

**MAMMALS FROM THE BLUE ASH LOCAL FAUNA (LATE OLIGOCENE), SOUTH DAKOTA.
ADDITIONAL SPECIMENS OF *HERPETOTHERIUM* COPE (MARSUPIALIA, DIDELPHIDAE)**

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ABSTRACT

Additional specimens of the didelphid marsupial *Herpetotherium* from the late Whitneyan Blue Ash fauna of South Dakota are described. There are two species recognized: *H. fugax* and a larger species assigned to *Herpetotherium* sp. The sample of *H. fugax* is consistent in size and morphology with collections of this species ranging in age from the Orellan to early Arikareean. The slightly smaller size of the specimens most closely matches the size range of Arikareean populations from Nebraska. Two upper molars are larger than any other recorded of *Herpetotherium* and cannot be assigned to any recognized species.

INTRODUCTION

Simpson (1985) was the first to recognize marsupials from the Harris Ranch fauna of South Dakota. He identified two species of the didelphid *Herpetotherium* Cope, 1873; *H. cf. H. fugax* Cope, 1873 and a second species identified only as *Herpetotherium* sp. A. Simpson (1985) was uncertain of the age of the fauna and suggested that it was either latest Whitneyan or earliest Arikareean. Later, Korth (2007, 2009) in describing the Blue Ash anthill fauna from Harris Ranch, also identified two species of *Herpetotherium*, again as *H. fugax*, and a smaller species referred to *Herpetotherium* sp. The Blue Ash identifications were based on a total of approximately 20 specimens of almost exclusively isolated cheek teeth. Korth (2010, 2014) demonstrated that the Harris Ranch beds were late Whitneyan in age, and that this was the first description of *Herpetotherium* from the Whitneyan. Specimens of *Herpetotherium* reported from the Cedar Ridge fauna of Wyoming were originally considered as Whitneyan (Setoguchi, 1978; Hayes, 2005) but the fauna has been shown to be Orellan in age (see Korth, 1989, 2007).

Additional specimens of *Herpetotherium* have been discovered from the Blue Ash anthill collection that has more than doubled the number of known specimens. Although the sample remains limited to nearly all isolated molars, with this larger sample, the

species represented in the fauna can be better identified and defined.

Dental nomenclature for marsupials is from Crochet (1980). Capital letters indicate upper teeth; lower-case letters indicate lower teeth (e.g., m1 or M1). Institutional abbreviation: CM, Carnegie Museum of Natural History (Pittsburgh).

SYSTEMATIC PALEONTOLOGY

Order Marsupialia Illiger, 1811

Family Didelphidae Gray, 1821

Herpetotherium Cope, 1873

Herpetotherium fugax Cope, 1873

(Figure 1A-H; Table 1)

Referred Specimens—CM 76760, 89314, 89316, 89321, 89324, m1s; CM 76315, 76318, 76319, 76323, 76755, 76759, 89315, 89317, 89319, 89320, m2s; CM 76317, 76321, 89319, m3s; CM 76320, partial dentary with m2-m3; CM 76319, partial dentary with m3-m4; CM 76302 – 76304, 89303, 89308, M1s; CM 76306, 76307, 89301, 89302, M2s; CM 76308 – 76313, 89304 – 89307, 89309, 89310, M3s; CM 76314, M4; CM 76305 fragmentary maxilla with M1-M2.

Discussion—Korth (2007) originally described two species of *Herpetotherium* from the Blue Ash anthill fauna that could be separated by size and the reduction in the number of styler cusps on the upper molars of the smaller species (*Herpetotherium* sp.). However, with a larger sample, it appears that there is

TABLE 1. Dental measurements of *Herpetotherium fugax* the from Blue Ash anthill fauna. Abbreviations: L, maximum anteroposterior length; W, maximum transverse width; N, number of specimens; M, mean; Min, minimum measurement; Max, maximum measurement; SD, standard deviation; CV co-efficient of variation. Measurements in mm; to nearest 0.01 mm.

