [HPIP] = 0; height of base of anterolabial inflection on m1 [HAI1] average = 0.47; height of anterior enamel chevron on m1 [CH1] average = 0.11; height of anterolabial inflection on P4 [HALP] average = 0.50; difference of depth of bases of anterolingual and anterolabial inflections on P4 [DLIP/] average = 0.07); P3 not as anteroposteriorly elongated as in other species (WLP3/ = average = 0.94), similar to that of *N. koerneri*; central valleys of upper molars blocked centrally by metaconule at later stage of wear than other species; protocone crest variably present on M2, absent in other species; posterolabial fossettid on p4 not as widely open as in other species (similar to *Meniscomys*); mesostylid on lower molars larger and more distinct than in other species (near that of *Meniscomys*); central fossettid on m2 variably present; posterolingual and posterolabial fossettids not open posteriorly m3.

Referred Specimens.–CM 72574, cranial fragment with right and left M1 and unerupted P4s; CM 75855, anterior half of skull with incisors, dP3–M1 and right dP3–M2; CM 75856, palate with right and left dP4–M1; CM 75857, associated maxillae with right P3–M2 and left P3–M3; CM 75887, palate with right and left P3–M2; CM 90504, partial skull lacking rostrum and neurocranium with right and left P3–M3; CM 90505, both maxillae with left P3–M3, right M1–M3, and premaxillary fragment with left I1; CM 90506, palate with right P4–M3 and left M1–M3; CM 75861, right maxilla with P3–M2; CM 75889, partial maxilla with right P3–M1; CM 75858 and 75895, maxilla with P3–P4; CM 75859, 75860, 75862, 75888, maxilla with P4–M2; CM 90507, partial maxilla with right P4–M1; CM 75896–75899, P4; CM 75863–75865, maxillary fragment with M1–M2; CM 75866 and 90508, maxillary fragment with M2–M3; CM 90509, right M1; CM 75867 left M2; CM 75869, 75873, 75879, 90510, 90511, dentary with p4–m3; CM 72575, 75870, 75871, 75880, 90513, 90516, dentary with p4–m2; CM 90512 right dentary with p4–m1 and m3; CM 75890, 75891, partial dentary with p4–m1; CM 75868 and 75878, dentary with dp4–m2; CM 86521 and 86522, p4; CM 72566, 75875, 75881, 75892, dentary with m1–m3; CM 75874, 75876, 75882, 75900 dentary with m1–m2; CM 75883 partial right dentary with m2–m3; CM 75872, p4; CM 75886, 75893, 86523, m1; CM 75884, 75885, 75887, 75894, 90518, m2.

Description.–Portions of the skull are preserved on three specimens from Mill Point; CM 72574, juvenile skull with posterior half of the rostrum and most of the medial orbital wall (P4s unerupted); CM 75855, a juvenile skull (deciduous premolars retained) with complete rostrum, palate, dorsal skull roof, and orbital walls; and CM 90504, a partial adult skull (premolars erupted) with the skull roof, palate and orbital walls (Figure 1). The cranial morphology does not differ markedly from previously described skulls of prosciurine and allomyine aplodontids (Wahlert, 1974; Korth and Emry, 1991). In dorsal view (Figure 1E), the rostrum tapers anteriorly. The nasals widen only slightly anteriorly, and end posteriorly at the same level as the premaxillaries. The posterior suture of the nasals and premaxillaries runs transversely across the skull, level with the posterior margin of the dorsal zygomatic arch. On the right side of CM 90504, the dorsal surface of the lacrimal is present at the anterodorsal corner of the orbit. The dorsal surface of the frontals is flat to slightly concave. The bases of the postorbital processes are preserved on CM 90504; they appear small (width of base = 2.4–2.5 mm). Parasagittal crests run posteriorly from the posterior margin of the postorbital processes as low ridges that extend posteriorly parallel with the edge of the frontals.

In lateral view (Figure 1A), the ventral surface of the diastema is slightly arched dorsally. The premaxillary–maxillary suture runs almost directly ventrally, just anterior to the anterior surface of the zygomatic arch (approximately 2 mm). The infraorbital foramen is small, slightly ovoid in outline, and oriented slightly obliquely (laterodorsal–medioventral). The long diameter ranges from 1.4 to 1.7 mm. The anterior end of the zygomatic arch is slightly arched dorsally with distinct ridges anteriorly and posteriorly for the attachment of the masseter muscle. Although the orbital wall is best preserved on CM 90504 (Figure 1C), it is badly fractured, so most sutures are difficult to discern. The frontal–maxillary suture extends posteroventrally from the anterodorsal edge of the orbital wall to near its center, then turn directly ventrally to the bottom of the orbital wall. The nasolacrimal foramen opens dorsally, and is positioned along the anterior margin of the orbital wall near its center–line, just dorsal to the posterior opening of the infraorbital foramen. There are numerous small foramina along the furrow at the base of the orbital

