Paludicola 8(2):75-90 March 2011

RODENTS FROM THE CHADRONIAN (LATEST EOCENE) MEDICINE POLE HILLS LOCAL FAUNA, NORTH DAKOTA. PART 1. EUTYPOMYIDAE, CYLINDRODONTIDAE AND *PIPESTONEOMYS*

Allen J. Kihm

Department of Geosciences, Minot State University, 500 University Ave W,
Minot, ND 58707 <allen.kihm@minotstateu.edu>

ABSTRACT

The Medicine Pole Hills local fauna is a large Chadronian fauna composed of more than 4600 mammal specimens, mostly isolated teeth, derived from a limited sequence of mudball conglomerates and sandstones. The producing layer probably represents an early stage of deposition of the Chadron Formation in North Dakota, but it may not be related to any of the named members of the formation. The material described includes *Eutypomys parvus*, *Cylindrodon collinus*, *Pseudocylindrodon neglectus*, *Ardynomys saskatchewensis* and *Pipestoneomys* sp. The samples of *E. parvus* and *A. saskatchewensis* include teeth not previously described for these taxa. The assemblage has the greatest commonality to the middle Chadronian Calf Creek local fauna of southern Saskatchewan. This similarity does not necessarily indicate a middle Chadronian age for the Medicine Pole Hills local fauna. The lack of late early Chadronian localities with large samples of rodents may exaggerate the apparent differences between these faunas and the Medicine Pole Hills sample. The Calf Creek and Medicine Pole Hills local faunas may represent an intermediate stage between the McCarty's Mountain and Pipestone Springs faunas of Montana. The Medicine Pole Hills fauna may be somewhat older than the Calf Creek local fauna based on the occurrence of *Leptomeryx yoderi*.

INTRODUCTION

This is the third in a series of papers that describe the mammals of the Medicine Pole Hills local fauna of southwestern North Dakota. Previous papers have dealt with the multituberculates (Schumaker and Kihm, 2006) and soricids (Kihm and Schumaker, 2008). In relationship to the rest of the fauna, rodents comprise about 60% of the more than 4600 mammal specimens, most of which are isolated teeth. The most common rodents are the eomyids, totaling more than 2300 specimens and about 50% of the total mammal specimens. The three rodent groups described in this study represent about 4% of the total mammal specimens.

Background—The Medicine Pole Hills local fauna specimens in this study come from a single quarry, Pioneer Trails Regional Museum (PTRM) Locality V89002, in Bowman County, North Dakota. The quarry sample was taken from a series of mudball conglomerate and sandstone units (see Schumaker and Kihm 2006, for details) totaling approximately 5.5m in total thickness. These lie unconformably on the late Paleocene Tongue River Formation and are not overlain by any other geologic unit in any of the known exposures. The beds have been correlated with the Chalky Buttes Member of the Chadron Formation (Murphy et al., 1993), but continuing studies of the geology, particularly the heavy minerals, suggest this correlation is poorly supported (Webster and Kihm, 2009). The unit producing the fossils probably belongs within the Chadron Formation, but its correlation to, or stratigraphic relationship with the Chalky Buttes Member is yet to be determined.

The specimens described in this study were collected by dry and wet screening over a number of years. The initial sample was collected between 1989 and 1993 by personnel of the PTRM through surface collecting and dry screening an undetermined amount of matrix from the most surficial units. This collection includes approximately 1500 mammal specimens. Stratigraphically controlled samples were taken in 2004 from a trench cut down to the base of the unit. Seven samples totaled 3.1 tonnes of matrix and produced approximately 1100 mammal specimens. The specimens recovered from each of the sampled intervals were compared and no faunal distinction was noted between the lowest and highest units, although the samples did vary in abundance of fossils. As there was no evidence of a faunal distinction between the sampled intervals, a portion of the spoil pile associated with digging the trench was processed in 2006. From the 4.4 tonnes processed, approximately 2000 mammal specimens were recovered.

At a minimum, 7.5 tonnes of fossiliferous matrix were processed using 0.84mm screens. More than 50% of the more than 4600 mammal specimens were recovered from the smallest screened interval (0.84-1.4 mm). The only collections of Chadronian material of comparable magnitude are the Raben Ranch local fauna (Ostrander, 1980) with 4462 specimens, the Calf Creek local fauna with approximately 7000 specimens (J. Storer, pers. comm. 2005), the Flagstaff Rim sequence of faunas with very approximately 10,000 specimens (R. Emry, pers. comm. 2008) and the Pipestone Springs local fauna which is represented by several hundreds of specimens in each of several major museums (Carnegie Museum of Natural History, US National Museum, American Museum of Natural History, Field Museum of Natural History, among others).

TABLE 1. Abbreviations used in this paper

Museums	
PTRM	Pioneer Trails Regional Museum, Bowman, North Dakota
CM	Carnegie Museum of Natural History, Pittsburgh, Pennsylvania
CMN	Canadian Museum of Nature, Ottawa, Ontario
RSM	Royal Saskatchewan Museum, Regina, Saskatchewan
ROM	Royal Ontario Museum, Toronto, Ontario
Measurements	
n	number of specimens
OR	observed range
AP	Anteroposterior length
W	Width, maximum
Wa	Width anterior
Wp	Width posterior
Teeth (subscript = lower tooth, superscript = upper tooth)	
P	Premolar
D	Deciduous
M	Molar
R, L	Right, Left

Abbreviations used are given in Table 1. All measurements are given in millimeters unless otherwise indicated. The classification of rodents follows Korth (1994) and tooth nomenclature is based on Wood and Wilson (1936).

SYSTEMATIC PALEONTOLOGY

Family Eutypomyidae Miller and Gidley 1918
Genus *Eutypomys* Matthew 1905
Eutypomys parvus Lambe 1908
(Figure 1, Table 2)

Referred Specimens—all PTRM: RDP^4 8338; LDP^4 1398, 4866, 6100, 7924, 10967; RP^4 10417, 10973; LP^4 4900, 10997; RM$^{1 \text{ or } 2}$ 1364, 1955, 7290, 7715, 8323, 10966, 10971, 10980, 10986, 10989, 10991, 10992, 10993; LM$^{1 \text{ or } 2}$ 1327, 2098, 7292, 8006, 10985; RM^3 10969, 10987; LM^3 6275, 7935, 10968, 10979, 10990; RDP$_4$ 7425, 7949, 10982, 10983, 10994, 16012; LDP$_4$ 11013; RP$_4$ 5028, 10965; LP$_4$ 6150, 10972, 10975, 10996; RM$_{1 \text{ or } 2}$ 1488, 2629, 5022, 5029, 5105, 6158, 6206, 7291, 7943, 10970, 10976, 10978, 10981, 10988, 11019; LM$_{1 \text{ or } 2}$ 2012, 6126, 7397, 7712, 8319, 10995, 11004; RM$_3$ 1397, 5095, 10977; LM$_3$ 5027, 5032.

Description—The DP^4 (Fig. 1F) is similar to the P^4 (Fig. 1G) with three notable differences. The DP^4 is smaller than the P^4, the anterocone is more widely separated from the protoloph expanding the anterobuccal portion of the tooth, and the protocone/hypocone are more widely separated from the paracone/metacone. As noted by Storer (1978), the P^4 of *E. parvus* is similar to that of *E. thomsoni*, but the tooth does show distinctions. The anterior cingulum is connected to the protoloph at about the midline of the tooth and continues as a strong loph to the anterobuccal corner of the tooth, often ending in a large oval anterocone which is not connected to the paracone. This creates an expanded anterobuccal corner for the tooth, a feature which can be seen on ROM 6314, a specimen figured by Russell (1972, Figure 9I) which he identified as a RM$^{1 \text{or } 2}$, but which is actually a left P^4. This is in contrast to the condition described by Wood (1937) for *E. thomsoni* where the anterior cingulum connects to the protoloph near the paracone and extends both lingually towards the protocone and buccally to the anterobuccal corner of the tooth. However, it is not known how consistent this connection is in specimens of *E. thomsoni*.

The protoloph and metaloph are complete in all specimens. The mure is typically diagonal with the connection to the protocone on the buccal or posterobuccal corner of the cusp. From there, the mure trends buccally then bends posterolingually to the hypocone. In some specimens, there are constrictions on the mure and in PTRM 8338 (a DP^4) the mure does not connect to the protocone. The mesoloph is variable, typically reaching the buccal margin of the tooth, but the mesoloph may also be paired (PTRM 10973). The posterior cingulum descends from the hypocone and ends near the posterior face of the

