

ADDITIONAL SMALL MAMMALS FROM THE OLIGOCENE BRULE FORMATION (LATE ORELLAN-WHITNEYAN) OF SOUTHWESTERN NORTH DAKOTA

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ABSTRACT

Several recently published studies documented much of the micromammal portion of the Oligocene faunas recovered from the Fitterer Ranch and Obritsch Ranch localities in Stark County, North Dakota. That work identified four stratigraphically segregated faunas that range in age from latest Orellan to late Whitneyan. This study reviews the remaining micromammals from those localities, the leptictids and lipotyphlans, recognizing the presence of ten taxa. One species, *Mystipterus austinae* (Talpidae, Uropilinae), is new and represents the earliest occurrence of the genus. In addition to *Leptictis dakotensis*, the presence of a new leptictid taxon is documented but is not named pending a detailed revision of that group. The recognition of the erinaceid *Amphechinus horncloudi* represents the earliest occurrence of this species, which was previously restricted to the Arikarean. Four other taxa previously known from older faunas are identified, extending their known ranges into the Whitneyan (*Centetodon marginalis*, *Cryptoryctes* sp., cf. *C. kayi*, *Domnina gradata*, and *Oligoscalops galbreathi*). With the incorporation of the data from this study, the well-sampled micromammal faunas from Fitterer Ranch and Obritsch Ranch provide important information for evaluating broader patterns of micromammal evolution, dispersal, and extinction within the Great Plains region of North America.

INTRODUCTION

The stratigraphy and age of Fitterer Ranch and Obritsch Ranch localities in southwestern North Dakota is described and detailed sections provided elsewhere (Skinner, 1951; Stone, 1973; Murphy et al., 1993; Korth et al., 2019a, 2019b, 2021a; Boyd et al., in press). Both localities are stratigraphically situated within the Brule Formation (White River Group) and are predominantly Whitneyan in age with only the basal stratum at Fitterer Ranch being questionably latest Orellan or earliest Whitneyan (Korth et al., 2019a, 2019b). In a recent series of papers, the marsupials (Korth et al., 2021a), rodents (Korth et al., 2019a, 2019b) and lagomorphs (Boyd et al., in press) from these localities have been described in detail. The only groups of micromammals that remain undescribed are those discussed here: the leptictids and lipotyphlans.

Terminology—*Dental terminology* follows that of Rich (1981). *Stratigraphic Terminology*: Sampling intervals cited in this study correspond to those used by Korth et al. (2019a, 2019b, 2021a) and were based on the stratigraphic units first defined by Skinner (1951) for the White River Group at Fitterer Ranch. The discreet, temporally segregated faunas defined by Korth et al. (2021a) in the study area are applied in this study, though we modify Obritsch Ranch Fauna B to include specimens from Fitterer Ranch sampling interval 7 for

the purposes of this study. *Biostratigraphic Terminology*: The North American Land Mammal Ages (NALMA) used in this study follow the terminology and definitions of Prothero and Emry (2004).

Measurements—All measurements taken with optical micrometer to nearest 0.01 mm.

Abbreviations—(for dentitions) C/c, upper/lower canine; P/p, upper/lower premolar; M/m upper/lower molar. (for institutions) NDGS, North Dakota Geological Survey; USNM, United States Museum of Natural History (Smithsonian).

SYSTEMATIC PALEONTOLOGY

Order Leptictida McKenna, 1975

Family Leptictidae Gill, 1872

Genus *Leptictis* Leidy, 1868

Leptictis dakotensis (Leidy, 1868)

Figure 1; Table 1

Referred Specimens—NDGS 9905, cranium lacking anterior rostrum, orbital walls, and zygomatic arches with left P4-M3 and right P5-M3; NDGS 9593, left maxilla with M1-M2; NDGS 9579, right P4; NDGS 9585, left M1; NDGS 9666, right M3; NDGS 9665, partial right M3; NDGS 9575, left dentary with p4, m1-m2, partial m3; NDGS 9573, dentary fragment with dp5 (p5 erupting); NDGS 9907, partial right dentary with p4-m1; NDGS 9906, partial left dentary with m2-m3;

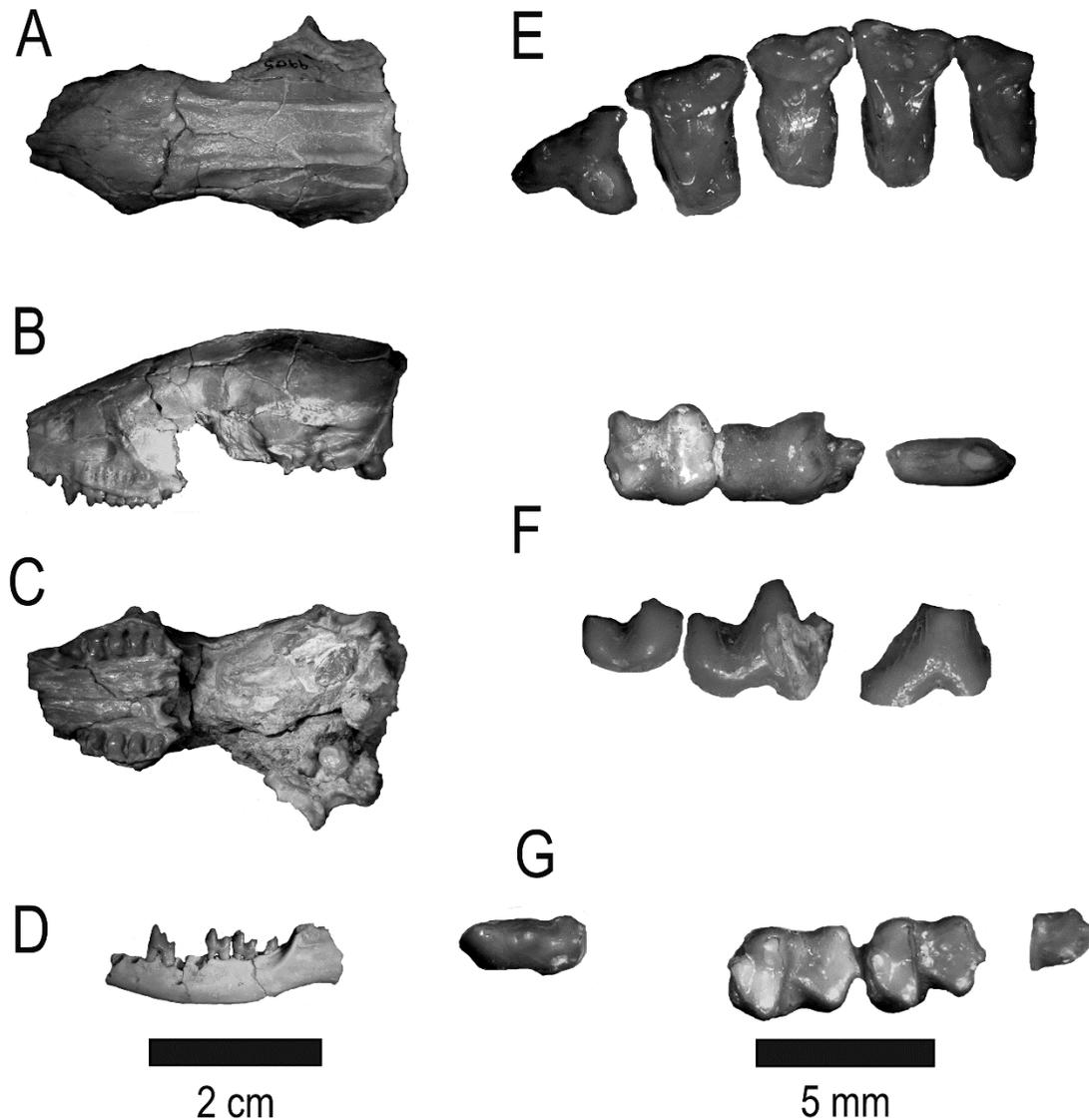


FIGURE 1. *Leptictis dakotensis* from the Whitneyan of North Dakota. A-C NDGS 9905, cranium. A, dorsal view. B, left lateral view. C, ventral view. D, NDGS 9575, lateral view of dentary. E, NDGS 9905, left P4-M3. F, NDGS 9907, right p4-m1 (occlusal view above, labial view below). G, NDGS 9575, left p4, m1-m3(partial). A-D to same scale (below left); C-H to different scale (below right).

