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MULTITUBERCULATES FROM THE MEDICINE POLE HILLS LOCAL FAUNA (CHADRONIAN) OF BOWMAN COUNTY, NORTH DAKOTA.

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ABSTRACT

The presence of *Ectypodus lovei* in the Medicine Pole Hills Local Fauna makes it one of only three potentially early Chadronian occurrences of this multituberculate species. The Medicine Pole Hills specimens match the published descriptions of *E. lovei* with the only differences being a slightly higher cusp formula on the P^4 . The sample is significant because it is the largest known (80 specimens) and represents a complete dental arcade with the first known anterior upper premolars, mandible and unbroken $P^4/_4$s for the species. The sample supports ideas suggested by earlier authors: the structure of the P_4 supports the assignment of the species to *Ectypodus* as opposed to *Parectypodus*; there appears to be a slight increase in size from the Duchesnean to the middle Chadronian for the species; and there is an increase in the development of the first cusp in the medial row of the M^2 over this same time. The large sample size also allows for the assessment of individual variation, supporting the idea that only one species is present at the Badwater Creek Localities. A second species of multituberculate is represented in the fauna by a single, partial M^1. It most likely represents a ?neoplagiaulacid, larger in size and with a higher cusp formula than *E. lovei.*

INTRODUCTION

The Medicine Pole Hills are a series of small buttes located 11 km south of Rhame in southwestern-most North Dakota (Figure 1). The hills extend in a generally northeast-southwest trend and their elevations are approximately 60 to 90 m above the surrounding countryside. In the southwest portion of the Medicine Pole Hills, conglomeratic and poorly consolidated, fine to medium sandstones are present as caps on the buttes and are the fossil-bearing unit.

Leonard (1922) first noted the presence of brontothere bones from the Medicine Pole Hills. Hares (1928 with identifications by J.W. Gidley), Benson (1952) and Denson et al. (1959) listed additional taxa, but the focus of these papers was the geology of the area, rather than description of the fossils. The taxa represented were generally medium to large mammalian species typical of White River Formation faunas.

In 1989, reconnaissance work by a team from the Pioneer Trails Regional Museum (PTRM) discovered a diverse microfauna at the Medicine Pole Hills. Collection included both surface collecting and quarrying. Dry screening of the quarried sediment led to a much more diverse fauna than had previously been reported. Pearson (1993) designated the Medicine Pole Hills Local Fauna for the fossils from the series of lithologic and stratigraphically similar deposits capping the tops of the Medicine Pole Hills and presented a preliminary faunal list including fish, amphibians, reptiles, birds, and mammals. This faunal list was expanded by Pearson and Hoganson (1995), but identifications remained preliminary. Recently, more detailed work has been done on *Leptomeryx* (Heaton and Emry, 1996), lizards (Smith and Gauthier, 2002), marsupials (Warner et al., 2001; Kihm et al., 2001), and *Domnina* (Schumaker, 2003). Schumaker and Kihm (2002, 2005) reported preliminary results on *Ectypodus lovei*, but the current study is a much more detailed and based upon a larger sample.

Heaton and Emry (1996) presented a detailed study of *Leptomeryx,* primarily based on the extensive collections of Chadronian specimens from the Flagstaff Rim Local Fauna in central Wyoming. *Leptomeryx*

specimens from the Medicine Pole Hills Local Fauna were also studied, but were not described in the paper. Heaton and Emry noted that the material most closely matched *Leptomeryx yoderi* in size and morphology. Based on the slightly smaller size of the *L. yoderi* specimens from the Medicine Pole Hills, the authors suggested that they might represent "an early grade of *L. yoderi* or possibly a new species". Based on this early grade of evolution they also suggested that the Medicine Pole Hills fauna may be early Chadronian (Heaton and Emry, 1996). If this age interpretation is correct, the Medicine Pole Hills Local Fauna is one of only six early Chadronian faunas in North America (Prothero and Emry, 2004). The other five localities are the Airstrip Local Fauna in Texas (Novacek, 1976; Wood, 1974), Yoder Local Fauna (Kihm, 1987), Pilgrim Creek Local Fauna (Sutton and Black, 1975, Krishtalka et al., 1982), the lower Flagstaff Rim fauna (base to Ash A) in Wyoming (Emry, 1992), McCarty's Mountain Local Fauna in Montana (Tabrum et al., 1996), and the Southfork and Simmie Local Faunas in Saskatchewan (Storer, 1996). The Flagstaff Rim and the Pilgrim Creek faunas are the only other early Chadronian localities to produce multituberculates.

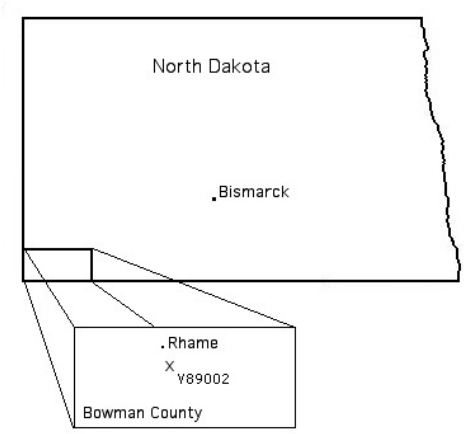

FIGURE 1. Location map of V89002.