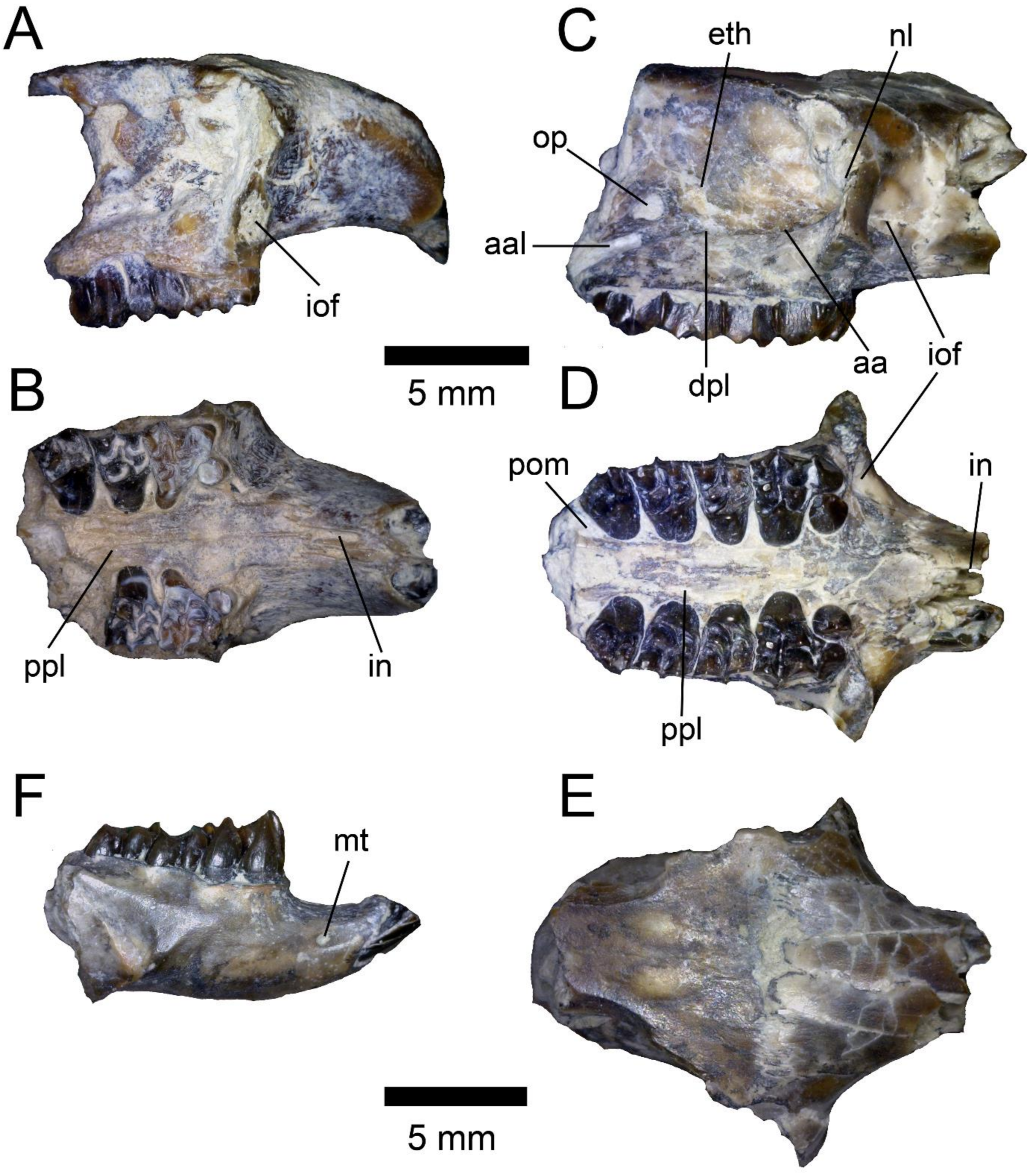

FIGURE 1. Crania and dentary of *Niglarodon brachyodon* from Mill Point, Montana. A, B, CM 75855. A, right lateral view. B, ventral view. C–E, CM 90504. C, right lateral view. D, ventral view. E, dorsal view. F, CM 90513, right dentary with i1, p4–m3, lateral view. Abbreviations for foramina: aa, anterior alveolar; aal, anterior alar fissure; dpl, dorsal palatine; eth, ethmoid; in, incisive; iof, infraorbital; mt, mental; nl, nasolacrimal; op, optic; pom, posterior maxillary; ppl, posterior palatine. Anterior to the right on all figures.

wall and the lateral extension of the maxilla. The most anterior, dorsal to the center of P4 is considered to be the anterior alveolar foramen. The optic foramen is approximately 1 mm in diameter, is dorsal to M3, and opens anteroventrally. Anterior and slightly ventral to it (dorsal to the boundary between M2 and M3) is an oval foramen that appears to be the sphenopalatine. No dorsal palatine foramen is recognized. The anterior alar fissure is deep and extends posteriorly from a point ventral to the optic foramen. Anterior and slightly dorsal to the optic foramen, near the center of the orbital wall, is a small opening that appears to be the ethmoid foramen.

Ventrally, the rostrum tapers anteriorly in the juvenile skull (CM 75855; Figure 1B). The length of the incisive foramen is 35% that of the upper diastema, shorter than in prosciurines, but well within the range for other aplodontoids (Wahlert, 1974). The maxillary–premaxillary suture crosses the ventral surface of the rostrum perpendicular to its long axis, crossing at the posterior margin of the incisive foramina. The ventral palatal surface is slightly concave upwards with a small ridge running anteroposteriorly along the central suture of the maxillae forming two shallow grooves on either side of the ridge. The posterior palatine foramina are medial to the boundary between M1 and M2, and anteroposteriorly elongated (length =approximately 1.6 mm). The maxillary–palatine suture is not distinguishable on any of the specimens. It evidently is not anterior to the posterior palatine foramina, but it cannot be determined where it crosses them. The posterior maxillary foramen (Figure 1D) is a small oval along the maxillary–palatine suture posterior to the center of M3 and not open laterally.

The upper incisor is longer than wide in cross–section. The anterior surface is smooth and gently convex with a shallow groove along the medial edge that runs the length of the tooth. Enamel extends only slightly onto the lateral side of the incisor.

DP3 is only present on one specimen, CM 75855 (Figure 2A). It is circular in occlusal outline, but is so heavily worn that no morphology other than shape can be observed. P3 averages slightly longer than wide but is wider in a few specimens and round to oval in occlusal outline (Figures 2C, D). The average width to length ratio (WLP3/) = 0.94. All specimens have a main, central cusp that is just labial to the center of the tooth. On most specimens, there is a low loph that extends anteriorly from the main cusp to the base of the crown (Figure 2D). All specimens have a more distinct loph running posteriorly from the apex of the cusp to the posterolabial base of the tooth, then curves lingually forming a small basin (Figure 2C).

DP4 is triangular in occlusal outline (Figure 2A), and markedly lower–crowned than P4 and the roots are widely splayed. The anterocone is smaller than the paracone and metacone and is crescentic in shape. A minute anterosyle is present just lingual to the anterocone on the anterior margin of the tooth. A distinct parastyle is posterior to the anterocone along the labial edge of the tooth between the anterocone and paracone. The buccal cusps (paracone, metacone) have concave labial margins and are continuous with one another along that margin. The mesostyle is anteroposteriorly compressed, but large and continuous with both of the labial cusps. The paracone is rectangular in shape and the protoloph is continuous from the posterolingual corner of the paracone to the posterolabial corner of the protoconule. The protoloph appears to be separated from the protocone and metaloph until very late stages of wear. The metacone is crescentic in outline, but does not fuse with the metaconule. The metaconule is rectangular in outline and oriented slightly obliquely (posterolingual–anterolabial). The anterior arm of the metaconule extends anterolabially but does not cross the central transverse valley of the tooth to fuse with the paracone or protoloph. The protocone is a thin crescent. A thin arm extends labially from the center of its labial side toward the center of the tooth, joining the anterolingual arm of the metaconule, completing the metaloph. The anterior cingulum runs lingually along the anterior margin of the tooth from the anterostyle to the anterolabial corner of the protocone. Similarly, the posterior cingulum extends along the entire posterior margin of the tooth from the posterolingual edge of the metacone to the posterolabial corner of the prototcone. There is no distinct hypocone on any of the specimens, but there is a wear facet on the posterolingual side of the protocone on CM 75855.

P4 is the largest of the upper cheek teeth (Table 1). Its anteroposterior length is always slightly less than its transverse width. The length of P4 averages 3.19 mm (range 2.85–3.39 mm), shorter than other species of *Niglarodon* for which the shortest length is 3.24 mm (Rensberger, 1981: fig. 10). The occlusal morphology is similar to that of dP4. The anterocone is at the anterolabial corner of the tooth and is large, rounded anteriorly and flattened posteriorly, and oriented slightly obliquely (anteroligual–posterolabial; Figures 2B–D). A parastyle is always present at the posterolabial corner of the anterocone. The arrangement of the major cusps is similar to that of dP4, but the crown is higher and the mesostyle is much more pronounced along the labial border of the tooth. There is no indication of a hypocone on any specimen. The anterostyle is continuous with the anterior cingulum lingually, but always separated from the anterocone labially except in extremely worn specimens. On less than half of the specimens, the anterior arm of the metaconule extends anterolabially, fusing with the paracone or protoloph, and bisceting the central transverse valley to form a cresentic posterolabial fossette (Figures 2B, C). On other specimens the anterior arm of the metaconule extends directly labially, joining the metacone at its anterolingual corner, leaving the central transverse valley undivided (Figure 2D). There are also some