NDGS 9574 right dentary fragment with m2; NDGS 9577, right dentary fragment with m3; NDGS 9605, 9664, isolated m1 or m2.

Occurrence—Fitterer Ranch sampling intervals 2, 4, and 5; Obritsch Ranch sampling interval 1 (NDGS 9593 only).

Discussion—The specimens from Fitterer Ranch and Obritsch Ranch best fit *Leptictis dakotensis* based on size and morphology of the cheek teeth (Douglass, 1905: 223; Scott and Jepsen, 1936: 19, 20; Novacek,

1976: tables 1, 2). The only other species of similar size and occurrence is *L. haydeni* Leidy, 1868, (type species of the genus) which is only known from the holotype and differs from *L. dakotensis* in dental morphology in the lack of a distinct protocone on P4. None of the specimens of upper dentitions referred here have this morphology of P4. *L. dakotensis* is previously reported from both the Chadronian through Whitneyan (Clark et al., 1967; Evanoff et al., 1992; Gunnell et al., 2008a) and possibly Arikareean (Simpson, 1985).

TABLE 1. Dental measurements of *Leptictis dakotensis* from Fitterer and Obritsch ranches, North Dakota. Measurements in mm. *, tooth present but unmeasurable. **, m1 or m2. **L**, anteroposterior length; **W**, transverse width.

NDGS #	P4L	P4W	P5L	P5W	M1L	M1W	M2L	M2W	M3L	M3W	M1-M3
9585					3.23	4.49					
9593					3.62	4.47	3.14	4.19			
9579	4.17	2.51									
9905	3.56	2.76	3.40	4.03	2.74	4.42	2.68	4.56	2.11	3.77	7.79
9905			3.19	3.84	2.73	4.06	2.61	4.28	1.83	3.43	7.59
9665									*	*	
9666									2.18	3.27	
Mean	3.87	2.64	3.30	3.92	3.18	4.42	2.99	4.44	2.04	3.49	7.99
	p4L	p4W	p5L	p5W	m1L	m1W	m2L	m2W	m3L	m3W	
9577									3.25	2.11	
9575	4.55	1.42			3.62	2.72	3.56	2.80	3.00		
9574							3.62	2.69			
9573											
9906							2.84	2.35	3.19	2.22	
9907	3.55	1.19	3.88	2.14	2.86	2.38					
9605**					3.50	2.65					
9664**					3.44	2.53					
Mean	4.05	1.31	3.88	2.14	3.36	2.57	3.34	2.61	3.15	2.17	

Genus and species undetermined

Referred Specimens—NDGS 724, left maxilla with P5-M2; NDGS 9578, dentary fragment with p5.

Occurrence—Fitterer Ranch sampling interval 2 (Fitterer Ranch Fauna A).

Discussion—These two specimens will be described and figured elsewhere as a part of a larger study of late Eocene to Oligocene leptictids currently in progress. The unique characters of these specimens that separate them from those of *L. dakotensis* are the development of the ectocingulum and styler cusps on the upper cheek teeth and the size and proportions of p5.

Order Lipotyphla Haeckel, 1866
 Family Geolabididae McKenna, 1960
 Genus *Centetodon* Marsh, 1872
Centetodon marginalis (Cope, 1873)
 Figure 2; Table 2

Referred Specimens—USNM PAL 768790, right M1; NDGS 9587, left M3; NDGS 9601 left dentary with p4-m2; NDGS 9602, left dentary fragment with m2

(partial)-m3; NDGS 9588, 9600, 9603, dentary fragment with m3.

Occurrence—Fitterer Ranch sampling intervals 4 and 5 (Fitterer Ranch Fauna B).

Discussion—The dental morphology of *C. marginalis* has been described in detail previously by Lillegraven et al. (1981). The specimens from Fitterer Ranch fit this description and have the distinctive splayed roots diagnostic of *C. marginalis* in the single specimen of M3 (NDGS 9587). Elsewhere this species is limited to the Orellan (Lillegraven et al., 1981: appendix 1; Gunnell et al., 2008b: 105). This is the first reported occurrence of this species from the Whitneyan NALMA.

Family Erinaceidae Fischer de Waldheim, 1817
 Genus *Ocajila* Macdonald, 1963
Ocajila macdonaldi Korth, 2022
 Figure 3; Table 2

Referred Specimens—NDGS 2433, right M1; NDGS 9660 right M2; NDGS 9657, partial left dentary with i1, i2, c1 and alveoli for i3, p1, p2; NDGS 9564, right dentary with p4-m3; NDGS 9589, 9596, dentary

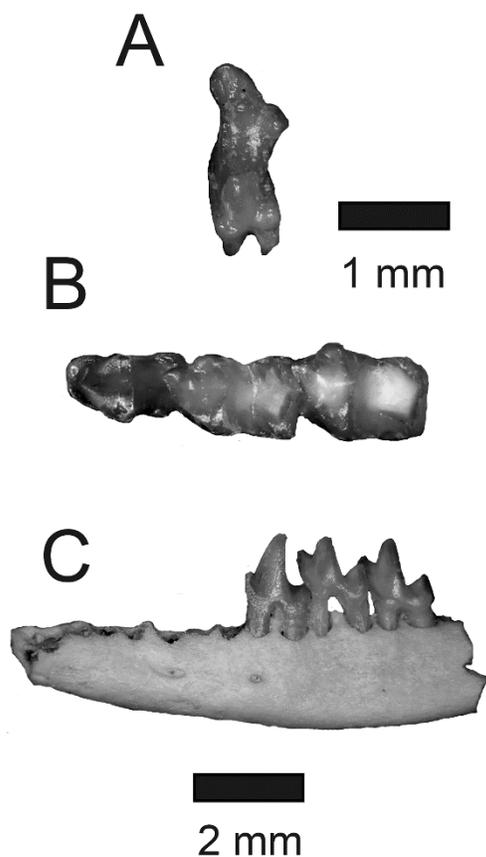


FIGURE 2. *Centetodon marginalis* from the Whitneyan of North Dakota. A, NDGS 9587, left M3. B, C NDGS 9601. B, left p4-m2. C, labial view of dentary. A and B to above scale; C to scale below.

with m1-m3; NDGS 9586, partial right dentary with heavily worn m2-m3; NDGS 9631, partial right dentary with right p3-p4; NDGS 9591, right dentary fragment with p4; NDGS 2434, left m1; NDGS 9565, dentary fragment with m2; NDGS 2482, m2.

Occurrence—Fitterer Ranch sampling intervals 2, 4, and 5 (Fitterer Ranch Faunae A and B); Obritsch Ranch sampling interval 2 (Obritsch Ranch Fauna B).

Description—The dentary is slender; the ventral margin generally parallels the alveolar margin and is deepest ventral to the molars. The mental foramen is only preserved on a single specimen, NDGS 9631, and is ventral to the p3, just dorsal to mid-depth of the dentary. The ascending ramus is best preserved on NDGS 9565. It arises posterior to the alveolus for m3. The anterior margin is nearly vertical, angling only slightly posteriorly. The masseteric scar is shallow and extends anteriorly but ends well posterior to the posterior edge of the alveolus for m3.

NDGS 9657 preserves the anterior portion of the dentary and retains i1, i2, c1 and the alveoli for i3, p1,

and p2. The preserved incisors have elongated crowns that project anteriorly and only slightly dorsally. The i1 is slightly larger and longer than i2 and is more spatulate. The i2 is much narrower but equally as long as i1. The alveolus for i3 is also oriented anterodorsally as in the other incisors. The alveolus is approximately the same size as that for i2. The canine is more vertically oriented than the incisors but is angled slightly anterodorsally and dominated by a single conical cusp. It is oval in occlusal outline and slightly longer than wide. There is a small heel along the posterior margin. There are two additional small alveoli posterior to the canine for p1 and p2.

The p3 is markedly smaller than p4, is two-rooted, and consists of a central globular cusp with a minute anterostylid and a narrow posterior cingulum that spans the width of the tooth. The p4 is dominated by a large central protoconid that is relatively rotund. There is a minute cusp (paraconid) at the center of the anterior margin. The metaconid is markedly smaller and lower than the protoconid and situated on its posterolabial slope, connected by short postprotocristid. The talonid does not have any distinguishable cusps but is an elevated ridge that crosses the posterior edge of the tooth and is continuous with a low labial cingulid that wraps around the labial side of the tooth onto the anterior base of the tooth, ending ventral to the anterostylid.