History of *Ectypodus lovei*—*Ectypodus lovei* is known from multiple North American localities ranging from late Uintan to middle Chadronian in age. Sloan (1966) first described the species as *Parectypodus lovei* from the Badwater Creek Local Fauna in Wyoming. His description was based on partial P $^4/_4$s, although molars were also present in the sample. Additional specimens from the Badwater Creek localities were reported by Krishtalka and Black (1975) along with more complete descriptions. They questioned Sloan's assignment of the species to *Parectypodus* and reassigned it to *Ectypodus* based on a nearly complete P_4.

Krishtalka and Black (1975) noted the presence of a second species, which they identified as *Ectypodus* sp., which was slightly larger and had a bulge on the posterobuccal corner of the M_1. Ostrander (1984) questioned the separation of *Ectypodus* sp. and suggested that the differences were due to the highly variable nature of *Ectypodus lovei.* Storer (1993) supported Ostrander's conclusion of individual variation being the source of the differences. Additional evidence from the Medicine Pole Hills Local Fauna corroborating Ostrander's and Storer's conclusion will be discussed later in the paper.

Geology—The Medicine Pole Hills deposits cap a series of small buttes. Exposures are poor with fossils found in a few blowouts near the butte tops. Nowhere is the deposit exposed in vertical section, but as part of this study, a trench was cut from the top to the lower contact at one locality (V89002). The geologic description of the unit is based primarily on that section. The sandstones and conglomeratic sandstones occur in a series of units, each channeled into the underlying unit. The lowermost unit is channeled into a green mudstone of the underlying Tongue River Formation. Each of the sandstone units tends to be coarser grained at the base, typically containing gray and green mudball clasts and black chert pebbles, grading upsection into cleaner, fine to medium grained, golden-brown to gray quartz-rich sandstones with a significant lithic component (sublitharenite). Bed thickness is variable, from 28 cm to 170 cm with a measured total thickness of just over 6 m (Figure 2). The mudball clasts are typically a few centimeters in diameter, but some very large clasts with intermediate diameters of more than 30 cm were seen. Bedding is variable, from massive in the mudball conglomerates to well-developed, high-angle tabular cross bedding in some of the sandstones. In one unit, the mudballs were not concentrated at the base, but instead were distributed on the cross beds.

The origin of the Medicine Pole Hills deposits is fluvial, probably very rapidly deposited in episodic high flow events. Mudballs were created by bank erosion not too distant from the site of deposition. The amount of time represented by the entire deposit is unknown, but there does not appear to be any faunal difference between the material recovered from the lowermost and that of the uppermost unit (although differences do occur in abundance of fossils).

These sandstones of the Medicine Pole Hills have been interpreted by Murphy et al. (1993) to represent the Chalky Buttes Member of the Chadron Formation. The Chadron Formation, named for a locality near Chadron, Nebraska, is divided into two members in North Dakota, the Chalky Buttes Member and the overlying South Heart Member. In North Dakota, the Chadron