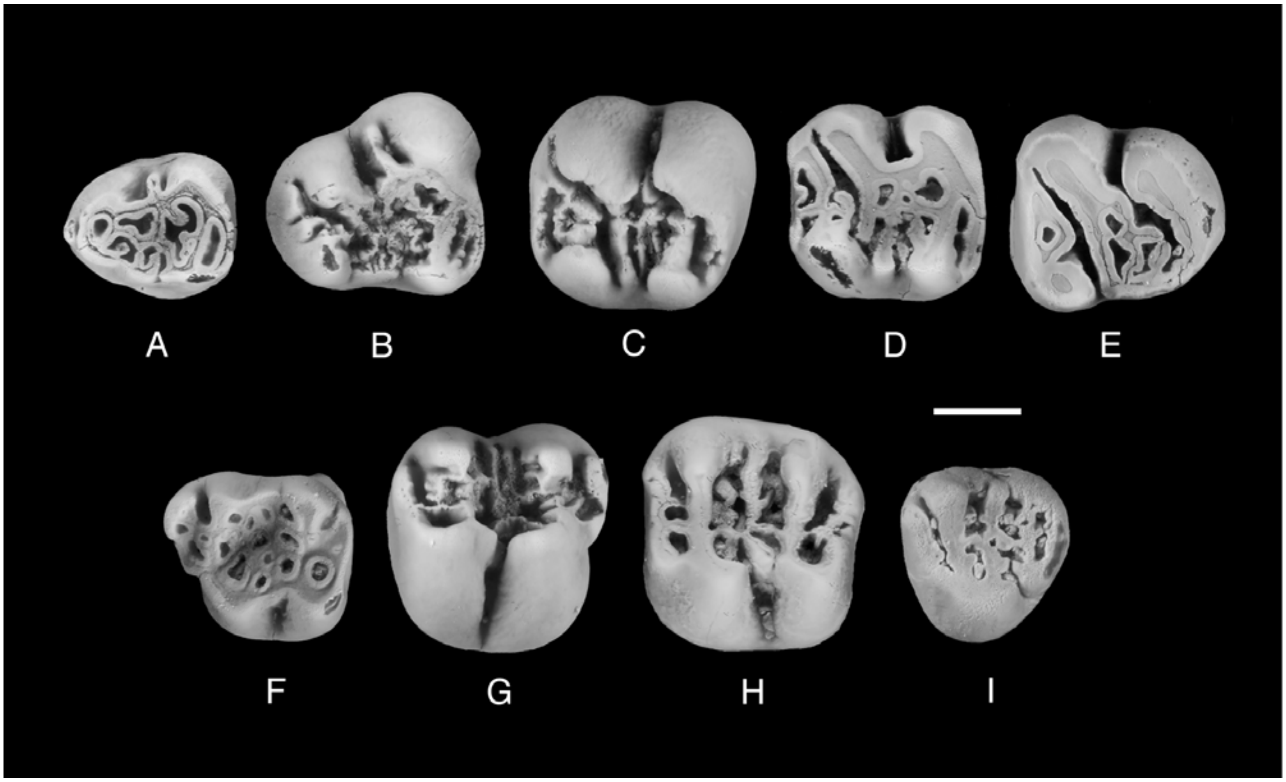

FIGURE 1. *Eutypomys parvus* from the Medicine Pole Hills local fauna. A, PTRM 16012 RDP_4; B, PTRM 5028 RP_4; C, PTRM 10978 R$M_{1 \text{ or } 2}$; D, PTRM 7291 R$M_{1 \text{ or } 2}$; E, PTRM 1397 RM_3; F, PTRM 4866 LDP^4; G, PTRM 10417 RP^4; H, PTRM 10985 L$M^{1 \text{ or } 2}$; I, PTRM 10990 LM^3. Buccal is up and the bar scale represents approximately 1 mm.

metacone, but does not attach to that cusp, leaving at least a portion of the posterior valley open buccally. The posterior cingulum is close to the metaloph as in *E. thomsoni*. The mesostyle is variable, distinct in some specimens, not developed in others. The number and positions of accessory lophules from the protoloph, metaloph, mesoloph, anterior and posterior cingula are variable.

The M^1 and M^2 specimens are generally similar to the P^4 except that the anterior cingulum attaches more lingually, either to the protocone or to the protoloph just buccal to the protocone (Fig. 1H), and the anterior cingulum parallels the protoloph, but does not merge with it until very worn. None of the specimens show the development of a parastyle. The mure is typically complete forming a posterolingual loph to the hypocone, but in some specimens the connection to the protocone is either weak, or the mure attaches to the protoloph (PTRM 1327, 10991) which allows the lingual valley to extend towards center of the tooth. The metaloph is complete on all specimens and the posterior cingulum parallels the metaloph but does not attach to the metacone until a late stage of wear.

The M^3 of *E. parvus* (Fig. 1I) has not previously been described. The tallest cusp is the paracone. The anterior cingulum is complete from the protocone to the paracone and unlike the more anterior teeth, it attaches to the paracone at the anterobuccal corner of the tooth. The protoloph is complete, the hypocone is variable, but typically is reduced. The posterior cingulum extends from the hypocone, or from the protocone if the hypocone is indistinct, to the buccal margin of the tooth. The metacone is very reduced. In PTRM 10969 it is a distinct cusp, in 6275 it is indistinct, but the mesostyle is enlarged and forms an elongate ridge, and in 10979, the mesostyle is either paired, or the more posterior cusp is the metacone (although it is not attached to the metaloph). The mesoloph is variable. The metaloph typically reaches the buccal margin of the tooth, but makes a weak connection in some specimens (PTRM 6275, 7425) to the posterior cingulum.

In the lower dentition, smaller premolar specimens are interpreted as DP_4, the larger as P_4. RSM P1585.491 described by Storer (1978) as a P_4 is likely a DP_4 based on its small size and diverging roots. The permanent P_4 specimens in the Medicine Pole Hills collection have parallel roots. The protoconid and metaconid of the DP_4 are reduced (Fig. 1A), in some specimens they are separated at the apices and a small trigonid basin is present (PTRM 10983, 10994, 16012), in others the cusps are separated only by a minor groove. The ectolophid is complete in all specimens. The mesoconid is variable, in PTRM 16012 it is a distinct cusp with a buccad extension. In other specimens the mesoconid is less distinct and the buccad extension is absent. The mesolophid is variable, bifurcating or trifurcating with accessory ridges to the metalophulid II, lingual margin or hypolophid. The hypolophid is complete on all specimens as is the posterior cingulum. On some specimens the posterior cingulum is attached to the hypocone, in others it attaches to the hypolophid near the midline of the tooth. The metastylid is typically developed and nearly closes the talonid basin lingually.

TABLE 2. Measurements of *Eutypomys parvus* teeth.

Tooth Position		n	Mean	OR
DP^4	AP	5	2.50	2.39-2.68
	Wa	6	2.26	2.13-2.42
	Wp	6	2.30	2.20-2.49
P^4	AP	4	2.64	2.39-2.84
	Wa	4	2.66	2.58-2.84
	Wp	4	2.56	2.42-2.67
$M^{1\text{ or }2}$	AP	18	2.63	2.31-3.06
	Wa	17	2.98	2.67-3.45
	Wp	15	2.90	2.67-3.33
M^3	AP	7	2.20	2.00-2.52
	Wa	7	2.31	2.23-2.47
DP_4	AP	7	2.15	2.10-2.26
	Wa	7	1.44	1.32-1.58
	Wp	7	1.74	1.58-1.84
P_4	AP	5	2.71	2.62-2.81
	Wa	5	1.78	1.65-1.91
	Wp	6	2.40	2.23-2.55
$M_{1\text{or }2}$	AP	18	2.56	2.29-2.88
	Wa	17	2.57	2.13-2.88
	Wp	18	2.60	2.23-2.94
M_3	AP	5	2.71	2.52-2.88
	Wa	5	2.45	2.33-2.65
	Wp	5	2.08	1.91-2.26

The P_4 is similar to the DP_4, but significantly larger (Fig. 1B). The only noted differences are that the metaconid and paraconid are taller than the talonid portion of the tooth and the mesoconid is more typically developed and it often has a buccad extension.

The M_1 and M_2 (Figs. 1C,D) show the same level of variability as the DP_4 and P_4. The metaconid is the tallest cusp, with the entoconid a bit shorter. The protoconid is not connected to the metaconid by any loph until very late stages of wear, and this connection occurs initially at the lingual or buccal margins of the tooth. A valley extends from the anterobuccal corner of the tooth obliquely across the tooth to the metastylid. The protoconid is connected to the metastylid by a ridge (metalophulid II) on most specimens. On a few specimens (such as PTRM 7291), this ridge connects to the posterior face of the metaconid and on a few specimens it connects to the mesolophid. The ectolophid is complete in all specimens except PTRM 5022 on which a narrow fissure occurs near the midpoint. On all other specimens, the buccal valley does not extend into the talonid basin. The hypolophid and posterior cingulum are complete in all specimens. The M_3 is similar to the anterior molars (Fig 1E), the only noted difference is that the ectolophid is incomplete in two of five specimens, although the gaps in the ectoloph are narrow. In PTRM 5027, the mesoconid is separated by narrow notches both anteriorly and posteriorly. In PTRM 10977, the hypolophid does not reach the entoconid.

Discussion—The collection from the Medicine Pole Hills represents the largest sample of teeth of *E. parvus*. The species was described by Lambe (1908) based upon a single P_4 from the Chadronian of the Cypress Hills Formation. Russell (1972) described five additional specimens and Storer (1978) added six more, all isolated teeth, from the same formation. The Medicine Pole Hills sample includes 75 isolated teeth, including several tooth positions that have not been previously represented.

E. parvus is smaller than *E. thomsoni* (Matthew, 1905). Based upon measurements of *E. thomsoni* given by Wood (1937), comparable tooth dimensions are 19%-50% larger than *E. parvus* specimens from the Medicine Pole Hills. The upper dentitions of these two species are generally similar in morphology. In the lower molars the primary difference is seen in the connection between the metalophulid I and the metalophulid II. In *E. thomsoni*, the metalophulid I connects to the ectolophid, metalophulid II, or mesolophid by a cross loph near the midline of the tooth and the valley beginning at the anterobuccal corner of the tooth does not reach across the tooth to the lingual border of the tooth. In *E. parvus*, there is no connection between the metalophulid I and the metalophulid II until very late stages of wear. The protoconid is typically connected to the metastylid, so the valley extends across the entire tooth (or to the internal margin if the metastylid is enlarged).

Eutypomys inexpectatus (Wood, 1974) is larger than *E. parvus*, being comparable in size to *E. thomsoni*. The lower dentition is similar to *E. parvus* in having a valley separating the protoconid and metalophulid II from the metaconid and melatlophulid I, but this valley opens on the lingual face of the lower molars rather than on the anterolingual corner as in *E. parvus*. In addition, the basin between the anterior cingulum and the metalophulid I opens posteriorly, a condition not seen in *E. parvus*.

E. parvus differs from *E. obliquidens* (Storer, 1988) in having somewhat larger molars (2%-17%). In *E. obliquidens*, both the valley between the protoconid and metalophulid I and the valley between the protoconid and hypoconid extend across the entire tooth to the lingual margin. In *E. parvus*, the buccal valley between the protoconid and hypoconid ends at the ectolophid, which is almost always connected to the hypocone. If there is a gap in the ectolophid, it is narrow, unlike the wide valley seen in *E. obliquidens*.