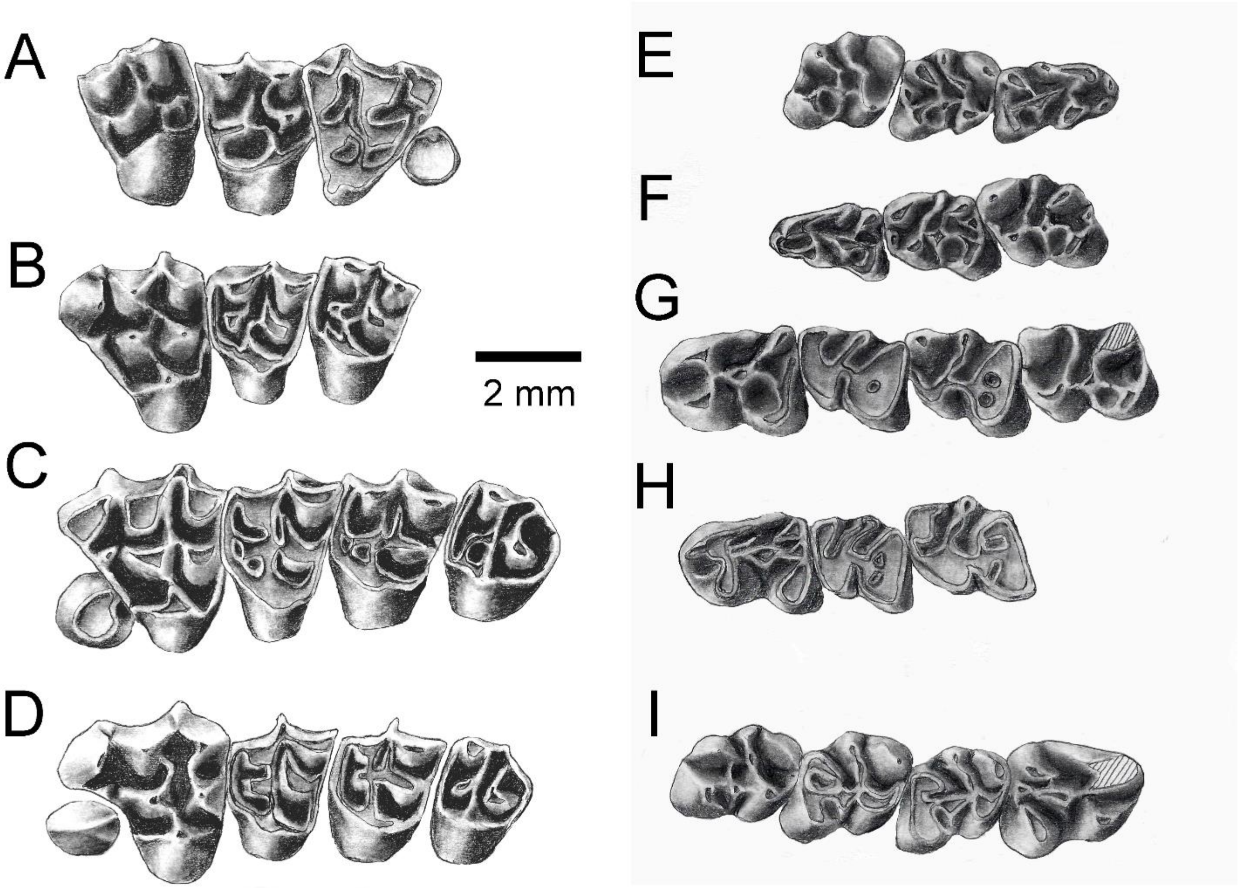

FIGURE 2. Cheek teeth of *Niglarodon brachyodon* from Mill Point, Montana. A, CM 75855, right dP3–M2. B, CM 75859, left P4–M3. C, CM 75857, left P3–M3. D, CM 90504, left P3–M3. E, CM 75878, right dp4–m2. F, CM 75868, right dp3–M2. G, CM 90510, right p4–m3. H, CM 75871, right p4–m2. I, CM 75879, right p4–m3. Anterior to the right on A, E, and I, to the left on all others.

specimens that have a very weak extension anteriorly from the metaconule that reaches the base of the protoconule, and will likely divide the central valley at late stages of wear. On approximately half of the specimens, the protoconule is elongated anteriorly and fuses, or nearly fuses with the anterostyle (Figures 2C, D). The posterolingual reentrant valley is blocked posteriorly by the posterior cingulum on approximately half of the specimens (Figure 2B), and remains open on the other half (Figure 2D). The average length to width ratio of P4 = 0.94 (range = 0.86–1.06), higher than most other species. The average height of the anterior enamel above the anterolabial inflection of P4 (HALP/) = 0.50 (range = 0.27–0.69), markedly lower than in any other species (Ransberger, 1981: fig. 8). The average difference in depth of the bases of the anterolingual and posterolingual inflections on P4 (DLIP/) = 0.07 (range 0.02–0.14), again, lower than in any other species of *Niglarodon* (Rensberger, 1981: fig. 8). However, the length of the ectoloph segment of P4 (ECPT/) averages 1.04 mm (range = 0.80–1.20 mm) far longer than any other species of *Niglarodon* (Rensberger, 1981: fig. 9).

M1 and M2 are nearly identical in size and morphology. The overall morphology is similar to that of P4, but lacking the enlarged anterocone (Figure 2). A minute parastyle is present at the anterolabial corner of the tooth, and the labial cusps (paracone, metacone) are concave labially and connected by a strong ectoloph with a large central mesostyle. An anterior arm of the metaconule extends labially, ending just short of the ectoloph. On some specimens it reaches the protoloph, dividing the central valley into two (Figure 2C). The anterolabial and anterolingual fossettes are nearly equal in depth, the labial being slightly deeper and more persistent. The posterolabial and posterolingual

TABLE 1. Dental measurements of *Niglarodon brachyodon* from Mill Point. Abbreviations: L, anteroposterior length; W, transverse width; N, number of specimens; M, mean; Min, minimum; Max, maximum; SD, standard deviation; CV, co–efficient of variation. Measurements in mm.

	dP3L	dP3W	dP4L	dP4W	P3L	P3W	P4L	P4W	M1L	M1W	M2L	M2W	M3L	M3W	P3–M3L	P4–M3L
N	2	2	2	4	11	11	19	20	27	26	22	22	9	9	4	5
M	1.04	1.01	2.43	2.71	1.34	1.26	3.19	3.39	1.93	2.89	1.96	2.80	1.85	2.27	9.53	9.38
Min	0.99	0.98	2.31	2.45	1.22	1.08	2.85	3.19	1.78	2.66	1.80	2.51	1.75	1.98	9.31	9.18
Max	1.09	1.04	2.54	2.94	1.56	1.50	3.39	3.60	2.16	3.26	2.14	3.13	1.95	2.41	9.82	9.61
SD	0.07	0.04	0.16	0.25	0.09	0.13	0.14	0.13	0.11	0.14	0.09	0.13	0.07	0.14	0.22	0.17
CD	6.80	4.20	6.71	9.18	6.49	10.00	4.42	3.71	5.82	4.74	4.72	4.77	3.82	6.39	2.32	1.76

	dp4L	dp4W	p4L	p4W	m1L	m1W	m2L	m2W	m3L	m3W	p4–m3L
N	2	2	17	17	27	27	28	28	11	11	6
M	2.36	1.54	2.75	2.15	1.90	1.84	2.03	1.89	2.29	1.77	9.42
Min	2.32	1.52	2.50	1.90	1.67	1.55	1.90	1.65	2.02	1.58	8.98
Max	2.40	1.56	3.03	2.42	2.14	2.04	2.14	2.16	2.49	1.96	9.81
SD	0.06	0.03	0.17	0.17	0.12	0.14	0.07	0.14	0.15	0.11	0.33
CV	2.40	1.84	6.01	7.91	6.13	7.63	3.57	7.60	6.43	6.30	3.50

fossettes are approximately equal in depth, elongated, and U–shaped. A minute protocone crest is present on some little–worn M2s (Figures 2B, C). On some M1s there is a slight swelling of the cingulum in this area. There is no hypocone on any of the upper molars. The length to width ratio of M1 averages 0.67 (range = 0.59–0.79), similar to that of *N. koerneri* and greater than other species (Rensberger, 1981: fig. 10).