As in the premolars, all of the cusps of the molars are round and inflated. All of the lower molars have a distinct cingulid that wraps around the base of the teeth from a point ventral to the paraconid, runs along the labial base of the tooth, and rises along the posterior side of the tooth to join a small hypoconulid at the center of the posterior margin. The molars decrease in size from m1 to m3. The trigonid of m1 is nearly as wide as the talonid and anteroposteriorly compressed, with only a narrow lingual opening between the paraconid and metaconid. The protoconid is the highest cusp with the metaconid and paraconid being slightly lower and of nearly equal size. The paraconid is slightly obliquely compressed, whereas the protoconid and metaconid are round in occlusal outline. The talonid is slightly lower than the trigonid and is squared posteriorly. The hypoconid is slightly crescentic at the posterolabial corner of the tooth, and the entoconid is round and at the posterolingual corner of the tooth. There is a minute hypoconulid along the posterior margin of the tooth at its center where the posterior cingulid rises to meet it. The talonid basin is open both lingually and labially by narrow valleys that separate the metaconid and entoconid (lingually) and protoconid and hypoconid (labially). The cristid obliqua runs anteriorly from the hypoconid but ends before joining the poster margin of the trigonid labial to the apex of the protoconid.

The m2 is only slightly smaller than m1 and nearly rectangular in occlusal outline. The paraconid is

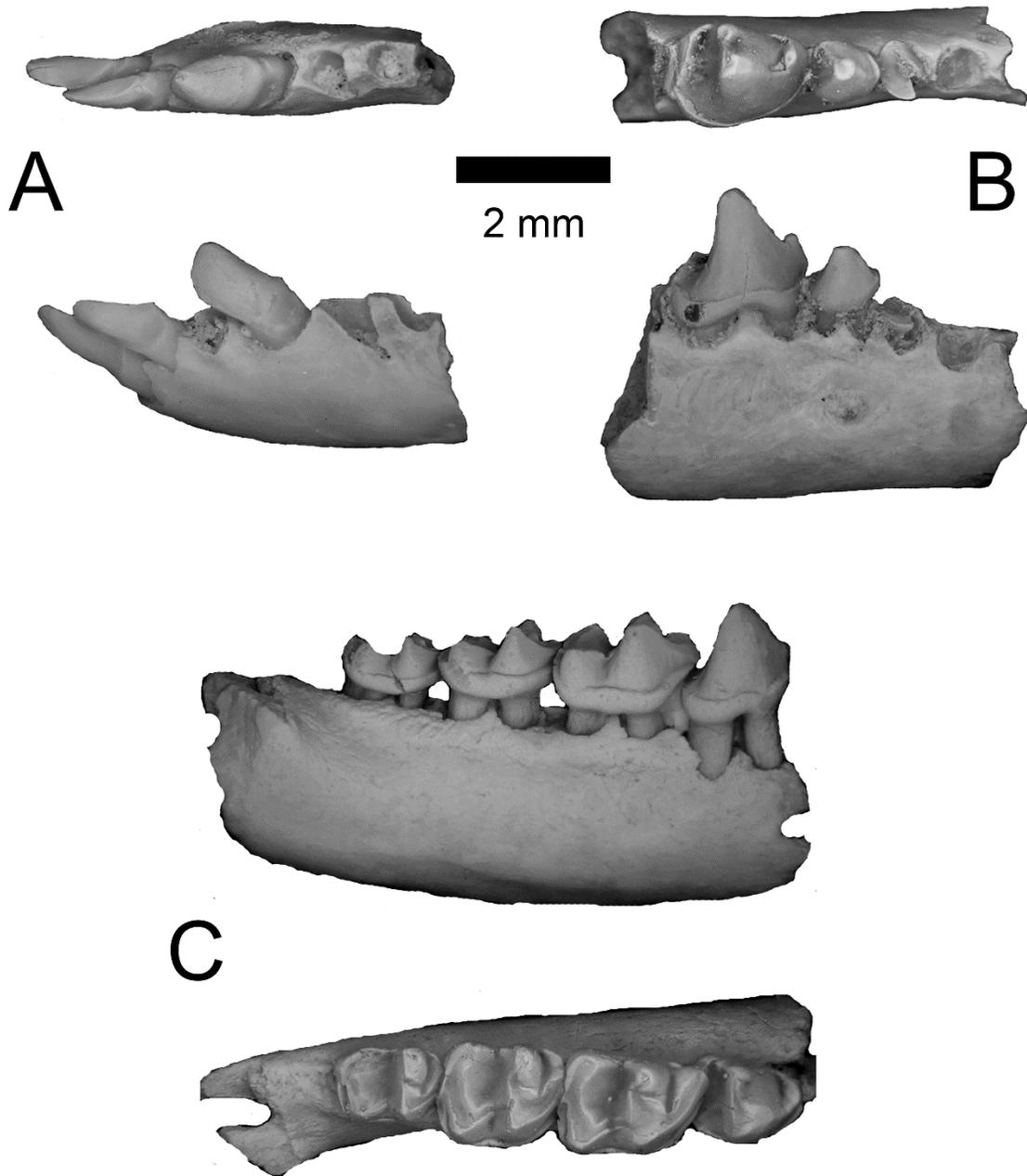


FIGURE 3. *Ocajila macdonaldi* from the Whitneyan of North Dakota. A, NDGS 9657, left partial dentary with i1-i2, c1. B, NDGS 9631, right partial dentary with p3-p4. C, NDGS 9564, right dentary with p4-m3. All figures occlusal view above, labial view below. All figures to same scale (above).

markedly reduced relative to m1 and at the center of the anterior margin of the trigonid. It is continuous with a low ridge that wraps around the anterior margin of the tooth and extends along its lingual side to the anterolingual base of the metaconid. The talonid of m2 is nearly identical to that of m1 but the cristid obliqua is

oriented nearly directly anterior-posterior and ends short of the posterior wall of the protoconid forming a narrow valley. As in m1, there is a narrow but deep valley on the lingual side of the tooth separating the metaconid from the entoconid.

TABLE 2. Dental measurements of *Centetodon marginalis*, *Amphichinus horncloudi*, and *Ocajila macdonaldi* from Fitterer and Obritsch ranches, North Dakota. **L**, anteroposterior length; **W**, transverse width. Measurements in mm. *, tooth present but unmeasurable.

<i>C. marginalis</i>											
Specimen #	M1L	M1W			M3L	M3W					
NDGS 9587					0.98	2.1					
USNM 768790	*	2.55									
	p4L	p4W	m1L	m1W	m2L	m2W	m3L	m3W			
NDGS 9601	1.31	0.92	1.49	0.93	1.57	1.09					
NDGS 9603							1.31	0.94			
NDGS 9600							1.54	1.05			
NDGS 9588							1.77	0.87			
NDGS 9602					*	*	1.45	0.92			
Mean							1.52	0.95			
<i>A. horncloudi</i>											
	p4L	p4W	m1L	m1W							
NDGS 9594	2.27	1.26	3.32	2.09							
<i>O. macdonaldi</i>											
	M1L	M1W	M2L	M2W	M3L	M3W					
NDGS 2433	1.65	2.14									
NDGS 9660			1.54	2.12							
	p3L	p3W	p4L	p4W	m1L	m1W	m2L	m2W	m3L	m3W	m1-m3
NDGS 9564			1.52	1.31	2.17	1.65	1.8	1.46	1.63	1.08	5.73
NDGS 9596					2.09	1.63	1.71	1.48	1.55	0.98	5.66
NDGS 9591			1.74	1.33							
NDGS 2434					2.4	1.66					
NDGS 9586					*	1.35	*	1.27			
NDGS 9589					2.09	1.52	1.79	1.43	1.64	1.03	5.67
NDGS 9631	0.97	0.8	1.78	1.38							
NDGS 2482							1.7	1.29			
NDGS 9565							1.84	1.37			
Mean	0.97	0.80	1.68	1.34	2.19	1.56	1.77	1.38	1.61	1.03	5.69

The m3 is the smallest of the molars and proportionally longer than m1 or m2. The trigonid is identical to that of m2 but the talonid is more elongated with a distinct hypoconulid along the posterior margin, lingual to its center, and adjacent to the posterolabial side of the entoconid. The hypoconulid is equal in size

to the hypoconid and entoconid. As in m1 and m2, a narrow transverse valley separates the entoconid from the metaconid and cristid obliqua from the base of the protoconid.