E. parvus appears to be intermediate between *E. obliquidens* and *E. thomsoni* in several features. *E. parvus* is intermediate in size between these species. *E. obliquidens* has both the anterior and posterior lingual valleys extend across the lower molars, *E. parvus* has only the anterior valley and *E. thomsoni* has neither of the valleys extend across the tooth. Finally, *E. parvus* is intermediate in age between the Duchesnean *E. obliquidens* and the Orellan *E. thomsoni*. The only record of *E. thomsoni* from the Chadronian is from Clark (1937) who reported two teeth which he compared to *E. thomsoni*, but which he later reported could not be found (Clark and Beerbower, 1967).

Ostrander (1980) suggested that the eutypomyid material from the Raben Ranch local fauna represented a new species, which he did not name. The Raben Ranch sample included only two upper and two lower molars. The upper molar he described has features duplicated by several of the Medicine Pole Hills specimens, although perhaps not all on the same specimen. The mure connects the hypocone to the protoloph in PTRM 1327 and 10991 and the cross loph connecting the paracone to the metaloph is absent in some specimens (PTRM 10993), partial in others (PTRM 7292) and complete in others (PTRM 8006). The single M$_{1\text{ or }2}$ which Ostrander (1980) described has the characteristic separation of the protoconid from the metaconid by the oblique valley typical of *E. parvus*. The only feature which appears to distinguish the Raben Ranch species from *E. parvus* in the Medicine Pole Hills sample is the smaller size of the Raben Ranch teeth.

Family Cylindrodontidae Miller and Gidley 1918
Genus *Cylindrodon* Douglass 1902
Cylindrodon collinus Russell 1972
(Figure 2, Tables 3-4a-e)

Referred Specimens—all PTRM; RDP^4 7722; LDP^4 5915, 6229, 11002, 11012, 14606; LP^4 8336, 10999; RM$^{1\text{ or }2}$ 4988, 5023, 7455, 7719, 8324, 8335 (cf), 10299, 10398, 11006, 11027, 11028, 11030; LM$^{1\text{ or }2}$ 2615, 5103, 5907, 7294, 7479, 7723, 8000, 8007, 10952, 10998, 11009, 11011, 11015, 11032; RM^3 11010, 11014; LM^3 5017, 7391; LDP$_4$ 10301, 10936; RP$_4$ 7718, 7946; LP$_4$ 1399, 2047 (cf), 7710, 11005, 11025; RM$_{1\text{ or }2}$ 7660, 10300, 11003, 11008, 11016, 11017, 11018; LM$_{1\text{ or }2}$ 2587, 5021, 5024, 5098, 5911, 7711, 7923, 7934, 8320, 10935, 11000, 11029; RM$_3$ 5529, 5899, 7938; LM$_3$ 10962 (cf), 11031, 11033.

Description—The DP^4 (Fig. 2E) has not previously been described for *C. collinus*, but is similar to that of *C. fontis* figured by Black (1965). The protocone is more cuspate than on the molars. The anterior cingulum forms the anterior margin of the tooth and encloses the anterior basin. It attaches either to the protocone or to the protoloph. In one specimen (PTRM 11012, Fig. 2E) there is a lophule connecting the anterior cingulum and the protoloph dividing the anterior basin into two pits. The metaloph is complete except in PTRM 5915 where it essentially ends at the large metaconule. A metaconule is typically present, but unlike the condition seen in the upper molars, none of the specimens show a lophule connecting the metaconule with the posterior cingulum. The posterior cingulum is complete and attaches to the posterior face of the metacone, enclosing the posterior basin. The central basin is the deepest basin and rises to a broad buccal notch. Only PTRM 11012 has a mesostyle which is located on the posterior face of the paracone.

The only P^4 in the sample that preserves much of a crown pattern has a complete protoloph (Fig. 2G). There is a slight notch in the anterior cingulum and the shallow anterior basin opens anteriorly. The posterior basin is smaller, but deeper than the anterior basin. The central basin opens by a notch buccally. The specimen differs from the P^4 of *C. collinus* figured by Russell (1972) in having the anterior cingulum with a notch, which is more similar to the P^4 of *C. fontis* (Black 1965); however, in *C. fontis*, there is no protoloph.

The upper molars are generally as described by Storer (1978) for the species, but the Medicine Pole Hills specimens show some additional variation (Fig. 2H-J). The protoloph is always complete to the paracone and about one quarter of the specimens show some development of a lophule from the protoloph to the anterior cingulum. In all specimens the anterior cingulum is complete to the buccal margin of the tooth and in most specimens ends at a parastyle. This cusp is variable when present, from a swelling on the anterior cingulum to a cusp as large as the paracone and separated from it by a distinct notch (PTRM 11032). The metaloph typically has a distinct metaconule, which may be a small swelling on the metaloph (PTRM 11006) or a large cusp (PTRM 7294). In PTRM 7455 (Fig 2I), the metaloph is not complete, but ends at the large metaconule. In all other specimens, the metaloph narrows lingual to the metaconule, but

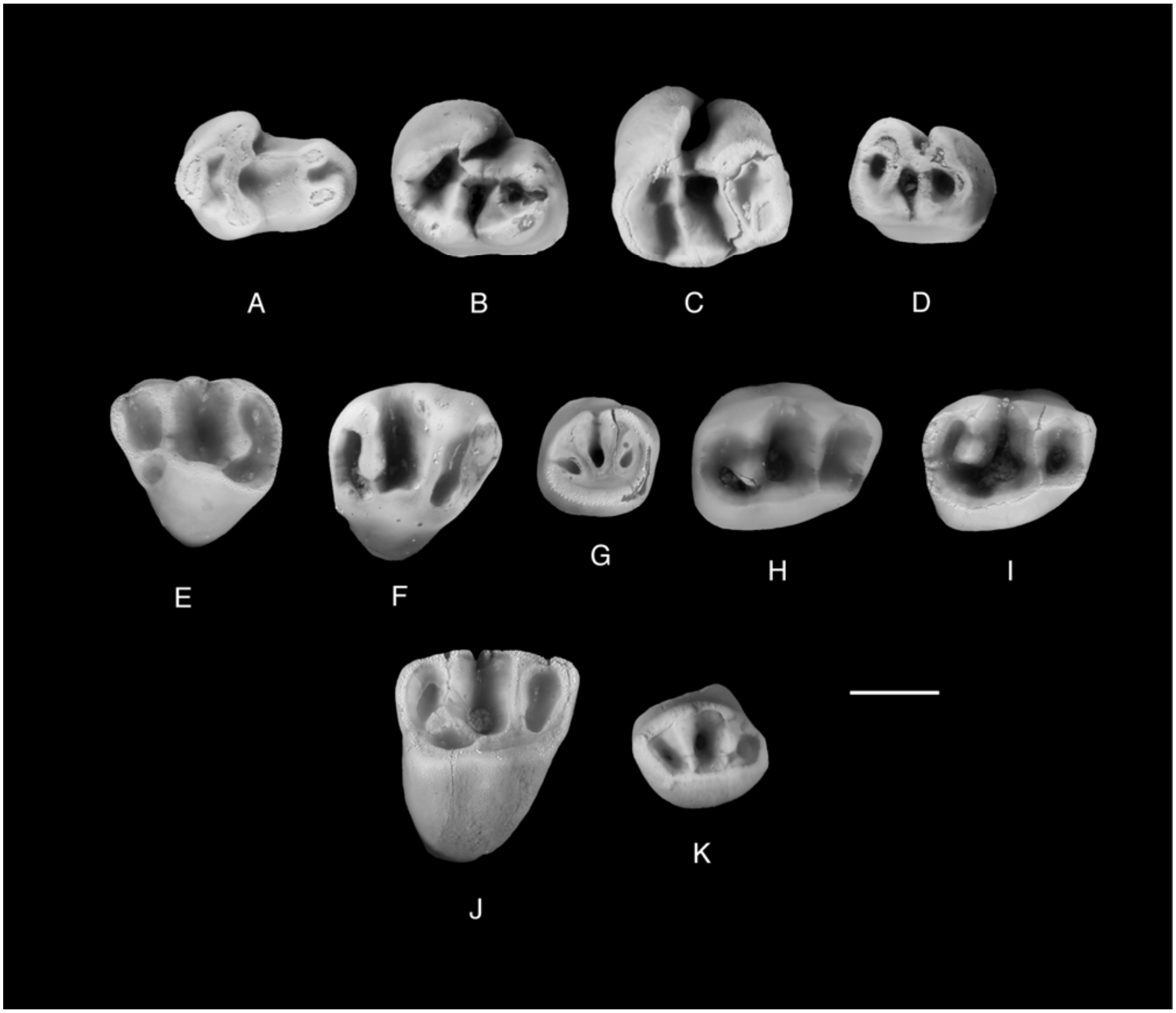

FIGURE 2. *Cylindrodon collinus* from the Medicine Pole Hills local fauna. A, PTRM 10301 LDP$_4$; B, PTRM 7710 LP$_4$; C, PTRM 7711 LM$_{1 \text{ or } 2}$; D, PTRM 5529 RM$_3$; E, PTRM 11012 LDP^4; F, PTRM 7722 RDP^4; G, PTRM 10999 LP^4; H, PTRM 10299 RM$^{1 \text{ or } 2}$; I, PTRM 7455 RM$^{1 \text{ or } 2}$; J, PTRM 8324 RM$^{1 \text{ or } 2}$; K, PTRM 7391 LM^3. Buccal is up and the bar scale represents approximately 1 mm.

attaches to the protocone. In most specimens the metaconule gives rise to a lophule which attaches to the posterior cingulum. With wear, this divides the posterior basin into two pits. The posterior cingulum is complete to the posterior face of the metacone. The central basin is variably shaped; in some cases the protoloph and metaloph diverge buccally, in other specimens the lophs are nearly parallel. The central basin is deep and steep sided. It opens buccally by a notch which is variable in depth. In some specimens, a small mesocone is present.