	m1L	m1W	m2L	m2W	m3L	m3W	m4L	m4W
N	5	5	11	10	4	4	1	1
M	1.74	0.95	1.79	1.07	1.89	1.12	1.49	0.85
Min	1.65	0.84	1.58	0.86	1.80	1.07		
Max	1.88	1.07	2.01	1.21	1.97	1.16		
SD	0.09	0.09	0.15	0.11	0.07	0.04		
CV	5.03	9.68	8.40	10.27	3.70	3.30		
	M1L	M1W	M2L	M2W	M3L	M3W	M4L	M4W
N	6	6	4	5	12	12	1	1
M	1.69	1.62	1.76	1.86	1.59	2.03	0.84	2.04
Min	1.58	1.53	1.66	1.69	1.43	1.70		
Max	1.82	1.70	1.84	2.01	1.78	2.41		
SD	0.10	0.07	0.08	0.12	0.12	0.24		
CV	5.77	4.23	4.40	6.59	7.63	11.95		

only one species present based on size (Table 1). Hayes (2005) demonstrated that the number and relative size of the stylar cusps on the upper molars of *Herpetotherium* varied with the overall size of the tooth; larger specimens having more and larger stylar cusps, smaller specimens having fewer and smaller stylar cusps. This appears to be the case with the Blue Ash fauna. The presumed smaller species (Korth, 2007:fig. 1F) had only a single stylar cusp on the upper molars, whereas the specimens of the larger *H. fugax* had at least two larger cusps (cusps B and D) and often a third smaller cusp (cusp C). With the additional specimens it appears that on M1 and M2 especially, the larger specimens have a larger stylar cusp B and C and the smaller specimens have a much reduced cusp C (often minute and on the anterior slope of cusp D).

The size range of the sample from the Blue Ash fauna is consistent with that of other reported samples of *H. fugax* from other faunas ranging from middle Chadronian to early Arikareean (Green and Martin, 1976; Setoguchi, 1978; Korth, 1994; Hayes, 2005) with mean measurements being only slightly smaller, most similar to those of the Arikareean sample from Nebraska (Table 2). This suggests that there is a general decrease in size of *H. fugax* through time, but due to the great amount of overlap in size and lack of significant morphological differences

from the different horizons, the Blue Ash sample is referred to *H. fugax*.

Herpetotherium sp. (large)
(Figure 1I, J)

Referred Specimens—CM 89313, M2 and CM 89311, M3.

Measurements—CM 89313 (M2), length = 2.66 mm, width = 2.86 mm; CM 89311 (M3), length = 1.94+, width = 2.45+ mm (+, due to breakage, actual measurements are slightly larger than those given).

Description—The M2 referred to *Herpetotherium* sp. is larger than any recorded for any previously described species of the genus. The length of the M3 (CM 89311) is less than that given for the holotype of *H. merriami* Stock and Furlong, 1923 (see Korth, 1994:table 5) and within the range of the Duchesnean *H. sp. cf. H. marsupium* (Troxell, 1923; Rothecker and Storer, 1996:table 1) and of the Chadronian *H. valens* (Lambe, 1908; Eberle and Storer, 1995:table 1). However the Blue Ash specimen is broken along the buccal border and the given measurements are less than the actual dimensions of the unbroken tooth.

M2 is similar in morphology to that of all species of *Herpetotherium* (Korth, 1994), but the stylar cusps are much larger than in other species

TABLE 2. Comparison of means of dental measurements for samples of *Herpetotherium* from different localities. Measurements in mm. Abbreviations as in Table 1.