Based on similar size to that of the lower molars, more rotund cusps and general erinaceid morphology,

only two upper molars that can be referred to this species; NDGS 2433 and NDGS 9660. NDGS 2433 is identified as M1 and NDGS 9660 as M2 given their relative widths (M1 wider posteriorly, M2 wider anteriorly) and the relative position of the hypoconid (more lingual in M1). Both molars are similar in morphology. The labial side of the tooth is dominated by a pronounced labial cingulum that wraps around the antero- and posterolabial corners of the tooth. The anterior cingulum continues along the anterior margin of the tooth to the base of the tooth even with the apex of the protocone. Similarly, the posterior cingulum extends for most the width of the tooth along the base of the posterior margin, ending at the posterolabial base of the hypocone on M2, but continuing to the base of the anterolingual corner of the hypocone on M1. The labial cusps (paracone, metacone) are round in occlusal outline and of equal size on the M2, however the metacone is missing on the M1. A minute prepraeacrista extends anteriorly from the apex of the paracone to join the anterior cingulum. There is a distinct postpraeacrista and premetaacrista, but a distinct, narrow valley separates them at the center of the tooth where they meet. The postmetaacrista on M2 curves posterolabially from its apex to join the posterior cingulum. Both conules are small but slightly larger on the M1, the metaconule being slightly larger than the protoconule. The preprotocrista and postprotocrista are continuous from the protocone to the conules, forming a 'U-shape.' On M1 the hypocone is nearly equal in size to the protocone, but lower and slightly more lingual. On the M2 the hypocone is smaller than the protocone and positioned slightly more labially. There appears to be a weak ridge on the M2 extending anterolingually from the hypocone to join the postprotocrista near its center.

Discussion—The most distinctive morphologies of the dentition of *Ocajila* are the retention of all antemolars (3 incisors, canine, 4 premolars), cheek teeth with more rotund cusps, better development of cingula, and reduction of the paraconid on m2-m3. These differ from teeth of other erinaceids that have sharper, more conical cusps, lack the pronounced labial cingula (-ids), and have more distinct, lingual paraconids on m2-m3 (Korth, 2022).

The type species of the genus, *O. makpiyahe*, was originally reported from the early Arikareean Sharps Formation of South Dakota and limited to the holotype and one referred specimen (Macdonald, 1963, 1970; Hutchison, 1972). However, specimens identified as *O. cf. makpiyahe* have also been reported from both the Orellan and Whitneyan of Montana (Tabrum et al., 1996; Tabrum et al., 2001), and Whitneyan of South Dakota (Korth, 2009). In two unpublished dissertations, *Ocajila* was identified from the Arikareean of both Nebraska (Martin, 1973) and Montana (Rasmussen, 1977). All were recently reviewed and the Whitneyan

material from Montana was referred to a new species *O. macdonaldi* and the Arikareean specimens from Montana were referred to another new species, *O. rasmusseni*, and the Orellan material was identified as *Ocajila* sp. (Korth, 2022). The specimens from Fitterer Ranch and Obritsch Ranch are clearly referable to *O. macdonaldi*.

Genus *Amphechinus* Aymard, 1850

Amphechinus horncloudi (Macdonald, 1970)

Figure 4; Table 2

Referred Specimen—NDGS 9594, right dentary with p4-m1.

Measurements—p4: length = 2.27 mm; width = 1.26 mm. m1: length = 3.32 mm; width = 2.09 mm.

Occurrence—Fitterer Ranch sampling interval 5 (Fitterer Ranch Fauna B).

Description—The dentary is relatively deep (4.34 mm), and the ventral margin parallels the dorsal margin. The ascending ramus is missing, and the anterior portion is broken away. The root of i1 is preserved and followed by four alveoli before p4. It appears that the single alveolus posterior to the root of i1 represents the canine, followed by a single-rooted premolar (p2) and a double-rooted premolar (p3). There are two mental foramina just dorsal to mid-depth of the dentary; one ventral to the alveolus for p2 and the second ventral to the anterior root of p4. On the medial side of the dentary there is a remnant of the symphysis along the ventral margin directly ventral to the alveolus for p3.

The p4 is markedly smaller than m1. It is widest along the posterior margin. The protoconid is the tallest of the cusps of the trigonid near the center of the tooth. The paraconid is small and markedly lower than the protoconid, at the anterolingual corner of the tooth and continuous with the protoconid via the protocrista. The metaconid is on the posterolingual side of the protoconid and markedly smaller. No cusps can be distinguished on the talonid. The talonid is slightly wider than the trigonid. There is a low ridge that runs from the center of the posterior margin of the tooth to the base of the protoconid. The talonid slopes labially from this ridge to the base of the crown. On the lingual side of the ridge is a smaller basin that slopes lingually but does not extend to the base of the crown.

The m1 is much larger than p4. The trigonid is markedly higher than the talonid. The protoconid is the tallest of the trigonid cusps; the metaconid only slightly lower, and the paraconid the lowest. The trigonid basin is a narrow, transverse valley between the preprotocrista and postprotocrista, and forms a 'V-shape.' The metaconid is even with the protoconid so the posterior wall of the trigonid is directly transverse. The hypoconid is broadly 'V-shaped' at the posterolabial corner of the talonid. The cristid obliqua runs from the apex of the

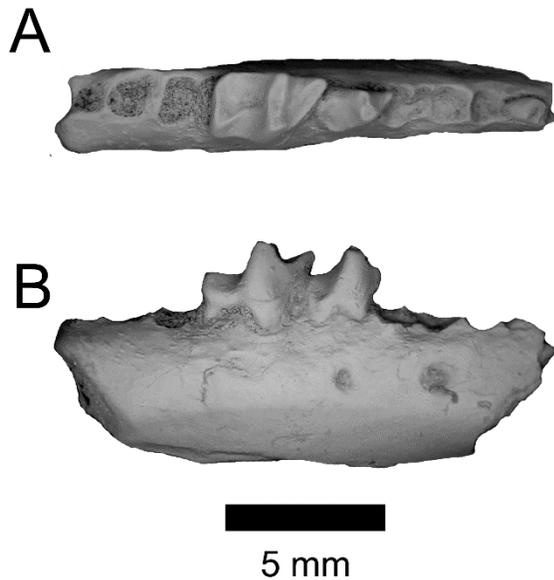


FIGURE 4. *Amphechinus horncloudi* from the Whitneyan of North Dakota. NDGS 9594, right dentary with p4-m1. A, occlusal view. B, lateral view. Both figures to same scale (below).

hypoconid anterolingually, ending at the base of the center of the posterior wall of the trigonid. The posthypocristid runs directly lingually from the hypoconid to the small entoconid at the posterolingual corner of the talonid. There is a distinct cingulid along the labial side that wraps around the base of the tooth. There are three alveoli posterior to m1. Based on these alveoli, m2 has an estimated length of 2.95 mm, slightly shorter than m1. There is only one alveolus for m3, but the dentary is broken, so it cannot be determined whether there was a second. Regardless, the small remaining alveolus indicates that m3 was smaller than m2.

Discussion—The specimen from Fitterer Ranch cannot be distinguished from previously described specimens of *Amphechinus horncloudi* (Macdonald, 1970; Rich and Rasmussen, 1973; Rich, 1981). However, this occurrence in the Whitneyan is the earliest for this species that elsewhere is limited to the Arikarean of South Dakota, Colorado, Nebraska, and Montana (Macdonald, 1970; Rich and Rasmussen, 1973; Rich, 1981; Korth, 1992; Gunnell et al., 2008b).

Family Soricidae Fischer de Waldheim, 1817

Genus *Domnina* Cope, 1873

Domnina gradata Cope, 1873

Figure 5; Table 3

Referred Specimens—NDGS 9672, right I1; USNM PAL 768764, 768766, NDGS 9648, P4; USNM

PAL 768760, 768765, 768767, NDGS 9647, M1; USNM PAL 768761, 768768, 768769, M2; USNM PAL 768762, 768763, M3; NDGS 9598, 9599, partial maxilla with M1-M2; NDGS 9584, dentary with i1-m2; NDGS 9629, left dentary with a4-m3; NDGS 9570, 9571, 9592, 9595, 9597, 9607, dentary with m1-m3; NDGS 9580, partial dentary with m1-m2; NDGS 2462, left partial dentary with m2(partial); NDGS 2432, left dentary fragment with m1; NDGS 9621, left a4; USNM PAL 768771, 768772, m1; USNM PAL 768770, 768773, 768774, 768776, m2; USNM PAL 768775, NDGS 2458, m3.