The M^3 is similar to the description given by Storer (1978) although with some additional variability (Fig 2K). The metaloph is complete on all specimens, but on PTRM 5017 it is a thin loph connecting low on the protocone. The metacone of this specimen is also oriented posterolingually, which creates a posterior basin that is elongate anteroposteriorly and which opens by a notch on the posterior face of the tooth, a condition similar to that described by Black (1965) for *C. fontis*. In all other specimens, the posterior cingulum is complete, enclosing a circular posterior basin.

The protoconid and metaconid of the DP$_4$ are separated by a valley (Fig. 2A). The posterior face of the trigonid forms a long sloping surface into the talonid basin. PTRM 10301, the less worn specimen, has a complete hypolophid and the posterior basin is enclosed, although the entoconid is separated by a notch from the posterior cingulum. The only additional feature of note is the development of a large, crescentric hypoconulid. The P_4 (Fig. 2B) matches the description of *C. collinus* given by Storer (1978). The only additional variation noted is in PTRM 7946 which has no development of a metalophid. All other specimens have the trigonid basin closed posteriorly by this lophule. The M_1 and M_2 match the description of these teeth given by Storer (1978). On the only two unworn specimens (PTRM 5911 and 7711, Fig. 2C), the metalophulid II is transverse rather than trending anterolingually as in *C. fontis*. The M_3 (Fig. 2D) does not have the reduced posterior half seen in *C. fontis*, instead the talonid is only slightly narrower than the trigonid on unworn specimens and the hypolophid is as long as, or longer than, the metalophulid II.

TABLE 3. Measurements of *Cylindrodon collinus* teeth, combined data.

Tooth Position		n	Mean	OR
DP^4	AP	6	1.87	1.74-1.94
	W	6	1.44	1.23-1.65
P^4	AP	2	1.47	1.36-1.58
	W	2	1.44	1.23-1.65
$M^{1\text{ or }2}$	AP	24	1.80	1.42-2.16
	W	24	1.65	1.13-2.49
M^3	AP	4	1.50	1.39-1.58
	W	4	1.27	1.03-1.52
DP_4	AP	2	2.00	2.00-2.00
	Wa	2	1.15	1.03-1.26
	Wp	2	1.52	1.45-1.58
P_4	AP	6	1.99	1.74-2.20
	Wa	6	1.28	1.13-1.49
	Wp	6	1.80	1.58-2.00
$M_{1\text{ or }2}$	AP	17	1.96	1.78-2.13
	Wa	17	1.77	1.42-2.00
	Wp	16	2.05	1.49-2.20
M_3	AP	6	1.71	1.55-1.91
	Wa	4	1.57	1.42-1.68
	Wp	6	1.43	1.32-1.52

Discussion—As noted by Emry and Korth (1996) there is considerable overlap in the sizes of the species of *Cylindrodon*. The Medicine Pole Hills sample is assigned to *C. collinus* because of the variable presence of a lophule connecting the metaloph and posterior cingulum on the upper molars. This loph is present to some degree in 11 of 13 specimens in the Medicine Pole Hills sample, and in 17 of 22 specimens in the Calf Creek sample at the Royal Saskatchewan Museum. In both samples, approximately one-half of the specimens show a strong connecting loph, and in the remainder there is a low or weak lophule. This loph is absent in *C. fontis* and consistently present in *C. natronensis*, *C. solarborus* and *C. nebraskensis* (Emry and Korth 1996). The Medicine Pole Hills specimens are larger than *C. natronensis*, and similar in size to *C. solarborus* when compared by stage of wear (Tables 3, 4a-e).

Ostrander (1980, 1983) identified three species of *Cylindrodon* in the Raben Ranch local fauna, *C. fontis*, *C. collinus* and *C. galbreathi*. The only feature he used to distinguish *C. fontis* from *C. collinus* in the Raben Ranch sample was the separation of the posterior basin of the upper dentition into two pits, but as noted by Emry and Korth (1996) this feature is variably present in *C. collinus*, and as such the bulk of the Raben Ranch sample is likely composed of *C. collinus*. Korth (1992) synonymized *C. galbreathi* with *C. nebraskensis*, so two species of *Cylindrodon* do occur in the Raben Ranch fauna.

Genus *Pseudocylindrodon* Burke 1935
Pseudocylindrodon neglectus Burke 1935
(Figure 3, Table 5)

Cylindrodon fontis Matthew, 1903, in part
Pseudocylindrodon neglectus Burke, 1935
Pseudocylindrodon silvaticus Russell, 1954

Referred Specimens—all PTRM RDP^4 8288, 14960, 14705; RP^4 10934; LP^4 7388, 7393, 10945, 10946; R$M^{1\text{ or }2}$ 5000, 7390; L$M^{1\text{ or }2}$ 5010, 8009, 11024; RM^3 4999 (cf), 7927, 8333; LM^3 11026, 14970; LDP_4 5537; RP_4 6123, 7297, 7395, 10947; R$M_{1\text{ or }2}$ 7944, 10413; L$M_{1\text{ or }2}$ 7427, 7716, 7925, 7931; RM_3 5525, 8337; LM_3 5096, 5871, 11022.

Description—The DP^4 is triangular in occlusal outline. The single unworn specimen (PTRM 14705, Fig 3F)) has an anterior cingulum on the buccal half of the tooth that encloses a semicircular basin. The protocone is large and is connected by complete protoloph and metaloph to the external cusps. The posterior cingulum is only on the buccal half of the tooth and encloses a very narrow posterior basin. The central basin opens buccally by a wide V-shaped notch. PTRM 8288 differs in having a large anterocone separated by a notch from the paracone and in having a mesostyle which projects buccally at the opening of the central valley. The P^4 (Fig. 3G) matches the description given by Black (1965) for this species. The $M^{1\text{ or }2}$ (Fig. 3H) specimens differ slightly from the Pipestone Springs specimens. In one specimen the anterior valley is open buccally, but in the other specimens, the anterior valley is either closed by a parastyle, or by the anterior cingulum attaching directly to the anterior face of the paracone. The posterior valley is closed in all specimens and the metaconule is attached to the posterior cingulum by a short loph in some specimens.

TABLE 4a. Measurements of *Cylindrodon collinus* teeth in wear stage I*.

Tooth Position		n	Mean	OR
DP^4	AP	4	1.91	1.87-1.94
	W	4	1.37	1.23-1.62
P^4	AP	-		
	W	-		
M$^{1 \text{ or } 2}$	AP	10	1.93	1.71-2.16
	W	10	1.27	1.13-1.52
M^3	AP	2	1.53	1.49-1.58
	W	2	1.11	1.03-1.20
DP$_4$	AP	1	2.00	
	Wa	1	1.03	
	Wp	1	1.45	
P$_4$	AP	2	1.92	1.91-1.94
	Wa	2	1.28	1.26-1.29
	Wp	2	1.81	1.78-1.84
M$_{1 \text{ or } 2}$	AP	2	1.89	1.78-2.00
	Wa	2	1.44	1.42-1.45
	Wp	2	1.66	1.49-1.84
M$_3$	AP	1	1.91	
	Wa	1	1.68	
	Wp	1	1.52	

*Wear stage defined by Emry and Korth (1996)

TABLE 4b. Measurements of *Cylindrodon collinus* teeth in wear stage II.

Tooth Position		n	Mean	OR
DP^4	AP	1	1.87	
	W	1	1.49	
P^4	AP	1	1.36	
	W	1	1.23	
M$^{1 \text{ or } 2}$	AP	3	1.84	1.81-1.87
	W	3	1.49	1.32-1.58
M^3	AP	2	1.47	1.39-1.55
	W	2	1.42	1.32-1.52
DP$_4$	AP	1	2.00	
	Wa	1	1.26	
	Wp	1	1.58	
P$_4$	AP	4	2.03	1.74-2.20
	Wa	4	1.28	1.13-1.49
	Wp	4	1.80	1.58-2.00
M$_{1 \text{ or } 2}$	AP	2	1.89	1.81-1.97
	Wa	2	1.79	1.62-1,97
	Wp	1	2.16	
M$_3$	AP	2	1.68	1.62-1.74
	Wa	2	1.49	1.42-1.55
	Wp	2	1.41	1.32-1.49

TABLE 4c. Measurements of *Cylindrodon collinus* teeth in wear stage III.

Tooth Position		n	Mean	OR
DP^4	AP	1	1.74	
	W	1	1.65	
P^4	AP	-		
	W	-		
M$^{1 \text{ or } 2}$	AP	1	1.78	
	W	1	1.52	
M^3	AP	-		
	W	-		
DP$_4$	AP	-		
	Wa	-		
	Wp	-		
P$_4$	AP	-		
	Wa	-		
	Wp	-		
M$_{1 \text{ or } 2}$	AP	3	2.03	1.94-2.13
	Wa	3	1.73	1.65-1.81
	Wp	3	2.10	2.00-2.20
M$_3$	AP	-		
	Wa	-		
	Wp	-		

TABLE 4d. Measurements of *Cylindrodon collinus* teeth in wear stage IV.

Tooth Position		n	Mean	OR
DP^4	AP	-		
	W	-		
P^4	AP	1	1.58	
	W	1	1.65	
M$^{1 \text{ or } 2}$	AP	4	1.80	1.71-1.94
	W	4	1.97	1.84-2.16
M^3	AP	-		
	W	-		
DP$_4$	AP	-		
	Wa	-		
	Wp	-		
P$_4$	AP	-		
	Wa	-		
	Wp	-		
M$_{1 \text{ or } 2}$	AP	5	1.98	1.87-2.10
	Wa	5	1.81	1.62-1.94
	Wp	5	2.06	1.97-2.16
M$_3$	AP	2	1.73	1.71-1.74
	Wa	-		
	Wp	2	1.42	1.36-1.49

TABLE 4e. Measurements of *Cylindrodon collinus* teeth in wear stage V.