Age (location)	m1L	m1W	m2L	m2W	m3L	m3W	m4L	m4W	Reference
<i>Herpetotherium</i> sp.									
Hemingfordian (South Dakota)	1.63	0.81	1.59	0.89	1.74	1.00	1.62	0.96	Green and Martin, 1976
<i>H. youngi</i>									
Arikareean (Nebraska)	1.72	1.04	1.79	1.16	1.97	1.13	1.79	1.72	Korth, 1992
Arikareean (South Dakota)	1.57	0.85	1.71	1.07	1.83	1.09	1.71	0.96	Green and Martin, 1976
<i>H. fugax</i>									
Arikareean (Nebraska)	1.66	0.97	1.71	1.04	1.66	1.06	1.77	1.00	Hayes, 2005
Arikareean (Florida)	1.71	1.02	1.69	0.95	1.84	1.11			Hayes, 2005
Whitneyan (South Dakota)	1.73	0.98	1.88	1.12	1.92	1.12			This paper
Orellan (Nebraska)	1.86	1.09	2.01	1.21	2.05	1.22	1.95	1.13	Korth, 1994
Orellan (Colorado)	1.79	1.06	1.93	1.17	2.05	1.16	1.90	1.10	Korth, 1994
Orellan (Wyoming)	1.80	1.02	1.93	1.12	2.01	1.18			Setoguchi, 1978
Orellan (South Dakota)			1.85	1.13	1.95	1.15	1.94	0.99	Green and Martin, 1976
	M1L	M1W	M2L	M2W	M3L	M3W	M4L	M4W	
<i>Herpetotherium</i> sp.									
Hemingfordian (South Dakota)	1.75	1.54	1.65	1.58	1.51	1.60			Green and Martin, 1976
<i>H. youngi</i>									
Arikareean (Nebraska)	1.55	1.79	1.70	1.93	1.62	2.10			Korth, 1992
Arikareean (South Dakota)	1.82	1.69	1.76	1.79	1.80	2.08			Green and Martin, 1976
<i>H. fugax</i>									
Arikareean (Nebraska)	1.70	1.58	1.74	1.85	1.80	2.11	1.02	1.95	Hayes, 2005
Arikareean (Florida)	1.68	1.52	1.69	1.88	1.70	2.10	1.08	1.96	Hayes, 2005
Whitneyan (South Dakota)	1.74	1.64	1.93	1.94	1.70	2.03	0.84	2.04	This paper
Orellan (Nebraska)	2.02	1.69	1.97	1.98	1.93	2.19	1.09	2.10	Korth, 1994
Orellan (Colorado)	1.76	1.58	1.80	1.80	1.70	2.10	1.15	1.96	Korth, 1994
Orellan (Wyoming)	1.79	1.64	1.84	2.10	1.89				Setoguchi, 1978
Orellan (South Dakota)	1.85	1.68	1.75	1.88	1.74	2.08			Green and Martin, 1976

(Figure 11). The tooth is triangular in occlusal outline, slightly wider than long, typical of M2. The buccal cusps are typically dilambdodont with the metacone higher than the paracone. The protoconule and metaconule are minute but distinct. There is a slight inflection along the buccal margin of the tooth (=ectoflexus). The styler cusps are generally large. Cusp B and D are approximately equal in size, and

the largest of the styler cusps. Cusp B is positioned at the buccal end of the preparacrista. Cusp C is nearly as large as cusps B and D, anteroposteriorly elongated, at the center of the buccal margin of the tooth, and posteriorly connected to cusp D. Cusp E is slightly smaller than the anterior styler cusps but present at the posterobuccal edge of the tooth.