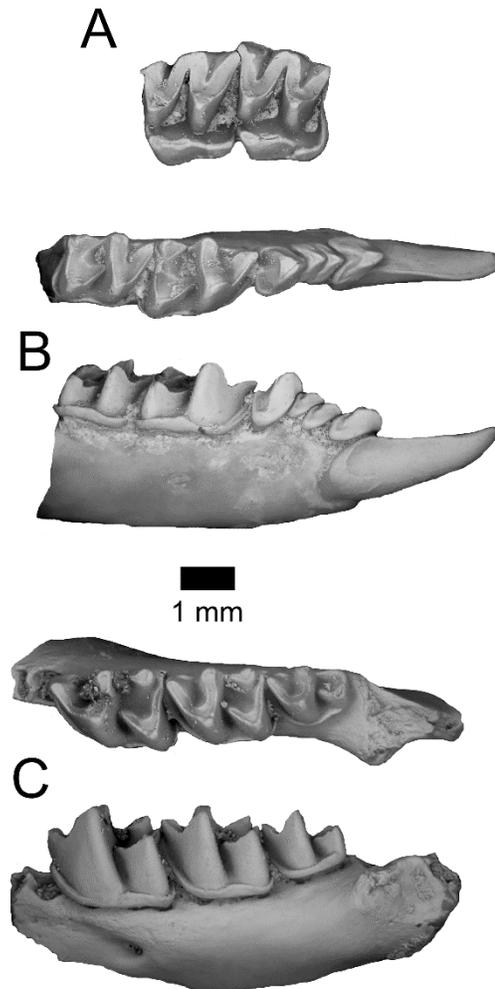


FIGURE 5. *Domnina gradata* from the Whitneyan of North Dakota. A, NDGS 9599, left M1-M2. B, NDGS 9584, right dentary with i1-m2. C, NDGS 9571, left partial dentary with m1-m3. B, C, occlusal view above, labial view below. All figures to same scale (center).

TABLE 3. Dental measurements of *Domnina gradata* from Fitterer and Obritsch ranches, North Dakota. Measurements in mm. Abbreviations: **N**, number of specimens; **M**, mean; **Min**, minimum measurement; **Max**, maximum measurement; **SD**, standard deviation; **CV**, coefficient of variation; **L**, anteroposterior length; **W**, transverse width; **a**, antimolars.

	P4L	P4W	M1L	M1W	M2L	M2W	M3L	M3W		
N	3	3	5	5	5	5	2	2		
M	1.71	1.65	1.82	1.99	1.66	1.93	0.93	1.39		
Min	1.58	1.50	1.72	1.93	1.57	1.85	0.87	1.31		
Max	1.83	1.83	1.95	2.04	1.75	2.08	0.98	1.46		
SD	0.13	0.17	0.09	0.05	0.07	0.09	0.08	0.11		
CV	7.34	10.05	5.12	2.34	3.98	4.76	8.41	7.66		
	m1L	m1W	m2L	m2W	m3L	m3W	m1-m3			
N	12	11	14	13	7	7	6			
M	2.00	1.31	1.68	1.18	1.41	0.89	5.25			
Min	1.82	1.18	1.49	1.07	1.32	0.81	4.96			
Max	2.22	1.47	1.86	1.25	1.45	1.03	5.69			
SD	0.10	0.09	0.12	0.05	0.05	0.08	0.25			
CV	5.14	6.90	7.15	4.46	3.31	8.54	4.71			
	i1L	i1W	a1L	a1W	a2L	a2W	a3L	a3W	a4L	a4W
NDGS 9629									0.81	0.82
NDGS 9621									0.91	0.90
NDGS 9584	3.50	0.91	0.69	0.81	0.27	0.66	0.32	0.65	0.77	0.88

Occurrence—Fitterer Ranch sampling intervals 5, 6, and 7 (Fitterer Ranch Faunae B and C); Obritsch Ranch sampling interval 2 (Obritsch Ranch Fauna B).

Discussion—The material from North Dakota does not differ in morphology or size from the previously described material (Patterson and McGrew, 1937; Repenning, 1967). Elsewhere, *D. gradata* is generally limited to the Orellan (Patterson and McGrew, 1937; Repenning, 1967; Gunnell et al., 2008b) but may also occur in the late Chadronian (Korth et al., in press). The occurrence at Fitterer Ranch and Obritsch Ranch extends the known range of this species into the Whitneyan.

Family Proscalopidae Reed, 1961
Genus *Oligoscalops* Reed, 1961
Oligoscalops galbreathi (Reed, 1956)
Figure 6; Table 4

Referred Specimens—USNM PAL 768778, right partial maxilla with P4-M1; USNM PAL 768777,

NDGS 2138, 2140, M2; NDGS 2168, right M3; NDGS 9568, left partial dentary with four antemolars and m1; NDGS 2141 and 2431, m3; USNM PAL 768779, 768780, NDGS 9604, 9668, partial humeri; USNM PAL 768781, carpal and tarsal elements.

Occurrence—Fitterer Ranch sampling intervals 2, 5, 6, and 7 (Fitterer Ranch Faunae A, B, and C); Obritsch Ranch sampling interval 2 (Obritsch Ranch Fauna B).

Description—The molars of *O. galbreathi* have been described elsewhere in detail (Reed, 1961; Barnosky, 1981), however, the anterior dentition has not. NDGS 9568 preserves the anterior half of the dentary which contains the alveoli for i1-i2, the root of i3, the canine, and p2-m1. The dentary is slender (depth below m1 = 1.68 mm). The deepest part is anterior below c1-p2. The ventral margin is weakly curved. There are two mental foramina at mid-depth of the dentary, one ventral to the anterior margin of p4 and the second ventral to the posterior root of p4.

The alveolus for i1 is long and extends ventrally along the base of the dentary to a point ventral to the root

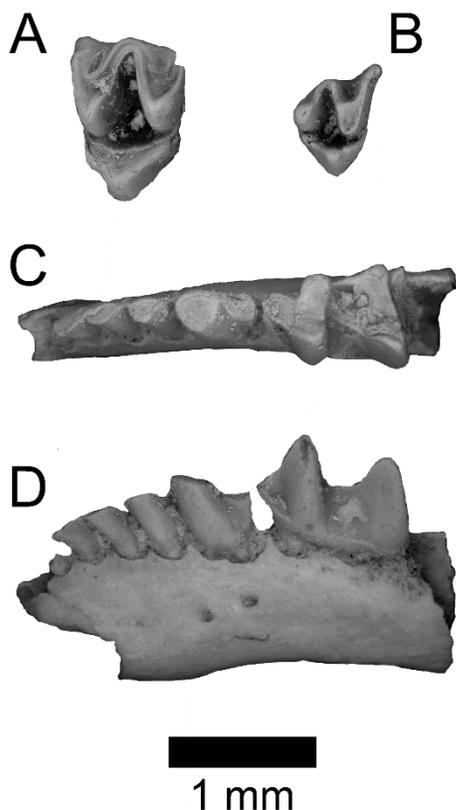


FIGURE 6. *Oligoscalops galbreathi* from the Whitneyan of North Dakota. A, NDGS 2140, left M2. B, NDGS 2168, right M3. C, D, NDGS 9568, left dentary with a1-m1. C, occlusal. D, labial view. All figures to same scale (below).

of c1. Only the alveolus for i2 is preserved, it is wider than long, and slightly larger than the root of i3, which is the smallest of the antemolars. The canine and p2-p3 are nearly identical in size and morphology. All are single-rooted and peg like, with crowns sloping anterodorsally. In occlusal view they are predominantly circular in outline but there is a small spur (?talonid) at the posterolingual corner of the crown that extends posterolingually. The p4 is two-rooted. It is dominated by a large central cusp (?protoconid) that is conical in shape. Near the base of the anterolingual corner is a minute paraconid. The talonid consists of a single cusp at the posterolingual corner of the tooth. The labial half of the talonid slopes labially from the talonid cusp.