Tooth Position		n	Mean	OR
DP^4	AP	-		
	W	-		
P^4	AP	-		
	W	-		
$M^{1 \text{ or } 2}$	AP	6	1.55	1.42-1.65
	W	6	2.20	2.00-2.49
M^3	AP	-		
	W	-		
DP_4	AP	-		
	Wa	-		
	Wp	-		
P_4	AP	-		
	Wa	-		
	Wp	-		
$M_{1 \text{ or } 2}$	AP	5	1.96	1.81-2.10
	Wa	5	1.89	1.78-2.00
	Wp	5	2.14	2.03-2.20
M_3	AP	1	1.55	
	Wa	1	1.62	
	Wp	1	1.44	

The M^3 (Fig. 3I) specimens match the description given by Black (1965) for *P. neglectus*.

The DP_4 (Fig 3A) is very low crowned. There is a minute remnant of a trigonid basin, and the trigonid forms a long slope into the shallow talonid basin. The ectolophid is complete as is the posterior cingulum. There is no evidence of a hypolophid. The entoconid is separated from the posterior extension of the metaconid by a wide shallow notch.

Only one of the P_4 specimens preserves details of the crown (PTRM 10947, Fig. 3B). In addition to being more mesodont, worn specimens differ from those of *Cylindrodon collinus* in being as broad as they are long. The trigonid has two distinct cusps with the metaconid larger and taller than the protoconid. These cusps are separated by a narrow fissure. The posterior slope of the trigonid is relatively long and less steep than that of *C. collinus*. The ectolophid is complete as is the posterior cingulum which rises to a tall entoconid. A very short hypolophid is attached to the entoconid, but this loph does not extend even to the midline of the tooth. The talonid basin is wide and shallow and opens buccally by a narrow notch that is almost as deep as the floor of the talonid basin. There is a posterior extension on the metaconid but there is no distinct metastylid.

Two of the lower molar specimens are relatively unworn. PTRM 7925 (Fig. 3D) is very similar to the description given by Black (1965) for *P. neglectus*. Of note is the metalophulid II which drops from the apex of the protoconid to attach low on the posterolingual face of the metaconid. A posterior extension of the metaconid attaches to the entoconid and completely encloses the central basin. The hypolophid is complete, but is very low and rises little above the floor of the posterior basin. The entoconid rises above the posterior cingulum and is separated from it by a shallow notch. The second unworn specimen, PTRM 7931, differs in several features (Figure 3C). The metalophulid II is complete, but has its low point in the middle rather than at the metaconid. The hypolophid is complete and although below the level of the posterior cingulum rises well above the floor of the posterior basin. The posterior cingulum has a notch at the hypoconid and another shallower notch at the entoconid. The central basin opens lingually by a deep notch that extends to about one-half the depth of the central valley. A swelling on the posterolingual corner of the metaconid may represent a metastylid. Because these specimens are isolated teeth, it is not known if the variation relates to tooth position or represents individual variation.

The M_3 is similar to the description given by Black (1965), with one specimen (PTRM 8337) having a complete hypolophid, one (PTRM 5096) having an incomplete hypolophid with lophules from both the entoconid and hypoconid, and two specimens (PTRM 5871, 11022, Fig. 3E) having only minor lophules extending a short distance from the entoconid.

TABLE 5. Measurements of the *Pseudocylindrodon neglectus* teeth.

Tooth Position		n	Mean	OR
DP^4	AP	3	1.53	1.45-1.68
	W	3	1.88	1.78-2.03
P^4	AP	4	1.44	1.39-1.49
	W	4	2.10	1.84-2.29
$M^{1 \text{ or } 2}$	AP	5	1.63	1.55-1.74
	W	5	2.11	1.97-2.26
M^3	AP	4	1.47	1.39-1.65
	W	4	1.68	1.49-1.81
DP_4	AP	1	1.58	
	Wa	1	1.07	
	Wp	1	1.32	
P_4	AP	4	1.89	1.78-2.00
	Wa	4	1.34	1.16-1.52
	Wp	4	1.93	1.81-2.10
$M_{1 \text{ or } 2}$	AP	5	1.71	1.55-1.91
	Wa	5	1.57	1.49-1.71
	Wp	5	1.81	1.78-1.84
M_3	AP	5	1.89	1.68-2.16
	Wa	5	1.66	1.36-1.94
	Wp	5	1.59	1.42-1.78

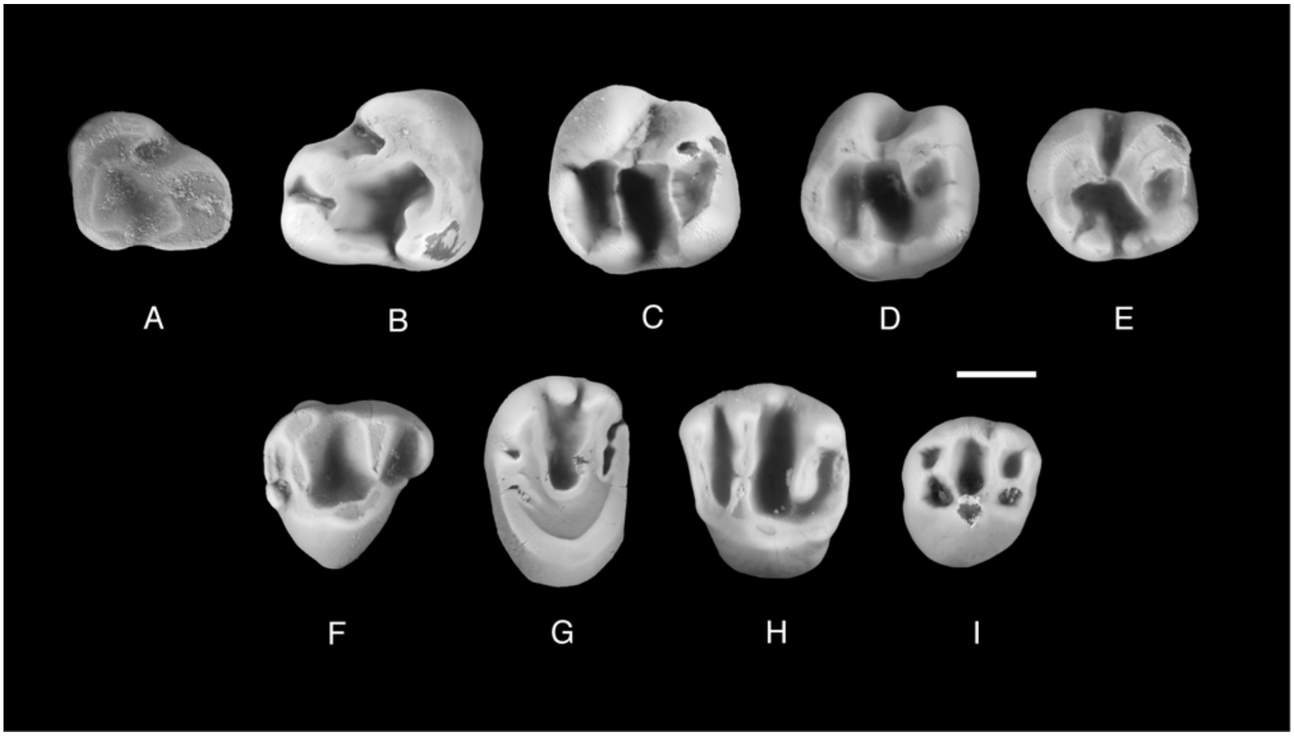

FIGURE 3. *Pseudocylindrodon neglectus* from the Medicine Pole Hills local fauna. A, PTRM 5537 LDP$_4$; B, PTRM PTRM 10947 RP$_4$; C, PTRM 7931 LM$_{1 \text{ or } 2}$; D, PTRM 7925 LM$_{1 \text{ or } 2;}$ E, PTRM 11022 LM$_3$; F, PTRM 14705 RDP^4; G, PTRM 10934 RP^4; H, PTRM 11024 LM$^{1\text{or } 2}$; I, PTRM 8333 RM^3. Buccal is up and the bar scale represents approximately 1 mm.

Discussion—The Medicine Pole Hills specimens do not represent *P. medius* (Burke, 1938) that has a P$_4$ which is longer than it is wide, and a well developed hypolophid. In addition, the P^4-M^2 have mesostyles, which are absent in *P. medius* (Black, 1965). The Medicine Pole Hills specimens are comparable to the specimens from both the Calf Creek local fauna (Storer, 1978) and from the Pipestone Springs local fauna (Black, 1965), but are consistently smaller than *P. neglectus* from the Raben Ranch local fauna (Ostrander, 1980). *Pseudocylindrodon silvaticus* from the Kishenehn Formation of British Columbia. was considered distinct because the hypolophid of the M$_3$ was incomplete (Russell, 1954). This condition is seen in several of the Medicine Pole Hills specimens (PTRM 5871, 11022) and, as noted by Russell, *P. silvaticus* is the same size as *P. neglectus*. Wood (1980) considered *P. silvaticus* to be a junior synonym of *P. neglectus,* a determination supported here by the variation in the Medicine Pole Hills M$_3$ specimens.

Genus *Ardynomys* Matthew and Granger 1925
Ardynomys saskatchewensis (Lambe) 1908
(Figure 4A-G, Table 6)

Sciurus? saskatchewensis Lambe, 1908
Prosciurus saskatchewanensis Russell,1934
Prosciurus saskatchewensis Russell, 1972
Ardynomys saskatchewensis Storer, 1978
?Prosciurus saskatchewaensis Wood, 1980
Ardynomys saskatchewaensis Emry and Korth, 1996

Referred Specimens—all PTRM RM$^{1 \text{ or } 2}$ 7478, 7926; LM$^{1 \text{ or } 2}$ 11023, 11052; RM^3 8332; LM^3 11001, 14968; RDP$_4$ 10932; RP$_4$ 7295, 7717, 7726; LM$_{1 \text{ or } 2}$ 8322, 11007, 11021; LM$_3$ 7272, 11020.