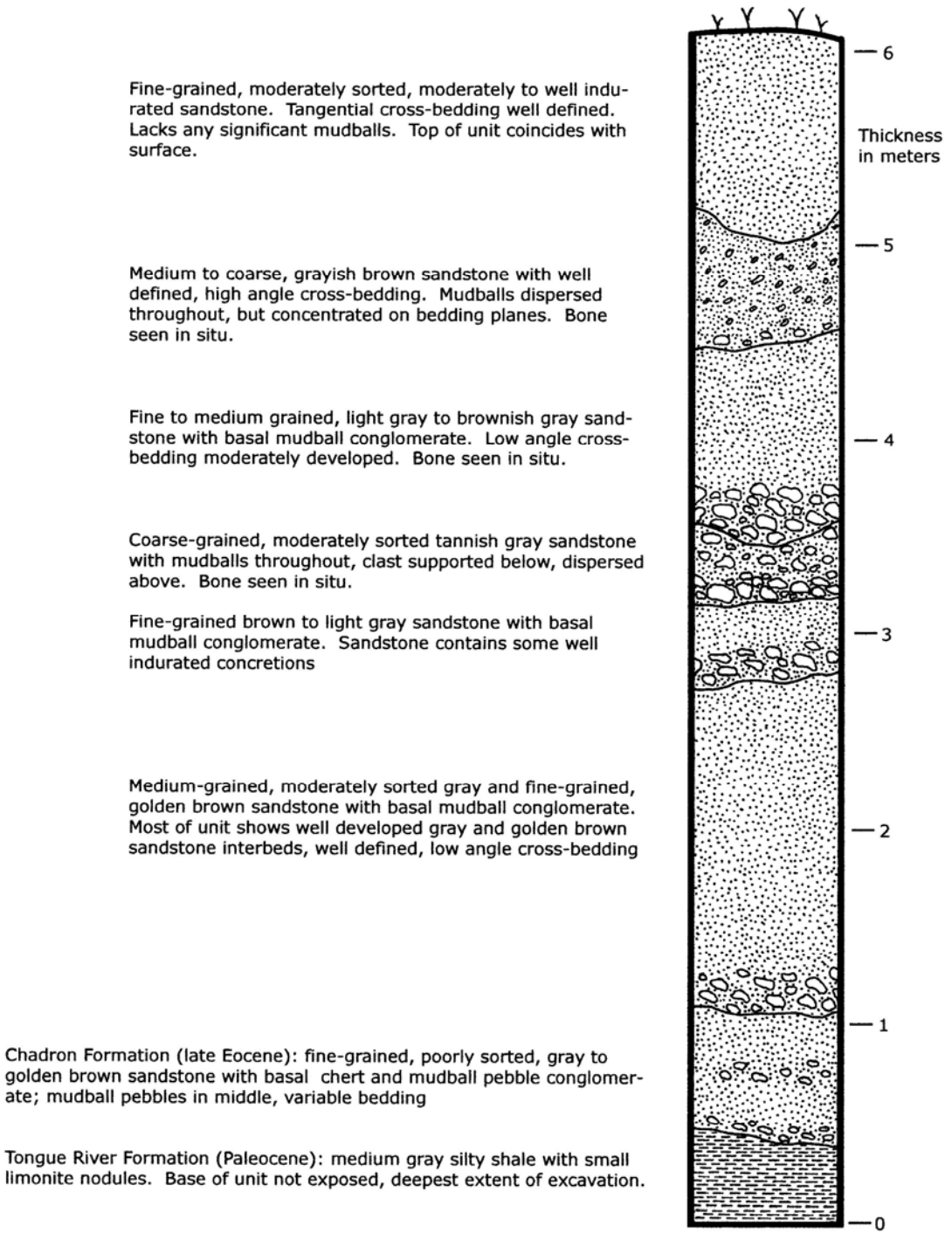

FIGURE 2. Stratigraphic section of V89002.

Formation unconformably overlies the late Paleocene to early Eocene Golden Valley Formation, or the late Paleocene deposits of the Fort Union Group. The Chalky Buttes Member consists of white, gravel-bearing, cross bedded medium to coarse, quartz-rich sandstones with a significant feldspar fraction (subarkose) and sandy mudstones from 3.0 to 25.0 meters in total thickness (Murphy et al., 1993).

The lithology of the Medicine Pole Hills deposits is not similar to the Chalky Buttes Member of the Chadron Formation in North Dakota, and the lithology is not known to occur elsewhere in the state. Although both the Chalky Buttes Member and the Medicine Pole Hills sandstones are conglomeratic, the nature of the large clasts is very different. The Chalky Buttes Member gravel clasts are dominated by igneous cobbles with a significant percentage of sedimentary and metasedimentary clasts. Most of these clasts were transported into southwestern North Dakota from some distant source as there are no outcrops of either igneous or metamorphic rock in the state. The primary clasts in the Medicine Pole Hills conglomerates are mudballs, locally derived from the underlying Tongue River Formation. Less common are chert clasts, which likely are also locally derived from the units of the Fort Union Group and metasediment clasts derived from a more distant source. The sandstones preserved in the Medicine Pole Hills could represent a unique facies of the Chadron Formation, or possibly a sedimentary event separate in time from the deposition of the Chalky Buttes Member. The relationship of the Medicine Poles Hills sandstone to the Chadron Formation and the Chalky Buttes Member is, as yet, unresolved.

Methods—All specimens reported here were collected from the PTRM Locality V89002. The matrix was collected from a single quarry, in stratigraphically controlled horizons. There appears to be no significant difference in the fauna from the lowest part of the section at V89002 to the uppermost unit, so the deposit is believed to represent a limited amount of time. The specimens reported here came from the lowermost to uppermost units of the section, but are treated as a single population. The matrix was screened on-site to remove the coarsest fraction (examined for fossils) and the fine fraction (less than 0.8 mm) which was discarded. The remaining matrix was wet screened (water only) to facilitate breakdown of the sand aggregates, then picked for fossils. Teeth obtained from the matrix were mounted on wire pins and catalogued with PTRM specimen numbers.

Measurements were made with an ocular micrometer on an Olympus SZH 10 binocular microscope. Measurements are given to the nearest 0.01 mm. Measurements for anterior-posterior length (AP) were taken along the long axis of the tooth at the longest portion. The buccal-lingual widths (BL) were taken at the widest part of the tooth perpendicular to the long axis of the tooth. Measurements were taken only on unbroken specimens, except for two specimens where the missing corner was assumed to not extend farther than the preserved end. Abbreviations used in the paper are given in Table 1. Cusp and tooth nomenclature is taken from Krause (1977).

Table 1. Abbreviations used in this paper.

Museum Acronyms		
	PTRM	Pioneer Trails Regional Museum, Bowman, ND
	SDSM	South Dakota School of Mines and Technology, Rapid City, SD
Tooth Descriptions		
	P	Premolar
	M	Molar
	R	Right
	L	Left
		Subscripts indicate lower teeth and tooth position
		Superscripts indicate upper teeth and tooth position
Measurements		
	AP	Greatest Anterior-Posterior Length
	BL	Greatest Buccal-Lingual Width
	HGT	Height, P_4 height as in Krause (1982)
	DPTH	Depth, P_4 depth as in Krause (1982)

SYSTEMATIC PALEONTOLOGY

Class Mammalia Linnaeus, 1758
Order Multituberculata Cope, 1884
Suborder Ptilodontoidea Sloan and Van Valen, 1965
Family Neoplagiaulacidae Ameghino, 1890
Genus *Ectypodus* Matthew and Granger, 1921

Ectypodus lovei (Sloan) 1966
(Figures 3, 4, Table 2)

Referred Specimens—All numbers have the prefix PTRM - P^1 6162, 8221, 8227, 10425, 10429; P^2 4984, 5771, 7672, 7803, 7811, 7813, 8226; P^3 7657, 7804; P^4 2068, 4932, 4934, 4935, 5480, 5901, 7456, 7463; M^1 1962, 2029, 2060, 4840, 4842, 4925, 4928, 5796, 5861, 6156, 6241, 7268, 7451, 7457, 7461, 7673, 7805, 7808, 7814, 8222, 10424, 10428; M^2 4937, 6243, 7807, 7810, 8220, 8224; Mandible 7459; P_4 1328, 4927, 4933, 4938, 5854, 6240, 6242, 6244, 7403, 7460, 7462, 10427; M_1 4841, 4930, 4931, 4936, 5481, 5785, 5806, 5881, 6124, 7458, 7815, 8219; M_2 7806, 7809, 8223, 8225, 10426.