The m1 is as has been described elsewhere: dilambdodont with the trigonid narrower than the talonid; a hypoconulid posterior to the entoconid with a posterior cingulid that slopes ventrally from the hypoconulid along the posterior margin of the tooth to the base of the posterolabial corner.

Discussion—In the last review of the Proscalopidae, Barnosky (1981) presented a detailed diagnosis of *Oligoscalops* and recognized only the type species, *O. galbreathi*. He listed the range of occurrence as Chadronian to Orellan NALMA. Korth (2020) identified *Oligoscalops* sp. from the late Whitneyan Blue Ash fauna of South Dakota, matching the age of the North Dakota specimens described here and extending the known range of this species.

Family Oligoryctidae Asher, McKenna, Tabrum, and Kron, 2002

Genus *Oligoryctes* Hough, 1956

Oligoryctes altitalonidus (Clark, 1937)

Figure 7; Table 5

Referred Specimens—NDGS 9643, right P4; NDGS 2479, left M1(partial); NDGS 9646, left M3; NDGS 2109, 9566, partial dentary with p4-m2; NDGS 9623, left dentary fragment with p3-p4; NDGS 12612, 12613, partial dentary with m1-m3; NDGS 9581, partial right dentary with m2-m3; NDGS 9567, left p3; NDGS 2436, 9671, m1 or m2; NDGS 2142, 9618, 9651, 12614, m3.

Occurrence—Fitterer Ranch sampling intervals 2, 5, and 6 (Fitterer Ranch Faunae A, B, and C); Obritsch Ranch sampling interval 2 (Obritsch Ranch Fauna B).

Discussion—*Oligoryctes altitalonidus* was described in detail by Asher et al. (2002) who cited the occurrence of this species from Fitterer Ranch but listed it as Orellan in age. The specimens from Fitterer Ranch and Obritsch Ranch are distinctly smaller than those of *O. cameronensis* (Hough, 1956: 475) and larger and relatively wider than those of *O. tenutalonidus* (Korth et al. in press).

O. altitalonidus was previously reported to range from the middle Eocene to the early Oligocene (Uintan to Orellan NALMA: Gunnell et al., 2008b) so its presence at Fitterer Ranch is its latest occurrence (Whitneyan NALMA).

Family Talpidae Fischer de Waldheim, 1817

Subfamily Uropsilinae Dobson, 1883

Genus *Mystipterus* Hall, 1930

Mystipterus austinae n. sp.

Figure 8

Type and Only Specimen—NDGS 9569, right dentary with m1-m3.

Occurrence—Fitterer Ranch sampling interval 5 (Fitterer Ranch Fauna B).

Measurements—m1: length = 1.72 mm, width = 1.15 mm. m2: length = 1.43 mm, width = 1.18 mm. m3: length = 1.33 mm, width = 0.93 mm. m1-m3: length = 4.59 mm. Dentary depth = 1.66 mm.

TABLE 4. Dental measurements of *Oligoscalops galbreathi* from Fitterer and Obritsch ranches, North Dakota. L, anteroposterior length; W, transverse width. Measurements in mm.

Specimen #	P4L	P4W	M1L	M1W	M2L	M2W	M3L	M3W				
NDGS 2168							1.28	1.79				
NDGS 2140					1.69	2.5						
NDGS 2138					1.67	2.61						
NDGS 9658	1.76	1.39										
USNM 768777					1.61	2.23						
USNM 768778	1.55	1.23	2.32	1.86								
Mean	1.66	1.31	2.32	1.86	1.66	2.45	1.28	1.79				
	a2L	a2W	a3L	a3W	a4L	a4W	a5L	a5W	m1L	m1W	m3L	m3W
NDGS 9568	0.54	0.38	0.51	0.32	0.44	0.47	1.06	0.67	2.06	1.47		
NDGS 2431											1.55	1.06
NDGS 2141											1.68	1.25

TABLE 5. Dental measurements of *Oligoryctes altitalonidus* from Fitterer and Obritsch ranches, North Dakota. Measurements in mm. L, anteroposterior length; W, transverse width. **, m1 or m2.

NDGS#	P4L	P4W	M1L	M1W	M2L	M2W	M3L	M3W				
9643	1.00	1.67										
2479			0.91									
9646							0.89					
	p3L	p3W	p4L	p4W	m1L	m1W	m2L	m2W	m3L	m3W		
2109	0.88	0.46	1.04	0.68	0.84	0.74						
9566	0.82	0.42	0.99	0.56	0.96	0.72						
9618									1.17	0.66		
9671**					0.94	0.78						
9651									0.86	0.51		
2142									1.07	0.56		
2436**					1.19	0.98						
9567	0.89	0.69										
9623	0.75	0.43	0.96	0.57								
9581							0.97	0.71	1.05	0.62		
Mean	0.84	0.50	1.00	0.60	0.98	0.81	0.97	0.71	1.04	0.59		

Diagnosis—Similar in size to *M. pacificus* Hutchison, 1968, larger than *M. vespertilio* Hall, 1930, and *M. martini* (Wilson, 1960); lower molars decrease in length from m1-m3 (m2 longest in other species);

mental foramen ventral to center of m1 (ventral to anterior root of m1 in other species).

Etymology—Patronym for Melinda Austin in honor of her years of service for the North Dakota Geological Survey and interest in paleontology.

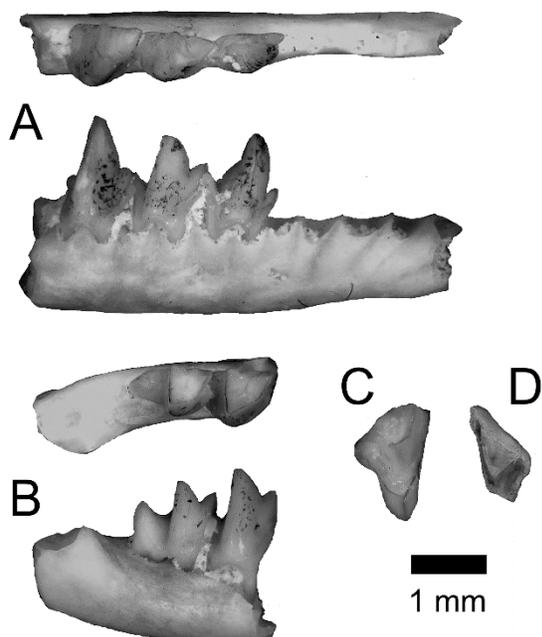


FIGURE 7. *Oligoryctes altitalonidus*, from the Whitneyan of North Dakota. A, NDGS 9566, right dentary with p4-m2 (occlusal view above, labial view below). B, NDGS 9581, right partial dentary with m2-m3 (occlusal view above, labial view below). C, NDGS 9643, left P4 (partial). D, NDGS 9646, left M3 (partial). All figures to same scale.

Description—The dentary is slender and deepest below m1 (1.87 mm). The remainder of the dentary anterior to m1 is lacking. The anterior margin of the ascending ramus arises just posterior to m3 and is inclined slightly posteriorly and extends well dorsal to the ramus (3.55 mm) ending in a point dorsally. The posterior margin of the ascending ramus is vertical. The masseteric fossa is triangular in outline, deep anteriorly and gradually shallows posteriorly. The condyle is at a level just dorsal to the occlusal surface of the molars. In posterior view, it is transversely elongated and oriented slightly dorsolateral to ventromedial. The angle is a sharp point oriented slightly posteroventrally and extends posteriorly nearly as far as the condyle.