M3 is similar in length to M1 and M2, but not as wide (Table 1). The anterior half of the tooth is similar to that of M1 and M2 (Figures 2C, D). The mesostyle and posterior half of the tooth are greatly reduced relative to the other molars and variable. In half of the specimens the metaconule is crescentic (U–shaped) and extends both labially and posteriorly, reaching the labial margin of the tooth, and variably reaching the posterior cingulum posteriorly. In the other half of the specimens, the metaconule is an anteroposteriorly oriented loph that connects the center of the protoloph to the center of the posterior cingulum. On one specimen, CM 90504, the left M3 has the U–shaped metaconule (Figure 2C), and the right M3 has the anteroposterior loph. Posterolabial and posterolingual fossettes are not open posteriorly as in other species; posterior cingulum is as high as, or only slightly lower than anterior cingulum.

The dentary is not very deep, averaging 4.58 mm ventral to m1 (Figure 1F). The diastema is shallow, dipping only slightly below the alveolar margin. The length of the diastema averages approximately half the total length of p4–m3. The masseteric scar extends anteriorly to below m1, ranging from the posterior margin to the anterior margin. The dorsal and ventral ridges fuse anteriorly in a V–shape with a short anterior extension at the junction of the ridges. The ridges unite at approximately mid–depth of the dentary, or slightly lower on some specimens. The mental foramen is small and positioned dorsal to the mid–line of the dentary and just posterior to the center of the diastema. A complete ascending ramus is not preserved on any specimen, but its anterior margin rises anteriorly even with the center of m3.

The lower incisor is gently convex anteriorly, and has a shallow groove on the anterior surface along the medial side of the tooth similar to I1. However, in cross–section, i1 is slightly wider relative to length than I1.

Dp4 is markedly lower–crowned then p4 or any of the molars, and more anteroposteriorly elongated than p4 (Figures 2E, F). There are two distinct anterior cuspules near the center of the anterior cingulid that bracket the anterior inflection anteriorly. The larger of the two is at the center of the anterior margin, the second is on the labial side of the tooth and more anteroposteriorly elongated. The metaconid and protoconid are closely spaced and the trigonid basin is closed posteriorly by a complete metalophid. The metastylid crest extends posteriorly along the lingual margin of the tooth for more than half its length, and ends posteriorly in a distinct mesostylid. The mesoconid is in the center of the tooth and triangular in shape. The ectolophid is continuous from the posterolabial corner of the metaconid, to the center of the posterior margin of the tooth. The lingual and labial inflections are broadly open to their respective sides of the tooth. The entoconid is obliquely compressed and oriented posterolingual–anterolabially. The hypoconid is anteroposteriorly compressed. A low, minute lophid extends anterolabially from the base of the entoconid and joins the mesoconid, isolating a small, shallow posterolingual fossettid.

The p4 is larger than m1, but smaller relative to m1 than in other species (Figures 2G–I). Length of p4 divided by length of m1 averages 1.45 for *N. brachyodon* (range = 1.30–1.60), in *N. koerneri* it is 1.63 (Black, 1961: 5), in *N. petersonensis* it is 1.82 (Nichols, 1976: table 2). The proportions of p4 (length vs. width) are also less than in other species (mean = 1.28; range 1.13–1.46). Among other species, p4 is the narrowest for *N. koerneri* which has a range of 1.4–1.5 (Rensberger, 1981). The anterior inflection is open on all specimens, unlike dp4 and typical of other species (Figures 2G–I). The metastylid crest is always present and a mesostylid is present on nearly half of the specimens. The posterolabial fossettid is generally open anteriorly, but the anterior opening is variable in width. The posterolabial fossettid is open to the base of the crown in all specimens of p4. In *N. koerneri* it ranges from the base of the crown to 0.4 mm above the base (mean approximately = 0.2 mm; HPIP of Rensberger, 1981: fig.5). All other features are similar to those of other species (see Black, 1961; Nichols, 1976; Rensberger, 1981).

The lower molars are similar in size to those of *N. koerneri*, and smaller than other species (Table 1). A distinct mesostylid is present on approximately two–thirds of the specimens. The length of the mesostylid crest and posterolingual inflection is variable; ranging from long (*Niglarodon*–like) to short (*Meniscomys*–like; Rensberger, 1981). The metastylid crest is poorly developed, but is generally oriented obliquely (posterolingual to anterolabial) as in *Meniscomys*, but is more anteroposteriorly oriented as in *Niglarodon* on approximately one–fourth of the specimens. A central fossettid at the labial end of the posterolingual inflection is present on approximately half of the specimens (Figure 2E). The height of the base of the anterolabial inflection (HAI1) is lower than in all other species (average = 0.47 mm; range = 0.31–0.61 mm); elsewhere it is lowest in *N. koerneri* with a range of 0.8–0.9 mm in length (Rensberger, 1981). On topotypic specimens of *N. brachyodon* the anterolabial inflection ranges from 0.4–0.5 mm. Similarly, the height of the anterior enamel chevron on m1 (CH1) is markedly lower (average = 0.11 mm; range = 0–0.28 mm) than in *N. koerneri* (range = 0.9–1.1 mm; Rensberger, 1981). On the few topotypic specimens of *N. brachyodon*, there is never an enamel chevron (CH1= 0). The posterolabial inflection on m3 is oriented anteroposteriorly on approximately half the specimens (*Niglarodon*–like) and oblique on half of the specimens (*Meniscomys*–like; Figs. 2G, I; see Rensberger, 1981, 1983).

Discussion.–The specimens of *Niglarodon* from Mill Point are referred to the Whitneyan *N. brachyodon* based on their smaller size, lesser development of enamel chevrons, inflections, and other features associated with increased crown–height. Although the molars of the Mill Point sample are similar to those of *N. koerneri* in size, the premolars are distinctly smaller (Table 1).

Overall, the morphologies of the cheek teeth of *N. brachyodon* are more primitive than other species of the genus in retaining features such as: 1) variable connection of the anterior arm of the metaconule on the upper molars (always with the paracone in other species); 2) the variable presence of a protocone crest on M2 (absent on all other species); 3) the posterior fossettes of M3 variably blocked posteriorly (open in all other species); 4) variable retention of the central fossettid on m2 (only elsewhere in *N. koerneri*); 5) and, variably larger mesostylid on the lower molars (reduced or absent in other species).

Korth (2009) cited a specimen from the early Arikareean of South Dakota that was originally referred to *N. koerneri* by Macdonald (1970), and suggested that it might be referable to *N. brachyodon*. Based on the smaller size of p4 and low enamel inflections on the teeth of this specimen compared to the larger Montana sample of *N. brachyodon*, it is more likely referable to the latter.

Taphonomy.—The large number of specimens of *Niglarodon* collected allows a suggestion as to whether a catastrophic or an attritional accumulation is represented, based on ontogenetic age distribution. In order to determine the ontogenetic age of the individuals of *Niglarodon*, the height of the protoconid on m1 was measured, then divided by the maximum width of the tooth, resulting in an index of age: the higher the index, the younger the individual. The resultant curve generated produces a survivorship curve which is useful in determining whether the fossil assemblage is the result of attritional or catastrophic death. This determination is based on the frequency of the different age groups of individuals: a large number of individuals at the later stages of wear combined with a minimal number of individuals with moderate wear suggests an attritional assemblage, whereas a large number of individuals with little to moderate wear combined with few individuals at late stages of wear would suggest a catastrophic death assemblage (Voorhies, 1969; Korth and Evander, 1986; Andrews, 1990; Korth et al., 2015).