Description

cf P^1 (Figure 3a)—These teeth represent an anterior premolar, but because an associated dentition for *Ectypodus lovei* is unknown, the position of the tooth is uncertain. The tooth is somewhat rectangular with the AP dimension greater than the BL dimension. The anterior end of the tooth is wider than the posterior end. There are three cusps; one main cusp and two smaller anterior accessory cusps. The larger of the two accessory cusps is present along the anterobuccal margin of the tooth and is slightly elongate in the BL dimension. The second accessory cusp is on the anterolingual margin of the tooth. The main cusp is posterior to the two cusps and along the midline of the tooth. It is elongate in the AP dimension, with the posterior portion of the cusp showing more wear than the anterior portion.

cf P^2 (Figure 3b)—These teeth represent an anterior premolar, most likely a P^2. It has a larger AP than BL dimension and one dominant cusp, which is on the buccal margin of the tooth and elongate in the AP dimension. There are three accessory cusps; two are well developed and one is very small. One of the larger accessory cusps is directly anterior to the main cusp. The second large accessory cusp is lingual to the anterior end of the main cusp. The small accessory cusp is lingual to the anterior accessory cusp, anterior to the lingual accessory cusp and may disappear with wear. There are no cusps on the posterior one-third of the tooth. There is a slight cingulum on the anterobuccal corner of the tooth.

cf P^3 (Figure 3c)—These teeth are rectangular in outline with the AP dimension slightly greater than the BL dimension. There are four main cusps on the tooth, with a cusp formula of 2:2 and a series of small accessory cusps along the anterior and buccal margins of the tooth. The cusps of the internal row are pyramidal, equal in size with the posterior cusp and taller than the anterior cusp. The internal row of cusps is on the lingual margin of the tooth. The cusps in the external row are also pyramidal and nearly equal in size and height. The cusps in the internal row are taller than the cusps in the external row. The anterior cusp in the external row is slightly more posterior than the anterior cusp in the internal row. The anterior margin of the tooth is gently convex and on the posterior margin a broad shallow notch is present along the mid-line of the tooth. A small accessory cusp is present on the anterior margin of the tooth, anterior to the anterolingual face of the first cusp in the external row. This anterior accessory cusp may be doubled, or just elongate in the buccal-lingual dimension; the condition cannot be definitively determined due to wear. On the buccal margin is a ridge of enamel on which accessory cusps are present. These accessory cusps are expansions of the enamel ridge as opposed to actual cusps and give the buccal margin a scalloped appearance. The first buccal accessory cusp is buccal to the first cusp in the external row, a second cusp is on the buccal margin between the two cusps in the external row and the third cusp is buccal to the second cusp in the external row. There is a small posterobuccal expansion, so the buccal margin of the tooth extends further posterad than the lingual margin. There is no development of cusps on the posterobuccal expansion.

P^4 (Figure 3d)—The P^4 is gently arched in profile view. The anterior slope is straight and the posterior slope is variable ranging from straight to slightly concave. The lingual margin of the tooth has a gentle, concave shape. The buccal margin has a sharp indentation posterior to the end of the external row which is directly buccal to the third cusp of the internal row. The anterior margin of the tooth significantly overhangs the anterior root. The posterior margin slightly overhangs the posterior root. The cusp formula is 2-?6:5-6:0. The external row is highly variable with two to ?six cusps. There is no relation between the number of cusp in the external row and the number of cusps in the internal row. If only two cusps are present in the external row, they are in line AP with each other. If three cusps are present, their orientation ranges from all three cusps directly in line with each other to two cusps anterior with the third cusp posterior and between the two anterior cusps. When there are more than three cusps, typically three of the cusps are large with the remaining cusps very small. The cusps are arranged in two rows with the larger cusp typically found in the more internal of the rows. The cusps in the external row are low, rounded, mounds of enamel and the larger cusps in the more internal row are conical. The medial row is less variable with five or six cusps. If there are five cusps, the first cusp is slightly elongate in the AP dimension, the first three cusps are widely separated and the fourth and fifth cusps are close together. If there are six cusps, the first two cusps are close together giving the appearance of the first cusp being doubled. When there are six cusps, the third cusp is widely separated

FIGURE 3. Composite dentition of *Ectypodus lovei* from the Medicine Pole Hills Local Fauna. Upper dentition, occlusal view: a, PTRM 8221 right P^1; b, PTRM 7811 left P^2 (reversed in figure); c, PTRM 7804 left P^3 (reversed in figure); d, PTRM 5480 right P^4; e, PTRM1962 right M^1; f, PTRM 4937 right M^2. Lower dentition, occlusal view: g, PTRM 1328 right P_4; h, PTRM 7458 right M_1; PTRM 7809, right M_2. Bar scale is approximately 1 mm in length.

from all other cusps in the row. The penultimate cusp is the tallest, but the antepenultimate and penultimate cusps become the same height with wear. There is no development of cusps in the internal row or on the posterolingual expansion.