Description—The single unworn M$^{1 \text{ or } 2}$ (PTRM 11052, Fig. 4F) has a large protocone with a slight anterior expansion that extends anterolingual to the attachment of the anterior cingulum. The anterior cingulum is complete and attaches to the anterior face of the paracone, enclosing a narrow anterior basin. The protoloph is complete. The posterior cingulum begins as a robust extension from the posterior face of the protocone that then trends buccally to attach to the posterior face of the metacone. The posterior basin is enclosed anteriorly by the complete metaloph. The metaconule is distinct and expanded toward the posterior cingulum, which would result in two distinct pits at a later stage of wear. The central basin is the deepest basin and rises buccally to a high notch. A weak mesocone is attached to the paracone. The M^3 (Fig. 4G) is more circular in outline compared to the broadly rectangular anterior molars. The anterior cingulum, protoloph, metaloph and posterior cingulum are all complete and the buccal margin is completely enclosed. The mesocone is moderately to well developed. The metaconule is present on all specimens.

The single specimen interpreted as a DP$_4$ (Fig. 4A) is longer than wide, in contrast to the P$_4$ which is as wide as it is long. It also has a lower crown and the enamel does not extend down the posterobuccal root as it does in the permanent tooth. The metaconid forms the tallest portion of the trigonid, but there is no groove separating it from the protoconid. If there was a trigonid basin, it has been eliminated by wear. The posterior face of the trigonid slopes gradually into the talonid basin. The ectolophid is complete as is the posterior cingulum. The entoconid is positioned somewhat anteriorly, and a weak hypolophid extends from the entoconid about halfway across the basin towards the hypoconid. The talonid basin opens by a relatively broad notch. A posterior extension on the metaconid may represent the metastylid.

The P$_4$ (Fig. 4B,C) is about as broad as it is long. The metaconid and protoconid are separate at their apices by a shallow groove. These cusps are connected by a very low metalophid which encloses a shallow trigonid basin. The ectolophid is complete as is the posterior cingulum. The entoconid is not placed as far forward as in the deciduous tooth and forms the posterolingual corner of the tooth. A low hypolophid connects the posterior cingulum and ectolophid and encloses a shallow basin on one specimen (PTRM 7726); other specimens show no evidence of a posterior basin either because of wear or because of the absence of a hypolophid. The talonid basin opens lingually by a V-shaped notch. The posterior face of the metaconid has an expansion, but not to the extent seen in the deciduous tooth.

PTRM 11021 (Fig. 4E) is an unworn M$_{1\text{ or }2}$. The metaconid is the tallest cusp and is connected to the protoconid by a strong, transverse anterior cingulum. The protoconid is elongate anteroposteriorly and the metalophid is attached approximately halfway between the anterior and posterior margins of the tooth. The metalophid is as strong as the anterior cingulum, although somewhat lower, and attaches to the posterior expansion of the metaconid on the lingual margin of the tooth. The ectolophid is complete, with the apex of the hypoconid placed close to the buccal attachment of the metalophid. The hypolophid is complete and attaches to the hypoconid and the entoconid. The posterior cingulum is complete and bends anteriorly on the lingual margin of the tooth to attach to the entoconid. The anterior and posterior basins are totally enclosed and nearly equal in size. The central basin is deep, anteroposteriorly narrow and very steep sided. It opens by a narrow notch between the entoconid and the metalophid. PTRM 11007 (Fig. 4D) differs slightly, in that the metalophid attaches to the protoconid and the metaconid, enclosing a smaller, more shallow anterior basin. The central basin is wider and there is a distinct metastylid closing the lingual end of the basin. The M$_3$ has a narrow trigonid basin enclosed by metalophid which attaches to the metaconid. The hypolophid is complete from the entoconid to the ectolophid. The posterior cingulum is complete and encloses a semicircular posterior basin.

TABLE 6. Measurements of *Ardynyomys saskatchewensis* teeth.

Tooth Position		n	Mean	OR
M$^{1\text{ or }2}$	AP	3	1.98	1.84-2.20
	W	3	2.75	2.49-3.18
M^3	AP	2	2.28	2.10-2.45
	W	2	2.26	2.20-2.33
DP$_4$	AP	1	2.13	
	Wa	1	1.49	
	Wp	1	1.97	
P$_4$	AP	3	2.23	2.20-2.26
	Wa	3	1.64	1.52-1.71
	Wp	3	2.28	2.10-2.39
M$_{1\text{ or }2}$	AP	3	2.27	2.10-2.36
	Wa	3	2.20	1.78-2.68
	Wp	3	2.39	2.03-2.81
M$_3$	AP	2	2.50	2.36-2.65
	Wa	2	2.28	2.13-2.42
	Wp	2	2.28	2.16-2.39

Discussion—These specimens are assigned to *A. saskatchewensis* because of the connection of the metaloph and posterior cingulum seen on most of the upper molars. This connection is not seen in *A. occidentalis* (Emry and Korth, 1996). The upper molars all have the anterior and posterior cingulum fused to the buccal cusps, completely enclosing the anterior and posterior basins. The specimens are larger than named species of *Pseudocylindrodon*, except for *P. texanus*. *Pseudocylindrodon texanus* does not show an enlarged metaconule and there is no connection between the metaloph and the posterior cingulum (Wood, 1974).

The rather convoluted taxonomic history of this species has been summarized by Emry and Korth (1996), but in short the species has previously been represented by only a single unworn tooth (the holotype, CMN 6479). The only additional specimens referred to this species are a very worn upper molar

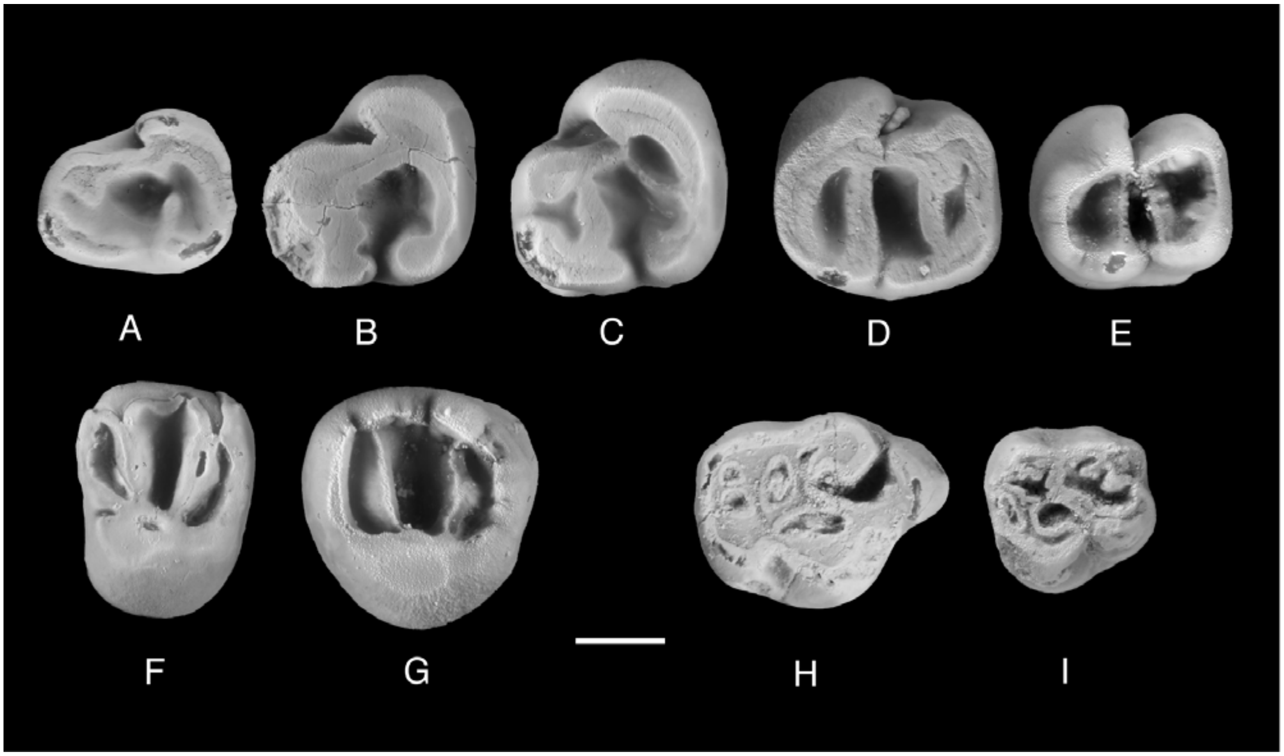

FIGURE 4. *Ardnyomys saskatchewensis* and *Pipestoneomys* from the Medicine Pole Hills local fauna. A-G, *Ardnyomys saskatchewensis*; A, PTRM 10932 RdP_4; B, PTRM 7295 RP_4; C, PTRM 7726 RP_4; D, PTRM 11007 $LM_{1 \text{ or } 2}$; E, PTRM 11021 $LM_{1 \text{ or } 2}$; F, PTRM 11052 $LM^{1 \text{ or } 2}$; G, PTRM 14968 LM^3. H-I *Pipestoneomys* sp.; H, PTRM 10974 RP^4; I, PTRM 6167 $LM^{1 \text{ or } 2}$. Buccal is up and the bar scale represents approximately 1 mm.

(RSM P661.44) and an edentulous maxillary fragment (RSM P661.45). Assuming that the Medicine Pole Hills specimens are correctly assigned, they represent the most complete record of the dentition of *A. saskatchewensis* to date.

The species named by Lambe (1908) clearly has priority over *A. occidentalis* (Burke 1936) as noted by Storer (1996). if the species are synonymous. Storer (1978) noted several features that distinguished the holotype of *A. saskatchewensis*, from the referred skull of *A. occidentalis*. Storer erroneously stated that CM 1055, the skull figured by Burke (1936, Fig. 1) was the holotype; the correct holotype is CM 1056, the lower jaw shown in the same figure. That being the case, the holotypes of *A. saskatchewensis* and *A. occidentalis* have no teeth in common. That point aside, the features noted by Storer (1978, p. 16) that distinguish *A. saskatchewensis* were a) "strong anterior and posterior cingula that close off valleys" b) "distinct metaconule", c) "metaloph very low near protocone" and d) "metaloph broader than protoloph". Emry and Korth (1996) added the connection of the metaloph to the posterior cingulum as another diagnostic feature of *A. saskatchewensis*. The Medicine Pole Hills specimens are approximately the same size as *A. occidentalis* (Table 6) although the lower teeth tend to be narrower and the upper teeth tend to be wider than comparable teeth of that species. Finally, the Medicine Pole Hills M^3 specimens all have the posterior and central valleys closed buccally, in contrast to the condition of *A. occidentalis* in which the central valley is open buccally, a feature noted by Burke (1936). Based on these differences, *A. occidentalis* appears to be distinct from *A. saskatchewensis*.