The curve generated by the sample of *Niglarodon* from Mill Point strongly suggests an attritional assemblage due to very large number of individuals at the very latest stage of wear, and markedly fewer at early or moderate stages of wear (Figure 3). The lack of youngest individuals (which should be the greatest number in either situation) is not uncommon in fossil assemblages, most likely due to the fragility of the juvenile specimens, making them more susceptible to surface processes (Voorhies, 1969, Korth and Evander, 1986; Korth et al., 2015).

The source of the accumulation cannot be readily determined because the entire sample was surface–collected and the majority of the fractures and modifications to the bones are post-fossilization (vertical breaks; see Andrews, 1990: 22). The abundance of a single species can either indicate accumulation by a single predator, such as a barn owl, that predominantly preys on a single species (Andrews, 1990), or may reflect the actual rodent population in that area.

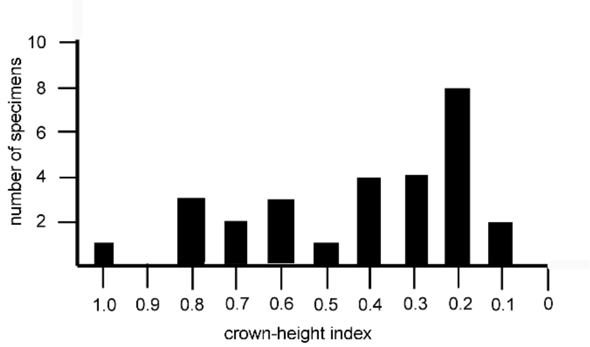

FIGURE 3. Age distribution of *Niglarodon brachyodon* from Mill Point, Montana. Horizontal axis (age) = height of protoconid/ maximum width of m1. Vertical axis = number of individuals.

Family Sciuridae Fischer de Waldheim, 1817
Nototamias Pratt and Morgan, 1989
Nototamias sp.
(Figure 4; Table 2)

Referred Specimen.–CM 75902, left dentary with i1 and p4–m3.

Description.–The anterior and posterior portions of the dentary are broken away (Figure 4B). The dentary is fairly deep (approximately 5 mm below m1). The masseteric scar is marked by a high, rounded ridge that forms a V–shape, ending anteriorly at mid–depth of the dentary below the posterior edge of p4. The diastema appears shallow, but its length cannot be determined. The mental foramen is small and circular in outline. It lies just below the posterior end of the diastema, less than a millimeter anterior to p4.

The lower incisor has a smooth anterior enamel surface, and in cross–section is rounded laterally and flattened medially. It is more than twice as long (1.94 mm) as wide in cross–section (0.86 mm).

All of the cheek teeth are partially broken (Figure 4A); the lingual edges are slightly to moderately chipped. The p4 is markedly wider posteriorly than anteriorly. Most of the enamel on the lingual side of the tooth is missing. The metaconid and protoconid are closely positioned, similar in size, and round in occlusal outline. The metaconid is slightly anterior to the protoconid. A small trigonid basin between the two cusps, and is closed anteriorly and posteriorly. The ectolophid consists of a small mesoconid that joins the protoconid and hypoconid and there is a minute lophid extending buccally from it. The posterolophid is continuous along the entire posterior margin of the tooth, and connects with both the hypoconid and entoconid.

The m1 is the most complete tooth, lacking only a small chip of enamel on the metaconid. The tooth is typically rhomboidal in occlusal outline, and slightly narrower anteriorly than posteriorly. The metaconid is more anterior than the protoconid and connected to it posteriorly via the metalophulid II, and anteriorly by the anterior cingulid, enclosing a small trigonid basin. A minute anteroconid is present anterior to the protoconid. As in the premolar, the ectolophid consists of a single, small mesoconid that connects to both the protoconid and hypoconid. The central basin of the tooth is broad and shallow with a smooth enamel surface. A distinct metastylid is present at the center of the lingual side of the tooth and is connected anteriorly to the posterior side of the metaconid by a minute lophid. There is a narrow valley separating the metastylid from the anterior edge of the entoconid. The entoconid is round in outline and continuous with a posterior cingulid that wraps round the posterior side of the tooth, joining the hypoconid at its buccal end. The hypoconid is anteroposteriorly compressed, and angled slightly anterobuccally–posterolingually.

The m2 is missing much of its lingual side (Figure 4A). In most features it is similar to m1. However, the posterior arm of the protoconid is shorter than in m1, leaving the small trigonid basin open posteriorly.

The m3 is the longest of the molars. As in m2, much of the lingual border of the tooth is missing. The anterior half of the tooth and the ectolophid are similar to that of m2, but the trigonid basin is much smaller. The hypoconid is larger than in m2 and the tooth is elongated posteriorly. The hypoconid is arcuate and continuous with the posterolophid that wraps around the posterior end of the tooth. The lingual cusps are completely missing.

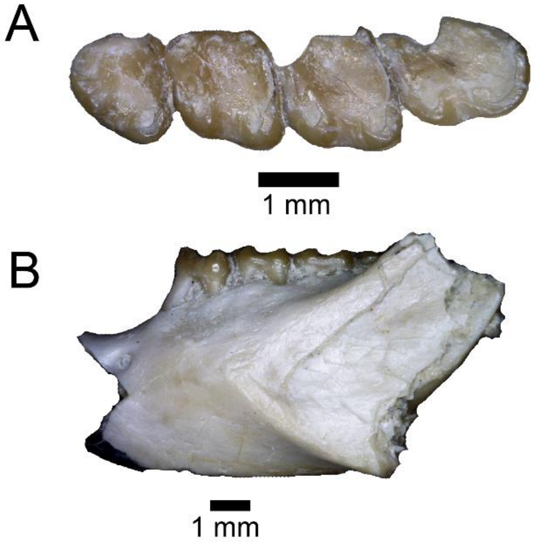

FIGURE 4. Lower cheek teeth and dentary of *Nototamias* sp., CM 75902, from Mill Point, Montana. A, p4–m3, occlusal view. B, lateral view of dentary. Anterior to the left. Different bar scales (below each figure).

Discussion.–In size and development of the entoconid, the Mill Point specimen most closely approaches that of the isolated specimens referred to "*Tamias* sp." by Macdonald (1963, 1970) and Black (1963) from the early Arikareean Sharps Formation (=Ar1, Tedford et al., 2004; Janis et al., 2008). The dental dimensions of CM 75902 (Table 2) are slightly larger than those of *Nototamias* sp. described from the late Whitneyan Blue Ash fauna (Korth, 2009: 52), and are compatible with those of the reported Arikareean specimens (Black 1963:134; Macdonald 1963:table 11).

Family Castoridae Hemprich, 1820
Palaeocastor Leidy, 1856
Palaeocastor wahlerti Korth, 2001
(Figure 5; Table 3)

Referred Specimens.–CM 86524, partial rostrum with both incisors; CM 75903, left P4; CM 72572, 75904–75908, 86525, M1 or M2; CM 72571, 75909, 75910, M3; CM 72570 and 75912, partial dentary with m1–m2; CM 75911, left dp4; CM 90517, left p4; CM 75913 and 95914, m2.

Description.–The rostral fragment (CM 86524) contains both incisors and some of the ventral surface of the rostrum. The maximum transverse width of the rostrum is 10.23 mm but the height cannot be accurately measured due to breakage. The only recognizable suture is the premaxillary–maxillary suture that extends nearly vertically down the sides of the rostrum and crosses the palatal surface perpendicular to it at the posterior end of the incisive foramina. The incisive foramina extend the length of most of the preserved area (length = 5.23 mm).