M^1 (Figure 3e)—The M^1 is nearly rectangular in occlusal outline. In lateral view, the tooth is concave dorsally. The cusp formula is 8-6:8-9:3-6 and is highly variable. The most common number of cusps for each row is seven in the external row, nine in the medial row and five in the internal row. The external row of cusps is along the buccal margin of the tooth. The cusps in the external row are pyramidal when unworn and have an elongate AP dimension. The anterior-most cusp of the external row is joined to the anterior-most cusp of the medial row by a ridge on the anterior margin of the tooth. The medial row is the longest. The cusps are crescentric and increase in size posteriorly. The internal row is the most variable with regards to the number and the size of the cusps. The most posterior cusp in the internal row is the largest and is typically connected to the most posterior cusp in the medial row by a thin ridge. The first cusp in the internal row is generally very small and may represent a short ridge rather than a rounded cusp. The internal row originates on the buccal margin of the fourth cusp of the medial row.

M^2 (Figure 3f)—The M^2 is triangular in occlusal outline with the posterior margin forming the apex of the triangle. The anterior margin is straight to slightly concave and the posterior margin is rounded. The buccal margin is straight to gently convex and the lingual margin is virtually straight with both margins obliquely oriented to the AP axis of the tooth. The cusp formula is 1:3:3. The single cusp in the external row is posterior to the anterobuccal corner. It is not a distinct cusp, but rather an expansion of a ridge which is continuous for most of the anterior and buccal margins of the tooth. The anterior portion of the ridge along the anterior margin of the tooth is connected to the first cusp in the medial row and ends at the first cusp in the external row. The buccal portion of the ridge attaches to the second cusp in the medial row and the ridge narrows and drops in elevation on the buccal face of the first cusp in the medial row. In the medial row, the first cusp is very compressed in the AP dimension causing it to appear as an expansion of the anterior ridge. The second cusp in the medial row is the largest cusp of the tooth. The third cusp in the middle row is well developed, but is not as large as the second cusp. The second and third cusps in the medial row are crescentric with the third cusp more crescentric than the second cusp. The internal row is along the lingual margin of the tooth and is the longest row. The cusps are crescentric and decrease in size posteriorly. A thin ridge on the lingual side of the cusps connects the three cusps of the internal row.

Table 2. Measurements of *Ectypodus lovei* from the Medicine Pole Hills Local Fauna.

Tooth	Parameter	N	OR	Mean	SD	CV
P^1	AP	5	0.82-1.10	0.95	0.103	10.87
	BL	5	0.58-0.68	0.64	0.048	7.49
P^2	AP	7	0.97-1.19	1.07	0.085	7.92
	BL	7	0.58-0.63	0.60	0.022	3.65
P^3	AP	2	0.85-0.93	0.89	0.057	6.36
	BL	2	0.71-0.68	0.70	0.021	3.05
P^4	AP	6	1.81-1.91	1.85	0.034	1.85
	BL	6	0.76-0.90	0.82	0.057	6.93
M^1	AP	19	2.00-2.49	2.21	0.155	7.03
	BL	19	0.97-1.32	1.17	0.092	7.87
M^2	AP	6	1.07-1.17	1.10	0.373	3.39
	BL	6	1.05-1.37	1.19	0.133	11.17
P_4	AP	4	2.58-3.25	2.99	0.293	9.81
	BL	4	0.82-1.14	0.97	0.140	14.43
	HGT	4	0.84-1.33	1.15	0.222	19.33
	DPTH	1	1.14			
M_1	AP	10	1.51-1.81	1.72	0.098	5.68
	BL	10	0.85-1.10	0.95	0.074	7.78
M_2	AP	4	0.97-1.24	1.06	0.121	11.38
	BL	5	0.90-1.17	1.04	0.102	9.83

Mandible (Figure 4a, b)—PTRM 7459 is a partial right mandible. The incisor is broken off at the base, with part of the incisor remaining in the alveolus. A partial P_4 is present, as well as the alveoli for the M_1 and M_2. The mandible is broken at the posterior alveolus of the M_2, so nearly all of the ascending ramus is absent. The ventral border of the mandible is convex from the incisor alveolus to a position below the posterior edge of the P_4. The ventral border posterior to the P_4 is virtually straight with a very small degree of convexity. The anterior portion of the masseteric fossa

is preserved and is well developed. The height of the anterior portion of the mandible is nearly one-half the height of the mandible in the location of the molars. The tooth row is obliquely oriented to the AP axis of the mandible. The anterior edge of the P_4 slightly overhangs the mandible buccally. The lingual surface of the dentary is gently concave. The diastema between the incisor and P_4 is approximately 2.1 mm from the alveolus of the incisor to the anterior root of the P_4.

P_4 (Figure 3g, 4c, d)—The P_4 is large and blade-like with eight serrations and one pseudoserration. The crown is high and arched in lateral profile view. The anterior margin is more arcuate than the posterior margin and the leading edge of the tooth below the pseudoserration is nearly straight. The angle of the posterodorsal corner and vertical posterior border is approximately 134˚. There is a well defined posterobuccal ledge which descends from the most posterior serrations. There is no development of cusps on the ledge. No bifurcation of the ridges is seen and the distance between the ridges increase posteriorly. The ridges are better developed on the buccal side of the tooth than on the lingual side with no distinct ridges associated with the last two serrations on the lingual side of the tooth. The first serration is virtually straight with all other serrations curving posteriorly. The third serration is the highest of all the serrations. The exodaenodont lobe is well developed and extends for nearly one-half the length of the anterior root.