The molars decrease in length from m1 to m3 and are typically dilambdodont and mesodont to submesodont in crown-height. The cusps of the trigonid of m1 are nearly equal in height, the paraconid being the lowest, the protoconid the tallest. The trigonid is widely open lingually. The paraconid is obliquely compressed and the protoconid is crescentic in occlusal view. The metaconid is slightly anteroposteriorly compressed. The cusps of the talonid (entoconid, hypoconid) are only slightly lower than the trigonid cusps. The postmetacrista is continuous along the lingual side of the tooth connecting the metaconid to the entoconid, and

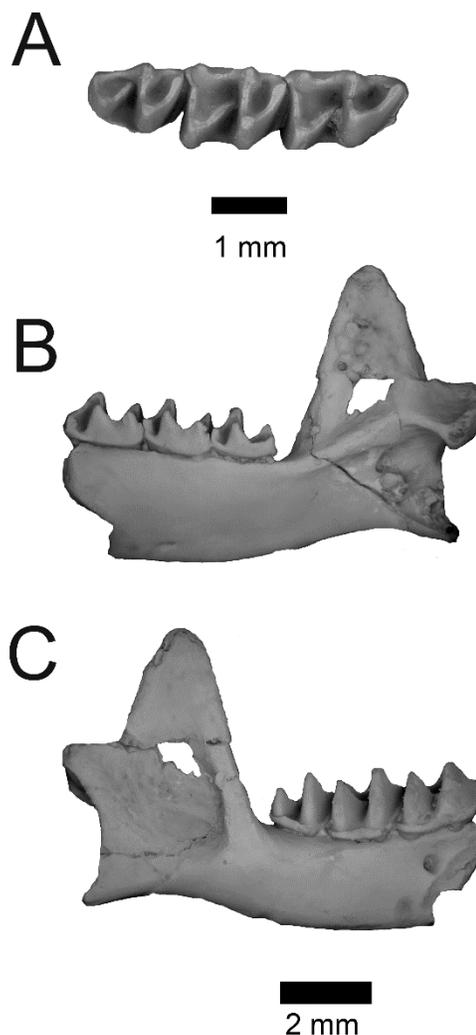


FIGURE 8. *Mystipterus austinae* n. sp., NDGS 9569 (holotype) from the Whitneyan of North Dakota. A, occlusal view of right dentary with m1-m3. B, medial view of dentary. C, labial view of dentary. A to above scale; B and C to scale below.

ultimately ending in a minute hypoconulid directly posterior to the entoconid. The hypoconid is a sharp ‘V-shape’ in occlusal view. The prehypocristid extends anterolingually, ending at the base of the posterior wall of the trigonid near its center. The posthypocrista runs directly lingually from the hypoconid to the entoconid. A distinct basal cingulid extends along the labial side of the tooth from below the paraconid, ultimately wrapping around the posterolabial corner of the tooth and ending along the base of the posterior wall.

The m2 is shorter but slightly wider than m1. It generally has the same morphology as m1 except that the trigonid is not as open lingually (trigonid more

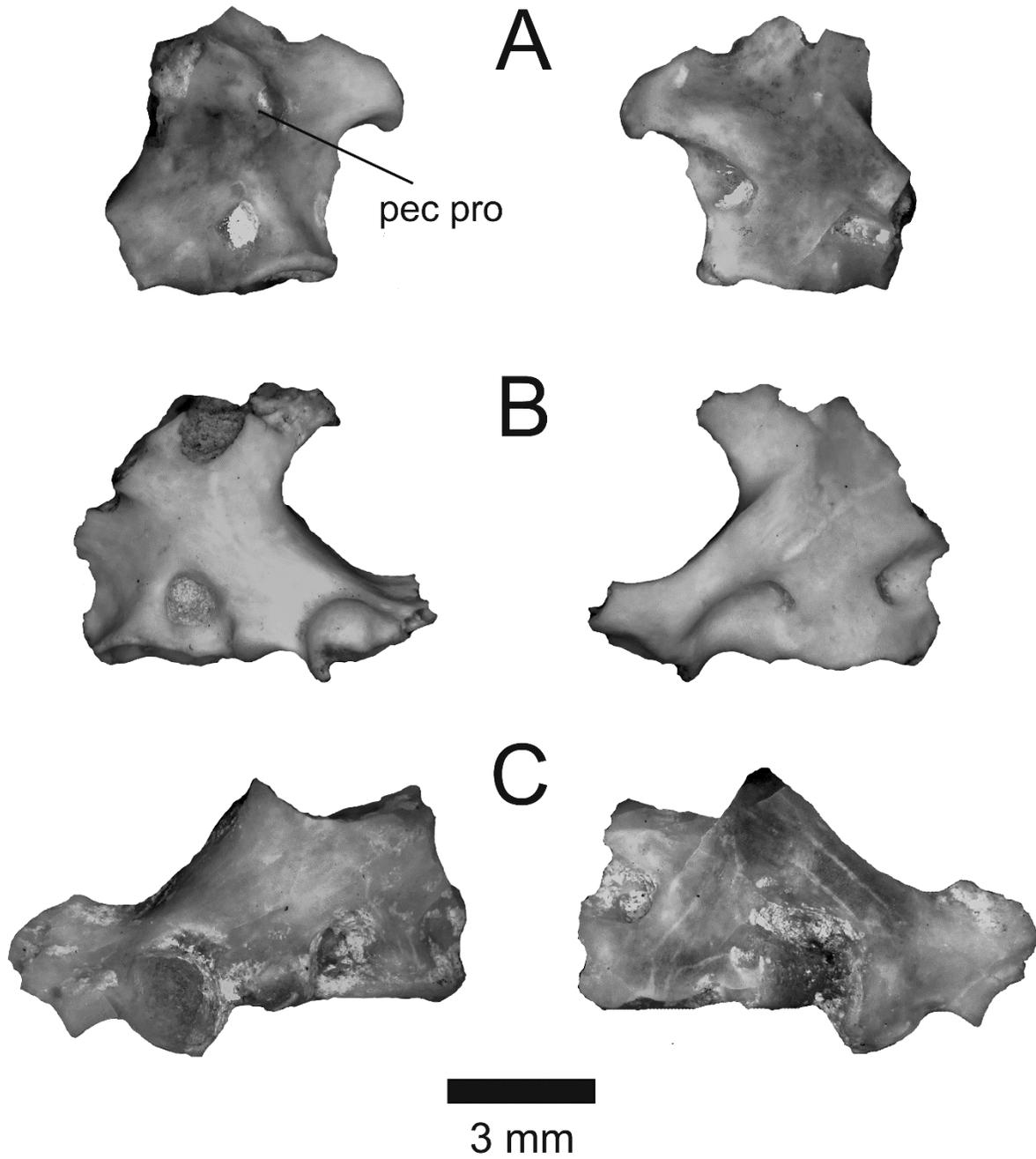


FIGURE 9. Humeri of *Cryptoryctes* sp., cf. *C. kayi* from the Whitneyan of North Dakota. A, NDGS 9667, right central diaphysis. B, NDGS 9583, left central and partial distal diaphysis. C, NDGS 9582, right distal diaphysis. For all figures, anterior view on left, posterior view on right; proximal end to top of page. All figures to same scale. Abbreviation: pec pro, pectoral process.

compressed) and the hypoconulid is reduced to a minute bulge on the posterior slope of the entoconid.

The m3 is only slightly shorter than m2 but narrower. The trigonid is as in m2, only slightly smaller. The talonid is markedly reduced relative to m1 and m2. It is markedly lower than the trigonid and is an elongated basin that narrows anteriorly, ending directly posterior to the metaconid. No individual cusps are recognizable, but the talonid is surrounded by a thin ridge that encloses it on all sides. As in m1 and m2, the basal cingulid originates at the paraconid and wraps around the base of the tooth along its labial and posterior sides.

Discussion—*Mystipterus austinae* differs from all other species of the genus in that m1 is longer than m2 (m2 longest in other species) and having the mental foramen more posterior, ventral to center of m1 (ventral to anterior root of m1 in other species). The trigonid on m1 is more widely open lingually than in *M. pacificus* (Hutchison, 1968: fig. 24), similar to that of *M. martini* (Wilson, 1960: figs. 32a, 33). In size, it is larger than both *M. vespertilio* and *M. martini* (Wilson, 1960: 40; Hutchison, 1968: table 3). This is the earliest record of *Mystipterus* (Whitneyan); elsewhere it is known to range from the Arikareean to Hemingfordian (Hutchison, 1968; Gunnell et al., 2008b).

Family Micropternodontidae Stirton and Rensberger,
1964

Genus *Cryptoryctes* Reed, 1954
Cryptoryctes sp., cf. *C. kayi* Reed, 1954

Figure 9

Referred Specimens—NDGS 9582, right distal humerus; NDGS 9583, left distal humerus; NDGS 9667, central diaphysis right humerus.

Occurrence—Fitterer Ranch sampling intervals 5 and 7 (Fitterer Ranch Fauna B and Obritsch Ranch Fauna B).