In cross–section, the upper incisors are approximately equal in length and width (Figure 5A; Table 3), with a flattened anterior enamel surface. The enamel extends only slightly onto the lateral and medial sides of the tooth.

The only P4 (CM 75903) is virtually unworn, approximately equal in width and length (Table 3), and three–rooted (Figure 5B). The lingual side of the tooth is slightly higher–crowned than the labial, and the occlusal surface is rectangular and slightly wider than long. There is no apparent wear facet on the anterior side of the tooth to indicate a P3, but there is a slight concavity. The mesostria extends approximately half the labial height of the tooth, and the hypostria extends nearly to the base. The occlusal surface is a complex pattern of fossettes. The mesoflexus extends lingually from the center of the labial surface for short distance where it is blocked by a short lophule extending anteriorly from the metalophid. Lingual to this, it bends slightly posteriorly near its lingual end. The hypoflexus is short, extending only slightly anterolabially. Of the complex of small fossettes on the occlusal surface, only four appear to be deep enough to be persistent: parafossette (anterior), mesofossette, and metafossette (posterior) on the labial half of the tooth, and an additional fossette in the anterolingual corner of the tooth.

Since the sample of upper molars only consists of isolated teeth, M1 cannot be distinguished from M2. In occlusal dimensions, these teeth are always slightly wider than long (Table 3). On the least–worn specimens (CM 75906, CM 75907), the mesoflexus remains open labially and extends lingually for more than half the width of the tooth, curving posteriorly at its lingual end, dividing the tooth into two (Figure 5C). The hypoflexus extends anterolabially from the center of the lingual side of the tooth, ending anterior to the lingual end of the mesoflexus. On the anterior half of the tooth, there are three fossettes. A smaller, transversely oval fossette at the anterolabial corner of the tooth, and two larger transversely oval fossettes, parallel to and just anterior to the mesoflexus. On CM 75906, these latter fossettes fuse. On the posterior half of the tooth, there are three fossettes: one in the posterolabial corner, one posterior to the lingual end of the mesoflexus, and a smaller one near the labial edge of the tooth, just posterior to the labial end of the mesoflexus. On one of the specimens (CM 75907) it opens anteriorly into the mesoflexus.

TABLE 2. Dental measurements of *Nototamias* sp., *Leidymys* cf. *blacki*, and *Geringia gloveri* from Mill Point. Abbreviations: L, anteroposterior length; W, transverse width; N, number of specimens; M, mean; Min, minimum; Max, maximum; SD, standard deviation; CV, co–efficient of variation. Measurements in mm.

Nototamias sp.	p4L	p4W	m1L	m1W	m2L	m2W	m3L	m3W	p4–m3L
CM 75902	1.32	1.42	1.30	1.51	1.42	1.59	1.60	–	5.86
Leidymys cf. *blacki*			M1L	M1W	M2L	M2W			
CM 75916			2.20	1.55	1.60	1.54			
CM 75917					1.47	1.58			
			m1L	m1W	m2L	m2W	m3L	m3W	m1–m3
CM 90514					1.72	1.48			
CM 75919			1.85	1.25					
CM 75918			1.85	1.26	1.77	1.36	1.75	1.32	5.63
Geringia gloveri			m1L	m1W	m2L	m2W	m3L	m3W	m1–m3
CM 72567			1.53	1.27	1.44	1.40	1.53	1.32	4.89

On more heavily worn specimens (CM 75905, CM 75908), the mesofossette is formed by the labial closure of the mesoflexus but the pattern of other fossettes and the hypoflexus is nearly the same as in the little–worn specimens (Figure 5D). There are always three fossettes on the posterior half of the tooth, and one or two on the anterior half, the most anterior (and smallest) being eliminated, and the more posterior fusing together. On the M1 or M2 with the greatest amount of wear (CM 86525), there are only three fossettes present; the mesofossette on the labial half is oriented anterolabial to posterolingual, the hypofossette is lingual and parallel to the former, and a small circular fossette is anterior and labial to the anterior end of the hypofossette.

M3 is the smallest of the upper molars and oval in occlusal outline (slightly wider than long). CM 72571 is completely unworn, suggesting that it had not yet erupted, CM 75909 has minimal to moderate wear (Figure 5E), and CM 75910 is heavily worn. On the unworn to little worn specimens, the mesoflexus and hypoflexus are as in the anterior molars. There are three distinct fossettes on the anterior half of the tooth and two smaller fossettes posterior to the mesoflexus. On the heavily worn tooth, only three fossettes remain, an oblique hypoflexus, a small, circular fossette near the center of the anterior margin of the tooth, and an oblique mesofossette on the labial half of the tooth.

The dp4 is represented by a single, partially broken specimen, CM 75911 (Figure 5F). The tooth is heavily worn, outlined with enamel, and preserves four small fossettids and a shallow hypoflexid. All four fossettids are small, transversely oriented ovals that are aligned in an anteroposterior line along the center–line of the tooth. The posterolingual corner of the tooth is broken away. The tooth is very low–crowned, but the hypoflexid remains open labially even at this late stage of wear. It is markedly smaller than the known p4 (Table 4).

The single, isolated p4 (CM 90517) is similar to the specimen of P4 in that it is virtually unworn (Figure 5G). It is slightly higher–crowned labilially than lingually. It is oval in occlusal outline, and the mesostriid extends ventrally approximately one–third the height of the crown at the center of the lingual side of the tooth. The hypostriid is nearly the full height of the crown on the center of the labial side of the tooth. The tooth is oval in occlusal outline and slightly wider posteriorly than anteriorly. The parafossettid is transversely oriented at the anterior end of the tooth, but does not open onto either of the lateral sides of the crown. Similarly, the hypofossettid is entirely enclosed and at the posterolingual corner of the tooth. The mesoflexid extends into the center of the tooth, where it appears to branch in several directions. The hypoflexid is only a slight indentation along the labial side of the occlusal surface.

Two fragmentary dentaries contain both m1 and m2 in early to moderate stages of wear (CM 72570, CM 75912). The two molars are approximately equal in size, rectangular in occlusal outline, and slightly wider than long (Figure 5H). The mesostriid extends ventrally for slightly more than half the height of the crown on the lingual side, and the hypostriid extends nearly to the