M_1 (Figure 3h)—The M_1 is somewhat rectangular in outline with the anterior margin rounded. A small expansion on the posterobuccal corner of the tooth causes the posterior margin of the tooth to be obliquely oriented, with the buccal margin of the tooth longer than the lingual margin. The buccal margin is variable, ranging from virtually straight to the presence of a well developed bulge. If the bulge is present, it begins around the position of the fourth cusp in the external row. The cusp formula is 7:4-5. The cusps of the external row are slightly crescentric and are fairly consistent in size from front to back. The cusps in the internal row are pyramidal, slightly elongate in the AP dimension and increase in size posteriorly. If five cusps are present in the internal row, the first cusp is minute.

M_2 (Figure 3i)—The M_2 is somewhat triangular in outline. The anterior and buccal margins are virtually straight. The lingual margin is convex for the anterior half of the tooth and is obliquely oriented for the posterior half of the tooth. The cusp formula is 2:4. The cusps in the internal row are very large with the first cusp larger than the second cusp. The first cusp is slightly crescentric and "curls" posterad (in lateral view). The second cusp has a small ridge which extends off the posterior side of the cusp and parallels the posterolingual margin of the tooth. The posterior ridge appears to have two small cuspules, but these are entirely lost with wear. The development of the ridge appears to be variable. The internal row of cusps is on the lingual margin of the tooth. The external cusps are smaller than the cusps in the internal row and are approximately one-half the size of the internal cusps. The cusps of the external row are compressed in the AP dimension. They also have the appearance of curling posterad (in lateral view). The first three cusps are very similar in size and morphology. The last cusp in the external row has a slightly larger AP dimension and a ridge which extends off the posterior side of the cusp. The cusps in the external row are on the buccal margin of the tooth.

Discussion—All small multituberculates from post-Bridgerian rocks have been assigned to *Ectypodus lovei* and nothing in the Medicine Pole Hills sample suggests otherwise. The Medicine Pole Hills sample is the largest known sample of *E. lovei*, containing 80 specimens and nearly doubles the total known M^1s of *Ectypodus lovei*. The morphology and size range of the teeth in the Medicine Pole Hills sample match that of *Ectypodus lovei* as described by Storer (1993) with only a few minor differences. The cusp formula for the internal row of the P^4 is slightly higher than in previously described samples of *E. lovei.* This may be due to the larger sample size from the Medicine Pole Hills rather than an actual difference between *Ectypodus* from the Medicine Pole Hills and *E. lovei* from other localities. There is also a slightly lower cusp count for the external row on the M^1, but this is well within the range of variation for *E. lovei*.

The Medicine Pole Hills sample adds a significant amount of new information about *E. lovei* due to the large sample size and complete dental arcade. The sample includes the first known anterior upper premolars. The lack of associated teeth allowed for only tentative assignments for tooth positions of the P^1 and P^2. Although a P^3 has never been described for the species, a more confident assignment of P^3 can be made due to the similarity of these teeth to the P^3 of *Ectypodus tardus*. Ostrander (1984) identified possible premolars of an indeterminate multituberculate from the Raben Ranch Local Fauna (SDSM 10433, 10434, 10397, 10514 and 10515); based on physical comparison, these specimens most likely represent anterior premolars of *E. lovei*.

The Medicine Pole Hills sample also has the first complete P^4s known for *E. lovei*. A nearly complete P^4 from the Badwater Creek Local Fauna has a posterior slope which is straight and short with the possible development of a posterobasal cuspule. Based on these features (and other features of P_4), Krishtalka and Black (1975) transferred the species from *Parectypodus* to *Ectypodus*. The P^4 specimens from the Medicine Pole Hills support Krishtalka and Black's reassignment, based on the morphology of the posterior slope, but