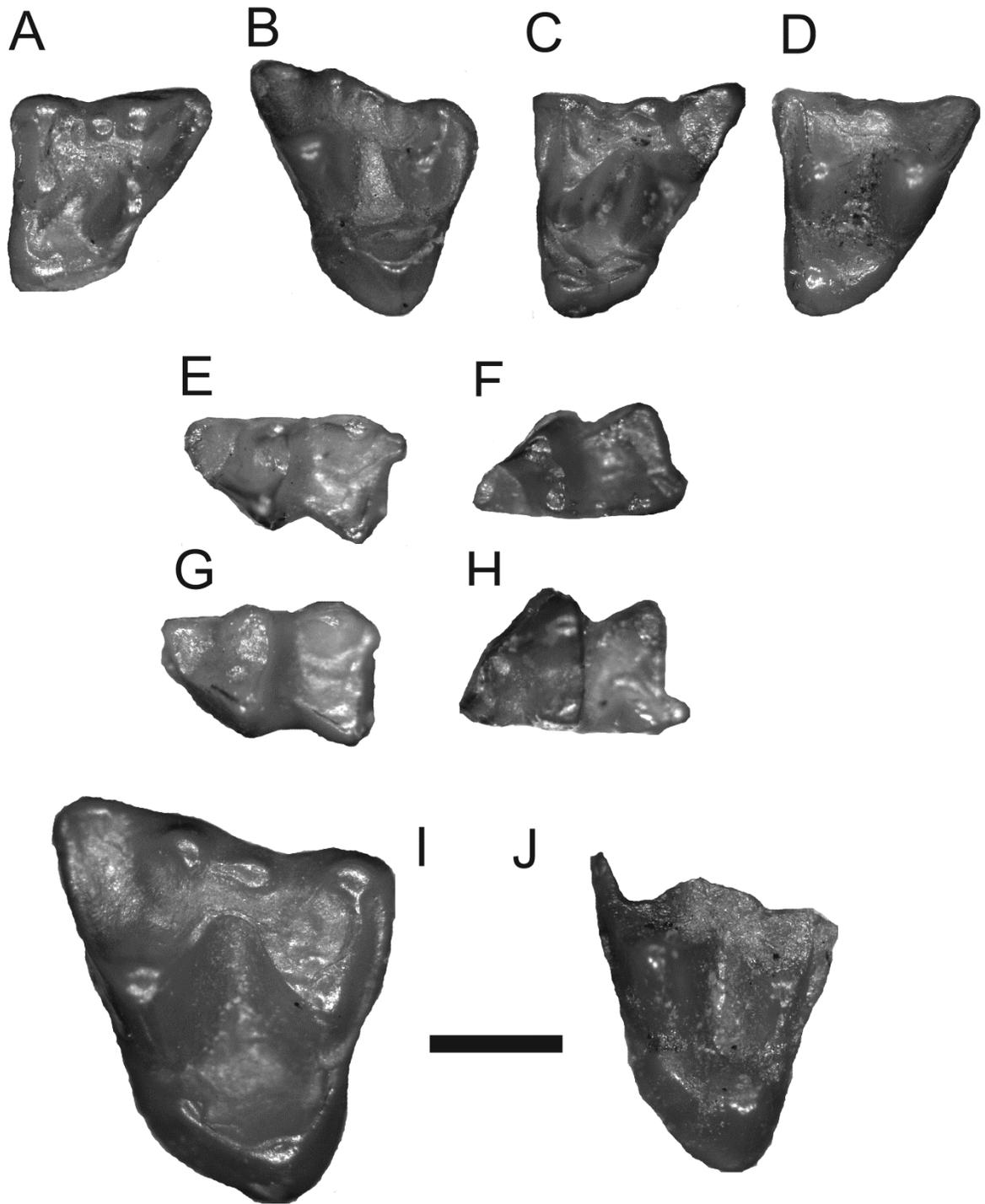


FIGURE 1. Cheek teeth of *Herpetotherium* from the Blue Ash anthill fauna, South Dakota. A-H, *H. fugax*. A, left M1, CM 89308. B, right M2, CM 89302. C, left M3, CM89304. D, right M3, CM 89305. E, left m1, CM 89316. F, right m1, CM 89321. G, left m2, CM 89317. H, right m3, CM 89319. I-J, *Herpetotherium* sp. I, right M2, CM 89313. J, right M3, CM 89311. Bar scale = 1mm.

M3 (CM 89311) is more transversely elongated than M2, but otherwise similar in morphology (Fig. 1J). The buccal margin of the tooth is broken away, so not all stylar cusps are preserved. However, there is an obvious large cusp D just posterior to the center of the buccal edge of the tooth and a slightly smaller cusp C just anterior to it, similar to the configuration as in M2. All other morphologies are as in M2.

Discussion—The two isolated upper molars referred here to *Herpetotherium* sp. are larger than all previously reported specimens of the genus. The measurements of M3, CM 89311, fall within the size range of some larger species, but the tooth is broken along the buccal margin, producing measurements less than the actual size. The referred M2, CM 89313, exceeds the measurements for *H. valens* and *H. merriami*, the previously largest species of the genus (see Korth, 1994:table 5). The size of the stylar cusps on the M2, as well as the presence of a distinct cusp E, also differs from the morphology of previously described species. In all other species, cusp E is lacking. The cusp C on M3 is distinct from cusp D, also rarely seen in others species where these cusps are completely fused, cusp C is minute and along the anterior slope of D, or cusp C is entirely lacking (Korth, 1994; Hayes, 2005). These two specimens clearly represent a new, larger species of *Herpetotherium*. However, due to the poor representation and the known wide range of variation in size and morphology of other species of the genus, a new species cannot be formally named at this time.