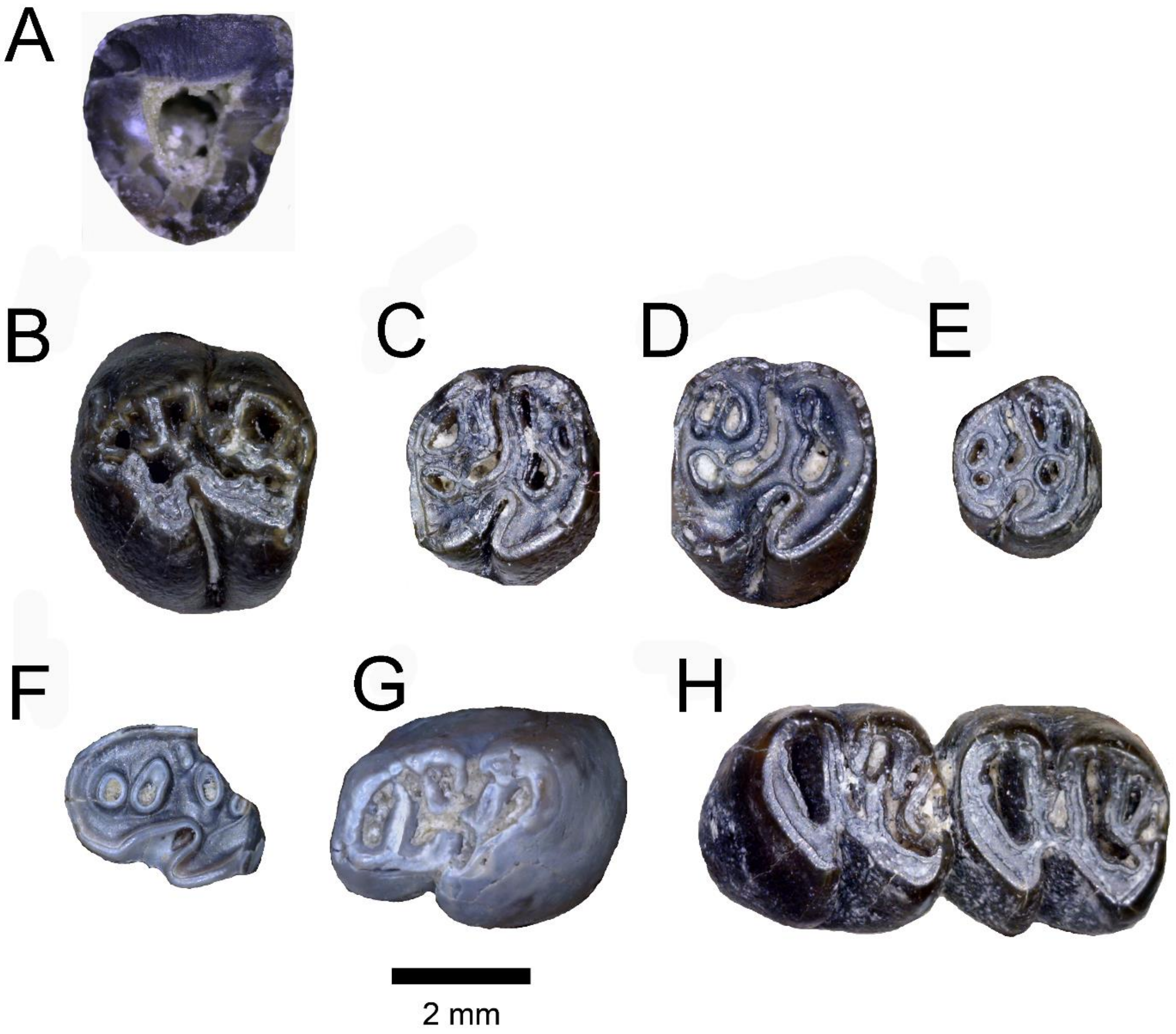

FIGURE 5. Occlusal view of teeth of *Palaeocastor wahlerti* from Mill Point, Montana. A, CM 86524, cross section of right I1. B, CM 75903, left P4. C, CM 75907, right M1 or M2. D, CM 75908, right M1 or M2. E, CM 75909, right M3. F, CM 75911, left dp4. G, CM 90517, right p4. H, CM 72570, right m1–m2. Anterior to top of page for figure A, the left on figures B, F, and G, to the right on all others.

base on the labial side, leaving the mesoflexid and hypoflexid open on both specimens. The parafossettid and metafossettid are transversely elongated and gently concave anteriorly. On all of the teeth there is a small fossettid just posterior to the anterior margin of the tooth and anterior to the parafossettid. On both molars of CM 72570, which are slightly less worn, there is an additional fossettid on the lingual side of the tooth between the parafossettid and the small anterior fossettid that is also present on an isolated molar, CM 75913. CM 75914 is a heavily–worn m1 or m2. Only the hypoflexid remains open and there are three small fossettids in the center of the tooth (para–, meso–, metafossettids). The central meso–fossettid is slightly transversely elongated and the other two are circular in outline.

Discussion.–In the morphologies of the cheek teeth, the Mill Point beaver most closely resembles *Palaeocastor wahlerti* from the Whitneyan of South Dakota (Korth, 2001, 2014). Most notable is the interrupted mesoflexus on P4 and the anteriorly flattened upper incisors. These are both considered diagnostic of the species (Korth, 2001). This is the first record of this species outside of South Dakota.

TABLE 3. Dental measurements of *Palaeocastor wahlerti* from Mill Point. Abbreviations: L, anteroposterior length; W, transverse width; N, number of specimens; M, mean; Min, minimum; Max, maximum; SD, standard deviation; CV, co–efficient of variation. *, indicates M1or M2 and m1 or m2. Measurements in mm.

	I1L	I1W	P4L	P4W	M1L*	M1W*	M3L	M3W
N	2	2	1	1	6	6	3	3
M	3.44	3.28	3.92	4.16	3.01	3.72	2.41	3.14
Min	3.34	3.21	–	–	2.69	3.08	2.37	2.74
Max	3.53	3.34	–	–	3.24	4.05	2.40	3.41
SD	–	–	–	–	0.20	0.40	0.02	0.09
CV	–	–	–	–	6.80	10.66	0.88	2.92

	dp4L	dp4W	p4L	p4W	m1L*	m1W*	m3L	m3W
N	1	0	1	1	4	4	2	2
M	3.24	–	4.35	3.60	3.26	3.53	3.19	3.61
Min	–	–	–	–	3.08	3.31	3.08	3.60
Max	–	–	–	–	3.46	3.76	3.30	3.61
SD	–	–	–	–	0.16	0.19	–	–
CV	–	–	–	–	4.90	5.45	–	–

Family Cricetidae Fischer de Waldheim, 1817

Leidymys Wood, 1936

Leidymys sp., cf. *L. blacki* (Macdonald, 1963)

(Figs. 6A–C, Table 2)

Referred Specimens.–CM 75916 right maxilla with M1–M2; CM 75917, maxillary fragment with right M2; CM 75918, right dentary with incisor and m1–m3; CM 75919 right m1; CM 90514, right m2.

Description.–The sample of *Leidymys* from Mill Point does not differ morphologically from that previously described for *L. blacki* (see Macdonald, 1963; Martin, 1980; Korth, 2010).

Discussion.–In dimensions of the cheek teeth, the Mill Point sample is nearly identical to the sample referred to *L.* cf. *blacki* from the late Whitneyan Blue Ash fauna of South Dakota (Korth, 2010: table 4; Table 2, this paper) and slightly smaller than the type and referred material of *L. blacki* from the Arikareean (Macdonald, 1963: 99, 1970: table 32). The size difference between these latter fossil populations is not statistically distinct, due to lack of specimens from the Arikareean. However, the Mill Point specimens more closely approach the size of the Whitneyan sample and are smaller than the type material of *L. blacki* (Macdonald, 1963: 99).

Geringia Martin, 1980

Geringia gloveri (Macdonald, 1970)

(Figure 6D–E; Table 2)

Eumys gloveri Macdonald, 1970
Geringia gloveri (Macdonald) Martin, 1980

Referred Specimen.–CM 72567, right dentary with i1, m1–m3.

Description.–The dentary is relatively deep for the size of the molars (3.65 mm below m1). The masseteric scar has prominent dorsal and ventral ridges that meet in a V–shape (dorsal ridge partially broken away) below the posterior root of m1 at mid–depth of the dentary (Figure 6E). The posterior half of the mental foramen is positioned below the anterior root of m1 just anterior to the junction of the dorsal and ventral ridges of the masseteric scar. The incisor is approximately as wide as long in cross–section (1.40 mm length; 1.12mm width). The anterior enamel surface of the incisor is gently convex with a single, central ridge that runs the length of the tooth.