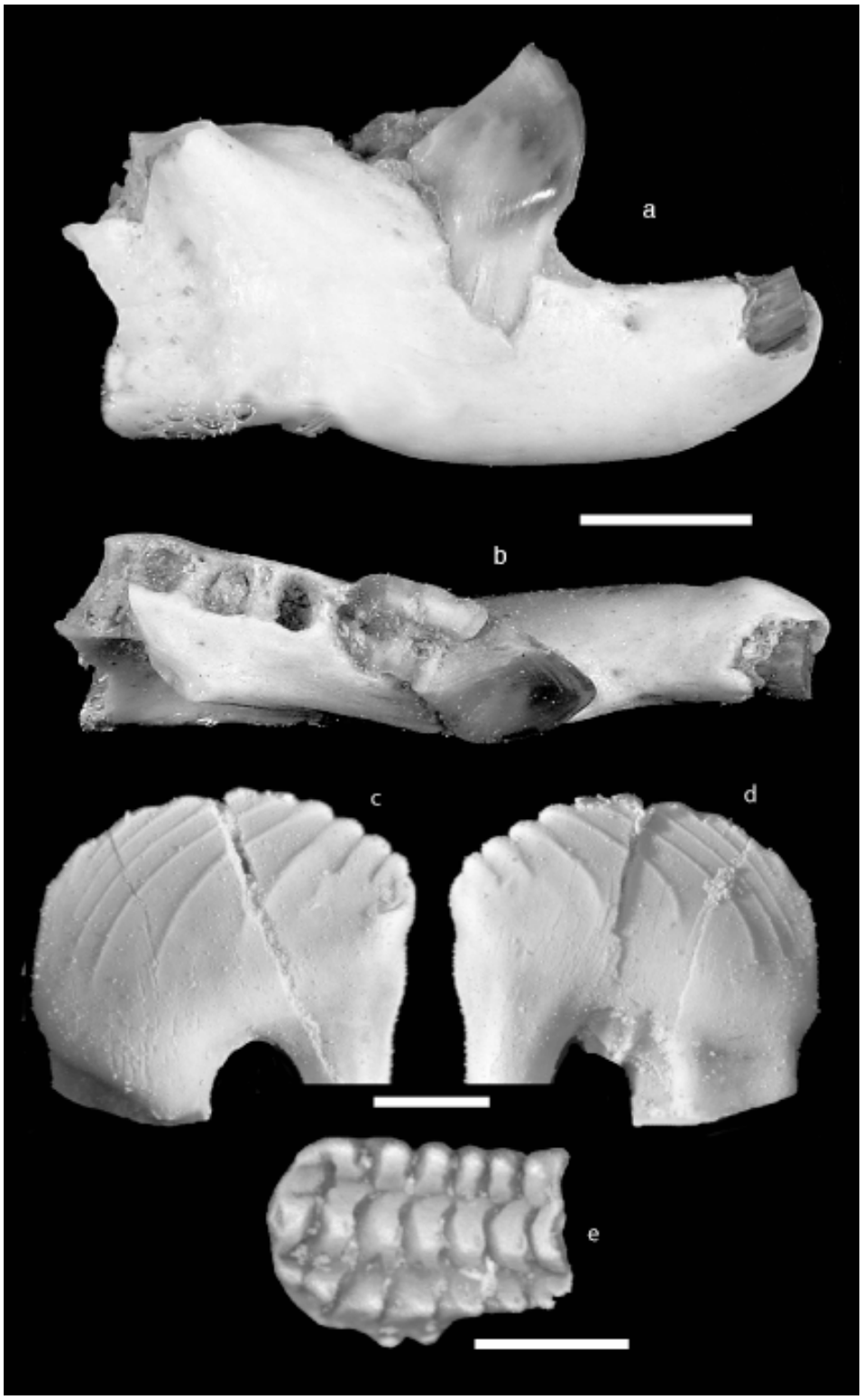

FIGURE 4. *Ectypodus lovei* and ?Neoplagiaulacidae gen. et sp. indet. from the Medicine Pole Hills Local Fauna. *Ectypodus lovei*, a, PTRM 7459, right mandible, buccal view; b, PTRM 7459 occlusal view. Bar scale is approximately 2 mm in length. *Ectypodus lovei*, c, PTRM 10427 left P_4, buccal view; d PTRM 10427 lingual view. Bar scale is approximately 1 mm in length. ? Neoplagiaulacidae gen. et sp. indet., e, PTRM 7812, partial right M^1, occlusal view. Bar scale is approximately 1 mm in length.

unlike their description, the P^4s from the Medicine Pole Hills sample show no development of a posterobasal cuspule. There is a well developed posterobuccal expansion, but no cuspules are present on this expansion. Ostrander (1984) described a partial P^4 (SDSM 9964) of an indeterminate multituberculate from the Raben Ranch Local Fauna. This tooth can be also be assigned to *E. lovei* based on physical comparison with complete specimens.

The Medicine Pole Hills sample contains the first partial dentary reported for the species. The lack of an alveolus for the P_3 is consistent with other species of *Ectypodus* such as *E. tardus* (Krause, 1982). Krishtalka and Black (1975) transferred the species from *Parectypodus* to *Ectypodus* based on the morphology of a nearly complete P_4, which showed a straight anterior slope, characteristic of *Ectypodus*, rather than a convex anterior slope that is characteristic of *Parectypodus*. The complete P_4 specimens from the Medicine Pole Hills have a virtually straight anterior margin supporting the assignment of the specimens to *Ectypodus*.

Krishtalka and Black (1975) also discuss "the angle formed at the posterodorsal corner of the P_4 between the slope and vertical posterior border of the blade" which is definitive of certain genera. The specimens from the Badwater Creek Local Fauna have a posterior angle of approximately 120˚ which is consistent with *Ectypodus*. Ostrander (1984) questioned this statement with angle measurements of partial specimens from the Raben Ranch Local Fauna ranging from 120˚-135˚. The specimens from the Medicine Pole Hills sample show this slightly larger posterior angle measurement, similar to that of the Raben Ranch specimens.

Krishtalka and Black (1975) identified a second multituberculate species from the late Eocene, which they called *Ectypodus* sp., based on a slightly larger tooth size, higher cusp formula and a bulge on the external margin of the M_1 when compared to *E. lovei*. Ostrander (1984) questioned this separation and Storer (1993) concluded the differences were due to individual variation. M_1 specimens from the Lac Pelletier Lower Fauna are in the size range of the Badwater sample of *E. lovei*, but show the higher cusp formula attributed to *Ectypodus* sp. Specimens from the Medicine Pole Hills sample do not show two distinct morphologies, i.e., a bulge on the external margin or a straight external margin, but rather a continuum from a straight external margin to a well developed bulge on the external margin. As in the Lac Pelletier specimens, there is no correlation between cusp count, size, and the presence of the bulge. The Medicine Pole Hills sample supports the conclusions made by Ostrander and Storer that *Ectypodus* sp. from the Badwater localities is not distinct from *Ectypodus lovei*.