Family incertae sedis
Genus *Pipestoneomys* Donohoe 1956
Pipestoneomys sp.
(Figure 4H-I)

Referred Specimens—Both PTRM $RP^4$10974, $LM^{1\text{or } 2}$ 6167

Description—PTRM 10974 (Fig. 4H) is most probably a P^4, although it may also represent a DP^4. The amount of wear and the relative development of the roots suggest the former interpretation. There is a very large anterocone that is connected by the anterior cingulum to the protocone. The protocone is connected to the hypocone, in contrast to the P^4 of *P. pattersoni*. The posterior cingulum is complete to the posterobuccal corner of the tooth. The metaloph is complete and the posterior basin is divided into two pits. There is no distinct metacone, but this may be due to the relatively advanced wear. The hypocone is connected to the paracone by an oblique loph which encloses a basin between the metaloph and the oblique loph. A lophule connects the oblique loph to the anterior cingulum. This encloses a basin between the protocone and hypocone. The ectoloph is complete from the metacone to the paracone but the paracone is separated by a deep groove from the anterocone. The anterior-posterior length is 2.71 mm, Wa is 2.03 mm and Wp is 1.81 mm. These measurements are greater than those of the P^4 of *P. pattersoni* given by Alf (1962), but similar to the P^4 measurements of *P. pattersoni* and *P. bisulcatus* given by Ostrander (1980).

PTRM 6167 (Fig 4I) is an upper molar. The protocone is crescentric and gives rise to two lophs. The anterior cingulum forms the anterior border of the tooth. Just posterior and parallel to this is a second loph which encloses a transverse basin. These lophs join each other lingual to the paracone and are separated from the paracone by a shallow groove. There is no distinct parastyle. This differs from the holotype of *P. bisulcatus* in which the groove between the paracone and the buccal end of the anterior cingulum is deeper. There is a minor expansion on the more posterior loph towards the oblique loph from the hypocone. The hypocone is not connected to the protocone and the lingual valley extends across the tooth to the shallow groove at the anterobuccal corner of the tooth. An oblique loph connects the hypocone to the paracone and there is a very short lophule on the anterior side of the loph. The posterior cingulum is complete to the metacone. There are two minor lophules from the metacone extending into the posterior basin, but these to not reach the oblique loph. The metacone is connected to the paracone by a complete ectoloph which closes the posterior basin. The anterior-posterior length is 1.78 mm, Wa is 1.73 mm and Wp is 1.42 mm.

Discussion—The P^4 differs considerably from the only previously described P^4 of *Pipestoneomys* (Alf, 1962). Some of these differences may be due to the more worn condition of the Medicine Pole Hills specimen, but some are probably due to individual variation. First, in *P. pattersoni* an oblique valley crosses the tooth, separating the protocone-anterocone from the hypocone. In PTRM 10974 this valley is closed lingually and medially by lophs. In *P. pattersoni*, the oblique loph does not reach the paracone (unlike the condition of the molars). In PTRM 10974, lophs from the hypocone reach both the metacone and the paracone. The characters that support an assignment to *Pipestoneomys* are the very large anterocone and protocone, and the anterior width being greater than posterior width. Ostrander (1980) reported P^4 specimens of *P. bisulcatus* from the Raben Ranch local fauna but did not describe their morphology, the amount of variation of that tooth, or why these teeth were assigned to *P. bisulcatus* rather than *P. pattersoni*. The P^4 of *P. bisucatus*, other than the specimens reported by Ostrander, is unknown and the species are similar in size.

The single upper molar in the Medicine Pole Hills collection differs from the pattern of both *P. bisulcatus* and *P. pattersoni* in having two anterior lophs from the protocone to the anterobuccal corner of the tooth. The groove between the anterior lophs is very shallow, more similar to the pattern described for *P. pattersoni* (Donohoe, 1956), but in contrast to *P. patterson*i, the posterior basin is not divided into two pits. The single posterior basin is more similar to the condition of *P. bisulcatus*.

There appear to be several options on where to assign these specimens. The two anterior lophs from the protocone are unlike either *P. bisulcatus* or *P. pattersoni*, which could be used to justify, to some degree, assigning the specimen to a new species. The single posterior basin could support an assignment to *P. bisulcatus* as opposed to *P. pattersoni*. The shallow groove separating the anterior lophs from the paracone could support an assignment to *P. pattersoni*. Ostrander (1980), with a larger collection of *Pipestoneomys* specimens from the Raben Ranch local fauna, chose to assign some of those specimens to each of the named species, but provided no discussion on the range of variation. It seems equally likely, given the nature of the variation in taxa such as *Eutypomys*, that there may be considerable variation in the relative development and strength of lophs in *Pipestoneomys*. The fact that three different morphologies of similar sized upper molars, the only comparable teeth, occur at three different localities (Pipestone Springs, Sioux County, Nebraska and Medicine Pole Hills) could be indicative of distinct species, especially given the age differences between the faunas. However, at least two of these morphologic types occur in the Raben Ranch local fauna. Ostrander (1980) chose to interpret this as evidence of two contemporaneous species. Alternatively, it is not unreasonable to consider the identified differences between *P. bisulcatus* and *P. pattersoni* to be variants of a single species, with *P. pattersoni* being a junior synonym. The Medicine Pole Hills specimens suggest a higher degree of variation than previously described within *Pipestoneomys*, but the available sample does not allow for a determination of whether this variation is intraspecific. Pending a review of all of the *Pipestoneomys* material, no specific assignment is suggested for the Medicine Pole Hills specimens.

CONCLUSIONS

Eutypomys parvus has been reported from the Calf Creek local fauna (Storer 1978) and the Pipestone Springs local fauna (Tabrum et al., 1996). Both of these faunas are considered to be middle Chadronian by Prothero and Emry (2004), although they suggested that the Calf Creek local fauna is somewhat older than the Pipestone Springs local fauna (Prothero and Emry, 2004, Figure 5.2). Storer (1996) strongly suggested that the Calf Creek local fauna matched the late early Chadronian fauna from Flagstaff Rim, but reluctantly adopted a middle Chadronian interpretation. *Eutypomys* occurs in other Chadronian faunas, including *E. inexpectatus* from the earliest Chadronian Little Egypt local fauna of Texas (Wood, 1974) and *E. cf. thomsoni* from the late Chadronian Peanut Peak local fauna of South Dakota (Clark and Beerbower, 1967).

Cylindrodon collinus has been reported from the Calf Creek local fauna (Storer, 1978) and the Raben Ranch local fauna (Ostrander, 1980), both of which are middle Chadronian. *Cylindrodon natronensis* (Emry and Korth, 1996) and *C. fontis* (Tabrum et al., 1996) have been reported from early to middle Chadronian faunas of Wyoming and Montana, respectively. *Cylindrodon solarborus* has been reported from the middle Chadronian of Wyoming, and *C. nebraskensis* has been reported from the middle to late Chadronian of Nebraska and Colorado (Emry and Korth, 1996).

Pseudocylindrodon neglectus has been reported from the Duchesnean Porvenir, early Chadronian Little Egypt, and the late early Chadronian Airstrip local faunas of Texas (Wood, 1974), as well as the middle Chadronian Calf Creek (Storer, 1978), Raben Ranch (Ostrander, 1980), and Pipestone Springs (Black, 1965) local faunas. *Pseudocylindrodon medius* has been reported from the late early Chadronian McCarty’s Mountain local fauna and *P. texanus* has been reported from the Duchesnean Porvenir, late early Chadronian Little Egypt and late Chadronian Ash Springs local faunas of Texas (Wood, 1974).

Ardynomys saskatchewensis has been reported only from the middle Chadronian Calf Creek local fauna (Storer, 1978). *Ardynomys occidentalis* has been reported from Duchesnean Diamond O and the late early Chadronian McCarty’s Mountain local faunas of Montana (Tabrum et al., 1996), the Duchesnean Porvenir, the earliest Chadronian Little Egypt and late early Chadronian Airstrip local faunas of Texas (Wood, 1974). *Pipestoneomys* has been reported from the middle Chadronian Pipestone Springs local fauna (Donohoe, 1956) and Chadron Formation of Nebraska (Alf, 1962; Ostrander, 1980), and the Orellan of Nebraska (West and Korth, 1994).

The most obvious interpretation from the rodent taxa considered in this report would be that the Medicine Pole Hills local fauna is middle Chadronian in age. All of the taxa, other than *Pipestoneomys*, occur in common with the Calf Creek local fauna. The Medicine Pole Hills fauna lacks any species (of the taxa considered in this report) restricted to early Chadronian or older faunas (e.g. *Pseudocylindrodon medius*, *Ardynomys occidentalis*). The only rodent taxon in the fauna of those considered here that occurs in the early Chadronian is *P. neglectus*, but this wide ranging species has been reported from the Duchesnean to the late Chadronian and from Texas to Saskatchewan.

There does not appear to be a consistent biogeographic distribution for the taxa. *Pseudocylindrodon neglectus* occurs from Texas to Saskatchewan, *Eutypomys parvus* is known only from Montana, North Dakota and Saskatchewan. In contrast, the species of *Cylindrodon* seem to show restricted geographic distribution. *Cylindrodon natronensis* and *C. solarborus* occur in the late early and middle Chadronian of Wyoming (Emry and Korth, 1996), *C. fontis* occurs in late early and middle Chadronian of Montana (Tabrum et al., 1996), and *C. collinus* occurs in the middle Chadronian of Saskatchewan (Storer, 1978) and the Medicine Pole Hills local fauna. *Ardynomys saskatchewensis* is known only from Saskatchewan and North Dakota although the genus is widespread and was originally named based upon material from Asia (Matthew and Granger, 1925). *Pipestoneomys* has been reported from Nebraska, Montana, North Dakota, and perhaps from Saskatchewan (West and Korth, 1994).