Description—None of the specimens from this sample are complete. However, enough of the humerus is present to identify these specimens as belonging to *Cryptoryctes*. The humerus is anteroposteriorly flattened, transversely broad, and the diaphysis is angled obliquely. The most diagnostic feature preserved on these specimens is the shape and position of the pectoral process. It is on the proximal half of the diaphysis and angled dorsomedially. The distal breadth can only be measured on NDGS 9582 and is 9.04 mm. Reed (1954: table 1) listed this measurement on the holotype of *C. kayi* as 10.9 mm but noted it was an approximation. The distal shaft breadth for the Fitterer Ranch specimens averages 3.70 mm on all four referred specimens (range = 2.65–4.10 mm). Reed (1956: table 1) measured four topotypic specimens that averaged 3.55 mm (range 3.4–3.8 mm).

Discussion—Although none of the humeri referred here are complete, it appears that they can be referred to *Cryptoryctes* based on the observable morphology. The only other species represented in this collection known for its broadened humerus is *Oligoscalops*. However, the position and orientation of the pectoral process is distinct between these two genera. In *Cryptoryctes* it is limited to the proximal half and oriented posteromedially, whereas in *Oligoscalops* (Reed, 1956: fig. 130A; mislabeled as *Arctoryctes galbreathi*) it slopes distally to the distal half of the diaphysis and extends laterally at the distal end.

Elsewhere *Cryptoryctes* is limited to the Duchesnean through the Chadronian of Montana and Saskatchewan (Storer, 1996; Gunnell et al., 2008b: 111), making its presence in Whitneyan faunas at Fitterer Ranch markedly later than previously reported. It has been suggested by a number of authors that *Cryptoryctes* (known only from humeri) is a junior synonym of the micropternodontid *Micropternodus* (see Korth et al., 2021b, for historical review). The previously reported range of *Cryptoryctes* has been limited to the Duchesnean through the Chadronian and that of *Micropternodus* from the Uintan to the Arikareean (Storer, 1996; Gunnell et al., 2008b: fig. 7.5). If this synonymy should ultimately prove verified this occurrence from North Dakota would not be unexpected.

TABLE 6. Age occurrence of species of insectivorans identified from Fitterer Ranch and Obritsch Ranch in other North American faunas. *, unique to Fitterer Ranch or Obritsch Ranch; ¹, earliest occurrence of genus in North America. Abbreviations for North American Land Mammal Ages: **Ch**, Chadronian; **Or**, Orellan; **Wh**, Whitneyan; **Ar**, Arikareean.

Taxon	Ch	Or	Wh	Ar
<i>Leptictis dakotensis</i>	X	X	X	
Gen. & species new.*				
<i>Centetodon marginalis</i>		X		
<i>Ocajila macdonaldi</i>			X	
<i>Amphechinus horncloudi</i> ¹				X
<i>Domnina gradata</i>		X		
<i>Oligoscalops galbreathi</i>	X	X		
<i>Oligoryctes altitalonidus</i>	X	X	X	
<i>Mystipterus austinae</i> * ¹				
<i>Cryptoryctes</i> sp., cf. <i>C. kayi</i>	X			

CONCLUSIONS

The ten species described here are represented by over 100 specimens, dominated by the lipotyphlans (85 percent of specimens, 8 of 10 species). These species represent a mix of taxa elsewhere known from different NALMAs (Table 6). One species is previously known exclusively from the Chadronian (*Cryptoryctes* cf. *C. kayi*), two are exclusively Orellan (*Centetodon marginalis*, *Domnina gradata*), one exclusively Whitneyan (*Ocajila macdonaldi*), and one exclusively Arikareean (*Amphechinus horncloudi*) (see Gunnell et al. 2008a). Of the other species, *Oligoryctes altitalonidus* elsewhere ranges from the Chadronian to the Whitneyan, *Leptictis dakotensis* ranges from the Orellan to Whitneyan, and *Oligoscalops galbreathi* is limited to the Chadronian and Orellan (Gunnell et al. 2008a, 2008b). This is also the earliest occurrence for the talpid genus *Mystipterus* elsewhere first occurring in the Arikareean (Hall, 1930; Wilson, 1960; Hutchison, 1968; Gunnell et al., 2008a).

There is no obvious pattern observed in the stratigraphic distribution of these taxa in the study area (Figure 10). As noted in prior investigations of the micromammal fauna in the study area, Fitterer Ranch Fauna B is the most intensely sampled interval. That increased sampling likely explains why Fitterer Ranch Fauna B displays the highest number of micromammal taxa identified and why several taxa are sampled only from there, including three of the taxa in this study (*Centetodon marginalis*, *Mystipterus austinae*, and *Amphechinus horncloudi*). Future work in the study area will be focused on increased sampling of the other faunae in an effort to further refine the local stratigraphic distribution of micromammal taxa. Additionally, a fossiliferous bed within Fitterer Ranch sampling interval 7 was recently discovered and is under study via screen-washing to extend our sampling of micromammal taxa higher into the local section. Finally, studies are currently underway to examine collections of micromammals from other localities within the Brule Formation of North Dakota. Those studies will benefit from the detailed record now available from Fitterer Ranch and Obritsch Ranch that will serve as a key reference point for assessing biostratigraphic ages and identifying temporal and/or geographic faunal differences.

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the smaller specimens from screen-washed concentrate for the NDGS. Laboratory, workspace and facilities provided for WWK by the Rochester Museum & Sciences Center (RMSC). G. McIntosh (RMSC) assisted in the photography of specimens. Earlier versions of the paper were critically read by L. Flynn and E. Welsh.

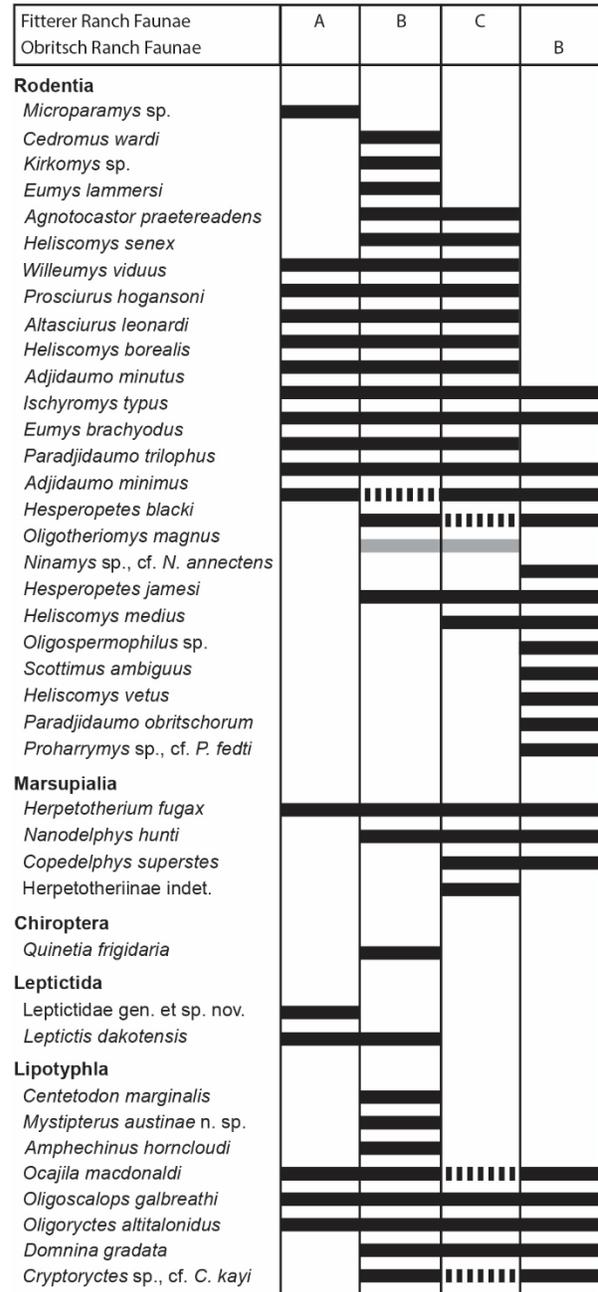


FIGURE 10. Biostratigraphic distribution of micromammal taxa within the four faunae described at Fitterer Ranch and Obritsch Ranch. Oldest fauna on the left and youngest fauna on the right. Data taken from this study, Korth et al. (2019a, 2019b, 2021), and Czaplewski et al. (2019). See Korth et al. (2021) for definitions of the Fitterer Ranch and Obritsch Ranch faunae

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