The molars are heavily worn, but the occlusal pattern can be, for the most part, determined (Figure 6D). The m1 and m3 are approximately the same width and length, and m2 is shorter but wider than the other two molars. The m1 tapers anteriorly in occlusal view. There does not appear to be a distinct anteroconid. The metaconid is a large wear fossettid at the anterolingual side of the tooth that extends labially across the anterior side of the tooth, ending labially just anterior to the protoconid. Posterior to the metaconid on the lingual side of the tooth is a round wear fossette (=metastylid). The protoconid is small and the posterior arm extends lingually, fusing with the posterior edge of the metaconid fossette. The ectolophid (=mure) extends posterolingually from the protoconid across the tooth. There is a very short mesolophid extending lingually from its center. The entoconid is a transversely elongated fossette that joins the ectolophid at its posterior end. The hypoconid is crescentic in shape. The ectolophid attaches to the center of the anterior edge of the hypoconid wear fossette, just posterior to the junction of the hypolophid. The posterolophid wraps around the posterior end of the tooth, ending at the entoconid.

The m2 is nearly square in outline (Figure 6D). The occlusal pattern is dominated by three enamel fossettids, aligned anteroposteriorly along the centerline of the tooth separating the metalophid, mesolophid, and hypolophid. There is a small emargination in the anterolabial corner of the tooth, indicating the separation of a short anterior cingulid with the anterior margin of the protoconid. The ectolophid extends posterolingually across the tooth, as in m1. The posterior half of m2 is the same as in m1.

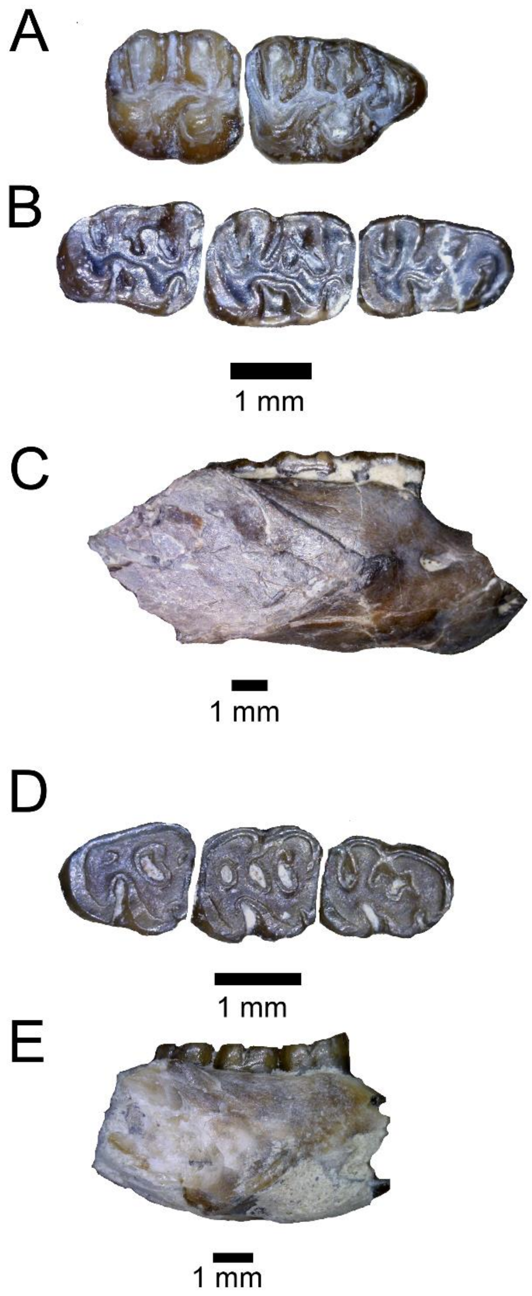

FIGURE 6. Molars and dentaries of cricetid rodents from Mill Point, Montana. A–C, *Leidymys* cf. *blacki*. A, CM 75916, right M1–M2. B, C, CM 75918. B, occlusal view of right m1–m3. C, lateral view of dentary. D, E, *Geringia gloveri*, CM 72567. D, occlusal view of m1–m3. E, lateral view of dentary. Anterior to right on all figures. Teeth and dentaries to different scales (below each figure).

The m3 tapers posteriorly, having a much wider metalophid. There are two enamel fossettids; a gently curved anterior fossettid and a minute posterior one (Figure 6E). It appears that the anterior cingulid was unattached at both its lingual and labial ends. The cusps of the hypolophid are greatly reduced relative to the anterior molars.

Discussion.–The size and morphology of the molars and the central ridge on the incisor on CM 72567 are the same as in the holotype of *G. gloveri* from the Wounded Knee fauna of South Dakota (Macdonald, 1970). Although the Mill Point specimen is heavily worn, it is evident that the lateral sides of the molars are vertical, implying that the teeth are at least mesodont in height, characteristic of the genus (Martin, 1980; Lindsay, 2008).

Eumys gloveri was originally reported from the Monroe Creek Formation of South Dakota (=Ar3; Janis et al., 2008) based on a single dentary with incisor and m1–m2 (LACM 15434) by Macdonald (1970). In the same publication, Macdonald (1970) named *Paciculus mcgregori* from the earlier Sharps Formation (=Ar1; Janis et al., 2008). Martin (1980) referred both species to a new genus *Geringia*, noting that the only difference between the species was size and questioned whether they might be synonymous (Martin, 1980: 30). Later, Williams and Storer (1998) referred specimens from the Kealey Springs fauna of Saskatchewan (=Ar2; Janis et al., 2008) to *G. gloveri* but noted that the two known species were likely synonyms because they were differentiated only by size (Martin, 1980) and the dental dimensions of their sample overlapped those of both species.

Based on measurements taken from Martin (1980: figs. 17, 18) the molars of *G. mcgregori* are larger than those of the holotype of *G. gloveri* (Macdonald, 1970: table 34). The measurements given by Williams and Storer (1998: table 4) are closer to those of *G. gloveri* with the exception of the single M1 which is the largest of any specimen cited or figured of either species elsewhere. Due to its late stage of wear (Williams and Storer, 1998: fig. 1R), this tooth may not be referable to this species. The Mill Point specimen most closely matches the holotype of *G. gloveri* and is thus referred to this species. Additional referred material from the Monroe Creek Formation will be necessary to determine whether the size ranges of the two proposed species from the two different horizons are truly distinct or overlap enough to be synonymized.

The Mill Point specimen cannot be referred to the Whitneyan *G. copiosus* Korth, 2010, because the m2 is approximately equal in length and width (longer than wide in *G. copiosus*) and the m3 is longer than m2 (m2 longer than m3 in *G. copiosus*).

CONCLUSIONS

Although the age of the Mill Point fauna was originally suggested as early Arikareean based on tentatively identified mammal species (=?Ar2; Tabrum et al., 2001; Janis, 2008), it appears to be either latest Whitneyan or at the Whitneyan–Arikareean boundary. Three of the rodents recognized here, *Niglarodon brachyodon*, *Palaeocastor wahlerti*, and *Leidymy*s cf. *blacki* have only been reported previously from the late Whitneyan (Korth, 2001, 2009, 2010). However, *Geringia gloveri* is known only from the early Arikareean (Macdonald, 1963, 1970), and the specimen of *Nototamias* from Mill Point is closest to *Nototamias* sp. reported from the early Arikareean (=*Tamias* of Black, 1963; Macdonald, 1963, 1970). Since the locality from which these specimens were collected is limited in exposure, and not contiguous with a formation of known age (Tabrum et al., 2001), it is possible that it is older than other deposits in the area. At present, it appears that the fauna, based on the rodent species, is latest Whitneyan or very near the Whitneyan/Arikareean boundary. A detailed analysis of the remaining fauna is necessary for a more accurate age determination.

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