Based on the three most abundant samples, Storer (1993) suggested that there is a gradual increase in mean size of *E. lovei* from the late Uintan into the Chadronian. The Medicine Pole Hills sample generally supports the trend of increase in mean size. The average AP and BL dimensions of the M^1s are intermediate between the Badwater (localities 5 and 6) and Raben Ranch samples. However, the average AP and BL dimensions of the M^2s are greater than those for the Raben Ranch sample and the Medicine Pole Hills sample of M_2s has a greater AP dimension and a smaller BL dimension. The overall increase in average size noted by Storer is very small, and validation of this trend requires additional *E. lovei* specimens and additional samples. It is also possible that the determination of the Medicine Pole Hills sample as early Chadronian could be incorrect. Any revision in the age of the fauna would require a reevaluation of the size trends in *Ectypodus lovei*.

A trend of increased cusp development may be present on the M^2. The first cusp in the medial row on the M^2 of specimens from Badwater Creek (Uintan to Duchesnean) appears to be only an expansion of an anterior ridge (based on comparison photographs and not physical comparison). This is true of the Medicine Pole Hills specimens; however there is a more distinct development of the anterior cusp. The specimens from Raben Ranch (medial Chadronian) show a distinct anterior cusp which is incorporated into the anterior ridge. This is only a preliminary observation due primarily to the lack of specimens. Only 15 M^2s are known from six localities, with 6 from the Medicine Pole Hills. Additional specimens are needed to substantiate this trend.

?Neoplagiaulacidae gen. et sp. indet.

Referred Specimen—M^1 PTRM 7812

Description—PTRM 7812 (Figure 4e) is a broken M^1 representing the posterior three-quarters of the tooth. On the preserved portion the cusp formula is 6:7:6 with two small cuspules extending off the buccal margin of the tooth. The cusps in the internal row are conical although slightly compressed in the AP dimension. There is only a slight increase in cusp size from anterior to posterior. The cusps in the medial row are compressed in the AP dimension and are larger than the cusps in the internal and external rows. The cusps increase in size from anterior to posterior. The cusps in the external row are slightly crescentric with a slight increase in size posteriorly . There are two small accessory cuspules buccal to the external row of cusps. The accessory cuspules are very small, low and conical. The accessory cuspules are buccal to the second and third to last cusps in the external row. The specimen has a width of 1.37 mm. A length measurement is not possible.

Discussion—The fragment of the M^1 is much larger than M^1s of *E. lovei* in the Medicine Pole Hills Local Fauna (BL width of 1.37 mm compared to an average of 1.16 mm for *E. lovei*), but is not complete enough to determine the full cusp formula. The number of cusps on the preserved portion of the tooth suggest that the cusp formula would be significantly higher than the cusp formula for *Ectypodus lovei*. Based on the combination of a larger size and supposed higher cusp count, the specimen is more likely to represent a distinct species and not a variant condition of *Ectypodus lovei*. The specimen most likely represents a neoplagiaulacid, but not enough diagnostic characteristics are preserved for a precise identification.

Storer (1993) reported a large ?neoplagiaulacid from the Lac Pelletier based on a partial P^4 and complete M^2. He described the specimens as "much larger than other material from the Lac Pelletier Lower Fauna" and stated that it is larger than all other Eocene multituberculates except *Neoliotomus ultimus*. He believes that the material almost certainly represents a neoplagiaulacid.

The Medicine Pole Hills specimen is similar to ?Neoplagiaulacidae gen. et sp. from the Lac Pelletier lower fauna in that it is large in size. However, due to the extremely small sample size from both faunas and no comparable teeth, the Medicine Pole Hills specimen cannot be considered to represent the same species (or even genus) until additional material is found.

SUMMARY

The Medicine Pole Hills Local Fauna is a diverse microfauna from the Chadronian of North Dakota. The multituberculate specimens assigned to *Ectypodus lovei* are only the third known occurrence of the species during the early Chadronian and the first sample to be described. The Medicine Pole Hills specimens match the published descriptions of *E. lovei* with the only differences being a slightly lower cusp formula on the M^1 and a higher cusp count for the external row of the P^4.

The Medicine Pole Hills sample is the largest known with 80 specimens which can be assigned to *E. lovei*. The morphology of the complete P^4s support assignment of the species to *Ectypodus* as suggested by Krishtalka and Black (1975). The large sample size also allows for a better assessment of individual variation, supporting the idea that only one species is present at the Badwater Creek Localities as discussed by both Ostrander (1984) and Storer (1993). The lack of correlation between cusp count, size and morphology of the external margin on the M_1s in the Medicine Pole Hills sample supports this idea. Storer (1993) suggested the presence of a slight increase in size from the Duchesnean to the middle Chadronian for the species. Measurements of the Medicine Pole Hills specimens show average dimensions for some teeth to be intermediate between older and younger samples, but this is not true of all teeth. Finally, a possible increase in the development of the first cusp in the medial row of the M^2 is seen over time although additional specimens are needed to substantiate this idea.

The Medicine Pole Hills Local Fauna also shows the presence of a possible second species of multituberculate, ?Neoplagiaulacidae gen. et sp. indet. which is larger and has a higher cusp count than *E. lovei* from the Medicine Pole Hills. *Ectypodus lovei* also lacks the two buccal accessory cuspules which are present in ?Neoplagiaulacidae gen. et sp. indet. The specimen may or may not represent the same species of neoplagiaulacid noted by Storer (1993) from the Lac Pelletier lower fauna, but until additional specimens are found, the Medicine Pole Hills specimen should be considered distinct from the Lac Pelletier lower fauna specimens.

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