CONCLUSIONS

The species of *Herpetotherium* from the late Eocene and early Miocene (Chadronian-Hemingfordian) have been distinguished by differences in size and morphology of the stylar cusps on the upper molars (i.e. position, number, and size). As noted by Green and Martin (1976) in their study of marsupials from South Dakota, the range of variation in stylar cusp morphology is the same for all of the species from Orellan to Hemingfordian, and that the different species names applied were merely an artifact of the horizon in which they were found: *H.* (= *Peratherium*) *fugax* from the Orellan (Brule Formation), *H.* (= *P.*) *spindleri* (Macdonald, 1963) from the early Arikareean (Sharps and Monroe Creek formations), *H.* (= *P.*) *youngi* (McGrew, 1937) from the late Arikareean (Harrison Formation), and *Herpetotherium* sp. from the early Hemingfordian (Rosebud Formation). However, they did note a slight decrease in size of the molars through time. Of the three possible explanations offered, they suggested that the most likely scenario

was that only a single variable species was represented from all of these horizons.

Korth (1994) noted a distinct reduction in size through time as well as the reduction in number of stylar cusps on the upper molars, referring the Orellan species to *H. fugax*, the Arikareean species to *H. youngi* (= *H. spindleri*), and the Hemingfordian species to *Herpetotherium* sp. The only exception to this sequence was the Arikareean *H. merriami* (Stock and Furlong, 1922) from Oregon, the largest species recognized, that had larger and more distinct stylar cusps than the other Orellan or later species. Hayes (2005) pointed out that the number and size of the stylar cusps on the upper molars was a function of size of the individual within a population (fewer and smaller stylar cusps in smaller specimens), and included early Arikareean specimens from Nebraska and Florida to the otherwise Orellan *H. fugax*. He also noted a slight decrease in size in his Arikareean sample, but noted a great deal of overlap in the size ranges. He questionably maintained the late Arikareean species *H. youngi* based on the reduction of stylar cusps to one (central) on most of the upper molars (Korth, 1992, 1994).

The sample of *Herpetotherium fugax* from the late Whitneyan Blue Ash anthill fauna falls well within the range of other populations of the species in size and morphology. In size, it is closest to the sample from the early Arikareean of Nebraska (Hayes, 2005), slightly smaller than Orellan populations of *H. fugax* (Table 2). The Blue Ash sample maintains the wide range of variation in the stylar cusps of the upper molars that is dictated by size of the individual, also noted by Hayes (2005) for the early Arikareean sample.

The variation in stylar cusps mainly comes from the variation in stylar cusps B and C. In early species, on M1 and M2, cusp B is present but small and cusp C is slightly smaller (often minute) than cusp D and frequently joined to it. On M3 cusp B is even smaller and there is a single, central stylar cusp D, with a minute or fused cusp C (Korth, 1994:table 2). Although Green and Martin (1976) noted that the latest occurring specimens maintained the entire range of variation of the earlier species, according to their descriptions and figures, the overwhelming majority of the specimens in their samples from the later horizons (Green and Martin, 1976:figs. 4-6) have only a central cusp C on M1 and M2 and a central cusp D on M3 with cusp B being minute or absent. Only two specimens of M1 are figured with a minute cusp C on the anterior slope of cusp D (Green and Martin, 1976:figs. 4a, b), the remainder lack cusp C entirely. It appears that in these specimens, there may be the entire range of variations, but the upper molars predominantly have a single, large, central stylar cusp, a characteristic of *H. youngi*.

In the specimens of *H. fugax* the single, central stylar cusp (especially on M1 and M2) occurs in equal amounts to other configurations (Hayes, 2005:table 2). The Arikareean samples of *Herpetotherium* from South Dakota (Green and Martin, 1976) and from the late Arikareean of Nebraska (Korth, 1992) are dominated by the single stylar cusp even on the anterior molars, distinguishing them as a whole from the samples referred to *H. fugax* from the Orellan, Whitneyan and early Arikareean (Korth, 1994; Hayes, 2005). This predominance of the single stylar cusp is accepted here as separating the populations with this morphology from those where this occurs in only a fraction of the sample. This indicates a gradual change in morphology rather than a distinct sudden morphologic shift in the lineage of *H. fugax*-*H. youngi*.

The larger species from the Blue Ash fauna is clearly distinct from all known species of *Herpetotherium* in size as well as number and relative size of the stylar cusps.

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