A middle Chadronian age interpretation would contradict the conclusion of Heaton and Emry (1996) who noted the occurrence of *Leptomeryx yoderi* in the Medicine Pole Hills fauna, a species that has been considered an index fossil for the late early Chadronian. However, the rodent data presented here cannot be taken as conclusive evidence for a middle Chadronian age. The late early Chadronian rodent fauna is not well known. The primary localities considered to represent the late early Chadronian are the Airstrip local fauna (TX), the Ahearn Member of the Chadron Formation (SD), the McCarty's Mountain local fauna (MT) and the Yoder and Flagstaff Rim (>15m below Ash B) faunas of Wyoming. Of these, the Airstrip local fauna has 5 rodent specimens representing 4 species (Wood, 1974), the Ahearn Member fauna given by Clark and Beerbower (1967) listed only a single specimen of *Ischyromys*, the Yoder local fauna has 24 rodent specimens representing 4 species (Kihm, 1987) and the McCarty's Mountain local fauna has approximately 225 specimens representing 7 species (A. Tabrum, pers. comm. 2009).

The lower Flagstaff Rim fauna contains 11 species (Emry, 1992). In comparison, the middle Chadronian rodent fauna is much better represented. The Calf Creek local fauna has more than 500 specimens representing at least 8 taxa (Storer, 1978) and the Raben Ranch local fauna has more than 3000 rodent specimens which Ostrander (1980) assigned to 30 taxa. The Medicine Pole Hills rodent fauna may look more similar to middle Chadronian faunas, at least in part, because of this sample bias. This would only be true if the rodent fauna of the late early Chadronian is incompletely known and if that unknown fauna looks similar to the middle Chadronian rodent fauna.

At this time, the age of the Medicine Pole Hills local fauna could be considered either late early Chadronian based on *Leptomeryx yoderi* or middle Chadronian based on the similarity of the described rodents. The third alternative was suggested by Storer (1996) in stating that the Calf Creek local fauna may be intermediate between the late early Chadronian McCarty's Mountain and middle Chadronian Pipestone Springs local faunas. The Medicine Pole Hills might also represent an intermediate fauna similar to the Calf Creek local fauna. If the Calf Creek and Medicine Pole Hills faunas represent an intermediate stage, the occurrence of *Leptomeryx mammifer* in the Calf Creek fauna and *L. yoderi* in the Medicine Pole Hills fauna would suggest that the Medicine Pole Hills fauna is older than the Calf Creek fauna.

ACKNOWLEDGEMENTS

The author would like to thank Messrs. Bill Simpson and Paul Mayer of the Field Museum of Natural History, Dr. Harold Bryant and Ms. Lee Ann Wright of the Royal Saskatchewan Museum for access to specimens. Mr. Guy Hanley of Minot State University produced the photographs. Mr. Jeff Oakland of Rhame, North Dakota allowed the collection of material on his lands and Mr. Dean Pearson of the Pioneer Trails Regional Museum aided in the collection of specimens as well as arranging the loan of specimens for study. Without all of their cooperation, this study would not have been possible. Drs. William Korth of the Rochester Institutute for Vertebrate Paleontology, John E. Storer and Robert J. Emry reviewed the manuscript and provided salient comments that improved the document.

LITERATURE CITED

Alf, R. 1962. A new species of the rodent *Pipestoneomys* from the Oligocene of Nebraska. Breviora 172:1-7.

Black, C. C. 1965. Fossil mammals from Montana. Part 2. Rodents from the early Oligocene Pipestone Springs local fauna. Annals of Carnegie Museum 38(1):1-48.

Burke, J. J. 1936. *Ardnyomys* and *Desmatolagus* in the North American Oligocene. Annals of Carnegie Museum 25:135-154.

Burke, J. J. 1938. A new cylindrodont rodent from the Oligocene of Nebraska. Annals of Carnegie Museum 27:255-274.

Clark, J. 1937. The stratigraphy and paleontology of the Chadron Formation in the Big Badlands of South Dakota. Annals of the Carnegie Museum 35:262-350.

Clark, J. and J. R. Beerbower, 1967. Geology, paleoecology, and paleoclimatology of the Chadron formation. Pp. 21-74 in J. Clark, J. R. Beerbower, and K. K. Kietzke (eds.), Oligocene sedimentation, stratigraphy, paleoecology and paleoclimatology in the Big Badlands of South Dakota. Fieldiana: Geology Memiors 5:1-158.

Donohoe, J. C. 1956. New aplodontid rodent from Montana Oligocene. Journal of Mammalogy 37(2):264-268.

Emry, R. J., 1992. Mammalian range zones in the Chadronian White River Formation at Flagstaff Rim, Wyoming. Pp. 106-115 in D. R. Prothero and W. A. Berggren (eds.), Eocene-Oligocene Climatic and Biotic Evolution. Princeton University Press.

Emry, R. J., and W. W Korth. 1996. Cylindrodontidae. Pp. 399-416 in D. R. Prothero and R. J. Emry (eds.), The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press.

Heaton, T. H. and R. J. Emry. 1996. Leptomerycidae. Pp. 581-608 in D. R. Prothero and R. J. Emry (eds.), The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press.

Kihm, A. J. 1987. Mammalian paleontology and geology of the Yoder Member, Chadron Formation, east-central Wyoming. Pp. 28-45 in J.E. Martin and G.E. Ostrander (eds.), Papers in vertebrate paleontology in honor of Morton Green. Dakoterra 3:1-122.

Kihm, A. J. and K. K, Schumaker. 2008. *Domnina* (Mammalia, Soricomorpha) from the latest Eocene (Chadronian) Medicine Pole Hills local fauna of North Dakota. Paludicola 7(1):26-36.

Korth, W.W. 1992. Cylindrodonts (Cylindrodontidae, Rodentia) and a new genus of eomyid, *Paranamatomys*, (Eomyidae, Rodentia) from the Chadronian of Sioux County, Nebraka.

Transactions of the Nebraska Academy of Sciences 19:75-82.

Korth, W. W. 1994. The Tertiary Record of Rodents in North America. Plenum Press, 319 pp.

Lambe, L. M. 1908. The Vertebrata of the Oligocene of the Cypress Hills, Saskatchewan. Contributions to Canadian Palaeontology 3(4):1-64.

Matthew, W. D. 1905. Notice of two new genera of mammals from the Oligocene of South Dakota. American Museum of Natural History Bulletin 21(3):21-26.

Matthew, W. D. and W. Granger. 1925. New creodonts and rodents from the Ardyn Obo Formation of Mongolia. American Museum Novitates no. 193:1-7 pp.

Murphy, E. C., J. W. Hoganson , and N. F. Forsman. 1993. The Chadron, Brule and Arikaree Formations in North Dakota. North Dakota Geological Survey Report of Investigation no. 96:1-144.

Ostrander, G. 1980. Mammalia of the early Oligocene (Chadronian) Raben Ranch local fauna of northwestern Nebraska. Unpublished M.S. thesis, South Dakota School of Mines and Technology. 288 pp.

Ostrander, G. 1983. New early Oligocene (Chadronian) mammals from the Raben Ranch local fauna, northwest Nebraska. Journal of Paleontology 57(1):128-139.

Prothero, D. R. and R. J. Emry. 2004. The Chadronian, Orellan, and Whitneyan North American Land Mammal Ages. Pp. 156-168 in M. O. Woodburne (ed.) , Late Cretaceous and Cenozoic Mammals of North America, Biostratigraphy and Geochronology. Columbia University Press.

Russell, L. S. 1954 Mammalian fauna of the Kishenehn Formation, southeastern British Columbia. Bulletin of the National Museum of Canada 132:92-111.

Russell, L. S. 1972. Tertiary mammals of Saskatchewan. Part II: The Oligocene fauna, non-ungulate orders. Royal Ontario Museum Life Sciences Contribution 84:1-97.

Schumaker, K. K. and A. J. Kihm. 2006. Multituberculata from the Medicine Pole Hills local fauna (Chadronian) of Bowman County, North Dakota. Paludicola 6(1):9-21.

Storer, J. E. 1978. Rodents of the Calf Creek local fauna (Cypress Hills Formation, Oligocene, Chadronian), Saskatchewan. Saskatchewan Museum of Natural History Contributions 1:1-54 pp.

Storer, J. E. 1988. The rodents of the Lac Pelletier lower fauna, late Eocene (Duchesnean) of Saskatchewan. Journal of Vertebrate Paleontology 8(1):84-101.

Storer, J. E. 1996. Eocene-Oligocene faunas of the Cypress Hills Formation, Saskatchewan. Pp. 240-261 in D. R. Prothero and R. J. Emry (eds.), The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press.

Tabrum, A. R., D. R. Prothero , and D. Garcia. 1996. Magnetostratigraphy and biostratigraphy of the Eocene-Oligocene transition, southwestern Montana. Pp. 278-311 in D. R. Prothero and R. J. Emry (eds.), The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press.

Webster, J. R. and A. J. Kihm. 2009. Heavy mineral analysis and correlation of late Eocene sandstones of the Williston Basin. Geological Society of America Abstracts with Programs 41(7): 690.

West, C. M. and W. W. Korth. 1994. First record of Pipestoneomys (Mammalia: Rodentia) from the Orellan (Oligocene). Transactions of the Nebraska Academy of Sciences 21:147-150.

Wood, A. E. 1937. The mammalian fauna of the White River Oligocene. Part II. Rodentia. Transactions of the American Philosophical Society 28:155-269.

Wood, A. E. 1974. Early Tertiary vertebrate faunas Vieja Group Trans-Pecos Texas: Rodentia. Texas Memorial Museum Bulletin 21:1-112.

Wood, A. E. 1980. The Oligocene rodents of North America. Transactions of the American Philosophical Society 70:1-68.

Wood, A. E. and R. W. Wilson. 1936. A suggested nomenclature for the cusps of the cheek teeth of rodents. Journal of Paleontology 10(5):388-391.